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Global Challenges in Construction Industry

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We are very thankful to the authors who have submitted papers for this conference, as if not for them, we could not hold this event. Next, our thanks go to the eminent International and Local Scientific Committee members for reviewing and offering constructive comments to make the papers more meaningful and contextual. We would like to extend our gratitude towards the chief guest, keynote speaker, session chairs, paper presenters, best paper award selection committee and other invitees for their commitment and contribution to the conference.

We are also thankful for the organisations that have provided sponsorships. Last but not least, all our colleagues in the organising committee are especially thanked for devoting their time and effort to make 'World Construction Conference 2012' a success.

Editors
World Construction Conference 2012
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PREFACE

The 'World Construction Conference 2012' on 28 – 30 June 2012 in Colombo, Sri Lanka is jointly organised by the Ceylon Institute of Builders (CIOB); International Council for Research and Innovation in Building and Construction (CIB); and, Building Economics and Management Research Unit (BEMRU). The main theme of this international research conference is '*Global Challenges in Construction Industry*'. The conference will provide a special forum for researchers and practitioners in the area of challenges for construction industry worldwide to share their knowledge, experience and research findings.

The sub themes of the conference covered a wide spectrum of areas such as; Project Financing and Risk Management; Construction in Developing Countries; Sustainability and Energy Management; Procurement and Integrated Project Delivery; Stakeholder Management in Construction; Multinational Construction Practices; Construction Quality and Productivity; Construction Research and Education; and Law and Dispute Resolution.

We received number of abstracts and full papers for the conference covering above themes. All full papers went through a rigorous double-blind peer-review process by a well qualified panel of international and local reviewers with respect to the originality, significance, reliability, quality of presentation and relevance, prior to selection. Priority was given for the quality and standard of papers rather than the number of papers presented at the conference. It is our firm belief that the publication that emerged from this conference is the result of the tireless effort of all authors, reviewers and conference organising committee members and that it would pave way for advancement of knowledge.

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MOTIVATING THE CONSTRUCTION ACADEMIC: A CONCEPTUAL STUDY

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ABSTRACT

The main purpose of this study is to understand factors that motivate and demotivate a construction academic based on existing literature. An extensive examination of published literature failed to reveal any studies on motivation or demotivation of construction academics but for a few studies on motivation of academics in general. These studies revealed over 25 intrinsic and extrinsic factors which were differentiated between factors cited in conceptual and empirical studies. A further distinction was made between factors cited in studies focussed directly on motivation of academics, and factors cited in studies investigating a different topic. Factors so identified, provide a broad base for understanding 'what' factors affect motivation and demotivation of academics However, these studies have not taken into account discipline specific, job level, and other contextual issues or prioritised factors based on importance. Moreover, 'how' these factors could be used for improving organisational performance focussing on different disciplines and roles within these disciplines have not been studied either. Nevertheless, an examination of these factors revealed that most fall within the control of the university management. As such, there is a need for understanding what management styles could be used for increasing motivation and minimising demotivation, and this is an area that needs investigation focussing on construction specific issues vis-à-vis context and job roles.

Keywords: *Construction Academic, Demotivation, Motivation, University Management.*

1. INTRODUCTION

The emergence of construction as an academic discipline can be evidenced by the birth of number of undergraduate and postgraduate courses in universities and associated professional bodies that accredit these programs of study. Some have raised questions on whether such programs should be located within civil engineering schools as in the United States (Chinowsky and Diekmann, 2004). Others have housed such programs in faculties other than engineering particularly in commonwealth countries. Some others have raised questions on whether existing knowledge is of high quality (Ofori, 1994). Whilst the practices are heterogeneous in nature with a rapidly growing body of knowledge in the area of construction management, construction economics, construction project and production management, sustainable construction, construction business management, and so on all of which could be classed broadly brought under the umbrella of construction education. Those who primarily teach and research in these areas whilst employed in a university may be broadly classified as a 'construction academic' – at least for the purpose of this study.

2. CHALLENGES FACING CONSTRUCTION ACADEMICS

Challenges could be both motivating and demotivating. Before these topics are explored, it is useful to understand the context within which construction academics operate.

The university is one of the longest surviving organisational forms in the world with a history of over two millennia (Wernick, 2005, p.20). However, the first universities which offered organised education

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resembling the contemporary university were set up in the 11th century (Haskins, 2001). Universities did not change much till the 19th century. Then, with the industrial and scientific revolution that was taking place in the western world, the university focussed on research as an integral part of learning and became an institution which was devoted to the pursuit of knowledge and solution of problems as well as training students at a higher level (Bowden and Marton, 1999). Thereafter, in the latter half of the 20th century, when government funding was made available to the universities, the universities were expected to perform a third task, service to the community. Thus, the contemporary university regards teaching, research and service to the community as their primary responsibilities.

The late 20th century universities expanded rapidly and became even more diverse and a lot more complex. The governments started to monitor and to some extent control university activities (Wernick, 2005), even though their funding reduced and universities were asked to be more self-reliant. University management changed from the 'collegial model' to a 'managearilistic model" (Ylijoki, 2003) and universities adopted corporate management principles modelled on the private sector (Wernick 2005). The new model emphasised on 'accountability, efficiency, cost effectiveness, marketisation, and quality assessment in academic work' (Ylijoki, 2003, p.2). Corporate reforms such as performance appraisal and financial reporting were introduced (Winter and Sarros, 2002) and key performance indicators, explicit targets, outputs and income became common concepts in the contemporary university (Winter and Sarros 2002; Bellamy *et al.*, 2003).

In this business-like environment, where change is the norm, not the exception, university academics are increasingly exposed to changes in their work practices. For some academics, e.g. construction academics, this appears to be a greater challenge than to others, as they have to at times challenge popularly held beliefs about various disciplines (for example, as to whether engineering is part of construction or whether construction is part of engineering), promote change according to their expertise and experience in environments where others may have little understanding of the discipline and the profession, and to engage with practitioners who have qualifications different to 'construction' or have no related formal academic qualifications given that 'construction' is a relatively new field of study though spanning at least three decades.

Academics are known as a professional group (Bess, 1998; Aronsson *et al.*, 1999) committed to their profession (McInnis, 2000; Houston *et al.*, 2006). However, they do not belong to or seek membership of an exclusive professional body for academics as a professional such as an architect or an engineer or for that matter a construction professional. In relation to construction, it is not uncommon for a construction academic in commonwealth countries to seek membership of multiple organisations such as the Royal Institute of Chartered Surveyors (RICS) or the Chartered Institute of Building (CIOB) and with memberships with relevant local and international bodies accrediting construction programs but in doing so bear membership fees without any financial assistance from the University which could contribute towards demotivation.

The challenges seem to be far greater when employed in a Faculty where multiple programs are delivered (say architecture or engineering). Raising the profile and esteem of construction graduates and the construction profession in general seems harder unless there is empathy and respect for the construction profession from often powerful academics of the Faculty who belong to other professions. In situations where new programs have been developed with a greater focus on a business-model (than a content driven model), it is never an easy task to change the curriculum to differentiate construction programs with other programs when driven by a desire to deliver discipline specific knowledge and skills. The task of creating a catalytic environment lies squarely with management which could act as a catalyst for motivation.

As with all academics, construction academics are also involved with teaching, research and also administration. In newly established programs, they need to seek the support of the senior management to foster such programs which includes harnessing limited funds to market their programs particularly when the Faculty or the department name does not carry the name of the degrees offered (i.e. 'construction'). Similarly, they need support to eliminate curriculum-waste, when non-discipline specific courses are included in the core curriculum (such as when core courses are drawn from Business Schools on topics such as health and safety, law, or project management in preference to 'construction health and safety', 'construction law' or 'construction project management') akin to including non-essential content (at the expense of essential content). The appointment of qualified and competent academics to head such programs may help improve motivation as it will provide opportunities for their voices to be heard. Moreover, with the growth of new programs, delays in appointing new staff may result in high workloads with a commensurate delay in developing a critical mass of academics to foster discipline specific teaching and research, raise esteem of the construction profession as not being second to any other (say architecture, engineering, or project management), develop a vision and strategy for the future harmonising with existing values and visions, and in doing so to inform other academics on discipline specific issues and trends in order to achieve value-adding outcomes for construction students and the university. No doubt, all these could be *quite challenging* and *indeed motivating*, but could also *be demotivating* particularly if the management does not understand or appreciate the challenges faced by construction academics.

Academics are drawn to the university by the passion for their discipline and scholarship (Meyer and Evans, 2003). The values of academic profession are rooted in autonomy (Del Favero, 2003). They are committed to the principle of professional autonomy and regard their judgement as authoritative in their area of specialisation (Goodpastor and Montoya, 1996). They value the right to engage in scholarly inquiry of their choice without fear of retaliation (Kinser and Fossey, 2001). Academic freedom, collegiality, flexibility, high trust and high discretion status, are also very important to them (Coaldrake and Stedman, 1999; Hazelkorn, 2008). They remain in the university because of the flexibility and autonomy they have in carrying out what they like to do, i.e., teaching, research and service to the community, and their membership of a community of scholars (Bellamy *et al.*, 2003). When these are compromised as when the university hierarchy fails to create a suitable environment, it may be hypothesised that there is opportunity for demotivation to set in.

Many have noted the commitment of academics towards their primary duties such as teaching and research (Berman and Skeff, 1988; Currie, 1996; Currie *et al.*, 2000; Bellamy *et al.*, 2003; Chinowsky and Diekmann, 2004; Houston *et al.*, 2006). Currie (1996) for instance asserts that "… academics cannot give enough to their teaching and research. There are always students who need more help. … more books and articles to read. … more research that needs to be published". Moreover, because of their commitment to the academic profession, Harman (1988) believes that the academic life should be seen as a calling rather than a job, although not in a religious sense (Bellamy *et al.*, 2003). Understanding such imperatives would be useful in creating environments for harnessing the power academics have, to make a substantial and significant difference to the university, students, industry, and community.

3. PURPOSE OF THE STUDY

In managing their employees, management needs to be aware of what motivates and demotivates them. Motivated academic employees are essential to the survival and development of the university (Rowley, 1996; Ramsden, 1998; Capelleras, 2005; Houston *et al.*, 2006) as motivation is a key determinant of work-performance (Evans, 1986; Pringle, 1986; Greenberg and Baron, 1993; Sackett *et al.*, 1998). Academics play a key role in achieving the goals and objectives of the academic institution (Capelleras, 2005). They are the fundamental source for the institution to have a quality student interface and to build the quality of research in the university (Rowley, 1996). Well motivated academic staff will not only build a reputation for themselves but also will enhance the reputation of the institution and thus attract high calibre students and also attract research funds. Poor motivation and declining commitment of academics produce negative results in productivity and profitability of the university (Ramsden, 1998).

In response to the demands in the changing environment as articulated earlier, construction and other academics are now called upon to do a variety of complex work in an increasingly demanding environment while responding to traditional academic tasks (Houston *et al.*, 2006). Old ideas of teaching, research, and faculty administration changed at a rapid speed as new departments, research institutes, and vast libraries were brought into the university among other things. Academics have to respond to 'diverse student expectations, a competitive research environment, community expectations for relevance, declining public funding, and increased administrative and fiscal accountability' (Houston *et al.*, 2006, p.20). These new and sometimes conflicting demands have had marked effects on academics' motivation as there is an obligation for them 'to perform better in all aspects of academic work, and to do it, of course, with fewer resources' (Ramsden, 1998, p.351). In other words they are asked to do more with less (Meyer and Evans, 2003) which could be demotivating.

Researchers have argued that these changes have deeply affected the core values and basic beliefs of academic work (Parker and Jary, 1995; Smith and Webster, 1997; Slaughter and Leslie,1997; Rhodes,1998; cited in Ylijoki, 2003). Literature illustrates that academics are not happy with the new developments. Rowley (1996) and Ramsden (1998) inform of a growing sense of disillusionment among academics. They have reported high level of personal stress (Gillespie *et al.*, 2001), lack of consultation (Winter *et al.*, 2000), an increased workload (Paewai *et al.*, 2007), and alienation from their organisation (McInnis, 1992 cited in Ramsden, 1998) all of which may lead to demotivation if not given adequate attention.

Clearly, high performing staff is a key to the development of any organisation and the contemporary university is no exception. The skills, experience and knowledge employees possess have economic value to organisations and represent human capital as they enhance productivity (Snell and Dean, 1992). Emphasising the importance of motivated employees in organisational performance, Osteraker (1999) states that if an organisation does not motivate its employees, the knowledge within that organisation will not be used to the fullest.

Researchers note that there are several determinants of job-performance, and motivation is one of these. Baron and Greenberg (1994, p.90) propose that "motivation together with a person's skill and abilities, role perceptions, and opportunities combine to influence job performance".

The general assumption is that employee motivation is complex. There are no set of guidelines to which will assure motivated employees, and different employees may need different approaches to be motivated. However, there is no dispute that having motivated employees is one of the highly worthy goals for any employer. Therefore, the purpose of this study is to undertake a comprehensive literature review to investigate the motivational and demotivational factors of academics as an initial step to fostering an understanding about the motivation and demotivation of construction academics.

4. STATE OF THE ART: MOTIVATION STUDIES

Prior to undertaking the review of literature on motivational and demotivational factors of the academics, it is necessary to define work motivation and demotivation. It also interesting note the concept of amotivation proposed by Deci and Ryan (1985). Amotivation is defined as the lack intention to act. Its meaning is similar to that of demotivation as it occurs when there is an absence of motivation (Alexandris and Grouios, 2002; Sharp *et al.*, 2006 Watts, 2008). However, amotivation was not considered in this study.

4.1. MOTIVATION AND DEMOTIVATION

4.1.1. MOTIVATION

Motivation in general is an area that is well researched. However, there are numerous researcher definitions of motivation with overlapping as well as different features (Grubsic and Goic, 2003, p.388). According to Locke and Latham (2004, p.380) motivation refers to "internal factors that impel action and to external factors that can act as inducements to action". It is a "set of processes that arouse, direct, and maintain human behaviour toward attaining a goal" (Baron and Greenberg, 1994, p.75). Motivation arises from a need to achieve better standards (Kiziltepe, 2008). There are three aspects of action that motivation can influence i.e., choice, effort, and persistence of a person (Steers, *et al.*, 2004, p.379).

In an organisational setting, work motivation is the employee keenness to achieve the goals of the organisation (Grubsic and Goic, 2003). It is their willingness to work at a certain level of effort (Sullivan, 1989). Yan's (2009, p.110) describes motivation as "to exert high levels of effort towards organisational goals, conditioned by the effort's ability to satisfy some individual need". Yan's description resonates with Sullivan's while taking another step higher i.e. from 'a certain level of effort" to 'a high level of effort'.

Motivation is a "set of internal and external forces that initiate work-related behaviour and determine its form, direction, intensity, and duration" (Ambrose and Kulik, 1999, p.231). Myers (1964) explains that a 'challenging job which allows a feeling of achievement, responsibility, growth, advancement, enjoyment of work itself, and earned recognition' will motivate employees to work effectively (p.71). For the purpose of this study, based on the above explanations, motivation is defined as a force that persistently drives employees to achieve personal and organisational goals (in a complimentary manner, influenced by both intrinsic and extrinsic factors which determine the nature of the effort invested.

4.1.2. DEMOTIVATION

As with 'motivation', an agreed definition of demotivation does not exist (Kupers, 2001), and there are only a few studies that have examined demotivation (Grubsic and Goic, 2003; Keblawi, 2005; Yan, 2009) compared to research on motivation.

Kupers (2001) claims that demotivation is a 'reduced force for thinking, feeling, or acting" (p.3). Demotives are negative counterpart of motives; motives increase an action tendency while demotives decrease it (Kiziltepe, 2008; Yan, 2009). Dornyei (2001) too suggests that demotivation is the flip side of motivation (Keblawi, 2005), which consists of "specific external forces that reduce or diminish the motivational basis of a behavioural intention or an ongoing action" (Yan, 2009, p.110). Grubsic and Goic (2003) agree stating that it is a "condition of damaged or destroyed motivation" (p.155). However, Kupers (2001) believes that demotivation is just not a reversal of motivation; it may result not in just non-acting or unmotivated behaviour but also in counter-productive behaviour.

Furthermore, Smith (2004) claims that an employee's unfulfilled needs may lead to demotivation. Meyer proposes that demotivation has six stages starting with the employee feeling confused, leading to becoming uncooperative, and finally departing the organisation (Meyer, 1977; Meyer, 1978). Grubsic and Goic (2003) describes areas of influences on demotivation and Spitzer (1995) explains several workplace demotivators. Demotivation is reflected in dysfunctional behaviour (de Treville and Antonakis, 2002). Though most employees arrive at work already motivated to carry out their tasks well, usually due to some external reasons they get demotivated and lose interest of continuing the task with the same force (Meyer, 1977; Keblawi, 2005; Yan, 2009).

Based on the above explanations, for purposes of this study demotivation is defined as an internal or external force that diminishes or eliminates the willingness of an employee to perform tasks to achieve complimentary personal and organisational goals, which can also be termed as the reversal of motivation.

4.2. MOTIVATIONAL AND DEMOTIVATIONAL FACTORS OF THE UNIVERSITY ACADEMIC

It should be noted that there were only a handful of studies that have investigated the motivational and demotivational factors that affect academics, as the primary focus of the investigation (see Section 4.2.1), though several researchers have noted the importance of a motivated faculty to the growth and sustainability of the university. This drew on the need for a further review of literature to ascertain whether there are studies that have come across motivating or demotivating factors of academics while investigating another subject (see Section 4.2.2).

4.2.1. MOTIVATIONAL AND DEMOTIVATIONAL FACTORS OF ACADEMICS AS THE PRIMARY FOCUS

Rowley (1996) is one of the first researchers on academic motivation. The recommendations in Rowley's conceptual study are based on a discussion of motivation theories such as Taylor's (1947) rational economic model, Mayo's (1975) social model, Maslow's (1970) self-actualising model, and Herzberg's (1959) two factor theory. Rowley (1996) suggests that financial rewards may not motivate all staff as different staff are motivated by different factors. Appropriate appraisal and development schemes, proper acknowledgement, and autonomy, are other issues impacting motivation of the academics positively. Rowley (1996) does not specifically discuss demotivators, but recommends that managers must eliminate or reduce dissatisfiers such as lack of resources, and insufficient communication. Perhaps, it is worthwhile to note that Herzberg's (1959) study also uses satisfaction and motivation as interchangeables.

Winter and Sarros's (2002) empirical study spanning across four universities was aimed at identifying motivating and demotivating sources of academics. Their study found positive job characteristics such as role clarity or low levels of role ambiguity, and supportive supervisory leadership as motivating factors for academics. Academics are motivated by clear and achievable roles, by "knowing exactly what is expected of them" (p.250). It is established that role ambiguity, which is the flip side of role clarity, leads to job stress (O'Driscoll and Beehr, 1994) and also has been noted as a characteristic of job dissatisfaction (Glisson and Durick, 1988). Winter and Sarros's (2002) also note challenging job tasks are a key source of motivation for the academics. Indeed, according to Fried and Ferris (1987), challenging roles provide opportunities for recognition, responsibility and personal growth at work (Fried and Ferris, 1987 cited in Winter and Sarros, 2002). Considerate and supportive supervisors are also a motivating factor for the academics (Winter and Sarros, 2002); supportive leadership has been established as a strong work motivator in other studies as well (Ramsden, 1988; Brown, 1996).

The demotivating factors for the academics determined by the above named authors, i.e. Winter and Sarros (2002) are role overload, low job feedback, and low levels of participation in decision making. Academic research participants state that "massive teaching and admin responsibilities threaten to overtake their research" (p.251), and they find work overload exhausts them and feel that their "job has taken over their life" (p.252). The academics are also demotivated by low feedback as they do not know "how well they were doing their jobs", and as a result they do not always know "when and how to change their work performance to increase desired outcomes" (Winter and Sarros, 2002, p. 252). Other studies also have noted that when academics do not receive sufficient feedback, it lowers their commitment to the university (Martin, 1999; Taylor, 1999; Trowler, 1998 cited in Winter and Sarros, 2002). Additionally, academics resent and are demotivated by the lack of opportunities available to them to participate in decision making, as they wish to be consulted when the university hierarchy makes decisions, especially, when these have an impact on their work (Winter and Sarros, 2002).

Winter and Sarros's (2002) research is one of the few studies that clearly identifies both motivating and demotivating factors of academics. However, the authors mainly derived the motivating and demotivating factors from a close ended questionnaire. Even though, there was an open ended question which asked the respondents to comment on their feelings towards their current job environment, there was no opportunity for the academics to freely discuss the factors that motivates and demotivates them. Their research identified the motivators and demotivators by different academic staff levels such as professor, senior lecturer etc. and the survey questionnaires were administered to five academic of disciplines areas. However, construction academics were not included in this survey. Further, the findings were generic to all academics. In other words, results were not categorised by discipline areas.

The conceptual study of Meyer and Evans (2003) proposes that the academics can be motivated with intrinsic rewards (Hertzberg *et al.*, 1959), as they desire to advance in their field, value peer recognition, and feel proud when they see their name in print. In order to achieve these, Meyer and Evan's (2003) suggest that institutional incentives such as good technical support, study leave, increased lab space or computer facilities, collegial exchange, international conference attendance etc. be given to the academics. Demotivating factors of academics are not discussed by Meyer and Evan (2003) and the main objective of the study was to examine approaches to motivating the professoriate.

Kiziltepe's (2008) research aimed to examine the sources of motivation and demotivation of academic staff in a Turkish university: the author carried out an empirical survey requesting the respondents to rank three factors that motivated and demotivated them most. The respondents identified enthusiastic students, social status, and prestige from research publications as motivating factors. The demotivating factors were lack of interest shown by students, low salaries, and lack of opportunity to do research. Unlike the study of Winter and Sarros (2002), Kiziltepe (2008) provided the academics the freedom to put forward the factors as they perceive as motivators or demotivators without being prompted by the researcher. However, Kiziltepe's (2008) study does not analyse or explain how and why these factors motivate or demotivate the academics, nor did it differentiate between various disciplines or academic staff levels.

Summarised below in Table 1 are the motivational and demotivational factors of the above mentioned studies. For the purpose of this study an 'empirical' study is termed as a research where the conclusions or the research ends are based on evidence and not just on theory, while a conceptual study is a research based only on theory.

Table 1: Motivational and Demotivational Factors of Academics as the Primary Focus

Author	**Motivation Factors**	**Demotivation Factors**	**Empirical Study (E)/ Conceptual study (C)**
Kiziltepe (2008)	enthusiastic students, social status, prestige from research publications	lack of interest shown by students, low salaries, lack of opportunities to do research	E
Winter and Sarros (2002)	role clarity, challenging tasks, supportive leadership	role overload, low job feedback, lack of participation in decision making, Administrative tasks	E
Myer and Evans (2003)	peer recognition, pride in seeing their name in print, opportunity to advance in their field, study leave, provision of resources, conference attendance		C
Rowley (1996)	financial rewards, appropriate appraisal and development schemes, proper acknowledgement, autonomy	lack of resources. insufficient communication	C

4.2.2. MOTIVATIONAL AND DEMOTIVATIONAL FACTORS OF ACADEMICS AS A SECONDARY FOCUS

The study of Tipples *et al.* (2007) reviewing the Australasian academics' psychological contracts and how they are changing, examined the potential of the psychological contract as a means of understanding and managing contemporary academic workplace relations and performance. These authors found that commitment to teaching and the desire to contribute to the society are powerful motivators for the academics to be attracted to academia.

The study of Winter *et al.* (2000), examined the quality of academic work-life (QAWL) issues in an Australian university. These authors invited the academic from across five disciplines and five academic levels to comment on their job environment and large scale changes taken place in the higher education sector. Though the study was not primarily focused on discovering motivational or demotivational factors for the academics, it revealed some positive aspects of QAWL such as high level of task identity, autonomy, skill variety, and job challenge, which are established to be motivating job characteristics (Hackman and Oldham, 1980 cited in Winter *et al.*, 2000).

Literature reveals that researchers fall into two categories when considering the roles of intrinsic rewards and extrinsic rewards (Hertzberg *et al.*, 1959) play in motivating the academics. One group claims that the academics are motivated intrinsically. Coaldrake and Stedman's (1999) report considered the implications of changing policies and practices in higher education governing university staff and mentions that academics remain intrinsically motivated by their work. Berman and Skeff (1988) while assessing the academics attitudes towards teaching and teaching improvement, state that at a time when universities are facing financial constraints, intrinsic motivation may play an important role. While investigating on how to manage an effective university, one study states that the academics who have a high level of intrinsic motivation are twice as productive as the least intrinsically motivated (Ramsden,1998). The academics can be intrinsically motivated by several factors, i.e., flexibility and autonomy (Bellamy *et al.*, 2003; Houston *et al.*, 2006), a co-operatively-managed environment (Ramsden, 1998) and the membership of a community of scholars (Bellamy *et al.*, 2003). Another study also reported that when dissatisfied academics decide to leave the university, they do not put much weight on extrinsic factors such as income, to affect their decision (Lacy and Sheehan, 1997).

The other group of researchers feel that extrinsic rewards are also important as these too help to motivate the academics. The extrinsic motivators include expressions of appreciation by students and peer recognition (Houston *et al.*, 2006), transparent pay-for-performance appraisal systems (Turk, 2008), and financial rewards (Berman and Skeff, 1988; Matier, 1990). The proposition that academics are motivated by extrinsic awards such as financial rewards contradicts the conclusions of some researchers who have noted that the academics are not motivated by such rewards (Bellamy *et al.*, 2003; Houston *et al.*, 2006). In fact, McKeachie (1982) argued that extrinsic rewards such as salary increments "are likely to have undesirable long-term effects on motivation" (Moses, 1986).

Exploring the inconsistencies for access and equity to perform research in higher education, Massey and Milsom (2000) discovered that motivating factors for academics to do research include advancement of knowledge, peer recognition and prestige, personal and professional development, success in grant rounds, acknowledgement of research performance, and the opportunity to do team work. While investigating impacts of changing funding patterns have on university research, Ylijoki (2003) also found that recognition and prestige within the scientific community as an important motivational force for academics. Demotivating factors for research performance include teaching load, lack of appropriate resources, challenge of finding industry or other research partners (Massey and Milsom, 2000).

In a research study to academic staff attitude to promotion procedures, Moses (1986) found that equal recognition for both teaching and research is necessary for motivation of academics, as they are dissatisfied when promotion systems undervalue teaching excellence and mostly rewards excellence in research. They were motivated by promotion decisions which recognise teaching as well. Ramsden and Martin (1996) also state that there is a perception in the academia that universities in general recognise good research but not good teaching. A sense of achievement, autonomy, advancement, growth opportunities and status of being a university staff are also factors that motivate academics (Moses, 1986).

Table 2 illustrates the motivational demotivational factors mentioned in studies where the main purpose was to investigate another issue.

Table 2: Motivational and Demotivational Factors of Academics as a Secondary Focus

Author	Motivational Factors	Demotivational Factors
Bellamy *et al.* (2003)	flexibility, autonomy, community of scholars' membership	
Berman and Skeff (1988)	financial rewards	
Bess (1998)	peer approbation, clear avenue, to higher status and respect, opportunity to shift intellectual directions on occasion without penalty, trust and good will	
Houston *et al.* (2006)	flexibility and autonomy, student appreciation, peer recognition	
Massey and Milsom (2000)	advancement of knowledge, peer recognition, personal and professional development, success in grant grounds, acknowledgement of research performance, opportunity to do team work	teaching load, lack of appropriate resources, challenge of finding research partners
Moses (1986)	equal recognition for research and teaching, autonomy, advancement, growth opportunities and status of being a university staff	
Ramsden (1988)	cooperatively management environment	
Tipples *et al.* (2007)	commitment to teaching, contribution to society	
Turk (2008)	pay-for-performance appraisal system	
Winter *et al*, (2000)	growth opportunities, status, task identity, autonomy, skill variety, job challenge	
Ylijoki (2003)	recognition and prestige within the scientific community	lack of opportunity to do academic research

5. REFLECTING ON MOTIVATIONAL AND DEMOTIVATIONAL FACTORS

It was surprising to note that there are only a very few studies that investigated the motivating and demotivating factors of academics as the primary focus when many have stressed the importance of motivated academic staff to the growth and sustainability of the contemporary university. Moreover, there are only two empirical studies that ascertained the motivational and demotivational factors of academics. Additionally, the empirical investigations are limited by the lack of opportunity given to the academics to freely express their perceptions about the motivational and demotivational factors that affect their work-life. Further, there is only one study which considered various job levels and discipline areas of academics, however, none of the studies included construction academics. This brings out the need for an in-depth empirical study to ascertain the motivational and demotivational factors affecting construction academics, also taking into consideration different academic levels and contextual factors (such as whether construction taught in a separate school or not, development stage of program, strength of discipline specific staff, etc.).

As noted before, the lack studies investigating the motivating and demotivating factors of academics as the primary focus prompted a review of indirect studies on this topic (i.e. studies that listed motivational/demotivational factors while investigating another topic). Once again, it was seen that there were only a few more. It is seen that some of the factors listed in Table 1 are identified as motivational and demotivational factors in Table 2 as well. All factors given in Tables 1 and 2 are summarised in Table 3 (a total of 19 factors) and Table 4 (a total of 8 factors).

On further reflection, as illustrated in Tables 3 and 4, it is important and interesting to note that majority of the factors which motivate university academics are within the control of the university management. Further, it is also seen that academics are motivated by both intrinsic and extrinsic factors.

Table 3: Motivational Factors

Motivating Factors	Within Mgmt. Control	Outside Mgmt. Control	Extrinsic	Intrinsic	Primary Focus	Secondary Focus
Role clarity	√			√	√	√
Challenging tasks	√			√	√	
Supportive leadership	√			√	√	
Peer recognition/prestige		√		√	√	√
Autonomy	√			√	√	√
Flexibility	√			√		√
Trust and goodwill	√			√		√
Opportunity for teamwork	√			√		
Equal recognition for teaching and research	√		√	√		√
Career advancement / Development schemes	√			√	√	√
Pay for performance appraisal Schemes	√		√		√	√
Financial rewards	√		√		√	√
Enthusiastic students		√		√	√	
Student appreciation		√		√		√
Prestige from publications		√		√	√	√
Study leave	√		√		√	
Conference attendance	√		√		√	
Social status		√		√	√	
Advancement of knowledge/ Contribution to society		√		√		√

As noted earlier, Table 4 provides a list of all demotivating factors. Interestingly, except for one factors, all others are within the university management control. Additionally, as before, it is seen that academics are demotivated by both extrinsic and intrinsic factors.

Table 4: Demotivational Factors

Demotivating Factors	Within Mgmt. Control	Outside Mgmt. Control	Extrinsic	Intrinsic	Primary Focus	Secondary Focus
Lack of interest by students		√		√	√	
Low salaries	√		√		√	
Lack of opportunity to do research/ resources	√			√	√	√
Role overload	√			√	√	√
Low job feedback	√				√	
Lack of decision making participation	√			√	√	
Administrative task	√			√	√	
Insufficient communication	√			√	√	

6. CONCLUSIONS

The purpose of this study was to investigate the motivational and demotivational factors of construction academics given the unique challenges such academics are faced with. An extensive literature search failed to reveal any studies but for a limited number of studies on motivation and demotivation of academics in general. A review of such literature produced a generic list of factors (over 25) affecting motivation and demotivation of academics despite a paucity of empirical studies on a topic that many consider as important for achieving university goals and objectives. Moreover, given that these studies do not identify which factors are of greater importance depending on discipline and job levels, this study finds that there is a need to investigate this issue further including whether there are additional factors that motivate or demotivate academics.

As majority of the factors referred to above was found to be within the control of university management, it is clear that university senior management has an important role to play in motivating academics. It is important for them not only to know what factors motivate and demotivate academics but also understand what strategies could be adopted to improve motivation and prevent any demotivation. In this regard, understanding how management styles can play a catalytic role vis-à-vis motivating the academics also becomes an important area for investigation.

This study also highlighted some of the challenges faced by construction academics, briefly, which could be both motivating and demotivating depending on contextual factors and job levels (and roles) – an area that also needs to be investigated further taking into consideration the above mentioned facts. A study to develop a suitable management model is proposed investigating how the construction academics wish to be motivated, with reference to university management. It is envisaged that the proposed model will assist the university management to provide a stimulating work environment for such academics.

Academics are a key resource in achieving the goals and objectives of a higher educational institution. They are independently-minded, and leading them have been compared to herding cats (Spendlove, 2007) illustrating the difficulty in managing them. Understanding factors that motivate and demotivate them including management styles that could harness the power within them is fundamental as universities venture into a more challenging future than in the past.

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AN ANALYSIS OF CONSTRUCTION LAW AND DISASTER MANAGEMENT LAW RELATING TO SUSTAINABLE DEVELOPMENT IN SRI LANKA

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ABSTRACT

Construction Law may be defined as the law that regulates built environment in relation to construction activities. This law also deals with physical planning techniques and protection of natural environment. Law governing in built environment in Sri Lanka is largely based on legislation. Main physical planning legislations in Sri Lanka are Urban Development Authority (UDA) Law No. 41 of 1978, Town and Country Planning Ordinance No. 16 of 1946, Municipal Council Ordinance and Urban Council Ordinance of 1947, Pradeshiya Sabhas Act of 1987, and their amendments. Provisions of these legislation are controlling construction activities in their regions. National Environment Act of 1980 controls EIA and EPL relating to the construction industry. The Sri Lanka Parliament enacted two legislations after the tsunami namely Tsunami (Special Provisions) Act No. 16 of 2005 and Disaster Management Act No. 13 of 2005 for the rehabilitation activities. These two Acts have mentioned planning and recovery techniques and elements of disaster management law. In the post tsunami reconstruction work, the government has given high priority to rebuild human settlements. However there are some discrepancies in these legislation and are not accepted in sustainability concepts. Hence, the aim of this research is to compare existing Construction Law and Disaster Management Law relating to the construction industry in Sri Lanka and recommend improvements to the Construction Law practices in order to make sustainability concepts more effective. Through a literature review of recent court cases, this research has analysed the basic concepts and discrepancies of the above mentioned law in Sri Lanka.

***Keywords**: Planning Legislation, Environment, Disaster Management.*

1. INTRODUCTION

Construction Law is part of Civil Law. At present, Construction Law is one of the main branches of Civil Law or Private Law. Construction Law may be defined as the law that regulates built environment in relation to construction activities. This law also deals with physical planning techniques and protection of natural environment. Law governing in built environment in Sri Lanka is largely based on legislation. This research compares environmental law and planning law with special reference to construction law and and disaster planning law in Sri Lanka. The study further suggests improvements to the Development Law and Construction Law in order to make planning procedure more effective.

2. LEGISLATION PROVISIONS FOR CONSTRUCTION LAW

Environmental and Physical Planning Law is a sub division of the Construction Law and that law may be defined as the law that regulates natural resources in relation to human behaviour and this law deals with improvement and protection of natural and built environment. At present, there are different Environmental and Physical Planning Law in Sri Lankan legal system and it is stated in the Figure 1.

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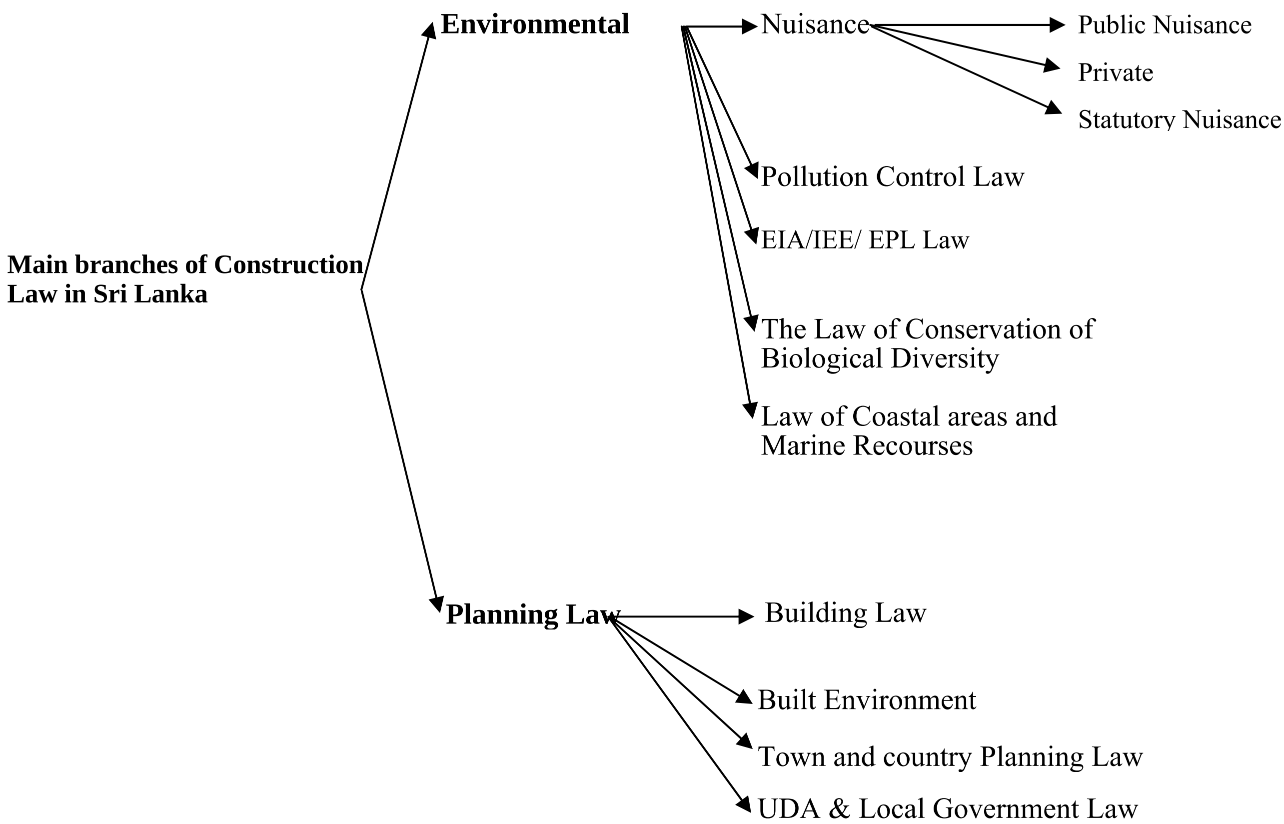

Figure 1: Main Branches of Environmental and Physical Planning Law in Sri Lanka

2.1. ENVIRONMENTAL LAW, PHYSICAL PLANNING LAW AND DISASTER MANAGEMENT LAW AS PARTS OF CONSTRUCTION LAW

The methods of economic development, which the mankind has followed, are also creating environmental problems through construction activities. Urbanisation and construction industry has affected the natural environment adversely. Sri Lanka's Constitution adopted in 1978 specially refers (Article 27) to the preservation of the environment. The laws governing the protection of environment and conservation in Sri Lanka are largely based on legislative enactments. Sri Lanka Parliament enacted National Environmental Act No. 47 of 1980 to the establishment of the Central Environmental Authority (CEA) in 1981 as the state agency responsible for the formulation and implementation of policies and strategies for the protection and management of environment in Sri Lanka. Also the Parliament enacted different legislation for protection of environment such as Fauna and Flora Protection Ordinance No. 02 of 1931, Forest Ordinance No. 16 of 1901, Coast Conservation Act etc. Towards the protection of environment, aspects of control of physical planning and built environment in the country have a considerable role to play.

There are many physical planning legislation in Sri Lanka such as *Housing and Town Improvement Ordinance No. 19 of 1915, Urban Development Authority (UDA) Law No. 41 of 1978, Town and Country Planning Ordinance No. 16 of 1946 ,Municipal Council Ordinance and Urban Council Ordinance, Pradeshiya Sabahas Act, etc. Housing and Town Improvement Ordinance No. 19 of 1915* is controlling physical planning matters and main objective of this Ordinance is to deal with the problem of insanitary conditions of urban overcrowding as well as to prevent such situation. *Urban Development Authority Law No. 41 of 1978* (UDA Law) marks a new era in the physical planning exercise in Sri Lanka and this law was in acted in 1978 due to inadequacies found in both Housing and Town Improvement Ordinance No. 19 of 1915 and Town and Country Planning Ordinance No. 16 of 1946 to deal with physical planning problems of the urban areas of Sri Lanka. According to the preamble to the UDA law, the objective of the law is to promote planning of economic, social and physical development and its implementation in the urban areas declared under this law and control of environment. In order to realise these objectives, clearance of slums and shanties, coordination and control of development projects carried out by other governmental agencies, exercising of development controls to ensure conformity to development plans and planning regulations. UDA has introduced a new set of development regulations in areas under replacing the provisions of Housing and Town Improvement Ordinance.

UDA Regulations may be made by the Minister of Construction and Urban Development for the purpose of carrying out or giving effect to the principles and provisions of the UDA Law No. 41 of 1978 as amended by Act No. 4 of 1982 to regulate any physical planning projects or schemes prepared by any Government Agency or other persons in such areas or regulating the use of land and buildings in different zones, and imposition of conditions and restrictions in regard to several factors of building development or regulations regarding clear distances of buildings from electrical, telephone, telegraph, microwave and other lines or regulations in respect of unsafe buildings and prescribing standards of fitness of buildings (Item 4 (l) of Schedule of Amendment Act No. 4 of 1982) or regulations for attaining urban design objectives etc.

Sri Lanka is one of the countries that were hardest hit by the tsunami tidal waves that ravaged severed countries in the Indian Ocean rim on December 26, 2004. The tsunami caused extensive damage and disruption to human life, livelihood, public and private property, economic infrastructure, buildings in Sri Lanka. The main objectives of the planning laws in the tsunami affected areas are to provide immediate to communities and local government authorities to speedy restart functions through protection of environment. The Sri Lanka Parliament has enacted special two Acts namely *Tsunami (Special Provisions) Act No. 16 of 2005 and Disaster Management Act No. 13 of 2005* for path of rehabilitation. These two Acts specially mentioned planning and recovery techniques of disaster management law of Sri Lanka. The Government has been taken steps to shift from registering deeds to registering titles in tsunami damaged areas. The Registration of Titles Act complies with this task. Main objective of this is grant rights with absolute rights and maintain a better land management system and scientific utilisation of lands for any industry. Government of Sri Lanka implemented the disaster management plan for the development and support of rehabilitation of construction projects through these Acts. In the post tsunami reconstruction work, the government has given high priority to rebuild human settlement and shelters. Therefore, relevant these legislations are related to the rehabilitation and reconstruction strategies in tsunami affected areas. However, there are different loopholes in these legislation and sometimes courts were observed.

3. ENVIRONMENTAL LAW AS A PART OF CONSTRUCTION LAW

Environmental Law may be defined as the law that regulates natural resources in relation to human behaviour. The environmental law deals with improvement and protection of environment. This law is one of the instruments that enable the community and the country to achieve the objective of environmental protection. Environmental destruction and pollution have seriously threatened the human life, health and livelihood. While the scientifically and technological progress of men has invested him with immense power over nature, it has also resulted in the use of such power encroaching endlessly on nature.

3.1. CONSTITUTIONAL AND STATUTORY PROVISIONS

Sri Lanka's present Constitution specially refers to the preservation of the environment through the Article - 27 (14). It is stated as the State shall protect, preserve and improve the environment for the benefit of the community. The conservation of environment was for many decades vested with large number of state institutions and agencies and earlier there was no central legislation. Neither was there a central body to coordinate efforts to unsure that the laws and regulations were properly implemented. Up to 1980 environmental provisions were scattered over large number of separate statues. More over in the 1980s, the issue of the environment became more and more prominent and rose higher in the national agenda. Recognising this lacuna and institutionalising the constitutional pledge to safeguard the environment, the government introduced a statue called National Environmental Act No. 47 of 1980.This Act led to the establishment of the Central Environmental Authority (CEA) in 1981 as the premier state agency responsible for the formulation and implementation of policies and strategies for the protection and management of environment in Sri Lanka.

Recognising that the CEA lacked regulatory powers to act on environmental pollution, the National Environmental Act was amended in 1988. The amendment requires all project approving agencies to obtain an Environmental Impact Assessment (EIA) from the developer proposing a development activity. The EIA process is a useful tool in assessing the impact of development projects and activities. Environmental Impact Assessment (EIA) us a term used define a document which assesses the environmental effects for proposed development projects or policies and evaluates alternatives to that project/policy that might be environmentally better. This concept originated in the United States where in 1970 National Environmental Policy Act (NEPA) required all major Federal activities significantly affecting the environment to have an EIA. The EIA serves as an information base on which important decisions about the development activity is taken. EIA has become a decision making tool throughout the world and multilateral banks and aid agencies now require it as part of project appraisal. The important of the EIA lies also in the fact that an EIA can become the basis on which community participation is encouraged and information about the development project is made transparent. The procedure established provides for the submission of EIA's in respect of projects that are generally determined by the Minister of Environment. Ones an EIA is submitted, the Act provides for a public inspection period with mandatory 30 day period for the receipt of public comments. A public hearing may be held where the public interest so demands and a decision to proceed with a project with or without conditions have to be arrived at thereafter.

Therefore EIA process is a useful tool in assessing the impact of development projects and activities. Further Antiquities Ordinance has been amended by Act No .24 of 1998 to obtain an approval from the Department of before any major project is launched by any developer. This process is known is *Archaeological Impact Assessment (AIA) Survey. Coast Conservation Act* is another two statutes with provisions for physical planning matters in coastal belt relating to the Construction industry.

4. Physical Planning Legislation as a Part of Construction Law

Towards the protection of environment, aspects of physical planning and built environment in the country have a considerable role to play. In this regard an account of some important statues seeking to regulate physical planning matters in the country is useful. There is much important planning legislation in Sri Lanka. Planning is meant to create better place for people to live. Legal provisions are very essential to achieve the orderly development through planning measures. Planning and Environmental Laws provide legal power to carry out planned development in a sustainable manner. The Planning law in Sri Lanka was introduced by British in 1915 and in 1946 and later amendments were made by proceeding governments since independence.

Planning Laws in Sri Lanka

- Housing and Town Improvement Ordinance No. 19 of 1915
- Town and Country Planning Ordinance No. 13 of 1946
- Urban Development Authority Law No. 41 of 1978
    - Urban Development Authority Amendment Act No. 70 of 1979
    - Urban Development Projects Special Provisions Act No. 2 of 1980
    - Urban Development Authority Amendment Act No. 4 of 1982
    - Urban Development Authority Special Provisions Act No. 44 of 1984
    - Urban Development Authority Amendment Act No. 49 of 1987
    - Urban Development Authority Amendment Act No. 41 of 1988
- Town and Country Planning Amendment Act No. 49 of 2000

- Coastal Conservation Act No. 57 of 1981
- Board of Investment Act No. 23 of 1991
- Urban Council Ordinance No. 61 of 1939
- Municipal Council Ordinance No. 29 of 1947
- Pradeshiya Sabhas Act No. 15 of 1987
- Nuisance Ordinance No. 15 of 1862

The objective of this Housing and Town Improvement Ordinance No. 19 of 1915 is to deal with the problem of insanitary conditions of urban overcrowding as well as to prevent such situation. Towards this end, this Ordinance has introduced insanitary and environmental standards in urban areas and to improve the quality of the housing stock. Accordingly a set of building regulations are set out in the Schedule to the Ordinance. These regulations relate to controlling height, light, ventilation and accessibility. In addition, the Ordinance provides for the introduction of town improvement schemes, slum clearance schemes and street line schemes. Until the introduction of the Urban Development Authority Law (UDA) Law in 1978, this Ordinance together with Town and Country Planning Ordinance, 1946 were the main legal instruments with regulated the physical planning and development of urban areas in Sri Lanka. Today these two Ordinances are operation in areas which have not been declared under the UDA Law.

Urban Development Authority Law No. 41 of 1978 marks a new era in the physical planning exercise in Sri Lanka. This law was in acted in 1978 due to inadequacies found in both Housing and Town Improvement Ordinance No. 19 of 1915 and Town and Country Planning Ordinance No. 16 of 1946 to deal with physical planning problems of the urban areas of Sri Lanka. According to the preamble to the UDA law, the objective of the law is to promote planning of economic, social and physical development and its implementation in the urban areas declared under this law. In order to realise these objectives, the Urban Development Authority is vested with wide powers with regard to preparation and implementation of integrated plans for development, acquisition and disposal of property, clearance of slums and shanties, coordination and control of development projects carried out by other governmental agencies, exercising of development controls to ensure conformity to development plans and planning regulations. UDA has introduced a new set of development regulations in areas under replacing the provisions of housing and Town Improvement Ordinance.

4.1. TOWN AND COUNTRY PLANNING ORDINANCE NO. 13 OF 1946 AND ITS AMENDMENT

The Town and Country Planning Ordinance was introduced to regulate physical development in Sri Lanka.

Its purpose is mentioned in its preamble as "An Ordinance to authorise the making of schemes with respect to the planning and development of land in Ceylon to provide for the protection of natural amenities and the preservation of buildings and objects of interests or beauty, to facilitate the acquisition of land for the purpose of giving effect to such schemes"

Under this Ordinance, there shall be established a commission to be called the Central Planning Commission consisting of senior representatives from relevant authorities.

The duties of the Central Planning Commission are;

- To Advice the minister with regard to the declaration of development areas and to the necessity for the preparation of planning schemes in any such areas
- To advice planning authorities with regard to the preparation of surveys of urban and rural areas and of planning schemes, and to investigate defects or delays in the preparation or execution of such schemes
- To make recommendations to the minister as the commission may consider for the regulation of the development of land in any part of Ceylon, the creation of satellite towns and garden cities

- To make to the minister and to any planning authority such general or special recommendations as the commission may consider necessary with reference to the control of architectural design and of outdoor advertisements
- To consider and examine all draft planning schemes submitted to the commission under this Ordinance, and to tender advice to the minister with respect to the approval or modification of such schemes
- To formulate for the guidance of the minister and of planning authorities as a national plan or policy

Under Town and Country Planning Ordinance No. 13 of 1946, planning areas were categorised into three as follows;

(1) Urban Development areas include Municipal Council areas, Urban Council Areas and declared Town Council Areas
(2) Trunk Route Development areas include any area within a specified distance on either side of any principal thoroughfare
(3) Regional Development Areas include each province in Sri Lanka as separate Regional Development Area

Town and Country Planning Ordinance No. 13 of 1946 was amended by Town and Country Planning Act No. 49 of 2000. According to the amendment the purpose of the law is as follows,

"An Ordinance to authorise the formulation and implementation of a national physical planning policy; the making and implementation of a national physical plan with the object of promoting and regulating integrated planning of economic, social, physical and environmental aspect of land in Sri Lanka; to provide for the protection of natural amenities, the conservation of natural environment, buildings of architectural and historic interest and places of natural beauty; to facilitate the acquisition of land for the purpose of giving effect to such plan."

Under the Town and Country Planning Act No. 49 of 2000, The Central Planning Commission was amended as National Physical Planning Council. The Amendment Act provided powers to establish Inter-Ministerial Co-ordinating Committee and Technical Advisory Committee.

4.2. MUNICIPAL COUNCIL ORDINANCE NO. 29 OF 1947

Municipal Council Ordinance was introduced in Sri Lanka in 1947 in order to maintain the services provided to the Areas under its jurisdiction, such as water supply, storm water drainage system, sewerage system, road network, electricity, solid waste management etc. Later except the solid waste management service, the responsibility for all other services was given to various government institutions. Planning and Building Regulation also is maintained by Municipal Council in conjunction with UDA.

4.3. URBAN COUNCIL ORDINANCE NO. 61 OF 1939

Urban Council Ordinance was introduced in Sri Lanka in 1939 in order to maintain the services provided to the areas under its jurisdiction such as water supply, storm water drainage system, sewerage system, road network, electricity, solid waste management etc. Later except the solid waste management service, the responsibility for all other services was given to various government institutions. Planning and Building Regulation also were maintained by Urban Council in conjunction with UDA.

4.4. PRADESHIYA SABHA ACT NO. 15 OF 1987

Pradeshiya Sabha Act was enacted in 1987. An Act to provide for the establishment of Pradeshiya Sabhas with a view to provide greater opportunities for the people to participate effectively in decision making process relating to administrative and development activities at a local level; to specify the powers, functions and duties of such Sabhas.

4.5. UDA REGULATIONS

Regulations may be made by the Minister for the purpose of carrying out or giving effect to the principles and provisions of the UDA Law No. 41 of 1978 as amended by Act No. 4 of 1982.The above would normally comprise the making of Regulations on all matters stated or required to be prescribed or authorised under the UDA Law. It comprises the following in respect of authorised provisions;

(1) To regulate any planning projects or schemes prepared by any Government Agency or other persons in such areas (Section 8 (r) of UDA Law)

(2) The provision of regulating the use of land and buildings in different zones, and imposition of conditions and restrictions in regard to several factors of building development (Item 3 in Schedule of Amendment Act No. 4 of 1982)

(3) Regulations regarding clear distances of buildings from electrical, telephone, telegraph, microwave and other lines (Item 4 (k) of the schedule of Amendment Act No. 4 of 1982)

(4) Regulations in respect of unsafe buildings and prescribing standards of fitness of buildings (Item 4 (l) of Schedule of Amendment Act No. 4 of 1982)

(5) Regulations for attaining urban design objectives (Item 5 of the Schedule of Amendment Act No. 4 of 1982)

In addition, regulations may also be made on several matters on which they are required to be prescribed. One of the latter is on “the levy of fees and service charges in respect of different categories of developments”. However, all of the above matters should relate to a Development Plan prepared and sanctioned for the development of the corresponding UDA declared area. On the other hand, since there were no Development plans prepared for the UDA declared areas in the immediate period after the establishment of the principal enactment (No. 41 of 1978), and of its amendment (No. 4 of 1982), the Minister at that time, acting under the generality of the powers conferred by Section 21, has published the, UDA Planning and Building Regulations 1986” in Gazette No. 392/9 of 1986.03.10. It specifically stated that the provisions of these regulations shall be applicable to every area for the time being declared by the Minister as a UDA Area. These regulations were approved by Parliament as required by Section 21 (3) of the law. In these circumstances, it needs to be verified whether the 1986 Regulations are valid for the UDA Declared areas for which development plans and the corresponding regulations have been approved, and gazetted. For example, the Colombo Municipal Council (M.C.) area is UDA declared area.

5. DISASTER MANAGEMENT LAWS IN SRI LANKA AS A PART OF CONSTRUCTION LAW

Sri Lanka is one of the countries that were hardest hit by the tsunami tidal waves that ravaged severed countries in the Indian Ocean rim on December 26, 2004. Hence, Sri Lanka Government enacted new laws to better protection of property rights and disaster management planning matters for affected cities. The Sri Lanka Parliament has enacted special two Acts such as Tsunami (Special Provisions) Act No. 16 of 2005 and Disaster Management Act No. 13 of 2005 for path of rehabilitation. These two Acts specially mentioned planning and recovery techniques of disaster management of Sri Lanka. Those two Acts main objective is grant rights with absolute rights and maintain a better land management system and scientific utilisation of lands for any industry. The main objectives of the Disaster management Law are to provide immediate to communities and local government authorities to speedy restart functions Laws and regulations relating to the Tsunami Reconstruction are,

- Re-construction of economic infrastructure facilities in cites in Sri Lanka under the new planning methods
- Re-settlement of displace families outside buffer zone with property law rights
- Provide disaster management development laws through new legislation
- Upgrading regional planning institutions and its laws
- New regulatory laws and institution arrangements for re construction work

Government of Sri Lanka implemented the disaster management plan for development and support of rehabilitation construction projects through this Acts. In the post tsunami reconstruction work, the government has given high priority to rebuild human settlement and shelters. Therefore, relevant this legislation is related to the rehabilitation and reconstruction strategies in tsunami affected areas. In the post tsunami reconstruction work, the government has given high priority to rebuild human settlement and shelters. Therefore, relevant this legislation is related to the rehabilitation and reconstruction strategies in tsunami affected areas. However there are various loopholes in these legislation and sometimes courts were observed.

6. NUISANCE LAW AND ITS RELATIONSHIP TO THE CONSTRUCTION LAW

Nuisance action is a common law tort action which is based on the premise that one should use one's property in such a manner so as not to injure the interests of others. This action was one to the earlier tools used for the purposes of environmental protection. There are three types of nuisance actions, namely private nuisance, public nuisance and statutory nuisance. As far as environmental related actions in nuisance are concerned, the most common actions would related to noise, pollution of the air, water ways, disposal of garbage, etc. As regards statutory nuisance, the *Nuisance Ordinance* provides that whosoever shall commit any of the offences specified in that Ordinance shall be guilty of an offence. Apart from this Ordinance, Municipal Councils, Urban Council Ordinance and Pradeshiya Sabha Act also provide for the prevention of nuisance.

A nuisance may be public or private. A public nuisance may also be a private nuisance and a tort, but to prevent multiplicity of actions a public nuisance is actionable as a tort only by one who has suffered particular damage over and above that suffered by the public at large. E.g.: obstructing a high way by the construction activity, keeping of dangerous premises near a highway etc. This is some unlawful act or omission endangering or interfering with the lives comfort, property, or common rights of the public. A public nuisance is also a crime for which the remedy is criminal proceedings brought by the Attorney-General. Private nuisance consists essentially of damage to the plaintiff arising from unlawful interference with his use of employment of land of which he is the owner of occupier. In this connection injuries to servitudes may amount to private nuisance as where the defendant obstructs a right of way, or interferes with the plaintiff's water supply, access of air light or support. In *Keangnam Enterprises Ltd. vs Abeysinghe and Others case (1992 SLLR 116)* Sri Lanka supreme courts developed the Environmental Law. In this case the Petitioner-Company had established a metal quarry, a metal crusher and a premix plant at a site taken on lease for developing and rehabilitating the Ambepussa - Dambulla - Anuradhapura road: The Informant-Respondents complained of a public nuisance created by the Petitioner-Company. The Magistrate granted an injunction restraining the operation of the quarry under section 104(1) of the Code and also entered a conditional order under section 98(1) of the Code for the removal of the public nuisance caused by the quarry.

7. CONCLUDING REMARKS

This literature review into recent court cases has established that Environmental Law is one of the instruments that enable the community and the country to achieve the objective of environmental protection. The laws governing the protection, conservation and the use of natural resources in Sri Lanka are largely based on legislative enactments and government introduced a statue called National Environmental Act No. 47 of 1980.This Act led to the establishment of the Central Environmental Authority (CEA) in 1981 as the state agency responsible for the formulation and implementation of policies and strategies for the protection of environment in Sri Lanka. The amendment requires all project approving agencies to obtain an Environmental Impact Assessment (EIA). The EIA process is a useful tool in assessing the impact of development projects and activities. Towards the protection of environment, aspects of physical planning and built environment in the country have a considerable role to play. There are many planning legislation in Sri Lanka. One such early legislation is Housing and Town Improvement Ordinance No. 19 of 1915. The objective of this Ordinance is to deal with the problem of insanitary conditions of urban overcrowding as well as to prevent such situation. Urban Development

Authority Law No. 41 of 1978 marks a new era in the physical planning exercise in Sri Lanka. Cost Conservation Act No. 57 of 1981 and the Board of Investment Act No. 04 of 1978 are another two statues with provisions of environmental protection and management. The nuisance action was one of the earlier tools used for the purposes of environmental protection. Despite all these current regulations for environmental protection, it is observed that improvements are needed to make sustainability concept more effective.

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ARBITRATION AS AN ALTERNATIVE DISPUTE RESOLUTION METHOD IN THE CONSTRUCTION INDUSTRY OF SRI LANKA

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ABSTRACT

The construction industry in Sri Lanka covers a complex and comprehensive field of activities. Disputes might arise at any point during the construction process. Dispute resolution systems are changed with the interaction of the parties. Arbitration is a voluntary procedure available as an alternative resolution to litigation, however not enforceable as the means of settling disputes except where the parties have entered into an arbitration agreement. Construction claims tend to be of the most technical nature - intensive and multifaceted than most other commercial disputes. The desirable features of arbitration are fast, inexpensive, fair, simple, flexibility, confidentiality, minimum delay. Sri Lanka Arbitration Act No. 11 of 1995 stated arbitration principles and UNCITRAL Model Law. However, there is a necessity to reviewing and improving of the arbitration practice periodically in order to minimise the cost and complexity of the procedure.

This research is ultimately aims to assess significant attributes of arbitration in construction industry of Sri Lanka. This paper reports on findings gained from the literature review and preliminary survey conducted to explore the current status of arbitration as an alternative dispute resolution method in Sri Lankan construction industry. Current findings indicate that the construction professionals have minimum level of satisfaction on the current arbitration practice; however, they believe that arbitration is an effective mechanism for dispute resolution. The results of this study enabled to gain an understanding on the current arbitration practice and its significance and offer suggestions to improve current arbitration practices in the Sri Lankan construction industry.

Keywords: *Arbitration, Construction Industry, Dispute Resolution.*

1. INTRODUCTION

Dispute has been defined (Collin, 1995) as disagreement and argument about something and also as a difference between two or more beliefs, ideas an interests' since, conflict is 'inevitable in human relationships' (Rhys Jones, 1994). Construction contracts have evolved significantly in recent times, mainly as a result of the enormous growth of buildings, economic infrastructure and urban development. Disputes connected with construction contracts are becoming a common feature in the industry and number of disputes within this sphere continue to increase. If the dispute resolving mechanism becomes too expensive or too slow or otherwise fail to meet the legitimate requirements of the clients, they will become frustrated and decide to take their enterprises elsewhere to greener pastures. On the other hand, conflicts and the ensuing matters signify a general state of hostility between parties. The possibility of disputes and claims are illustrated in Figure 1, which sets out the basic relationship between conflicts, interests, ADR methods and Litigation in construction sceneries, Disputes are taken to imply prolonged disagreements on unsettled claims and protracted unresolved conflict.

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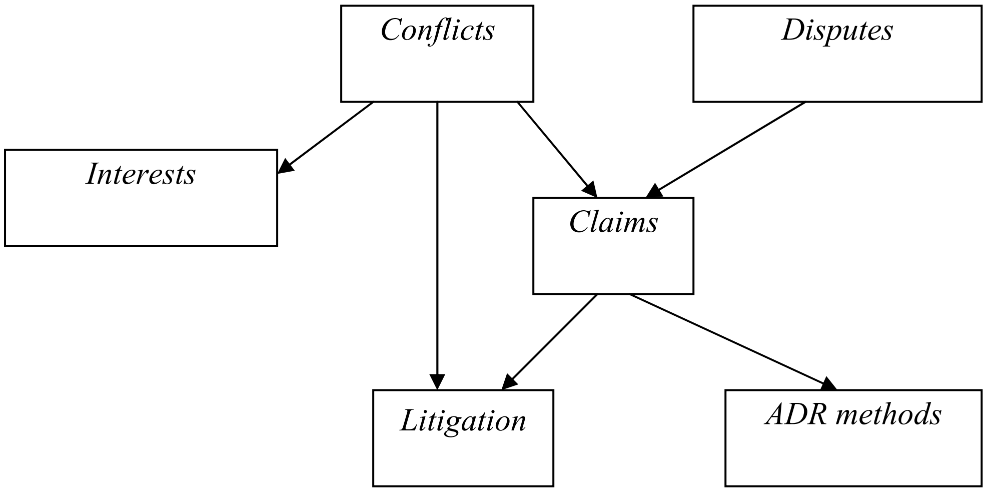

Figure 1: Relationship between Conflicts, Claims, Interests, Dispute, Litigation and ADR Methods.

Arbitration Legislation of the most countries (including those following the UNCITRAL Model Law) usually allows parties to change the substantive law to be applied, if it is a transactional contract. The Arbitration Act of Sri Lanka goes a little further. The Sri Lankan courts refused to incorporate the arbitration agreement into a subcontract. Sri Lanka arbitration process has become very adversarial and very expensive. Therefore is important to review and improve the process. Justice Saleem Marsoof (2006) suggested that there should be a change of attitude of parties concern to improve the arbitration procedure and it is better to improve the effectiveness of proceeding to obtain its advantages.

The main aim of the research was to review the current situation of arbitration practice in the construction industry of Sri Lanka and introduce new legal amendments to arbitration legislation. That means analysis the arbitration legislation and its procedure and suggests improvements to the legislation and arbitration procedure in Sri Lanka in order to make arbitration procedure more effective or viable. The construction industry has generally used arbitration rather than the courts as the means of settling any disputes which arise between the contractor and the employer. This arise because the disputes were more generally of a technical nature and the parties were happier to refer their dispute to a person who understood the technical problems involved and who could bring a knowledge of the usual practices of the industry to the formation of his judgment as well as it is a method of private, binding and enforceable dispute resolution.

2. Main Reasons for Disputes in Sri Lankan Construction Industry

Main reasons for the construction disputes are,

- Breaches of contracts by any party to the contract.
- Inadequate administration of responsibilities by the client or contractor or sub contractors.
- Some plans and specifications that contain errors, omissions and ambiguities.
- Sudden tax and cost increase.
- Negligence and poor performance of the construction professionals.

Generally, construction contracts disputes are more lengthy and complicated than ordinary civil cases in Sri Lanka. As projects increase in size and complexity so the risks of cost and time overrun, which invariably lead to disputes. In certain circumstances, lack of skills amounts to negligence. Where this is so, it is because a person has voluntarily engaged in some activity which is likely to cause danger to other. The negligence does not consist in the lack of skill but in undertaking the work without skill. Where a person has engaged in a profession which calls for special skill, the degree of skill which is required of him is that reasonably to be expected of a person engaged in such profession. Negligence and poor performance of the construction professionals is a reason for dispute. Sometimes professionals' disputes cannot be resolved only by negotiation between the parties. Resolution of the matter can be facilitated by the use of Arbitration techniques. Arbitration is a voluntary procedure available as an alternative to litigation. In such cases the right of either party to have disputes resolved by arbitration will no doubt be beneficial to the country in the context of construction law or foreign investment law.

3. REMEDIES FOR BREACH OF CONSTRUCTION CONTRACTS

Construction Law is a part of civil law and construction contracts are legally binding and legally enforceable agreements. Whenever there is a breach of contract by one party, the other is entitled to bring an action for damages which are calculated in accordance with the civil law provisions. The aim of the damages is to put the innocent party in the same financial position as he would have been if the contract had been performed according to its terms. When there is a breach of construction contract the following remedies may be available for the innocent party.

- A right of action for damages (the most common remedy)
- A right of action on a *quantum meruit*
- A right to sue for specific performance
- A right to for an injunction
- A right to ask for rescission of the contract
- A right to get *Restitutio in Intergrum*
- A refusal of any further performance by the injured party

Above remedies can be get from the use of litigation system by the innocent party. In such cases the right of either party to have disputes resolved by arbitration will no doubt be beneficial to the economy.

4. ARBITRATION AS AN ALTERNATIVE DISPUTE RESOLUTION METHOD

4.1. LEGAL DEFINITION FOR ARBITRATION

Arbitration is a legal technique for the resolution of disputes outside the courts, wherein the parties to a dispute refer it to the Arbitrator (Sims *et al*., 2003). Arbitration is a private means of dispute resolution whereby the parties agree to be bound by the decision of an arbitrator of their choice whose decision is final and whose award has the legal force by a Commercial High Court order.

The main feature of arbitration is that it is consensual in nature and private in character. The concept of “Party autonomy” associated with arbitration not only allows the parties to select their arbitrators, the seal of arbitration and the rules of procedure to be followed by the arbitrators (Articles 10, 19 and 20 of the United Nations Commission On International Trade Law [UNCITRAL] model law) (UNCITRAL, 2008). The ability the parties have to choose their arbitrator taking into consideration *inter alia* their special expertise in the relevant field.

5. ARBITRATION PRACTICE IN SRI LANKA

5.1. SRI LANKAN ARBITRATION HISTORY

Among the legal practices that crept in to Sri Lankan law, especially in the commercial field was arbitration. Even though, Arbitration was a legal dispute resolution method in the Roman law it did not find its way in to Roman Dutch law as was practiced in Sri Lanka. Arbitration was deliberately introduced by the British as a less formal dispute resolution mechanism in 1866 by the adoption of the Arbitration Ordinance No.15 of 1866. Prior to the enactment of the Act No. 11 of 1995, Arbitration was formally linked to the legal system of Sri Lanka in the 19th century by the enactment of two statutes viz:

- The Arbitration Ordinance No. 15 of 1866, and
- The Civil Procedure Code of 1889.

Under these two statutes Arbitration was categorised into two groups:

- Voluntary, and
- Compulsory

Whilst the Arbitration Ordinance dealt only with compulsory Arbitration the Civil Procedure Code governed both types of Arbitration.

5.2. ARBITRATION ACT OF SRI LANKA AND ITS PROCEDURE

The Arbitration Act of Sri Lanka No. 11 of 1995 provides for a legislative framework for the effective conduct of arbitration proceedings as well as the most practicable or methodical mechanism for the enforcement of arbitral awards thereby making arbitration a viable and expeditious alternative to litigation for the resolution of commercial disputes. This Act treats arbitration in the field of construction without taking in to consideration the value of contract or the disputed amount. Preamble of the Act is stated, one of its objects is to make “Comprehensive legal provisions” for the conduct of arbitration proceedings and the enforcement of arbitral awards. The object is to make legal provision to “give effect”, to the principles of the convention on the recognition and enforcement of foreign award of 1958 (The New York Convention). This Sri Lankan Act to a great extent follows the UNCITRAL Model Law.

The Sri Lanka Act Provides that by an agreement “any dispute” can be determined by arbitration “unless the matter in respect of which the arbitration agreement is entered into is contrary to public policy or is not contrary to determination of Arbitration. The Act provides that an arbitration agreement shall be in writing. It can be contained in a single document or in an exchange of letters telexes, telegrams or other means of telecommunication which provide records of the agreement. It also mentions challenge to jurisdiction, duties of the arbitrators, corrections and interpretation etc.

Most Arbitration Acts (including those following the UNCITRAL Model law) usually allow these parties to change the substantive law to be applied, if it is a transactional contract. The Arbitration Act of Sri Lanka goes a little further and material part of section 24(1) provides “An arbitral tribunal shall secede the dispute in accordance with such rules of law as are chosen by the parties as applicable to the substance of the dispute”. When there is an arbitration clause the aggrieved parties concerned cannot seek a remedy in courts because in such case the jurisdiction is ousted by virtue of the arbitration agreement. Construction projects usually involve sub contractors and a common problem is whether the term in a main contract, including the arbitration clause, have been incorporated into a sub contract. Therefore Sri Lankan courts refused to incorporate the arbitration agreement into a subcontract.

5.2.1. ARBITRATION AGREEMENT

According to the Act, an arbitration agreement may be in the form of an arbitration clause in a contract or in the form of a separate agreement. Further, Kanag-Isvaran (2006) stated that most of arbitration agreements are made before a dispute arises as included in many standard conditions of contracts such as SBD, FIDIC, JCT forms. According to the SBD, any dispute arising out of the agreement, on the interpretation, rights, duties, obligation or liabilities of any party, operation, breach, termination, abandonment, foreclosure or invalidity thereof shall be referred to by either party for final settlement in accordance with the Arbitration Act No. 11 of 1995 or any amendment. However, Arbitration Act stated that arbitration shall be deemed to have been commenced if a dispute to which the relevant arbitration agreement applies has arisen or if a party receives a notice requiring the arbitration from another party.

5.2.2. CONSTITUTION OF THE ARBITRAL TRIBUNAL

Under SBD, the arbitral tribunal shall consist of a sole arbitrator. The party desiring arbitration shall nominate three arbitrators out of which one to be selected by the other party within 21 days of the receipt of such nomination. If the other party does not select one to serve as Arbitrator within the stipulated period, then the Arbitrator shall be appointed in accordance with the Arbitration Act. Further, according to the Arbitration Act, the parties shall be free to determine the number of arbitrators of an arbitral tribunal. If no such determination is made, the number of arbitrators shall be three. Where the parties appoint an even number of arbitrators, the arbitrators appointed shall jointly appoint an additional arbitrator who shall act as chairman. Further, if the parties failed to agree or appoint the arbitrator, the arbitrator shall be appointed by the High Court on the application of a party.

The Act stated an arbitral tribunal shall deal with any dispute submitted to it for arbitration in an impartial, practical and expeditious manner. In addition to that, Arbitration Act stated that, an arbitral tribunal shall afford all the parties an opportunity, of presenting their respective cases in writing or orally and to examine all documents and other material furnished to it by other parties or any other person. Further, the arbitral tribunal may, at the request of a party, have an oral hearing before determining any question before it is based, unless the parties have agreed that no reasons are to be given on the award is an award on agreed terms. After the award is made, a copy sighed by the arbitrators shall be delivered to each party. Further, the award made by the arbitral tribunal shall be final and binding on the parties to the arbitration agreement.

5.2.3. ENFORCEMENT OF AWARD

According to the Arbitration Act, a party to an arbitration agreement pursuant to which an arbitral award is made may, within one year after the expiry of fourteen days of the making of the award, apply to the High Court for the enforcement of the award. In addition to that, an arbitral award made in an arbitration held in Sri Lanka may be set aside by the High Court, on application made within sixty days of the receipt of the award is based, unless the parties have agreed that no reasons are to be given on the award is an award on agreed terms. After the award is made, a copy signed by the arbitrators shall be delivered to each party. Further, the award made by the arbitral tribunal shall be final and binding on the parties to the arbitration agreement. The Act is mentioned a party to an arbitration agreement pursuant to which an arbitral award is made may, within one year after the expiry of fourteen days of the making of the award, apply to the High Court for the enforcement of the award. In addition to that, an arbitral award made in an arbitration held in Sri Lanka may be set aside by the High Court, on application made within sixty days of the receipt of the award.

5.2.4. PROVISIONS OF THE SBD AND FIDIC CONDITIONS OF CONTRACTS

Further, arbitration is introduced to construction industry by Federation Internationale Des Ingenieurs-Counseils (FIDIC) for international contracts and by Standard Bidding Document (SBD) for local contracts. However, arbitration practice is discussed according to the Arbitration Act and Standard Bidding document (SBD).

An arbitration agreement must be in the duly prescribed up or formulated form. There should be in the form an arbitration clause in Institute of Construction Training and Development (ICTAD). Conditions of Contract provide an Arbitration Clause No. 67 for building disputes. According to the arbitration agreement recommended by ICTAD the period for commencement of arbitration must take place within a maximum of 90 days. In accordance with the *Federation Internationale Des Enginieurs* (FIDIC) the maximum period to appoint an arbitrator is 154 days to arrive at the final decision. However, Sri Lankan Act does not specify a time limit. Section 48.1 of the Standard Bidding Document (SBD) of the ICTAD (Guidelines of the Government of Sri Lanka) provides Arbitration clause for construction contracts.

In Sri Lanka, all disputes arising out of contract agreements should be dealt with in accordance with the provisions of Arbitration Act No. 11 of 1995. A FIDIC condition of contracts 1999 has introduced Dispute Adjudication Board (DAB) system as a pre-Arbitration requirement. Accordingly dispute between client and contractor shall be referred to Dispute Adjudication Board as a pre-Arbitral step before reference same for arbitration according to the Clause 20 of FIDIC 1999. When there is no settlement before DAB only the same dispute can be referred for Arbitration. As far as the nature of some contracts is concerned, involvement of more parties than two in a single dispute can be seen, e.g. involvement of client, contractor and number of sub-contractors in construction contracts and disputes relevant to them. Generally ICTAD-

SBD documents are applicable to the only Sri Lankan Construction industry .On the other hand, British Forms of Conditions and some provisions of the FIDIC Forms are not applicable to the Sri Lankan construction industry due to its limitations for international related contracts.

Arbitrators may keep away from writing reasons for the award and only the final decision of the Arbitrators will be enough for a valid award. This will be very useful for the settlement of disputes relevant to construction industry. However, if the parties do not agree, the Arbitrators shall give reasons for the award under section 25(2) of the Arbitration Act of Sri Lanka No. 11 of 1995. This Act treats arbitration in the field of construction on the same basis without making any distinction in the value of contract or the disputed amount. With the introduction of the Arbitration Act No. 11 of 1995, construction disputes are more likely to move towards the arbitration in Sri Lanka.

6. DISADVANTAGES OF THE LITIGATION SYSTEM AND ADVANTAGES OF THE ARBITRATION PRACTICE

6.1. DISADVANTAGES OF THE LITIGATION

Breach of construction contract litigation is so common at present that District Courts in Sri Lanka and the two Commercial High Courts in Colombo, Sri Lanka are unable to cope with the large volume of cases. The result is that today our courts are not in a position to dispense justice expeditiously to those litigants who have recourse to them. All too often the effects of litigation are,

- Long – drawn – out proceedings (lengthy hearing)
- Cost of litigation are far too high (High legal cost)
- Wastage of the client's managerial time
- Damaged commercial relationships
- Sometimes judgment that is impossible to enforce
- Use of deliberate delaying tactics by a defendant or respondent who knows how to play the system
- Parties must comply with formal rules of procedure or evidence for litigation
- Possible over – simplification of complicated technical and legal issues

6.2. ADVANTAGES OF ARBITRATION

Construction claims tend to be of the most technical nature - intensive and multifaceted than most other commercial disputes. Hence construction industry needs a fast and cost effective means for dispute resolution. In this regard the Arbitration Act of Sri Lanka was enacted by Parliament of Sri Lanka, which became law on 1st August 1995. It expects to make the arbitration process more definitive, streamlined and effective. Today Arbitration is an alternative to litigation in Sri Lanka. It originated as a method of resolving disputes quickly and without legal formality. Advantages of Arbitration are,

- Economical – Arbitration is cheaper than a court action.
- Simplicity – Procedure is simple.
- Mutual agreement – Meetings can be conducted anywhere and at any time which is suitable for the parties. Parties do not have to wait for the court's free dates.
- Private – The entire hearing takes place in private.
- Speedily – Arbitration is speedier. A court action will take at least one or two but in arbitration can be agreed to settle the disputes within 6 months.
- Expertise – Arbitrator is normally selected for his expert knowledge but the judge will not have the knowledge of technical side of each field.

7. NEW TRENDS BY CASE DECISIONS IN SRI LANKA

Most arbitration awards in Sri Lanka are challenged by the parties at commercial high court. Following two cases were developed and interpreted arbitration procedure of Sri Lanka and courts observed that Arbitration is a voluntary procedure available as an alternative dispute resolution method to litigation.

Mahaweli Authority of Sri Lanka vs. United Agency Construction (Pvt.) Ltd. (Sri Lanka Law Reports, 2002) was an appeal to the Supreme Court from an order of the Commercial High Court under Section 37 of the Arbitration Act No. 11 of 1995 and it decided the time period necessary for leave to appeal.

In *Southern Group Civil Construction (Pvt.) Ltd vs. Ocean Lanka (Pvt.) Ltd.* (Sri Lanka Law Reports, 2002) application for setting aside arbitral award under Section 32 of the Arbitration Act of Sri Lanka. The need to set out in the application the grounds for setting aside the award period for making the application – whether grounds set out in written submission after lapse of that period can be considered.

8. SURVEY FINDINGS

To explore the current practice in construction industry, a preliminary survey was conducted to collect data from the industry practitioners, who have a good experience on the arbitration practice. The findings are reported below.

8.1. EFFECTIVENESS OF ARBITRATION AS AN ADR METHOD

First, through this survey, ADR methods were ranked in Table 1 considering mean rating of their effectiveness in the present practice.

Table .1: Ranked ADR Methods Based on Their Effectiveness

ADR Method	Rank
Negotiation	**1**
Adjudication	**2**
Mediation	**3**
Arbitration	**4**

Arbitration got the fourth place of ranking, however, the practitioners believed that it should still serve as an ADR method in order to settle disputes, which have complex scope and to avoid litigation for different kinds of disputes.

8.2. DRAWBACKS OF ARBITRATION

Next, drawbacks of arbitration were ranked based on the mean weighed rating worked out by the questionnaire survey as shown in the Table 2.

Table 2: Ranked Drawbacks of Arbitration

Statement	Rank
Higher involvement of lawyers	**1**
Less concentration on technical issues of the matter	**2**
Delay of the solution or remedy	**3**
Same procedure apply for all disputes	**4**
Cost of the arbitrators and other facilities	**5**
Weak arbitral tribunal	**6**
Similar to court procedures	**7**

Sometimes award is dragged for long period and finally the award is based on those unfruitful hearings. In construction disputes, there are some inherent characteristics which did not recognised by the Act and by leading Arbitrators in Sri Lanka. Parties have great autonomy to control procedures and select Arbitrators, but in practice they do not use this opportunity to increase the effectiveness of the arbitration.

It was noted that in Sri Lanka, arbitration process has become very adversarial and expensive. It is important to review and improve the process since construction is a process where people come together for a short period of time and then disburse after the construction. The serious criticisms against the arbitration in Sri Lanka are the time factor. The Arbitration agreement incorporated in the ICTAD conditions of contract under clause No. 67 stipulates that the period within which the award should be made in 4 months, although the Arbitration Ordinance of 1948 stipulates a period of 3 months. The present Arbitration Act does not specify a time limit. Parties are free to fix a desired time period for proceeding and award the agreement. However this may be an extension if done with the consent of the parties. According to the arbitration agreement recommended by ICTAD the period for commencement of arbitration must take a maximum of 90 days and in accordance with the FIDIC the maximum period to appoint an arbitrator is 154 days. Hence the time factor remains a major drawback in the arbitration process. Unawareness of professionals' and parties involve in construction is major problem for better practice of arbitration. When Sri Lanka considers about disputes in the construction field, concerning or involving subjects relevant to Architecture, Engineering and Law, appointment of a Lawyer, an Architect and an Engineer to the Arbitral tribunal may be very successful.

8.3. SUGGESTIONS TO IMPROVE ARBITRATION PRACTICE IN SRI LANKA

Suggestions given by the survey participants were ranked based on the mean weighted rating as shown in the Table 3.

Table 3: Ranked Suggestions for Development of Arbitration

Statement	**Rank**
Adopting qualified arbitrators	**1**
Change the attitude of professionals	**2**
Conducting awareness programmes	**3**
Involvement of expertise from construction industry as arbitrators	**4**
Introduce recommended arbitration clause and agreement	**5**
Introduce construction industry arbitration rules	**6**

The suggestions which were ranked above were descriptively analysed in order to create broad scope of them. The parties should select qualified Arbitrators considering the nature of the dispute. Further that awareness should focus on changing attitude of professionals on arbitration and promote the correct practice of arbitration as alternative dispute resolution method. Professionals involved in the construction have the knowledge and suitable background to give the most suitable and fair award for disputes. Thus Engineers, Quantity Surveyors and Architects should develop their knowledge on arbitration and try to involve as Arbitrators and increase the effectiveness of this method. FIDIC and SBD forms of contracts provide arbitration clause, but it should describe more than that in the conditions of contract in construction contract in order to understand easily. Therefore qualified arbitrators and professionals should draft and publish an arbitration agreement. Further they should prepare model arbitration rules and guideline for the parties and arbitrators who wish to use arbitration as dispute resolution method.

9. CONCLUSIONS

This study has identified the current arbitration practice in construction industry. Among ADR methods, Arbitration is generally regarded as one of the best methods. Because of its flexibility, wide range of disputes can be resolved, not only the construction industry disputes, but every kind of commercial disputes without going to the litigation system. Flexibility, privacy and the time are the most important factors. Cost for the arbitration process is considerably high, but it hides automatically with its number of advantages. However, it is noted that these advantages are not reaped by the Sri Lankan construction industry and arbitration is not very effective due to several drawbacks identified in its current practice. Several suggestions are offered in this paper to overcome this situation. Finally, Government of Sri Lanka should repeal existing provisions of the Act and introduced new arbitration legislation and permanent arbitration tribunals (courts) to increase the effectiveness of the arbitration procedure.

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RESOLVING RETENTION POLARITY: THE PERCEPTIONS OF STRUCTURAL STEEL SUBCONTRACTORS

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ABSTRACT

This study aims to understand the perceived polarity between main contractors and subcontractors with a view to resolving problems connected with retentions in an environment where a sliding-retention regime is utilised with a retention rate of 10% for work below NZ$ 200,000. Eight structural steel subcontractors operating in Auckland were interviewed. Contrary to popular belief, subcontractors are not averse to retentions with most taking a middle ground. Nevertheless, the apparently fair practice of using back-to-back contract terms is not seen as fair and reasonable. Most solutions acceptable to subcontractors impact negatively on contractors' cash flow highlighting the need for some form of reciprocity from subcontractors (price discounts, improved performance, etc.) to induce contractors to offer favourable retention regimes. This highlights the need for a theory on 'retention reciprocity' to supplement the five theories on retentions. However, given that not all contractors can be expected to display reciprocity fairness, an interventionist approach may be necessary in order to neutralise any imbalances in power between the contracting parties possibly through amendments to the Construction Contracts Act, and when doing so, there is a need to exercise much caution as the outcome of chaotic systems could be quite unpredictable.

Keywords: *Reciprocity, Retentions, Construction Contracts Act.*

1. INTRODUCTION

Some countries have declared war on the use of retentions. Some have effectively eliminated retentions (Abeysekera *et al.*, 2009). Others lament, citing unprecedented problems (Abeysekera, 2008). Yet, some are convinced that it is an essential vehicle of modern day business. Others point out its power and how retentions may be harnessed for greater good (Abeysekera, 2005). Some have already created retention based funds to finance construction, given the reluctance of commercial banks to understand construction (Abeysekera, 2002, 2003). Others have tried to abolish retentions but failed (House of Commons, 2003). Moreover, practices related to retentions vary from country to country, from one standard form of contract to another and also from one contractor to another. Rates, limits, and release mechanisms vary too with many permutations and combinations. Thus, on the face of it there is chaos. It is this phenomenon that is being investigated focussing on perceptions of structural steel subcontractors in New Zealand in order to find a way to resolve problems and issues connected with retention regimes.

2. THE NEW ZEALAND CONTEXT

It is interesting to note that New Zealand is one of the few countries that had legislation on retentions as way back as the latter part of the last century with a rate as high as 25%! Whilst the intentions for having retentions then were different to the current, this 'ancient' practice has continued over the years but with diminishing rates of retention regulated since 1892 until the act legalising retentions were abolished in 1987 leaving industry to regulate itself. Interestingly, the retention regime in New Zealand is not a flat one but a sliding one as shown in Figure 1.

In formal construction, it is standard practice to use back to back contract terms. Thus, retention regimes imposed on main contractors are usually imposed on subcontractors too as it is considered to be fair by the main contractors. However, what is interesting about this practice is that on large projects, the effective rate of retention imposed on main contractors is much less (2.5% for a 8M project as shown in Figure 1)

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although the rates for subcontracted work are much higher (10% for a 200,000 package, 6% for a 1M package)! The use of back to back terms also suggests that defect liability period (DLP) is the same and front end trades (such as structural steel) can expect to receive their retentions back only at the end of the main contractor's (MC) DLP. Thus, one may argue that this apparently fair practice of using back to back terms may result in higher retention rates and longer defects liability periods. Is this really the case? Is there a need for higher rates of retentions and longer DLPs? Perhaps, one needs to look at the purpose of retentions to answer this intriguing question (see: Abeysekera and Soysa, 2012).

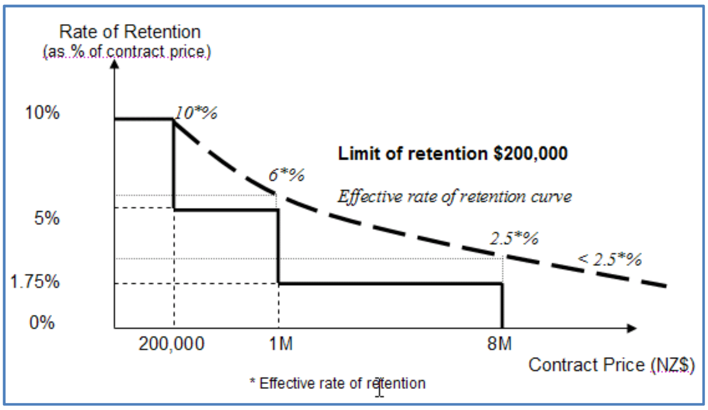

Figure 1: Sliding Retention Regime Commonly Used in New Zealand

In formal construction, it is standard practice to use back to back contract terms. Thus, retention regimes imposed on main contractors are usually imposed on subcontractors too as it is considered to be fair by the main contractors. However, what is interesting about this practice is that on large projects, the effective rate of retention imposed on main contractors is much less (2.5% for a 8M project as shown in Figure 1) although the rates for subcontracted work are much higher (10% for a 200,000 package, 6% for a 1M package)! The use of back to back terms also suggests that defect liability period (DLP) is the same and front end trades (such as structural steel) can expect to receive their retentions back only at the end of the main contractor's (MC) DLP. Thus, one may argue that this apparently fair practice of using back to back terms may result in higher retention rates and longer defects liability periods. Is this really the case? Is there a need for higher rates of retentions and longer DLPs (Abeysekera and Soysa, 2012)? Perhaps, one needs to look at the purpose of retentions to answer this intriguing question.

The debate on whether retentions are fair or unfair, whether favourable to one party than the other seems unresolved. Main contractors in New Zealand are keen on retaining retentions whilst subcontractors appear to oppose, or at least point out the unfavourable aspects including abuse (Abeysekera, 2002, 2008). This is not surprising given that main contractors in New Zealand could generate considerably large surpluses of cash deploying what Abeysekera (2005) had referred to as the 'retention differentiation' strategy; indeed, an interesting mechanism for financing construction work reinforcing the author's Cash Cow Theory of Retentions not without beastly characteristics according to the author's Beast Theory of Retentions (Abeysekera, 2008). It must be noted that these theories are yet to be subjected to greater scrutiny by the academic community although the nature of 'theory' is such that it is neither complete nor perfect with the opportunity to criticise and refine with greater understanding given that theory development is an on-going process (Shoemaker *et al.,* 2004).

It must also be mentioned that cases of front-end subcontractors such as those involved in demolition, excavation, concreting and structural steelwork are sometimes imposed high retention rates (Abeysekera and Soysa, 2012) and long DLPs, sometimes as long as 2 years, before they could get their retentions released. Given this background, it is easy to argue that contractors and subcontractors must be polarised on the issue of whether or not to use retentions in the form it is practiced in New Zealand. It is this 'perceived' polarity that this paper attempts to resolve by investigating the perceptions of one of the front end trades, namely, the structural steel fabricators, in an industry where subcontracting is rampant.

3. METHODOLOGY

As mentioned before the main aim of this study is to understand the perceptions of structural steel fabricators (SSF) with a view to ascertaining ways to resolve the retention polarity that appear to loom large in the New Zealand construction industry.

This exploratory study focuses on SSF in Auckland (the most populous city in New Zealand) and where probably the largest number of structural steel fabricators resides. Whilst there are many structural steel subcontractors in Auckland, only contractors whose annual turnover was more than one million NZ dollars was selected as such subcontractors operate in the formal construction sector. Subcontractors with an annual turnover of NZ$ 12.5 to 20M were categorised as Large, 5 to 12.5M as Medium, and 1 to 5M as Small.

A two-pronged approach was used for selection SSFs to be interviewed: Firstly, large scale contractors were contacted to identify well-known structural steel subcontractors, and secondly, subcontractors were asked to suggest names of others who were generally well known in the industry. Selections were limited to those who have been in industry for at least half a decade to ensure that they had a better understanding of the issues. In all eight subcontractors were selected based on their reputation.

In order to improve the reliability of the data collected only directors, commercial managers, and chief quantity surveyors were interviewed. The interview guide was emailed to them prior to the meeting. Whilst most interviews were completed within an hour there were few which took over an hour. In one instance, the interview took about 2½ hours: In this instance, the director who was interviewed invited his Financial Controller to participate as well.

The interview guide had 20 questions and a form for evaluation of alternative approaches to retentions. Data so collected were displayed using a conceptually clustered matrix. In doing so, the interview questions and responses were re-examined for potential concepts (or variables) by clustering several research questions together so as to generate meaning more easily. In other words, both a conceptual and an empirical approach were adopted when constructing these conceptually-coherent matrices with columns representing the concepts and rows containing the names of SSF firms and their responses. In all nine matrices were constructed with one matrix devoted to the ‘context’ of the situations being studied.

4. PURPOSE OF RETENTIONS

Unfortunately, it appears that none of the standard form contracts define or explain the purpose of retentions. According to many sources of literature, Das (2008) asserted that retentions are useful for the following purposes:

- A fall back fund for the employer in case the contractor defaults or goes bankrupt;
- As an incentive for completing a project as early as possible (as part of the money will become available at practical completion);
- As a protection against any defects that might arise during the defects liability period;
- To act as a deterrent against contractors who fail to respond without delay to rectify defects during the defects liability period
- As a protection against any overpayments; and
- As a fund to respond to any lien claims of unpaid suppliers (say in the event of a subcontractor abandons work).

The importance of these considerations accentuate with respect to subcontract work as it is not common practice to use performance bonds despite back to back contract terms (which seems favourable towards subcontractors as subcontractors rarely provide such bonds) although it is not clear whether retentions bonds would be accepted by main contractors. Given this background, the following non-performance situations usually covered by performance bonds as noted by Bunni (2005) can also be expected to be covered by retentions for subcontract work:

- Improper execution of the works by the contractor involving material, plant, workmanship, or design leading to defective work or work not in accordance with the contract which is discovered during the contract period and ending with the issue of the final certificate;
- Improper execution of the works by the contractor involving material, plant, workmanship, or design leading to defective work or work not in accordance with the contract which is discovered after the issue of the final certificate;
- Delayed completion of the works beyond the stipulated date stated in the contract; and
- Failure to complete the works as a result of the contractor's inability to continue with the performance of his contractual obligations.

As part of this study, structural steel subcontractors were asked to explain the purpose of retentions. Their responses are given in Table 1. Thus, it is clear that subcontractors perceive that retentions are of 'value' to main contractors and as such, it would be difficult to imagine that they would let go of this practice.

Table 1: Purpose of Retentions as Perceived by Structural Steel Subcontractors

Size of Firm	Reasons for MCs holding retentions
1. Large	Quick response trigger for defective remedial work Cash flow Investment opportunities (e.g. purchase of land)
2. Large	-
3. Large	Facilitate cash flows of MCs
4. Medium	As a warranty "Interest generating capability has been calculated into winning the job."
5. Medium	Security of performance, risk of over certification (billing is not an exact science), positive cash flow for MCs. "The old thing about the 10% retention is that it gives the MCs greater comfort in using an untested subcontractor with an unviable price…! That's a quite real consideration"
6. Medium	-
7. Small	Quick response trigger for defective for remedial work (only reason) [Did not say about cash flow benefit to MCs]
8. Small	-

Thus, it seems useful to have retentions for subcontract work (from a main contractor's point of view). Given this scenario, it would be useful to understand the acceptability of retentions from the point of view of the structural steel subcontractors.

5. ACCEPTABILITY OF RETENTIONS

A representative selection of the types of responses received when the interviewees were questioned on whether 'retentions' was an acceptable practice is given in Table 2.

Results show that contrary to popular belief, subcontractors are not totally averse to the concept of retentions! In fact, the peaked central tendency of the inclinations (see number of responses in the second row of Table 2) suggests that the majority view is to accept (with reservations) rather than to reject. This middle ground seems useful for resolving retention polarity. However, in order to make better sense of the data, after some deliberation, four concepts were synthesised, i.e. 'fairness', 'reasonableness', 'power' and 'rights' all of which are grounded in the data itself (see underline phrases in Table 2). These four concepts could play a significant role (with others) to diffuse the state of polarity that exists between contractors and subcontractors particularly by understanding concepts of 'fairness' and 'reasonableness'.

Table 2: Acceptability of Retentions and Possible Clusters for Resolving Polarities

<table>
<tr><th>Acceptable</th><th colspan="2">Acceptable with reservations</th><th colspan="2">Not acceptable</th></tr>
<tr><td>1 (L)</td><td colspan="2">5 (1L,2M, 2S)</td><td colspan="2">2 (L,M)</td></tr>
<tr><td>L: “Strategically advantageous to compete with smaller fabricators [A1]”</td><td colspan="2">L: Duration of DLP: “We don’t mind retentions to some degree. But, why should we wait for years and years after we’ve finished the work… Retentions should be released three months after our completion…It is greatly abused…It is not fair [B1]”

M: Rate of retention: “It is a form of security, [for] workmanship and quality, progress payments are never exactly quantified…I will qualify this statement by saying that 10% is not an acceptable practice when the main contractor has much less than that up against them. It is a very distorted situation where main contractors will generate positive cash flows through higher retentions…[B2] So, when it comes to completion, it’s actually in main contractor’s interest to not complete projects [not common though]. I am quite happy with retentions but it is the application of the scale that is objectionable [C1].”

S: Rate of retention: “Absolutely, it should be there…[B3]We all want to play safe…You need to look at both sides and I think, it is a fair thing [B4] to have…. You can’t really eliminate. To be reasonable [C2], rates [should be reduced to] 5% and DLP to 3 months from our sectional completion.”

M: Interest for moneys held “It is there for a purpose [C3]. But we must get interest. The client has a right [D1] to keep our money but it is our money. If [at all] he should return our money with interest [D2].”(M)

S: Retention rate: “Need for some form [B5] but 10% is not acceptable [C4]. On A 400,000 job what can go wrong is only special coatings (if any) and this will not cost so much[C5]”</td><td colspan="2">L: Pre-trade quality issues “Normally retentions are based on quality of work. Lot of our work is based on what we are given to work with. When we hand over our work steel must be plumb, true and correct. But, when they handover the concrete to us, it is not plumb, it is not true, and not correct…[B6] You have to accept to work your way through it…. They say they use a ISO 9001 system yet they get nothing is right…When we are handed a floor, it’s 25mil out, bolts are miles out, nothing is level, and nothing is checked… They must have good quality controls. We work according to specs. The builder should have someone to check that we are working according to specs. If you are not, should they not tell you as you are doing the work? Why check something when it’s finished? [C6]”

Retentions create a big-brother syndrome.[A2]”

M: Cost “I think it is stupid. It is an additional cost[C7]”</td></tr>
<tr><td>Concepts</td><td>Fairness (B)</td><td>Reasonableness (C)</td><td>Power (A)</td><td>Rights</td></tr>
<tr><td>Indicators</td><td>B1,B2,B3,B4,B5,B6</td><td>C1,C2,C3,C4,C5,C6,C7</td><td>A1,A2</td><td>D1,D2</td></tr>
<tr><td>Concerns for subcontractors</td><td>Duration of DLP; Quality of work of other front-end trade; Better cash-flows for MCs</td><td>Rate; Interest for moneys held; type of defects</td><td>-</td><td>Interests for retentions held</td></tr>
</table>

(Note: L, M, S Refers to Responses by Large, Medium, and Small)

6. THE DEFECTS LIABILITY PERIOD

Shown in Table 3 are the responses received when subcontractors were questioned on the acceptability of a defects liability period for structural steel work.

Once again it appears that subcontractors are not totally averse to having a defect liability period but what concerns them is the duration of such periods, quantum of retentions held, and timely release.

This raises some fundamental questions on the issues mentioned above (rate, duration, release) in relation to what is *fair and reasonable*. In other words, is there a rational basis for setting up a retention regime for subcontract work whilst meeting subcontractor’s test of fairness and reasonableness? Unfortunately, this is an issue that needs to be investigated further. Understanding defects regime for structural steelwork would assist but it is not sufficient. Investigations carried under this study reveal that most of the defects seem to be in relation to paint coatings which are not costly to remedy although the greatest risk seems to be when such problems arise during the defects liability period.

On the other hand, are there solutions to overcome some of the concerns related to fairness and reasonableness expressed by subcontractors? Are there win-win solutions?

Table 3: Acceptability of Defects Liability Period

Acceptable	Acceptable with reservations	Not acceptable
2 (L,M)	**3** (L,M,S)	**3** (2L,M)
M: DLP for coatings "Defects period is necessary. You can enter into say whether the DL is limited only to the coatings [as] generally nothing should go wrong with steel but that is splitting ears…It is just as simple to take it overall." Cost of remedial work: Rework extreme cases – 25%; on the average 10%. 99% of the time with paint coatings. Frequency of projects with defects: "Very rare. In 5 yrs. it must be handful of projects with varying degrees of work." Comparison with other trades: "It is not like air-conditioning or things like that where you can technical problems and other situations where the following trades are painting over someone else's work. We don't encounter such problems." Latent defects/Duration of DLP: "It is usually not until well into the defects period if not the end of the defects period…Coatings don't fail over the short term. [So the long wait is reasonable?] Absolutely – from the owner's point of view" M: "It is ok. The Client should also have something."	L: Duration of DLP: Maintenance period after our practical completion should be 3 months. Dealing with latent defects: "If there is a problem we will fix it because we want to work with these guys" Minimal risks to contractors: "Risk is so minimal. It is not existent." M: Risk to contractors: "I have no issues with the DLP. It limits our exposure. We are not indefinitely held to the performance of an item that we are doing. That means there is a set time frame that we guarantee this single work for. That also offers the client a form of warranty that if something is going to go wrong it's likely to go wrong within that time frame and therefore there is some redress to get it fixed." Duration of DLP/Nature of trade: "Industries like reinforcing concrete. Once the steel is in the concrete there is nothing that can really go wrong or happen. So, they don't accept DL periods. Likewise, we have tried to reduce our DL to reduce to 3 or 6 mths. DLP from subs completion: Typically MCs adopt 12 mths but that too we try to negotiate from our practical completion and not from MCs." S: Yes with reservations	L: Type of trade: "Useful but not with respect to steel work as any defects are immediately visible." S:Inefficient specifications: "Sometimes steel is exposed inside the building. They don't specify any [protection]. Shop priming is not enough" "The problem we have faced is only touch up paint. So many trades work on ours. There are problems of damages during erection. But, so far as retentions are concerned I don't think these have anything to do with it." L: No

7. VALUE OF RETENTION SOLUTIONS AND THEIR FEASIBILITY

Interviewees were requested to provide a rating for seven solutions based on their value perceptions with 'A' for solutions that were of much value, 'B' for moderate value, and 'C' for no value. A brief description was given to explain what a retention-based fund is (Abeysekera, 2005), but no explanations were provided against other solutions though it would have been useful in hindsight.

The results in Table 4 show that 'trust accounts' and a 'retention-based fund' were of value. It is not surprising that the use of warranties instead of retentions was another good solution. Interestingly, the practice of negotiating a better retention regime was perceived as valuable given the success some subcontractors have had though not everyone indicated that they had done so or tried to do so. However, according to Abeysekera's Cash Cow Theory, it would be difficult for New Zealand contractors to let go a 'free' financing facility (i.e. the opportunity to create surplus cash through retention differentiation described earlier) given that trust accounts, retention-based funds, and warranties are solutions that nullify the cash flow benefit main contractors could have by differentiating retention regimes (Abeysekera, 2006) particular when using back to back contract terms with work packages of less than 200,000 dollars which attracts a retention of rate of 10% as the per the commonly practiced declining rate of retention (see Figure 1). In fact, all the solutions barring the first solution (negotiating favourable regimes) would have a strong negative impact on the cash flow of a main contractor. This raises the question whether there are any win-win solutions, which is discussed in the next section.

Table 4: Rated Retention Solutions Rated

Solution	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Size of Firm	**Negotiate favourable regimes**	**Trust a/c**	**Interest bearing a/c**	**Retention -based fund**	**Performance bonds**	**Retention bonds**	**Warranties instead of retentions**
1. Large	-	A	B	B	A	A	A
2. Large	-	C	C	C	C	C	A
3. Large	B	A	B	B	A	B	A
4. Medium	A	B	B	B	A	A	A
5. Medium	-	A	A	A	B	B	A
6. Medium	A	A	A	A	B	B	A
7. Small	A	B	C	A	C	C	C
8. Small	A	B	B	A	B	B	C
Summary:							
A	4	4	2	4	3	2	6
B	1	3	4	3	3	3	-
C	-	1	2	1	2	3	2
Total responses	5	8	8	8	8	8	7
Conceptual value score (%)	90	69	50	69	56	44	75

Weights for Conceptual Value Scores: A – 2; B- 1; C-0

8. WIN-WIN SOLUTIONS

Given that most of the preferred solutions have a negative impact on contractor’s cash flow (see Cash Cow Theory), it would be interesting to find out whether there are any other solutions that might be of value to the contracting parties. Subcontractors’ responses are given in Table 5. Results show that there are more solutions than originally envisaged (e.g. treating each trade and subcontract differently) but these are not necessarily win-win solutions. In fact, retention solutions can be categorised into four main types, viz. subcontractor focussed, contractor focussed, mutually beneficial solutions, and industry focussed solutions.

The current retention regimes with higher rates of retention for subcontractors than for main contractors seem favourable to contractors. So is the case when back to back contract terms are used with final retentions released at main contractor’s practical completion. Solutions such as eliminating retentions, trust accounts, or mobilisation advances (from contractors) have a negative impact on contractor’s cash flow with no extra benefit to contractors. These are subcontractor focussed solutions.

Mutually beneficial solutions are not too many. Negotiating retention regimes is one such and aligns well with the following suggestion:

> “Treat each subcontract on its merit rather than as a head contract thing.
>
> Each trade to be treated on its own merit.”

In fact, there does not seem to be too much rationality in treating all subcontractors alike. Clearly, there are subcontractors who meet contractors’ expectations time and time again: Indeed, it may be argued that they receive better terms incentivising their performance further (see Abeysekera’s Steroid Theory of Retentions, 2008). Moreover, there is no apparent reason why all trades should be treated alike as well. Indeed, this is a positive way forward which seems to be in harmony with the test of fairness and reasonableness that subcontractors seek.

Table 5: Perceptions on Win-Win Solutions

Size of Firm	Solution
1. Large	"Not really"
2. Large	"Do away retentions. "Quality control is the secret"
3. Large	"Treat each subcontract on its merit rather than as a head contract thing. Each trade to be treated on its own merit."
4. Medium	"Eliminate retentions. Reduce costs for the client."
5. Medium	"Trust fund could be a practical solution unlike bonding" "If you look at the big picture it is in their interest to not hold on to the cash because long term positive cash flow is a temporary substitute for lack of profitability. They can overcome working capital restrictions through exploiting subcontractors' cash flow to grow and thereby increase competitiveness amongst their own ranks. So, if they were to look at it from a big picture point of view, it would actually be advantageous to remove that ability."
6. Medium	MC to give a mobilisation advance to cope with cash flow problems. If that is the case, retentions are ok: "If they want a job done, then they must invest and not us."
7. Small	Strongly advocates retentions [with emphasis on reduction of time period for release] "The first thing, I would say is to negotiate. The second would be the retention-based guarantee."
8. Small	Ideally there shouldn't be retentions; cover through insurance. Smaller retention margin about 5% reducing to 2 ½% on practical completion. More regulated and a structured way of getting the money back. We don't know when the builder reaches practical completion. Half the time we don't know. Even when people are living in the building we still don't know whether the builder has got PC.

However, the nature of the relationship that contractors have with subcontractors is such that they might exercise their position of power to negate any apparently mutually beneficial solutions in favour of self-centred solutions (also see Abeysekera's, Beast Theory of Retentions, 2008). As such, one wonders whether it would be possible and desirable to develop industry-focussed, trade-specific solutions which are fair and reasonable. In this regard, it would be useful to assess their perceptions on the role of government and industry associations.

9. ROLE OF GOVERNMENT AND INDUSTRY ASSOCIATIONS

It was noted earlier that the amount of retentions to be held was legislated in New Zealand as far back as 1892 and later abolished in 1987 for industry to regulate its own mechanisms. The Construction Contract Act (CCA) 2003 did not make any reference to retention-issues. Although provisions under the Act could be used to overcome payment problems (particularly when payments are not released), by and large, it left contracting parties to agree on contract terms on their free will. As so long as the parties did so, such contract terms were seen as fair and reasonable irrespective of whether retention rates were too high or whether defects liability periods were too long.

Interestingly, some respondents pointed out as noted in Table 6 that CCA could be broadened to deal with any unfair and unreasonable practices. As such, one way forward would be to develop some 'regulations' (similar to what has been achieved under the Health and Safety in Employment Act) or to have an endorsed code of practice for fair and reasonable contracting which will in due course change the behaviour of contractors as noted by another (see Table 6). Thus, is there a pressing case for government's involvement? It is worth noting that none of the subcontracting organisations seem to have lobbied the government thus far on a possible way forward. Would it be of public interest?

Perhaps, there are other organisations that need to be consulted such as the Master Builders Association, Association of Consulting Engineers, Standards New Zealand for a nationally agreed standard form of contract for subcontract work along with a set of guidance notes if this approach is to be pursued when searching for a fair and reasonable solution to the retention polarity.

Table 6: The Role of Government

Size of Firm	Role of Government
1. Large	Construction Contracts Act to be broadened to regulate retentions. Set up retention based guarantee fund.
2. Large	"Limit retentions – maximum of 1- 2.5%. If MCs can't show that there is a fault, they should pay the money out.
3. Large	Should be legislated. Give guidelines for holding retentions.
4. Medium	"If the government was involved that competitive aspect of utilising retentions was removed for every one – to put everyone on an even playing field."
5. Medium	"They need a certain level of protection. They don't have the commercial knowledge."
6. Medium	"It is our money somebody is holding. Hold it in a trust or [something like that] where we can earn interest…"
7. Small	"CCA is good. It is working. It will take time." It has changed the behaviour of contractors. The government can set up a guarantee fund. Specify maintenance periods with respect to trade.
8. Small	"Industry should be able to regulate itself".

According to Abeysekera's 'Retentions as Chaos' Theory (2008) the retention-scenario in New Zealand is chaotic. Given this situation, Abeysekera claims that understanding the behaviour of chaotic systems may assist in taking new approaches for dealing with the retention-chaos. However, it is cautioned that there is considerable difficulty in predicting the outcome of interventions (such as introducing legislation) although by creating more chaos, it should be possible to move a chaotic system to a more orderly state by pushing it to the edge of chaos; leaving industry to regulate itself may not actually manifest in a new order from this perspective.

10. CONCLUSIONS AND RECOMMENDATIONS

Contrary to popular belief, structural steel subcontractors are not averse to retentions with most taking a middle ground. Nevertheless, the situation in New Zealand is such that they see the need for solutions which are fair and reasonable concerning retentions rates, release mechanisms, and defects liability period in relation to the types of defects they need to be held accountable. The current practice of using back-to-back contract terms which appears to be fair and reasonable to main contractors is not perceived so by the subcontractors interviewed when taking their responses as a whole. There is a need to investigate further as to what constitutes fair and reasonable particularly in relation to how a retention regime may be set up for subcontract work.

Most of the solutions that seem to be fair and reasonable to subcontractors impact negatively on main contractors' cash flow. As such, it is will be difficult for main contractors to forgo this benefit (as per the Cash Cow Theory of Retentions) without some form of reciprocity, or trade-off, such as good performance, price discounts, mobilisation advances from clients, or through some other form of reciprocal response given that contractors in New Zealand seem to need at least 10% of retentions for the risks they take with regard to most type of building work (Abeysekera and Soysa, 2012). Perhaps, this observation could lead to what may be referred to as the 'theory of retention-reciprocity' to add to the five theories on retentions the author proposed in 2008.

According to Fehr and Gächter (2000), economic models have typically portrayed humans as exclusively self-centred beings. As such, what percentage of people or organisations would be interested in the concept of fairness and reasonableness is a concern. However, many people deviate from purely self-centred (i.e. self-interested) behaviour in a reciprocal manner (Fehr and Gächter, 2000). According to these authors, many studies have shown that reciprocal types vary between 40-66% whilst self-centred types vary between 20-30%. This is indeed fortunate, as selfish behaviour does not embody fairness and reasonableness whereas reciprocal behaviour is; in other words, there is said to be reciprocity fairness when people reciprocate in a 'tit-for-tat' manner. Whilst there is no information on reciprocal behaviour for those who operate in the construction industry, there appears to be role for the government or industry associations given that not all contractors would display reciprocity-fairness. Interestingly, it is in this respect that there seems to be a role for government and industry organisations given that some respondents had suggested amending CCA to deal with unfair and unreasonable practices. Moreover, this approach would neutralise the imbalance of power in the contracting relationship. However, this must be done with care as the nature of chaotic systems seems difficult to predict according to theory of 'Retentions as Chaos' described by the author. As to whether such actions should make a distinction between different building trades (as suggested by a respondent) or whether it should be common to all trades needs further investigation whilst augmenting this study with trades involved with civil construction.

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A CONCEPTUAL FRAMEWORK FOR CLIENT FINANCED CONSTRUCTION AND NON-TRADITIONAL APPROACHES FOR FINANCING CONSTRUCTION WORK

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ABSTRACT

The basic premise of the client-financed-construction philosophy is that those who commission service providers must not only pay for their services for the cost of their labour, materials, plant and equipment but do so in a manner that adds value to all parties. A new framework for proposing, evaluating and implementing such systems has been conceived which is used for evaluating three non-traditional approaches for financing construction work, and thereby validating the framework. The three approaches, namely, 'rolling advance payment', 'rolling material price advance', and 'direct financing' have been described and analysed with the 'rolling advance payment' approach being described as a revolutionary approach for solving problems connected with financing contractors and as an approach that has much potential to add value to all parties. The two systems are particularly useful as a crisis management system in projects saddled with cash flow problems bringing 'life' to almost 'dead' projects with potential benefits to all parties. The paper calls for good construction project management as an essential condition for implementing these schemes with particular attention given to risk management and local construction culture.

Keywords: *Cash Flow, Construction Contracts, Contractor Finance, Risk Management.*

1. INTRODUCTION

Client financed construction is a philosophy adduced by the author (Abeysekera, 2002). The basic premise of this philosophy is that those who commission service providers must not only pay for their services for the cost of their labour, materials, plant and equipment but do so in a *manner* that adds *value* to all parties. The following supports this notion though falling short:

> "The payment term is something we [i.e. the ADB] consider very important again because we believe that it has an effect on the price and also on the efficiency of the contractor. The cardinal principal we have in this regard is that the contractors should not be required to fund the construction. There must be an appropriate flow of funds so that … [the contractor] doesn't have to commit his resources for the funding of the construction. At the same time, the flow of funds will not be such in which he would be tempted, having got more than enough, to slow down" (Institute for Construction Training and Development, 1992).

Despite such laudable comments, traditionally this is not how construction had been practiced by and large, and indeed, this is not how it seems to be practiced even today. Opportunities for adding greater value is available but for one reason or the other not explored. For example, clients who have access to cheap funds often expect contractors to source expensive funds to finance construction. They little realise that by doing so, they are indeed paying more than what they should. Often public organisations seem to fall into this category.

There is little consideration to payment terms. 'Get work done first and pay later' seems to be the motto hinting that some clients or their professional advisors seem to have little understanding of the challenges faced by contractors (and subcontractors) to manage their cash flow: It is not difficult to understand (only if an attempt is made) that contractors need to commit funds upfront as they get paid generally only after two months of commencing work during which time they need to find funds to purchase materials seeking credit facilities paying a premium when there isn't adequate cash, pay wages, settle dues for services

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rendered, and a host of other expenditure, and also deal with problems associated with getting paid less than they should as clients hold back ‘retentions’. For contractors who are not cash rich, getting a good start to a project becomes a challenge and sometimes run into cash flow difficulties with increased costs of borrowing, weakened bargaining powers when purchasing materials which in turn leads to enriching suppliers (who get favourable facilities from banks) and also commercial banks (Abeysekera, 2009). Not surprisingly these costs are passed over to clients, and it is clear why it costs more to build this way. Moreover, in some situations technically competent contractors sometimes fail to perform as they become cash strapped, not being able to pay their suppliers and subcontractors bringing construction to a halt.

Thus the aim of this study was to examine non-traditional (i.e. unusual) approaches for financing construction contractors which fits within the broad spectrum of client financed construction using author’s experience of working in industry with some of the approaches suggested portrayed as radical ones with far reaching implications.

2. CLIENT FINANCED CONSTRUCTION (CFC) AND A FRAMEWORK FOR IMPLEMENTATION

The rationale for such a philosophy has been discussed in detail by the author elsewhere so no attempt is made herein to do so (Abeysekera, 2002a). Understanding how such a system could be designed or how a business case could be developed is discussed first vis-à-vis the factors that need to be taken into account as a basis for supporting the non-traditional approaches for financing discussed in this paper. Moreover, the three schemes described in Section 3 would also assist in validating the conceptual framework described below.

BENEFITS

Broadly, two types of benefits can be identified viz. economic and non-economic. Whilst economic benefits to a client include reduction of the overall costs, non-economic benefits include the completion of the project on time. To a contractor, benefits include a hassle free approach to finance, better bargaining positions with suppliers, and on the whole an ability to give a competitive price to a client.

NEEDS OF CONTRACTORS

If such a scheme is to make a beneficial impact on project costs and progress, it is necessary to make an attempt to understand the needs of contractors, giving consideration to issues such as project type, duration of project, and other project specific issues. For example, the financing needs of a short term project are different to a long term project; a 20% advance on a 3 month project is hardly sufficient to fund the flow of cash whereas it may well be adequate for a 12 month project. Similarly, the financing needs of a project where a major piece of plant or equipment has to be bought say for a dam or tunnel project, would clearly be different. Thus, it is necessary to consider the actual needs of contractors in general when designing a system where the client takes the role of the financier.

TYPES OF EXPENDITURE TO BE FUNDED

Funds can be advanced for all categories of expenditure, from materials to plant, and to expenditure connected with the running of site and head offices. Material purchase advances could be for specific materials (say those to be specially imported), or for non-perishable materials like (tiles, ceramic ware), or even for temporary materials like a special type of formwork. Needless to say in inflationary situations, benefits of advancing funds for financing such purchases are considerable particularly on medium to long term projects. Moreover, if cash purchases can be made as against credit purchases, the cost of construction could be brought down further (Abeysekera, 2009). The challenge would be to develop value-adding, risk-managed, contractual clauses as there are substantial benefits to be realised. The rolling mobilisation advance discussed later is a scheme that fits within this category.

STAGE OF PROJECT

Often the need for finance is felt during the initial stages of a project as explained earlier. However, the purchase of an expensive piece of equipment or a large quantity of materials that has to be imported may require large amounts of funds at a different stage of a large construction project. Thus, there is a need to take cognisance of such needs. A cash flow forecast would be helpful in identifying the timing of these needs (Edgerton and MacDermott, 1997).

QUANTUM OF FINANCING, TIMING OF RELEASES, AND ECONOMIC BENEFITS

Once the decision has been made to finance, it is necessary to decide on the quantum of finance and the timing of releases. Some of the options available are:

(1) Contractor bids the amount of advance required (unlimited)

(2) Contractor bids as above but with a ceiling specified by the client

(3) Client pre-decides the amount and specifies it in bid documents

(4) Client advances funds from time to time as and when necessary

The advantage of options (1) and (2) to a client is the ability to compute economic benefits. For example, interest can be charged for funds advanced or the bid price can be inflated by this amount when evaluating bids. Bid documents must describe the procedure that will be adopted including the rate of interest that will be used. Option (3) is different in that the client does not charge interest for funds advanced and it is in effect an interest free loan. Therefore, benefits to a client are generally non-economic. The amount specified depends on the needs of contractors, types of expenditure for which funds are required, stage of project, and risks involved.

In all four approaches mentioned above, the release of funds may be triggered by (a) project commencement (b) in the passage of time (i.e. over the construction period, say in instalments) (c) based on expenditure, and (d) in the accomplishment of specific tasks (Edgerton and MacDermott, 1997). As most formal contracts require the submission of a performance bond, it is a good practice to await releases under options (a) and (b) until after the performance bond is received (For some examples see Institute for Construction Training and Development, 1988). With regard to item (c), releases are made on providing details of expenditure incurred or by the presence of materials or plant on site. A typical example of the latter type is the payment for materials on site – a standard clause on many standard form contracts. The last of these items is (d) which is the 'accomplishment-of-tasks' method. As the terms imply, releases are triggered by completion of specific activities. Some examples are reaching a certain stage of a construction project, or providing proof of placing orders for an expensive item of construction plant. Edgerton and MacDermott (1997) have given some good examples of the latter.

The last of the approaches (i.e. option 4) is usually adopted in situations when contractors run into difficulties for one reason or the other. The 'direct finance scheme' and the 'rolling mobilisation advance' scheme fit within this category.

MECHANISMS FOR CHANNELLING OF ADVANCES AND RECOVERY

Funds may be channelled directly to the contractor or directly to those providing services to a contractor. In the same token, the client could open up letters of credit in favour of such organisations and deduct these from progress payments. Whilst the latter ensures that funds are not misused, it would however create more administrative work for the client. All funds advanced must be recovered and one of the simplest ways of doing so would be to recover from progress payments, ideally in instalments. But this decision will depend on many factors. Consider a scheme (described later) where a contractor works only up to the extent of funds advanced in which case there is no recovery! It must be pointed out that whatever procedures are adopted, these must be written into the contract but will not be able to replace the trust, and the spirit in which such financing relationships are sought.

RISK MITIGATION

RISKS OF FAILURE TO PERFORM HAVING RECEIVED ADVANCES

Advancing funds before they are due, i.e. before work is performed, is no doubt risky. However, this mind set could be overcome by carefully thought out measure. Some of the options available are:

(1) Obtain stocks, property, plant and equipment as security

(2) Obtain and/or increase the amount of the performance bond

(3) Obtain a bond/guarantee (even on an unconditional basis) for the amount loaned

(4) Assigning all items financed to the client until they are released

With regard to item (3) acceptance of insurance bonds would be a relief to contractors. So, would be the case, if a client can accept a combined bond for advances and performance. In fairness to the contractor, it must be noted that value of the bonds need to be reduced with reducing risks but this may not be acceptable to clients. The task of getting a bond/guarantee is however proof that the contractor has a good image in industry and as such that itself should be good enough to overcome this mind set.

RISKS OF MISUSE OF FUNDS ADVANCED

The approaches mentioned above do not prevent a contractor from utilising such funds to finance other projects thereby abusing the facility afforded. Additionally, such funds could be completely misused for personal enrichment through the purchase of non-liquid assets or even on non-construction related investments (Kenley, 1999). However, if payments are made directly to a beneficiary (say to a supplier, or to a subcontractor) on invoices submitted, such malpractices could be minimised. Another approach would be to insist on an ‘application of funds’ statement as a precondition for release. For this approach to work meaningfully, a contractor must provide documentary evidence from time to time that funds advanced are utilised accordingly which may involve additional costs to administer.

3. NON-TRADITIONAL APPROACHES FOR FINANCING CONSTRUCTION WORK

Three non-traditional approaches are described herein with the first being the most radical with author’s personal involvement in all schemes described herein.

3.1. ROLLING ADVANCE PAYMENT METHOD

It was mentioned earlier that the traditional method of paying for work done after work has been completed is unsatisfactory as it falls short in making construction hassle free and value adding. The method herein has the power to transform the construction industry completely making it more competitive, efficient, an indeed an industry that many would wish to be involved with.

The method is simple: If payments can be made in advance, then problems such as those described earlier would almost be non-existent. Indeed, on the face of it, this looks almost impossible, but there is a way forward! On further reflection this is not a practice that is totally alien in nature as this is not uncommon in other industries although not to the same scale. For example, house rent is always paid in advance in Australia and New Zealand (i.e. before the service is provided). So is the case with payments for internet and television services! The difference is that such services are guaranteed and is almost sure of receiving the promised services although in construction this may not appear to be so. Yet, most construction contractors are there for the long term and backed by professional organisations such as Master Builders in countries like New Zealand and Australia, with these organisations stepping into complete projects of a defaulting member. Even otherwise, if this mind set could be brought to the table with good project management, implementing this method would be easy.

The scheme described herein was implemented in Sri Lanka by the author in order to overcome potential risks of non-payment and/or payment delays on projects undertaken for clients residing overseas. Such clients were asked to provide funds in advance with the guarantee that work will be carried up to the extent of funds advanced based on a priced bill of quantities which was submitted to the client and accepted. Any variations would be dealt as usual. The client's risk of advancing funds could be eliminated by an 'on-demand' advance guarantee bond for the amount advanced or a multiple of it which needs to be negotiated. Thus on a million dollar contract, with five stage payments of (say) 200,000 each, a 400,000 advance guarantee bond would permit the second stage payment to be released without any measurement of the work done. The third stage payment could also be released similarly provided the work done was more than 200,000 and so on. The payment at the fifth stage (i.e. at completion) would be released only on actual measurements. If necessary, the validity of the bond may be extended to cover part of the maintenance period as well. Clearly, many variations of this model could be implemented as required and contractor's price may reflect the advantages offered. The following analysis would be useful in this regard.

On a project where payments are to be made monthly with a payment delay of 'D' months from the date of submitting a progress payment (with no advance payments) and an interest rate of 'R%' per year (i.e. cost of funds), with value of work done varying linearly with time, it can be shown that the loss of interest to the client is {(1+D)/12} x R% x contract sum. The relationship between the monies lost by the client (as a result of advancing funds) with respect to varying rates of interest (for different periods of payment delays) is shown in Figure 1 (The impact of retention has been neglected for simplicity). For example, with an interest rate of 5%, and with a payment delay of 1 week, the loss to a client would be about 0.05% of the contract sum. If contractors were to take a lead, then it would be prudent for them to provide an incentive to the client by offering a discount of such a magnitude. This is an interesting scheme that will almost eliminate cash flow difficulties faced by contractors and is bound to have a positive impact on price and productivity. However, contractors must assess their risks of providing advance payment guarantees to clients and make a decision on the terms and conditions of the guarantee they would provide.

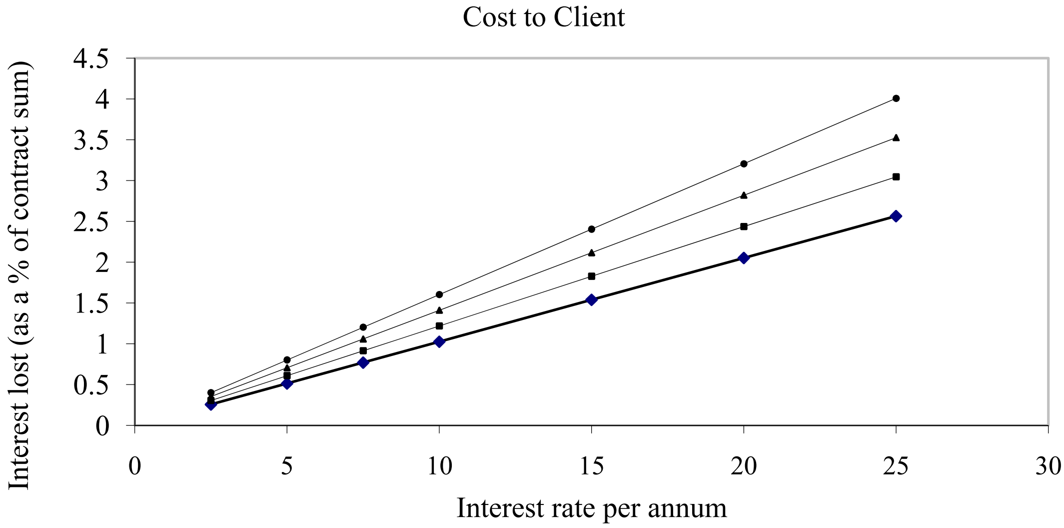

Figure 1: Cost to Client: Re-engineered Payment Procedures
Source: Abeysekera (2002a)

The benefits of this scheme are clear with economic and non-economic benefits to all. In this regard, comments made in 'Section 2: Quantum of Financing, Timing of Releases, and Economic Benefits' is particularly noteworthy to get greater value for the client. However, if this approach is to be used in formal construction, it needs to be properly project managed as there is opportunity for misuse despite the many value-addition options it presents. Thus risk mitigation strategies described as part of the conceptual framework has much relevance. For example, contractors with a good track record would minimise any risks. Organisations with good performance management databases would be in a better position to manage risks. Thus organisation culture and construction culture (Abeysekera, 2002b) are two issues that need to be considered when developing contractual and other mechanisms for managing risk. In general, it should be possible to use existing standard form contracts with a set of special conditions which the author is currently working on using the CFC framework proposed in Section 2.

3.2. ROLLING MATERIAL PRICE ADVANCE METHOD

Mobilisation advances are not common in developed countries such as New Zealand and Australia. However, it is common in Sri Lanka to the extent that construction work is rarely carried without an advance (Abeysekera, 2002b). The scheme described herein is different in that mobilisation advance is used on a rolling basis.

This scheme was used on a large building project in Sri Lanka where the author was acting in the capacity of Client's Representative. Progress was slow and it was clear that it would come to a halt unless the client intervened to alleviate acute cash flow difficulties of this technically competent contractor. A summary of the original proposal that was approved by the client is given in Figure 2.

It is useful to examine the features of this scheme with respect to the 'framework for client financing' described in Section 2. The main benefit to the client in this case was the timely completion of the project that could have easily been delayed if not for this scheme. Despite the slight increase in costs arising out of the extra administrative duties such as record keeping, it could be argued that the net cost to the client would be more in the event of having to terminate the contract. Clearly, it was a case where the needs of the contractor were met though initiated by the project consultants. The funding was limited to material purchases and the scheme was operated in the latter part of the project successfully. Nevertheless, such a scheme could have been operated at any stage of a project. The quantum of financing was based on a percentage assessment of the cost of material based on anticipated monthly turnover. The timing of the releases was not fixed but flexible and was based on a perpetual assessment of the value of the guarantee. Advances were channelled directly to beneficiaries. Hence the potential for any misuse of funds were minimised. Contractor's technical competency to complete the work was assessed too. Funds so advanced were recovered by deducting from progress payments. All in all, there was hardly any risk to the client.

1. Payment to the contractor for purchase of essential materials issued in favour of manufacturers or suppliers against a rolling materials purchase bank guarantee for US$ 12,500 – 25,000 from a reputed bank (1US $ = Rs. 40/= approx, 1990).
2. Deduction of the cost of materials delivered upon the site from the advance payment at 100% of invoice value.
3. Payment to be made to the contractor for unutilised materials on site at 90% of the invoice value (as per existing contract conditions).
4. Deduction so effected which would bring about a reduction in the advance, to be re-utilised for purchase of additional material and the process repeated.
5. The cost of the material on order and not delivered to site at any given time should not exceed the amount of the bank guarantee.

Figure 2: Operational Details of a Rolling Advance Scheme

As shown in Figure 2, funds released under this scheme were only for the purchase of materials. However, funds could have been released for all types of expenditure if the need arose.

Clearly, the scheme proposed was beneficial as it was possible to complete the project without delay and at more or less planned costs but for the loss of interest on moneys advanced though the actual savings were much greater than terminating the contractor and seeking a new contractor. It also met the needs of a technically qualified contractor to overcome cash flow difficulties. The type of expenditure to be funded and the quantum of funding were clearly stated. Mechanisms for channelling the advances were also spelt out and risk management strategies were built in through bank guarantees. In this sense, the scheme was well designed. This also goes to show the conceptual framework is valid.

3.3. A DIRECT FINANCING SCHEME

This scheme was used on a large construction project for a government client in Nigeria which involved the construction of a number of single story, two story and four story buildings on a secure compound with internal roads, recreation facilities, and a large communication centre with expensive telecommunication and electronic equipment in addition to a separate building for two 1000kVA generators. The project was undertaken on a design and built at a fixed price by a reputed international organisation (TELECS) who subcontracted all building and civil works to an international contractor (GC).

Halfway during the construction, there was a management changeover with a change of senior management roles from overseas to local. The project slowed down significantly and came almost to a halt with serious concerns expressed by the client and TELECS at which point of time TELECS could have terminated the contract and sought the services of another construction contractor. However, they decided not to having identified the problem of poor progress to be due to an acute liquidity problem. As construction slowed down, suppliers were reluctant to extend credit to the contractor. Moreover, commercial banks were not keen on augmenting the lines of credit made available to GC, the civil contractor (GC) requested TELECS for an on-account payment which TELECS declined.

Having done so, TELECS, nevertheless, decided to fund purchases of materials, plant hire charges, payment for subcontractors, and also to pay wages of on-site staff and other on-site expenses to ensure that funds were not misused and the project benefitted. Abeysekera (1987) provides a detailed explanation of how this scheme was operated, discussing potential problems and solutions including pitfalls and precautions to be taken when operating such a scheme to increase productivity particularly in a crisis situation though not only limited to such situations. Some of the main features of this system were the development of appointment of TELECS's representative (with a technical background) who was to a large extent resident on this (large) site, preparation of an inventory of items on site, frequent preparation of cash flow statements and also fund-flow statements, direct payment to service providers and subcontractors, tight control of payment for cost-significant materials and monitoring of deliveries (vis-à-vis paid-for and delivered), recovery of funds so advanced from monthly valuations of work done using rates available in the bill of quantities, all of which need to be agreed upon (in writing) before such a scheme is to commence in what may be referred to as a 'procedures manual' for the operation of this direct-financing-scheme. Of course, it would be necessary to make a due-diligent check whether sufficient funds were available (as per tendered rates) for balance work as against actual cost of construction. These activities would necessitate the involvement of a project manager/quantity surveyor and this would be an additional cost.

Time and time again, industry has witnessed situations where clients have taken the path of terminating a contract and incurring a substantially higher cost to complete the works, sometimes incurring as much as twice or thrice the cost of the balance work! However, in making such decisions, it would be necessary to assess whether the contractor was not only technically capable but also managerially capable to continue construction. As noted before an assessment will need to be made whether it would be possible to complete the balance work using existing unit rates.

Although the idea embodied in this scheme is a simple one, it involves careful planning to ensure that funds advanced are used effectively. It involves the development of a management system where the client (in this case TELECS) plays a role similar to that of contractor's head office. Whilst the decision to operate such a system can be initiated by either party, there are some broad issues to be considered as noted below with the operation of such a system are detailed above.

One thing clear is that not all aspects described in the conceptual framework were considered before implementing this case. A sound business case was not developed in a transparent manner. In hindsight, if a conceptual framework as described in this paper was available, it would have been easier to address issues that could have impacted negatively on the success of this initiative.

It must be said that a direct financing scheme such as what was described herein may be applied in a wide variety of situations and in a wide variety of ways. For example, it can be applied to a specific section of a project that is critical to completion, or a similar section of work that has to be completed by another contractor. Such a scheme could also be used by a main contractor saddled with a subcontractor who is technically capable but is constrained by the lack of cash. The scheme presented is ideal as a 'crisis management', having the power to give 'life' to an almost 'dead' project with potential cost benefits to a client. A good rapport between parties including trust is essential for implementation of such a system. Additionally, it would be necessary to put up a business case using the client financed construction framework proposed above as noted earlier.

4. CONCLUSIONS AND RECOMMENDATIONS

Clients financed construction is a philosophy that is worthy of further consideration as it has much promise. A framework was proposed for further investigation which was used to evaluate the schemes proposed and in the process validating the suitability of the framework.

Of the three methods proposed the 'rolling advance method' has the greatest promise to the extent that it could revolutionise how construction projects are managed making the industry more competitive, efficient, and cheaper to build. However, this method calls for good project management with particular attention to risk management without which the system could be abused. It would be also necessary to take into consideration issues related to the local construction culture as bonds and guarantees may not be in common usage and also quite restrictive impacting on lines of credit provided by banks. This could be overcome by the use of insurance bonds which are relatively easier to secure though costlier. There will be a need to develop special conditions of contract to supplement existing standard form contracts.

The 'rolling mobilisation advance' scheme is not as resourceful as the 'rolling advance scheme'. Yet, it provides many benefits particularly in troubled projects particularly with cash flow difficulties. The scheme is relatively risk-free. The same is true for the 'direct financing scheme' too. Both these methods calls for greater control in relation to the use of funds advanced (and thereby prevent misuse). Successful implementation calls for good 'construction project management' without which there is opportunity for abuse. The client-financed-construction framework described in this paper would be a useful aide for designing and implementing such schemes.

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MONETARY RETENTIONS FOR SUBCONTRACT WORK: A RISK-BASED APPROACH

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ABSTRACT

The subcontracting culture in New Zealand is such that the same retention regime imposed on contractors is imposed on subcontractors by and large. This paradoxically fair contractual practice of back-to-back terms results in high retention rates (10%) and long defects liability periods set from contractor's practical completion which has caused concerns for subcontractors with no rational basis for resolving such concerns. This study investigates this phenomenon from a risk based perspective to understand the link between risk and retentions particularly in relation to current practice. Accordingly, it is found that current retention rates do not show an association with overall risk computed as a product of likelihood and consequence based on contractors' perceptions. However, when risk is viewed through these two components, it is seen that trades with high default risks for either likelihood or consequence results in high retention rates. Additionally, it is also seen that high risk is associated with subcontractor-harsh retention regimes with some exceptions lowering the strength of this association suggesting the need to investigate such trades to understand whether there are other overwhelming reasons for such exceptions. Thus, it is concluded that risk and retention regimes are linked to this extent although for a given level of risk, subcontractor friendly or unfriendly regimes could be achieved by a mix of different retention rates and release mechanisms. In this regard, it is seen that contractors seem to prefer high retention rates than longer defects liability periods for trades which have high risk levels. A further understanding about this relationship could be developed by undertaking a study on perceived overall risk levels and perceived retention regimes.

Keywords: *Contracting Culture, Defects Liability Period, Retentions, Retainage, Subcontracting.*

1. INTRODUCTION

The practice of retaining a percentage of money from payments due to a subcontractor is not new. During the last few decades, subcontractors have from time to time raised their concerns about this practice particularly with regard to rates, release mechanisms, and abuse. Given the freedom to contract, the practice continues, without much differentiation with most subcontractors being treated alike irrespective of whether their performance or the type of work they do.

Retentions have been labelled as a wasteful practice (Latham, 1994, 1997). Yet, it continues to be used in formal construction. Interestingly, it is a practice that could be used by main contractors to generate a positive cash flow without having to seek funds from commercial banks using what Abeysekera (2006) has labelled as the retention differentiation strategy. From time to time, a number of authors have pointed out the beastly nature of retentions suggesting solutions such as retention bonds, trust accounts, retention-based funds, and through legislative arrangements (Abeysekera, 2003, 2005, 2008; Pearman, 2004; Robinson, 2002) which are often not readily available to subcontractors. Moreover, practices vary world over with different rates and release mechanisms.

Given this background, this study pursues a greater understanding of ways and means of dealing with retentions by attempting understand the nature of risk-retention relationship.

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2. CONTRACTING CULTURE IN NEW ZEALAND

Most of the building construction work in New Zealand is outsourced particularly in the formal construction sector. This includes the supply of materials like pre-cast concrete products and also work that involves a component of labour with or without materials. It is for such types of work that retentions seem to be applied which raises fundamental questions on the purpose of retentions which almost all standard-form contracts have failed to define (Abeysekera, 2012) whether it is in work contracted by clients or work undertaken by subcontractors. Given that subcontracting is common and there is no indication that it will change in the near future, sometimes with almost 85% of the work subcontracted particularly in large building projects, this practice of handing work to teams specialising in various types of work needs greater attention for construction to be managed efficiently.

One common feature of such work is that imposition of retentions particularly in the formal construction sector imposing back-to-back contract terms on subcontractors meaning that quite often the same retention regime is applied to subcontractors (Abeysekera, 2012). Prima-facie this seems fair and reasonable. However, given that main contractor's get their retentions released partly on practical completion and the rest at the end of the defects liability period, it is not surprising that subcontractors have a genuine cause for concern if and when such regimes are applied.

Interestingly, New Zealand employs a sliding retention regime in most projects (Abeysekera, 2006) with a retention rate of a high of 10% with progress claims up to NZ $ 200,000 with the percentage of deduction declining as the size of the subcontract package becomes bigger with an effective rate of around of 1.75% when the value of the work reaches $8 million whilst capping retentions at this level (i.e. no retentions once this turnover is achieved). Of course, with larger projects, the retentions used are different (see, Abeysekera, 2008). Nevertheless, the sliding retention regime is used frequently as noted above. In order to maximise retentions, some main contractors deliberately limit the monetary value of subcontract work packages to $200,000 so that the retention rate of 10% could be held! Although main contractors circumvent retention deductions by providing a retention-bond to clients, such facilities do not seem to be available to subcontractors. Even if it was the case, subcontractors may not wish to provide bonds as it costs money to get a bank guarantee but more importantly submission of bank bonds and guarantees tie up capital and erode lines of credit. It is also worth noting that it is rare for subcontractors to provide non-bank securities (say a guarantee from an insurance company) or for that matter performance or retention bonds. Accordingly, employing back-to-back contract terms do not seem to have manifested as a subcontractor-friendly option in New Zealand. Is subcontracting really risky…?

As noted before, subcontracting is common in New Zealand. Specialisation has advantages: when work is handled by small groups there is greater opportunity for work to be done right-the-first-time, on time, to specifications, and as per other contractual obligations and other benefits that come from similarity and familiarity of work. However, experience shows that this is not necessarily the case and subcontracting seems risky as not all subcontractors discharge their contractual and other duties diligently for one reason or the other despite years of experience and expertise of performing similar work!

In other words, contractors are exposed to *risk* when subcontracting – a level of uncertainty with respect to the performance of subcontractors – the *possibility that an unknown and unexpected event with adverse consequences could take place* irrespective of whether a particular subcontractor is considered reliable, trustworthy, diligent, or not – all of which must be managed by the main contractor.

3. RISK AND RETENTIONS

What types and levels of risks do contractors' face when contracting subcontractors? It can be stated that a main contractor carries three primary risks:

- Subcontractor will default;
- Subcontractor cannot perform and/or at the rate required;

- Misunderstandings due to the extent of work the subcontractor has priced and what the main contractor expected.

In other words, a subcontractor having started could abandon the job altogether. The project could suffer due to delayed completions, quality problems (including repeat work and defects detected upon work completion), health and safety issues, non-compliance with the laws of the land, etc. Moreover, performance could also be hampered by pricing issues arising from the anticipated and perceived scope of work being different with the subcontractor which may lead to claims for extra work done or claiming for more work than what has been performed.

On the one hand if the main contractor chooses a subcontractor with mediocre skills of performance, one could argue that the responsibility should lie fairly and squarely with the main contractor. For example, the main contractor could intentionally select a subcontractor, whose quality of work is not excellent, at a cheaper price, taking upon themselves to rectify any defects. On the other hand, ground realities may be such that contractors may not have a choice given that there is a shortage of skilled subcontractors. Even if this is not the case, what if the selected subcontractor does not provide its best team to the job? What if the subcontractor having completed the work seemingly well does not return back to fix a latent defect? What if the main contractor overpays a subcontractor for one reason or the other? There is no doubt of the risks that prevail.

Main contractors may choose to accept such risks or transfer these to other parties depending on who is best suited to manage the risk. On the other hand, irrespective of who is best suited, the main contractor may choose to accept the risk for a reward (e.g. a cheaper price resulting in lower costs and greater profits) but in doing so minimise any risks by adopting other strategies, for example, by providing better supervision, seeking performance bonds, or *even retaining a percentage from payments due to a subcontractor*. However, what seems to occur in practice is that all subcontractors are treated alike when back-to-back contract terms are applied irrespective of their performance history, the type of work undertaken, or their risk profile (Abeysekera, 2012).

Does risk really play a role in retention rates imposed on subcontractors…? Do some trades carry more risk than other trades? Are some subcontractors riskier than others? Does a high retention rate of 10% provide a safety net against adverse consequences? Is it a blanket response? These are some questions that need to be answered to understand the risk-retention mechanism in order to develop a lasting solution to ‘retention’ concerns of subcontractors.

4. A Methodology for Understanding the Risk-Retention Relationship

Given the above background, the main purpose of this study is to develop a methodology for understanding the risk-retention relationship for which purpose, it is necessary to:

- understand current practice
- assess level of risk of the selected building trades
- assess level of risk in relation and retention regime

In order to achieve the above objectives, the study focussed on building work in the formal sector of the construction industry.

Selection of Trades

Given that there is extensive subcontracting as noted before, it would be necessary to consider all building trades, and the trades listed in the Standard Method of Measurement of Building Works (NZS4202:1995) was used for this purpose. As there were over 35 trades, it was decided to narrow down the number to a manageable proportion focussing on typically subcontracted trades which are shown in Table 1. In all 22 trades were selected.

SAMPLE SELECTION

One of the characteristics of the New Zealand construction industry is that there are only a handful of contractors who handle large scale construction work. They are well known and occupy an envious position in construction industry with each of these companies employing a large volume of subcontractors often influencing how the rest of the construction industry engages with subcontractors. All such companies operate in all the main cities with Auckland being the most populous city in New Zealand and perhaps the city with the highest volume of commercial construction work. Thus, the companies were selected from Auckland. The study focussed on these large and medium-scale construction companies and a number of construction companies were approached with 10 companies agreeing to participate in this study.

Data was collected through face to face interviews mainly as a strategy to ensure that all these companies participated. It was seen necessary to select interviewees who had the authority to fix retention regimes and who had a good understanding of the implementation of such regimes. Pursuant to a desk-top survey, it was established that the chief quantity surveyor was the best person to be interviewed.

DATA COLLECTION

In order to achieve sub-objectives (noted at the beginning of this section), data were collected using two score cards, one for current practice, and the other for level of risk indicating whether the likelihood and consequence was high, medium, or low whilst keeping in mind the do's and don'ts when conducting such interviews.

To assess the level of risk for the selected trades, interviewees were questioned on the likelihood and consequences of a performance default when working with an 'average' subcontractor. A qualitative scale of 'high-medium-low' with three responses was used for assessing likelihood and consequence (AS4360:1999). When assessing overall risk in relation to a retention regime, the same qualitative scale was used.

DATA ANALYSIS

Qualitative data related to current practice was tabulated as shown in Fig. 1 and a composite retention rate was calculated as follow (see Figure 1 for data). This was repeated for the selected trades (22 in all):

Current Composite Retention Rate = (4 x 0% + 1 x 5% + 5 x 10% x 0 x 15% + 0 x 20%)/10 = 5.5%

An average defects liability period (DLP) was also calculated depending on whether the DLP was from subcontractor(SC)'s or main contractor(MC)'s practical completion (PC), making a note on whether these practices were adopted mainly by large contractors or medium scale contractors (see bottom right corner of Figure 1).

Sub Trade Retention Rates & Defects Liability Period (DLP) - Current Practice for Value <$200K

Demolition	Respondent Contractors										Current Composite Retention Rate				
	Large Scale			Medium Scale							0%	5%	10%	15%	20%
	1	2	3	4	5	6	7	8	9	10	4	1	5	0	0
Rate of Retention %	5	10	10	10	0	0	0	0	10	10				5.5	
DLP (months)	1s	3m	1s	3s	0	0	0	0	3m	6m					
s=sub cont.'s practical completion / m = main cont. practical completion date															

Av. Defects liability period (months)			
Subs PC =	1.667	3	Mainly LC
MC's PC =	4	3	Mainly MC
Non DLP =	0	4	Mainly MC

Figure 1: Current Practice for Demolition Trade

As mentioned before, levels of risks for different trades were assessed through a qualitative approach using high, medium, and low to assess performance default risk. Data so obtained was transferred to a matrix form with livelihood and consequence as axes (Figure 2). Notations '1' and '2' were used for depicting the responses of medium-scale and large-scale contractors respectively. These responses were converted to numeric data by assigning values for high, medium, low risk as 2.5, 1.5 and 0.5 mainly as a means of comparing risks across trades than as an absolute measure of risk. The relative proportions could have been taken as 3, 2 and 1 as well or any other but in this case, distance (along the axes) to the centre of box (square) depicting a level of risk was taken as the relative weights. Data in Figure 1 shows responses from 10 contractors consisting of 3 large scale contractors (note as '2') and 7 medium scale contractors (noted as '1'). Accordingly, the average overall likelihood score and consequence would be as follows noting that the maximum score possible is 2.5:

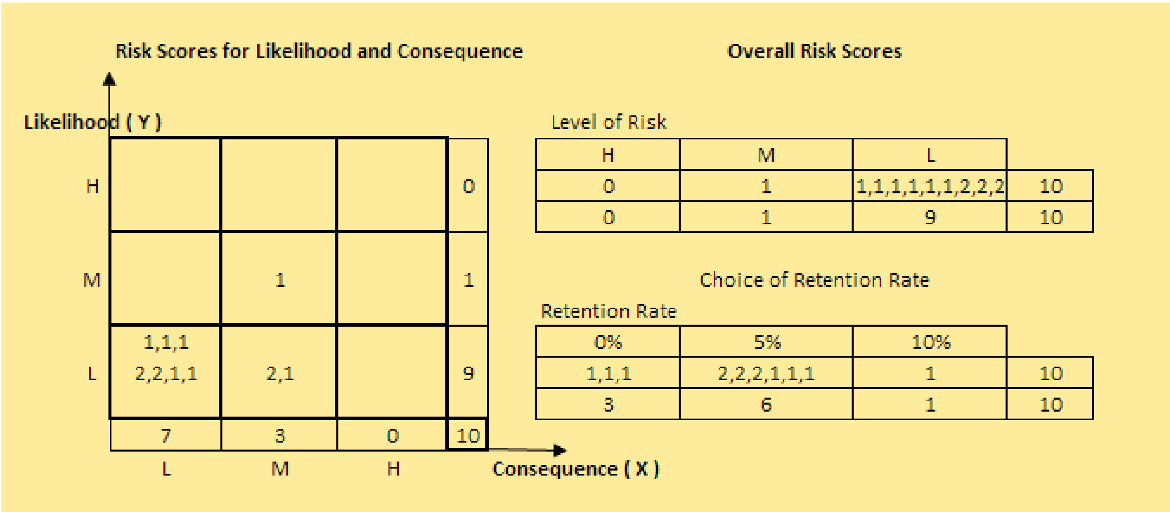

Figure 2: Tabulated Data for Demolition Trade

Average Overall Likelihood (L) Score = (0 x 2.5 + 1 x 1.5 + 9 x 0.5)/10 = 0.6

Average Overall Consequence (C) Score = (0 x 2.5 + 3 x 1.5 + 7 x 0.5)/10 = 0.8

Data so converted for likelihood and consequence was multiplied to arrive at an overall risk for a particular trade as noted below:

$$Risk = k \times L^a \times C^b \text{ (HB436, 2004) with}$$

'k' (a constant), 'a' and 'b' as powers of L and C being taken as 1.

Accordingly,

Average Overall Risk Score for Trade = 0.6 x 0.8 = 0.48 ≈ 0.5 … (1)

These scores relate to the second objective. It is useful at this stage to review what these mean noting that these are not absolute scores of risk. However, in comparison with the maximum score of 2.5 for L and C, the scores of 0.6 and 0.8 indicate a low performance default. Similarly, as the overall score is only 0.5 when compared with a maxim of 6.5 (2.5 x 2.5), the potential for a performance default of this trade can be concluded to be low.

Ideally, a third measure is required, i.e. an overall measure of risk as perceived by the contractors in relation to the rate and the release mechanisms they wish to apply taking risk as the main criterion (quite apart from market and other considerations). This would have been useful for validating the product measure of risk (i.e. L x C) which is not discussed in this study.

Results so computed were analysed to ascertain whether practices of large and medium scale contractors were different with respect to building trades. Additionally, trades were classified into three categories, viz. front-end trades, mid-trades, and end-trades (see Table 1) to examine whether these broad categories of trades were treated differently by main contractors.

5. CURRENT RETENTION PRACTICES IN SUBCONTRACTING

In order to describe current practice, there is a need for a number of indicators as a cursory examination of theories on retentions would provide (Abeysekera, 2008). However, in this study, this has been limited to indicators for retention regimes only. These indicators shown in Table 1 present a rich picture giving a first time understanding on existing practices in the New Zealand building industry.

Results show that two trades, namely, Metal Windows and Doors, and Solid Plaster/Cladding are significant in that all respondents stated that they hold 10% as retentions. Interestingly, there were another 12 trades with this high retention rate (see shaded values in Table 1) where over 80% of the respondents claimed usage. Excavation was another trade that had a high retention rate with a composite retention rate higher than 8%. Approximately 2/3rds of the trades fell within the above mentioned characteristics. Furthermore, defects liability period for these trades were computed mainly from contractor's practical completion (PC) and not from SC' PC with the exception of four trades, namely, Excavation, Piling, Drainage, and Brick/Blockwork where some contractors opted for setting DLPs from subcontractor's PC. Interestingly, these exceptions were all frontend trades (see comment about backend trades and DLPs later). In essence, this amounts to the use of back-to-back contract terms with the exception of DLPs which is seen to be the most unfavourable/harshest retention regime for subcontractors. However, not all trades attract retentions: One such trade is Reinforcement Steel where 80% of the contractors did not claim to hold retentions. The others that followed closely are Precast Concrete (50%), Demolition (40%), Concrete Work (40%) and Excavations (30%) with such favourable retention regimes provided mainly by medium scale contractors and not by large scale contractors (Table 1). As to why this is so needs more investigation and has not been undertaken in this study.

It is also useful to note that of the frontend trades one third had relatively low DLPs, namely, Excavation, Pre-cast Concrete, and Reinforcement (see '#' on last column of Table 1) although this would not be the case where contractors set DLPs from MC's PC. Of the mid-trades, none had low DLPs as the period was set mainly from MC's PC. This is the case with back-end trades too. From a project management perspective, this seems to be a convenient approach for the MC (with one release date for most subcontractors) although this was not examined in this study. On further reflection of the results in Table 1, it should be possible to classify retention regimes as shown in Table 2. As to whether these and other observations made above are linked with performance default risk is discussed in Section 6.

Table 1: Current Practice in Relation to Elements Defining a Retention Regime

TRADES	Retention rate			Com-posite Reten tion Rate: CRR	DLP (months)					Trades with-out DLPs by	Trades withoutD LPs offered by	DLP commences from (S: sub-contractor; M- main contractor)	Avg. DLP from MCs PC (m)	Avg. DLP from Sub's PC (m)
	0 %	5 %	10 %		0	1	3	6	12					
	% of respondents				% of respondents									
Frontend Trades														
Demolition	40	10	50	5.5	40	20	30	10		40%	MC only	S+M's PC	4.0	1.7
Excavation	10	20	70	8.0	30	20	40	10		30%	MC only	S+M's PC	3.6	1.0#
Piling		10	90	9.5	20	20	50	10		20%	MC only	S+M's PC	3.6	1.7#
Concrete work	40	30	30	4.5	40	20	30	10		40%	MC only	S+M's PC	4.0	1.7
Pre-cast Conc.	50	20	30	4.0	50	10	30	10		50%	LC+MC	S+M's PC	3.0	3.3#
Reinforcement Steel	80	-	20	2.0	80		20			80%	LC+MC	S+M's PC	3.0	-
Structural Steel	-	20	80	9.0	-		70	20	10	-	-	MC's PC always	4.7	5.0
Brick and Block Work	10	10	80	8.5	10		60	20	10	10%	MC only	S+M's PC	4.9	3.0
Drainage	-	10	90	9.5		10	50		40	-	-	S+M's PC	**7.5**	2.0
Mid Trades														
Metal Window & Doors	-	-	**100**	10.0	-		70	20	10	-	-	MC's PC always	4.5	-
Carpentry	40	30	30	4.5	40	10	40	10		40%	MC only	Mainly MC's PC	3.6	1.0#
Joinery	10	10	80	8.5	10	10	70	10		10%	MC only	Mainly MC's PC	3.4	1.0#
Roofing	-	10	90	9.5	-	-	70	20	10	-	-	MC's PC always	4.5	-
Plumbing and Gas	-	10	90	9.5	-	-	50	10	40	-	-	MC's PC always	**7.1**	-
Mech. Services	-	10	90	9.5	-	-	40	10	50	-	-	MC's PC always	**7.8**	-
Fire Protection	-	10	90	9.5	-	-	40	10	50	-	-	MC's PC always	**7.8**	-
Electrical Services	-	10	90	9.5	-	-	40	10	50	-	-	MC's PC always	**7.8**	-
Backend Trades														
Solid Plaster / Cladding	-		**100**	10.0	-	-	80	10	10	-	-	MC's PC always	4.2	-
GIB Fix and Stop	20	20	60	7.0	20	10	60	10	-	20%	MC only	Mainly MC's PC	3.4	1.0#
Suspended Grid Ceilings	-	20	80	9.0	-	10	80	10	-	-	-	Mainly MC's PC	3.3	1.0#
Floor Coverings	-	10	90	9.5	-	10	80	10	-	-	-	Mainly MC's PC	3.3	1.0#
Painting & Sp. Finishes	-	10	90	9.5	-		80	10	10	-	-	MC's PC always	4.2	-

Table 2: Classifying Retention Regimes in Practice in Increasing Order of Favourability to Subcontractors

	Retention Characteristic					
	Retention Rate	DLP mainly from MC's PC	DLP	Some DLP from MCs and/or some from SC's PC	No. of Trades	Trade descriptions
1	HIGH	√	High	-	4	Plumbing and Gas, Mechanical Services, Fire Protection, Electrical
2	HIGH	√	Med	-	5	Structural Steel Work, Metal Windows and Doors, Solid Plaster/Cladding, Roofing, Painting
3	HIGH	-	Low	√	3	Excavation, Piling, Brick/Block Work, Joinery, GIB Fix and Stop, Ceilings, Floor Covering
4	MEDIUM	-	High	√	1	Drainage
5	MEDIUM	-	Med	√	1	Demolition
6	LOW	√	Low		1	Carpentry
7	LOW		Med	√	1	Concrete Work
8	LOW		Low	√	2	Pre-cast Concrete, Reinforcement

Notes: 1. Retention rates: High – CRR >8; Med - CPR 5 to 8; Low – CPR <5
2. DLP: High - > 7.5 months; Med - 4 to 7.5 from MC's PC, or 2 to 7.5 from SC's PC; Low - <4 from MC's PC, or < 2 from SC's PC.

6. RISK-RETENTION RELATIONSHIP

In order to understand whether current retention rates correlated with performance default risk, a plot between these two variables was examined as illustrated in Figure 3. It became clear that retention rates (note: not regimes) in practice did not appear to show an association with risk, given the scatter of the distribution with no apparent relationship.

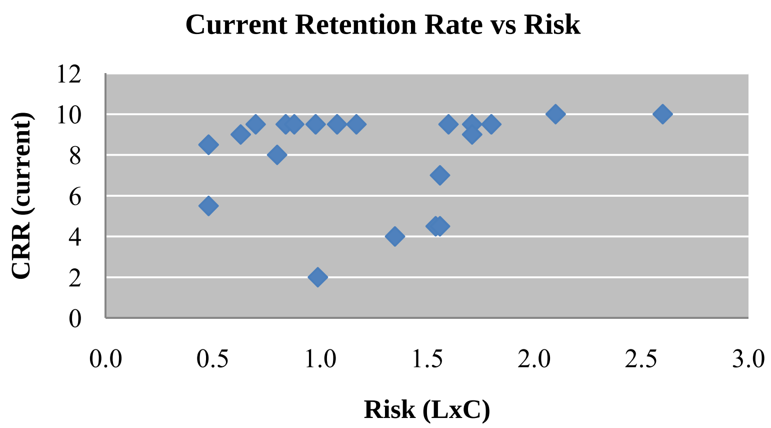

Figure 3: Variation of Current Retention Rates with Perceived Risk

This raises the question whether current practice when viewed holistically, i.e. from a retention regime perspective, has an association with risk. For instance, it was mentioned in Section 5 that two thirds of the trades (14 in all out of the 22 studied) had high retention rates. Of these 14 trades, according to information given in Table 2, had longer DLPs with releases tied to MCs' PC (categories 1 and) with the most unfavourable retention regimes from a subcontractor point of view. Thus one of the questions that arise is whether the risk levels of these trades are high enough to warrant an extreme retention regime. Information in Table 4 with regards to risk levels marked within parenthesis, and Table 5 information on 'likelihood' (L) and 'consequence' (C) levels of different trades provides greater insights as discussed below.

Firstly, consider issues related to L and C based on results in Table 5. Consider a composite retention rates (CRR) 9% and over as *high*. This is a reasonable choice. Focussing on the front-end trades, it is seen that all trades with a *high* consequence (i.e. above median), has a *high* CRR (see shaded cells). Similarly, with respect to mid-trades, all trades but one (Carpentry) that have *high* (above median) values for L or C, has *high* CRRs. Finally, focussing on the backend trades, unlike the frontend and mid trades, of the five trades therein, only one trade showed such an association (Solid Plaster/Cladding). As for other trades, one with a *high* L (GIB Fix and Stop), and three others (i.e. Suspended Grid Ceiling, Floor Coverings, Painting and Special Finishes) with *high* CRRs (>9%) did not show the association that a *high* L or C results in a *high* CRR. Whilst these trades need further investigation, 17 out of the 22 trades displayed this association. This is an interesting discovery about the link between risk and retention of current practice despite the lack of association with respect to retention rate and overall risk described earlier (see Figure 3).

Table 4: Superimposing Current Practice with Risk Levels

		Current practice categories as in Table 1	
Type 1	1a	1	Plumbing and Gas (1.2), Mechanical Services (1.6), Fire Protection (0.8), Electrical Services (1.0)
	1b	2	Structural Steel Work (1.7), Metal Windows and Doors (2.6), Solid Plaster/Cladding (2.1), Roofing (1.8), Painting (1.1)
Type 2		3	Excavation (0.8), Piling (1.7), Brick/Block Work (0.5), Joinery (0.5), GIB Fix and Stop (1.6), Ceilings (0.6), Floor Covering (0.9)
		4	Drainage (0.7)
		5	Demolition (0.5)
		6	Carpentry (1.6)
Type 3		7	Concrete Work (1.5)
		8	Pre-cast Concrete (1.4), Reinforcement (1.0)

Secondly, consider issues related to defects liability period and risk focussing on Table 4 with Table 2 re-cast with risk levels shown within parenthesis and retention regimes amalgamated into three types based on non-friendliness/harshness of the retention regime for subcontractors. What is interesting about Type 1 trades is that all have risk levels above the median except for Painting (which is a median trade). In fact, for all Type 1 trades, contractors set DLPs mainly from their PC. Thus, higher the risk, more harsh the regime applied. As for Types 2 and 3 trades, risks are below the median and holding/release mechanisms for retentions are seen to be less harsh thereby establishing an association between risk and retention regime with the exception of Piling, Carpentry, Concrete Work and Pre-cast Concrete all of which have a risk level above the median. These exceptions need to be investigated further to understand whether there are more overwhelming reasons for less than harsh and comparatively favourable retention regimes (which may be the result of market forces). Others that need further investigation are Demolition, Brick/Block work, Joinery with the lowest level of risk yet with a Type 2 regime than a Type 3 regime if risks associate with retention regimes. Could the reasons for the latter be explained through Abeysekera's Cash Cow Theory (2008)? Only further investigations would reveal this.

Table 5: Performance Default Risk Levels

<table>
<tr><th colspan="2" rowspan="2">TRADES</th><th colspan="3">Perceived Risk Profile Av. (Max score 2.5 for L & C; Max score for L x C is 6.25)</th><th rowspan="2">Current Composite Retention Rate</th></tr>
<tr><th>Overall Likelihood (L) Av.</th><th>Overall Consequence (C) Av.</th><th>L x C
Risk 1</th></tr>
<tr><td colspan="2">**Frontend**</td><td></td><td></td><td>**L x C**</td><td></td></tr>
<tr><td colspan="2">Demolition</td><td>0.6</td><td>0.8</td><td>0.5</td><td>5.5</td></tr>
<tr><td colspan="2">Excavation</td><td>0.8</td><td>1</td><td>0.8</td><td>8</td></tr>
<tr><td colspan="2">Piling</td><td>0.9</td><td>1.9</td><td>1.7</td><td>9.5</td></tr>
<tr><td colspan="2">Concrete Work</td><td>1.1</td><td>1.4</td><td>1.5</td><td>4.5</td></tr>
<tr><td colspan="2">Pre-cast Conc.</td><td>0.9</td><td>1.5</td><td>1.4</td><td>4</td></tr>
<tr><td colspan="2">Reinforcement Steel</td><td>0.9</td><td>1.1</td><td>1.0</td><td>2</td></tr>
<tr><td colspan="2">Structural Steel</td><td>0.9</td><td>1.9</td><td>1.7</td><td>9</td></tr>
<tr><td colspan="2">Brick and Block Work</td><td>0.6</td><td>0.8</td><td>0.5</td><td>8.5</td></tr>
<tr><td colspan="2">Drainage</td><td>0.7</td><td>1</td><td>0.7</td><td>9.5</td></tr>
<tr><td colspan="2">**Mid**</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Metal Windows and Doors</td><td>1.3</td><td>2</td><td>2.6</td><td>10</td></tr>
<tr><td colspan="2">Carpentry</td><td>1.2</td><td>1.3</td><td>1.6</td><td>4.5</td></tr>
<tr><td colspan="2">Joinery</td><td>0.6</td><td>0.8</td><td>0.5</td><td>8.5</td></tr>
<tr><td colspan="2">Roofing</td><td>1.2</td><td>1.5</td><td>1.8</td><td>9.5</td></tr>
<tr><td colspan="2">Plumbing and Gas</td><td>0.9</td><td>1.3</td><td>1.2</td><td>9.5</td></tr>
<tr><td colspan="2">Mech. Services</td><td>0.8</td><td>2</td><td>1.6</td><td>9.5</td></tr>
<tr><td colspan="2">Fire Protection</td><td>0.6</td><td>1.4</td><td>0.8</td><td>9.5</td></tr>
<tr><td colspan="2">Electrical Services</td><td>0.7</td><td>1.4</td><td>1.0</td><td>9.5</td></tr>
<tr><td colspan="2">**Backend**</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Solid Plaster/ Cladding</td><td>1.5</td><td>1.4</td><td>2.1</td><td>10</td></tr>
<tr><td colspan="2">GIB Fix and Stop</td><td>1.3</td><td>1.2</td><td>1.6</td><td>7</td></tr>
<tr><td colspan="2">Suspended Grid Ceilings</td><td>0.7</td><td>0.9</td><td>0.6</td><td>9</td></tr>
<tr><td colspan="2">Floor Coverings</td><td>0.8</td><td>1.1</td><td>0.9</td><td>9.5</td></tr>
<tr><td colspan="2">Painting & Special Finishes</td><td>0.9</td><td>1.2</td><td>1.1</td><td>9.5</td></tr>
<tr><td rowspan="2">Range</td><td>Max.</td><td>1.5
Plaster</td><td>2
Windows/Mechanical Services*</td><td>2.6
Windows</td><td>10
Windows/ Plaster</td></tr>
<tr><td>Min.</td><td>0.6
Demolition, Brick and Block Work, Joinery, Fire Protection</td><td>0.8
Demolition, Brick/Block work</td><td>0.5
Demolition/Brick/ Joinery</td><td>2
Reinforcement</td></tr>
<tr><td></td><td>Median</td><td>0.9</td><td>1.3</td><td>1.1</td><td></td></tr>
</table>

* Piling/Structural Steel 1.9

Thirdly, consider the situation of Category 2 trades (Type 1b) all of which have a *high* risk level than Category 1 trades although with a somewhat *lower* DLP suggesting that contractors seem to prefer higher retention rates than longer DLPs despite higher risks without taking into consideration the nature of the trade (for instance, where a longer DLP would have been more suitable to judge performance over changing seasons). Whilst this seems to provide further evidence that retention regime has a better association with risk than retention rate, it seems that contractors appear to prefer higher retention rates than longer durations. Whilst the reasons have not been investigated, once again, Abeysekera's Cash Cow Theory (2008) may provide an explanation.

These observations raise the question as to whether given an opportunity of setting a retention regime entirely on consideration of risk levels, would retention regimes for Concrete Work and Pre-cast Concrete etc. be different. This is a matter that needs to be investigated by seeking information from these respondents regarding their perceived levels of risk and associated retention regimes. Moreover, it would also be useful to investigate whether for a given level of risk, the trade-off between retention rate and holding/release mechanism of retentions. For instance, as to whether contractors would prefer a higher retention rate for a less than adequate defects liability period, is a connected issue. This is an important and useful exploration of this study that seeks to understand the *risk-retention* relationship.

The study mentioned in the previous paragraph provides another measure for risk (i.e. overall risk without the product measure of 'likelihood' and 'consequence') which can then be used for validating the product measure of risk (i.e. L x C) with this overall measure based on high, medium, or low type responses for '*overall risk*' of a trade. Collecting data for other trades (not covered in this study) could be used for checking external validity. The weights used for converting qualitative scores to numerical scores (i.e. 2.5, 1.5, and 0.5) need further investigation including whether 'x' and 'y' of the product measure of L^x x C^y should be taken as 1 (see Section 3, data analysis).

7. CONCLUSIONS

As mentioned earlier, the main purpose of this study was to investigate the risk-retention relationship by developing a methodology to understand this relationship.

In general, it was found that retention *rates* used in practice did not show an association with the overall (performance default) risk as current rates were primarily based on a paradoxically fair contractual practice of using back-to-back terms except with regard to holding/release mechanisms.

In contrast, when the risk-retention relationship was examined by the two components of risk, it is seen that for trades with high (above median) values of either consequence or likelihood (or both), composite retention rates used are high (over 9%), and for less than high values, the retention rates are lower thereby establishing a relationship between risk and retention to this extent with 17 out of the 22 trades studied displaying this association. The trades that did not, need further investigation to check whether there were other overwhelming reasons for these exceptions.

When examining the risk-retention relationship from a holistic approach taking retention regime as consisting of rate and release mechanisms, it may be concluded that higher the risk, harsher the retention regime. The converse is also true too but a lower level of risk or a medium level or risk, did not necessarily result in a commensurate response, i.e. low risks with favourable regimes, and medium risks with less than harsh regimes. This may be due to other overwhelming factors related to market conditions, project management convenience, or due to other considerations.

For a given level of risk, theoretically there could be many different types of retention regimes. However, for trades with high levels of risks, contractors seem to prefer higher retention rates than longer defects liability periods.

If the risk-retention relationship was examined purely from a risk perspective using perceived risks and perceived retention regimes, it should be possible to obtain a greater understanding about this relationship.

In relation to the theory of Retention Reciprocity, it appears that if contractors are to provide favourable regimes, subcontractors may need to address ways and means of reducing risk for the main contractor. However, one of the contentious issues is whether in fact, despite a high level of risk, the retention regimes imposed are fair (see Abeysekera, 2012). Finally, it needs to be mentioned that 'risk' as discussed herein is no doubt a beastly characteristic for the client – a characteristic the principal author had not addressed in his Beast Theory on Retentions. Understanding gained from this study would assist in developing this further vis-a-vis how best to cope with this beastly characteristic.

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COST OVERRUN ASSESSMENT FOR GREEN CONSTRUCTION PROJECT

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ABSTRACT

Green construction projects are initiated in complex and dynamic environments resulting in circumstances of high uncertainty and risk, which are compounded by demanding cost and time constraints. This paper describes a systematic way to consider and quantify uncertainty in green construction process based on LEED rating system adopted by Indian Green Building Council (IGBC). The system incorporates knowledge and experience acquired from many experts, project-specific information, decision analysis techniques, and a simulation model to predict risks for different green ratings in the construction schedule at the initiation of a project. The model provides sensitivity analyses for different outcomes wherein the effect of critical and significant risk factors can be evaluated. The study focuses on lessons learned from past projects and describes a risk assessment process involving typical inputs and expected outputs. The paper also investigates practical applications of risk management in green construction industry.

Keywords: *Uncertainty, Risk, Cost, Green Construction.*

1. INTRODUCTION

A 1992 worldwide survey reported that the majority of construction projects fail to achieve the objectives of the schedule (Cooper, 1994). For many projects schedule overrun analysis was not seem adequate at the beginning of the project. However schedule targets are vanished because of unforeseen events that even experienced construction managers could not anticipate. However, schedule target dates are more often missed because of events, such as design problems and industrial disputes, that were predictable but their likelihood and effects are difficult to predict with any precision because no two construction projects are the same (Thompson and Perry, 1992).

A survey by Laufer *et al.* (1992) of forty U.S. construction managers and owners indicated that for scope and design objectives only 35% of the projects considered had low uncertainty and the remaining 65% had medium to very high uncertainty at the beginning of construction. The costs of the projects averaged $5,000,000 which confirmed another report by Laufer and Howell (1993). It also concluded that approximately 80% of projects at beginning of construction possessed a high level of uncertainty.

The aim of green construction is primarily to minimise demand on non renewable resources and maximise utilisation efficiency of resources when in use. Secondly it aims at maximising reuse and recycling of available resources, and improving indoor environment quality thereby aiming to lower the operational and maintenance cost. The challenge of a green building is to achieve all its benefits at an affordable cost.

The amount of uncertainty in internal and external environments of a green construction project is an important factor in determining the likelihood of schedule overrun. However, attempting to consider realistically the uncertainty in construction schedules poses three challenges. The first challenge is that systems are not endorsed professionally or available commercially such that it can be used to structure project uncertainty and measure the effects on the project schedule. The second challenge is lack of easily accessible information and documentation of experience of construction industry or the knowledge scattered within a corporation. The third challenge is difficult motivating involvement of senior project management team to address adequately schedule risks. Project teams generally are too preoccupied with solving current problems involved with getting work done and therefore have insufficient time to think about, much less time to carry out, a formal risk assessment program (Oglesby *et al.*, 1989).

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This paper explores all the important risk factors contributing to cost and time overrun and identifying the critical elements in green construction sector so that appropriate mitigation measures can be devised. The study also provides new insights about the variation of cost and time overrun by establishing distribution curves based on the field data.

The study envisages analysis at three levels primarily the planning, execution, and the closing down phases in green construction process with respect to the primary data obtained from professionals through questionnaires and personal interviews. The indicators obtained from the above analysis are further scrutinised and analysed with the aid of secondary data and by which general solutions and observations are formulated. This study will pave way for further research in risk assessment, cost and time overruns in green construction industry.

2. PROBLEM STATEMENT

Various attempts have been made to understand the present status of the green construction industry. This has thrown light on lack of exploration of various cost management strategies, tools and techniques adopted in green construction process, apart from certain case studies highlighting various problems associated with the lack of efficient risk management leading to time and cost overruns.

During the study, 34 factors were identified and analysed for assessment of potential overruns associated with duration and cost in the green construction industry. The status of cost and time overruns in green construction industry is untouched, and this study offers an insight into identification of risk for project time and cost overruns in green construction sector.

3. RISK IDENTIFICATION

A perusal of the guidelines on green rating systems included Leadership in Energy and Environmental Design (LEED) India – CS & Green Rating for Integrated Habitat Assessment. Expert opinions from LEED professionals and other green experts utilised to identify a number of time and cost overrun causes in the green construction industry scenario. In India 80 green projects are registered under LEED of which only 28 have been completed. Five experts from different parts of India, who had more than ten five years experience as Project Manager for green building construction project presented the opinion of the factors affecting the overrun. Three iteration of the expert opinion in Delphi methodology, thirty four (34) factors were finalised to be made part of the survey questionnaire.

Three types of questionnaires were prepared based on the guidelines prescribed by LEED INDIA-CS & GRIHA. In this study the three main aspects taken into account are: (i) Planning Stage, (ii) Construction Stage, and (iii) Closing down Stage.

A survey was conducted through internet, postal mail and personal interviews in which respondents were asked to rank and score these factors according to their experience along with the cost overruns during the projects they had undertaken. Twenty five (25) construction firms were approached for these surveys out of which seventeen (17) responses were received with the response rate of 68%.

4. COST OVERRUN FACTOR ANALYSIS

In totality 34 risk factors were identified and the respondents ranked them for duration and cost overruns. The risks are qualitatively those that have both the highest impact on the project and are most likely to occur. Here the impact, probability, and severity (criticality) of each risk factor were quantified into zones in the probability-impact matrix (Graves, 2000).

The risks associated with the construction industry were extensively analysed using factor analysis with multiple regression models, ANOVA and T-tests (Sundarajulu *et al.*, 2007). The values used for probability and impact are indices that represent combined effect of the risks. The quantitative assessment is based on the mean values which was proposed by Sundarajulu *et al.*, 2007 This study incorporates nonnumeric probability scale (a three-level scale), where, 1=Low Probability, 2=Intermediate Probability, 3=High Probability, and impact is measured as deviation in project schedule, which is also represented on a nonnumeric scale of 1-3 where, 1=Low Impact, 2=Intermediate Impact, 3=High Impact which is presented in Table 1. The impact on the project schedule was measured for the schedule project delay on a scale of 1-3 (Graves, 2000).

Table 1: Rating Risk Impact on a Three-Level Scale

Scale	**1**	**2**	**3**
Risk Impact	Less Delay	Some Delay	Delay
Risk on schedule of project	Overall project delay<5%	Overall project delay<5-25%	Overall project delay>25%

In conjunction with this, a list of 34 risk factors was provided to the respondents to rank and score them according to the severity on the scale of 1 to 10 and they were instructed to rate score 1 to the factors which they find least contributing towards the time and cost overrun and a score of 10 to those factors they regard as most significant towards generating project time and cost overruns, and rating of in between to mark the severity of factor ranging from low to high.

Impact of each factor is calculated by

$$impact = \frac{\sum f_i \times i}{n} \qquad \text{(Eq: 01)}$$

Where:

i –the severity score from 1 to 10
f_i -the frequency of factor getting score i
n –number of responses

Figure 1 indicates the resultant impact ranking of the time and cost overrun factors as depicted by the survey analysis, impact ranges were divided into three regions, range of 0 to 2.5 (on severity impact axis) is neglected from the analysis due its insignificance and ranges are developed for severity impact as low, medium and high.

Low severity range (with impact score of 2.5 to 5), medium severity range (impact score of 5 to 7.5) and high severity range (ranges from 7.5 to 10).Results represents that very few (3) factors were rated as low severe, majority of the scores lies in the high medium severity**.**

5. HIGH SEVERITY RISK COST OVERRUN DISTRIBUTION

The cost overrun data obtained from the questionnaire survey was plotted to obtain the cost overrun probability distribution for high severity risks. It was established that high severity risk for a green construction projects follows Weibull distribution and the results are presented in Figure 2. Probability-Probability (P-P) graphs were plotted for the distribution of the input data (Pi) vs. the distribution of the result (F(xi)). Also Quantile-Quantile (Q-Q) graphs were plotted for percentile values of the input distribution (xi) vs. percentile values of the result (F-1(Pi)). Since the plots were nearly linear, the fit is "good".

6. MEDIUM SEVERITY RISK COST OVERRUN DISTRIBUTION

The cost overrun data obtained from the questionnaire survey was plotted to obtain the cost overrun probability distribution for medium severity risks. It was established that high severity risk for a green construction projects follows Log Logistic distribution and the results are shown in Figure 3.

Probability-Probability (P-P) graphs were plotted for the distribution of the input data (Pi) vs. the distribution of the result (F(xi)). Also Quantile-Quantile (Q-Q) graphs were plotted for percentile values of the input distribution (xi) vs. percentile values of the result (F-1(Pi)). Since the plots were nearly linear, the fit is "good".

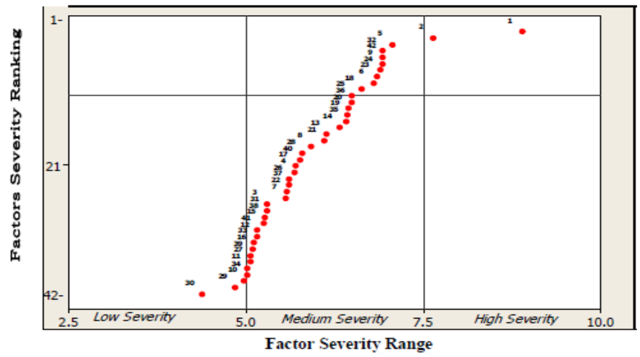

Figure 1: Severity Analysis

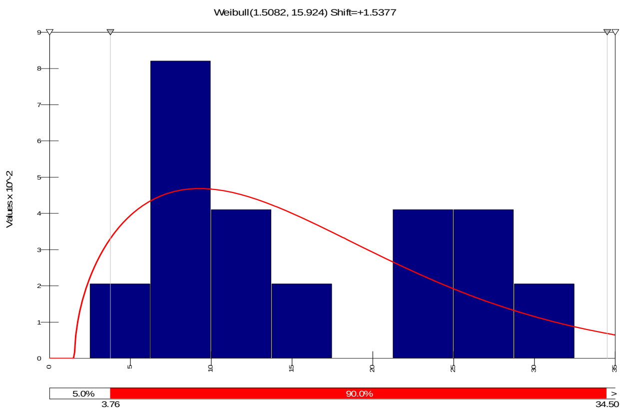

Figure 2: Weibull Distribution for High Severity Risk for Green Construction Projects

7. TIME OVERRUN DISTRIBUTION

The time overrun data obtained from the questionnaire survey was plotted to obtain the time overrun probability distribution for green construction projects. It was established that high severity risk for a green construction projects follows Beta distribution and the results are indicated in Figure 4. Probability-Probability (P-P) graphs were plotted for the distribution of the input data (Pi) vs. the distribution of the result (F(xi)). Also Quantile-Quantile (Q-Q) graphs were plotted for percentile values of the input distribution (xi) vs. percentile values of the result (F-1(Pi)). Since the plots were nearly linear, the fit is "good".

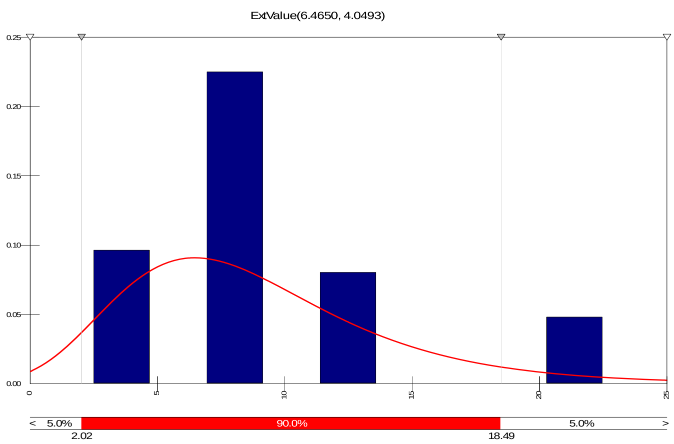

Figure 3: Medium Severity Risk follows Log-Logistic Distribution

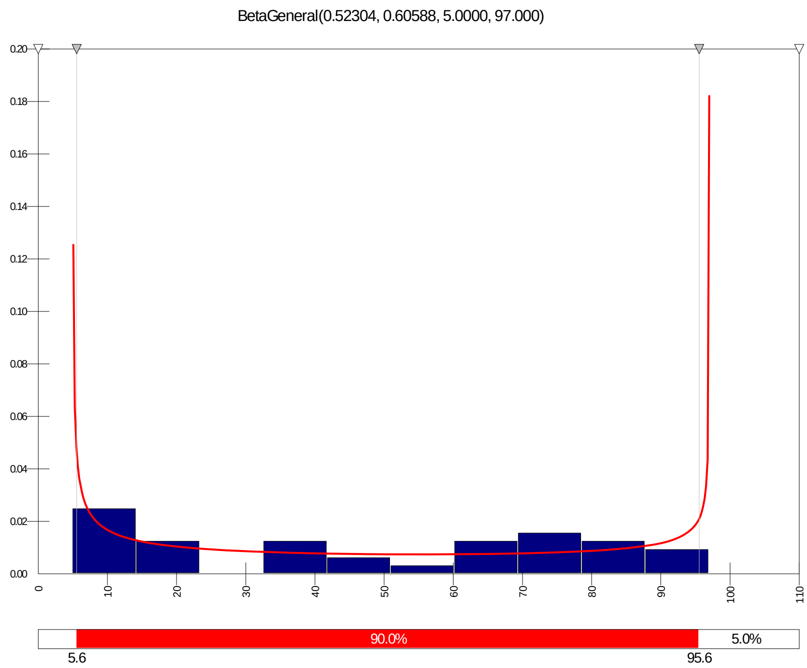

Figure 4: Time Overrun-Beta Distribution

8. Simulation for Risk Prediction

In this study, range for random variable for each of the factors was identified based on the probability distribution curves developed from the primary survey. Cumulative probability of occurrence of each risk is calculated based on the response received in the survey. A random number generated is linked to a risk based on the class intervals decided by the cumulative probability obtained from survey.

Monte Carlo Simulation was used as an effective tool for risk prediction. Simulation runs of 1000, 10000, 50000 and 100000 were tabulated to predict the risks identified using survey response. All the inputs were taken from green experts to take the process more close to the real world. Simulation was carried out varying the number of runs to determine any converging trend in the overruns associated with cost and duration for various types of rating according to LEED INDIA CS. The results based on this simulation analysis are presented in Table 2. The result based on the simulation model indicates that minimum credits that are required for each type of rating with most likely overrun with respect to cost and duration. It is evident from the study that the duration overrun associated with the project targeting Platinum rating is comparatively lesser than the Silver rating while the cost overrun associated with a Platinum rated green building is more in comparison with silver rated building. This is due to the fact that the execution of various activities associated with the Platinum rated building is carried out with an efficient technology and advanced materials. However there is only a marginal variation when Platinum rated building is compared with the Gold rated construction. This is due to the fact that the variation in credit requirement is minimal in between the two certifications. However a large overrun is observed in the case of Green Certified building compared to the higher rating even though the credit requirement according to LEED NC is lowest for this group. This is due to higher degree of randomness associated with this type of construction. It was observed during the simulation study that as the higher rating system is target for a building, the randomness associated with various parameters is reduced.

Table 2: Simulation Results

Type of Certification		**100 runs**	**1000runs**	**10,000runs**	**50,000runs**
Platinum Rated Green Building	Total Credits	59	59	59	60
	Duration Overrun (%)	13.42	7.84	12.04	11.43
	Cost Overrun (%)	23.96	13.99	21.49	20.40
Gold Rated Green Building	Total Credits	44	48	46	48
	Duration Overrun (%)	11.53	18.19	16.19	67.09
	Cost Overrun (%)	10.65	4.78	12.06	23.34
Silver Rated Green Building	Total Credits	38	33	34	33
	Duration Overrun (%)	1.75	27.94	39.60	89.02
	Cost Overrun (%)	2.45	10.96	13.23	12.43
Certified Green Building	Total Credits	32	31	30	31
	Duration Overrun (%)	10.45	98.56	93.95	15.99
	Cost Overrun (%)	17.89	17.57	16.76	89.76

Based on the analysis the risks identified are ranked according to the likelihood of occurrence and impact on the project which is targeting various rating. The various intends required for the green rating is rated based on the cost impact and duration impact from lower value to higher value on the project based on the simulation study. The results obtained in this study presented in Table 3 indicates for obtaining any rating, the reduction in site disturbance has the lowest impact on the project with respect to cost and duration while the next higher impact is for the factor site selection amongst various factors that need to be considered in Sustainable sites.

9. Conclusions

The study was carried out based on various green building construction projects in India and abroad. However emphasis was given in developing a risk modelling tool that can predict the overrun associated with duration and cost of Green Building. The survey results indicated that the majority of cost overrun factors (89%) lie in medium severity impact range. However these factors need to be attended as they tend to increase in the cost of the project compared to the initial estimation. Even though the likelihood of cost overrun for construction projects targeting green rating is high, minimum range of cost overrun in percentage of the estimated cost is found to be 8%. The cost overrun for high severity risks occurring in green construction sector was found to follow Weibull Distribution. Similarly, cost overrun for medium severity risks in green construction industry was found to follow a Log- Logistic distribution. Time overrun in green construction industry was found to follow Beta distribution. The highest risks were associated with Reduced Site Disturbance, Innovative Waste Water Technologies, Renewable Energy, Construction Waste Management, Indoor Chemical and Pollutant Source Control, LEED^{TM} Accredited Professional. Care and proper mitigation measures should therefore be taken while including the factors with lower rank in risk factors.

Table 3: Risk Ranking for Different Green Ratings of the Building

		Credits	Certified	Silver	Gold	Platinum
Sustainable Sites	Reduced Site Disturbance	1	1	1	1	1
	Site Selection	1	2	2	2	2
	Alternative Transportation	1-3	3	4	3	3
	Storm water Design, Quantity Control	1	4	3	4	4
	Development Density & Community Connectivity	1	5	5	5	5
	Brownfield Redevelopment	1	6	6	6	6
	Heat Island Effect, Roof	1	8	8	8	8
Water Efficiency	Water Efficiency	1-2	2	2	2	2
	Water Efficiency in Air-conditioning System	1	4	4	3	3
	Innovative Waste Water Technologies	1	1	1	1	1
	Water Use Reduction	1-2	3	3	4	4
Energy and Atmosphere	Optimize Energy Performance	1-10	5	5	1	5
	Renewable Energy	1-3	1	1	2	1
	Additional Commissioning	1	2	2	3	2
	Ozone Depletion	1	3	3	4	3
	Measurement and Verification	1	4	4	5	4
Materials and Resources	Building Reuse	1-3	4	4	6	4
	Construction Waste Management	1-2	1	1	4	1
	Resource Reuse	1-2	2	2	1	2
	Recycled Content	1-2	6	6	2	6
	Local / Regional Materials	1-2	3	3	3	3
	Rapidly Renewable Materials	1	5	5	5	5
	Certified Wood	1	7	7	7	7
Indoor Environmental Quality	Outdoor Air Delivery Monitoring	1	3	3	3	3
	Increased Ventilation	1	4	4	4	4
	Construction IAQ Management Plan	1-2	5	5	5	5
	Low-Emitting Materials	1-4	6	6	6	6
	Indoor Chemical and Pollutant Source Control	1	1	1	1	1
	Controllability of Systems	1-2	7	7	7	7
	Thermal Comfort, Design	1	8	8	8	8
	Thermal Comfort, Verification	1	9	9	9	9
	Daylight and Views	1-2	2	2	2	2
Innovation in Design	Innovation in Design	1-4	2	2	2	2
	LEED^{TM} Accredited Professional	1	1	1	1	1

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APPLICATION OF CONCURRENCY IN DELAY CLAIMS

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ABSTRACT

It was observed that the consideration of concurrency in delay claims in Sri Lankan construction industry is significantly low. A study was conducted to identify key reasons for low consideration of concurrency in delay claims analysis. A three-round study method was adopted. First was a pilot study by means of interviews to explore concurrent delay practice in Sri Lanka. Second was a round of semi-structured interviews among key parties to a contract to identify significant causes affecting consideration of concurrency in delay claim analysis. Third round was a document survey aiming to identify lapses in documents which could affect successful practice of concurrent claim analysis. The study concludes that quality of documents is the most significant cause affecting the consideration of concurrency in delay claims analysis and identifies number of lapses in documents which contribute to low consideration of concurrency in delay claims. In addition to improving documentation practices, enhancing employers' awareness on concurrency is also suggested as a necessity to improve concurrent delay analysis practice in the Sri Lankan construction industry.

Keywords: *Concurrent Delay, Claims Management, Construction, Sri Lanka.*

1. INTRODUCTION

An instance where two or more independent delays, which falls under 'Employer Risk' and 'Contractor Risk' occur at the same time and affect the ultimate completion date of the project is defined as 'Concurrent Delay' (Rubin *et al.*, 1983 cited in Arditi and Pattanakichamroon, 2006 and Cushman *et al.*, 1999). This paper presents findings of a study on application of concurrency in delay claims in Sri Lanka. The aim of the study was to identify the key reasons for low consideration of concurrency in delay claims analysis.

Concurrency in delays is a special aspect in claims management. Both Contractors and Employers use concurrency as a shield in defending delay claims. Contractor may use concurrency to defend delay damages, while Employer may use it to avoid paying compensation for the prolongation to the Contractor. Concurrent delays are known to be complex to analyse and difficult to prove. Because whenever Employer and Contractor concurrently delay the work, responsibility for the delay cannot be identified and shared properly (Williams, 2003). However, for accurate accounting of the contractual liability for delays, impact of concurrency cannot be ignored.

It was observed that the consideration of concurrency in delay claims in Sri Lankan construction industry is significantly low. This implied that the contractual liabilities of delays may not be accurately accounted. Therefore, exploring what has been instrumental in discouraging the application concurrency became interesting.

2. STUDY METHOD

The study was conducted in three rounds. The arrangement was effective due to the nature of problem being studied. The first round was a pilot study by means of unstructured interviews with three claims experts. The primary objective was to verify if the authors' personal observation of low application of

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concurrency in Sri Lankan construction delay claims was in fact true. The study also helped to receive a general yet extensive overview of the nature and issues in application of concurrency in delay claims. Verification of the aim of the study was also an objective of the pilot study.

The second round was a semi-structured interview. The objective was to identify the significant causes affecting the consideration of concurrency in delay analysis. 36 professionals representing Employers', Engineers' (consultants) and Contractors' organisations (12 numbers from each) took part in interviews. All participants had minimum of 5 years experience in claim handling and/or post contract management.

By analysing the responses of the interviewees, the primary cause of the problem was hypothesised. Third round was a document survey which was used to test the set hypothesis. The survey was conducted at 24 Engineers' and Contractors' (12 numbers from each) organisations. Binomial test was used to test the statistical hypotheses.

Second and third rounds of the study are detailed below together with their relevant literature synthesis.

3. REQUISITES FOR SUCCESSFUL CONCURRENT DELAY CLAIM PRACTICE

Delays in construction can result in number of changes in a project; for example, they may cause late completion, productivity reduction, need for acceleration, increases in costs, or even contract termination. When one party to the contract has suffered damage, it should be compensated by the other party according to the responsibility of the cause. A construction claim is a statement of demand for compensation, which provides arguments based on evidence (Kululanga *et al.*, 2001).

The main requisites for successful concurrent delay claim practice are,

a) Parties' awareness on contractual entitlement for Extension of Time (EOT) for completion and Delay Damages (DD)
b) Parties' awareness on concurrent delay and its analysis methods
c) Parties' proper documentation or record keeping

The party suffered from a delay should have the ability to recognise the delay event, potential damage and the parties who are responsible, in order to recover the time and cost incurred. The identification of delay causes should be timely done with the proper understanding of claim process (Arditi and Pattanakichamroon, 2006 and Kumaraswamy, 1997).

3.1. CONTRACTUAL PROVISIONS AND ENTITLEMENTS

When the Contractor caused a delay and if it has impacted on project completion, the Contractor shall pay DD to the Employer. DDs are reasonable pre-estimates of losses of the Employer which are likely to incur if the project completion gets delayed.

If Contractor suffers delay and/or incurs cost as a result of the Employer's failure, Contractor is entitled for EOT and payment of cost plus profit. If it occurred from causes beyond the parties control, such as weather and fossils found on the site, the Contractor will only be entitled for EOT and cost incurred, but not for the profit.

The provisions are reviewed primarily in respect of FIDIC Conditions of Contract for Construction-1999 (known as FIDIC99) which has global application. However, the Sri Lankan standard form, ICTAD Standard Bidding Document for major contracts-2007 (SBD) (ICTAD, 2007), is very much similar to FIDIC (1999). Both FIDIC and SBD are used in Sri Lankan projects.

3.2. CLAIM PROCESS

Time related claims are often very difficult from preparation to evaluation. Any time related claim situations need to be resolved with regard to three basic elements: Causation, Liability and Damages (Cushman *et al.*, 1999). It is necessary to follow a proper claim process for effective claim management. Key steps of a claim process are identified below.

Step 01: Claim Identification

Construction claim identification should be done accurately and at the right time by the Contractor. This is the first and critically important ingredient of the claim process (Kululanga *et al.*, 2001). Due to failure of identification, a claim can be completely lost. Identification is effected mainly by two factors.

a) Contractor's awareness of possible claim causes and claim processes required, according to contractual provisions.

b) Contractor's awareness of job and identification of direct actions on site that initiate the claim. e.g. Work content, Each activity description, Duration of each activity, Party who will perform the activity, Resource allocation for each activity, Lag between two activities, Any one or more activities are to be sequenced in relation to other activities (Pickavance, 2005 and O'Connor, 2003)

Step 02: Claim Notification

The purpose of a timely notice is to provide the other party with an opportunity to assess the circumstances to determine whether there is an alternate method of dealing with the problem and to avoid the costs associated with a claim. The prevention of notification will lose the other party's opportunity to mitigate the loss (O'Connor, 2003 and Barnard, 2004). Therefore, if notice of a claim is not given within the specified period given, the time for completion shall not be extended. Further, Contractor shall not be entitled to additional payment (FIDIC, 1999 - Sub Clause 20.1).

The notice should be short, clear, simple, conciliatory and cooperative (Kululanga *et al*,, 2001). It should be with the relevant circumstances, including the cause or causes of the delay and illustrate any event which in Contractor's opinion is an Employer's time risk event, date which the event took place, cause, likely duration and potential impacts (Pickavance, 2005; Birkby and Brough, 1993).

Step 03: Claim Examination and Presentation

Claim examination should be done by the Contractor. This involves;

a) Establishing the legal and factual grounds on which the claim is to be based

b) Estimates of potential recovery

The primary sources for claim examination are the documentation and records maintained in the site itself, written correspondences, memos, meeting minutes, etc. Within given time in condition of contract, the Contractor shall prepare a fully detailed claim which includes full supporting particulars and send it to the Engineer.

Step 04: Claim Evaluation

Upon receiving a claim and supporting particulars, within a specified time agreed in conditions of contract, Engineer shall respond with approval or disapproval with detailed comments. Before approving or disapproving the claim, the Engineer should evaluate it. Evaluation of claims is not an exact science. The basis of calculation depends on the complex interaction of factors which may be unique to the project (Thomas, 2001). There are three steps to be taken to judge a delay event. These are, (a) occurrence of a causal event, (b) a delay to progress of the works, and (c) delay to completion (Pickavance, 2005).

Step 05: Claim Negotiation

At the negotiation, both parties have an equal opportunity to represent and discuss findings before making a decision. It is an approach to identify party's own position in complex circumstances of claims. A successful negotiation should be flexible, because the result achieved should be fair to both Employer and Contractor. Negotiation is not just the final settlement for resolving a claim; if the parties are not be able to come to an agreement they can go for other alternative dispute resolution methods (Turner and Turner, 1999; Pickavance, 2005 and Omar, 2007).

3.3. CONCURRENT DELAYS AND APPROACHES TO APPORTIONMENT

When there is a concurrent delay, which both the Contractor and Employer simultaneously delay the project's critical path, it becomes difficult to identify the responsible party for the delay. In case of concurrent delays, consequences should be apportioned between Contractor and Employer on the basis of their contribution. The apportionment should answer the following questions (Marrin, 2002).

a) Is the Contractor to be granted an EOT?

b) Is the Contractor entitled to recover worth of prolongation costs? or

c) Is the Employer entitled to recover worth of DDs?

Compensation and DD are decided according to the apportionment entitlement for the EOT (Davison and Mullen, 2009). When there are number of delays affecting project's completion date, there is no hard and fast rule concerning which delay takes the priority. Each case has to be judged on its own merits (Knowles, 2005). Therefore apportioning method should be selected depending on the circumstances. Common methods in practice are (a) But for Test, (b) Dominant Case Approach, and (c) use of common sense.

By reviewing the requisites along with what was found through the pilot study, lists of causes which are likely to impact the consideration of concurrency in delay claims were developed. Three lists were prepared to cover three main parties involving in delay claims viz. Employers, Engineers, and Contractors. The lists can be found in Tables 1, 2 and 3 below.

4. IDENTIFICATION OF SIGNIFICANT CAUSES AFFECTING THE CONSIDERATION OF CONCURRENCY

The significance of the causes identified as described above was analysed through descriptive methods using the data collected through the semi-structure interviews (i.e. second round of the study). Analysis was conducted separately for each group (party); and a global analysis was not possible because there were differences among the lists of possible causes of three groups, and in fact the causes acts differently in influencing concurrent delay consideration.

The objective of analysis was to identify if a cause considered has been instrumental. There are two possible outcomes when analysing an organisation:

- Organisations which have considered concurrency
- Organisations which have not considered concurrency

First outcome could occur either with the presence or absence of a cause in concern. Similarly second outcome could also occur either with the presence or absence of a cause in concern.

In order to identify if the selected cause significantly impacts on consideration of concurrency, the pooled number of organisations which fall into following categories were counted against the total number of organisations in the group.

- Consideration of concurrency with the presence of the cause in concern
- Non consideration of concurrency with the absence of the cause in concern,

which is denoted by + in Tables 1, 2, and 3..

How this pooling yield the significance can be explain by taking the data shown in Table 1 below as examples. "Capacity to involve in post-contract management" was there with most organisations (9 numbers) among 10 organisations which did not consider concurrency. That shows that, while the capacity is there, organisations still did not consider concurrency, which means that "capacity to involve in post-contract management" is not a significant cause. Therefore, more of "Yes" in "Not Considered" group means, the cause is not significant. Inversely, more of "No" in this group means that the cause is significant. In the group which considered concurrency, more of "Yes" means that the cause is significant, and vice-versa.

4.1. Significant Causes for Employers to Consider Concurrency

Table 1 shows the analysis results of the Employer group's response. Accordingly, only about 17% from the sample had considered concurrency. Employers' awareness on concurrent delay was a significant cause on considering concurrency in delay claim analysis. The level of significance was 83% from total sample. The result came from the fact that 8 out of 10 who did not consider concurrency also did not have the awareness; and all who considered concurrency also had the awareness. Thus the consideration of concurrency is significantly impacted by Employer's awareness on concurrent delays and assessing techniques.

Table 1: Causes for Employers to Consider Concurrency

Concurrency / Employer's	Not Considered		Considered		Impact %
	Yes	No	Yes	No	
Capacity to involve in post contract management	9	1	2	0	25.0
Awareness on losses incur & right to recover DD	5	5	2	0	58.3
Awareness on provisions on EOT & Compensation	8	2	2	0	33.3
Awareness on concurrent delay	2	8	2	0	83.3
Acceptable quality of documentation	1	9	2	0	91.7
No preference for negotiated solution	6	4	1	1	41.7

However, the most significant cause in terms of Employer became the acceptable quality of documents with a calculated significance level of 91.67%. Therefore proper documentation and records becomes the most critical cause to enable consideration of concurrency from the Employers' end.

4.2. Significant Causes for Engineers to Consider Concurrency

Analysis results of the Engineer group's response are shown in Table 2. It was found that only 25% of the sample had considered concurrency in analysis of delay claims.

Accordingly, two causes, Engineer's satisfaction with current practice of claims management, and proper communication between Head Office (HO) and sites have 83.34% impact on consideration of concurrency. Interestingly, the most significant cause found in this group also was the acceptable quality of documentation showing 100% impact towards successful consideration of consideration of concurrency in delay claims.

Table 2: Causes for Engineers to Consider Concurrency

Concurrency / Engineer's	Not Considered		Considered		Impact %
	Yes	No	Yes	No	
Capacity to involve in post contract management	9	0	3	0	25.0
Acceptable communication between HO and Site	2	7	3	0	83.3
Awareness on provisions on EOT & Compensation	9	0	3	0	25.0
Awareness on concurrent delay	7	2	3	0	41.7
Acceptable quality of documentation	0	9	3	0	100.0
Satisfied with delay claims management	1	8	2	1	83.3

4.3. *SIGNIFICANT CAUSES FOR CONTRACTORS TO CONSIDER CONCURRENCY*

A quarter of the Contractors' organisations analysed had considered concurrency in delay claims. Acceptable quality of documentation became the most significant cause also in this group with an impact score of 83%. This was followed by their reluctance for a negotiated solution (i.e. preference for contractual entitlement) with an impact score of 75%.

Table 3: Causes for Contractors to Consider Concurrency

Concurrency / Contractor's	Not Considered		Considered		Impact %
	Yes	No	Yes	No	
Capacity to involve in post contract management	9	0	3	0	25.0
Acceptable communication between HO and Site	7	2	3	0	41.7
Awareness on provisions on EOT & Compensation	9	0	3	0	25.0
Awareness on concurrent delay	6	3	3	0	50.0
Acceptable quality of documentation	1	8	2	1	83.3
No preference for Negotiated solution	1	8	1	2	75.0

The interesting finding was that the acceptable quality of documentation is the most significant cause for all three groups. Among the groups, other causes had varying degrees of impact on consideration of concurrency. Comparing this result with the comments made by the experts during the pilot study, it was hypothesised that the acceptable quality of documentation being the most significant cause, unacceptable quality of documentation is in fact the primary cause for low consideration of concurrency in Sri Lankan construction industry. To verify this, a further study was conducted.

5. Document Requisites for Successful Concurrent Delay Claim Practice

Claim documentation is a collection of hard facts that depicts the actual history of a claim. At claim presentation and evaluation it is vital to refer the relevant records and documents as evidence, to establish the truth of facts and the opinions based on those facts. Clear factual evidence is crucial to a successful claim (Davison and Mullen, 2009; Turner and Turner, 1999; Kululanga *et al*., 2001 and Pickavance, 2005). Documentary evidence requirement, vary from claim to claim. Therefore, it is hard to list out all the documents or records necessary (Birkby and Brough, 1993). Thus, most common supportive documents required for a successful claim management were identified for the verification study.

Document requisites for a successful concurrency consideration were studied initially through a literature survey. Identified key requisites are introduced together with their status in Sri Lankan construction industry through subsections 0 to 0 below.

6. Status of Documentary Requisites in Sri Lankan Construction Industry

Status of document requisites was assessed through a document survey. Documents used and produced at 24 numbers of organisations were scrutinised in detail to identify whether they are at appropriate standard to be used in a concurrent delay analysis. The required were identified through literature, and a checklist was prepared as the assessment tool. What checked were the availability, completeness and timeliness of the documents. However, it was impractical to assess the accuracy of the documents. This is a limitation of the study, albeit is unlikely to be significant due to the fact that once the document is presented, any errors (inaccuracies) would be challenged by the other party. Binomial test was used to make inference about the population using the sample data. Analysis of the status of the common document requisites for concurrent delay analysis is followed.

6.1. Notice of Claim

Notice of Claim initiates the claim process, in a delay context, it also ensures that the delay causing party is made aware of it and is given the opportunity to mitigate the delay if possible. Importance of notice of claim was discussed in subsection 3.2 – Step 02: Claim Notification. Table 4 shows the summary data on quality (primarily in terms of completeness) of claim notices found in sample Contractor organisations.

Table 4: Content of Notice

	Event	Events occurred dates	Cause	Likely duration	Potential impact	Only necessary details
No	0	7	2	9	9	12
Yes	12	5	10	3	3	0

Significant weaknesses identified in the notice are;

- Including unnecessary details – with 95% confidence level
- Not including likely duration and potential impacts of delay – each with 90% confidence level

6.2. Daily Site Record

Diary records of site observations provides useful source of information or evidence on day to day events (Birkby and Brough, 1993). Any notable events such as events that may cause delay or affect the productivity shall be included in records. It should be ensured that entries express facts, rather than opinions. Examples of records include-instructions issued, weather condition, manpower utilised, visitors' arrivals to the site, Subcontractors on site, and key deliveries of material. The survey results showed that all organisations in sample maintained these records and therefore it is likely that this is not a weakness in Sri Lankan construction organisations.

6.3. *CONSTRUCTION PROGRAMME*

Among numerous documentation required in concurrent delay analysis, most imperative document is the construction programme. This is because, the damage caused to project's time and cost targets due to an Employer caused delay and a Contractor caused delay cannot be distinguished without it, especially due to following features of it;

a. an as-planned programme and its critical path shows the Contractor's intended work programme to achieve project targets. Further, revised programme is the changed programme while work in progress according to circumstances and revised to achieve projects time target. Few examples for such circumstances are: variations, required acceleration, and granted EOT.

b. an as-built programme demonstrate the work and sequence actually carried out (The SCL Delay and Disruption Protocol - 1.10.5 and Davison and Mullen, 2009).

Table 5 shows the availability of three types of programmes in the sample which included both Engineers' and Contractors' organisations.

Table 5: Programme

	As-planned	As-build	Revised
No	0	0	19
Yes	24	24	5

It can be stated with 95% confidence that the majority of organisations are not used to prepare revised programmes in cases of actual progress deferring from as-planned programme.

6.4. *CONTENT OF PROGRAMME*

An as-planned programme is submitted by the contract at the beginning of the project, usually because of the contractual requirement. The programme should include several details so that the programme can be effectively used in concurrent delay analysis. Table 6 provides summary results of status of those details in as-planned programmes observed in the sample organisations.

At 95% confidence level, it was recognised that following were not included in majority of as-built programmes in Sri Lankan industry: critical path identification, labours and suppliers in each activity or work sections, earliest and latest start and finish of activities or sections, milestones and key dates, dates of design works or test to be submitted to the Engineer, dates the Engineer will re-submit after approval or disapproval and dates the information required by the Engineer and work contain as provisional sums. It can also be stated with 90% confidence level that the delivery dates of major items are not included in majority of programmes.

Table 6: Content of Programme

	Identification of Critical Path	Activities - work packages	Labour& suppliers	Earliest & latest start & finish of activities	Access dates for sections	Earliest & latest start & finish of sections	Milestones & key dates	Holidays	Designs, tests submit dates to Engineer	Engineer's re-submit dates	Delivery dates of major items	Information required dates	Provisional Sums	Commissioning period
No	23	0	21	24	6	24	17	3	23	24	16	22	24	10
Yes	1	24	3	0	18	0	7	21	1	0	8	2	0	14

6.5. METHOD STATEMENT

A method statement demonstrates the assumptions that have been made in forming the factual basis for setting key dates and logic for which the programme has been developed. Therefore it is essential that an as-planned programme will necessarily be followed by the methodology stated in the method statement (Pickavance, 2005 and Birkby and Brough, 1993). Status of important details in a Method Statement required for successful consideration of concurrency in a delay event is shown in Table 7.

Table 7: Content of Method Statement

	Method of construction	Resources to be used	Work included in activities	Logical interface between activities	Lag between activities	Productivity expected	Method of calculation of time lags	Manpower	Work rate	Monitory value of the activity
No	0	10	21	24	24	24	24	14	21	24
Yes	23	14	3	0	0	0	0	10	3	0

Significantly large weaknesses are identified in Method Statements. It can be stated with 95% confidence that the organisations do not include a proper description on work included in each activity, logical interface between activities, lag between activities, productivity expected and methods of calculations of the time lags, work rates, and monitory values of the activities.

7. CONCLUSIONS AND RECOMMENDATIONS

The significant causes that affect the consideration of concurrency in delay claims slightly varied among three major parties - Employers, Engineers and Contractors. Interestingly, acceptable quality of documents became the most significant cause for all three groups. Awareness of concurrent delays became the second significant cause for Employers, while it was not so for Engineers. For Engineers, their satisfaction on current delay management practice became second. For Contractors, their disfavour for negotiated solution became the second significant.

Acceptable quality of documents was identified to be the primary or root cause for low consideration of concurrency in delay claims in Sri Lanka. Documents were found to have number of lapses in causing successful concurrence delay analysis difficult or often impractical. Among the identified lapses; absence of potential impacts of delays but other unnecessary details in claim notices, absence of revised construction programmes, and omission of important information in as-planned programme, found to be critical. Significant lapses were found also within the Method Statements. These included absence of proper description on work included in each activity, logical interface between activities, lag between activities, and productivity expected.

Synthesising the findings it can be concluded that the above identified lapses in the documents are the primary reasons for low consideration of concurrency in delay claims in Sri Lankan construction industry. Therefore, improving the documentation practice in the industry is a necessity. In addition, increasing the awareness of concurrent delays among Employers is important. Once the Employers demand, Engineers will no longer be able to disregard concurrency in delay claim analysis. When the practice is established and the documents are in order, establishment of contractual entitlements will not be difficult. As a result, preference for negotiated settlement for delay claims will diminish. The resulting overall context will establish a good concurrent delay claim practice. This will enable accounting of contractual liabilities of delays more accurately in construction contracts in Sri Lanka.

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DEVELOPING A FRAMEWORK TO BENCHMARK OPERATIONAL ENERGY IN SUSTAINABLE COMMERCIAL BUILDINGS IN SRI LANKA

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ABSTRACT

Benchmarking of operational energy efficiency stands for an influential tool to promote the efficient use of energy in buildings. This research stands for developing a framework to benchmark operational energy efficiency in sustainable commercial buildings in Sri Lanka. The developed framework offers the opportunity to achieve advance efficiency in energy, compares to the buildings which are just built to code. The benchmark is to be served as a referencing point of comparing and contrasting best practices within local context, while offering a realistic energy goal and eligibility to sustainability. The developed framework can be adapted to any context in order to benchmark operational energy consumption as well as any other sustainability domains such as water, indoor environmental quality and site development. The motivation behind this paper is to provide an energy benchmarking framework to evaluate the facility, which gives competitive advantages and better approach to the up-coming challenges in the fast growing world.

Keywords: *Operational Energy Benchmark, Sustainability Initiatives, Operational Energy Aspects, Operational Energy Indicators, Weighted Average Method.*

1. INTRODUCTION

Sustainability is one of the most widely used words in the scientific field as a whole and in the environmental sciences in particular due to increasing natural disasters, depletion of natural resources and the growing problems of waste materials as a by-product of the global economy. World Commission on Environment and Development (1987) defined sustainability as the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable buildings are regarded as buildings that use key resources like energy, water, materials and land more efficiently than buildings that are just built to code (Kats, 2003), while emphasising that sustainability is a moving goal with ‘green’ or ‘sustainable’ being reserved for those that are built ‘beyond compliance’ with regulation (Sayce *et al.*, 2007).

The aim of this paper is therefore to review different sustainability initiatives and develop a framework to benchmark operational energy in sustainable commercial buildings in Sri Lanka. The paper presents a brief introduction to the sustainability, sustainability initiatives and relationship between sustainability and energy. The paper finally presents the developed framework for benchmarking operational energy in sustainable commercial buildings in Sri Lanka.

2. SUSTAINABILITY INITIATIVES

Since, the prospects of climate change, resource depletion and emissions generation have combined to create an increasing awareness of sustainability issues and demand for green construction practices in general, a need has being appeared to rate practices and products in order to compare and contrast best practices (Presley and Meade, 2010) and the sustainability indicators have emerged as one widely accepted tool at all levels, national, community, organisation and company (Veleva *et al.*, 2003). According to Green Rating for Integrated Habitat Assessment (2010), these indicators/rating systems are an evaluation tool that measure environmental performance of a building throughout its life cycle which

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usually comprises of a set of criteria covering various parameters related to design, construction and operation. In that manner, the international 'grading systems' have been put in place to define and show levels of achievement in green, sustainable, intelligent and secure buildings such as Building Research Establishment Environmental Assessment Method (BREEAM), Comprehensive Assessment System for Building Environmental Efficiency (CASBEE), Green globes, Green star and Energy star (Miller *et al.*, 2008).

3. SUSTAINABILITY AND ENERGY

One of the common major criteria addressed by most of the sustainable built environment initiatives (rating systems) is the 'energy', as sustainable building design is about limiting their negative environmental effects and using materials, energy and other resources in a sustainable manner (Margret, 2008). Besides, Chandratilake and Dias (2010) have taken the 'energy efficiency' as one domain of sustainability, in order to undertake the survey of 'sustainability rating systems for buildings: comparisons and correlations', among other sustainability domains such as site, water, materials, indoor environmental quality and waste and pollution. As stated by the Gowri (2004), efficient use of energy is a key element in the design of a green building, whereas the principles of sustainable building design promote energy conservation, healthier and safer buildings for occupants, and a reduction in greenhouse gas emissions, environmental stewardship and social responsibility.

Energy use during the lifespan of buildings consists of embodied energy, operating energy and demolition energy. The total embodied energy demand includes energy used in producing and transporting the building materials and components, and energy used for various processes during the production and demolition of the building, whereas operational energy is the energy use in keeping the indoor environment within the desired range (Chen *et al.*, 2001). According to the Sartori and Hestnes (2007), the operational energy is the energy used in buildings during their operational phase, as for, heating, cooling, ventilation, hot water, lighting and other electrical appliances. However, managing operational energy in buildings becomes more significant, as Kofoworola *et al.* (2009) found that, the average annual energy consumption over 50 years of operation of the building, the embodied and operating energy of the building over its lifespan indicated that the embodied energy is about 15% of the operating energy. In addition, Sartori and Hestnes (2007) mentioned that the operating energy represents by far the largest part of energy demand in a building during its life cycle, also been shown a linear relation between operating and total energy. Hence, energy plays a key role, particularly in the context of sustainability, while, the operational energy plays a key role in the context of building energy usage. The framework, therefore, is developed to benchmark the building operational energy and can also be adapted to benchmark entire energy domain and other sustainability domains such as water, indoor environmental quality and site development.

4. METHODOLOGY

The research introduces a framework to benchmark operational energy in sustainable commercial buildings in Sri Lankan context. In order to facilitate the framework, the research has reviewed seven (7) key sustainability initiatives, namely, Leadership in Energy and Environmental Design (LEED) (USGBC, 2008), Building Research Establishment Environmental Assessment Method (BREEAM, 2010), Comprehensive Assessment System for Building Environmental Efficiency (CASBEE, 2008), Green Building Index (GBI, 2009), Green Rating for Integrated Habitat Assessment (GRIHA), Green Star (2012) and Green Mark (BCA, 2009), to identify common contributory aspects on operational energy efficiency within the sustainable built environment. The study further identified available indicators for such operational energy aspects along with benchmark values by referring same sustainability initiatives and energy efficiency building code published by Sri Lanka Sustainable Energy Authority (SSEA, 2008). The referred sustainability initiatives provide different contributory aspects and different weight allocations to such aspects based on miscellaneous dissimilarities of related countries. Therefore, an expert survey was undertaken to identify the importance levels (weights) of identified operational energy performance aspects within Sri Lankan context. Thirty experts from three different professions were selected based on their experience and awareness on subject matter. Hence, ten (10) Facilities Managers, ten (10) Engineers, ten (10) Architects were selected who have more than 5 year experience in the building industry and whose majority are involved in sustainable projects. Then a weighted average formula was developed and identified values were applied to such formula in order to obtain benchmarks for identified aspects. Finally, the framework leads to develop a benchmark for entire operational energy domain and continuous monitoring and review of the process.

5. THE OPERATIONAL ENERGY BENCHMARKING FRAMEWORK

In order to develop an operational energy benchmark, a proper consideration on all related operational energy performance aspects should be given in a systematic way. Because, the ultimate energy domain benchmark is to be represent a 'perfect target', covering all aspects. Therefore, to develop the operational energy benchmark, a framework has been developed as follows (Figure 1).

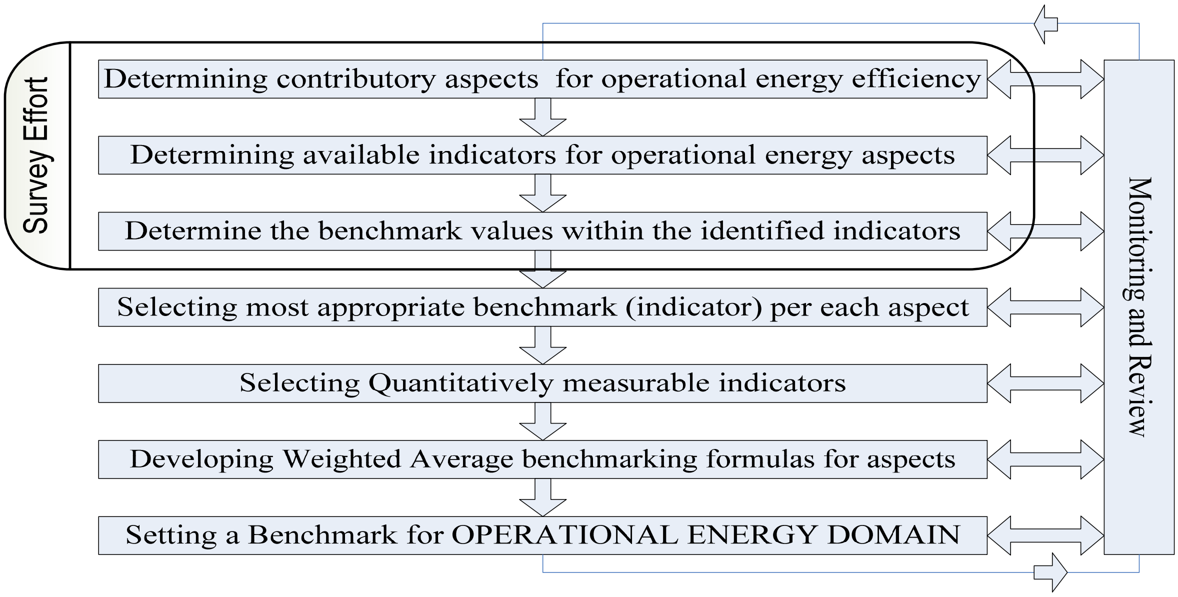

Figure 1: Framework for Benchmarking Operational Energy

5.1. DETERMINE ASPECTS CONTRIBUTING TO OPERATIONAL ENERGY EFFICIENCY

Sustainability initiatives/ rating systems have provided different criteria/ aspects, in order to achieve operational energy efficiency within the sustainable built environment, based on their own requirements. Therefore, from the referred key sustainability initiatives, a common list of contributory aspects for operational energy analysis was identified, by amalgamating and splitting sub-aspects among identified common aspects to undertake the survey in a common basis. The identified common operational energy aspects now follow.

BUILDING DESIGN / ORIENTATION

Building design refers to the broadly based architectural, engineering and technical applications to the design of the buildings, while the orientation of the building generally used to refer to solar orientation, which is the setting of building with respect to solar access. Building energy efficiency in design/ orientation of building is achieved in terms of, proper orientation of the building block and interior spaces; proper designing of the building, related to building typology, solar geometry, predominant wind direction, existing vegetation, climatic zone, Window to Wall ratio (WWR) etc; designing, installation, commissioning of energy-related systems, such as Heating, ventilating, air conditioning and refrigeration (HVAC&R) systems (mechanical and passive) and associated controls, lighting and day lighting controls, renewable energy systems (e.g., wind, solar) at an optimum to realise their full potential and intent; Extent of natural ventilation and day lighting to the building etc.

BUILDING ENVELOP PERFORMANCE

Building envelope is the separation between the interior and the exterior environments of a building. It serves as the outer shell to protect the indoor environment as well as to facilitate its climate control. This element contributes to a substantial share of the cooling or heating load. The HVAC system has to cater to this load as well as in order to maintain the comfort, process condition. The building envelop performance is optimised in terms of; U-values and Overall Thermal Transmission Value (OTTV) of facades and roof; Visual Light Transmission (VLT) for fenestrations; control of shading coefficient (glass type), Window to Wall Ratio (WWR) and use of internal shading devices (SCint), external shading devices (SCexe); envelop sealing, caulking, gasketing or weather stripping; fenestration and doors to limit air leakages.

SYSTEM/ SERVICE ENERGY PERFORMANCE

Building energy related systems/ services such as HVAC&R systems, lighting, elevators, plug loads and other miscellaneous loads totally contributes to operational energy consumption of a facility. Maximum energy performance of such systems is achieved in terms of; use of efficient energy-related systems, such as HVAC&R systems (mechanical and passive) and associated controls, lighting and day lighting controls, elevator systems, plug loads and other miscellaneous loads; use of energy efficient practices and features which are innovative and/or have positive impact; proper operation and maintenance of such systems/ services for optimised energy efficiency.

CO_2 EMISSION RATE REDUCTION

Control/ reducing of building carbon emission rate or the energy related CO_2 emission in terms of; use of low carbon emission energy sources (avoid use of coal, oil, natural gas etc); use of zero carbon emission energy sources (some renewable such as solar, wind etc).

REDUCED OZONE DEPLETION

Control of energy related greenhouse/ozone layer depleting gas emission in terms of; zero or minimum use of chlorofluorocarbon (CFC)-based refrigerants in new base building HVAC&R systems; provision of a replacement schedule for CFC-based refrigerants in existing HVAC systems; design and operate the facility without mechanical cooling and refrigeration equipment; select HVAC&R equipment with reduced refrigerant charge and increased equipment life; maintain equipment to prevent leakage of refrigerant to the atmosphere.

ON-SITE RENEWABLE ENERGY

The self sufficiency in energy through renewable technologies for on-site power generation and use within the building such as solar, wind, geothermal, low-impact hydro, bio-mass/ bio-gas, or any other forms of renewable energy.

OFF-SITE RENEWABLE ENERGY

Investments in off-site renewable energy technologies to be exported to the grid (engage in green power contract).

COMMISSIONING AND TESTING

Ensure building's energy related systems are designed and installed to achieve proper commissioning so as to realise their full potential and intent in terms of; begin the commissioning process early in the design process and execute additional activities after systems performance verification is completed; developing and incorporating commissioning requirements into the tender documents; Developing and implementing a commissioning plan; verifying the installation and performance of the systems to be commissioned; reviewing contractor submittals applicable to systems being commissioned for compliance.; developing a systems manual that provides future operating staff the information needed to understand and optimally operate the commissioned systems.; verifying that the requirements for training operating personnel and building occupants are completed.

MEASUREMENT AND VERIFICATION

Ongoing accountability of building energy consumption over time to evaluate building and/or energy system performance and verify predicted energy use of key building systems/ services, in terms of; install the necessary metering equipment to measure energy use including sub-metering.(Electrical sub-metering to encourage and recognise the provisions of energy sub-metering to facilitate energy monitoring of base building services while tenancy sub-metering to encourage and recognise the provisions of energy sub-metering to facilitate energy monitoring by tenant/end user); track performance by comparing predicted performance to actual performance; installing diagnostics within the control system to alert when equipment is not being optimally operated; use Energy Management System (EMS) to monitor and analyse energy consumption including reading of sub-meters.

ENERGY AUDIT AND VALIDATION

Auditing and validating the predicted energy consumption while maintaining proper process of auditing and validation.

5.2. DETERMINE AVAILABLE INDICATORS FOR IDENTIFIED ASPECTS

Appropriate benchmarks for each identified operational energy efficiency aspects have to be developed, in order to develop the benchmark for energy domain ultimately. The referred sustainability initiatives consist of variety of indicators for contributory aspects. However, appropriate indicator/s and locally applicable benchmark values for such indicators have to be found to facilitate benchmarking process of each aspect, therefore, available indicators for each and every aspect from each rating systems were identified as shown in Table 1. During the effort, both expressed indicators and implied indicators were taken out, which provide the most appropriate representation of aspect efficiency, but regardless to their characteristics of quantitative or qualitative measurability.

5.3. DETERMINE THE BENCHMARKS WITHIN THE IDENTIFIED INDICATORS

Initially, the indicators for each energy performance aspects have identified. Therefore, in this step, an attempt was taken to identify the benchmarks included in such indicators. For an instance, the building envelop performance aspect came about few benchmarks, namely, OTTV $\leq$ 50 W/m^2 (GBI), ETTV < 50 W/m^2 (Green Mark), PAL = 300 MJ/m^2/yr (CASBEE), OTTV < 50 W/m^2 (SSEA) and improved percentage of proposed building performance rating compared to baseline > 10% (LEED). In this manner, benchmarks included in each identified indicator were taken out for each aspect, however, some indicators were converted to format of benchmarks while some were directly come across in such a format.

5.4. SELECTING MOST APPROPRIATE INDICATOR PER EACH ASPECT

At this point, the finalising of benchmarks was undertaken. Some available local benchmarks from ‘Code of practice for energy efficient buildings in Sri Lanka 2008’ - Sri Lanka Sustainable Energy Authority (SSEA) were also selected for energy performance aspects. For other aspects, benchmarks were selected from referred rating systems. Since, each rating systems hold different benchmarks either by benchmark value or benchmark nature/ type/ definition etc. most appropriate benchmark was selected based on certain similarities (climatic, geographical etc) with the local context and presented in Table 2. Since, GRIHA (India), GBI (Malaysia), Green Mark (Singapore) are rather similar to Sri Lankan context in both climatic and geographical conditions, indicators from such rating systems were selected. Besides, LEED (US) and above mentioned rating systems are having strong positive relationships, which justifies the selection of appropriate indicators in advance.

Table 1: Available Indicators for Contributory Aspects

Energy Performance Aspects	Indicators							
	LEED	BREEAM	GRIHA	GBI	Green Mark	Green Star	CASBEE	Sri Lanka Sustainable Energy Authority
Building design/orientation	Building orientation performance	N/A	Level of Climate responsiveness	N/A	N/A	Green star office desing certified rating	N/A	N/A
Building envelop performance	Building performance Rating (BPR)	Minimum standards not available	Envelop Performance Factor (EPF)	Overall Thermal Transfer Value (OTTV)	Envelop Thermal Transfer Value (ETTV)	N/A	Peremeter Annual Load (PAL)	Overall Thermal Transfer Value (OTTV)
System/Service energy performance	Percentage of Energy cost savings	•Availability of energy efficient features in lifts •Luminous efficiency •Availability of sustainable IT equipment	Reduced energy consumption	Building Energy Intensity (BEI)	Energy Efficiency Intensity (EEI)	•Improvement in energy effciency •Peak energy demand reduction •Availability of office lighting zoning Lighting Power Density (LPD)	Coefficient of Energy Consumption (CEC)	•Energy Efficiency Rate (EER) •Integrated Part Load Value (IPLV) Lighting Power Density (LPD)
CO_2 emission rate	Maximum threshold for the combined contributions to ozone depletion and global warming potential	Power Usage Effectiveness(PUE) & CO_2 index	N/A	N/A	N/A	Percentage of reduced building's CO2 emission	Life Cycle CO_2 emission	N/A
Reduced Ozone depletion		Percentage of reduced building's CO2 emission	CFC-based refrigerants in HVAC system	N/A	N/A	N/A	Ozone Depletion Potential (ODP)	N/A
On-site renewable energy	Percentage of energy produced by the renewable systems over the building's annual energy cost	Percentage of reduced building's CO2 emission	Percentage of renewable energy over lighting and space conditioning load or its eqalent	Percentage of renewable energy generation from total electricity consumption	Percentage of replacement of electricity by renewable energy sources	N/A	Percentage of converted renewable energy usage	N/A
Off-site green power	Percentage of building electricity by renewable energy No of years of green power contract	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Commissioning & testing	Availability of proper commisiioning process	N/A	N/A	Availability of pre-comissioning, commissioning and post occupancy commisioning	N/A	N/A	N/A	N/A
Measurement & verification	The coverage of M & V period	•Availability of separate meters •Availability of BMS	N/A	Availability of EMS including Maximum Demand Limiting programme	Availablity of sub-metering	•Availability of sub metering for base building services •Availability of sub metering for end user	Introduction of BEMS	N/A
Energy Auditing	N/A	N/A	Availability of energy auditing process	N/A	N/A	N/A	N/A	N/A

Table 2: Finalised Benchmarks for Aspects

Energy Performance Aspects	Selected indicator benchmark	Reference
Building Design/Orientation	Building orientation performance (Computer based acceptance)	LEED
Building Envelop Performance	OTTV < $50W/m^2$	SSEA
System/Service Energy Performance	EEI < 150 kWh/m^2y	Green Mark
CO_2 Emission Rate	LCGWP + LCODP x 105 ≤ 100	LEED
Reduced Ozone Depletion		
On-site Renewable Energy	Energy produced by the non-renewable systems over the building's annual energy cost <99%	LEED
Off-site Green Power	Percentage of building electricity by non-renewable energy < 65%	LEED
Commissioning & Testing	Availability of pre-commissioning, commissioning & post occupancy commissioning	GBI
Measurement & Verification	Availability of EMS including Maximum Demand Limiting programme	GBI
Energy Auditing	Availability of energy auditing process	GRIHA

5.5. *SELECTING QUANTITATIVELY MEASURABLE INDICATORS*

The finalised benchmark list consists of both quantitatively measurable benchmarks and qualitatively measurable benchmarks. Due to the incapability of developing benchmarks for qualitative measures at this research level, only the quantitatively measurable benchmarks were selected. Therefore, only six energy performance aspects were left to the benchmarking process ultimately. (Table 3)

Table 3: Finalised Quantitative Benchmarks

Energy Performance Aspects	Selected indicator benchmark	Reference
Building Envelop Performance	OTTV < $50W/m^2$	SSEA
System/Service Energy Performance	EEI < 150 kWh/m^2y	Green Mark
CO_2 Emission Rate	LCGWP + LCODP x 105 ≤ 100	LEED
Reduced Ozone Depletion		
On-site Renewable Energy	Energy produced by the non-renewable systems over the building's annual energy cost <99%	LEED
Off-site Green Power	Percentage of building electricity by non-renewable energy < 65%	LEED

5.6. *DEVELOPING WEIGHTED AVERAGE BENCHMARKING*

The expert survey collected data from thirty (30) experts on the importance level/significance/ weights of each aspect, on the operational energy of buildings within the local context. The average comparison within local context allows identifying the weight of each aspect, where high averages stand for high importance and less averages stand for less importance levels (Table 4).

Table 4: Weights from Expert Survey

Aspect	Weight
Building design/orientation	16
Building envelop performance	9
System/Service energy performance	20
CO_2 emission rate	6
Reduced Ozone depletion	5
On-site renewable energy	9
Off-site green power	4
Commissioning and testing	11
Measurement and verification	10
Energy audit and validation	10

The highest average stands for the 'system/ service' aspect. Since the operating energy represents the largest part of energy demand in a building life cycle, it is evidently reasonable to have this highest average in the system/ service energy performances. The CO_2 emission rate and reduced ozone depletion hold relatively lower average when comparing to other aspects. Because, the Sri Lankan annual CO_2 emission is 0.04% while, calculated annual green house gas emission is 0.05% (Wikipedia, 2012), which is in a range of insignificance and, demarcates the necessity of less concern as an aspect. In the ranking list of CO_2 emission and calculated annual green house gas emission of countries, Sri Lanka is having the 91st place and 103rd place respectively. In order to calculate the benchmark values, a formula has then developed as follows (Equation 1), using identified base benchmarks and relevant weightings.

The aspects comprise of different measurements and weightings. Due to these comparative difficulties, the formula was developed in a manner that it to be normalised and derived unit free benchmarks, proportionate to their own weightings. However, final benchmark is a negative side benchmark where lower the better.

$$Aspect\ Benchmark = \frac{Building\ Aspect\ Value \times Weight}{Base\ Benchmark\ Value} \qquad \text{(Eq: 01)}$$

Base Benchmark value: *This stands for the benchmark value which is in the relevant indicator of the aspect. Simply, it means the indicator's benchmark with related to the aspect.*

Weight: *This stands for the importance of the particular aspect within the local context. Here, it is the average value of the aspect, which is derived from expert survey.*

Building aspect value: *This means the real value of commercial building with related to the relevant aspect which is going to be measured by the benchmark*

The Figure 2 consists of developed benchmarking formulas for each aspect using the standard format above discussed.

ASPECT	BENCHMARK FORMULAR
Building Envelop Performance	$OTTV = \frac{\text{Building OTTV}}{\text{OTTV Base Benchmark}} \times \text{Weight}$
System/service Energy Performace	$EEI = \frac{\text{Building EEI}}{\text{EEI Base Benchmark}} \times \text{Weight}$
CO_2 Emission Rate; Reduced Ozone Depletion	Combined contribution $= \frac{\text{Building LCGWP+LCODPx105}}{\text{Base Building LCGWP+LCODPx105}} \times \text{Weight}$
On-site Renewable Energy	$NRE_{on\text{-}site} = \frac{\text{Building NRE \%}}{\text{NRE Base benchmark}} \times \text{Weight}$
Off-site Renewable Energy	$NRE_{off\text{-}site} = \frac{\text{Building NRE \%}}{\text{NRE Base benchmark}} \times \text{Weight}$

OTTV - Overall Thermal Transfer Value
EEI - Energy Efficiency Intensity
LCGWP - Lifecycle Direct Global Warming Potential (lb CO2/Ton-Year)
LCODP - Lifecycle Ozone Depletion Potential (lb CFC 11/Ton-Year)
NRE on-site - Non Renewable Energy for On-site aspect
NRE off-site - Non Renewable Energy for Off-site aspect

Figure 2: Benchmark Formulas for Aspects

In this stage, the values are applied to developed formulas. Once the values are applied to the formulas, a unit free benchmark will be developed for each aspect due to the normalising effect. Generally the identified aspects are differing from each other by their measure of units. So in order to have a common benchmark later, the each aspect's formulas have been normalised (Figure 3).

ASPECT	BENCHMARK FORMULAR
Building Envelop Performance	$OTTV = \frac{\text{(Building OTTV) W/m}^2}{50\text{W/m}^2} \times 0.09$
System/service Energy Performace	$EEI = \frac{\text{(Building EEI) kWh/m}^2\text{y}}{150\text{ kWh/m}^2\text{y}} \times 0.2$
CO_2 Emission Rate; Reduced Ozone Depletion	Combined contribution $= \frac{\text{(Building LCGWP+LCODPx105)}}{100} \times 0.11$
On-site Renewable Energy	$NRE_{on\text{-}site} = \frac{\text{(Building NRE) \%}}{99\ \%} \times 0.09$
Off-site Renewable Energy	$NRE_{off\text{-}site} = \frac{\text{(Building NRE) \%}}{65\ \%} \times 0.04$

Figure 3: Benchmarks for Aspects

5.7. *SETTING A BENCHMARK FOR THE ENERGY DOMAIN*

Since, the energy domain is made out of all above discussed aspects, the individual benchmarks for each energy performance aspects should be summed to have a benchmark for entire energy domain. By undertaking this matter, a unit free benchmark value has been received (Figure 4).

Figure 4: Benchmark for Energy Domain

5.8. MONITORING AND REVIEW

The monitoring and review should be incorporated with the process in order to determine that, expected results are achieved, results of benchmarking are in line with the actual experience, identified aspects, indicators, benchmarks are correct and remain valid, the factors on which developed benchmark is based, including internal and external context remain valid and developed benchmark is effective etc.

6. CONCLUSIONS

The rising population and extensive development activities around the world, has given an increasing intention on sustainability in the built environment, greater than ever. The sustainable buildings are to be capable of managing key resources, not only in an optimum way, but also in an environmentally, ecologically and socially acceptable manner. Thereby, energy use of buildings started to view broadly, with the increasing concern about ecological preservation, mainly in the context of global warming, energy resource depletion, and local and regional pollution. When undertaking the energy matter in detail, it is evidentially clear that operational energy shall be more concerned over embedded energy in a built environment, since, the operating energy represents by far the largest part of energy demand in a building during its life cycle, and also been associated with a linear relation between total energy. Besides, when considering energy in terms of sector, past as well as recent statistics provide evidences that, commercial buildings contribute significantly to energy consumption, as well as to other environmental impacts, such as air emissions among other sectors locally as well as globally.

However, an instrument or a measure is required to rate energy practices and energy products in order to compare and contrast best practices within a built environment. Therefore, this research was undertaken to develop an operational energy benchmarking framework for commercial buildings while, providing a benchmark to such buildings to make their facility efficient in energy use and eligible in sustainable accreditation as well.

The framework was developed by facilitating the process of developing benchmark for operational energy, by means of determining contributory aspect to operational energy, determining indicators to measure efficiency of such aspects, determining locally applicable benchmarks, finalising quantitative indicators, and development of benchmark for entire ‘Operational Energy Domain’. The research was based on a literature survey and an expert survey. The literature survey assisted the determination of aspects contributing operational energy performance of a commercial built environment and identification of available indicators for such aspects while selecting most appropriate indicators together with locally applicable benchmarks. The expert survey facilitated the obtaining importance levels or weights for each aspect with related to the local context, but in the mean time associating with individual perspectives, professional disciplinary, and awareness on sustainability.

As a whole, this benchmark framework enables an approach towards not only energy efficient commercial buildings, but also sustainable commercial buildings and, benchmark itself is a self and/or external reference towards the concept of sustainable built environments in the fast growing world, while, enhancing competitive advantages and sustainable development. The developed framework only facilitate a benchmark for operational energy domain by using quantitatively measurable aspects, however, it can be further developed to any sustainable domain (embedded energy, water, indoor environmental quality and site development) along both quantitative and qualitative measures. The framework can be adapted to other sustainability domains by following the same steps mentioned. However, future research works can also address the qualitative measures by referring related literature and undertaking case studies. The framework may be generalised to contexts which are still absent of sustainability initiative and/or energy performance reference point themselves.

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BUILDING ENERGY CONSUMPTION FACTORS: A LITERATURE REVIEW AND FUTURE RESEARCH AGENDA

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ABSTRACT

The Sri Lankan energy supply system faces several major strategic challenges due to high annual electricity demand growth rate and hence it is required to double the electricity generation capacity in every ten years. Ministry of Power and Energy predicted regular power cuts in the foreseeable future due to lack of rainfall within the hydro-catchments areas. In the coming years, oil price hikes will have a great impact on the operation of thermal power plants. Sri Lanka has now become the highest electricity bill spender in Asia and the status of energy poverty seems rather alarming. Sri Lankan energy statistics confirm that the building sector has contributed heavily on the energy, exceeding the industrial and transportation sectors. Occupant behaviour toward energy consumption have a significant impact on energy poverty and the initiation of large scale development projects after the three decades conflict pave the way to energy poverty to step up. In order to alleviate energy poverty, it is important to investigate the factors influencing the building energy consumption and their impact on power crisis. Therefore, the aim of this paper is to critically review the factors affecting building energy consumption. A comprehensive literature review and a desk study of Sri Lankan energy reports were used out to investigate the power crisis in Sri Lanka and the factors influencing building energy consumption. Five factors and 36 sub factors identified from the literature review will be used to identify critical factors affecting building energy consumption during the next phase of the study.

Keywords: *Energy Poverty, Power Crisis, Building Energy Consumption, Building Energy Consumption Factors.*

1. INTRODUCTION

The planet is progressively stepping towards a serious energy crisis due to an escalating energy demand compared to supply. Energy crisis is a situation in which the nation suffers from a disruption of energy supplies accompanied by rapidly increasing energy prices that threaten economic and national security (Williams and Alhajji, 2003). Energy consumption causes a wide range of environmental problems, and with the increase in energy demand, the issue of energy crisis becomes cited. Energy use has recently become a major issue due to growing concern about CO_2 and other greenhouse gas emissions and the scarceness of fossil fuels (Escrivá-Escrivá, 2011). According to the current statistics and demands, the world's oil reserves will decline by 2052, gas resources are expected to run out within the next 60 years and coal will dwindle within the next 80 years (Dissanayake, 2012). Yanbin *et al.* (2011) states that in 21st century, all countries are facing the challenge of energy, whilst power crisis is one of the greatest crises in energy.

This study therefore, aims at finding factors influencing building energy consumption and to set future research agenda. The paper structure begins with a literature review on Sri Lankan energy crisis and building energy consumption. The paper then reviews major influential factors on building energy consumption and finally presents the discussion and future research agenda.

2. ENERGY CRISIS IN SRI LANKA

The Sri Lankan energy supply system faces several major strategic challenges due to high annual electricity demand growth rate and hence it is required to increase the electricity generation capacity. According to Abegunawadana (2011), electricity demand was rising at a rate of 7% per annum during the

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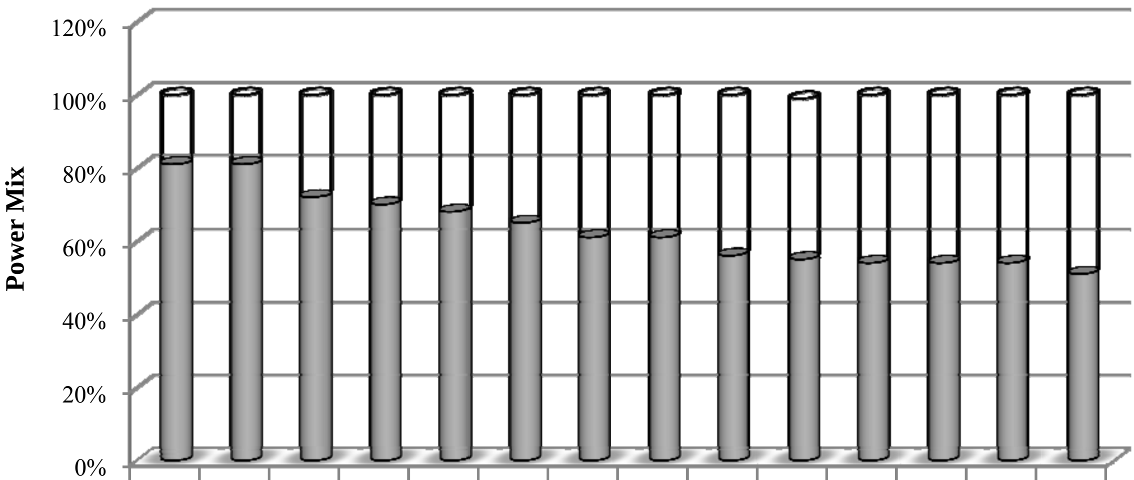
last two decades. The assessment of the Ceylon Electricity Board (CEB) reveals that the demand for electricity will increase by 7-10% per annum over the next twenty years, thereby, demand shall double every ten years (Abeygunawardana, 2008). Therefore, it is required to double the electricity generation in every ten years (Abeygunawardana, 2011).

The large-scale construction and development projects, following the end of three decades conflict in Sri Lanka pave the way to energy poverty to step up (Wijekoon, 2012). Sri Lanka Energy Balance (2007) anticipated a parallel growth in energy demand, with the rapid economic development drive launched by the Sri Lankan government. Consequently, the influx of foreign investments to the country and the population explosion over the last few years had been the principal reasons for the excessive demand for electricity at present (Wijeykoon, 2012). As energy demand rises, the energy consumption in Sri Lanka has become an act of suffer, being the highest electricity bill spender in Asia (Kumara, 2011). Hence, the status of energy poverty in Sri Lanka seems rather alarming.

According to Abeygunawardana (2008), a dialogue on the energy crisis commenced in Sri Lanka in the eighties when the goal of utilising the electricity generated from the newly constructed reservoir system of the Mahaweli scheme to feed the power needs of the entire nation and even sell excess power to India turned into a pipe dream. Abeygunawardana (2008) further explained that the anticipated outputs were never achieved due to various environmental and technological problems and "electricity" became a permanent crisis in Sri Lanka.

Thus, the energy generation attention has turned towards the thermal power apart from hydro power and other domestic energy sources such as wind and biomass. According to Jerome (2009), CEB had diversified into thermal power in the interest of speedy capacity augmentation. Figure 1 shows the thermal and hydro power generation mix from 1995 to 2008. According to the figure, there is a clear increment in thermal power generation and decline in hydro power generation during last two decades.



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Thermal	19%	19%	28%	30%	32%	35%	39%	39%	44%	44%	46%	46%	46%	49%
Hydro	81%	81%	72%	70%	68%	65%	61%	61%	56%	55%	54%	54%	54%	51%

Figure 1: Thermal and Hydro Power Generation Mix during 1995-2008
(Source: Economic and Social Statistics of Sri Lanka 2009 cited Jerome 2009)

Indratissa (2010) pointed out that the Sri Lankan energy future is uncertain as the electricity mix is very much depending on imported fossil fuel. In the coming years, oil price hikes will have a great impact on thermal power plants and climate change will interrupt the hydro power generation and therefore, Sri Lanka cannot sustain with the existing energy mix in the years to come (Abeygunawardana, 2011).

The present trend of increasing energy demand will continue while increasing energy costs and demand side management measures might dampen the rate of growth of energy demand (Sri Lanka Sustainable Energy Authority, 2007). Therefore, solutions should adhere and there is tremendous potential for alleviating energy poverty by reducing energy consumption or conserving energy itself.

3. BUILDING ENERGY CONSUMPTION

The European energy context identified buildings, industry and transport sectors as the three largest sectors of energy consumption (Paris *et al.*, 2010), while this is largely correct for many other countries. The built environment is a significant contributor to global greenhouse gas emissions, and buildings accountable for 30–40% of all primary energy used worldwide (Asif *et al.*, 2009 as cited in Ramesh *et al.*, 2010). According to forecasts energy use in the built environment will grow by 34% in the next 20 years, at an average rate of 1.5%.

In China, around 30% of the national energy consumption can be attributed to buildings and it is expected that the proportion of building energy consumption in national energy consumption will keep rising in the coming years (Liu *et al.,* 2012). The energy consumption of buildings accounts for 38.9% of the total primary energy requirement in United States (Wan *et al.*, 2011), where the particular contribution in United Kingdom is 44% (Energy Information Administration, 2011). In France, 25% of greenhouse gases emissions and 46% of energy consumption are due to buildings (Paris *et al.*, 2010). According to statistics of Sri Lanka, building sector also stands for the highest contributor to the total national energy consumption, which is about 48.5% (SSEA, 2010). The rest of national energy consumption is contributed by transport (26.64%), industrial (24.75%) and agriculture (0.11%) sectors. Therefore, global energy statistics confirm that the building sector has contributed heavily on the energy, exceeding the other major sectors of industrial, agriculture and transportation.

The annual electricity consumption by buildings increased from 45% to 60% of the total electrical energy use in Sri Lanka from 2002 to 2010 (SSEA, 2010), which accounted for the highest sector-wide electricity consumption growth in the past years. According to the total energy consumption trend analysis shown in Figure 2, electricity consumption in 2010 is 9208.5Gwh and the predicted electricity consumption in 2015 will be 11200Gwh. Therefore, an energy gap of approximately 2000Gwh is expected along with the increasing consumption of about 20% in next five years. Besides, the government of Sri Lanka recognises that improving energy performance of building is an important part of the strategy of the country's sustainable energy development (SSEA, 2008).

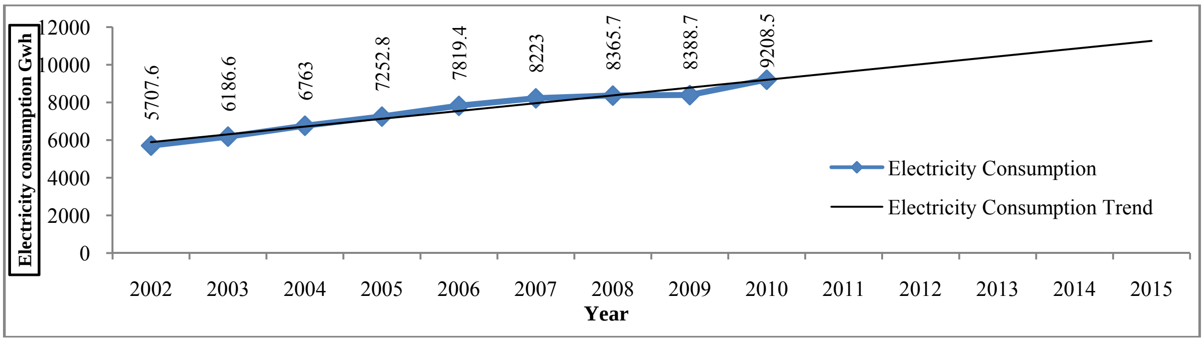


Figure 2: Trend Analysis of Total Energy Consumption in Sri Lanka from 2002 to 2015
(Source: Adapted from SSEA, 2010)

4. FACTORS INFLUENCING BUILDING ENERGY CONSUMPTION

Over the last decade, the potential of the building sector to contribute towards reductions in energy consumption and CO_2 emissions has increasingly recognised within the Sri Lankan context. However, study of the factors influencing energy consumption of buildings is essential for a better understanding of energy conservation. Past researches identified an array of factors influencing building energy consumption. This research study is analysed only a sample of 20 key research papers written on building energy consumption. A review of 20 key research papers that discovered factors influencing building energy consumption and their impact on energy crisis is presented in Table 1. Some referred articles were based on building categories (e.g. residential, hotel and office), while other were on the basis of broad-spectrum. A total of five (05) major influential factors and 36 sub factors identified from the literature are listed in Table 1. Given the ambiguity surrounding the terminology used by the different authors, best judgment has been used in grouping the main and sub factors.

Table 1: Factors Influencing Building Energy Consumption
Different Studies, Authors and the Factors Identified by Them

Studies' Authors / Factors	General						Hotel specific			Office specific					Residential specific					
	Yu et al 2011	Killip 2009 cited Janda 2011	Liu & Harris 2008	Saidur 2009	Papadopoulof et al 2002	Yildiz & Arsan 2011	Bohdanowicz and Martinac 2006	Deng and Burnett 2000	Priyadarsini et al 2009	Stoy et al. 2009	Kong et al. 2012	Wong et al 2007	Balaras et al 2002	Escrivá-Escrivá, 2011	Tso & Yau 2003	Yun & Steemers 2011	Yohanis 2012	Santamouris et al 2007	Yoshino et al 2006	Dascalaki et al 2011
Climate																				
Climatology/ Climatic location/ zone							■		■					■				■		
Weather parameters	■								■				■			■				■
Building related characteristics																				
Type															■	■		■		
Age				■			■	■	■		■				■	■	■	■	■	■
Size/ Gross Floor Area/ Number of floors				■	■			■	■		■				■	■	■	■	■	■
Class								■	■											
Usage hours			■	■						■										
Geographical Location							■													
Design/structural parameters			■		■	■	■							■		■		■	■	
Orientation			■		■	■				■				■						
Envelop/ fabric		■		■								■								■
Construction quality													■	■						
Worker density									■		■						■			
Share of areas served by a/c, lifts & illumination					■					■	■					■	■			
IEQ/ Indoor Thermal Quality	■								■										■	
Nature of surrounding			■																	
Rent															■					
Availability of infrastructure																		■		
Occupant-related characteristics																				
Occupancy Rate				■			■	■	■	■					■	■			■	
Occupant behavior/ activities	■	■														■			■	
Preference relevant to indoor comfort							■												■	
Awareness of energy consumption							■													
Building services systems related characteristics																				
Building services systems specification							■				■		■				■		■	■
Building services systems load		■						■		■		■	■			■			■	
Operation and maintenance schemes							■						■							
Efficiency/condition of building services systems				■	■									■						■
Age of building services systems							■		■											■
Sub facilities, services offered																				
Appliance ownership															■					
Socio-economic & legal related characteristics																				
Education	■																			
Culture							■													
Income/ social class															■	■		■	■	
Age of the head/householder																■				
Availability of energy resources locally							■													
Energy market prices				■										■						
Energy use regulations				■			■													

According to the above review, 'climate', 'building related characteristics', 'building systems and/services related characteristics', 'occupant related characteristics', 'socio-economic and legal related characteristics' are the most frequently addressed factors influencing building energy consumption. A review of these major factors now follows.

4.1. CLIMATE

Building acts as a climatic modifier, separating the indoor built environment from the external climate (Lam *et al.*, 2005). Energy demand of buildings is influenced by many climatic parameters (Kalamees *et al.*, 2012). Drake and Foster (1995) categorised the short-term behaviour of the atmosphere as "weather", while the investigation of long-term trends in the weather system as "climate". Ministry of Construction of People's Republic of China (1993 as cited in Wan *et al.*, 2011) identifies five climatology (climate types), namely severe cold, cold, hot summer and cold winter, mild, and hot summer and warm winter. The extent to which overall energy use for space conditioning would depend very much on the prevailing local climates and the actual climate change in future years (Wan *et al.*, 2011). Jim and Peng (2012) identified weather as a huge influential factor on building energy consumption in Hong Kong. Wan *et al.* (2011) listed temperature, solar radiation, wind speed/direction, moisture content of air as major weather parameters.

Kalamees *et al.* (2012) stated that in a cold climate, temperature has the strongest influence on the heating energy demand, and during summer, it has a similar influence on the cooling energy demand. The peak of Heating Ventilation and Air Conditioning (HVAC) occurred in the heating season, while the trough of HVAC occurred in the cooling season whereas, the peak of Hot Water Supply (HWS) occurred in cooling season where trough of HWS occurred in heating season due to the weather conditions (Yu *et al.*, 2011). According to Liu and Harris (2008), a small rise in ambient temperature could still give rise to a significant reduction in building energy consumption. Yu *et al.* (2011) discussed the impact of weather conditions on occupant behaviour and thereby on building energy consumption. Climatic data are however crucial for the building industry since a building's role is to provide comfortable and protective indoor conditions to its occupants against outdoor environment (Oxizidis *et al.*, 2008).

Although the Sri Lankan context is not largely affected by seasonal climatic changes, SSEA (2008) identifies three climatic zones as warm-humid (Dry Bulb Temperature (DBT) - 310^{0}C, Wet Bulb Temperature (WBT) - 270^{0}C), warm-dry (DBT- 330^{0}C, WBT- 260^{0}C) and uplands (DBT- 280^{0}C, WBT-230^{0}C). The outdoor design condition would vary based on the corresponding climatic zone and this will in turn dictate the thermo-physical properties of all building elements (SSEA, 2008). Therefore, climate can be identified as a major factor affecting building energy consumption in Sri Lanka. Further, long-term trend, which is 'climatology' and short-term behaviour of the atmosphere, i.e. 'weather' can be identified as two sub factors under the 'climate' category.

4.2. BUILDING RELATED CHARACTERISTICS

The European Union's energy performance of buildings directive mentioned that reducing energy consumption is affected by not just how buildings are designed, but also how they are built, commissioned and used (Janda, 2011). Liu and Harris (2008) argued that although many factors such as design and use influence the energy consumption of buildings, other factors such as orientation and the nature of the surroundings, also have an influence, but are often ignored. Yu *et al.* (2011) sated that even a slight difference in some building related parameters would result in remarkable fluctuations in the building energy consumption. Mourshed (2011), Yu *et al.* (2011) and Papadopoulof *et al.* (2002) identified floor area/size, age, envelope / fabric / shell, form, shape, materials and construction as building-related parameters.

Papadopoulof *et al.* (2002) highlighted some design parameters such as size of the building, surface to heated volume ratio as well as some structural parameters such as thermal insulation of roofs, windows and walls with related to influences of building energy consumption. Chan (2011) reports that the indoor climate and electricity consumption of a building can be affected by various building envelope characteristics such as building shape, thermal insulation, wall colour, window-to-wall ratio, glazing material, shading devices and green roof system.

According to the literature review presented in Table 1, type, age, size, class, usage hours, geographical location, design/structural parameters, orientation, envelop, construction quality, worker density, share of areas served by air-conditioning, lift and illumination, indoor environmental/thermal quality, nature of surrounding, rent and availability of infrastructure were identified as sub factors of 'building related characteristics'. These building related characteristics have very high impact on building energy consumption. Therefore, owners can considerably save energy by considering and upgrading the aforementioned building related characteristics.

4.3. Occupant Related Characteristics

Buildings do not use energy, but people do (Janda, 2011). Once the level of occupancy increases, the energy consumption of HVAC, lighting, elevators and other plug loads also increase. Janda (2011) argued that building users play a critical but poorly understood and often overlooked role in the built environment. The role of people in energy use can be seen as being even more influential. Yu *et al.* (2011) divided the effects of occupant behaviour into two categories, as the effects of building user presence and the effects of actions occupants took to influence energy consumption. For example, Emery and Kippenhan (2006 as cited in Yu *et al.*, 2011) found that the presence of occupants increase the total energy consumption, while Ouyang and Hokao (2009 as cited in Yu *et al.*, 2011) investigated energy-saving potential by improving user behaviour. However, it may be difficult to change the behaviour of people (Kempton *et al.*, 1992 as cited in Nair *et al.*, 2010) who do not have energy efficient habits, especially when the change involves personal inconvenience (Nair *et al.*, 2010). A survey of Swedish households showed that only 17% of the respondents regularly switched off lights when leaving a room (Linden *et al.*, 2006 as cited in Nair *et al.*, 2010).

According to the Janda (2011), the exact proportion of occupant influence is varying and it can be suggested that occupants are responsible for about one quarter of the problem with some probable influence over plug loads. Another research has shown that, while approximately half of the energy used in the home depends on the characteristics of a house and its equipment, residents and their behaviour influence the rest (Schipper *et al.*, 1989 as cited in Janda, 2011). As pointed out by Yu *et al.* (2011), different occupant behaviour, especially those associated with HVAC, can significantly affect indoor climate, thereby causing dramatic differences in building energy consumption. The work of Yun and Steemers (2011) found that behavioural patterns of air conditioning use as a highly influential factor in space cooling energy consumption, apart from climate conditions. Therefore, there has to be a trade-off between human thermal comfort and building energy consumption, and it is necessary to strike a balance between achieving a high comfort level and reducing energy consumption through modifying occupant behaviour (Yu *et al.*, 2011).

Occupancy rate and their behaviour are highly cited and influential factors on building energy consumption. However, complex need of occupants, their satisfaction and awareness are some other critical factors rarely investigated in past researches. Therefore, four sub factors, namely, occupancy rate, occupant behaviour/activities, preference relevant to indoor comfort and awareness on energy consumption were identified under the 'occupant related characteristics'.

4.4. Building Services and Systems Related Characteristics

According to International Energy Agency (2008 as cited in Oldewurtel *et al.*, 2012), energy efficient management of building systems plays a major role in minimising overall energy consumption and costs. The type, specification, load, operation and maintenance, management, efficiency/condition and age can be identified as sub factors under building systems and services related characteristics. Mourshed (2011) states systems' type, performance, control and schedules are influential towards building energy consumption. Yun and Steemers (2011) reveals that the type of cooling equipment (i.e. central or local systems) is also an influential determinant of cooling energy consumption as households with local air conditioning systems (individual units in windows or walls) consume only 34% of the cooling energy for those with central systems. Further, SSEA (2008) provides designs and/or retrofits on selection/specification, operation and maintenance, efficiency for Lighting, Ventilation and Air-conditioning, and service water heating through 'the code of practice for energy efficient buildings in Sri Lanka' to reduce energy consumption and reduced electricity demand in the country.

According to the review shown in Table 1, the 'building services and systems related characteristics' consists of seven sub factors, such as building services and systems specification, building services and systems load, operation and maintenance schemes, efficiency/condition of building services and systems, age of building services and systems, sub facilities/services offered and appliance ownership. Due to the long lifespan of buildings, it is important to increase the energy efficiency of the existing building services and systems by reducing energy use and utility costs, while guaranteeing comfort for the building's occupants. Therefore, proper selection, commissioning, installation, operation and maintenance of services and systems within a built-environment are essential for the energy conservation.

4.5. Socio-Economic and Legal Characteristics

How societies are motivated to use or conserve energy has been a topic addressed sporadically by social scientists for more than a century (Rosa *et al.*, 1988 as cited in Janda, 2011). Few studies identified level of education as a factor influencing the acceptance of energy efficiency measures (Held, 1983; Olsen, 1983; Urge-Vorsatz and Hauff, 2001 as cited in Nair *et al.*, 2010). Income is another important factor affecting energy use, but the fact that the relationship of income to education and awareness of environmental issues is complex, makes the relationship of income and energy use more complex (Kerkhof *et al.*, 2009; Roberts, 2008; Summerfield *et al.*, 2007; Wall and Crosbie, 2009 as cited in Yohanis, 2012).

Yu *et al.* (2011) found that a rational combination of electricity rates and primary heating/cooling sources could help reduce building energy consumption through influencing occupant behaviour, since a high electricity rate tends to restrict occupants' usage of electrical heating/cooling equipment. Homeowners' age influences their energy efficiency behaviour (Carlsson-Kanyama *et al.*, 2005; Mahapatra and Gustavsson, 2008 as cited in Nair *et al.*, 2010) where, older homeowners are less likely to adopt energy efficiency investment measures (Mahapatra and Gustavsson, 2008 as cited in Nair *et al.*, 2010). Further, homeowners' awareness of energy efficient measures may influence the adoption of such measures as awareness of an innovation may lead to a need creation and its subsequent adoption (Rogers, 2003 as cited in Nair *et al.*, 2010). From this perspective, it can be argued that reducing energy use in buildings requires changes in the entire fabric of society, not just changing the shape and nature of buildings (Janda, 2011).

Energy policy plays an important role in any country's sustainable development (Saidur, 2009). He further discussed different types of regulation (i.e., voluntary, mandatory and mix model) aimed at reducing energy use in appliances, machinery and buildings, such as energy efficiency labels, energy efficiency standards and building codes. Kofoworola and Gheewala (2009) state that existing building energy codes, utilised in combination with appliance standards, and labelling and information programs can reduce energy consumption. Building energy regulations, also referred to as building energy codes, emerged as an essential tool for improving energy efficiency and minimising energy consumption in buildings (Lombard *et al.*, 2011). Many governments use regulations on energy intensity to reduce building energy use (Saidur, 2009) and the local governments' actions to promote energy efficiency measures (Nair *et al.*, 2010).

Therefore, education, culture, income, age of the head / householder, availability of energy resources locally, energy market prices and energy use regulations can be identified as different socio-economic and legal factors affecting building energy consumption.

5. Discussion and Future Research Agenda

Building energy consumption is one of the major issues to be addressed in this era of energy poverty. Buildings stand for the highest energy consuming sector in most countries, exceeding other sectors, namely, industry and transport. In Sri Lankan context, energy statistics confirms the larger share of building sector to the nation's total energy consumption. Since, the status of energy poverty in Sri Lanka seems rather alarming, any decrease in energy usage in buildings would lead to significant energy conservation in the total energy consumption, hence alleviating the energy shortage.

Many factors are affecting the building energy consumption. The study identified five major factors, namely, 'climate', 'building related characteristics', 'building systems and services related characteristics', 'occupant related characteristics', 'socio-economic and legal related characteristics' and 36 sub factors by reviewing 20 research papers.

Under the 'climate' category, climatology and weather were identified as sub factors affecting energy usage of a building. The type, age, size, class, usage hours, geographical location, design/structural parameters, orientation, envelop, construction quality, worker density, share of areas served by air-conditioning, lift and illumination, indoor environmental / thermal quality, nature of surrounding, rent and availability of infrastructure were identified as sub factors of 'building related characteristics'. Further, four sub factors, namely, occupancy rate, occupant behaviour/activities, preference relevant to indoor comfort and awareness on energy consumption were identified under the 'occupant related characteristics'. The 'building services and systems related characteristics' consists of seven sub factors, such as building services and systems specification, building services and systems load, operation and maintenance schemes, efficiency/condition of building services and systems, age of building services and systems, sub facilities / services offered and appliance ownership. Moreover, 'socio-economic and legal related characteristics' comprises of seven factors, i.e. education, culture, income, age of the head/householder, availability of energy resources locally, energy market prices and energy use regulations.

Although the study identified a comprehensive set of five main categories and 36 sub factors affecting building energy usage, there is a common rule of thumb that roughly 80% of the effects come from 20% of the causes (Pareto Rule). Therefore, it is interesting and essential to identify key factors affecting building energy usage in order to reduce total energy consumption in an efficient and effective manner. Therefore, the article motivates an agenda for future research that advocates the identification of key factors affecting building energy consumption, from the factors identified through the critical review. These key factors can be used to reduce building energy consumption when designing new buildings and making improvements to existing buildings and hence to alleviate energy poverty in Sri Lanka in future.

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MAINTAINABILITY APPROACH FOR LEAN MAINTENANCE

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ABSTRACT

The concept of lean maintenance is promoted to eliminate maintenance waste and to maximise efficiency of the manufacturing process for overall cost reduction. The optimum usage of labour, material and technology is thus, proposed to eliminate waste during the maintenance process. This paper proposes a maintainability approach to minimise maintenance waste in order to promote lean maintenance concept to the construction industry. The approach has widened the focus of existing lean maintenance concept by moving it boundaries from the maintenance phase to early phases of the development process.

Eight challenges of lean maintenance have been established from fifty one maintainability causes of high-rise buildings. Their impact to maintenance cost was evaluated using a case study and found 40% reduction in the maintenance cost as wastage.

Keywords: *Lean Maintenance, Building Maintainability, Maintenance Cost, High-Rise Buildings.*

1. INTRODUCTION

The concept of lean maintenance which originated in the manufacturing industry is known as a systematic approach to identify, analyse and eliminate waste through proper management and continuous improvement (Bagadia, 2009). In the construction industry, the concept of maintainability of buildings focus on achieving efficient maintenance by eliminating waste in maintenance cost for rectifying maintenance deficiencies (De Silva, 2012). Thus, in turn this concept of maintainability promotes lean maintenance due to its similar focus on minimising waste.

The causes for deficiencies in maintenance can be considered as maintainability risks (Low and Chong, 2004; Wong and Hui, 2005; Flores-Colen *et al.*, 2008; De Silva and Ranasinghe, 2010). These risks are not occurred only during the maintenance phase of a building (De Silva and Ranasinghe, 2010; De Silva, 2012). They can moreover be originated from poor design and construction practices. Poor accessibility for maintenance, inadequate design detailing, poor quality and incompatibility of materials, poor specifications, non availability of spare parts, lack of standard tools and instruments for regular maintenance were some of the highlighted design and construction related risks which incur many wastes in terms of financial losses in maintenance (Shabha, 2003; Chew and De Silva, 2003; Chew *et al.*, 2004; Low and Chong, 2004; Wong and Hui, 2005; Flores-Colen *et al.*, 2008; De Silva and Ranasinghe, 2010). In addition, lack of maintenance policies and strategies, budgets, skills, technology are identified as some such risks faced during the maintenance phase of buildings (Shabha, 2003). These risks can also be defined as contributing factors for waste in maintenance and thus, are referred as "challenges of lean maintenance."

Costly, difficult and unsafe maintenance are recorded in the literature as a result of above deficiencies, increasing waste in maintenance (De Silva, 2012). For instance, Ramly *et al.* (2006) reviewed 4,389 records from 36 public housing areas in Kuala Lumpur, and found that 47% were caused due to design faults. There were 11,625 maintenance records which identified inferior quality of construction as the cause for houses built between 1982 to 1999 in Victoria, Australia (Mills *et al.*, 2009). Chong and Low (2006) found that nearly 60% of latent defects can be preventable with better design, 33% with better

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workmanship, 24% with better materials, and only 4% with better maintenance. Devoicing users from the design process has highlighted as a critical challenge by Sudjiman-Spinks (2002).

Therefore, minimising the causes of these defects can save a considerable amount of waste in maintenance budgets, by eliminating the unnecessary repairs and replacements. However, detailed studies are required to analyse these challenges of lean maintenance and their impact.

2. AIM AND OBJECTIVES

The aim of the paper is to analyse these challenges of lean maintenance to evaluate its impact to lean maintenance. Thus, the objectives of the study are as follows;

- identify the challenges of lean maintenance,
- analyse their impact in terms of monetary values.

3. METHODOLOGY

A survey based methodology was used in this paper to establish challenges of lean maintenance through identifying risk causes of maintainability. These risks that occur throughout the life cycle of buildings were compiled through an extensive literature survey and using a pilot survey of substantive experts. A total number of fifty one maintainability risks were established and grouped them into eight such challenging factors, considering their similarities. Views of two experts were obtained regarding the appropriateness of the assigned names for these challenging factors.

Field surveys were conducted to evaluate these risks related to thirty high-rise buildings. The building managers/engineers were interviewed to elicit their knowledge to estimate the significance of these risks in relation to their buildings. The building managers who are employed in these high-rise buildings were assumed to be substantive experts, as they have vast experience and knowledge by managing these buildings. The managers/engineers of these 30 buildings designated as "maintenance managers or engineers" (43%), "facilities managers or overall managers" (40%), and "building managers" (17%) were selected for the survey.

Interviews were conducted in an organised way with several steps: motivation, structuring and description and discussion, judgment and reporting as follows (Renooij, 2001; Dawes and Riebe, 2002; Chang *et al.*, 2008);

1. Motivation: Briefed the research objectives and information to be elicited.
2. Structuring and Description: Walkthrough survey was carried out with the building manager to explore the existing maintainability issues and challenges, maintenance-free features/situations and the condition of the building component. Elements covered during this survey were roof, façade, basement and internal areas. Pre-identified challenges of lean maintenance were then introduced to understand the question and mapped them with existing condition of the building to remember the relevant information.
3. Discussion and Conditioning: Pre-set interview guidance was used to start the discussions by focusing the minds of experts to a common set of measuring rules to maintain the consistency of the experts' judgments. The identified 51 maintainability risks were discussed under 8 challenges.
4. Making Judgment: Experts were asked to make subjective judgments of the significance on each challenge.
5. Response Mode or Reporting: Direct estimates were taken using a numerical scale of 1 to 7 Likert scale.

A high-rise building located in Colombo region was randomly selected and analysed to explore implications of these eight challenges to its maintenance budget. The data for the case study were obtained by field inspections of the building and subsequent interview sessions as discussed. The interview sessions were carried out with the maintenance manager to elicit subjective judgments on eight established factors.

4. CHALLENGES OF LEAN MAINTENANCE

The challenges were derived from eight significant maintainability risk factors, extracted from 51 maintainability risk causes. The significance these eight factors on lean maintenance were evaluated using data collected from thirty high-rise buildings which are of 10 or more storeyed high in Colombo metropolis and discussed in the next section.

4.1. ARCHITECTURE AND DESIGN OF THE BUILDING

Architecture and the design of the building elements have a greater role in facilitating the proper function of the building. Similarly, the flexibility of the design is important in further developments and expansions to meet the future demands (Ikpo, 2009). For instance, changes of the user demands and requirements at the later phases have increased maintenance waste when increasing the facility due to lack of provisions for such changes.

When the design of a building is suited for the exposure conditions such as loading conditions for future requirements, climatic and usage level of its stakeholders, the maintenance of such buildings are easier, thus waste in the maintenance cost is lesser (Ramly *et al.*, 2006; De Silva and Ranasinghe, 2010). Opposing to this, cracking, water seepages through window frames of flushed windows with lack of drainage provisions, water-ponding along open corridors under heavy rains, fungus growth and paint failures under moist conditions, and damp patches of ceiling boards caused due to the condensation of the air-conditioned buildings are some common issues found during survey, due to the lack of climatic considerations in the designs. Among them, some of these issues are not able to correct in the designs and thus, these failures are continued to be occurred.

4.2. STRUCTURAL AND DETAILING

It is presumed that all buildings should be structurally stable to retain them for their desired service life (Chew *et al.*, 2004; Adejimi, 2005). Thus, suitability of the building to its exposure conditions such as external forces and impacts created by loading conditions, rain, moisture, heat, UV rays, corrosion, pests, fire, etc., were identified as important to maintain the structural stability. This can in turn avoid early deterioration by saving money for rectifying them.

The preliminary findings of the survey showed that most of the buildings in Sri Lanka are provided with necessities for maintaining the structural stability and the reliability throughout their expected service life. However, the structural cracks including settlement and shear were observed in few buildings. The maintenance engineer of one such buildings mentioned "*I have to spend huge amounts of money as costs for rectifying the corroded re-bars, cracks and the spalled areas of the slab and some columns due to lack of sufficient cover provided to these structural elements under the coastal conditions*". The building age is approximately 28 years.

Secondly, the detailing to the structure and inter-connections are similarly important to the reliability of the structure throughout its service life (Chew and De Silva, 2003; Low and Chong, 2004). There were many failures such as cracks, water leakages, and deterioration of the finishes were observed due to lack of detailing to movements, moisture, ground water, condensation, chemical attacks, corrosion and pests attacks like termites.

4.3. INTEGRATION

The integration of building services is important to maintain the integrity of the building and also to serve at the maximum efficiency of these services in the operation of the building (Chan *et al.*, 2001). Further, the provisions made within the building elements to accommodate these building services have a great impact on their maintenance costs. Among them, accessibility plays a greater role in saving costs (Ikpo, 2009; De Silva and Ranasinghe, 2010). For instance, in one of the hotels, the minimum opportunity cost for repairing a pipe leakage in the bathroom of a guest room was approximately US$ 135-180 (SL Rs. 15,000 - 20,000) (US$ 1 = SL Rs. 110), as it is required to break the riser wall to gain access to the pipe line which runs in an enclosed vertical riser. Similarly, no space or provisions for accessibility for maintenance are provided in the suspended ceilings, service ducts, and embedded service runs in many buildings. Many "patchworks" were observed due to hacking of the building elements, mainly in walls, and slabs to accommodate the service runs during the construction process due to lack of coordination between the main contractor and the specialist contractors. These construction joints created by the "patchworks" could cause latent defects such as seepage problems, commonly in wet areas and on the external walls.

4.4. ACCESSIBILITY FOR MAINTENANCE

The safe and economic means of access for maintenance has been ignored in most of the buildings, as similar to cases found in the literature (Ikpo, 2009; De Silva and Ranasinghe, 2010). One of the maintenance managers of a high-rise building highlighted that "*no gondola can be installed for the external access due to the restrictions in movements at the roof top and also due to insufficient strength of the parapet wall. Therefore, the repairs to leakages of its curtain wall are costlier with erection of the temporary scaffolding and thus the remedial action is postponed*". Similarly, the painting cost of the external wall has been increased with the erection of temporary scaffolding for many instances when no other means of access systems are available in the high-rise buildings. The efficiency of the access systems has become lesser when the entire surface cannot be accessed by a single system. Under these circumstances, more than one system were utilised, due to odd shapes created by many discontinuities of the surface, sharp corners, and permanent architectural fixtures of the façade surface. Thus, the cost to provide additional support for accessibility can be considered as waste in the maintenance budget.

4.5. MAINTENANCE REQUIREMENTS

The future maintenance requirements were ignored in most of the buildings that were surveyed and thus, it has led to increase the maintenance cost. These findings are similar to established evidences given in the literature (Ikpo, 2009; De Silva and Ranasinghe, 2010).

In one of the Foreign Direct Investment (FDI) projects through the Board of Investment (BOI) of Sri Lanka, scaffoldings were imported as it was duty free to the foreign company. Unfortunately there are no local agents in the country for that type of scaffoldings. As a result, they are out of order today, and the management is facing difficulties in repairing the scaffoldings, as neither the technology nor the knowledge is available locally. The maintenance manager in another organisation said "*though we have a good access system, the availability of skilled workers who can operate the scaffolding to carry out regular maintenance and cleaning of the external wall is the biggest problem, to get the maximum use of it*". In some instances, the provided systems are not safe enough to operate under the prevailing wind conditions. Subsequently, the staining of the curtain walls has become permanent increasing the maintenance cost for such unnecessary cleaning.

Applicability and practicality of maintenance should be a primary consideration during the design phase. For instance, even when access to maintenance of services such as plumbing is provided, obtaining permission to carry out repairs is not possible if the access doors are located inside the residential units. Under these circumstances, rectification the defect has created huge non-value added cost component to the maintenance budget.

Therefore, a certification from a qualified facilities manager on the future maintenance requirements and their feasibility should be made a legal requirement, before approving the plans of high-rise buildings. This can be proposed as an important requirement in future developments.

4.6. MATERIALS AND SPARE PARTS

The performance of materials for local exposure conditions and for long service life is important to improve the reliability of systems (Ishak *et al.*, 2007; Yong, 2007). For instance, some sealants were noted cracked, giving early signs of deterioration under tropical conditions. One maintenance manager expressed "*most of the glass panels used in this building are faded due to direct exposure to the sunlight"* and he further added *"the building is just seven years old*". Not only fading of the glass panels, most of the aluminium panels were discoloured with stains and eroded due to rain water run-off along the surface.

The availability of similar materials and spare parts for future maintenance is an important fact to be considered during the material selection process to minimise waste in the maintenance budget for replacing. Many buildings developed as BOI projects in Sri Lanka have used foreign materials as they were free of duty. These may face difficulties when they require repairs and replacements. One maintenance engineer highlighted "*we are facing a problem in replacing the door locks which were imported from a foreign company which does not have local agents, nor is there a similar type of locks available in the local market*" and he further added "*the organisation is not in a position to open a letter of credit for direct purchasing of the locks from the foreign country, and thus we have to consider changing them into a locally available type*".

Similarly, the use of compatible and suitable materials for repairs is another risk for their durability. In many cases, cracks, hollowness and de-laminations were observed in the repair works increasing the frequency of maintenance cycles. However, with the advancement of new technology and material sciences, many new products which are more durable for unfavourable exposure conditions are available in the market.

4.7. CONSTRUCTABILITY AND CONSTRUCTION/INSTALLATION QUALITY

Constructability plays a bigger role in minimising the latent defects in buildings. Good project management, coordination, communication, commitment and performance of all parties involved in the construction process, clarity of the information such as drawings, bill of quantities, specifications and work orders, inspection, supervision and changes are the main factors and events that control the constructability and quality of the construction process (Andi and Minato, 2004). Constructability Appraisal System (CAS) (BCA, 2008) and Buildable Design Score of buildings in Singapore are typical examples to improve constructability (BCA, 2011). Further, many quality assurance systems including, international standards, in-house systems, checklists, manuals, and inspections and tests can be used to enhance the quality (Low and Wee, 2001).

Moreover, the construction process needs an integrated approach to minimise these latent defects due to the disintegration of different trades, professionals and phases. A considerable improvement can be expected with more integrated procurement types, such as design and built, BOO, and BOT, in which a single team handles different phases of the project, compared with traditional procurement approaches.

4.8. MAINTENANCE MANAGEMENT

The maintenance process is the "tail-end" actions to be performed to prevent the buildings from early deterioration. It is however known that these actions have little control over the maintainability of a building compared with other actions that can be executed during the design phase and the construction phase. When considering these "tail-end" actions, the maintenance strategies, performance of the staff and leadership, availability of the resources, mode and method of maintenance, materials and spare parts, planning and scheduling, availability of the documents and the performance policies and regulations are considered to be important to minimise waste in the maintenance budgets (Cholasuke *et al.*, 2004; Hui, 2005; Pintelon *et al.*, 2006; Marquez *et al.*, 2009; Flores-Colen and De Brito, 2010).

Based on our survey findings, the management has less interest in using the cost effective strategies such as condition-based maintenance, innovative techniques like risk analysis; feedback systems; recording systems, and IT related tools. Mostly, corrective maintenance strategies and few preventive actions were used. Lack of knowledge, qualified staff, existing regulations, and the attitudes are the main barriers, where high-rise buildings are concerned. This may cause lack of consideration of organisational goals and objectives by the maintenance personnel and thus maintenance is challenged as wastage by the top management (Chan *et al.*, 2001; Lee and Scott, 2009).

Lack of understanding the importance of maintaining the building as well as its services has created an attitude that maintenance of services is more important and critical than attending to the maintenance of civil works in the buildings. This may be due to the fact that they are not critical at the early stages (e.g.: *non structural cracks are not critical until it causes carbonation or chloride attacks and water seepages in the concrete elements*), results of the remedies are not immediate (e.g.: *extent of the services life of the building by doing preventive/corrective maintenance is not immediate nor visible*), and the high cost (e.g.: cost of *waterproofing paint over a wall will be around US $ 9 per* m^2). Most of the building managers are M&E qualified or promoted through experiences and thus have no proper background knowledge on building surveying or civil engineering. These factors compel the management to obtain short-term benefits. The long-term strategies like preventive methods or further cost effective strategies like condition-based methods and proactive strategies are still at infancy at the industry level. However, more efficient maintenance approaches such as predictive maintenance strategies should be introduced and practised (Wood, 2005; Baek, 2007; Hegazy *et al.*, 2010). In this strategy, it attempts to detect the onset of a degradation mechanism with the goal of correcting it, prior to significant deterioration in the component or equipment (Sullivan *et al.*, 2004). The proactive maintenance strategy in which the sources of the maintenance problems (i.e. root causes) are treated, is the most efficient approach to eliminate the waste, even though its application in the construction industry is very limited.

Lack of knowledge, manpower and IT tools are the main barriers to making the use of IT in developing very efficient and sustainable systems, feedback mechanisms, maintenance schedules and plans. However, a few organisations use IT tools such as facilities management software to programme the whole maintenance programme which reminds the facilities managers, engineers and supervisors of their daily duties, information on asset stocks and users' complaints and feedback. Further, in some large commercial buildings, technologies like "building management systems" (BMS) and "enterprise resource planning" (ERP) systems are used to maximise the efficiency of the facilities management process.

Proper leadership and the skills/ competencies of the maintenance staff are useful to take efficient decisions. Many large organisations have qualified building managers to take the leadership to run the maintenance and further some of them have been involved in the development phase of the building to increase maintainability right from the beginning to avoid wastage in maintenance.

The availability of resources such as financial, technical and human and their management are important to run an efficient maintenance programme (Cholasuke *et al.*, 2004; Ikpo, 2009). One of the best examples to view the consequences of lack of such resources is the condominiums developed for low income families in the past. The users lacked capabilities in terms of finance, technology and sometimes manpower to manage the building or rectify the problem when they arose. Their social background exaggerated the situation due to lack of knowledge to form a proper Management Corporation (MC) which is a legal requirement in buildings that are registered as condominiums.

5. IMPACT OF THE MAINTAINABILITY

A high-rise building owned by a private local bank in Colombo, Sri Lanka was selected to evaluate the impact caused by these challenges to the maintenance cost. It is a 15 years old building developed for a bank and customer activities. It has a basement floor which is used as the car park and machine rooms. The building was developed and constructed by a local engineering firm. It has a good architectural view created by the steps of the vertical façade. The flushed windows are provided at the façade to benefit from the surrounding view shaped by a lake. The building is located near a lake and the ground water table is high in this area. Two sides of the building border busy roads. Modern materials such as glazed windows, partitioning materials are used. The roof-top has been constructed with a garden to make it an entertainment area. The building is managed by a private company appointed by the management of the bank. This company has a maintenance manager and the technical staff to carry out the maintenance work.

The challenges were evaluated based on the findings of the field observations and interview sessions with the maintenance manager are summarised in Table 1.

Table 1: Challenges of Lean Maintenance

No	Challenge	Status
1	Architecture and design	• The shape of the building is complex. Accessibility to the external façade for maintenance has been limited by its shape from all sides. Temporary scaffolding has to be erected for each painting cycle.
2	Structural and detailing	• Several settlement cracks were observed at two sides of walls. However, it was identified that they have not created threats to the structure, according to the investigation report given by a structural engineer. • A severe ground water seepage was observed in the basement due to the high Ground Water Table (GWT). High GWT was not considered and detailing was not provided to the structure. Therefore the seepage problem has become a big issue during the rainy season. • Water seepage from the roof top' garden water was observed and it has damaged the internal wall paper, paint coating and ceiling boards at several locations. This seepage was due to lack of design of the water proofing system.
3	Services integration	• Services cores, duct lines and maintenance access for their maintenance are not properly designed. • According to the building manager, services were not installed according to the standard norms.
4	Accessibility	• A permanent access system was not provided for external cleaning and painting. • Provisions for temporary access system were not available due to the building's odd shape. • Accessibility for services was not considered as new service lines have been installed without repairing the existing lines due to lack of accessibility.
5	Materials and spare parts	• Most of the materials used in the building were available locally. • Poorly-performing materials under tropical conditions were not observed.
6	Maintenance requirements	• Future maintenance requirements are not well thought of in terms of accessibility, frequencies, method and technology. Examples: (1) Poor accessibility has created additional painting cost of external façade for erecting temporary scaffoldings. Regular painting cycles are important to maintain the prestigious look of the building being a private bank. Thus reduction of the extra high painting cost or cut down the painting frequencies is not possible. (2) Methods of maintenance of services such as plumbing, electrical, AC have not been thought as some have been already replaced with many lines due to lack flexibility and provision for maintenance work.
7	Construction quality	• Quality of construction of elements such as basement floor, walls were poor. Cracking and spalling caused by poor workmanship were evident for such quality of elements.

No	Challenge	Status
8	Maintenance management	• Only corrective maintenance strategies are being practised due to lack of knowledge. Sometimes improper maintenance works were carried out to patch-up the defect due to constraint in budgetary requirements. Therefore it was observed that some maintenance issues have happened repeatedly over the past several years. • Proper policies and maintenance documents were not developed or used. • Proper maintenance schedules, plans, budgets were not maintained to perform maintenance work systematically due to lack of professional staff, strategies and commitment.

The whole life maintenance cost of this building was estimated from the records of the client as US$ 5,127,000 (SL Rs. 563,970,567). The cost items considered in this case are small repairs such as replacing of ceiling boards; tiles; repairing of window fittings; skirting etc., and major repairs that include waterproofing, painting, etc., building materials and construction work, testing and consultancies, insurances, administration and other overheads (see Table 2 for a brief calculation process).

Table 2: Calculation Process

Existing Scenario

1	Whole life maintenance cost (US $)	*end of 15th year*:	5,127,000
2	Equivalent maintenance cost (US $)	*over 15 years*:	183,270
3	Equivalent initial construction cost (US $)	*for 40 years of service life*:	27,300
4	*MEI* – using cost data	*equation* (3.7):	6.7 (class 5)

Improved Scenario

1	Whole life maintenance cost, after removing the waste (US $)	*end of 15th year*:	3,096,740
2	Equivalent maintenance cost (US $)	*over 15 years*:	110,690
3	Equivalent initial construction cost (US $)	*for 40 years of service life*:	27,300
4	*MEI* – using cost data	*equation* (3.7): (class 3)	4.1

Existing maintenance issues for increased cost

1	Additional painting cost due to lack of access to the external wall (25%)	(a)*in year 2000* : (b)*in year 2010*:	8,180 10,900
2	Tile cracks due to settlements at internal areas	*to be repaired* :	450
3	Re-waterproofing of the roof top due to incomplete repair of waterproofing in the previous years	*to be repaired* :	1,360
4	Alternative work to the basement leakage	*suggested* :	725,450
	Cost Saving (US $)		2,030,260
	% Reduction		40%

As shown in the above calculation in Table 2, the whole life maintenance cost can be reduced to US$ 3,096,740 (SL Rs. 340,641,569), if waste could be eliminated by addressing the deficiencies identified by the eight challenges of lean maintenance. Then 40% reduction in the maintenance cost was shown.

6. CONCLUSIONS

The study highlighted that improving maintainability of buildings can promote lean maintenance. Fifty one maintainability causes were considered to establish eight challenges of lean maintenance. Many of these causes are initiated during the design phase and therefore, management and control of such challenges should start at the early stages of the life cycle of the building, and continue throughout the whole cycle.

The impact caused by maintainability of building to its reduction in the whole life maintenance cost was assessed using a case study. This reduction was obtained by reducing waste when managing and controlling the challenges of lean maintenance. The waste was calculated as US$ 2,030,260 which was 40% reduction in the whole life maintenance cost. Therefore, concept of lean maintenance can be promoted with the approach of improving maintainability of buildings.

Thus, achieving maintainable buildings will in turn create a momentum to promote lean maintenance by minimising waste in the maintenance cost. The waste minimisation should not focus only on the maintenance phase of a building, as the early phases such as design has a bigger role in this regard. At the cutting edge of the lean maintenance, its focus should be widen to capture the maximum benefits.

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THE IMPACT OF TRAINING AND DEVELOPMENT ON CAREER ADVANCEMENT OF PROFESSIONAL WOMEN IN THE UK CONSTRUCTION INDUSTRY

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ABSTRACT

The redressing the gender imbalance in the UK construction industry has been emphasised on numerous occasions and many researchers have identified that women can contribute in an immense way towards the construction industry development. However, construction industry has failed to attract and retain women who are interested in a construction career. Participation of women is still very low in some parts of the industry, in particular, at a time when skilled people at all levels of the industry are in demand. Further, Training and Development (T&D) activities have been identified as one of the vital element for professional women's career advancement in the construction industry. However, most of the concepts related to competitive advantages of T&D on professional women's career advancement are imprecise and unstructured in the construction industry. There is little evidence of an accepted theoretical framework for applying the ideas and there is even less in the way of empirical evidence concerning the validity and utility of these concepts. This paper presents the how much/how little impact T&D has on women's career advancement. This paper is based on data collected from professional women in the UK construction industry.

Keywords: *Career Advancement, Construction, Training and Development, Women.*

1. INTRODUCTION

The UK construction industry continues to suffer from a skill shortage, despite the global economic challenge. Skills within the construction industry are particularly vulnerable, as curtailments on training, apprenticeships and graduate recruitment in the past two years are likely to lead to a widening skills gap when the economy and the industry do inevitably rebound (CIOB, 2010). Therefore, skills gap is continued to present at the industry as demand for the skills cannot cater the existing workforce. Hence, practitioners and researchers have suggested numerous ways to address the shortage of skilled workers (Menches and Abraham, 2007). Among the most promising solutions are higher wages, increased training opportunities, improvements in productivity, implementation of technology tools, innovative recruitment techniques, and an increased commitment to diversity (Menches and Abraham, 2007). Within the solution, an increase commitment to diversity is quite popular in the industry. According to ONS (Office of National Statistics) (2009) the proportion of women in employment has grown markedly over the past four decade. At the start of 1971, the employment rate for women was 56% compared with 70% in September 2008 (ONS, 2009). This increase compares with a proportionately decrease in the employment rate for men over the same period, with the male employment rate falling from 92% to 78% (ONS, 2009). The constant reliance on a limited recruitment base disadvantages the industry by disregarding half the population and the diversity of skills these people have to offer (Gurjao, 2006). Indeed, it is said that a major obstacle to the industry in recruiting the best people is the fact that half of the population is largely ignored and also attracting more women is indeed giving them an equal opportunity as well (Green, 2005). Therefore, it is assumed that the recruitment of a greater number of women will be a clear indicator of the intention to reduce the skills gap and labour shortage in the industry and to increase the operation of equal

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opportunities policies (Greed, 2006). Thus, a logical solution to increase the number of women in the industrial professions is attracting more women to the industry initially and then subsequently increasing their retention (Gilbert and Walker, 2001). Hence, both recruitment and retention are equally important to raise the participation rate of women in construction.

The construction industry has a lower female representation rate of all major industries and service sectors in the UK; fewer than 12% of the industry's workforce is women (ONS, 2009). Most of the empirical work conducted thus far relating to women and construction, has concentrated on attracting them to the industry. However, a limited amount of successful recruitment initiatives will have a sustainable effect on the number of women entering the industry, unless those already working within it can be seen to be successful and can therefore act as role models and mentors for prospective female entrants (Amaratunga *et al*., 2007). Considering the changes to the construction labour market and the advances that women have made in improving their representation, there is now a need to gain a detailed understanding of what the precise nature of the barriers are to women's careers that can lead to their under-achievement (Amaratunga *et al*., 2007, Dainty *et al*., 2000). By considering previous studies, it can be highlighted that the lack of Training and Development (T&D) opportunities for career advancement is one of the barriers to women's retention in the industry (Fernando *et al.,* 2010; Amaratunga *et al.,* 2007; Feilden *et al*., 2001; Dainty *et al*., 2000; Sommerville *et al*., 1993). Women and employers believe there is a need for funded government/employer training programmes to ensure adequate training that fits in with childcare responsibilities particularly for the women returners after a career break (Turgoose *et al.*, 2006). Consequently, women are increasingly concerned about receiving adequate training particularly for non-traditional jobs (Turgoose *et al*., 2006).

Accordingly, the justification of the study was due to two main reasons. Firstly, engagement in necessary training and development activities is one of the important aspects for professional women in the construction industry in order to advance their careers. Secondly, although there is much research undertaken on need of T&D for career advancement in general , there is a lack of research conducted on the identification of necessary T&D activities in different career advancement phases; such as idealism (early career), endurance (mid career) and reinventive (advanced career) phases. Therefore, this study is aimed at addressing the how much or the how little impact T&D has on women's career advancement in the UK construction industry.

2. WOMEN'S CAREER ADVANCEMENT PHASES

Much of the career advancement work has focused on men and discusses the effects of age and career stage on an individual's attitudes and performance. The assumption behind much of this work is that, if people move through patterns of adjustment in their lives, then identifying the patterns associated with various ages and stages may help in our understanding of individuals' attitudes and behaviours in organisations. The question remains as to whether these theories enhance our understanding of women's careers. Following a review of the literature on career advancement phases, Swanson (1992) suggested that the stage theories that had received the most attention were those of Super (1957) and Levinson *et al.* (1978). Super (1957) proposed the four stages in his model of career development as:

1. Exploration
2. Establishment
3. Maintenance
4. Decline

Employees in the exploration stage have shown to hold lower levels of personal commitment to the occupation. These employees are more focused on trying to find out, if they belong and where they believe they can succeed in the organisation. In the establishment stage, employees are more concerned with salary increases, promotion, achieving success, and job security. In the maintenance stage, employees tend to be more concerned with maintaining present job status, position, and performance level. They express less interest in working harder to achieve additional rewards. Finally, in decline, individuals tend to psychologically separate themselves from their work, and performance declines.

Further, Levinson *et al*. (1978) proposed a series of age-related life stages which encompassed unique activities and adjustments. He discussed four life eras:

1. Childhood (0-20)
2. Early adulthood (20-24)
3. Middle adulthood (40-60)
4. Late adulthood (over 60)

Levinson (1978) believes women make career decisions based on unique experiences during each of the four eras.

In contrast to Levinson, Super posits that these stages are not determined by age but rather by an individual's circumstances and perceptions. Research comparing the career development models of Levinson *et al*. (1978) and Super (1957) found some support for both models. The Levinson model is more closely related to the individual's career decisions, while the Super model is more closely related to the individual's attitude to work (Orstein and Isabella, 1990). In an extension of this work, Orstein and Isabella (1990) compared the explanatory validity of the Super and Levinson models when applied to professional women. Their work suggested that shifting career attitudes are more a function of age. Women's experiences were closely aligned to how long they were in their career, thus lending greater support to the Levinson model. Further, O'Neil and Bilimoria (2005) discuss how women's careers develop over time, particularly with regard to the impact of career contexts (societal, organisational, and relational) and women's own changing images of their careers and career success. They proposed a three-phase, age-linked model for women's career development phases; these are: the idealistic achievement phase (phase 1), the pragmatic endurance phase (phase 2) and the re-inventive contribution phase (phase 3). This three-phase and age linked model is more appropriate for this study than Levinson's model because, though Levinson's model is categorised according to age, it is not built around career contexts such as societal, organisational, and relational aspects. Therefore, O'Neil and Bilimoria's (2005) three-phase and age linked model is used for this study to categorise the different stages of women's career development and to identify different career success factors in different career phases. These three-phases are further explained in the following section.

Career Phase 1: Idealistic Achievement Phase (Early Career)

The driving force of phase 1, early career (ages 24-35), is idealistic achievement. Women in this phase will most likely to base their career choices on their desires for career satisfaction, achievement and success, and their desire to positively impact on others (O'Neil and Bilimoria, 2005). According to O'Neil and Bilimoria (2005) women in this phase are most likely to see themselves in charge of their careers and will doubtless be proactive in taking strategic steps to ensure their career progress (internal career locus). They are; achievement-oriented, motivated to succeed and see their careers as opportunities to make a difference and as paths to personal happiness and fulfilment.

Career Phase 2: Pragmatic Endurance Phase (Mid Career)

As O'Neil and Bilimoria (2005) explained the driving force of phase 2, mid-career (ages 36-45), is pragmatic endurance. Women in this phase are pragmatic about their careers and are operating in production mode, doing what it takes to get it done. As O'Neil and Bilimoria (2005) discussed, their career patterns are reflective of both ordered and emergent tendencies. They have a high relational context and are managing multiple responsibilities both personally and professionally. They may have been in the world of work long enough to recognise that no matter how internally driven they were (when they were in career phase 1), to a large degree their career development is now impacted by others; professionally by managers and colleagues, and personally by spouses, children, families and friends.

Career Phase 3: Re-Inventive Contribution Phase (Advanced Career)

The driving force of phase 3, advanced career (ages 46-60) is re-inventive contribution (O'Neil and Bilimoria, 2005). As O'Neil and Bilimoria (2005) discussed, the women in this phase are focused on contributing to their organisations, their families and their communities. They are most likely to attribute others, personally and professionally, as having had input in to the direction of their careers (external career locus) and are likely to reflect a stable, planned career path (ordered career pattern). The women in the re-inventive contribution phase have experienced their personal lives being subsumed by their professional lives at some point during their careers. The women have advanced further into their careers; have re-conceptualised and reclaimed their careers as opportunities to contribute and to be of service to others without losing sight of themselves in the process.

3. IMPORTANCE OF TRAINING AND DEVELOPMENT TO WOMEN'S CAREER ADVANCEMENT

Skills shortage studies have tended to reinforce the view that the construction industry faces a skills crisis and desperately needs to invest in training its workforce (Chan and Dainty, 2007). These range from the annual skills foresight reports (e.g. CITB, 2003 cited in Chan and Rachel, 2009) that predicts industrial growth and resourcing levels to studies that consistently illustrate an industry encountering recruitment problems of both blue-collar operatives (e.g. Agapiou, 2002) and white-collar professionals (e.g. Dainty and Edwards, 2003). Too few people are being trained to replace the ageing skilled workforce, and too few are acquiring the technical and managerial skills required to get full value from new techniques and technologies are also issues for the skills shortage.

Turgoose *et al*. (2006) also argue that training is important particularly for women who return after a career break, in order to develop self confidence and to become familiar with new work. Further, women are particularly concerned about receiving adequate training for new jobs. Women who currently work in non traditional skills sectors experience considerable benefits from training and working in the sector. However, long and irregular hours in male-dominated professions with early starts and late finishes remain a barrier to women with children or caring responsibilities (Dale *et al*., 2005).

The Construction Industry Training Board (CITB) has also been involved in a range of projects that seek not just to bring young people into the sector, but also to identify and facilitate projects that can act as learning vehicles (Miller *et al*., 2004). The Women Building London campaign, Women in the Built Environment (WITBE), Oxford Women's Training Scheme, and Women and Manual Trades, can be identified as those vehicles in the construction industry that provide a guide to women entering into construction. However, these projects were mainly concerned with recruitment rather than the retention of women in the industry. The women returnees' strategy for the UK Resource centre (UKRC) for Women in SET (Science Engineering and Technology). UKRC can be identified as one of the initiatives which, provide better conditions for qualified women to return to SET careers. Provisions of advice, mentoring and networking, training and flexible work placements are provided by the women's strategy for the UKRC to return women the SET occupations. Construction skills (former known as CITB) has developed a three point plan to encourage more women into construction under its diversity strategy initiative. Through education, school children have been given the opportunity to sample the construction industry through class projects. Positive Image campaigning was aimed at attracting men and women into the industry by highlighting the positive aspects of a construction career. Finally, by continuing to support employers, there have been increased targets for apprenticeships and local regeneration projects have encouraged clients to seek out more women applicants for vacancies (Yuill, 2005).

Dainty *et al*. (2004) have identified that addressing skills needs in the long-term requires employers to buy-in to the training process. Conversely, they emphasised that employers felt the industry's funding and training infrastructure were overly rigid and do not meet the needs of the types of people entering the industry.

4. RESEARCH METHODS

The questionnaire survey was conducted to explore how much/how little the impact of T&D has had on women's career advancement in the UK construction industry. According to Antaki (1994), the questionnaire survey has clear advantages; they are easy to administer, they are consistent across subjects, and the attention is focused on topics that the researcher considers meaningful or important. The respondent therefore has little or no freedom to negotiate the meaning or relevance of the attribution with the researcher. Therefore, biasness is minimal in the questionnaire. In accordance with the above advantages of the questionnaire survey, the researcher conducted the online questionnaire survey. A sample of online questionnaire survey is shown in Figure 1.

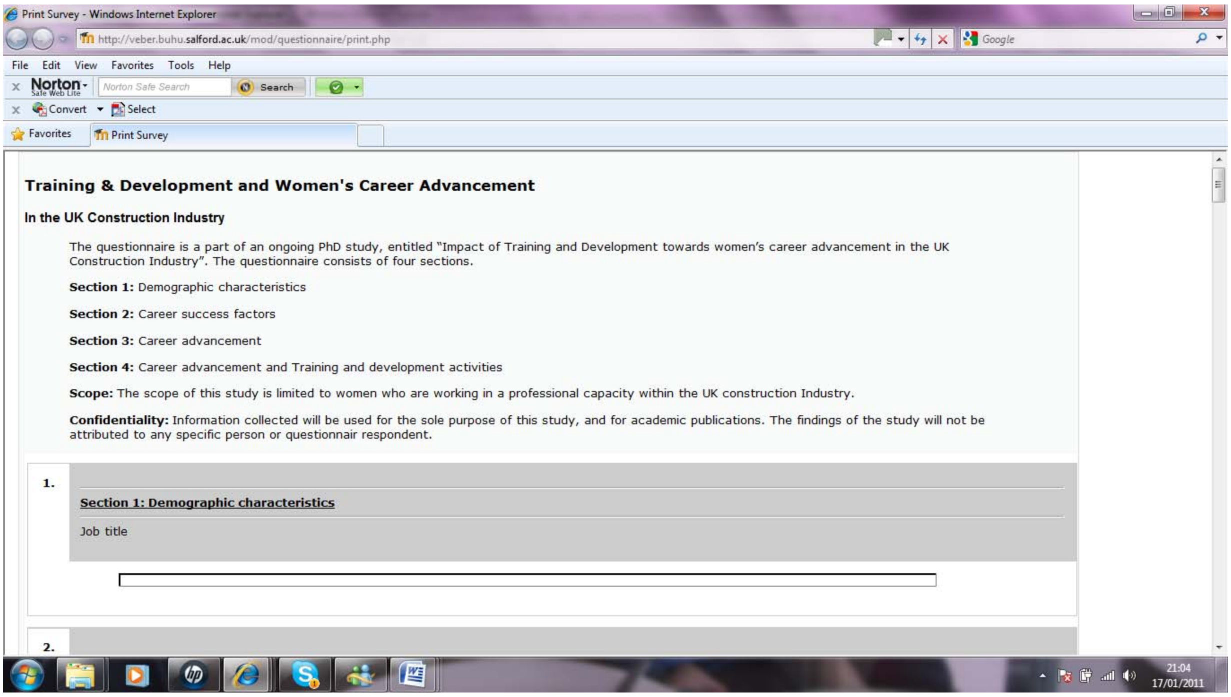

Figure 1: Sample of Online Questionnaire Survey

The impact is identified based on how much/how little impact T&D has had on women's career advancement. Respondents were asked to identify the level of importance given to T&D activities in their career advancement. The T&D activities are shown in Table 1.

Table 1: Training and Development Activities

T&D activities	Description
Orientation programme	Programme to brief new employees on rules and regulations, policies, procedures and benefits
Career development programme	Classes and/or seminars to help employees develop a greater awareness of their talents, interests, values, career goals, to develop career decision-making skills, and learn about different career opportunities
Technical training	Programmes designed to teach specific job related information and skills
Management development	Programmes designed to teach broad managerial skills such as supervision and coaching, management decision making, strategic policy making
Certification programme	Formal certification programme in which employees participate with company's financial support
Advanced management programme	Summer or year-long programme in management training and development typically conducted at a graduate or professional school
Coaching from peers in the organisation	Formal or informal process of day-to-day coaching and counselling by one or more of your peers on how to improve job performance and get along
Supervisory coaching	Formal or informal process of day-to-day coaching and counselling by supervisor on how to improve job performance and get along
Key project assignments	Formal or informal process of selection to carry out or assist in carrying out a specific project, typically involving work on a project team, task force, or ad hoc committee
Mentor	A relationship with a more experienced colleague in order to provide increased opportunities for advancement, corporate visibility, guidance and advice, and "running interference"
Sponsor	A relationship with an individual of higher status or greater impact in the organisation that provides "favoured status", special treatment, or increased power and influence
Networking	An informal set of contacts and channels of communication, inside or outside the organisation used to obtain information or advice relevant to job performance or personal and career goals
Career pathing	A process of promotion or transfer to a different job in the organisation to provide needed skills, experiences and exposure

The responses received from the questionnaire regarding the level of importance of such activities in their career advancement were analysed by using relative importance index.

$$Relative\ Important\ Index\ (RII) = \frac{\sum W}{A \times N} \qquad \text{(Eq: 01)}$$

Where W is the weighting given to each factor by the respondents, ranking from 1 to 7, A is the highest weight (i.e. 7 in the study) and N is the total number of samples. Based on the above equation, the relative importance index (*RII*) will be derived with a range from 0 to 1.

A likert scale was used to capture the opinions and behavioural variables; the opinion likert scale to represent seven scales of *"importance",* 1- unimportant and 7- extremely important. The online questionnaires were prepared and distributed among the respondents with web link, username and password. Duration of two weeks was given to the respondents to complete the questionnaire and at the end of the two weeks a reminder was sent with a one week extension. However, due to low response, the deadline for participants was further extended to three weeks. Table 2 shows the profile of the respondents who participated in the online questionnaire survey.

Table 2: Profile of the Respondents Participated in the Online Questionnaire Survey

Participants	Number of questionnaires sent	Number of responses received			Response rate
		From idealism career phase	From endurance career phase	From reinventive career phase	
Professional women in the construction industry	175	32	31	30	53%

Having elaborated on the research methods used for data collection and analysis of this study, the next section attempts to present the research findings.

5. RESEARCH FINDINGS

The aim of this section is to identify the impact of training and development on women's career advancement. The impact is identified based on how much/how little impact T&D has had on women's career advancement. Respondents were asked to identify the level of importance given to T&D activities in their career advancement. Those activities are shown in Table 1.

5.1. HOW MUCH / HOW LITTLE IMPACT T&D HAS ON WOMEN'S CAREER ADVANCEMENT IN IDEALISM CAREER PHASE

Table 3 shows the relative importance of identified T&D activities in the idealism phase with RII values and contribution of each T&D on career advancement. In this career phase, networking and career development programmes have the highest contribution to career advancement at 9%. The least contributions to career advancement are sponsor, advanced management programmes and certification programmes at 6%. However, the difference between the highest and lowest contribution is merely 3%. The rest of the T&D activities i.e. technical training, management development, coaching from peers in the organisation, supervisory coaching, key project assignments and mentor contributed to career advancement was 8%, while orientation programme and career pathing was 7%. Hence, the contribution given to T&D activities on career advancement in the idealism phase is merely similar in weight. This is shown in Table 3.

Table 3: Index of Relative Importance of T&D Activities and Percentage Contribution of T&D to Career Advancement in Idealism Career Phase

T&D activities	RII	Contribution of T&D's to career advancement (%)
Orientation programme	0.72	7.48
Career development programme	0.84	8.67
Technical training	0.79	8.20
Management development	0.78	8.10
Certification programme	0.59	6.05
Advanced management programme	0.63	6.48
Coaching from peers in the organisation	0.81	8.34
Supervisory coaching	0.78	8.05
Key project assignments	0.78	8.05
Mentor	0.78	8.10
Sponsor	0.61	6.34
Networking	0.86	8.91
Career pathing	0.70	7.20

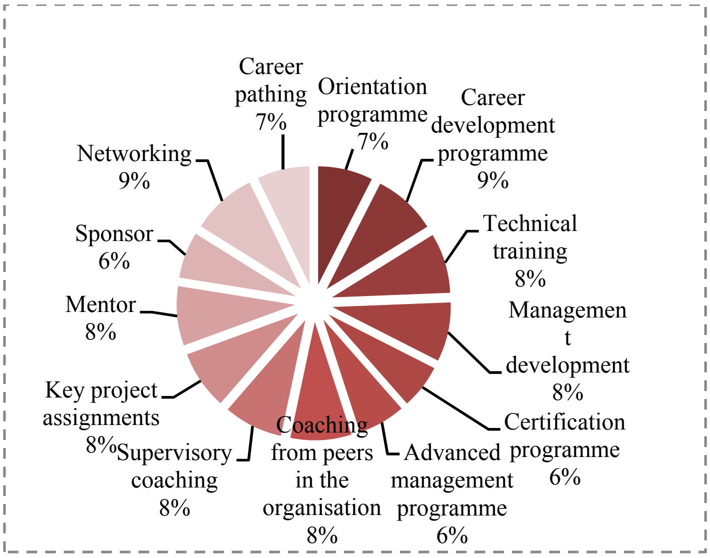

Figure 2: Contribution of T&D to Career Advancement of Women in Idealism Career Phase

5.2. HOW MUCH / HOW LITTLE IMPACT T&D HAS ON WOMEN'S CAREER ADVANCEMENT IN ENDURANCE CAREER PHASE

Table 4 shows the relative importance of identified T&D activities in the endurance phase with the RII values and contribution of each T&D to career advancement. In this career phase, networking and coaching from peers have the highest contribution to career advancement at 10%. The least contribution to career advancement is career pathing, orientation programmes, certification programmes and advanced management programmes at 6%. However, the difference between the highest and lowest contribution is merely 4%. The remaining T&D activities of management development, supervisory coaching contributed to career advancement by 9%, while career development programmes, technical training, and sponsorship was 7%. Career development programmes, mentor and key project assignment was 8%. Hence, the contribution of given T&D activities to career advancement in the endurance phase is merely similar in weight taken. This is shown in Figure 3.

Table 4: Index of Relative Importance of T&D Activities and Percentage Contribution of T&D to Women's Career Advancement in Endurance Career Phase

T&D activities	RII	Contribution of T&D's to career advancement (%)
Orientation programme	0.52	5.82
Career development programme	0.71	7.94
Technical training	0.67	7.41
Management development	0.76	8.47
Certification programme	0.52	5.82
Advanced management programme	0.52	5.82
Coaching from peers in the organisation	0.86	9.52
Supervisory coaching	0.81	8.99
Key project assignments	0.76	8.47
Mentor	0.76	8.47
Sponsor	0.67	7.41
Networking	0.86	9.52
Career pathing	0.57	6.35

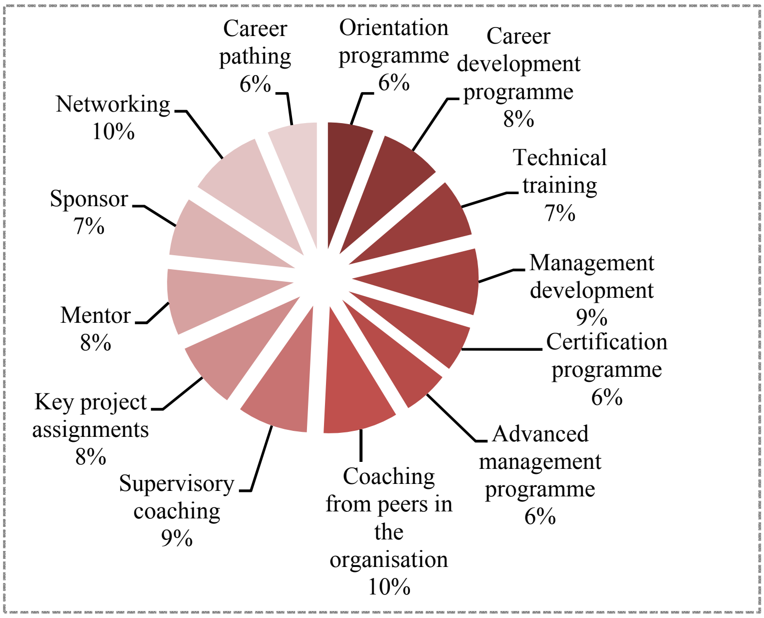

Figure 3: Contribution of T&D on Career Advancement Women in Endurance Career Phase

5.3. How Much / How Little Impact T&D has on Women's Career Advancement in Reinventive Career Phase

Table 5 shows the relative importance of identified T&D activities in the reinventive phase with the RII values and the contribution of each T&D on career advancement. In this career phase, networking has the highest contribution to career advancement at 13%. The least contribution to career advancement is advanced management programme at 2%. The difference between the highest and lowest contribution is 11%. The contribution of rest of the T&D activities are coaching from peers 11%, key project assignment and mentor 9%, career development programme, technical training and sponsor 8%, orientation programme 7%, career pathing 6% and certification programme 3%. This is shown in Figure 4.

Table 5: Index of Relative Importance of T&D Activities and Percentage Contribution of T&D to Women's Career Advancement in Reinventive Career Phase

T&D activities	RII	Contribution of T&D's to career advancement (%)
Orientation programme	0.50	6.67
Career development programme	0.57	7.62
Technical training	0.57	7.62
Management development	0.64	8.57
Certification programme	0.21	2.86
Advanced management programme	0.14	1.90
Coaching from peers in the organisation	0.86	11.43
Supervisory coaching	0.64	8.57
Key project assignments	0.64	8.57
Mentor	0.71	9.52
Sponsor	0.57	7.62
Networking	1.00	13.33
Career pathing	0.43	5.71

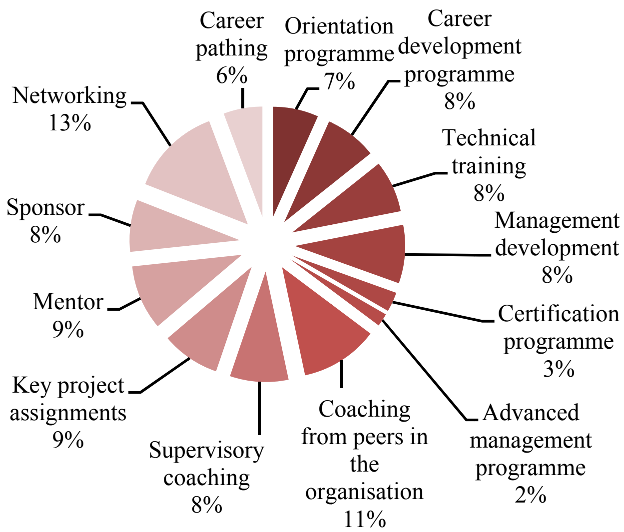

Figure 4: Contribution of T&D to Career Advancement Women in Reinventive Career Phase

6. DISCUSSION

Table 6 shows the findings of the impact of T&D activities on career advancement in idealism, endurance and reinventive career phases. The impact is identified as how much/how little influence T&D has on women's career advancement.

According to the Table 7, "networking" is identified as the highly impacted T&D activity in each career phase. In the reinventive career phase 13% of the entire T&D have identified networking, whereas, 10% from endurance phase and 9% from idealism career phase agreed with networking. Therefore, networking is a strong element out of all T&D activities, which in turn helps career advancement. Kirchmeyer (1998) also argue that involvement in mentoring and receiving network support, and similar associations resulted in a positive outcome of higher salary and level of position. Further, this is strengthened by Warroll *et al.* (2010) where networking and job shadowing support outlined the potential benefit of this in enabling them to learn about new career growth opportunities and in gaining additional experience that can direct their long term career goals, expectations and behaviours.

Table 6: Impact of T&D Activities on Career Advancement in Each Career Phase

T&D activities	Impact of T&D on career advancement (%)		
	Idealism phase	Endurance phase	Reinventive phase
Orientation programme	7	6	7
Career development programme	9	8	8
Technical training	8	7	8
Management development	8	8	9
Certification programme	6	6	3
Advanced management programme	6	6	2
Coaching from peers in the organisation	8	10	11
Supervisory coaching	8	9	9
Key project assignments	8	8	9
Mentoring	8	8	10
Sponsorship	6	7	8
Networking	9	10	13
Career pathing	7	6	6

The next highest proportion from T&D activities is "coaching from peers" in the organisation, which is 11% in the reinventive phase, 10% in the endurance phase and 8% in the idealism phase. Coaching from peers is a very effective and easy way of learning new things and getting clarification for existing queries associated with work. For this activity the involvement of cost to the organisation is minimal. Therefore, organisation also encourages this way of learning and giving training to their employees. For some time, peer coaching has been actively used in a business environment for enhancing the performance of staff. The belief is that the ability to raise staff performance and seek long-term goals for them to gain towards, is important. In their efforts to improve the relevance of the professional development opportunities made available to their staff they are increasingly making use of coaching for creating the climate, environment and context that empowers individuals and teams to generate results. Coaching is a way of working with colleagues supportively in order to encourage them to develop personally and professionally, thus helping them to improve beyond their present capability.

Mentoring is also an important way of gaining training for their career advancement. Mentoring focusing on the individual can enhance morale, motivation and productivity and reduce staff turnover, as individuals feel valued and connected with both small and large organisational changes (The Coaching and Mentoring Network, 2010). This role may be provided by internal mentors and, increasingly, by external mentors. According to the above findings mentoring programmes generally prove to be popular amongst employees as it achieves a balance between fulfilling organisational goals and objectives whilst taking into account the personal development needs of individual employees (The Coaching and Mentoring Network, 2010). It is a two-way relationship with both the organisation and the employee gaining significant benefits. The main reason for the popularity of mentoring among women in the organisation would be, that it is highly effective when used as a means of supporting training initiatives to ensure that key skills are transferred to the 'live' environment. Therefore, women in the idealism, endurance and reinventive phases have identified it as an important element among other T&D activities that provides a way of developing skills for their career advancement. Similarly, in endurance career phase networking and coaching from peers have also been identified and is the highest important T&D activities among all activities. Equally, women in the reinventive career phase consider the most important as networking and coaching from peers as the second most important T&D activity. However, in idealism career phase networking and career development programmes have been given the same and the highest ranking important among other T&D activities.

Career development programmes, technical training, management development programmes and supervisory coaching have been given a merely similar weighting among the three career phases. However, among each training activity are not similar. For instance, career development programmes and technical training do not have similar weighting.

7. CONCLUSIONS

Among 13 training activities such as: orientation programme, career development programme, technical training, management development, certification programme, advanced management programme, coaching from peers in the organisation, supervisory coaching, key project assignments, mentor, sponsor, networking and career pathing the contribution of each and every training activity for career advancement has been identified in each career phases. Accordingly, networking and career development programmes contributed the highest percentage among T&D activities at 9% in the idealism phase 10% in endurance and 13% in the reinventive phase. It was identified that impact of "networking" on women's career advancement has gradually increased with the career phase from idealism to reinventive phase. Further, this identified that when it comes to advance career phase such as endurance and reinventive career phases, need of "networking" for career advancement is highly important.

"Coaching from peers in the organisation" was identified as the second impacted T&D activity on women's career advancement among three career phases. Peer coaching helps employees to become an integral part of their peers' success by helping them flawlessly execute their personal and professional development plans. This taps into the talents of employees so that they act in leadership roles to help each other while reducing the overhead for managers and supervisors to drive the plan execution.

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FOSTERING CREATIVITY IN CONSTRUCTION EDUCATION: FINDING THE MEANING OF CREATIVITY WITHIN CONSTRUCTION INDUSTRY

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ABSTRACT

Many industries today attempt to meet their global challenges through two simple words: creativity and innovation. Construction industry more related to being a creative industry find no exemption. It constitute of realising buildings in Architecture and infrastructure in Engineering through technological interventions. It is an industry that relates to artistic, scientific and technical knowledge. Education in construction industry should also consider this complex nature and fostering creativity will differ from one subject area to another. One such basis for determining a definition and identifying a nuance of the creativity would be to interpret the creative definition into the education objectives: Knowledge, Skills and Attitudes. The composition of these three may differ from one discipline to another but a similar mechanism could be used to educate to foster creativity in any knowledge base either artistic, scientific or technical.

First step in this process is to find a working definition to creativity or innovation in the particular knowledge base, discipline or field. It could be done by simply asking "what does it meant to be creative in construction industry?" for the purpose of this paper or asking a similar question pertaining to any industry in a similar manner to kick-off a series of inner thoughts.

Keywords: *Creativity, Innovation, Construction Education, Education Objectives, Skills, Knowledge, Attitudes.*

1. INTRODUCTION

The significance of creativity and innovation has been felt for survival in any industry more than any time in the history. According to a recent study by IBM (IBM Corporation, 2010) with 1500 CEO's it has been highlighted that "creativity is the most important leadership quality". There have many other developments in various fields emphasising the needs for creativity for the advancement to meet the global challenges and construction industry will find no exemption specially being related to a creative industry as well. The paper attempts to discuss what creativity means in construction industry and its implications on fostering creativity in education programs.

Construction industry can be termed as a creative industry based on various aspects: it produces original products every time it goes into construction: there is a creative craft of architecture and design engineering involved in it: It produces creative products. It involves in realising buildings in architecture and Infrastructure in engineering through various technological interventions. It is an industry that relates to artistic, scientific and technological knowledge.

Any education program that relates to construction industry should understand this complex nature and allow for fostering creativity in their own definition. Defining would be the most difficult task and one suggestion is to define it in terms of education objectives (Bloom, 1956): Knowledge, Skills and Attitude (KSA). What is to be creative in construction industry? (or any related discipline) should we focus more on knowledge? Should we focus more on skills? Should we focus more on attitudes? What could be the magical formula of the composition of KSA? The composition of KSA may differ from one field of study to another based on the theoretical basis, focused subjects areas, philosophy of the school, socio-economic factors that will prevail from time to time. Designing the curriculum to get the desired KSA composition will provide a basis to foster creativity in an education program.

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2. FINDING SANCTUARY IN TWO WORDS: CREATIVITY AND INNOVATION

Darwin put his theory as the survival of the fittest: in today's context it is being creative and innovative that could be classified as the fittest. It is important to understand that creativity is commonly referred to as generating valuable original ideas while innovation is making those ideas in to a process or a product.

Recent development in the interest in study of creativity has demonstrated its significance in various fields. Europe has put creativity and innovation to fore in their cooperation where the Communication of March 2008 simply puts it as: 'Europe needs to boost its capacity for creativity and innovation for both social and economic reasons'. The decisions of the European council to establish the year 2009 as the European Year of Creativity and Innovation further strengthen their emphasis.

Creativity is a vague term to be defined and could only be defined relatively. Therefore, different individuals, disciplines, organisations, countries or regions may find their own way of being creative but the utmost necessity is consistently emphasised in various fields.

Out of the world self-made billionaires majority are engaged in knowledge based industries. The knowledge economies are rapidly taking over the industrial economies making a significant place for creative and innovative businesses to thrive in global markets. The intellectual property laws are becoming important aspect as the innovation become the key in success within global economical turmoil.

In economic development Asian region find it more important to develop entrepreneurship as opposed to large corporations in Europe and US (Bacon-Shone and Hui, 2009) and the degree of the regional creativity was enormous that Muhammad Yunus and Grameen bank was even awarded the Nobel Peace Award for their innovativeness.

As an Industry construction industry is significant for its visual component and making its mark for centuries. It is the landmarks of construction industry that tell the stories of the history civilisations are recognised through their interventions. Take the wonders of the world if it was not for the contribution of the construction industry they would not exist. All the wonders were outcomes of constructions industry and they were named wonders for their creativity and innovativeness. This fact itself provides strong evidence of its strong relation to creativity within the industry.

3. CONSTRUCTION INDUSTRY VS CREATIVITY

The relationship of construction industry to creativity is twofold: in one way it relates more to being a creative industry and in another way as in any other industry the need for creativity and innovativeness has become vital for its survival.

Defining it as a creative industry is more dependent on it being producing creative items, producing original products, engagement of a creative process, visual nature of the industry and engagement of creative professionals within the industry (refer interview outcomes, section 7, p. 5). Creating of visual landmarks makes it an important industry that demands for it to become a creative industry.

Understanding the degree of creativity or innovativeness within industry can be done in two ways: in one way theoretically it could be defined to give a framework for creativity and in another way it could be evaluated using various indicators.

Theoretically understanding the industry referring to the common attributes of creativity the Person, Product, Process and Place the creativity in construction industry can also be understood.

Using various indicators a composite index can be developed to measure creativity where these indicators could include research publications, patents, construction sector developments, new business registrations, revenue generations, income generation factors, GDP percentage growth. This is another vast interesting area for further investigations beyond the span of this paper but worth mentioning.

For any Industry its education would play a major role for its advancement. Considering the importance of creativity in construction industry it will be equally important to foster creativity within the making of their work force through the education system.

4. FOSTERING CREATIVITY IN EDUCATION

Education plays a crucial role in relation to creativity (Villalba, 2009). Education is the key to enhance creativity encouraging them to be innovative as a lifelong habit. Understanding creativity again plays a major role in fostering for creativity in education. David Bohm (1998, p. 1) states that creativity is something that is impossible to define and if the whole idea of creativity is so nebulous then an attempt to foster creativity in learning may be equally difficult. Ried and Petocz (2004, pp. 46-53) summarise many theoretical developments in educating for creativity that has been done mainly focusing on theories of creativity developed by educational psychologists.

Which attribute to focus: creative person, product, process seems to be in the debate and there are no hard rules and depending on the learning domain and within its relativity to its environment this could change (Reid and Petocz, 2004). Some theories have been developed on person (Amabile, 1998) and some have focused on process (Swede, 1993) whereas others have worked on the product (Sternberg and Lubert, 1995).

It is also argued that education systems educate children out of creativity (Sternberg, 2006; Villalba, 2009). Studies have shown that children's ability to come up with many original ideas decrease with the education systems educating to conformity. Sternberg (2006) argues that the creativity is destroyed when students are asked to colour within the lines of the colouring books. Judgement of creativity depends on the context and the stakeholders in that context (Beghetto, 2005) where it could also impact the creative output. Collins and Amabile's (1999) research on motivation and creativity also revealed that creativity is associated with high levels of interest, enjoyment and curiosity.

Recently there have been developments in education sector for fostering of creativity understanding its necessity. Education may play a major role in fostering for creativity in any industry for its progression. Therefore the education system should be consciously designed to cater to its contemporary needs in fostering creativity and brining innovative professionals. Understanding the industry, its socio-economic setting, cultural context, human capacity available are some factors to be considered in planning these education programs.

5. CONSTRUCTION EDUCATION

When the term construction education is used it refers to a broader spectrum with various definitions. In a broader sense it can be understood as the education system that educates labour at all levels needed for the function of the industry. This may include formal and informal sectors. Formal education will start from vocational training to undergraduate, postgraduate and professional education programs. Informal sector are unskilled and skilled labour that get there onsite training and knowledge transfer.

The history of the construction education runs back to a time the knowledge transfer was done by the teacher to student as a family held craft or a craft that was learnt by a student living with the teacher. All knowledge, skills and attitudes are transferred throughout a long time. The master builder or the Architect in the historical time was needed to have knowledge of many disciplines or rather almost ten disciplines (Vitruvius, 216 BC). A similar need is found in modern world but delivering mechanism has been changed to acquiring consultants for every lapse in knowledge. Different specialisations are available within one discipline allowing for very specific situational specialist to be consulted according to situation.

For the working framework of this paper the education that are concerned with professionals were considered. Within Sri Lankan Context four main disciplines with established professional bodies can be seen: Architecture, Civil Engineering, Quantity Surveying, Town and Country Planning. When the construction education is referred within the study the education programs that prepare the professionals needed for the industry are considered.

6. FINDING A WAY TO FOSTER CREATIVITY IN CONSTRUCTION EDUCATION

Understanding this complex nature the education must also suit the industry in fostering creativity and innovation not merely for its survival but for progression as well**.** Since the professional education as a whole was taken into consideration fostering creativity should also be discussed on ground that is common to all disciplines in a more objective stance. Therefore first a definition was to be formed for creativity within construction industry. This could be done by raising a simple question "what does it mean to be creative in construction industry?" To further interpret this into education term this can be elaborate in asking what could be more important out of three education objectives: Knowledge, Skills and Attitudes.

For conducting of the research a broader guide can be used in order to understand the education objectives in terms of construction education.

Knowledge: Subjects within cognitive domain are usually subjects with technical nature that deals with numerical notations, calculations, involves cognitive skills (Bloom, 1956). Majority of the subjects taught within the programs are under this category.

Skills: Subjects within psychomotor domain include ones that involved skill development (Harrow, 1972) such as drawing, sketching and all design projects.

Attitudes: Subjects within the Affective domain that involves understanding of value systems, emotions or feelings (Bloom, 1956). Subjects with more philosophical bias fall into this category.

Depending on the definitions the education can focus on a certain line of thinking. For a school of thought that is based on a philosophy that creativity in construction education is being able to respond to financial constraints therefore focusing more on knowledge would come up with a education program to suit that particular need. Even though the mechanisms showcase to be seemingly simple, actual realisation would be a complex task that involve in much more in depth study of the subjects and developing a taxonomy for the subjects to be divided into Knowledge Skills and Attitudes.

7. INTERVIEW OUTCOMES

A scope was defined for the particular study within the construction education and also within the suggested mechanism and then a method was derived to conduct the study.

7.1. SCOPE

The scope is framed for this paper in two ways: in one way it is defined within the construction education and again its scope is limited within the suggested mechanism to foster creativity within an education system for only attempting to find a definition for creativity.

When the term construction education is used within this paper it is referring the professional education including undergraduate, postgraduate and professional education programs. Ideally for the study views of the four professionals Architects, Engineers (Civil), Quantity Surveyors, Town and Country Planners would have been taken but making a realistic scope only Architectural view was taken. With the common view that they are the most creative professionals as a starting point their view was taken and leaving room for further studies with other professionals in the industry.

The suggested mechanism has more steps towards building education programs but within the scope of the paper only step in finding a working definition is considered. Finding the meaning of creativity and further the important education objective was only considered getting a rather qualitative view on the concept.

7.2. METHOD

The study was done using structured interviews of 20 professionals and academic Architects within construction industry. The group have experience ranging from 03 years to 37 years. 09 were females and 11 were males out of the interviewees. Out of the sample 09 were academics, 07 were professionals and 04 are engaged in both.

The interview was focused on raising structured questions including which education objective can be more influencing in fostering creativity as seen from a very basic professional or an academic point of view. The interviews were done covering their views on current Sri Lankan context. Then data was analysed using both qualitative and quantitative methods to draw some conclusive remarks.

7.3. IS CONSTRUCTION INDUSTRY A CREATIVE INDUSTRY

Answering for the question "Is construction industry a creative industry?" 87% answered yes while 13% answered as it depends on situation specially on the process of in which it is realised.

Conceptualising on the reason for categorising construction industry as a creative industry following concept map is drawn.

The construction industry was categorised as a creative industry based on four aspects of people involved, product, thinking process and nature of the industry. Each aspect again has its own different concepts making the total concept of construction industry is a creative industry.

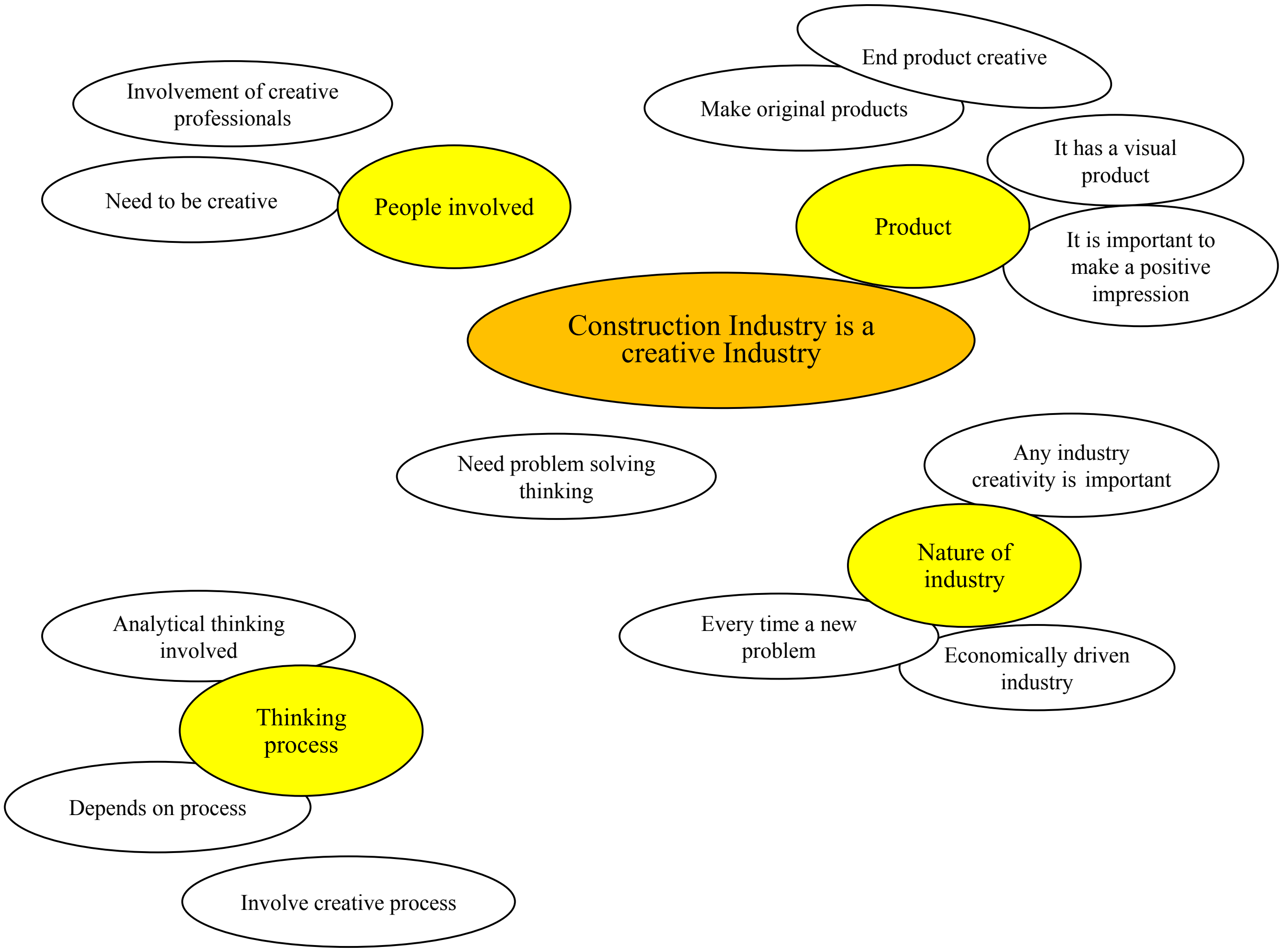

Figure 1: Concept Map of Why Construction Industry is Termed as a Creative Industry

7.4. WHAT DOES IT MEAN TO BE CREATIVE IN CONSTRUCTION INDUSTRY?

Analysing the various concepts from the interviews following concept map was drawn.

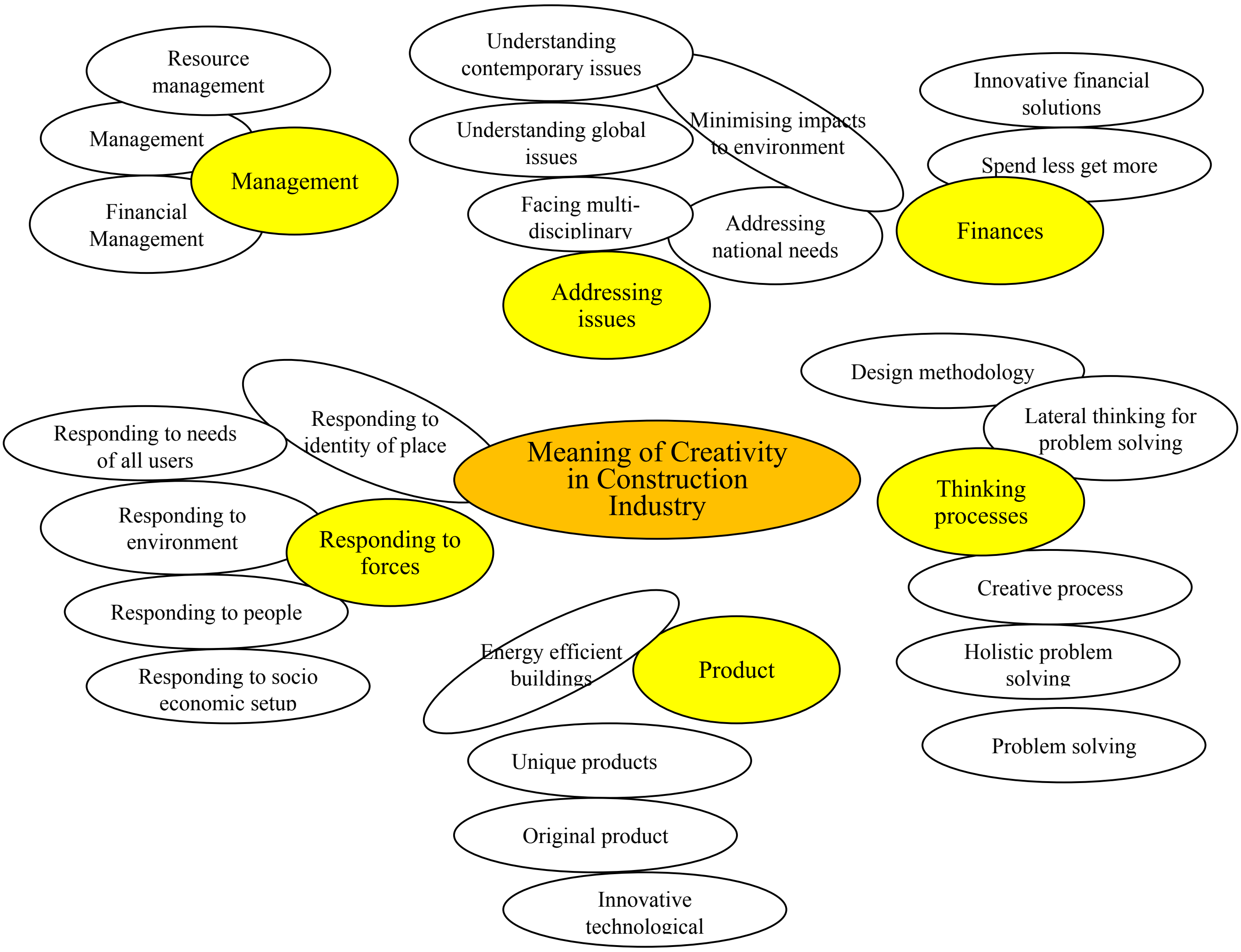

Figure 2: Concept Map of What Does it Mean to be Creative in Construction Industry

The responses to the question "what does it mean to be creative?" was analysed using a coding it is seen that six themes management, addressing issues, finances, responding to forces, product and thinking processes can be found constituting the meaning of creativity in construction industry. Every theme is again made up of various concepts that were stated during interviewed in defining the creativity within the construction industry.

7.5. WHAT IS MORE IMPORTANT, KNOWLEDGE? SKILLS? OR ATTITUDES?

Out of the interviews 18.75% responded as knowledge is important where only 6.25% responded as skill is important. 62.5% was with the view that attitude is the important factor in fostering creativity in an education programme. 12.5 % responded that all carry equal weight and it is a difficult task to prioritise.

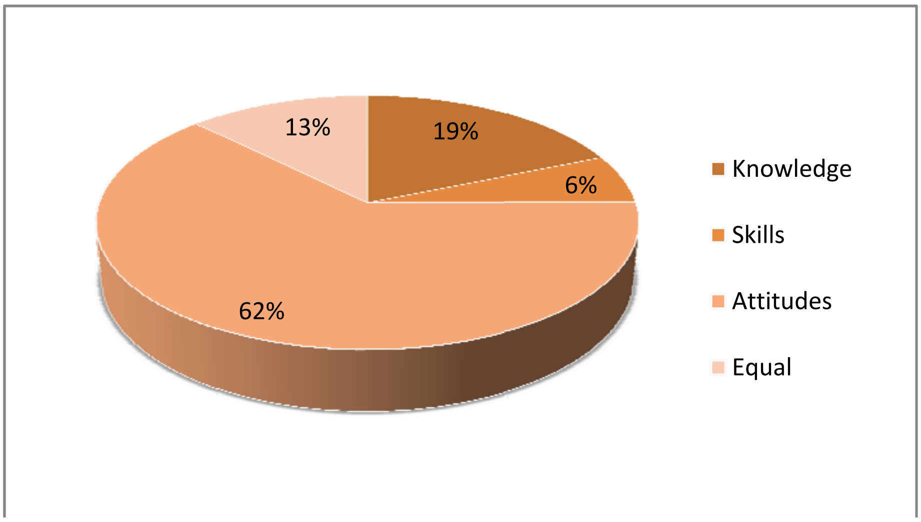

Figure 3: Pie Chart of Which Education Objective is More Important

7.6. Should the Composition Change According to Profession?

42.85 % believed that KSA composition in education programs should change by profession while 57.15% said that being professionals it should not change by profession. Out of the ones who believed that the composition should not be changed according to profession 91.66% have also believed that attitudes are important.

7.7. Should Education Programs in Construction Education Foster Creativity?

100% agreed that education programs within construction industry at all levels should foster creativity.

7.8. Current Rating for Fostering Creativity

Rating was done on a scale of 1 to 7 where 1 is being the lowest. Out of the rating of current situation following are the averages.

Table 1: Rating of Education Programs for Fostering of Creativity

Profession	Average Rating
Overall Construction Education	3.5
Architecture	4
Civil Engineering	2.5
Quantity Surveying	3.2
Town and Country Planning	2.8

It is noted that majority have said that the current education system is fostering creativity at an average level. Especially that architecture is fostering creativity at a higher level. The low figures in civil engineering and town and country planning are due to low rating of those disciplines as fostering creativity in current context.

8. Some Concluding Remarks

Deriving solid conclusions out of the discussion are totally out of the pure intentions of this paper and this aims to trigger inner thoughts among professional within the constructions industry. There seem to be interesting and valuable ideas among professionals both in profession and academia regarding the creativity within construction industry and the utmost need for its emphasis within education programs.

87% of the interviewed were under the strong belief that construction industry is a creative industry. The most unique reason for it was that it produces original different project every time a construction take place in a different location. The construction industry was also viewed as a creative industry since its visual components. Its products are seen on ground. Therefore people tend to perceive it as a creative industry.

It is also important to understand why some have doubts in categorising it as a creative industry. The comment was the process is important. If it is merely a mass production process of infrastructure development it is not fair to term the industry as a creative industry. But any industry will have this component. Even dress designing which can be categorised as a highly creative industry has a mass production process as well as a designer creative process. It understands the background setting in which it operates one will be able to understand its true creative nature.

Defining the meaning of creativity within construction industry most frequent answer was that it is a problem solving exercise and ability to solve complex problems is being creative in the industry. Even among architects who are considered to be creative professionals the analytical problem solving nature of the creativity was the emphasis for construction industry. Even the responses to other themes have stated that finding solutions to complex problems within the construction should be addressed within education programs. This pave way to think that education in totality should be more focused on problem solving, professional and practical aspects but at the same time building attitudes that is common for all professionals.

100% agrees that education programs within construction education should foster creativity which is a positive starting point in promoting creativity in education programs.

It is also important to emphasise on the fact that rating at present on overall construction education has given an average of 3.5 in a 1 to 7 scaling. Only architecture is given a value above overall rating where all others below it. This reflects the need to address this issue within all construction education programs including architecture which should yield a higher much value in a rating for fostering creativity.

There can be many ways used and can be used to effectively foster creativity in education programs. But focusing on a specific education objective is one such suggested method that can be used and the finding is also interesting where 62.5 % was with the view that attitude are the dominant factor in fostering creativity in any education program. And 88% who said attitude is important is also believed that the composition should not change from profession to profession. All the professionals should be educated more focused on attitudes.

It is again emphasised that above are some remarks not solid conclusions that could pave way to think on these lines. The viewpoints presented are an architectural point of view where others might have different stands on how to be creative in the industry. Further studies could be done with interviews covering other professionals getting a more comprehensive view on the concept and finding more methods to foster creativity in education programs. It is also important to emphasis the holistic nature of the construction industry in its education programs rather than educating isolated professionals. Being workforce of one industry proper integration will make efficient system of operation.

Whatever steps we take what experiments we do what remains important fact is that the industry educates its professionals fostering creativity to meet the demanding global challenges of the 21st century so that the industry is not left behind and the next wonders of the world may not become telecommunication products but construction outputs again and again.

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TEAM ROLE CONCEPT AND TEAM FORMATION IN DESIGN TEAMS IN SRI LANKA

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ABSTRACT

Construction is a collaborative activity which combines efforts of number of participants. Hence, teamworking in construction is inevitable. The purpose of teamworking is to exploit the benefit for the team as a whole by a particular combination of actions by team members of the team. But, if not properly managed, teams may result in process losses and inefficiencies as well. Therefore, practitioners in the industry should find ways to improve team performance. Since construction project teams consist with many sub teams such as design teams, performance of the construction industry can be improved, when team performance of sub teams are also improved. 'Team role' concept relates to team performance. Belbin's (1981, 1993) team role framework is regarded as one of the most prominent team role theory. But use of this concept in construction teams is questionable. Accordingly, this study explored consideration of team role concept in team formation in one major sub team in construction: design teams. To explore this research problem, three case studies of in-house design teams which were involved in building construction projects with separated procurement arrangement were conducted in Sri Lanka. Semi-structured interviews were used as main data collection technique. The findings revealed that individuals are assigned to design teams considering their functional roles rather than team roles and team selection is affected by several other factors such as special requirements of the project, experience of the members, qualifications required, availability of human resources, recommendations and workload. However, the study revealed implications particularly to design team selectors on how to apply team role theory in construction context.

Keywords: *Construction Industry, Teamwork, Team Roles, Team Formation, Design Teams.*

1. INTRODUCTION

Team role theory is used in a great variety of practical team development and management purposes at present in different fields. But, construction literature has not given a sufficient consideration to this area. Hence, this research aimed to identify the awareness on team role concept and the consideration of team role concept in team formation with regard to construction design teams. Section one aims to synthesis the current knowledge level regarding the research area and to establish the research problem. First, teams and teamworking in construction is discussed. Secondly, team role concept will be introduced and finally, it will be discussed with regard to design team selection.

1.1. TEAMS AND TEAMWORKING IN CONSTRUCTION

Team is a set of two or more people who interact dynamically, interdependently and adaptively towards a common and valued goal, each having specific roles or functions to perform and a limited life-span of membership (Salas *et al.*, 1992). Andras and Lazarus (2005) explained that the function of teamworking is to maximise the utility for the team as a whole by a particular combination of actions by team members of the team. According to Katzenbach and Smith (1993), teams perform better than individuals, especially when diverse skills, judgments and experiences are brought together. However, teamworking is not a new concept and the existence of teams in this society is rooting to the beginning of mankind when they started seeking basic shelter and food to survive (Cornick and Mather, 1999).

Cornick and Mather (1999) argued that construction project of any scale, can never be realised unless a team of people with diverse knowledge and skills is created and operates together. Teamwork is a

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prerequisite for the successful delivery of construction projects (Steward and Barrick, 2000; Wong, 2007). Therefore, necessity of teams and teamworking in construction are evident.

Project team in the construction industry can be defined as a group of construction professionals and personnel from one or more organisations who come together to fulfil the necessary design, detailing and construction functions which are involved in the construction project (Chan and Tam, 2000). Cornick and Mather (1999) explained the main parties of construction project teams as the client, designer, construction manager and specialist sub contractors. According to Senaratne and Hapuarachchi (2009, p.175), construction project team within traditional procurement is, "*a collection of two or more people with complementary skills, who come from different disciplines and organisations, to perform a common objective, but with individual objectives and operating from different locations with multiple reporting relationships, whose accountability and leadership are significantly governed by the contractual arrangements*". Teamwork is essential for integrating specialist work into total scheme of things associated with project (Fryer *et al.*, 2004). In terms of design teams, Pectas and Pultar (2006) mentioned that successful management of design is critical to quality, cost effectiveness and timeliness of projects. Further, in a survey of AEC companies in the USA (Arditi and Gunaydin, 1998) 'collaboration among parties' was the highest ranked factor among the many factors that affect quality in design phase. This marks the importance teamworking among the members in design teams. Thus, above literature findings elaborates the importance of teamwork in the total construction team and in design teams, particularly.

The rationale behind the role and growth in importance of teams in organisations is that teams produce superior performance to individuals (Ray and Bronstein, 1995). According to Castka *et al.* (2001) performance is implied as the purpose of teamwork. But, Steiner (1972 cited Stewart *et al.,* 2005) argued that although teams have been shown to synergistically combine the efforts of individual's contributors in some cases, they result in process losses and inefficiency in other instances. According to Macmillan (2001), some benefits of effective teamwork and drawbacks of teamwork can be shown as in Figure 1.

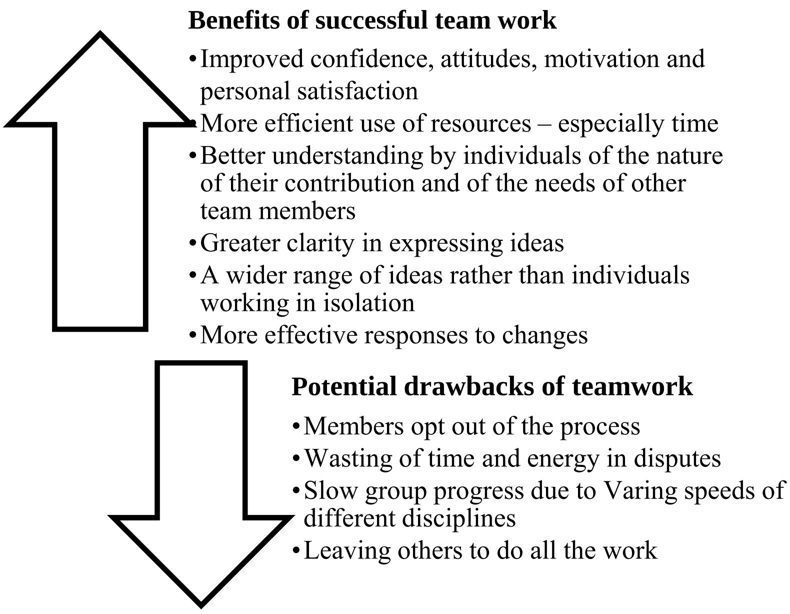

Figure 1: Potential Benefits and Drawbacks of Teamwork.
(Adopted from: Mcmillan, 2001, p.187)

Fryer *et al.* (2004) mentioned that since the energy of a team which can be devoted to its work is finite, the time spent on dealing with the drawbacks of the teamwork, is time loss to real work. Therefore, it is important for the industry's managers to know about teamwork and how to maintain its performance throughout a project (Fryer *et al.*, 2004). Teams being the primary unit of working in the construction industry, performance of industry can be improved when team performance is improved. Similarly, Pryke and Smyth (2006) highlighted the importance of adaptation of good teamworking practices in sub-sectors such as design organisations, in order to enhance the performance of construction projects. In order to improve performance of teams first, it is important to pay attention to the factors which might influence the performance of a team. According to Yeh (2006), the human resources making up the team are critical for its performance.

In a team, individual human inputs should aggregate to team level outcomes and one potential mechanism which links individuals and team-level characteristics is the concept of roles (Stewart *et al.*, 2005). Therefore, it can be argued that, roles of the team members are likely to have impact on the team performance. Senior (1997) also supported the fact that crucial to performance of teams are the abilities and behaviours of their members, which are related to the roles that they play. Therefore, the next section is dedicated to review literature on the concept of role and types of roles which the team members would play.

1.2. TEAM ROLE CONCEPT

Role is a sociology-origin concept and the use of role theory is has being extended to many fields like psychology, social psychology, sociology, organisational behaviour and human resources management (Gunduz, 2008). Basically, the concept of role is viewed from two types of perspectives in literature. Aritzeta *et al.* (2005) explained that from behavioural perspective (anthropological-sociological perspective), role can be defined as a combination of values, attitudes and behaviour assigned to an individual who occupies a social position (a location in a social network) associated with a specific social status (the functions assigned to that person). From the expectancy perspective (psychological perspective), a role can be defined as the behaviour expected from an individual occupying a specific position (Biddle, 1979 cited Aritzeta *et al.*, 2005). In both perspectives the role is explained in relation to a specific position occupied by the particular person. According to Higgs *et al.* (2005), the role is filled by the position owner based on his or her personal background (for example; experiences, talents, education) and on situational conditions (for example; requirements, perceptions, attitudes) which are influenced by that personal background. Externally, the role is framed by the position that is created by management, colleagues and subordinates. On the other hand, personality traits which are internally driven and relatively stable over time and across situations, also form a part of role definition (Chong, 2007).

In academic literature, roles have been classified into several types. Belbin had explained about two types of roles which are namely functional role and team role (Rajendran, 2005). ‘Functional role’ refers to the job demands that a person has been engaged to meet by supplying the requisite technical skills and operational knowledge, whereas ‘team role’ refers to a tendency to behave, contribute and interrelate with others at work in certain distinctive ways (Belbin, 1993). Belbin (1993) further emphasised that the team role describes how the individual fits into the team, not what particular function he or she performs. Thus, several people may have the same functional role but vary in their team roles.

Water *et al.* (2008) highlighted Belbin’s argument that team composition is a key factor in influencing team performance. They further argued that, when considering the team composition it is relevant to take into account the different roles which members play and the way they interact with one another. However, general composition of teams in the workplace has been determined through either functional or status considerations in order to ensure the right level of expertise and experience (Partington and Harris, 1999). Partington and Harris (1999) highlighted that this approach is failing to take into consideration the implications of individual personalities and behaviours in the team process thus, ignores the possibility that team members will have individual preferences for the roles they adopt in a team situation. Senior (1997) also argued that the notion of team roles emerged due to the fact that functional roles do not help in matters such as the way different team members approach a problem or task, the way team members interact with one another and their style of behaviour in general. She further demonstrated that individuals will not only bring the characteristics of their functional roles to their activities as members of teams, but also they will take up one or more team roles, naturally. Therefore, it is clear how the concept of team roles have become a popular issue which has a perceived bearing on team performance (Partington and Harris, 1999).

Various researchers have studied on team roles and offered different team role classifications. Among the number of team role theories available, Belbin’s team role theory (1981, 1993) is one of the most widely accepted and currently widely used, in a great variety of practical team development and management development purposes (Water *et al.* 2008). Belbin's team role model was proposed after a nine-year study of team building and team effectiveness with management teams taking part in an executive management exercise at the Henley Management College, England (Aritzeta *et al.,* 2005). A study carried out by Fisher *et al.* (2002) revealed extended generality of the Belbin team role theory and identified that it may also have validity in non-managerial contexts. Therefore, it can be argued that this theory can be applied in the construction project teams.

Belbin argued that while the types of behaviour that people engage in are infinite, the range of useful behaviours that make an effective contribution to team performance is finite. He grouped these behaviours into eight clusters, each of which described a pattern of behaviour characteristic of the way in which one team member interacted with another. However, Belbin (1993) further asserted that this 'team role behaviour' is not fixed by individual personalities, but could be changed by situational factors and also individual learning patterns. The next section will discuss how this 'team role' theory could be considered in construction team selection.

1.3. DESIGN TEAM SELECTION AND TEAM ROLE CONCEPT

The general composition of the project team in construction is clear with the traditional functional roles required for any project (Cornick and Mather, 1999). But beside these functional roles, individuals in any team inherently adopt natural roles based on their personal preferences and characteristics (Partington and Harris, 1999) which is not well addressed in construction literature. Fryer *et al.* (2004) pointed out that project teams are not usually put together in a systematic way and mostly it depends on who is available (and when), who has the necessary experience for this particular type of building, who recommends whom and so on. People who come into these teams from different professions are likely to have different interests, skills, backgrounds and personalities which are reinforced by the pattern and focus of the education and training adopted by each profession (Fryer *et al.*, 2004). Therefore, simply bringing together a group of professionals does not necessarily ensure that they will function effectively as a team (Cooley, 1994 cited Macmillan, 2001). Constructing Excellence (2004) suggests that in forming and managing a team, to consider not only individuals' technical skills, knowledge and experience but also their ability to co-ordinate actions, behaviours and interpersonal qualities which is much more associated with concept of 'team roles'. However, more research is required to identify the applicability of team role theory in construction. Hence, this study attempts to explore the awareness of design team members on team role concept and it's applicability in design team formation.

2. RESEARCH METHOD

Section one discussed the key research issues through a review and synthesis of the existing literature. This section aims at discussing the methodological framework which was adopted in the study.

Research philosophy of the study was 'Interpretivism'. When considering the research aim and the nature of this research, it was obvious that this study needs careful observation of human interactions and behaviours. According to Easterby-Smith *et al.* (2002), 'Interpretivism' is one of the philosophies where the reality is determined by people rather than by objective and external factors. Hence, interpretivism research philosophy was adapted in this research. According to Yin (2003), case study research is useful when, a 'how' or 'why' question is being asked about a contemporary set of events over which the investigator has little or no control. Therefore, empirical study was conducted by adapting case study research approach which helps to gain more in-depth knowledge pertaining to existing theoretical insights. Unit of analysis of the study was a 'design team' and three design teams were selected for the study, based on access and time limitations. In order to avoid complexities associated with virtual relationships in inter-organisational design teams, in-house design teams were only selected for the study. Further, design teams involved in building projects under separated procurement arrangement were selected, to avoid complexities which may occur when evaluating building and civil projects simultaneously and to avoid the contractor becoming part of the design teams. Although design teams operate from inception to completion of projects, their major role and most of the activities are in the design phase. Therefore, projects which completed the design stage were considered for the cases. Refer Table 1 for details of the cases.

Table 1: Details of the Selected Cases

Case	*Case A*	*Case B*	*Case C*
Type	Simulator training building	Bank branch office	Head office building
Project Cost (Rs.)	114 millions	48 millions	915 millions
Project Duration	8 months	20 months	22 months
Stage	Design completed, construction to commence	Design completed, piling work continuing	Design completed, piling work continuing
Nature of the Client	Private-Client	Government-Client	Government-Client
Composition of the design team	Architect (Leader) Chief Quantity Surveyor Project Quantity Surveyor Structural Engineer Services Engineer Electrical Engineer	Architect (Leader) Project Architect Quantity Surveyor Structural Engineer Electrical Engineer Draughtsman	Team Leader (design) Architect Quantity Surveyor Structural Engineer Services Engineer Electrical Engineer Interior Designer Town Planner Construction Coordinator

This paper reports the research findings on the first phase of a larger research study. The techniques used for this phase of the research can be discussed under two broad types as data collection techniques and data analysis techniques. Yin (2003) stated that interviews are essential sources of case study evidence, because most case studies are about human affairs and these human affairs should be reported and interpreted through the eyes of specific interviewees. Among the wide range of ways that interviews can be conducted, semi-structured interviews have attracted interest among researchers and are widely used due to the advantage that while having a well prepared structure in advance, the questions are formed as sufficiently open enough in way in which the view points of the interviewee are more likely to be expressed in an openly designed interview situation than in a fully standardised or unstructured interview (Flick, 2006; Wengraf, 2001). Accordingly, Semi-structured interviews were used as the main data collection tool during data collection process and data was analysed using the content analysis and cognitive mapping. The findings of these are presented and discussed next.

3. RESEARCH FINDINGS

The aim of this section is to explicate the research findings of the empirical investigation. First, details of case studies are presented and next, findings on awareness on team role concept and formation of design teams is discussed.

3.1. DETAILS OF CASE STUDIES

Selected cases were three in-house design teams of building construction projects which were adopting traditional (separated) procurement method. Cases had certain similarities and differences in terms of the background as follows;

- A project which was aimed to construct a three storey simulator training building was selected as Case A. Client has demanded for a unique building as it is the first building to be build in the country in that nature. An in-house design team of a government organisation was the design team of this project. In this organisation main person who is responsible for selecting members for design teams, is the Deputy General Manger (DGM) of Consultancy unit. When a new project comes, he selects key members. But, mostly division heads (architectural, structural engineering, mechanical engineering, quantity surveying) are also responsible for appointing members from their own divisions to the given project.

- Construction of two storey branch office for a corporate bank was the project selected for Case B. An in-house design team of a private consultancy organisation was the design team of this project. The client of this project has had a long term relationship with this consultancy organisation. Therefore, design team was much more familiar with the project with their previous experiences of other branch offices constructed for the same client. In Case B, Managing Director of the company was the person who is responsible for forming design teams for new projects by selecting suitable members.
- Construction of twelve story head office for a governmental department was the project selected for Case C. An in-house design team of a private consultancy organisation was the design team of this project. There was a separately appointed team leader for the design phase and he was responsible for coordinating within the team and with the client. Construction Coordinator has been appointed to coordinate design team with client and contractor. In this case, the person who is responsible for selecting team members for a design team was Head of Pre Contract Unit of the particular organisation.

Having discussed about the background of the teams, findings of the study will be discussed in coming sections.

3.2. Awareness on Team Role Concept and Formation of Design Teams

It was observed that some members of these studied teams were aware of the existence of team roles through their education, seminars or practical experience. Most of the members who were aware have learnt it by practical experience and not through education and training. Further, it was noticeable that most of the members in all three cases were not aware of Belbin's team role concept. However, when explained, team members emphasised that having a proper knowledge about team role theories will be beneficial for team working.

Turning to team selection, it was evident that 'team roles' was not currently a considerable factor in design team selection in these three cases. Instead, design teams were basically formed based on the functional roles required for the project. Composition of three teams considered was different in terms of the types of functional roles. Different types included architects, structural engineers, services engineers, electrical engineers, quantity surveyors, town planners, interior designers, draftsmen as well as especially appointed team leaders and/or coordinators. Team selector of case C mentioned, "*we basically analyse the project; size of the project, capacity and the features like foundation, structure, services to be incorporated (electrical, fire detection and fire fighting, air conditioning and so on), requirements for external works or interior decoration and based on that decide the composition of the design team*". Types of functional roles required for a particular project have been decided based on the scope of the project. For example, if the interior design is out of the scope of the particular project, the design team does not need to have an interior designer. Further, team selectors highlighted the importance of selecting suitable number of functional roles. Case B team selector mentioned that "*we have to provide sufficient number of functional roles for a particular project, otherwise project cannot be done*". Sufficient number of professionals from each discipline is appointed to the team based on the scale and complexity of the project. Sometimes, minimum number of professionals required from each discipline is indicated by the client or by his consultants on behalf of the client. In such instances team selectors have to strictly adhere to them in order to be competitive in the bidding process. Architect of Case A mentioned, "*Sometimes, architectural division itself has a team. This includes senior architect, project architect and more which depends on the scope of the project. Sometimes these two may be the same. It is similar in the engineering and quantity surveying also"*. This shows how the scale of project affects the number of members from each discipline.

According to all these cases, team selection which is mainly based on functional roles is again dependent upon some other factors such as special requirements of the project, experience of the members, qualifications required, availability of human resources, recommendations and workload. Figure 2 shows the cognitive map representing factors considered by team selectors in appointing team members to design teams as emerged through cases.

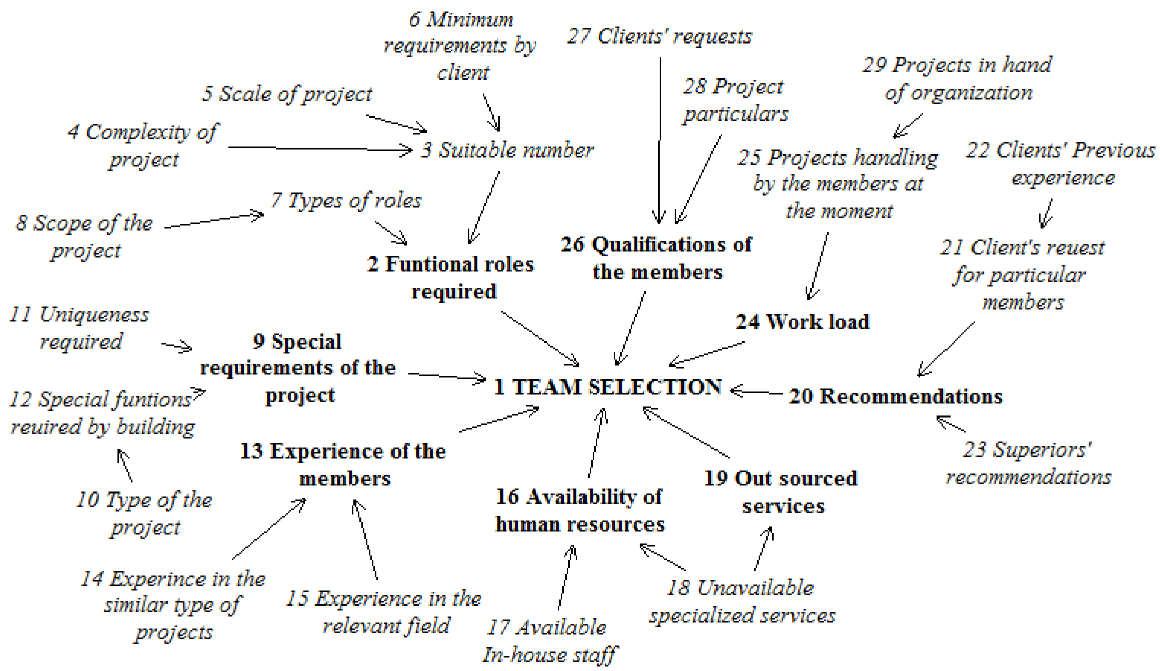

Figure 2: Cognitive Map Showing Factors Affecting Design Team Selection

Special requirements of the projects demands for particular persons needed for the project. For example, in a hospital project which has many complicated medical equipment, services of a bio medical engineer may require to assist architect, even though it is not normally required for a normal building project. Team selector of case A mentioned "*for example, when the client wants a unique building, we have to select the correct team and specially, pick the correct architect having particular skills*".

Member's experience on similar type of project and experience in the relevant field were considered in team formation. Team selector of case C stated, *"We try to get most experienced person for that particular project. If we are going to design a university, the first priority will be going to the architect who has experience in that. If it is a high rise building, structural engineer need to have high rise experience."* When there is no person who has the relevant experience or when the opportunity needed to be given to new members, experience gap is filled with the assistance of senior members who have overall knowledge in all the areas.

Recommendations made by clients and superiors are also become factor to be considered in team selection. In certain instances, members were selected considering the recommendations of clients and seniors of the organisation. Mostly this is based on the previous experience with the particular member. According to team selectors, this usually affects the selection of architect. Team selector of case C mentioned, *"Some clients prefer to go with the people who have worked previously. So, whenever possible, we give them that facility."* When technical or educational qualifications such as diploma level, B.Sc., M.Sc., and so on are mentioned under project particulars, members who fulfil those qualifications should be selected. Further, qualifications of the members should be sufficient enough to carry out the given task.

Mostly, team selectors have to select members from available resources. If the in-house staff is not enough they may have to go for outsourcing. Team selector of case B mentioned, *"We get the services from outside, when we don't have a certain specialisation. For example, we have out sourced structural* *engineering function."* Further, work load of the members also restrict the selecting a particular member to a team. Number of projects handled by the particular member at the moment, complexity of their work affects the selection of the particular member to a new team.

Hence, empirical findings revealed that design teams formed based on the functional roles of the members, but not according to their team roles. As mentioned in literature review, Cornick and Mather (1999) stated that general composition of the project team in construction is very clear due to the traditional functional roles required for any project and case study findings also confirmed the fact. Further, empirical findings showed that team selection is again dependant on the factors such as special requirements of the project, experience of the members, qualifications required, availability of human resources, recommendations and workload. These research findings are in line with the Fryer *et al.* (2004). Another thing which is apparent is that these factors act as barriers to consider team roles during the team selection.

4. CONCLUSIONS

This research study focused on how design team selection is done and its consideration to team roles with regard to design teams in Sri Lanka using three case studies. Many authors highlighted the importance of adopting good teamworking practices in construction industry. Accordingly, team role concept appeared in the literature as an important aspect of successful teams. In the case studies, although members believed that having a proper knowledge about concept of team roles would be beneficial to the construction professionals, it was apparent that team members were not properly aware of team role theories. Reason for this may be that, Sri Lankan education system had not sufficiently addressed this area. But, it would be beneficial to the professionals in design teams, if they are better educated about it while they are learning, before entering into the industry. Overall, research problem framework developed through the literature could be described through the empirical findings as given below.

As discussed in Section 3.2, design teams in the construction industry were found to be formed mainly based on the functional roles rather than team roles. Further, team selection was dependant on other factors such as special requirements of the project, experience of the members, qualifications required, availability of human resources, recommendations and workload. These factors are essential in order to provide required technical capacities and knowledge to carry out the required functions by each member. However, these factors could at the same time act as barriers to consider team roles in forming design teams.

The key massage delivered through this exploratory study for construction practitioners is to be knowledgeable on how to select and adjust their team roles depending on the project requirements, functional roles and associated responsibilities as well as, the team setting under which they operate. Similarly, recognising one another's team roles would help members to minimise internal conflicts and allow using the members' talents to the best advantage of the team. Hence, proper awareness on team role concept should be given to professionals working in design teams through education. Also, arrangements within design organisations should be made so as to improve teamworking capacity and successful team role behaviour. The future work of this research aims at exploring current team roles of the members in identifying effect of balanced teams on team performance.

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ELECTRONIC PROCUREMENT SYSTEM: A CASE OF MINISTRY OF WATER SUPPLY AND DRAINAGE IN SRI LANKA

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ABSTRACT

The Ministry of Water Supply and Drainage (MWS&D) has placed the highest priority to provide safe drinking water and adequate sanitation facilities to the community. It is imperative to ensure speed, transparency, Value for Money (VFM), and integrity in all the development spheres to achieve desired result, in line with on time completion, quality achievement, and cost efficiency when procure the goods, works, and consultancy and other services. However, majority of water supply projects of the Ministry have based on the funds from the foreign funding agencies even though, inadequate capacities of existing manual procurement process to work compatible with the funding agencies procurement policy is a critical issue. Accordingly, in this study explored the concept of e-procurement as an instrument to modernise, simplify, and improve the existing manual process.

Case study approach was selected and officers of the each and every profession of the MWS&D, National Water Supply and Drainage Board (NWS&DB), and the registered contractors of the Ministry were selected for collect the data on the existing manual procurement process, gaps, and requirements. Semi-structured interviews and observations were carried out as main data collection techniques. Experienced professionals in the field of procurement were also consulted to ascertain their opinions on verification of the feasibility of the scope of the proposed e-procurement system. Findings of the study analysed and presented by using Content Analysis and Cognitive Mapping.

Results verified the possibility of introducing and implementing the e-procurement system to the MWS&D by using available resources, infrastructure, and capacity with the Information Technology facilities and legal sanction on e-documents under the two phases.

Keywords: *E-Procurement System, Information Technology, Manual Procurement Process, Procurement.*

1. INTRODUCTION

The world has been globalised due to the Information Technology (IT) development. Foreign funding agencies emphasise that the advantages of that development should be utilised by the government organisations in Sri Lanka in order to improve and upgrade the existing manual process with the experience of other developed countries. Hence, in this paper MWS&D tends to explore the existing procurement process, identify the way of upgrading the existing manual procurement process, and further find out the feasibility of introduce and implement of the electronic procurement system for the government organisations as an alternative solution to upgrade the existing manual procurement process. Finally, evaluation was carried out to verify the feasibility of identified scope of propose electronic procurement system to the MWS&D.

Water supply and sanitation is a major responsibility entrusted to the MWS&D. The government's objective is to provide access to clean drinking water and adequate sanitation for all citizens by year 2025. Therefore water supply and sanitation sector has shown continues growth during the last three decades. Hence the government of Sri Lanka continues (GOSL) to take the lead role in the water and sanitation sector by investing on infrastructure development, operations, and maintenance of most of the water and sanitation projects in the country by using the funds from the foreign funding agencies (Corporate Plan of NWS&DB in Sri Lanka, 2007). However existing manual procurement process is the key problem to

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implement the water supply projects effectively and efficiently due to the impacts of poor disbursement of funds as a result of delay in Project implementation (Performance Report of MWS&D in Sri Lanka, 2010).

Therefore, the funding agencies have emphasised that MWS&D should have alternative solutions to overcome the above barriers and expedite the implementation process of the future water supply projects. Hence, there is a necessity requirement to enhance the effectiveness of manual procurement process in the Ministry in order to achieve the desired result. In compatible with that, the significant gaps from the manual procurement process to propose upgraded system are also identified and then explored the feasibility areas for enhance the effectiveness of existing procurement process. Finally e-procurement system is identified as a solution to fulfil the requirement of the funding agencies.

E-Procurement is practically used by not only developed countries but also developing countries such as Thailand, Korea, and Malaysia further numbers of benefits have been utilised by these countries when compared the earlier manual procurement process, on the other hand, rests of other developing countries also (like India) have started to convert procurement system from manual process to e-procurement system with affected from technological development (Bulusu, 2004). Accordingly in the study of World Bank, Procurement Policy and Services Group (2003) explains that in order to being compatible with the World Bank's procurement policy in terms of increase transparency, competitiveness, and efficiency of the procurement process the e-procurement system can be used as an instrument to upgrade, modernise, simplify, and improve existing government procurement procedure in the Sri Lanka.

Thus, in this research MWS&D was selected to identify the suitable areas of the existing manual procurement process which can be converted from manual procurement process to e-procurement system as a solution to strength and upgrade the existing process and further, explore the possibility to improve and upgrade the system.

2. LITERATURE REVIEW

This section provides theoretical background of procurement and e-procurement. Further identifies and describes the relevant theories, specify the gaps in the area, recent advances in the area and practical experience of upgrading the manual procurement process in Sri Lanka (SL) and other countries. Finally, attention draws to explore the impact of e-procurement system as a solution of improve and upgrade the manual procurement process of the Ministry.

Prior to 1900, procurement procedure was recognised as an independent function. Prior to World War I, procurement was regarded as primarily clerical. During World War I and II – the functions of procurement process were increased due to the importance of obtaining raw materials, supplies, and services that needed to keep the factories and mines operating (Wales, 2010). Table 1 illustrates the overview of evolution of procurement process throughout the years.

Table 1: Overview of Procurement

Time Period	Descriptions of findings in Global Context (Wales, 2010)	Time Period	Descriptions of findings in Sri Lankan Context (SL Procurement Guidelines , 2006)
-1900	Procurement used only railroad organisation and few of other organisations	-1997	Procurement process is the part of the activities of the division of the Accounts in the organisation.
1900-1950	Procurement used for obtain raw material, supplies, and services	2006-onwards	Develop the procurement system with the assistance of the funding agencies. Government also identified procurement system as the integral part of the development separation of the economy through the new procurement Guideline of 2006, further consider as the key driver that use all the stages of the project life cycle
1950-1960	Procurement system developed as professional function		
1960-1980	Procurement system developed as purchasing strategy		
1980-1990	Enhance the procurement system as strategic method to the business		
1990-onwards	Procurement system is used as integral part/ method of sustainable development for the organisations		

World Bank (2010) describes that public procurement as the process by the government which buys the inputs for vital public sector investments. In procurement terms those inputs are generally grouped into three categories; civil works, goods, and services. Sri Lankan Procurement Guidelines (2006) state that there are three stages should be followed in the project life cycle in order to complete the procurement process as shown in Table 2.

Table 2: Sub Activities of Procurement

Stage of the Project Lifecycle	Activities of the Procurement Process	Sub activities of the Procurement Process
Planning Stage	Identification Packaging	Estimating demand / preparation of the procurement plan Formulation of the catalogue
Pre Contract Stage	Bidding Document Evaluation	Selection of Bidders Invitation for Bids Issuing of Bid document Request for Bid document Submission of offers Bid opening and Evaluation Award and Modifications
Post Contract Stage	Contract Administration	Contract Management Dispatch Advice Invoicing Payments

E-procurement is the proper advancement of the manual procurement process due to the development of IT hence, refers the literature to identify the overview of e-procurement system and summary of the findings illustrate in Table 3 as follows;

Table 3: Overview of E-Procurement System

Time Period	Description of findings
1990-2000 (e-procurement era)	Introduced e-procurement system in order to remove the administrative cost and bureaucratic traditional parts and items (Bartezzaghi and Ronchi, 2003).
2000-2005	E-procurement system was used to enhance the efficiency of the each stage in the supply chain (Sheth, 2010).
2005- onwards	E-procurement system was used for all the commercial and administrative transactions as an alternative method to improve and upgrade the existing procurement system (Inman, 2010).

The first generation of electronic procurement phenomenon started with buy-side electronic catalogues implemented by software companies like Ariba, SAP, Microsoft Market, Intelisys and Commerce One. This generation refers as e-procurement era. The internet could streamline inefficient procurement processes by removing the manual, paper based, administrative and bureaucratic elements inherent in traditional purchasing systems (Bartezzaghi and Ronchi, 2003). Inman (2010) highlights that e-procurement is the business-to-business (B2B) or business-to-consumer (B2C) or Business-to-government (B2G) purchase and sale of supplies, works and services through the internet as well as other information and networking systems such as Electronic Data Interchange and Enterprise Resource Planning.

Sri Lankan Procurement Guideline (2006) explains that "Procurement Entities if they wish, may carry out procurement activities electronically with the concurrence of the respective Procurement Committees (PC), however, electronic submission of Bids will not be allowed".

2.1. Impacts and Advantages of E-Procurement

In this section carried out the literature survey find out the impacts of e-procurement system to the government sector in order to fulfil the requirements of the funding agencies.

When consider the e-Government Procurement (e-GP) in the world that breaking down the physical barriers of space and time and allows a more transparent and efficient information flow as well as improved access to information and services (Leipold, 2007). Beneficiaries include not only governments and suppliers but also the general public at large in having access to transparent information on the public expenditure of taxpayers' money (Leipold, 2007). Further explains that rather than being a technological improvement on the already complex environment, e-GP needs to be understood as a tool to reform public procurement underpinned by an appropriate policy and legal framework, effective buyer and supplier activation including strong awareness and capacity building programs, technological infrastructure development, established standards, and sustainable operational e-GP applications.

Procurement process depends on number of supportive services. The following Figure 1 illustrates the current situation of electronic commerce in SL as assessed by Lane *et al.*, (2004) in terms of infrastructure, financial, environment and the legal framework due to the reason that these are the top rank supportive services according to the assessment.

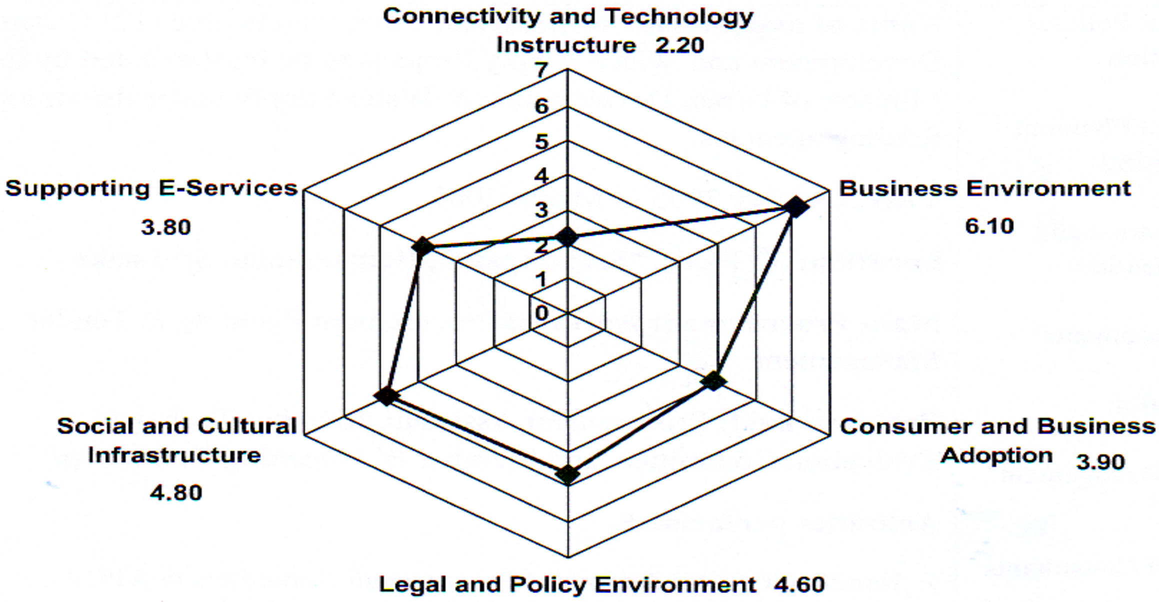

Figure 1: Analysis of E-Facilities in Sri Lanka

Lane *et al.* (2004) further explain that the Sri Lanka, with an overall score of 4.1, would appear to be somewhere below the median in terms of overall e-facilities. By comparison, countries like Sweden and Singapore have high overall e-facilities ranking scores of over 9. Through the above analysis electronic procurement/ commerce were identified as being: low telex density, an outdated legal infrastructure, a poor national communications backbone, prohibitive cost of internet access, a general low usage of e-documents and a lack of skilled human resources, Communication and Technology (ICT) industry in Sri Lanka.

United Nations publication (2006) states that the Thailand Cabinet mandated that all government purchases made after 1stJanuary 2005 follow the e-GP procedure developed by the Department of Controller General of the Ministry of Finance in Thailand. The aim of e-GP is to make the purchasing process more transparent, efficient, and open to a wider range of suppliers. It is expected to take more time to fully implement e-GP nation-wide. The preliminary scope has identified under the two stages illustrate as follows;

- Initial stage of introduce and implement e-procurement system for selected limited number of activities.
- Subsequent Stage implements e-procurement system as a total solution to the manual procurement process.

Corporate Plan 2007-2011 of the NWS&DB (2007) highlights the gravity of the e-procurement system explaining that NWS&DB can achieve their goals and objectives through the e-procurement system with the development of available IT facilities, Human Resources Management (HRM) and other infrastructure.

In summary, the above comprehensive literature survey is carried out to identify the concepts of procurement and e-procurement, advantages and impacts of e-procurement , drivers and barriers to adopting e-procurement in the context of global, Sri Lankan and MWS&D. Finally, identify the ambiguities and the gaps of existing manual procurement process and e-procurement system in order to explore the feasibility areas for introduce and develop e-procurement system in the MWS&D. Therefore, following research methodology was adopted to identify and develop the feasibility areas to initiate the e-procurement system.

3. RESEARCH METHODOLOGY

This section provides the methodology for data collection which was adopted to investigate the existing level of procurement process in the Ministry.

3.1. COMPREHENSIVE LITERATURE REVIEW

Literature survey was selected as a secondary source regarding the generalised details of procurement, e-procurement, definitions, theories, rules and regulations of procurement and e-procurement in the MWS&D, Sri Lanka, and Global context by referring documentaries and researches undertaken by other institutes.

3.2. RESEARCH APPROACH

The case study approach was adopted as a primary source to investigate the existing level of procurement process in the MWS&D. Even though the case study organisation is singular, the study involves two echelons in the procurement process such as government officers and the contractors. This can be classified as an embedded case study design (Yin, 1994). Further, Eisenhadt (1989) explains that case study useful for exploring new or emerging process or behaviour of the organisation. Furthermore, according to the research problem," how to enhance the effectiveness of the existing manual procurement process", suggests that the case study research approach for the study concerned (Yin 1994).

Fifteen numbers of officers were selected as the study profile including the profession of Engineering, Quantity surveying, Architecture, Planning, Contract Administration, Procurement and Project Management, and Accounts to cover all grades of the Ministry and further extended the collection of information up to the opinions of the five numbers of the experts in the field of procurement. As previously mentioned by Yin (1994) adopts the opinions of the experts for the value judgment of the findings and satisfy the quality of the criteria to increase the validity of the findings. Then, based on the opinions of the experts evaluate the feasibility of the scope of the proposed e-procurement system, identify the possibility of introduce and implement e-procurement system, and further explore the opportunities and threats to improve the scope of the propose procurement system.

3.3. ANALYSIS OF DATA AND PRESENTATION OF THE FINDINGS

The analyses of the qualitative data were done through the content analysis. Kuma (2005) explains this is analysis the contents of the data under the main themes that emerge the responses given by the interviewees. However, data displaying capabilities of content analysis is always a problematic issue, even though it enables better interpretation of qualitative data (Miles and Huberman, 1994). Therefore, the content analysis alone is not sufficient and effective in order to overcome these shortcomings. Hence, cognitive maps were selected as data displaying technique which demonstrate the relationships among the data analysis.

Literature review and case study methods were mainly adopted to study the phenomenon of the MWS&D and in addition collect the data through the observations and attending the meetings also. Then, collected data was analysed and presented through the content analysis and cognitive maps to explore the existing procurement process in the MWS&D. Finally, opinions of the experts were reviewed to identify and verify the feasibility of research problems, aim, and objectives.

4. DATA ANALYSIS AND RESEARCH FINDINGS

The aim of this section is explore the existing procurement process in the MWS&D by analysing the data collected through the data collection techniques of literature survey, interviews, and observations further, in detailed discusses on processing and analysing data in respect of the methods of qualitative techniques.

4.1. EXPLORATION OF EXISTING PROCUREMENT PROCESS IN THE MWS&D

According to the findings, existing procurement process could be categorised under the six sub activities first, *registrations of contractors and publication of name list* at present those activities are doing manually. As an example one of the officers in the NWS&DB stated that *"Manual procedure is followed due to the reasons on involvement of number of documentary evidence"* he further added that *"However publication of the name list of the registered contractors have been done by using both method of manual and electronic"*. It was apparent that procurement activities function manually. IT facilities use only for transfer the data from one place to another.

When it comes to the second and third sub activities the *appointment of Procurement Committee (PC) and Technical Evaluation Committee (TEC) members and Preparation of bidding documents,* officers of the MWS&D noted that *"We send formal request for the appointment through the manual procedures with the relevant documentary evidence but appointments have been informed to us by using both method of manual and electronic"*. Officers of the MWS&D further stated that *"Preparation of bidding documents have been done through the manual procedures due to the facts that involvement of number persons, institutes, and documents, however we use IT facilities only for typing and drafting the bidding documents and publications of Invitation for Bids"*.

The fourth function is *collection and submission of bidding documents,* Representatives of the contractors viewed that *"Formal request for collect the bidding document send through manually or electronically but normally we have to collect the document from the Ministry or sometimes they send documents through the post"*. When it comes to the fifth function of *evaluation and clarification procedures,* officers of the MWS&D stated that *"In the Ministry use only the manual evaluation process due to the reason of involvement of the number persons, institutes, clarifications, and documents. Sometimes both manual and IT facilities use for seek clarification but final decision make in line with the recommendations of the ordinary group meetings"*. It was shown that all the critical activities of the procurement process have been done through the manual process.

Consider the final functions of *awarding and contract administration*, representatives of the Contractors pointed out that *"Ministry uses only the manual procedure and we also agreed that because of legal sanction and validity of the documentary evidence for future contract management activities"*.

Thus, it is evident that majority of the present procurement activities have been done manually and usages of IT facilities are limited only for 30% of the activities that are also jointly carried out in parallel with the manual system.

4.2. DRAWBACKS OF EXISTING MANUAL PROCUREMENT PROCESS

Enhancement of the disbursement ratio of the funds is the main concern of the funding agencies and the GOSL, but representative of the contractors noted that *"Delay of the activities in the existing procurement process, more time consuming for the activities, and fraud and corruption involved are the main constrains to achieve the desired result"*. However, officers of the MWS&D argued that *"We were identified that the manual procurement system is suitable for large and complex projects and officers familiar with the system are positive drawbacks of the existing system"*. Therefore, empirical findings apparent that manual procurement process represents the lesser disbursement of funds when compared with the requirement of the funding agencies due to the reasons that delay in activities of the procurement process.

Efficiency of the existing procurement process highlighted all the interviewees as an example officer of the NWS&DB stated that " *I couldn't see the efficiency of the activities in the present procurement system due to the reasons of more time consume for activities, involvement of human errors, repetitive of activities, more documentary involvement, and cost and time overrun"*. It was identified that manual procurement process has shown inefficiency process in the procurement activities due to the facts that unnecessary movements, activities, time, and cost.

Reliability, accuracy, and transparency of the existing procurement activities are the highly sensitive areas for the private sector. As an example representatives of the contractors' stated that *"We can't expect the* *above aspects because existing procurement process involved fraud and corruption practice, human errors, large number of documentary involvement, and lack of knowledge of the officers".* That exposed the lesser reliability, accuracy, and transparency of the existing procurement system due to the above mentioned reasons..

Quality, cost, and time effectiveness of the manual procurement system, according to the views of the representative of the contractors, *"Present manual system take more time for the procurement activities, therefore it will lead to the delay of the procurement process subsequently that will create involvement of fraud and corruption in the system consequence of that quality of the goods and services will be reduced"*. However, officers of the MWS&D emphasised *"Manual Procurement process familiar to the officers in the Ministry"* further added that *"Manual procurement process is the suitable system for the large and complex projects".* It was apparent that existing procurement process not considers the quality, cost, and time effectiveness in the activities of the procurement process due to the reasons that excessive time consuming of the activities.

Considerations of VFM, enhance the competition, and encourage by the funding agency; as an example officers of the MWS&D stated that *"Manual procurement system should be developed and upgraded in order to achieve the desired objectives of the funding agencies".* It was shown that existing process doesn't consider the VFM due to the facts that lesser achievement of economic aspects, efficiency, effectiveness, transparency and accuracy. Hence, the Ministry is willing to improve the process in line with the requirement of the funding agencies.

In the interviews most of the respondents stated that the manual procurement process in the Ministry is lead to more time consuming of the activities in the procurement process, further cost for preparing documents, bidding, and delivering the documents become more expensive and which lead to increase the price of the procured goods, works, and services. Further they highlighted that it will lead to various subsequent bad effects to the final outcome of the projects such as cost overrun, time extension, reduce the reliability and quality, and involvement of bribe and corruption.

Presently, numbers of steps have been taken by the MWS&D in addition to the available basic requirements in order to fulfil the above gaps of the existing procurement process. Therefore, in the next sub sections propose the framework for e-procurement system on the available basic facilities and requirements in the MWS&D.

4.3. PROPOSE THE FRAMEWORK FOR THE E-PROCUREMENT SYSTEM OF THE MWS&D

Analysis of data gathered from the case study and the literature survey were based on proposed frameworks of e-procurement system which consists of key four elements as infrastructure, financial, environment and the legal. Infrastructure focuses on the proposed improvement in IT office facilities, server and user computers, English and IT knowledge of the officers and financial on the propose avenues to rise funding such as donor aids. Environment focuses on enhancing the training and awareness of propose system for both internal and external parties such as end-users and legal covers the IT Act and legal sanction on e-documents. The next sub section discusses the identified barriers based on the opinions of the experts.

4.4. BARRIERS AVAILABLE IN ORDER TO OPPOSE TO THE E-PROCUREMENT SYSTEM

In this subsection explore the barriers available for the proposed e-procurement system through the data collected from the opinions of the experts. It is first necessary to assess the existing levels of office facilities, server and user computers, knowledge about internet and e-mail, English knowledge of the officers, and new technical methods and compare them to optimum needs to build a plan to bridge the gaps within the country. Initially, it should be targeted at the areas of best potential such as particular divisions, departments, sub offices, and selected educational and training establishments of the Ministry and the other relevant organisations within the western province. There is considerable room in the MWS&D for manoeuvring in the establishment of an infrastructure for the above purposes.

4.5. UPDATED FRAMEWORK FOR E-PROCUREMENT SYSTEM

According to the findings of the literature survey in previous sections it was revealed that procedure for upgrade the existing procurement process should be implemented step by step depend on the availability of infrastructure and other facilities. As per the opinions of the experts in the field of procurement the valid IT Act and legal sanction on e-documents are the mandatory requirements for introduce and implement the each and every activities of the e-procurement system. However some activities of the proposed system can be implemented without having valid IT Act and legal sanction on e-documents. Therefore, identified and verified the activities of the proposed e-procurement system that can be carried out through 01st Phase and 02nd Phase as follows;

01st Phase of Introduce and Implement e-Procurement System to the MWS&D

- Publication of Information for Bids (IFB), registered suppliers and other relevant information of the Ministry via the internet, Preparation of Annual procurement Plans of the Ministry via the internet and Integrated Web Based Procurement monitoring system with the Ministry of Public Finance and other departments of the MWS&D.

02nd Phase of the System as a Total Solution to the Manual Procurement Process

- Registration of suppliers, E-Tendering system, Uploading the bidding documents, On- Line request for bidding documents, On- Line Submission of offers, Bid Opening and Evaluation,

  Clarification, On- Line Auctions and Reveres Auctions, Proceed the PC/ TEC meetings and decisions, Notification of Tender Awards/Modifications and Contract Management, Sign of Contract agreement and submission of bonds, Submission of Dispatch Advises by suppliers' and Invoicing, Inception meeting, Interim and final payments, and Request and issue the completion certificates.

When compare with existing literature there is an opportunity to upgrade the existing procurement process as per the fulfilment of the requirement of the funding agencies further that was verified by the experts in the field of procurement also. First stage of new e-procurement system will provides an interactive web base procurement monitoring and management system between MPF, MWS&D, and NWS&DB in combination with the entire ongoing water supply projects in island wide in timely manner. Therefore, introduce and implement first stage of new e-procurement system is cost effective in long run, user friendly, and finally it will lead to the sustainable improvement of the procurement process towards the country development when consider the results of the data analysis.

5. CONCLUSIONS

Literature revealed that the manual procurement process has number of defects and disadvantages to the beneficiaries. Further, the funding agencies encourage the borrowers to upgrade and strength the existing procurement process to overcome the aforementioned defects. Case study findings on the existing procurement process in the Ministry revealed the approaches to upgrade the system and the prevailing gaps of the existing process. It was also ascertained that e-procurement system is the only possible solution in order to upgrade the existing manual procurement process. Then proposed the framework for introduce and implement the new e-procurement system to the Ministry. Finally, evaluation and verification on the feasibility of the scope of the proposed system were carried out through the opinions of the experts in the field of procurement.

Accordingly, outcomes of the study concerned can be summarised as follows,

- Existing Procurement process should be upgraded
- E-procurement system should be recommended as a solution to upgrade the existing manual process in the MWS&D
- Drivers of the proposed e-procurement system should be used against the barriers in order to decide the scope of the proposed e-procurement system
- Proposed model should be implemented under the two stages

It is hoped that this framework will be useful in implementing e-procurement system in similar organisational settings.

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A LITERATURE SYNTHESIS: IS CONSTRUCTION INDUSTRY LOW RESPONSIVE TO CHANGE AND DEVELOPMENT?

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ABSTRACT

Construction faces many challenges, but one of its principle challenges is lack of innovation and research. This research tries to understand why the construction sector is slow to innovate and whether the industry needs to innovate. Further it discusses the role of academia as a prominent researching body in such a change. There are many reasons behind the slow responsiveness of the industry and it has been identified that economical characteristics of construction industry could be a major reason which creates lack of performance-based competition. Further, the inherent characteristics of the construction sector influence this slow innovation. Despite this slowness, there is a need for the industry to innovate with the global challenges taking place in the industry. Academia has an important role to play here in merging academic research to industry development needs. However, academics' choice in research area is mainly driven by the context, availability of funding and personal interest, rather than on industry requirements. It is believed that the Sri Lankan industry could be innovated with the correct cooperation of academia with the evidence from other countries. The PhD research which this research paper is based aims to merge academic research into construction industry requirements to build a better responsive industry. As a preliminary step, this paper reports on the literature findings on whether the industry is slow to innovate and the reasons behind this.

Keywords: *Construction Industry, Innovation, Development, Academic research.*

1. INTRODUCTION

The construction industry faces many challenges. It is considered to be one of the most important industries in the economy. However, construction is different from many other industries with its unique characteristics. Nowadays, one of its principle challenges can be considered as lack of innovation and research which could be generated from the synergies amongst opportunities, capacities, resources and incentives. This paper tries to discuss the level of innovation in construction industry which is an important issue for the development of the sector. The paper gives some evidence to support the hypothesis that construction industry lacks in adaptation of innovation together with some possible reasons for the slow response. Further it discusses on why the industry need to develop with innovation. Finally, it addresses upon what should be the academia's proper response to back-up the industry with academic research to move ahead with innovation happening all around the world.

2. INNOVATION, CHANGE AND DEVELOPMENT AROUND THE WORLD

Innovation changes the world. Innovation can be generated from the synergies amongst opportunities, capacities, resources and incentives. According to Meek *et al.* (2009), countries with robust innovation systems privilege research in a variety of contexts including universities and the private sector. In recent years, the changing external environment has seen some governments place unprecedented emphasis on research as a key motor for national development. This has led to new challenges for research management, and to universities expanding their research links with industry, commerce and government, and the community at large. Further, Laszlo and Laszlo (2002) strengths the idea, the knowledge economy is an emergent reality for many organisations and Nation states, "the wealth of a nation no longer depends on its ability to acquire and convert raw materials, but on the abilities and intellect of its

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citizens" (TFPL, 1999, p.2). This highlights the importance of updating the practical knowledge with the research.

According to Meek *et al.* (2009), innovation in developing countries poses very different challenges, in terms of understanding the process and of building systems for innovation. The lack of investments in research, low success in getting a substantial share of research funds from abroad and not considering themselves being in a position to make the necessary investments and benefit from the increasing opportunities for access to high-quality knowledge are a few key challenges. Further, increased global competition in higher education and research, and the related information systems on "World-Class Universities" and indicators of "cutting-edge" research are more likely to underscore gaps than to motivate the less privileged to 'catch up'. Moreover, transnational education provided or assisted by economically advanced countries might be low in quality, and might exploit those paying for it in many cases; the low- and middle- income countries have limited capacity for reviewing the quality of programmes and preventing the obvious low-quality programmes from spreading on their territory. On the other hand the resource pools for research in many low- and middle-income countries, even if financially sufficient, might be too small to compete with the larger pools of other countries. The programme goals of transnational education programmes and the paradigms of research might be so driven by the perspectives of economically advanced countries that the needs of low- and middle-income countries are neglected or even suppressed is another challenge for developing countries.

The identified background of innovation in common is very much aligning with the specific situation of construction industry nowadays. Especially the challenges for researchers to bringing in development to a specific sector are clearly seen at the construction background as discussed below.

3. PRESENT AND FUTURE OF CONSTRUCTION INDUSTRY

The construction industry is considered to be one of the most important industries in the economy. It interacts with nearly all fields of human endeavours. However, Pathirage *et al.* (2007), discuss that the construction industry is considerably more fragmented than many other industries. As to Toakley and Marosszesky (2003), the end users of the product will ultimately bear the costs through rent, lease or purchase and whose business are beneficially or adversely impacted by the effectiveness of the built infrastructure within which they operate. As a result of combination of process fragmentation, product complexity, poor definition of quality attributes and the "one off" nature of many projects, high level and consistent quality achievement is difficult to achieve both during the design and the construction process and particularly in terms of the whole-of-life performance of completed facilities.

Further, the services offered by the professional organisations are characterised by being highly tacit knowledge intensive in nature, together with wide range of professionals involved, working as an inter-disciplinary team in delivering the construction products (Løwendahl, 2000). In addition, the concept of the knowledge worker (Green *et al.*, 2004) has long been important within the construction industry, which is considered to be one of the labour intensive sectors of the economy compared to other industries.

These issues confirm how vulnerable the construction industry for challenges with its integrated characteristics. Construction therefore faces many challenges at the present and it will be at an increased rate in the future. But one of its principle challenges can be clearly seen as the lack of innovation and research. This is different from many other industries and it slower the innovation and development in construction sector.

4. CONSTRUCTION INDUSTRY RESPONSE TO CHANGE AND DEVELOPMENT

Today, in a highly competitive world, construction organisations need to adapt continuously to complex and changing conditions. With that only they could survive and proliferate through innovation. The internal dynamics of construction organisations must be such that they can respond to change by adapting their structure and orientation to reflect, and be able to respond to change (Steele and Murray, 2004). It is therefore important for the construction industry to move beyond the traditional practices to adopt new practices arising from research and development activities.

One can argue that the standard of innovation in the construction industry is good (MacLeod, 2010). However, major construction industry reviews in the Europe have identified the need for continuous performance improvement (Hughes and O'Rourke, 2009; Fairclough, 2002; Egan, 1998; Latham, 1994). The Latham (1994) report highlighted lack of innovation as being a likely result of low profit levels and clients who insist on a dominance of lowest-price criteria to award contracts. Further in 1998, Egan envisage the requirement of movement for change with committed to improving the delivery of projects and the performance of companies. The movement would be a network through which members could collaborate with each other in developing construction techniques and skills and exchanging ideas for increasing efficiency and quality. Later in 2002, Fairclough emphasised the influence of lack of innovation. R&D is an important driver of innovation. No valid argument was presented to justify the construction industry being any different therefore R&D is as important to the construction industry as any other. But it is not given the same priority as measured in R&D expenditure as a proportion of turnover. However the problem is continuing as to Hughes and O'Rourke (2009), development drives change in the construction sector as research and development (R&D) activities lead to innovation. However, the pace at which these developments are integrated and implemented in the sector is slow. The main barriers to unfolding the potential of these developments are unawareness, knowledge, competences among construction companies, and incentives.

Further, skills agenda is at the heart of current day organisational development. Without sufficient people with the requisite skills, companies will be unable to fulfil their potential for growth. It is difficult and there is a global battle for talent which is becoming more intense. While firms were probably slow to recognise it, the ability to attract, retain and develop skilled people is increasingly a required core competence (O'Donnell, 2008). Outdated skills of professionals in a particular firm will be therefore a strong disadvantage in the highly competitive construction environment. This emphasises the need for updating knowledge of the workers comparatively with the new knowledge generation. As an example, after more than two decades of investment decline, the profile of the engineering and construction industry in South Africa has been enhanced and demand for related human capital and leadership talent has increased. However, Wall and Ahmed (2008), point out that organisations are faced with increasing costs to train employees in today's high technology environment. According to Hall and Sandelands (2009), the primary challenge lies in the development of basic skills, the procurement and development of strategic and professional leadership and the protection of experience.

Further, the statistics on the construction industry strengthens the notion of low responsiveness to the changes as well as the low development rates compared to the other industries (Bettelle, 2010; Sabol, 2007; Koebel, *et al.*, 2004; Fiarclough, 2002). Fiarclough (2002) explains the statistical results of his study which is as another evident for the universally recognised reality that the industry must improve its performance. There are many pressures not least of which is the need for the industry to become more profitable and at the same time, deliver better value for money. This represents a significant challenge to the entire construction community, its processes and technologies, as well as to its clients and customers who must demand buildings whose economics are considered on a whole life basis. R&D has a pivotal role to play here but the effort needs to be carefully focused on those activities in which the industry will invest either out of enlightened self-interest or to respond to the demands of clients and government policy. In a study by Koebel *et al*, (2004) has found out that almost of all types of stakeholders believe it is highly important to adopt new building and construction products, materials, and practices but in actual situation very low percentage of usage was recorded.

In a study by Sabol (2007), has proven that less innovation adaptation as a possible reason for lack of productivity improvement of construction labour forces compared to the other industries. On the other hand, as the project teams rarely remain the same from one project to the next, information flow and methods of innovation diffusion are hindered by constantly changing team compositions and lack of teammate-to-teammate familiarity. Multiple, non-hierarchical teams from different organisations find themselves with little incentive to share knowledge or methodologies as there is lack of information technology developments are adopted by the construction industry. According to Bettelle (2010) the research results on R&D funding, even the volatility accompanying the recession has passed, current economic conditions still remain fragile. The impact of the overall economic climate in 2010 leads to a forecast a modest 2.4% growth forecast for U.S. R&D in 2011. This low growth rate has assumed a likely decline in federal R&D funding in 2011, as many federal agency budgets are likely to be cut over the next year. Hence, the situation of construction research was critical under such circumstances as the fund percentages upon related industry is something already comparatively low.

Research and development (R&D) activities, therefore, important to the construction industry to successfully address the challenges placed upon it and to be competitive (Kulatunga *et al.*, 2009). However, as to Pheng and Hua (2002), there is lack of evidence that construction industry adopts new findings of academic research into their practice as discussed next.

5. CONSTRUCTION INDUSTRY REQUIREMENTS TO DEVELOPMENT AND INNOVATION

With the above background it is clear that the construction sector is slow to innovation. However, before stressing that the industry need to respond to the R&D activities it is important to check whether there will be an important impact upon the construction industry if this R&D is integrated. Therefore this section presents some key advantages of adopting R&D in to the construction sector which have been identified by different researchers in different countries to highlight how the innovation would upheld the construction sector.

Maqsood and Walker (2007), therefore presents an important point, as effective adoption and diffusion of innovation has the potential to increase construction industry productivity. However, according to Sheffer and Levitte (2012), "integral innovations" that involve new interfaces and/or new integration procedures across the boundaries of firms/professions/trades are adopted far more slowly. Mediating this effect, vertical and horizontal integration of design and construction specialty firms involved in integral innovations significantly increase their rates of adoption.

Further by reapplying experience and avoiding the same mistakes, design and construction companies can realise cost efficiency improvements and increased design and performance quality. Thus, knowledge and experience become important intellectual assets. They are an integral part of the value creation process (Le and Bronn, 2007). Hence, such particular input should be included in research studies that aim to develop construction industry.

According to MacLeod (2010), in the construction industry there is a proportion of people who have good to excellent natural ability for innovation and who may have trained with people with such ability. Further, Wall and Ahmed (2008) discuss that it as a key driver in addressing the issues identified in many of the studies has been the recognition that learning and training are key elements in delivering good construction projects.

On the other side, according to Fairclough (2002), it is universally recognised that the industry must improve its performance. There are many pressures not least of which is the need for the industry to become more profitable and at the same time, deliver better value for money.

The global trends in construction sector nowadays, are in number of new different directions. The trends have helped polarise the financial and technical superiority of the developed countries and the corresponding inferiority of the developed countries in the region of the developing ones. Hence different global and Asian development trends suggest that the internal dynamics of construction organisations must be such that they can respond to change by adapting their structure and orientation to reflect, and be able to respond to change (Steele and Murray, 2004).

Further, Brandon (1982) has called for a "paradigm shift" in the research and practice of determining building costs – that was one of the first public pronouncements of the drastic need for radical change in how construction processes are researched and practiced. At that time, it seemed that the terms were not well appreciated, nor the alleged needs, particularly clear. However, in the years since Brandon's call, innovations have taken place and "new paradigms" have appeared but the questions remain of how far it has come – how much has the knowledge developed and to what extent have the methods improved to benefit humankind? (Fellows, 2010; Brandon, 2009).

Barrett (2007) states that Research and Development (R&D) can contribute to finding solutions to the challenges faced by the construction industry and making it highly valued by its customers. According to Kulatunga *et al.* (2005), the contribution from R&D to the development of the construction industry is immense as it enhances the effectiveness of construction organisations and raises the international competitiveness through technological advances and managerial developments. Further, R&D acts as a valuable input for the construction organisation by developing new products, materials, advanced construction processes, to meet the customer requirements and to address the economic, environmental and resource constraints.

These views suggest that it is important for the construction industry to move beyond the traditional practices to adopt new practices arising from research and development activities. Therefore, today in a highly competitive world, construction organisations need to adapt continuously to complex and changing conditions, with that only they could survive and proliferate through innovation.

6. Academic Research into Construction Industry - Possible Reasons for Low Responsiveness from the Construction Sector

According to Ordoñez and Serrat (2009), where efforts to disseminate knowledge products are earnest, low impact is mainly attributable to poor planning and the absence of a dissemination strategy. Traditionally, it is found that the academic researchers and the construction industry practitioners do not collaborate closely in most construction research projects. There is a perception among the construction practitioners that the academic research is more focused on subjects and issues which are not crucial for the construction industry. The practitioners also claim that the academic research results are sometimes inapplicable and impractical to use in real- life construction projects. The researchers on the other hand argue that the construction industry practitioners often do not entertain innovative research ideas which require a major change in the industry practices and procedures. This situation dictates the need to enhance the researcher-practitioner collaboration to conduct research on problems which are vital for the construction industry and to find out adoptable solutions (Azhar, 2007). In addition to this major reason, there are some more other reasons which need to be considered as discussed below.

Jones and Saad (2003, cited Maqsood and Walker, 2007) argue that the construction industry has considerable barriers to accepting innovation in general, mainly due to its culture of conservatism, lack of appropriate leadership, poor learning organisational orientation, lack of investment in people and its timidity in leading the adaptation of new technologies. These issues make it very difficult for the construction industry to make significant inroads to investing in the adoption and diffusion of innovation. Further this is largely driven by technology push rather than demand pull.

One more reason is lack of investment on R&D by the industry. NZCIC (2006) explains this is due to the nature of the way in which the construction services are purchased. As the construction client base is mostly formed out of relatively uninformed owners, there is little premium possible in prices to fund R&D. Many private owners purchase services relatively infrequently and have no interest in the long term viability of the industry whose services they wish to purchase.

Another reason is the industry’s short-term focus on achieving project goals. Observations of Dubois and Gadde (2002) indicate that the industry as a whole is featured as a loosely coupled system. Project success is dependent on the performance of the participants amongst other factors, who are entrusted to execute the project. Due to the complexity, dynamism, and uncertainty of the construction industry, project team is required to deliver high quality projects at lower costs in shorter times (Oyedele, 2010, Sexton *et al.*, 2007).

Lack of training for professionals can be another reason for the slow responsiveness. Practitioners require flexible education and training that complements work place experience rather than distracts from professional obligations. As a result of globalisation and technological development, people have to adapt to a number of changes at a personal and professional level at rapid pace, which increases the need for continuous learning throughout adult life (Reissner, 2005). Hence the lifelong learning is going to be a key requirement for construction professionals. As to Amaratunga *et al.* (2010), it is evident that there is a strong connection between the skills and employability. The more skills and knowledge one will demonstrate the more chances available for him getting employed. Therefore it is important to focus on matching the skills requirements with the level of skills one possesses which could be achieved by lifelong learning. However, even though significant opportunities exist to develop more mature workers already active in the workforce there is little evidence of using technology-based learning applications in construction related postgraduate course provisions (Hall and Sandelands, 2009).

Further, Sexton *et al*. (2007) have identified that the structure of the industry is seen to inhibit innovation. As an example, UK construction industry is predominantly made up of firms made up of less than five people, who have limited capacity to innovate due to their management abilities, limited resources and reduced opportunities for supply chain driven innovation because of their inability to form long-term relationships with other firms. Moreover, the adversarial culture of the industry which ushers in detrimental short-termism and opportunism manifest in procurement arrangements between project team participants. The net effect of this is that construction firms are commonly characterised as being conservative, risk averse, invest little in research and development, and look to suppliers to be the stimulus of innovation.

These reasons in total have made the construction industry less responsive to innovation. Next section tries to explain whether the industry really needs to do better, amidst its slow innovation and barriers to innovation.

7. RESPONSIBILITY OF ACADEMIA IN PROMOTING SECTOR DEVELOPMENT

The need for sharing knowledge between research institutions and industry has become increasingly evident in recent years. According to European Commission (2007), historically research institutions were perceived as a source of new ideas and industry offered a natural route to maximising the use of these ideas. However, the past decade has seen a significant change in the roles of both parties. Many companies are developing open innovation approaches to (R&D), combining in-house and external resources, and aiming to maximise economic value from their intellectual property, even when it is not directly linked to their core business. In particular, they have begun to treat public research as a strategic resource. In parallel, it has become clear that research institutions need to play a more active role in their relationship with industry in order to maximise the use of the research results. This new role requires specialist staff to identify and manage knowledge resources with business potential, i.e. how best to take a new idea to market, ensure appropriate resources (funding, support services, etc.) to make it happen, and to obtain adequate buy-in by all stakeholders.

Learning and knowledge sharing are essential drivers of innovation in order to sustain long-term competitive advantage of organisations. In a study of Sparrow *et al.* (2009), it has been identified that much of the research and practice of university-industry interaction is rooted in transfer of research expertise from universities to industry. Communicating research outcomes lies at the heart of academic endeavour, because it contributes to improved knowledge and understanding and guides further research. However, the bigger the project and the higher the level of the degree, the more likely it is that research outcomes will be worth communicating beyond the basic requirements to the broader research community. This may be beneficial to both the advancement of research in the particular field of interest and to the academic careers of the research graduates (Hays, 2007).

On the other hand, academia has an interest in fashionable management concepts since they have high practical relevance (Dean and Bowen, 1994). The popularity of fashionable management concepts in fact contrasts with academic discourse, which is virtually ignored by practitioners (Hambrick, 1994). Therefore, the relationship between academic discourse and popular management concepts is tense; possibly even antagonistic (March, 1991).

However at present, relationships between academia and industry are increasingly intimate and commercial. While opportunities are created for each partner, there are also important conflict of interest issues. Particularly challenging is ensuring that universities maintain their traditional role in public science while partnering with a commercial entity with a tradition of proprietary science (William *et al.*, 2004).

8. SUMMARY AND WAY FORWARD

The construction industry faces many challenges. It is considered to be one of the most important industries in the economy. However, construction is different from many other industries with its unique characteristics. Nowadays, one of its principle challenges can be considered as lack of innovation and research. Innovation can be generated from the synergies amongst opportunities, capacities, resources and incentives. Countries with robust innovation systems privilege research in a variety of contexts including universities and the private sector. Product and process development and innovation allows companies to gain competitive advantage, attract new customers, retain existing customers, and strengthen ties with their distribution network. This means that it is important for the construction industry to move beyond the traditional practices to adopt new practices arising from research and development activities. The internal dynamics of construction organisations must be such that they can respond to change by adapting their structure and orientation to reflect, and be able to respond to change. However significant evidence could be given from the industry to support the argument that the industry is slow in innovation adaption. At the same time, it is argued that the construction industry has considerable barriers to accepting innovation in general, mainly due to its culture of conservatism, lack of appropriate leadership, a poor learning organisational orientation, lack of investment in people, poor planning and the absence of a dissemination strategy, lack of investment on R&D by the industry, industry's short-term focus on achieving project goals, lack of training for professionals, limited capacity to innovate due to their management abilities, limited resources and reduced opportunities and its timidity in leading the adaptation of new technologies as some exemplary reasons for the slow responsiveness. The need for sharing knowledge between research institutions and industry has become increasingly evident in recent years. However, relationships between academia and industry are increasingly intimate and commercial. While opportunities are created for each partner, there are also important conflict of interest issues. A collaboration where the interests and values of each partner were articulated in advance and conflict of interest issues were resolved before legal and business arrangements were established in a contract is the correct path to head off. Even though the construction industry of Sri Lanka appears to be less pensive to the innovation, it could be put in to the correct track with correct changes happening in both sides: academia and the industry. Developed countries provide evidence for possibility of the identical scenario.

The focus of this research therefore is on merging of research and practice to create a better responsive construction industry for Sri Lanka. The "gap" referred here as the "slow responsiveness to change" has been identified with the reasons coming from both the academic side and the industry side. Hence, the academics and practitioners are both under pressure with the challenges they face. Academics are challenged when trying to implicate the research in to the practice especially as the research are in two directions as pure and applied. Moreover, the industry is having the challenge of moving away from the traditions and to go ahead with current development trends. Research and development therefore will be the key in addressing this issue. However, there are also some difficulties in terms of funds and the researching ability. This urges the need of merging the research and practice which will be the way forward. In merging the research and practice there are some critical requirements to be addressed with the preliminary requirement of developing relationships between researchers, funders and the practitioners. The forecast here is that, a success in merge will end up with a better responsive construction industry for Sri Lanka, which is strongly backed with knowledge created though academic research.

Hence this research aims to explain how to merge academic research and industry development requirements to have a better responsive construction industry practice in Sri Lanka.

In order to achieve the aim, the objectives have been set as follows;

- Explore the nature of researches undertaken by construction related academics in Sri Lanka.
- Explore the construction industry development requirements in Sri Lanka.
- Explore the current link between academic research and industry practice with the reasons for existing gap.

- Develop guidelines to merge academic research with industry development requirements.

The aim with these objectives will be explored through a “mixed research method.” As a research method, the mixed method focuses on collecting, analysing, and mixing both quantitative and qualitative data in a single study or a series of studies. As Cresswell, (2006) explains, its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than one approach alone. Surveys will form a part of the mixed method which will be followed here, which is discussed by Fowler (2008) as a method with the purpose to produce statistics, that is, quantitative or numerical descriptions about some aspects of the study population. In order to meet the first two objectives therefore two opinion surveys will be carried out. According to Yin (1994), case study is an in-depth inquiry in its real setting that offers an explanation, exploration or description based on the case study actors, when the boundaries between the phenomenon and the context cannot be separated. Hence, a case study will be followed to achieve the third objective of the research. Based on the findings of the first three objectives, the final objective will achieved at the end. Data which are to be collected based on this mixed method will be analysed scientifically. Conclusions will be to be made thereafter with the use of findings and a guideline will be developed to direct researchers and practitioners to create a better responsive construction industry for Sri Lanka.

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DOES "FRONT-END PLANNING" WORK FOR THE SINGAPORE CONSTRUCTION INDUSTRY?

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ABSTRACT

While technology advancement resulted in a spiral increase of complexity in construction projects, it tends to be unmatched with an equal increase in planning effort, especially at the pre-construction stage. Front-End Planning (FEP) is relatively new to the Singapore construction industry and its importance is not well recognised. As a result, this study aims to identify the implementation status of FEP in the Singapore construction industry and to analyse its impact on project performance, in order to encourage more organisations to practice and benefit from it. A questionnaire was developed and 327 projects from 27 companies were investigated. The analysis result revealed that about 40% of the companies and projects surveyed practiced FEP. In addition, the analysis reported that FEP can reduce project schedule and cost by up to 15%. Recognising the implementation status and impacts of FEP will be a starting point to improve project performance and to better manage projects, ultimately allowing the Singapore construction industry to significantly increase opportunities for project success.

Keywords: *Front-End Planning, Project Performance, Construction Industry, Singapore.*

1. INTRODUCTION

Project planning provides a common reference point that is a basis for monitoring, control and corrective action (Githens and Rosenau, 2005). While professionals in the construction industry understand the need for planning, it has not been well materialised due to the fact that changes to original plans are inevitable. As such, making a significant effort for planning tends to be considered a challenging process as it also requires vast capital, human resources and time. Under this assertion, a need exists to increase the understanding of the benefits that FEP can bring in construction projects as importance of FEP tends to be neither well recognised nor emphasised in Singapore. More than often, people in the Singapore construction industry perceive that rare value is found in project planning, and they give such excuses that "We do not have sufficient time to plan now, and we will have lots of time to fix things up later." This must be a misconception that should be corrected as changes that occur in the later part of a project would be more costly and time-consuming than in its initial stage.

Therefore, the objectives of this study are: (1) to investigate the status of FEP implementation in the Singapore construction industry; and (2) to explore the impact of FEP on achieving project schedule and cost objectives. Recognising the implementation status and impacts of FEP will be a starting point to better manage projects, ultimately allowing the Singapore construction industry to significantly increase opportunities for project success.

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2. LITERATURE REVIEW

2.1. FEP DEFINITION

FEP is the process of developing sufficient strategic information with which owners can address risk and decide to commit resources to maximise the chance for a successful project (Gibson, 1995). FEP was identified by Construction Industry Institute (CII) as an area deserving study due to its place in the construction life cycle and its potential for increasing project cost effectiveness and productivity. According to Gibson (1995) the term FEP is often used synonymously with pre-project planning, front-end loading, feasibility analysis, programming and conceptual planning ("It should be noted that one of these synonyms for FEP, front-end loading, is frequently associated with a negative practice related to contract progress payments. The negative practice involves estimating an artificially high earned-value for the early activities in order to improve the cash flow and collect the profit at the beginning of the project. However, this term is widely used in planning and execution in the industrial projects sector to stress the fact that the early activities in a project actually do have a high value and will have a lasting effect on the project" (Griffith and Gibson, 2001)). Gibson (1995) also defined FEP as the process of creating, analysing, and evaluating project alternatives during the early planning phase to support a decision whether or not to proceed with the project and to maximise the likelihood of project success.

As efforts made in the early life cycle of a project can have a greater influence on the project outcomes than those made later, the goal of FEP is to better define the scope of work of a project in order to meet both owners' expectations and project requirements in terms of budget, time, and performance. The ability to execute the planning effort with the right team and the right dedication of resources is paramount to project success (Gibson, 1995).

2.2. FEP PROCESS

FEP requires multiple analysis perspectives. It is not a job of just one person, but multiple parties who provide inter-related project information. For instance, when estimating construction cost, the quantity surveyor requires a description of the project scope prepared by the architect as defined by the client, indicating that outputs from one party become inputs for another. It is usually a project manager or a project planner who will get advice from various consultants and specialists (engineers, architects, quantity surveyors, etc.) to direct processes of FEP. He/She must consider all possible project alternatives to identify an optimum project configuration.

According to Gibson *et al.,* (1993), the process of FEP can be divided into four main steps (1 - organise for FEP, 2 - select project alternative(s), 3 - develop a project definition package, and 4 - decide whether to proceed) and it is depicted as shown in Figure 1.

The first step is to select a team for FEP. Teamwork and communication are critical to the FEP process. When organising for FEP, a multi-disciplinary team consisting of appropriately skilled and experienced personnel is required. This means that operations, business, project management, technical, and, if applicable, key consultant personnel must be closely involved in FEP in the early process. All pre-project personnel involved in the process need to understand what activities occur, and what their roles and responsibilities are in the process (Gibson *et al.*, 1994). Gibson *et al.* (1994) further argued that for FEP to be successful, team continuity is necessary, and the team must be cultivated through team building and open communication. The project, business, and operations managers need to understand that they have different views concerning project success and project objectives. These views need to be communicated, and project representatives should agree on project objectives. This agreement can be achieved through project objective setting exercises during FEP that considers corporate guidance, and the views of project managers, business managers, and operations managers. It is important that the corporate goals and guidelines for FEP are well defined. Other factors such as poor business decisions, unreliable data, or other assumptions can also affect the success of the project. These factors should be addressed in FEP if possible.

In the second phase, the qualified teams of skilled and experienced personnel verify inputs to the FEP process, conduct analysis, and make recommendations to the decision makers. The technical requirements of the project are also identified. This includes the identification of license agreements, testing procedures, and any security/secrecy requirements that may be needed for the project.

The third phase would include one of the key tasks of FEP – to develop a detailed scope definition for the project. Project scope definition, the process by which projects are selected, defined and prepared for definition, is one key practice necessary for achieving excellent project performance (Merrow and Yarossi, 1994). Extraordinary risks are many times the result of unresolved scope issues or unforeseen conditions (Smith and Bohn, 1999). Poorly defined scope definition elements are identified during the Project Definition Rating Index (PDRI) evaluation process and should be treated as potential risk factors that might cause negative impact to project outcomes. It is also important that the FEP team expand the resources necessary to insure a well-defined project scope before an authorisation decision is made. In addition, a comprehensive project execution plan should be developed to carefully identify how the project will be executed.

The last stage of FEP would be to carry out feasibility studies on the project to assess the viability of various options and present alternatives and thus to decide whether or not to proceed with the project. These studies typically consider: building use; business justification; business plan; economic analysis; facility requirement; future expansion or alteration considerations; site selection considerations; and project objectives in order to address the mission need (Federal Facilities Council, 2003).

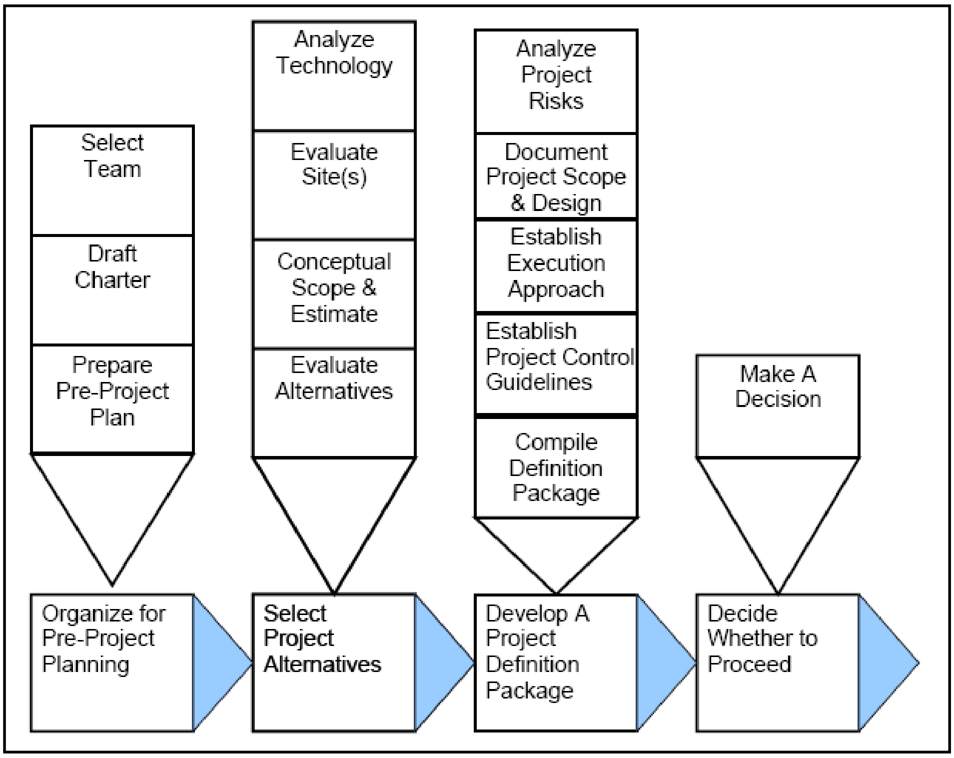

Figure 1: Front-End Planning Process (Source: Gibson *et al.*, 1993)

2.3. FEP BENEFITS

Several researches (Cho, 2000; Clarke, 1999; Gibson, 1994; Gibson *et al.*, 1994; Hartman and Ashrafi, 2004; Smith and Bohn, 1999) argued that FEP is a key element to improve project performance, increasing the likelihood of overall project success. Cleland and Ireland (2002) identified that decisions made early in the project process will, "…set the direction and force with which the project moves forward as well as the boundaries within which the work of the project team is carried out." Figure 2 depicts the conceptual relationship between influence and expenditure in a project life cycle.

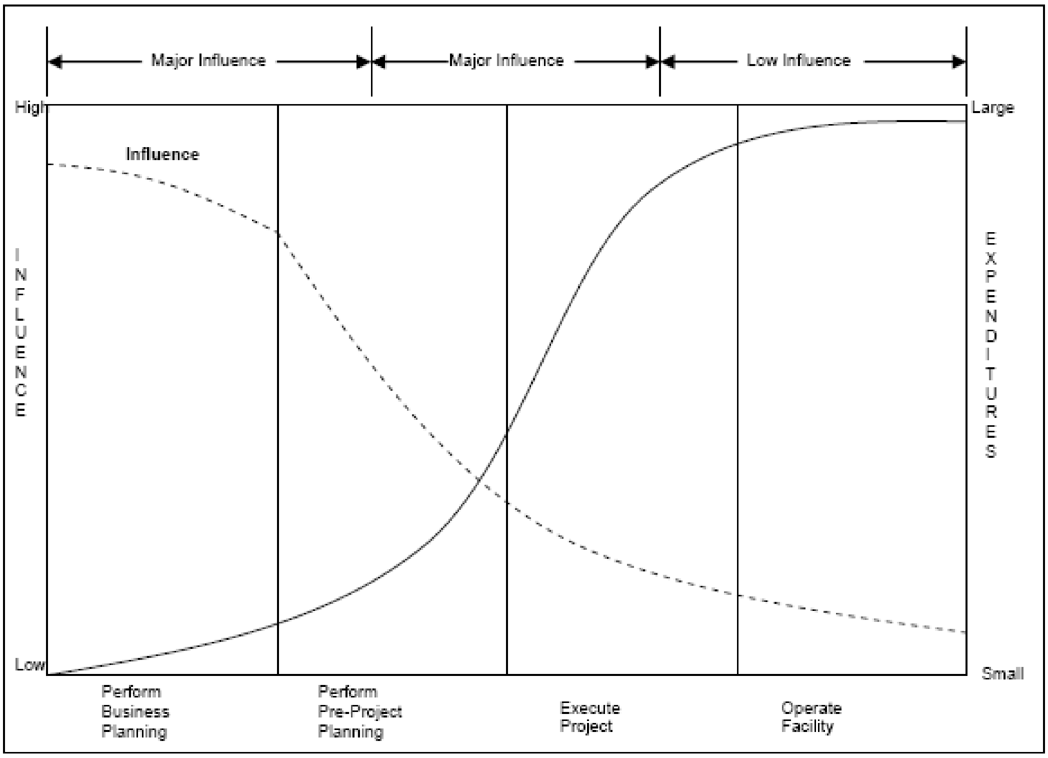

Figure 2: Influence and Expenditure Curve for Project Life Cycle (Source: Gibson *et al.*, 1994)

The curve labelled "influence" in Figure 2 reflects a company's ability to affect the outcome of a project during various stages of a project. The curve indicates that it is much easier to influence a project's outcome during the project planning stage when expenditures are relatively minimal than it is to affect the outcome during project execution or operation of the facility when expenditures are more significant (Gibson *et al.*, 1994). Experienced personnel within the construction industry believe that planning efforts conducted during the early stages of a project have much more effect on the success of the project.

Furthermore, FEP allows the project team to have greater influence over the project. Many potential problems are identified proactively before they can greatly affect project cost and schedule. Also, successful planning identifies which areas within the project need greater definition prior to execution. As the project enters the execution phase, the team has less influence to make low cost changes over the project (more costly to implement changes on the project). Figure 2 also illustrates this and the research done by Gibson and Hamilton (1994) also supports this relationship, arguing that more effort in project planning results in more successful projects.

Furthermore, according to Gibson *et al.* (1994), there is a positive co-relationship between the level of effort made for FEP and success rating for each project, as shown in Figure 3. Enhanced preparation can reduce the amount of change orders, misunderstandings, litigation and delays during project execution. Many studies have shown that poor project planning leads to large numbers of claims due to project specification and contractual incompleteness, and consequent adjustments, resulting in significant cost increases for the owners (Walrath, 2007).

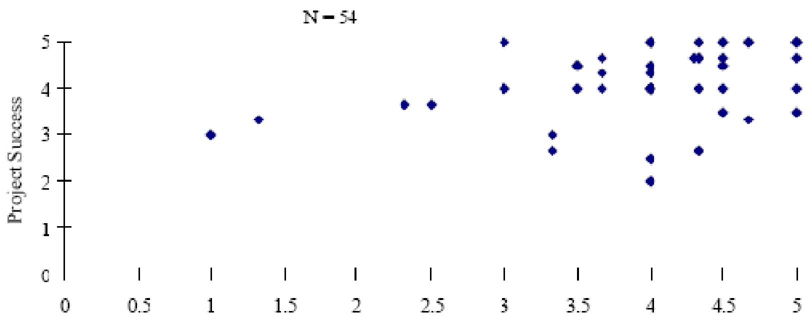

Figure 3: FEP Effort vs. Project Success (Source: Gibson *et al.*, 1994)

Some practitioners may argue that the amount of detail required for FEP increases project time and cost. However, such an assumption is considered as counterproductive. It may be true that time and cost may be up at the first instance of implementation, but from then onwards, the process would continue to improve performance, ultimately saving time and cost. Several experiences have shown that an investment in effective planning is fruitful and recording of achievements offers opportunities for improvement (Gidado, 2004). Good FEP can also reduce project complexity and project risk while project cost and schedule performance can be improved by 20% and 40%, respectively (Gidado, 2004; Gibson and Hamilton, 1994). More benefits that can be generated by the implementation of FEP have been identified by Walrath (2007) as follows:

- To alleviate information asymmetry between project partners;
- To ensure proper handling of the negotiation process and resolve intermediary agreements;
- To share the planning burden between involved project partners;
- To achieve a clear, optimised allocation of planning tasks to the proper, most proficient resource across organisations;
- To guarantee timeliness of invoking planning events and comprehensiveness of planning outcomes;
- To avoid an ad-hoc approach to contract definition;
- To foster knowledge retention across recurring projects within organisations;
- To enable industry-wide diffusion of best practices, thus increasing quality and productivity in Architecture, Engineering and Construction (AEC); and
- To increase transparency and mutual understanding of project expectations.

2.4. IMPLICATIONS OF FEP IN SINGAPORE

As every project in the construction industry is different and unique, different levels of planning are required for each endeavour and there is likely no single correct approach to planning a project and choosing the level of detail needed. While many studies discuss the implementation of FEP and its resulting benefits, these issues have been rarely explored in the context of the Singapore construction environment. According to Statistics Singapore (2009), the value of construction contracts to be awarded in 2011 and 2012 would be between S$21 billion and S$27 billion in 2011 and between S$18 billion and S$25 billion in 2012. Such a magnitude of capital expenditure confirms that the construction industry is one of the main pillars supporting economic growth and vitality in Singapore. Under this assertion, with recognition of the active utilisation and successful implementation of FEP in the U.S. construction industry, this study first explores the implementation status of FEP in the Singapore market, then quantifies its importance and impact on project outcomes in the local context in order to apply the lessons learned to the Singapore construction industry.

3. RESEARCH METHODOLOGY

This study was done by completing two major phases. The first phase was to carry out a comprehensive literature review to establish a foundation for this study and develop a survey questionnaire that could collect data to be analysed for achievement of the objectives stated before. As the second phase, a survey was conducted with representatives from companies registered in the Building and Construction Authority (BCA), which is an agency under the Ministry of National Development in Singapore.

The questionnaire consisted of three main sessions. The first section captured the profile of respondents, companies and projects that the companies had performed for the past three years. The next section was composed of questions that could diagnose the status of FEP implementation in the reported projects as well as in the companies. Lastly, the impact of FEP implementation on project cost and schedule was quantified.

The data collection effort produced 27 completed questionnaires from 27 different companies. The survey required each participating company to complete the questionnaire by assigning a representative with sufficient knowledge and experience in the operations and work processes of the company. In total, respondents provided data on the outcomes of 329 projects. The profile of the companies and respondents is summarised in Table 1. The characteristics of the projects investigated for this study are provided later in Table 2, with the information of whether or not the projects implemented FEP.

Table 1: Profile of Companies and Respondents

Characteristics of Companies		N	%	Characteristics of Respondents		N	%
Work Type	Quantity Surveying	2	7%	Job Title	Managing Director	19	70%
	Project Management	2	7%		Project/Construction Manager	5	19%
	Construction Contractor	23	86%		Project Engineer	2	7%
					Not Specified	1	4%
Tendering Limit	Unlimited	5	19%	Years of Experience	Less than 10 years	8	30%
	Up to S$40 million	9	33%		10 - Less than 20 years	17	63%
	Up to S$4 million	13	48%		20 years and above	2	7%

4. PRELIMINARY FINDINGS

4.1. CURRENT AND FUTURE IMPLEMENTATION OF FEP

The survey result revealed that at the company level, 12 companies (44%) out of the 27 companies surveyed practiced FEP while 131 projects (40%) out of a total of 329 projects were completed with implementation of FEP.

Table 2: FEP Implementation Status at the Project Level

Chracteristics of Projects		No. of Projs.	FEP Implemented		FEP Not Implemented	
			No. of Projs.	%	No. of Projs.	%
Type	Building	247	112	45%	135	55%
	Infrastructure	47	3	6%	44	94%
	Industrial	35	16	46%	19	54%
Size	Less than S$5 million	277	119	43%	158	57%
	S$5 - Less than S$15million	39	12	31%	27	69%
	S$15 - Less than S$50 million	11	0	0%	11	100%
	S$50 million and above	2	0	0%	2	100%
Nature	Addition	163	53	33%	110	67%
	Grass roots	81	5	6%	76	94%
	Modernization	85	73	86%	12	14%

According to the three major project types as shown in Table 2, FEP was implemented more to building (45%) and industrial projects (46%) than infrastructure projects (6%). Here, building projects include those of high rise offices, schools, hospitals, hotels and retail. Infrastructure projects include highways, roads, rails, tunnelling and bridges. Industrial projects include oil refinery, pharmaceuticals manufacturing and consumer products manufacturing. For building projects, requirements of users, for example, tend to be of top priority and thus planning should be done early to ensure that these needs will be met as the project proceeds. As for industrial projects, one of the reasons for doing more FEP might be due to the importance of long-lead items. Also, space for plants and major engineered equipment needs to be carefully planned to ensure optimal usage of the space as well as efficient arrangement of mechanical and electrical systems.

According to the different cost categories as presented in Table 2, it is of interest that the projects costing less than S$5 million implemented FEP more than the larger projects in terms of the total project cost. This is contrary to the belief that projects in larger scale may have a higher tendency of FEP implementation. One possible reason for the result might be the unbalanced sample size of the category. Nevertheless, this result proves that FEP can still be used for even small projects if it can help to increase the chances of project success.

Next, projects were investigated by their nature, namely Addition, Grass roots and Modernisation. Addition projects are those that include a new addition that ties in to an existing facility, often intended to expand capacity. Grass roots projects include a new facility from the foundations and up or a project requiring demolition of an existing facility before new construction begins. Modernisation projects are those that include a facility for which a substantial amount of the equipment, structure, or other components is replaced or modified, and which may expand capacity and/or improve the process or facility. As shown in Table 2, the highest percentage of FEP implementation was reported in the modernisation category. This might be due to the nature of modernisation projects that disruption to both users and production lines should be minimised to ensure continual operations. This may apply similarly to addition projects. While it was unexpected to observe less implementation of FEP into the grass roots projects, this might be due to the small sample size of the relatively large projects that tend to be grass roots project.

Respondents were also asked to assess the possibility of future implementation of FEP and the result is presented in Figure 4. Majority of the companies felt that there would be a future for FEP when the industry is educated on its benefits. However, there was one particular contractor who was uncertain about it and he felt that companies might not consider practicing FEP in their projects as it was more necessary for big projects consisting of several trades that have to be better coordinated and performed. The contractor reported that in small projects, works were direct and standardised, involving minimum coordination. Thus, procedures of works are most likely to be kept simple. As such, implementation of FEP may be irrelevant.

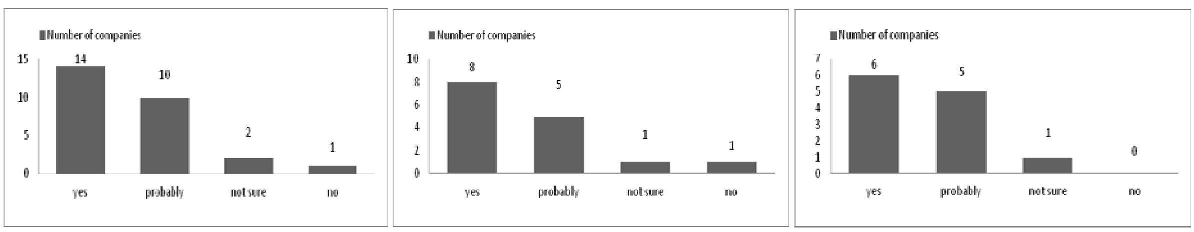

Figure 4: Future Implementation of FEP

4.2. *THE IMPACT OF FEP IMPLEMENTATION*

Following the analysis on the implementation status, the impacts of FEP on schedule reductions and cost savings were investigated. As the impacts were measured as percentage of schedule reductions and cost savings, the respondents were required to compare the planned budgets and durations of their projects with the actual costs and durations, respectively.

Table 3: The Impact of the Challenges on Project Performance

% of Schedule Reduction	All Companies			Companies Implementing FEP			Companies Not Implementing FEP			% of Cost Saving	All Companies			Companies Implementing FEP			Companies Not Implementing FEP		
	N	%	Mean	N	%	Mean	N	%	Mean		N	%	Mean	N	%	Mean	N	%	Mean
0%	6	22%	5.1%	2	17%	5.8%	4	27%	4.5%	0%	4	15%	5.7%	1	8%	6.1%	3	20%	5.4%
1%-5%	8	30%		3	25%		5	33%		1%-5%	9	33%		5	42%		4	26%	
6%-10%	11	41%		6	50%		5	33%		6%-10%	11	41%		4	33%		7	47%	
11%-15%	2	7%		1	8%		1	7%		11%-15%	3	11%		2	17%		1	7%	
>15%	0	0%		0	0%		0	0%		>15%	0	0%		0	0%		0	0%	

As shown in Table 3, ten out of the 12 companies that practiced FEP indicated that they could reduce their project durations by up to 15%, which is a bit low when compared to the 30% and 22% reductions claimed by CII (2010) and Ray *et al.*, (2006), respectively. As FEP can help to clearly define project scope, systematically identify potential risks, and effectively minimise changes, delays can be avoided and project schedules can be reduced.

In the case of cost savings, 11 out of the 12 companies implementing FEP reported that they could save project costs by up to 15%, with an average of 6.1%. CII (2010) argued that a maximum of 20% of total project design and construction costs might be reduced while the research done by Ray *et al.* (2006) reported that FEP can reduce the total costs of building projects by a maximum of 2%. Although previous studies report different levels of cost savings, this result provides positive evidence that should be used to encourage more industry players to implement FEP.

5. SUMMARY AND RECOMMENDATIONS

This study aimed: (1) to investigate the status of FEP implementation in the Singapore construction industry; and (2) to explore the impact of FEP on achieving project schedule and cost objectives. In general, about 40% of the companies and projects surveyed for this study practiced FEP. More specifically, at the project level, building and industrial projects tended to have higher implementation of FEP as compared to infrastructure projects. Modernisation projects in nature were also reported to have higher percentage of FEP implementation when compared to addition and grass roots projects. While the current implementation status in Singapore was relatively low, a potential for active implementation of FEP in the future was perceived through the survey. Furthermore, the analysis identified that FEP can reduce project schedule and cost by up to 15%.

Although the objectives of this study were achieved as summarised above, future studies are warranted. First, most of the respondents are from construction contractor firms and thus the results from the survey may represent more of contractors' perspectives on FEP. Considering that FEP tends to be driven by owners, perspectives of owners in implementing FEP should be investigated. Also, the projects investigated in this study are relatively small in terms of their size and more number of the building projects were analysed. Including large projects that probably require more planning effort will contribute to drawing solid conclusions. A balanced sampling among various types of projects will also be able to overcome the limitation of this study. Furthermore, the impact of FEP implementation on other project outcomes such as quality improvement and risk reduction should be further explored to better understand benefits of FEP.

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SUSTAINABLE PROJECT MANAGEMENT FOR GREEN CONSTRUCTION: CHALLENGES, IMPACT AND SOLUTIONS

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ABSTRACT

With augmenting cognizance of environmental issues and growing concern over climate change, sustainable construction is gradually put forth globally. However, construction of green buildings in Singapore still encounters impediments as there is a lack of proper project management framework for such projects. Based on the survey and interview results from 31 industry experts, this study aims to identify common challenges encountered during management of green construction projects and their impact on project performances, ultimately proposing some solutions to overcome the barriers. Findings from this study are: (1) main dissimilarities between conventional and green construction projects exist, especially in the level of details and communication required; (2) there is no paucity in sustainable knowledge in the Singapore construction industry; however, challenges against implementation of the knowledge exist, influencing project performances, and the lack of investment on management of green building construction is the most paramount barrier; and finally (3) to overcome the barriers, a project management framework for green building construction should be developed, possibly promoting adoption of sustainable management approaches for future green building projects.

Keywords: *Green Building, Sustainable Development, Project Management, Singapore.*

1. INTRODUCTION

In Singapore, buildings contribute 16% of the nation's total energy consumption and the energy cost can constitute about 20% to 40% of the total operating cost (IMCSD Committee, 2009). According to Perez-Lombard *et al*., (2008), both commercial and residential buildings are responsible for 20% to 40% of the world's energy consumption. With the recent mounting global concern of the negative impacts of human activities on the environment, almost all industries are steering towards sustainable development and implementing green measures (Gunawansa and Kua, 2011; Kua, 2011). The building construction industries from various countries have taken these 'green measures' in their strides, putting strong accent on green building construction (Hwang and Tan, 2010). In line with this trend, Singapore has also shifted its focus in making sustainable development a key national priority (Singapore Green Building Council, 2009; Lutchmeeduth *et al.,* 2010).

According to the Building and Construction Authority of Singapore, since the launch of the Green Mark Scheme in 2005, the number of green mark certified buildings in Singapore has increased to more than 750 from the mere 17 buildings in 2005 (BCA, 2011). To promote environmental sustainability in buildings, the BCA had also formulated the 1st and 2nd Green Building Masterplan together with other efforts to thrust forward in developing more green buildings in Singapore. By year 2030, through BCA's 2nd Green Building Master Plan, the Inter-Ministerial Committee on Sustainable Development (IMCSD) targets to have at least 80% of the buildings in Singapore to achieve the BCA Green Mark Certified rating (BCA, 2009b).

Under this circumstances, the specific objectives of this study are: (1) To compare design, construction, and commission stages between conventional and green building construction projects based on a

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comprehensive literature review; (2) To investigate common challenges that project managers encounter while managing green building construction projects; and lastly (3) To propose some plausible solutions for improving the current green construction project management. The findings from this study will contribute to more intensive and effective implementation of green building construction in Singapore.

2. GREEN BUILDING CONSTRUCTION

2.1. DEFINITION

The construction of green building is part of sustainable construction. According to Kibert (2008), sustainable construction addresses the ecological, social and economic issues of a building in the context of its community. Sustainable construction is applied throughout the entire life cycle of construction, from preconstruction to disposal of the building. Such construction aimed to reduce the impact of the construction practice on the environment through its planning and managing of a construction project complying with the contract document (Glavinich, 2008).

2.2. GREEN BUILDING DESIGN

Green building design can be more complicated than what is typically required for conventional buildings, considering that evaluation of alternative materials and systems is commonly necessary by the design team (Glavinich, 2008). In conventional building projects, schematic designs that consist of simplified and general concept of how buildings will be like, is being used at the beginning of the project process (iiSBE, 2009). However, in green building projects, a holistic and integrated design process is being used right at the start of the project as green buildings have many unique design features not typically found in conventional building and requires deep integration (Kibert, 2008). The cardinal green building design features are divided into three broad categories – namely indoor lighting, building materials and layout (Yudelson, 2008). In a green building, the lighting design integrates low-energy lighting fixtures with natural lighting through strategic window installation and usage of energy-efficient fluorescent lighting (Yudelson, 2008). Environmental friendly building materials, such as recyclable bamboo flooring, as well as toxic free materials, such as formaldehyde-free cabinets and non-toxic paint, are used in green buildings to ensure that they are sustainable (Yudelson, 2008). Building layout plays a significant role in ameliorating energy efficiency of the building. Green buildings also take advantage of natural ventilation through the building's orientation (Yudelson, 2008).

2.3. CONSTRUCTION OF GREEN PROJECTS

Other than conventional construction procedures, green building projects have to implement sustainable construction practices, which are usually listed in green building rating systems such as LEED. One example of such practices is a waste management plan (CIRIA, 2001) to minimise waste generation on the construction site (Kibert, 2008). A green building construction also have to adopt sustainable practices such as using recycled aggregates for concrete work and using timber which are from renewable sources (CIRIA, 2001). In addition, the main contractor and project manager have to ensure that pollution from the construction is kept to the minimum by controlling soil erosion, waterway sedimentation and airborne dust generation (USGBC, 2009). Furthermore, the natural habitat should be conserved through prudent sitting of building to minimise the disturbance to existing natural environment (USGBC, 2009). These considerations are often neglected in traditional construction.

2.4. GREEN BUILDING COMMISSIONING AND CLOSING OUT

The commission and closing out of a green building project is usually more complicated than that of conventional project (Glavinich, 2008). This is especially so when the developer wish to attain third party green certification (Glavinich, 2008) such as LEED, BREEAM and Green Mark. There is also a responsibility to impart the knowledge of green buildings system to new facilities management teams and end users to maintain sustainability (CIRIA, 2001). In addition, ease of maintenance has to be ensured (CIRIA, 2001).

3. Challenges in Green Construction Projects

3.1. Higher Costs for Green Construction Practices and Materials

As compared to conventional projects, green projects tend to cost more to construct. According to an estimate by Tagaza and Wilson, (2004) capital costs for green projects range from 1 to 25% higher. The higher costs are due to design complexity and the modelling costs needed to integrate green practices into projects (Zhang *et al.*, 2011). Higher costs are also associated with green materials and using green construction technologies (Hwang and Tan, 2010). Zhang *et al.* (2011) calculated that using green materials costs from 3 to 4% more than conventional construction materials. Some green materials cost significantly more than their conventional counterparts, compressed wheat board costs about ten times more than ordinary plywood (Hwang and Tan, 2010). The higher costs of green construction directly affect the project manager, because they are responsible for managing and delivering their projects within an allocated budget (Pettersen, 1999; Ling, 2003).

3.2. Technical Difficulty During the Construction Process

A project manager implements a project plan by authorising the execution of activities to produce project deliverables (Pettersen, 1999; Ling, 2003). Often, green technologies require complicated techniques and construction processes (Zhang *et al.*, 2011). If complexities are not addressed well then it may affect the project manager's performance. Tagaza and Wilson (2004) suggested that one of the main challenges in green building is the technical difficulties experienced during the construction process. Similarly, design can be more complicated than that of a conventional building due to the evaluation of alternative materials and systems (Hwang and Tan, 2010).

3.3. Risk Due to Different Contract Forms of Project Delivery

Tagaza and Wilson (2004) reported that the success of developing and implementing a green design depended greatly on the type of contract selected for the delivery of the project. The type of contract used in green projects must incorporate the details of a fully integrated green design. This creates a problem if the design is locked before being developed fully. Multiple changes of significant scale are likely if green features are incorporated at a later stage, resulting in a greater overall project cost (Hwang and Tan, 2010).

3.4. Lengthy Approval Process for New Green Technologies and Recycled Materials

The market environment suggests that the planning process can be protracted as the process of approving the use of new green technologies and recycled materials can be lengthy (Tagaza and Wilson, 2004). Similarly, surveys conducted by Zhang *et al.* (2011) and Eisenberg *et al.*, (2002) show that additional time is expected in order to gain approval. A lengthy approval process presents a challenge to project managers as they must develop the schedule and approve progress payments to vendors and suppliers (Pettersen, 1999; Ling, 2003).

3.5. Unfamiliarity with Green Technologies

Many studies have verified that green technologies pose certain challenges for developers, clients and contractors. Two reasons suggested by Eisenberg *et al.* (2002) are insufficient knowledge or technical expertise and unfamiliarity with the products, materials, system, or design. The main challenge is that green technologies are usually more complicated and are different from conventional technologies (Tagaza and Wilson, 2004). This was confirmed by Zhang *et al.* (2011). A project manager has to deliver the project with the required performance specified by the client (Pettersen, 1999; Ling, 2003), and unfamiliarity with the performance of green technologies may affect the performance outcome.

3.6. Greater Communication and Interest Required amongst Project Team Members

To be successful, the project manager must manage a large number of suppliers, subcontractors and team members. Communication is especially critical for the green project in order to convey the sustainable practices expected from the team members. Interest amongst team members is important, Tagaza and Wilson (2004) found that the initial enthusiasm for separating waste materials amongst sub-contractors dissipated as the projects progressed and the recycling skips were found to contain a mix of materials.

3.7. More Time Required to Implement Green Construction Practices on Site

Random checks and on-site visits by project managers are usually required to ensure that sustainable practices are implemented on-site (Tagaza and Wilson, 2004). This is essential because workers may tend to forego time-consuming sustainable practices when there are time pressures to complete a project.

4. Research Methodology

To achieve the objectives of this study, a comprehensive literature review on green and sustainable building construction was first carried out. The aim of the literature review was to find out what are the essential differences between conventional and green construction projects in design, construction, and commissioning phases and what are the challenges encountered in green building construction project management. In addition, the objective behind the review was to explore some innovative management skills applied in these projects that can be implemented in Singapore's context. The examination and analysis of past work related to green construction also provided a better understanding of green and sustainable building construction and the project management processes involved.

Then, a survey questionnaire was developed to capture a specific set of challenges encountered in the Singapore construction industry. The survey also captured a comprehensive and accurate outlook of management culture adopted by local green construction industry. The survey questionnaire consisted of a section that could capture the profile of respondents. The next section carried questions regarding the profile of green building construction projects undertaken by the respondents. The third section asked the respondents to rate challenges encountered during management of green construction, and the last section required the respondents to pick out solutions to overcome those challenges. The questionnaires were sent via email to 101 Green Mark Professionals (GMPs) and Green Mark Managers (GMMs) registered under the BCA's Green Certified GMP and GMM scheme.

5. Survey Results and Discussions

Out of the questionnaires disseminated, 31 completed sets were received. The survey results were analysed, performing descriptive as well as statistical analyses such as one sample t-test, ANOVA and Post-Hoc test. The respondents were from 19 consultancy (61%) and 12 project management companies (39%). All of the respondents had more than 2 years of experience on green building construction projects and majority of them (19 out of 31 respondents; 61%) had 3 to 4 years of experience. Also, there were 5 respondents (16%) who had more than 4 years of experience in the area. The following sections elaborate the analysis results.

5.1. Critical Challenges

The survey results revealed that all the respondents encountered some challenges during the management of green building construction. Table 1 presents the summary of Top 5 Challenges identified based on the respondents' input.

Table 1: Top 5 Challenges Faced in Green Building Construction Management

Respondent (%)	Challenges
100	Increase of Project Cost
83.9	Lack of Communication and Interest among Project Team Members
77.4	High Implementation Cost of Green Practices
67.7	Lack of Credible Research on Benefits of Green Buildings
51.6	Lack of Interest from Clients

The respondents reported that green construction projects would result in the increment of total project costs as relatively new technologies and systems are required to fulfil expected performances of buildings constructed. Also, consultants who are specialised in green technology need to be hired to assess and validate systems to be used for green buildings. This increases not only project cost, but also complexity of communication among project team members. The knowledge and critical information provided by green consultants should be clearly delivered and communicated to project team members who may not be familiar with specific knowledge areas required to construct green buildings. This may cause miscommunication or disconnection of information flow.

Furthermore, with consideration of tight schedule of construction projects, project team members may not take sufficient time to understand green requirements, negatively affecting their interests in green features. Similarly, green practices may be costly to be implemented. When new technology and systems are introduced, project team members need to be trained and until they exhibit a certain level of performance on the newly adopted concept and practices, the investment in implementing green practices may not be paid back. As a result, it is not surprising that a lack of expressed interest from clients becomes one of the critical challenges in managing green construction projects. This challenge may be solved by promoting various benefits and incentives from going green, but as indicated by the survey, the respondents felt a lack of research on true benefits of green buildings, which discourage project owners to consider and implement green measures to their projects.

5.2. IMPACTS OF THE CHALLENGES

The respondents were also requested to rate the extent to which the challenges described above influence three main project objectives, namely schedule, budget, and quality, with a scale of 1 to 5 (1 – No Impact; 2 – Insignificant Impact; 3 – Moderate Impact; 4 – Extensive Impact; and 5 – Extremely Extensive Impact). Table 2 summarises the analysis results. The analysis reported mean scores of 3.320, 4.100, and 3.160 for schedule, budget, and quality, respectively. According to the one-sample t-test performed, the mean scores of schedule and budget were statistically different from 3 at the significance level of 0.05, which was a hypothesised mean, indicating that the challenges would significantly influence schedule and budget objectives of green building construction projects.

In addition, the result from ANOVA and POST HOC test established that the challenges had the strongest impact on project budget, compared to their impact on project schedule and quality (ANOVA p-value = 0.000; POST HOC p-values = 0.010 for Budget vs. Schedule and 0.000 for Budget vs. Quality. This can be interpreted that the challenges discussed in the previous section indeed have more impacts on project cost.

Table 2: The Impact of the Challenges on Project Performance

Objectives	N	Mean	Standard Deviation	One Sample T-Test (p - value)	ANOVA test (p - value)	POST HOC (p - value)	
Schedule	31	3.320	0.871	0.048		Schedule vs. Budget	0.010
Budget	31	4.100	0.539	0.000	0.000	Schedule vs. Quality	0.609
Quality	31	3.160	0.820	0.282		Budget vs. Quality	0.000

5.3. SOLUTIONS FOR THE CHALLENGES

The respondents were also asked to choose solutions that could help to overcome the top 5 challenges listed in Table 1. The percentage of respondents who chose particular solutions for each of the challenges is provided Table 3.

Table 3: Solutions for the Challenges

Respondent (%)	Solutions	Challenges
67.7	Government to provide incentives to offset high premiums of green building projects	
64.5	Educating owners on the future benefits of green buildings	
48.4	Public and market demand for green buildings	Increase of Project Cost
25.8	Interest free lending schemes provided by government to overcome market and financial barriers.	High Implementation Cost of Green Practices
22.6	Insistence from client	
9.7	Green Mark Certification to be made mandatory for all new and existing buildings by authority	
74.2	Conduct tool-box meeting for regularly	Lack of Communication and Interest among Project Team Members
45.2	Engaging personnel with green building background	
96.8	Subsidy from government for R&D in green building systems and management	Lack of Credible Research on Benefits of Green Buildings
87.1	Bonuses provided for staff if the building is green mark certified or qualified for green mark awards	Lack of Interest from Clients

Both challenges involving “Increase of Project Cost” and “High Implementation Cost of Green Practices” are cost related and considered to be the biggest challenges that a project management team has to overcome. Considering that most projects performed in the Singapore construction industry are awarded based on the lowest tender price, project cost related issues are very sensitive to all stakeholders in the industry. Hence, a green building project will be pale in comparison to conventional building projects in terms of cost. While there is BCA’s green mark incentive scheme which is capped at an exhaustive amount of $20 million (BCA, 2009a), according to one of the survey respondents, the fund has been running out very fast and with tighter budget, future projects may only aim to attain minimum green requirements so as to comply with local regulations. To overcome the problem of high cost involved in green building construction, all respondents felt that the government should provide a larger scale of incentives. Also, about 65% of the respondents argued that educating clients on future benefits of going green could be one of the workable solutions to the cost related challenges. With clients internalising the potential benefits reaped from green buildings, high cost premium may have less deterrence from the perspectives of clients. Furthermore, this will become a remedy for the identified challenge, “Lack of Interest from Clients”.

Since green building construction is a fairly new concept in the Singapore construction industry, it is also important to communicate the green goals and objectives to all stakeholders and project team members in order to achieve successful project execution. For the lack of communication between project members as a challenge in green building project management, 74.2% of the respondents agreed that regular tool box meetings would work for ensuring that important information about the project is communicated. More specifically, engaging green consultants was recommended by 45.2% of the respondents to overcome communication problems among project team members.

The poor demand for green buildings could also be due to the lack of credible research on their benefits. 96.8% of the respondents felt that subsidy from government for research and development of green building systems and management could essentially provide concrete evidence of how beneficial they are to humans, society as well as the economy.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. CONCLUSIONS

This study aimed: (1) To compare design, construction, and commission stages between conventional and green building construction projects based on a comprehensive literature review; (2) To investigate common challenges that project managers encounter while managing green building construction projects; and lastly (3) To propose some plausible solutions for improving the current green construction project management. The literature review carried out for this study revealed that the main dissimilarities between conventional and green construction projects are the level of details and communication required. Succinct schematic design is usually adequate at the planning stage of conventional projects while green projects require superlative communication which can only be achieved through delivery systems like design-build, where building design and construction is carried out as a single entity. Furthermore, detailed integrated design process is employed at the start of the project as unlike conventional building design, green design features are unique and requires deep integration with every building aspect.

Results from the survey revealed the top 5 challenges in managing green building construction projects and there are: (1) Increase of Project Cost; (2) Lack of Communication and Interest among Project Team Members; (3) High Implementation Cost of Green Practices; (4) Lack of Credible Research on Benefits of Green Buildings; and (5) Lack of Interest from Clients. These challenges were found to be interrelated, ultimately resulting in high cost premium of green buildings. The lack of R&D on benefits of green buildings and green technologies is a main driver behind the lack of demand for green buildings to go beyond legislative requirement. In addition, green building constructions requires collaborative effort and communication between project team members. However, many local projects adopt conventional design-bid-build form for management, causing the lack of communication. All of these factors make it more difficult to manage green construction projects when compared to conventional projects, discouraging owners to take up green building projects.

6.2. RECOMMENDATIONS FOR THE INDUSTRY

As compared to conventional building project management framework, the framework for managing green building projects should be more detailed and allow greater communication between all personnel involved. Considering that such framework is still unavailable in Singapore and is perceived to be helpful in green building project management as reflected in the survey questionnaire, having a project management framework catered to green building construction can acilitate its adoption for future projects. Here, integrating the research findings with conventional project management framework and Sustainable Construction Framework (Hill and Bowen, 1997), a suggested Green Building Construction Project Management Framework (GBCPMF) for local construction industry is proposed.

During the inception of a green construction project, integrated environment management (IEM) (Hill and Bowen, 1997) should be implemented to reduce adverse impacts and at the same time, enhance the benefits of green projects on the surrounding environment. Environmental assessment is to be done to single out likely construction impacts on the environment; seeking alternatives to alleviate the impacts and establish rectification schemes and monitoring programmes if the impacts cannot be mitigated or removed (Hill and Bowen, 1997). Assessment of life cycle environmental costs of resources and products used should be carried out at the planning stage so that project teams can decide and choose suitable products to be used in green buildings. Throughout the whole construction project, the project team should abide to ISO4000 Environment Management System (EMS) and carry out EMS fitted for the project accordingly.

The next step of the planning stage is to set the desired level of environmental performance according to Singapore's environmental policies, which the clients or building owners wish to obtain. Therefore, the project team should look into BCA Green Mark Assessment Criteria and Building Control Act (Chapter 29) Building Control (Environmental Sustainability) Regulation 2008 to determine how the building should be built in order to comply with legislative requirement or to obtain certain level of awards.

The last step of the planning stage of a green construction project is to develop an organisational structure, which determines the relationship between important personnel involved in the projects. Some examples of these personnel are contractors, engineering consultants, environmental management team, client and affected parties. In addition, modes of communication between each team member should be established to facilitate great communication within the project team. The responsibilities and authorities of all personnel should also be clearly listed and defined to prevent any finger-pointing and confusion during the construction process.

During the construction of green buildings, environment management program based on Green Mark requirements on sustainable construction should be adopted. These sustainable construction practices includes efficient use of concrete for building elements, conservation of existing building structures and use of sustainable materials and products (BCA, 2009a). Standard work procedures of various activities should be communicated to all personnel involved in the project to have better control. Penalties and incentives schemes can be implemented during construction stage and operation of green buildings to ensure compliance with local environmental standards. The project should be monitored and documented to enhance management of the whole construction process. Audits of environmental performance should be carried out at fixed intervals internally by environmental managers or externally by consultants in accordance to Building Control Regulation and Green Mark Assessment to ensure compliance.

Last but not least, professionals' knowledge and experience on green building construction should be enhanced and upgraded through regular upgrading courses to keep them updated with the evolving information on technologies, products and materials relevant to green building construction.

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MOST APPROPRIATE DISPUTE RESOLUTION STRATEGY FOR SRI LANKAN CONSTRUCTION INDUSTRY

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ABSTRACT

With the surge of increasingly complex and fast-track construction projects, disputes are inevitable. Skills in dispute resolution should be part of the tool kit of any practitioner in a managerial position. However, the last decade evidenced the incorporation of increasingly complex dispute-resolution clauses in construction contracts, typically involving several alternative dispute resolution (ADR) techniques and arbitration arranged in sequential tiers. While the industry followed the standard guidelines, it was not clear what exactly the industry expect from the resolution process. In this study, a hierarchical model is developed to organise attributes of ADR processes. This hierarchical presentation fits with the use of analytical hierarchy process methodology by a group of experts to prioritise ADR process attributes. Frequently the question is how to select the most appropriate resolution method that can fit well with the disputing parties' needs. Hence, dispute resolution strategy selection model is developed in this research based on the above AHP results. The Model is considered beneficial to the industry, as it provides construction professionals with a systematic and objective approach in the selection of ADR methods for Sri Lankan construction project disputes.

Keywords: *Dispute Resolution, ADR Method Selection, Construction, Sri Lanka.*

1. INTRODUCTION

Alternative Dispute Resolution (ADR) is a voluntary approach that parties to a contract can agree upon for resolution of dispute outside the courts. The adoption of ADR methods has shown lack of rationality in the Sri Lankan construction industry. This paper presents findings of a rational approach to selection of ADR method.

2. BACKGROUND

Construction is a complex process that requires the coordinated effort of a temporarily assembled multiple-party organisation of many discrete groups, each having different goals and needs, and each expecting to maximise its own benefit (Walker, 1996). Because of difference in perception and frequent conflicting goals among partners to a project, conflicts in the construction project environment are inevitable. However, conflicts can quickly turn into disputes if not properly managed. Dispute is often regarded as a form of conflict that is made public and requires resolution (Brown and Marriott, 1999).

Disputes can arise due to several reasons including design errors, changes, multiple prime contracting parties, complexity and magnitude of the work, different site conditions, inadequate planning, defective specifications, financial issues and communication problems. Complicated litigation or arbitration could arise because of all the above factors affect the cost, communication and relationship of the parties. The progress and duration of construction projects are affected by such disputes and they may cause owners to lose their investment revenue because of the associated delays. They may have negative impacts on contractors since project delays are associated with increased materials and labours costs. Finally, both parties are affected by the time and monetary cost of dispute resolution itself. Construction disputes are

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characterised by features that differentiate them from other types of disputes (Marzouk and Moamen, 2009).

It is a known fact that the client and the contractor have to face significant difficulties in resolving disputes in construction industry (Murtoaro and Kujala, 2007). Therefore they always have to use different type of dispute resolution methods in practice. Though they use alternative dispute resolution methods such as Negotiation; Mediation; Adjudication; Arbitration; Litigation etc., it is complicated to make a decision on selecting a most appropriate dispute resolution method for a given context of a dispute. However, lack of experiences in these methods has hindered the acceptance of potential users. Hence, the industry's approach in the selection of dispute resolution method has been heavily criticised, where too much reliance is placed on intuitive judgments rather than on rational approach (Chan *et al.*, 2006).

In the current practice of the Sri Lankan construction industry, the choice of the ADR method to a great extend is involuntary; that is, the contracting parties adopt the ADR method stipulated on the standard form of contract. This is likely to increase the technical suitability because the ADR clauses are scrutinised against the other clauses within the standard form.

In addition to the technical suitability, the appropriateness is also affected by the contextual factors like culture and attitudes of the parties. As any other society, the Sri Lankan society is thought to have its own value system. A rational approach to identify the most suitable dispute resolving method according to Sri Lankan environment of construction is therefore a necessity. At the same time, management of construction disputes in an effective way requires mapping the dispute with the most appropriate dispute resolution method. Due to above reason, this research proposes a systemic, logically consistent and theoretically acceptable approach to identify the most appropriate dispute resolution strategy suit to Sri Lankan construction industry.

3. RESEARCH METHODOLOGY

The knowledge gathered through the literature survey was further strengthened from a round of pilot interviews among experienced construction professionals. A list of factors that can affect the selection of ADR method was developed through this process. The pilot interviews also had a secondary objective of identifying the experts who could be prospective participants/respondents for the study.

The intention of the study was to generalise the conclusions and develop a model that has an industry wide usage. The study was conducted within a positive philosophical stance, and a quantitative approach was preferred. However, a direct quantitative method was not possible due the nature of the subject of interest. A search for alternative options revealed that the Analytical Hierarchical Process (AHP) developed by Saaty (2008) would be the most suitable research method. AHP is a research method which has its own tool for data collection and analysis. The method was preferred primarily due to the nature of prospective participants/respondents of the research that they were experienced professional who could critically compare attributes for decision, and the attributes themselves fit into a two-tier hierarchical structure. The AHP tool allows a respondent to compare only two factors at a time, which is a strong feature that helps rational decision making.

Thirty experience professionals took part in the research study. They were a mixed of professional representing both clients and contractors and had active involvement of dispute resolution processes. The data analysis technique was that of AHP using a spreadsheet application. Graphical techniques were used to explore and describe the AHP output. Finally, the utility values attributes which had been found by Cheung and Suen (2002) were mathematically compared with the priority of attributes in Sri Lankan context in order to identify suitable ADR method.

4. IDENTIFICATION OF ADR PROCESS ATTRIBUTES

Dispute resolution has attracted the interest of many researchers and practitioners. Among the noteworthy, Goldberg *et al.* (1992) completed a comprehensive list of attributes of dispute resolution, including voluntariness, involvement of a third party, and degree of formality, nature of the proceeding, outcome, and privacy. York (1996) concerns more with the practical issues and identified time, cost, preservation of relationships, binding decision, degree of control by parties, flexibility in procedure, and confidentiality. Moreover, David (1988) focused on social and human issues such as impartiality, consensus, and continuing business relationships. Cheung and Suen (2002) had reviewed most of relevant literature, including the above in developing a list of 16 utility factors of dispute resolution. These were used as the basis of development of a list of attributes. Through the consultation of experts the following list of attributes were identified.

1. Voluntariness
2. Neutrality
3. Fairness
4. Knowledge in Construction
5. Creative Agreement
6. Enforceability
7. Scope of Remedy to satisfy interest
8. Speed
9. Consolidation
10. Cost
11. Range of Issues
12. Preservation of Relationship
13. Flexibility in issues, strategy and agreement
14. Binding decisions and enforcement
15. Degree of control by parties
16. Formality
17. Consensus Agreement
18. Privacy
19. Relative cost
20. Confidentiality

In identification of the above list, priority was a concise and comparable list. These attributes were then grouped and arranged in a two-tier hierarchy as Main Attributes and Sub Attributes and taken to expert response using the AHP tool.

5. GLOBAL PRIORITIES FOR SUB ATTRIBUTES

Based on the ranking by experts, the Local Priority Weightings (LPW) for each and every Sub Attributes was calculated using AHP tool. The Global Priority Weighting (GPW) or the overall importance for each Sub Attributes was then calculated by multiplying its LPW by its Main Attribute’s Priority Weighting. These are tabulated in Table 1.

AHP approach mainly focuses on prioritising attributes quantitatively from the priority weightings arrived thorough simple pair wise comparisons. All calculated Consistency Ratios (CR) were less than 0.1 as can be expected from judgements of experts. This was a signal of accuracy in judgement.

The most useful finding of the study is the quantitative weight for priority of each attribute. The GPW for each sub attributes as graphically illustrated in Figure 1 in the descending order of priority.

The "Degree of Control by the Parties" hit the top of the priority list showing that parties consider that they need to have a control over the process. In the second position is "Voluntariness" and "Confidentiality" was at third position. These attributes are in fact the key difference of ADR from litigation. Thus, ADR as a concept has been developed rationally. The top ten attributes (i.e. down to "privacy of the proceedings") covers 80% of total weightings. From the bottom of them, "privacy of the proceedings" was a common feature for ADR, "range of issues" was a subjective feature of the context, and "neutrality" was also a common feature for all ADR methods considered. Thus, only the balance seven attributes were taken to the next step, in order to find suitable ADR method for Sri Lankan construction industry. The selection is however bounded rational, based on quantitative significance and knowledge of the researchers. One may select more number of attributes, but unlikely to find different conclusions because of low weighting and low utility variation in those attributes.

Table 1: Global Priority Weightings

Priority Rank	**Main Attributes**		**Sub Attributes**		
	Attribute name	**Priority**	**Sub-Attribute name**	**Local Priority**	**Global Priority**
1	Non-Litigious Nature	0.549	1. Degree of control by the parties	0.251	0.138
			2. Voluntariness	0.245	0.135
			3. Confidentiality of the process	0.147	0.081
			4. Flexibility	0.136	0.075
			5. Range of issues	0.098	0.054
			6. Privacy of the proceeding	0.088	0.049
			7. Formality	0.034	0.019
			Non-Litigious Nature		0.549
2	Time and Cost Benefit	0.204	1. Speed to obtain	0.344	0.070
			2. Relative cost	0.312	0.064
			3. Preservation of business relationship	0.280	0.057
			4. Liability for opponent's cost	0.065	0.013
			Time and Cost Benefit		0.204
3	High Quality Settlement	0.129	1. Bindingness of the decision	0.273	0.035
			2. Fairness	0.218	0.028
			3. Consensus agreement	0.214	0.028
			4. Enforceability of the decision	0.145	0.019
			5. Creative Solution	0.086	0.011
			6. Scope of remedy to satisfy interest	0.064	0.008
			High Quality Settlement		0.129
4	Neutral Third Party	0.117	1. Neutrality	0.487	0.057
			2. Knowledge in construction	0.318	0.037
			3. Consolidation	0.196	0.023
			Neutral Third Party		0.117

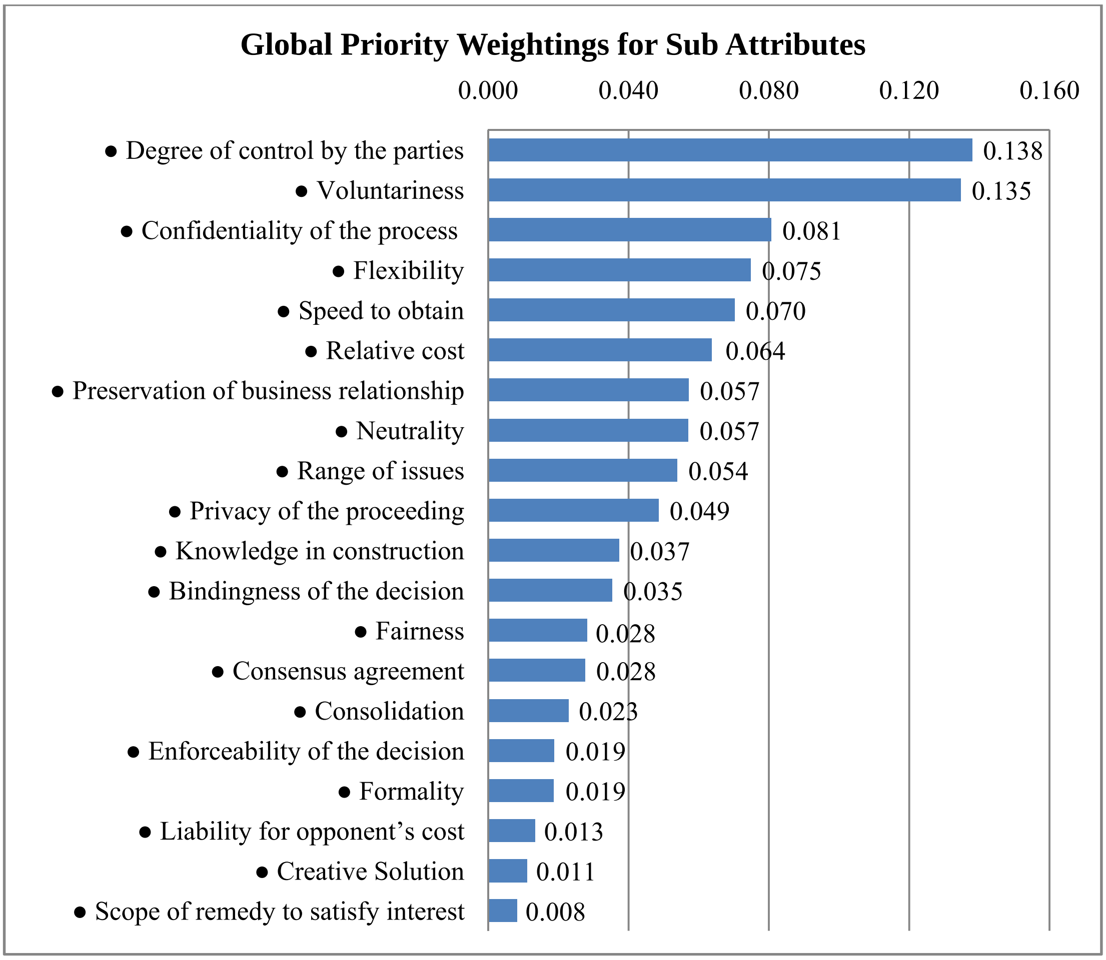

Figure 1: Global Priority Weightings for Sub Attributes

6. DEVELOPING A DISPUTE RESOLUTION STRATEGY SELECTION MODEL

The ADR selection model was developed by combining the findings of AHP and utility values which had been found by Cheung and Suen (2002). They had calculated the utility values as a percentage of overall average utility, thus having a centre value of 100. For this reason, simple multiplication of priority value became appropriate. However, for clarity, the priority values of the seven factors were transformed so that their total becomes one so that the expected Utility Score (US) becomes 100. The calculated Utility Scores are shown in Table 2.

From the Utility Scores it could be observed that the order of rational preference of ADR for a generic Sri Lankan context is in the order:

1. Negotiation (US = 94)
2. Mediation (US = 88)
3. Adjudication (US = 72), and
4. Arbitration (US = 53)

A wider gap is observed between the utility scores of adjudication and arbitration. Litigation also was scored for the utility for the same priorities and found to have a very low score of 26. These findings together with the GPW of attributes are used in drawing conclusions.

Table 2: Developed Model for Dispute Resolution Strategy Selection

Selection Factors	Global Priority Weight	Negotiation		Mediation		Adjudication		Arbitration		Litigation	
		U.F.	U.S.	U.F.	U.S	U.F.	U.S.	U.F.	U.S	U.F.	U.S.
Degree of control by the parties	**0.223**	105.00	**23.39**	91.50	**20.38**	51.50	**11.47**	51.50	**11.47**	29.20	**6.50**
Voluntariness	**0.217**	83.40	**18.14**	82.00	**17.83**	76.00	**16.53**	62.00	**13.48**	45.00	**9.79**
Confidentiality of the process	**0.130**	88.50	**11.53**	85.40	**11.13**	76.20	**9.93**	94.60	**12.33**	22.30	**2.91**
Flexibility	**0.121**	107.00	**12.93**	94.60	**11.43**	87.70	**10.60**	51.50	**6.22**	15.40	**1.86**
Speed to obtain	**0.113**	96.20	**10.91**	87.70	**9.95**	80.80	**9.17**	26.20	**2.97**	16.20	**1.84**
Relative cost	**0.103**	89.20	**9.18**	87.70	**9.03**	80.00	**8.23**	28.50	**2.93**	16.90	**1.74**
Preservation of business relationship	**0.092**	90.80	**8.38**	88.50	**8.17**	70.80	**6.53**	34.60	**3.19**	13.80	**1.27**
Total Score	**1.000**		**94.46**		**87.91**		**72.46**		**52.60**		**25.91**
Order of Preference		**1**		**2**		**3**		**4**		**5**	

7. CONCLUSIONS AND RECOMMENDATIONS

The research aimed to develop a model for rational selection of suitable Alternative Dispute Resolution (ADR) method. This became necessary and useful because the current practice of choice in the country was mostly by intuition or personal judgment, or merely by following what is given in standard forms adopted.

At the initial stage of the study, through a review of literature, 20 attributes of ADR were identified. Then they were got prioritised quantitatively by the judgments of 20 experts, professionals with an experience in ADR, by using the Analytical Hierarchy Process (AHP). Consistency ratios calculated showed high level of consistency throughout, which was not doubtful when the type of participants are considered.

Twenty number of attributes identified were studied in a two tier hierarchical model, with “Non Litigious Nature”, “Neutral Third Party”, “High Quality Settlement” and “Benefits” as top level (main) attributes, and 20 sub-attributes under them.

The Global Priority Weightings (GPWs) of 20 sub-attributes showed that “Degree of Control by the Parties”, Voluntariness”, “Confidentiality of the Process”, Flexibility”, “Speed to Obtain”, “Relative Cost”, and “Preservation of Business of Business Relationship” as top seven attributes. Therefore it can be stated that the construction industry of Sri Lanka gives a high priority on “Degree of Control by the Parties”. In fact all the top seven attributes are exclusively from the tier one attributes “Non-Litigious Nature” and “Benefit”, highlighting that these are the critical attributes for the industry. This also highlights the dislike for litigation in the industry.

The most suitable strategy for ADR in Sri Lankan construction industry was identified by using a model that combines the AHP output with the attribute utilities found by Cheung and Suen (2002). The calculated Utility Score shown in Figure 2 below gives a clear idea of level of utility each ADR method can deliver, and how they are comparable to litigation.

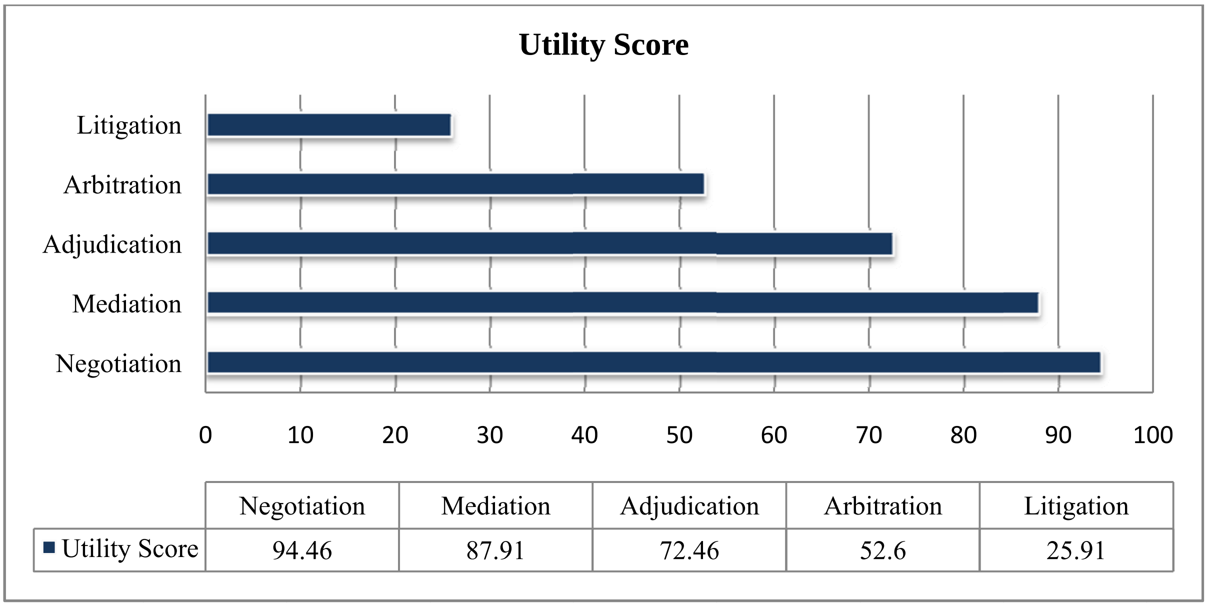

Figure 2: Utility Score of Dispute Resolution Methods

The recommended method is the one with the highest utility. Thus “Negotiation” is the preferred choice for the industry, and the others will be in the preference list in descending utility score order. It should be noted that this exercise was done with the industry expert from their judgement on the generic industry context. Thus this knowledge is ideally useful only for general contexts such as development of standard forms (conditions) of contracts. However, ADR is a choice for the parties in a dispute or who anticipate to resolve disputes, if arise, using ADR. In such a context, it is not necessary follow the generic conclusions. Instead, they can utilise the model developed herein to identify their own priorities and to find best ADR strategies accordingly. For example, in the generic model, “binding decision” and “enforceability of the decision” had a low priority score, if parties consider those to be high priority, a method like Arbitration would get highest utility score.

The Utility Score model is not a decision making model, but a decision support model. Parties should not totally rely on the final output. Instead, they should look at intermediate outputs, viz. Global Priority Weightings (GPW), Consistency Ratios (CR) and the final output - Utility Scores (US), in making an informed decision. CR must be first improved if found poor (i.e. higher than 10%). Attributes for the Utility Score model should be selected based on the GPWs. Necessary attribute utilities can be found from the works of Cheung and Suen (2002). However, it can be recommended to find the attribute utilities using AHP method as a further study. AHP is likely to yield more reliable results due to its unique scale and calculation method.

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ADAPTABILITY OF INTEGRATED PROJECT DELIVERY IN A CONSTRUCTION INDUSTRY

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ABSTRACT

Within the traditional procurement system, level of achievement of client and contractor objectives may vary depending on the type of procurement used. This may further create a gap between the expected and actual performance of the project. Integrated Project Delivery (IPD) is the modern development of the procurement systems in the industry where collaborative innovation is the path used to achieve the goals of a project. Appreciable characteristics and benefits of this concept convert the construction industry towards it. It is observed that United States of America is the first to develop and implement this concept specially focusing on the public sector. Although, the concept is not yet popular around the world, it is likely that the clients will demand for it in future due to economic and managerial advantages it brings. Thus, it is important that an industry be prepared to adapt the system as and when the need arises. Identifying this need, a literature synthesis on requisites and barriers for successful implementation of IPD is presented in this paper. The findings shall become valuable source for any construction industry to assess their readiness and take necessary steps to be ready to implement IPD system successfully.

Keywords: *Procurement, Integrated Project Delivery, IPD, Construction.*

1. INTRODUCTION

Within the traditional procurement system, level of achievement of client and contractor objectives may vary depending on the type of procurement used. This may further create a gap between the expected and actual performance of the project. Integrated Project Delivery (IPD) is the modern development of the procurement system in the industry where collaborative innovation issued to achieve the project goals. Appreciable characteristics and measurable benefits of this concept have given high potential for it to become the industry standard internationally. A literature synthesis on requisites and barriers for successful implementation of IPD is presented in this paper. The findings are beneficial in identifying the preparedness of an industry for IPD integration.

2. BACKGROUND

The procurement of construction project is immense in scope because it involves the gathering and organising of myriads of separate individuals, firms and companies to design, manage and build construction products for specific clients or customers. Project procurement is very much concerned with the organised methods or process and procedure of obtaining or acquiring a construction product. It also involves arranging and coordinating people to achieve the prescribed goals or objectives (Rashid *et al.*, 2006). Procurement is the process which is used to realise construction project within the budget, time duration and required quality by deciding the overall framework of the project, structure of the responsibilities and authorities of the key parties of the project. It is a key factor, which ultimately decides the overall success of the project. From time to time numerous procurement methods were developed within the industry to overcome the drawbacks of the previous methods (Alhazmi and McCaffer, 2000).

The major weakness of common procurement methods is that they do not ensure the productivity level required to the project. The failure to inline with schedule and budget, insufficient details in construction

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drawings, wastage of materials are the main reasons for lower productivity. IPD was designed overcome those problems (Jackson, 2011).

It is observed that United States of America was the first to develop and implement IPD concept. The American institute of Architects and American Institute of Architects California Council (AIA and AIACC, 2007, p.01) define "IPD is a project delivery approach that integrates people, systems, business structures, and practices into a process that collaboratively harnesses the talents and insights of all participants to optimise project results, increase value to the owner, reduce waste, and maximise efficiency through all phases of design, fabrication, and construction". They have shown that IPD can reduce the total project cost by 10% (AIA, 2009).

Although, the IPD concept is not yet popular around the world, it is likely that the clients will demand for it in future due to economic and managerial advantages it brings. Thus it is important that an industry be prepared to adapt the system as and when the need arises. Thus, a study was initiated aiming to identify requisites and barriers for successful implementation of IPD in a construction industry. A synthesis of current knowledge from a review of literature is presented in this paper.

3. INTEGRATED PROJECT DELIVERY

IPD may have two different but related meanings when thought of it as philosophy or delivery method. IPD as a philosophy occurs when integrated practices or philosophies are applied to more traditional delivery approaches such as Construction Management (CM) at-Risk, Design-Build or Design and Build (where the owner is not party to a multi-party contract). IPD as a Delivery Method occurs when the owner has elected to sign a multi-party contract with the prime designer, contractor and/or other key members of the project team. In addition to the multi-party contract, IPD as a Delivery Method is characterised by a contract that incentivises collaborative behaviour, team risk-sharing and other IPD principles and practices (NASFA *et al.*, 2010; Sive, 2009). This study focuses on IPD as a method, because that is the new approach for the industry which future clients may demand.

3.1. CHARACTERISTICS OF IPD

IPD encourages early contribution of knowledge and experience and requires proactive involvement of key participants. Responsibility is placed on the most able person with decisions being made on a "best for project" basis. Although it is possible to implement IPD without Building Information Modelling (BIM: discussed hereinafter), it is essential to efficiently achieve the collaboration required for Integrated Project Delivery (AIA *et al.*, 2007).

IPD is built on collaboration. As a result, it can only be successful if the participants share and apply common values and goals. IPD is a method of project delivery distinguished by a contractual arrangement among a minimum of the owner, constructor and design professional that aligns business interests of all parties. IPD motivates collaboration throughout the design and construction process, tying stakeholder success to project success, and embodies the following contractual and behavioural principles (AIA and AGC of America, 2011),

Contractual Principles

- Key Participants Bound Together as Equals
- Shared Financial Risk and Reward Based on Project Outcome
- Liability Waivers between Key Participants
- Fiscal Transparency between Key Participants
- Early Involvement of Key Participants
- Jointly Developed Project Target Criteria
- Collaborative Decision Making

Behavioural Principles

- Mutual Respect and Trust
- Willingness to Collaborate
- Open Communication

3.2. DIFFERENCE BETWEEN IPD AND OTHER PROCUREMENT METHODS

Understanding of the differences of IPD from the other systems is imperative in understanding the preparedness of an industry for its integration. Table 1 presents a comparison between IPD and Traditional Procurement Methods.

Table 1: IPD and Traditional Project Delivery – A Comparison
(Source: AIA and AIA California Council (2007); Mossman, *et al.* (2010))

Traditional Project Delivery		Integrated Project Delivery
Fragmented, assembled on just-as-needed" or "minimum necessary" basis, strongly hierarchical, controlled	Teams	An integrated team entity composed of key project stakeholders, assembled early in the process, open, collaborative
Linear, distinct, segregated; knowledge gathered "just-as-needed;" information hoarded; silos of knowledge and expertise	Process	Concurrent and multi-level; early contributions of knowledge and expertise; information openly shared; stakeholder trust and respect
Individually managed, transferred to the greatest extent possible	Risk	Collectively managed, appropriately shared
individually pursued; minimum effort for maximum return; (usually) first-cost based	Compensation/ Reward	Team success tied to project success; value-based
Paper-based, 2 dimensional; analog	Communications/ Technology	Digitally based, virtual; Building Information Modeling (3, 4 and 5 dimensional)
Encourage unilateral effort; allocate and transfer risk; no sharing	Agreements	Encourage, foster, promote and support multi-lateral open sharing and collaboration; risk sharing
Blame, finger pointing, exploiting loopholes, individual reward maximisation, risk averse	Culture	Learning, continual improvement, engaging with reality
Command a control; encourage unilateral effort; Break project into constituent parts; Optimise parts (especially "my bit")	Thinking	Systems thinking; optimise the whole; encourage, foster & support multi-lateral open sharing & collaboration
Top - down: Manage the contract, manage the programme, manage budgets, manage people	Management ethos	Outside- in: act on the system to improve it for customers (helped by those working in it).
Separated from work	Decisions	Integrated with work; based on data
Budget output, activity, standards, productivity	Measures	Related to purpose, capability and variation
Functional specialisation; fragmented, silo based, strongly hierarchical, controlled; constructors not generally added until late in process	Organisation design	Based on demand, value & flow; open, collaborative & integrated team of key players formed at the outset & added to as t he stakeholder group grows
Gathered "just - as - needed", hoarded in silos	Knowledge and expertise	Shared openly and early
Contractual	Attitude to customers	What matters to them? Understanding their human and technical concerns.

4. REQUISITES TO IMPLEMENT IPD

IPD is relatively a new concept that did not found enough time for maturity in different construction industries. Consequently, the current knowledge may not be comprehensive enough answer the question "what are the requisites to implement IPD" coherently. There were few studies carried out in different parts of the world which would help. However, the best approach would be to logically build up the answer by synthesising the findings of those studies and the characteristics of IPD.

Whether it is legislative restrictions, policy limitations or cultural barriers, there are a number of reasons that affect to implement the IPD process. Three studies found to present a good knowledge base on requisites.

O'Connor (2009) highlights the most important aspect – the mutual trust – is to be something that can be created by contract but must exist independently of it. He also identifies may other items and shows that they are directly influenced by parties' contracts. Cooper (2009) describes the key concepts that must be maintained when proceeding with the IPD procedure. Mossman (2009) presents a list of factors categorised into three groups as (a) IPD enablers, (b) requirements for IPD, and (c) supportive factors for IPD.

5. SYNTHESIS OF REQUISITES TO IMPLEMENT IPD

Thirty seven numbers of requisites to implement IPD were synthesised by reviewing the current knowledge and constructing arguments on it. For clarity and consistency, these requisites were categorised into four categories.

Requisites by IPD characteristics

1. Mutual trust among the parties
2. Open communication among parties
3. Mutual understanding with respect to each other's objectives
4. Frequent formal and informal meetings for continual improvement
5. Language directing the parties to collaborate upon developing project goals.
6. Lean logistics
7. System thinking and lean thinking
8. Early involvement of key team members
9. Clarity of client's understanding on purpose/end result
10. Early consideration of logistics and other buildability issues
11. Whole life value assessments that include organisational outcomes
12. Project bank account
13. Intensified Planning

Requisites from IPD agreement

14. Awareness of risks and rewards
15. Effective co-ordination
16. Collective responsibility instead of personal responsibility
17. Alignment of objectives
18. Agreed, clear and quick process for dispute resolution
19. Pioneering role of the owner/client
20. Legal implications
21. Risk allocation must be consistent with public low requirements
22. Project specific insurance may be required in order to achieve IPD risk shearing objective
23. Risk management team, include potential insurers should be engaged early in the process
24. Tolerance for risks retained must be evaluated for all stakeholders
25. Risk assessment, safety plan, project labour agreement, ADR for workers compensation should be part of the early collaboration

26. Good relational contract
27. Clarity of management decisions
28. Performance evaluations and payouts

Cultural requirements

29. Positive attitude of the project participants
30. Readiness to compromise on unclear issues
31. Professional ethics
32. Agreed mechanism for performance appraisal
33. Cost of implementing IPD
34. Willing to collaboration and flexibility
35. Compatible organisational cultures

Technological requirements

36. Appropriate Technology
37. Building Information Modelling (BIM), a single digital model to which all contribute

6. DISCUSSION

It is useful to review each of the requisite separately, but not be appropriate for a presentation of this nature. For simplicity, the discussion follows is based on four categories identified.

6.1. REQUISITES BY IPD CHARACTERISTICS

The significant characteristic of IPD is collaboration among the IPD team members. Collaboration requires freely soliciting and sharing information and ideas as equals, not as master and subordinate. A major shift is to engage the team in collaborating to define the problem, rather than critique a proposed solution (Mossman *et al.*, 2010). This requires all team members to approach collaboration as a process by which they have the opportunity to share with and learn from the talents, experiences and performance of others. Real collaboration cannot happen without trust amongst the team members and openness to the reality that each of us does not have the best idea for a solution (AIA and AIACC, 2007).

Trust must be a common thread running through the entire program and provides a foundation for collaboration. Trust is essentially a decision each person on the project makes every day to trust the other participants. To trust people is to count on their sense of responsibility, believing that they will choose to act in a trustworthy manner, while recognising the possibility that they may choose to betray the trust (Thomsen *et al.*, 2010). It is something that can be built intentionally and must be openly discussed. This requires the company to trust the participant to make important decisions in the project's interest and, simultaneously, the participant to trust that the company's long-term interests are best served by *project-first* thinking. Trust is realised through fulfilling commitments (Howard and Ashcraft, 2011).

In an integrated project, the key participants must get involved from the earliest practical moment. Decision making is improved by the influx of knowledge and expertise of all key participants (Thomsen *et al.*, 2010). Their combined knowledge and expertise is most powerful during the project's early stages where informed decisions have the greatest effect. Project goals are developed early, agreed upon and respected by all participants. Insight from each participant has to be valued in a culture that promotes and drives innovation and outstanding performance, holding project outcomes at the centre within a framework of individual participant objectives and values (AIA and AIACC, 2007).

The IPD approach recognises that increased effort in planning results in increased efficiency and savings during execution. Thus the thrust of the integrated approach is not to reduce design effort, but rather to greatly improve the design results, streamlining and shortening the much more expensive construction effort (Mossman *et al.*, 2010). IPD's focus on team performance is based on open, direct, and honest communication among all participants. Responsibilities are to be clearly defined in a no-blame culture leading to identification and resolution of problems, not on determination of liability. Disputes must be recognised as they occur and promptly resolved (Thomsen *et al.*, 2010).

Continuous improvement adds value to the owner as it affects every area of project development and implementation including site selection, design, procurement decisions, fiscal reporting, safety and quality issues, project delivery methods, material choices, vendor offerings, and operational efficiencies. Frequent formal and informal meetings must take place to measure continual improvement of the project team (Mossman *et al.*, 2010).

6.2. REQUISITES FROM IPD AGREEMENT

In IPD, the project team is an organisation in its own right and all team members are committed to the project team's goals and values. Leadership is taken by the team member most capable with regard to specific work and services. Often, design professionals and contractors lead in areas of their traditional competence with support from the entire team; however specific roles are necessarily determined on a project-by-project basis. Roles are clearly defined, without creating artificial barriers that chill open communication and risk taking (AIA *et al.*, 2007).

Using BIM and other tools to construct a building virtually in advance of actual construction substantially diminishes the risk of design errors and omissions. If the participants adopt "no suit" clauses, the risk of incurring internal first-party claims for economic loss can be eliminated (Bedrick and Rubel, 2009). It is now required that the insurance industry develops and offers alternative insurance products that align with the project goals and the specific risk allocation terms established among the IPD project participants (Howard and Ashcraft, 2011).

The Consensus DOCS (Design, Owner, Contractor, Subcontractor) and AIA A295IPD contract arrangements are standard IPD agreement published in the United States making them more manageable by insurance standards. Suitable contracts (standard forms) will be required by other countries integrating IPD (Ballobin, 2008).

Rather than simply shifting risk among each other, members of an IPD team have to agree in various ways to share risk and collectively manage it. By sharing risk, all project participants have a financial stake in effectively identifying and mitigating risks. Collective risk management brings less risk for the whole project (Mossman *et al.*, 2010). IPD projects use many creative ways of sharing risks and fostering collective risk management. Three common approaches involve sharing the cost-savings or cost overruns against an estimated cost of the work, pooling some portion of the team member's profit and placing it at risk, and/or pooling contingency funds and sharing any amount remaining after project completion (Thomsen *et al.*, 2010). The industry should be prepared for this and should have good awareness of risks and rewards to be motivated.

Periodic and timely performance evaluation is essential to reinforce good performance and address performance issues. Performance evaluations need to be done frequently in order for the project to be able to take advantage of lessons learned during the project (Howard and Ashcraft, 2011).

The IPD premise is that design and construction will improve if the designers and constructors align their interests and remove legal barriers to collaboration. When conflict surfaces within the team there must be someone to step in and align the team without the cost and delay of litigation. There should individuals among the parties to the contract who are skilful and with a charisma to do that. However, it is accepted that as long as multiple organisations have interests in the IPD Team and those organisations are doing at least some of the work independently, unaligned self-interest will exist.

6.3. CULTURAL REQUIREMENTS

A motivating culture is imperative for IPD success. Incentives are complex strategies. What "should" work may, or it may not work on the next project even if it did on the last. The owner and IPD team should be flexible regarding the incentive program so that they can adjust it mid-project to address changed project conditions; and they should be capable of detecting such requirement in order to make corrective adjustment (AIA and AIACC, 2007).

All members of the team should value reputation. Good people want repeat work and will work hard to build or uphold their reputation (Ballobin, 2008). IPD team has to be selected on qualifications, they should know they can be selected again if they deliver a great outcome or have a reputation for excellent client service (AIA *et al.*, 2007). Thus, IPD is for organisations which values professional ethics, who believes people are honest, and ready to compromise in unclear issues.

6.4 Technological Requirements

Integrated projects often rely on cutting edge technologies. Technologies are specified at project initiation to maximise functionality, generality and interoperability. Open and interoperable data exchanges based on disciplined and transparent data structures are essential to support IPD. Because open standards best enable communications among all participants, technology that is compliant with open standards has to be used whenever available (Ashcraft, 2009).

BIM (Building Information Models) are to be used in design and construction to increase communication and team efficiencies. Indeed, BIM demands collaboration in order for the participants to obtain the benefits of this technology. The use of this technology has immediate and demonstrable benefits (Glick and Guggemos, 2009). Only BIM can facilitate to have more than one person working in a project model simultaneously and the ability to have the entire project team work on the same model. This helps the work get done faster and prevents against duplicating information and conflicts in the building design. BIM adds additional value when used to integrate project delivery processes, and BIM is catalyse for the IPD process (Gerber and Kent, 2010). In addition to the availability of technology, skill of the team members to use the technology is also a requisite.

7. Conclusions and Recommendations

IPD holds the prospect of real productivity gains in the provision of design and construction services. Project delivery innovation is long overdue in the construction industry. The industries those have understood change is necessary are leading the way with the new method. The calculated benefits of IPD will yield demand for it in future; and thus it became necessary to identify the requisites for successful integration of IPD to a local construction industry.

By synthesising the current knowledge base from several perspectives, 37 requisites for successful integration of IPD to a construction industry were identified. It was emphasised that the mutual trust among the parties is critical. It was further identified that there were other requisites that yield the mutual trust such as culture, the contract, search for continuous improvement, and technological environment (especially BIM).

Scrutinising the list of requisites, one may realise that a particular construction industry lacks lot of them. This may be very much evident in an industry that does not practice collaborative methods like Partnering. However, it should be noted that previous studies in Sri Lankan context have shown that, some requisites for collaborative project delivery methods are not evident because of procurement methods in practice. The study showed that a change in the method and consequently contractual and functional relationships can surface some of the required features which would normally not found (Gunathilake and Jayasena, 2008). Thus the capacity of an industry to adapt IPD shall not be judged by simple observation. The status of the requisites is to be judged by simulating the IPD environment or by stimulating it features in conventional system. That is the way forward for this research.

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BUILDING INFORMATION MODELLING FOR SRI LANKAN CONSTRUCTION INDUSTRY

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ABSTRACT

Building Information Modelling (BIM) is relatively a new buzzword in the Construction Industry; however BIM is not yet practiced in Sri Lankan construction industry and not many in the industry know about it. BIM is now becoming popular and likely to be industry standard for project design and hence a key tool in project procurement in future. Integration of BIM into project development life cycle would create deviations in traditional parameters of procurement systems. As a result, a construction industry in which building procurement is based on BIM is thought to be quite different from the today's systems. The industry needs to understand its potentials in order to develop strategies for BIM integration. Under this context, a research is conducted with broader aim of integrating BIM in Sri Lankan construction industry. This paper is presented with its preliminary findings from a literature review on features and requisites of BIM, developing logical conclusions in terms of BIM's potentials for Sri Lankan construction industry. It finds that BIM leads to a more efficient industry and will save both time and cost; and the technology is unlikely to be a significant barrier for BIM implementation.

Keywords*: Building Information Modelling, BIM, Procurement, Construction, Sri Lanka.*

1. INTRODUCTION

Building Information Modelling (BIM) is becoming popular and likely to become industry standard for construction project design in future. BIM is not yet practiced in Sri Lankan construction industry and not many in the industry know about it. Whether the Sri Lankan construction industry is ready to adopt BIM technologies; or whether the acquisition of BIM technology is beneficial at all, remains unclear. This paper is a review of the issue which aims to build up logical conclusions from current knowledge. The work is a part of an ongoing research with a broader aim of integrating BIM into Sri Lankan construction industry.

2. BACKGROUND

BIM, or Building Information Modelling, is digital representation of physical and functional characteristics of a building creating a shared knowledge resource for information about it forming a reliable basis for decisions during its life cycle, from earliest conception to demolition (Construction Project Information Committee [CPIC], 2011). BIM may also stand for Building Information Model, or Building Information Management. While the former is the product of the process defined herein, the latter has related but different context, and thus is outside the scope of this paper. However, the products are often referred to as BIM Models, leaving BIM to mean Building Information Modelling.

As envisaged by a leading BIM application developer Autodesk (2003) a decade ago, BIM would support the continuous and immediate availability of project design scope, schedule, and cost information that is high quality, reliable, integrated, and fully coordinated. For each of the three major phases in the building lifecycle, BIM would offer access to critical information such as:

- design, schedule, and budget information (in the design phase)
- quality, schedule, and cost information (in the construction phase)

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- performance, utilisation, and financial information (in the management phase)

BIM's ability to keep this information up to date and accessible in an integrated digital environment gives architects, engineers, quantity surveyors, builders, and owners a clear overall vision of their projects, as well as the ability to make better decisions faster. A decade later, there is evidence that BIM has made all these possible, but how effective they are, is yet to be realised.

BIM has gained gradual popularity in United States over the decade, while United Kingdom looked for a kick-start in BIM with the UK Cabinet Office announcing the Government's new Construction Strategy in mid 2011 (Poletayeva, 2011) announcing the Government's intention to require collaborative 3D BIM (with all project and asset information, documentation and data being electronic) on its projects by 2016.

3. DEVELOPMENT OF BIM

BIM is not a software application. Instead it is an IT solution for integration of software applications and IT tools to design a building in a common platform, a platform which is independent of the software we use. The term BIM seems to have been coined by Autodesk (Laiserin, 2002), a leading software vendor for AEC (Architecture, Engineering and Construction) applications. However, Graphisoft claims that their Virtual Building concept introduced with ArchiCAD in late 80's was the first ever implementation of BIM concept in an AEC application (Laiserin, 2003).

The roots of real BIM reside however with the International Alliance for Interoperability (IAI) which initiate the development of open BIM. IAI started as Industry Alliance for Interoperability in 1994 as a consortium of group of US companies. They demonstrated interoperability among some CAD (Computer Aided Draughting) and simulation tools at the AEC Systems Show in Georgia in 1995. It became global organisation in 1996 and changed its name to International Alliance for Interoperability (Bazjanac and Crawley, 1997). In 2005, it was renamed to buildingSMART. The reason for the renaming seems superficial, i.e. to make it simple and easy for people to understand and remember (Eastman *et al*., 2011). The name itself represents the vision of the organisation: *Sustainability by building smarter*.

The mission of buildingSMART is stated as "Contribute to sustainable built environment through smarter information sharing and communication using open international standards in the building and construction sector, private and public" (Rooth, 2010). The keywords here are "information sharing and communication using open international standards". Thus, it intends to eliminate communication boundaries between software applications, operating systems and languages. BuildingSMART is a not-for-profit organisation. The organisation is responsible for developing and maintaining international standards for openBIM – an open source (i.e. free to use) BIM standards. These standards cover (buildingSMART, 2008):

a) buildingSMART Processes,

b) buildingSMART Data Dictionary, and

c) buildingSMART Data model.

It is worth exploring each of these for a better understanding of BIM.

3.1. THE PROCESSES

The construction industry is characterised by many different parties brought together in a temporary multi-organisation (TMO) for each individual project. They share many different information in variety of formats. For work efficiency, it is important that parties know which and when different kind of information is to be communicated. This becomes critical when digital tools are used, because these tools have very low threshold of tolerance in data interpretation ability, compared to the human brain. BuildingSMART develops "Information Delivery Manuals" (IDM) as ISO standards (currently ISO 29481-1:2010 "Building information modelling - Information delivery manual - Part 1: Methodology and format") in order to have a methodology to capture and specify processes and information flow during the lifecycle of a building. The main purpose of an IDM is to make sure that the relevant data are communicate in such a way they can be interpreted by the software at the receiving side (Karlshøj, 2011).

3.2. THE DATA DICTIONARY

BuildingSMART develops the standards for terminology libraries or *ontologies*, known as International Framework for Dictionaries (IFD). IFD is not just a dictionary; instead, it defines the framework for development of data dictionaries for BIM technology. IFD is a structure which can hold many dictionaries (terminology libraries or ontologies). The concept for the IFD Library is derived from internationally-accepted open standards that have been developed by ISO (Bjørkhaug and Bell, 2007). Software developers use this framework to develop BIM enabled software. Since interoperability is inherent feature of BIM, IFD will assure interoperability among these software.

3.3. THE DATA MODEL

The data exchange format for openBIM is called Industry Foundation Classes (IFC). This data model is supported and complies with IFD (described above). In simple, IFD specifies concepts and IFC is used to define the individual instances of the concepts. For example, IFD may define how to specify a wall, IFC specifications for certain type of a wall is specified accordingly, and in an IFC product model it may have defined the location and geometries (and much more information) of said wall type in a particular building. IFD holds the templates while IFC standards are used to fill them in (Bjørkhaug and Bell, 2007). The IFC can be called the master file format of a building project.

IFC is in fact an EXPRESS based entity-relationship model consisting of many entities organised into an object-based inheritance hierarchy (International Organisation for Standardisation [ISO], 2005). IFC consists of an information schema, i.e. a data model in a formal machine-readable notation, and associated informal human-readable semantic definitions (Liebich, 2011).

The scope of IFC schema is to define a specification for sharing data throughout the project life-cycle, globally, across disciplines and across technical applications. This is enormously broad and complex. Therefore most BIM applications use a sub-set of IFC schema depending on their requirements. Software applications have their inherent information schema. Importing from and exporting to IFC involves mapping of their internal information schema with the IFC schema. Because of the differences in the two data schemes, data losses can occur during the translation process (Exactal, 2012). This may be one of the reasons why proprietary BIM information schemas such as that is used in Autodesk's Revit, are also becoming popular.

4. APPLICATION OF BIM TECHNOLOGY

In simple, BIM allows for virtual construction of a building to its full details. How this has been made possible is through the global BIM initiatives which are currently led by buildingSMART. The background of the BIM (specifically the openBIM) technology is discussed above. Several proprietary BIM solutions are also developed to scales not yet matched by IFC (of buildingSMART) probably due to the competition and large budget allocation for R&D as a result of that. However, these developments are usually within limited scope in contrast to wider scope of buildingSMART initiatives.

The objects within BIM are termed "intelligent" because of defined properties and behavioural relationship with other objects. A door knows that it is a door, and when it is placed into a wall the wall knows it has to have an opening to suit that particular door. The parametric properties are inter-related. If the door size is changed, the wall opening will change to suit. All of the physical and functional characteristics of the building model are held in the central database. As the model develops, all of the objects within it parametrically adapt themselves to the new design. These models are therefore rich in information that can be extracted and used for a variety of analyses to assist in design, construction and operational optimisation (Exactal, 2012).

BIM technology brings in numerous advantages for designing, construction management and cost estimating of building projects. However, it should be noted that BIM may also bring various limitations to the process, which may have been already realised or yet to be realised. Nevertheless, it is evident that limitations get diminished with the advancement of technologies.

4.1. TRADITIONAL CAD VERSUS BIM

A computer graphic is usually a Raster Image. A raster image is made up of large number of tiny coloured dots (called piexels) which generate the image for the viewer. This is the common type of graphic generated by digital cameras and scanners.

Traditional Two-Dimensional (2D) and Three-Dimensional (3D) Computer Aided Draughting (CAD) programmes made use of geometrical primitives such as points, lines, curves and shapes or polygons, which are known as vectors. Vectors are based on mathematical equations. They lead through locations called control points. Each of these points has a definite position on the x and y axes of the work plane. For 3D graphics, a third axis z is added. Vector generated images are called Vector Graphics. 3D rendering (image generation) in vector graphics uses polygon fill to get the solid state appearance. However, the elements in fact do not have solid state characteristics (i.e. they are not machine readable as solid). There were other 3D authoring applications which could add parameters such as weight and friction to 3D elements, but were widely used in 3D animation industries.

BIM essentially does not require graphical interface. Industry Foundation Classes (IFC) is plain text database readable in any standard text reader. In order to interpret the text, one must know the relevant information schema. Still, the effort will become worthless because even the IFC file of a small building is near infinitely lengthy that makes it far beyond human cognition. However, since geometry is one of the parameter of a BIM element, software applications can generate vector graphics or raster images by reading BIM data. Advanced tools are developed which enables the designers to design buildings in a virtual 3D space without requiring them to have any knowledge on IFCs. Similarly, there are many other software applications developed with interpreters built-in in order to perform various tasks for design, development and lifecycle management of buildings. Some applications read and author IFCs, while others only read them to interpret information for tasks such as those in facilities management.

It should be noted that BIM is not an evolution 3D CAD modelling. Instead, it is a new breed of modelling. Thus, it is not possible to say that BIM is better than 3D CAD in terms of all aspects of 3D CAD. Whether BIM allows same level of flexibility of traditional CAD for designers is yet to be found (Lockley, 2011).

4.2. CONSTRUCTION MANAGEMENT WITH BIM

Construction Scheduling is known as 4D BIM, since time is considered to be the fourth dimension of an element. 4D BIM is about use of BIM technology for construction project visualisation (often in virtual 3D) and CPM scheduling. Associated processes such as supply chain management, procurement management, and risk management, are also considered within 4D BIM.

A highly welcomed feature of BIM in terms of construction management is Clash Detection. The word "clash," will bring to one's mind of pipes running into HVAC and cutting through a floor. Identifying and fixing these issues ahead of time has been one of the best uses of BIM technology. While been a useful feature during design phase, clash detection become invaluable when dealing with changes and unexpected physical conditions.

Clashes will not only occur in design, there can be other clashes such as scheduling clashes where too many labour gangs are required working in a limited space. The BIM and allied technology has been advanced to detect all these 2D, 3D and 4D clashes in project execution (Vico, 2012). Technologies are further extended from linking BIM models with popular project management software to subcontractor evaluation and management.

One of the barriers envisaged getting BIM to the worksite where parties of various financial calibres take-part, was the affordability of the technology. This is thought to be insignificant now since there are affordable (or sometimes free to use) software available for using BIM at site level (Tekla, 2011).

4.3. BIM AND COST ESTIMATING

The next parameter considered for incorporation to BIM is the cost. Thus, cost estimating with BIM is known as 5D BIM. However, there is no evidence of real integration of cost estimating into BIM. While "Cost" is a standard property of a BIM element, there is no popular usage of it for cost estimating. The possible reason is that summation of cost of elements would not yield the total cost, since there are many other parameters affecting the cost. What is evident is the development of tools for automation of quantity takeoff process by reading (interpreting) the BIM models and employ them in the conventional estimating process, which may also be partly automated. However, some are intuitively advanced that the estimate (or cost model) is visually linked to the 3D model view. For example, when a cost item in the schedule is selected, relevant building elements are highlighted in the 3D visual model (Exactal, 2012; Nomitech, 2011). While most of BIM cost estimating tools can only read BIM models, there are some estimating tools which can write back to BIM models updating its cost properties (Beck Technology, 2011).

5. BIM POTENTIALS OF SRI LANKAN CONSTRUCTION INDUSTRY

Sri Lankan construction industry does not possess BIM technology. Yet, it is not a critical barrier for BIM implementation. Technology can be acquired. The rational decision to acquire BIM technology would be on the balance of costs and benefits. In absence of knowledge and experience, it is difficult to know the benefits. While it is impractical to experience BIM in real life (due to absence of BIM), the only option is to become knowledgeable in order to make an informed decision.

Recent studies in United Kingdom show that there is a majority who are not properly aware of BIM; and those who are aware of BIM and adopt it, are pleased with its benefits and keen to invest for further benefits (Malleson, 2012). Thus, it is clear that the knowledge matters in getting the best use of BIM. However, an in-depth knowledge of core technology is not necessary to work with BIM. Many WYSIWYG and intuitive software are developed so that the users can master tools in their own domain and contribute to BIM effectively.

Once available, adoption of technology would not be a challenge in a nation with comparatively high IT literacy and AEC professionals with fair computer knowhow. The challenge is likely to arise from the resistance to change and overlapping professional boundaries. To receive the true benefits of BIM, changes in procurement strategies, processes, cultures and attitudes become necessary. The BIM friendly procurement strategy – Integrated Project Delivery (IPD) – is still not known to Sri Lanka. In fact BIM is a requisite for IPD (AIA California Council, 2007). Collaborative design development and construction will require significant deviations from current practices. Strong commitment of parties will therefore be required for successful implementation of BIM in Sri Lanka. The challenge may not be severe as much as the current experience would suggest. There has been evidence of positive changes in cultures and attitudes with the change of procurement strategies (Gunathilake and Jayasena, 2008).

6. CONCLUSIONS

Building Information Modelling (BIM) is relatively a new buzzword in the Construction Industry; and not many in the Sri Lankan industry know about it. The technological developments in BIM bring the construction to a new era. Contrast to the conventional ICT developments in the field of construction, BIM is based on a strong information schema which makes the building design fully machine readable. This enables automation of various design, construction management, quantity surveying and procurement processes; and minimising of design and construction errors. All will lead to a more efficient industry which will save both time and cost. Thus, BIM is a technology that Sri Lankan construction industry should go for. Most challenges are unlikely to be significant where there is commitment. What is likely to be critical at this point of time is the development of proper BIM knowledge base within the industry; and identification and elimination of barriers of integrating BIM enabled procurement strategies like IPD. These presents the questions for the way forward of the current research study.

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THE IMPACT OF INCLUSION OF ARBITRATION CLAUSE BY REFERENCE IN MAIN CONTRACT AND SUB CONTRACT DOCUMENTS IN THE CONSTRUCTION INDUSTRY AND ITS NEGATIVE CONNOTATIONS

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ABSTRACT

In construction contracts an arbitration clause comes into being, as an exclusive clause in the main contract or by reference to another contract. In the dispute resolution process the Arbitrator derive his power from the arbitration agreement and from the applicable law which invariably makes it mandatory for the arbitration clause to be in writing. Such clause prevents Court jurisdiction since party autonomy will prevail. Therefore, it is important to identify, which form of arbitration clause would serve the purpose, since the usage of such clause in the dispute resolution process may become void if it is incorporated by general reference. The Court will not allow proceedings unless the arbitration clause is properly constituted. The Arbitration Clause by reference in itself could lead to disputes! An arbitration clause in a contract comes into being through a separate agreement, as an exclusive clause in the main contract or by reference to another contract. Therefore, it is important to have a properly constituted clause, and if it is by specific reference or general reference, or both, it would pave the way for disputes. The arbitration clause is a self-contained co-lateral contract preventing Court jurisdiction and would survive even if the main contract is void. When the arbitration clause is incorporated with lacuna, the opposing party could successfully challenge its validity in Courts. Disputes can be compounded when a main contractor sub-contracts to another who in turn sub-contracts to others making reference to the terms of the main contract. In this context, this paper is presented with a literature review and English case law to show the importance of properly constituting an arbitration clause to reduce disputes in the construction industry.

Keywords: *Arbitration by Reference, Construction Industry, Dispute Resolution, Negative Connotations.*

1. INTRODUCTION

Historically Arbitration has been used to resolve commercial disputes. Generally contracting parties enter into a commercial Contract wherein they would also agree to resolve any disputes in an expeditious manner by referring such disputes through a quasi judicial process known as Arbitration. Generally all disputes which can be decided by a civil court involving private rights can be referred to Arbitration. In order to resolve a dispute by arbitration, a neutral third party would be appointed by the parties or by the process contained in the agreement which both parties had undertaken to abide by the decision of the so called third party who is known as an Arbitrator. Due to the development of commerce, in order to avoid the disputes that may arise by reference to litigation, internationally most governments have entered into treaties which are identified as the New York Convention. Arbitration can be classified into domestic arbitration, international arbitration, ad hock arbitration and institutional arbitration. The crux of the matter is the arbitration agreement through which the Arbitrator derives his power. The literature review indicates that arbitration has evolved in different forms in different nations.

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2. BACKGROUND

"The modern origin of international arbitration can be traced to the Jay treaty (1784) between the USA and the UK, which provided for the determination of legal disputes between the states by mixed commissions. The Hague Conventions of 1899 and 1907 contained rules of arbitration that have now become part of customary international law. The 1899 Convention created the Permanent Court of Arbitration which was not, strictly speaking, a Court but a means of providing a body of arbitrators on which the parties to a dispute can draw. Consent to arbitration by states is given in three ways: by inclusion of a special arbitration clause in the treaty; by a general treaty of arbitration which arranges arbitration procedures for future disputes; and by a special arbitration treaty designed for a current dispute (Oxford Dictionary of Law, 2009).

Arbitration in India can be traced back to ancient times. Lal and Singhe (1983) proposed that: "In ancient India a decision by Panchayats has been accepted as binding. In ancient India there were various grades of arbitrators or Panchayats namely Puga, Sreni, Kula."

Similarly in Sri Lanka ancient civilisation also adopted arbitration procedures in different forms to resolve disputes. More recent studies (Kanag-Isvaran, 2006) show that "Sri Lanka has a rich tradition of dispute resolution going back to over two thousand five hundred years".

During colonial times there were instances when British Government Agents used arbitration as a way of resolving disputes (Woolf, 1960). In Pryles (2002) in his famous study Dispute Resolution in Asia, claims similar evolution of the process in the People's Republic of China, Hong Kong, Indonesia, Japan, Malaysia, Vietnam and Thailand.

In every civilisation or every legal history dispute resolution has evolved and it has being embraced into the common law as well as civil law systems. Arbitration is an Alternate Dispute Resolution (ADR). Arbitration in particular has been advocated rigorously by civil law countries than that of countries with common law traditions. Even England, the originator of common law, now advocates ADR. The change in the civil litigation landscape in England by Woolf Reform stands for this rating.

In a study by Redfern and Hunter (2001), argued that: "It is private, it is effective and, in most parts of the world, it is now the generally accepted method of resolving international business disputes. International commercial arbitrations take place daily in different countries and against different legal and cultural backgrounds; because they take place by agreement between the parties and are conducted in private, there is an informality about them which is striking". The entire nation in the global village trade internationally and work towards ADR in order to resolve their commercial disputes expediently.

3. ALTERNATE DISPUTE RESOLUTION PROCESS

Gearey *et al*. (2009) conclude that: "The arbitration is one method of ADR amongst many others. ADR is the broad name for those methods of dispute resolution that do not involve recourse to the court system. These include Mediation, Arbitration, Conciliation and Early Neutral Evaluation. Mediation can be both formal and informal and it usually involves an experienced person (mediator) who acts as a facilitator to encourage discussion of the parties' concerns and tries to encourage the parties to reach a solution that they are all happy with. Conciliation is slightly different in that the conciliator is authorised to propose a solution for the parties to consider before they reach a conclusion. Neutral evaluation involves an expert considering all of the evidence and reaching a view which, although not binding, is used in an attempt for all parties to see what the effect could be if the case goes to courts. It is hoped that both parties will resolve their disputes if they are confronted by this neutral position. However, Arbitration tends to be used in commercial cases since it is legally binding and a professional arbitrator will determine how the case will be resolved. This is a much more formal process than the previous forms of ADR and it is often seen as an expensive but useful alternative".

4. Arbitration Agreement and Incorporation of the Arbitration Clause

The distinguishing feature in arbitration is the agreement to arbitrate. Though it is referred to as an agreement it is a co-lateral contract. In Lord Diplock in Bremer Vulkan *vs.* South India Shipping (1981) AC 909, states that: "The status of a so-called 'arbitration clause' included in a contract of any nature is different from other types of clauses because it constitutes a 'self-contained contract co-lateral or ancillary to the substantive contract". In the case of the arbitration clause over the doctrine of severability, the arbitration clause would survive even if the main contract is void.

The arbitration agreement, or rather the agreement to arbitrate, can come into existence as a separate agreement, as a clause in the agreement itself between the parties or incorporation by reference. The Oxford Dictionary of Law (2009) concludes that incorporation by reference is reference to named contract terms. This is often being sufficient to incorporate the term by reference to the contract, although the other party may not have taken the opportunity to read the terms. It is further enumerated that: "there are risks in incorporation if the terms are merely incorporated by reference".

It is these aspects of the risk that is necessary to encapsulate with particular reference to construction contracts. It is the common law position that the arbitration agreement may prevent the parties from bringing a dispute into the court. Further, more often than not, it has been laid down by statute that the agreement to arbitrate has to be a "written agreement". The object of the legislators is to ensure that one is not deprived of the right to have disputes resolved by court unless and until he has consciously and deliberately agreed to do so. Lastly, the nature of an arbitration clause in the contract is different to other type of clauses because it constitutes a self-contained contract co-lateral to or ancillary to substantive contract.

This agreement serves several features, namely parties have consented to resolve their disputes by arbitration and expression of the will of the parties on the basis of party autonomy. Once the consent is given it cannot be withdrawn unilaterally.

An arbitration agreement does not merely serve to evidence the consent of the parties and to establish the obligation to arbitrate in the event of a dispute being referred. The cardinal principle is, it is a basis of source of power to arbitrate although it is supplanted by statutes. In this sense it deprives one's right to determine a dispute by reference to court since in the case of determination of Scott *vs*. Avery by the English Court in favour of arbitration over litigation. Therefore the English Courts do not advocate such deprivations now unless by specific references since determination by Aughton Ltd. (formerly Aughton Group Ltd.) *vs.* MF Kent Services Ltd. (1991) 57 B.L.R. 1 at 30. The intention of this paper is to articulate instances where statutes have made it mandatory for the arbitration clause to be in writing. Courts are reluctant to construe an arbitration clause as properly incorporated unless there are specific references.

5. Emergence of UNCITRAL Model Law

In a study by Kwatra (1997, p.85) argued that: "Over the years nations after nations ventured into international trade resulting in the birth of The United Nations Commission on International Trade Law (UNCITRAL). UNCITRAL was established by the General Assembly in 1966. In establishing the Commission, the General Assembly recognised that disparities in national laws governing international trade created obstacles to the flow of the trade; it regarded the Commission as the vehicle by which the United Nations could play a more active role in reducing and removing these obstacles. It thus gave the Commission a general mandate to further the progressive harmonisation and unification of the law of international trade. The Commission has since come to be the core legal body of the United Nations system in the field of international trade law". Work carried out by UNCITRAL includes, but is not limited to, the "UNCITRAL" model law.

UNCITRAL Model Law is designed to assist states in reforming and modernising their laws and arbitral procedures so as to take into account the particular features and needs of international commercial arbitrations. It was adopted by UNCITRAL in 1985 and has already been enacted into law by a considerable number of jurisdictions from both developing and developed countries (Kwatra, 1997).

The Model Law provides a template for drafting national laws so that harmonisation may take place. The

Model Law Article (vii) covers the definition and the form of arbitration agreement. Article (vii) of The Model Law in its current form in 2006, provides that:

- Arbitration agreement' is an agreement by the parties to submit to arbitration all or certain disputes which have arisen or which may arise between them in respect of a defined legal relationship, whether contractual or not. An arbitration agreement may be in the form of an arbitration clause in the contract or in the form of a separate agreement.
- The arbitration agreement shall be in writing.
- The reference in a contract to any document containing an arbitration clause constitutes an arbitration agreement in writing, provided that the reference is such as to make that clause part of the contract."

6. CASE LAWS INCORPORATING ARBITRATION BY REFERENCE

In the Scott *vs.* Avery decision, common law had developed arbitration into greater echelons with many exceptions, and one such being the incorporation of the arbitration clause by reference and acceptance by the judiciary ranging from construction, shipping to insurance etc. Mustill and Boyd (2001) stated that: "Although in general the law takes a benevolent view of the use of general words to incorporate by reference terms to be found elsewhere, a stricter rule has developed in the case of bills of lading and charter parties. One reason is that the bill of lading, as a transferable document of the title, may come into the hands of person with no knowledge and no remedial means or knowledge of the charter party. (Federal Bulk Carriers Inc *vs.* C Itoh & Co. Ltd., The Federal Bulker (1989) I Lloyd's rep. 103)."

Stephen and Ramsey (2006) proposed incorporation by reference, where it is contended that an arbitration agreement is incorporated by references into another contract, distinct and specific written words were needed prior to the 1996 Act to effect the incorporation and to satisfy the requirement for writing. This still appears to be the position despite the provision in the 1996 Act that: "Reference in an agreement to a written form of the arbitration clause or to a document containing an arbitration clause constitutes an arbitration agreement if the reference is such as to make that clause part of the agreement."

It should be noted that the writers of the above are referring to the Arbitration Act of 1996 of England and Wales. The writer reproduces the long title: "An Act to restate and improve the law relating to arbitration pursuant to an arbitration agreement"

6.1. ENGLISH CONTRACT LAW PRINCIPLES WIDELY USED

Mckendrick (2011) discussed the subject that the 'Europeanisation' of contract law (in the sense of general principles) has been fairly limited because it has largely been aimed at consumer transactions (although the Directive on Self Employed (Commercial Agents) 1986/653/EC), has a more general impact on agency law in the commercial context This paper does not attempt to examine the extent of application of English contract law doctrines to other legal systems but proceeds on the basis of general application and persuasive effect.

6.2. BOUND BY SIGNATURE

Mckendrick (2011) argued that in general, the accepted common law position is that parties are bound by the parol evidence rule and sanctity of written documents. This applies in the case of the written arbitration clause as well. Once the contracting parties have elected to enshrine their contract in a written document, the courts have held that, as a general rule the parties cannot adduce extrinsic evidence to add to, vary or contradict the written document; the document is the sole repository of the terms of the contract. This rule has been called the 'parol evidence rule'. English law does attach importance to the sanctity of written documents and this can be seen in the general rule that a person is bound by the document which he signs, whether he reads it or not. This proposition is seen to be derived from the case of L' Estrange *vs.* F Graucob Ltd. (1934) 2 KB 394.

Poole (2010) discussed the subject as: "This is an important buttress of contractual certainty and a reflection of objective approach to the contract formation, since if the parties sign a document they are objectively to be taken to be agreeing to its terms. However, its unbending application has sometimes appeared to cause hardship".

6.3. INCORPORATION BY REFERENCE AS IN ENGLISH CASE LAW

There is a generally accepted common law position where parties can incorporate an arbitration agreement into a contract 'by reference'. There has been a mixed authority in England whether it is sufficient to refer to a contract containing an arbitration clause or alternatively if the arbitration clause itself must be referred in order to validly incorporate the arbitration agreement as held in Sir John Megaw in Aughton Ltd. *Vs.* MF Kent Services Ltd. (1991) 57 B.L.R. 1;31. Con. L.R.60 CA.

The mere reference to a contract containing an arbitration clause would not in itself be sufficient. Sir John Megaw in Lexair Ltd. *vs.* Edgar W. Taylor Ltd. (1993) 65 B.L.R. 87 QBD (Fox –Andrews J.) states that: "An arbitration clause cannot be incorporated by a mere reference to the terms and conditions of another contract containing an arbitration clause (known as "the rule in *Aughton*") has been applied reasonably consistently in subsequent English cases concerning the incorporation of an arbitration clause by reference".

To express it differently, even where the assent of the parties to an agreement is signified in some manner other than by signature on a document containing or referring to its terms, it is still possible for the terms contained in a document or documents to become part of the agreement between those parties, for instance in the industry or trade association terms the document or documents may even be the terms of another contract between the parties, or of a draft agreement between them, or of a contract between one of them and a third party. All that is required is a clear intention on the part of all parties to the agreement that the terms contained in that one or more documents be incorporated into their agreement.

The authority of English law for the principle as enumerated in the above paragraph is found in Modern Buildings Wales Ltd. *vs.* Limmer & Trinidad Co. Ltd., Court of Appeal, Civil division, Buckley and Ormrod LJJ, 7, 10 February 1975.

In *Arbitration Act* 1950, s 4(1) "Arbitration – Stay of proceedings – a Dispute as to existence of arbitration agreement arose – Determination of dispute on interlocutory motion for stay – Question was whether arbitration clause incorporated in contract – whether Duty of court had the power to determine before defendant took further steps in proceedings.

The plaintiffs were head contractors for the construction of a building. The defendants were nominated sub-contractors for the purpose of putting in ceilings in that building. The defendants' quotation for the work was accepted by the plaintiffs' order which contained the words 'in full accordance with the appropriate form for nominated sub-contractors (R.I.B.A., 1965)'. The plaintiffs sued the defendants for damages for breach of contract and applied for summary judgment under RSC Ord. 14. The defendants contended that the plaintiffs' order had incorporated a contract ('the green form') normally used by contractors and nominated sub-contractors when contracting inter se, which contained an arbitration clause. The defendants applied under s 4(1) of the Arbitration Act 1950 for stay of the proceedings in the action pending reference of the dispute to arbitration. The plaintiffs contended that the words in their order did not refer to the green form, that where there was doubt about the existence of an arbitration agreement the court should exercise its discretion to allow the action to proceed rather than deciding the question on an interlocutory basis, and that they knew of no defence to their claim. Section 4(1) is set out at p 551 a and b, post.

It was held – A stay would be granted for the following reasons -

(i) Where a party claimed that proceedings should be stayed because there was an arbitration agreement in force, the court was under a duty to construe the terms of the contract in order to decide whether there was a valid arbitration clause [1975] 2. All ER 549 at 550. That question had to be determined at an interlocutory stage because it had to be done before the defendant took any steps in the action (p 554 b and c and p 556 g to j, post).

(ii) The defendants' evidence showed clearly that the contract incorporated the green form, including the arbitration clause, and that there was a bona fide dispute between the parties. There was therefore no sufficient reason under s 4 of the 1950 Act for the Court to refuse a stay (see p 556 c to f and p 557 e g and h, post).

In adjudication of this case English judges distinguished in London Sack & Bag Co Ltd *vs.* Dixon & Lugton Ltd. where the plaintiff company bought from the defendant company 5,000 used cotton flour bags, and on delivery complained that the goods were not up to description and claimed repayment, with interest and damages. There was no arbitration clause in the written contract, but the point was taken that both the parties were members of a company called United Kingdom Jute Goods Association [1975] 2 All ER 549 at 553.

It is noted that the English court declined to infer that there was an arbitration clause thus reproduced the obit dictum by Scott LJ: 'The arbitration clause must be in the written submission. It cannot be said that there is a written agreement to arbitrate unless there is a clear reference in the written contract between the parties to the alleged arbitration clause and that reference must amount to an incorporation of it.'

6.4. Instances where the Arbitration Clause Does not Apply in Common Law

If the contract is in itself assignable, the arbitration clause being part of that contract, is also assignable; but if a contractor assigns the right to receive all the money due or to become due under a contract, the contract otherwise remaining in force between himself and the employer and the contractor contains an arbitration clause, the arbitrator has no power to make an award of such money in favour of the contractor.

Where the arbitration clause provided that the reference should not be opened until after the completion of the works and the contractor determined the contract before completion (as he had power to do under a clause in the contract), it was held that the arbitrator had no jurisdiction. Limitations on the opening of the reference are strictly construed.

Where a sub-contractor agrees to be bound by the terms of a principal contract, which contains a clause referring disputes between the employer and the contractor to arbitration, this does not necessarily operate as a submission to arbitration of disputes between the contractor and the sub-contractor, unless the language used by the parties to the sub-contract points plainly to an intention to incorporate the arbitration clause in the main contract.

In many building disputes the employer will wish to bring a claim against the contractor, with whom he may have an arbitration agreement, and against the architect or engineer with whom he may not have an arbitration agreement or an agreement requiring the disputes to be referred to the same arbitrator. In these circumstances, the Court is nonetheless obliged to grant a stay of proceedings unless the applicant has taken a step in proceedings to answer the substantive claim or the Court is satisfied that the arbitration agreement is null and void, inoperative or incapable of being performed. Once arbitration proceedings are started, the Court will not readily revoke the authority of the arbitrator.

Unless otherwise agreed by the parties, an arbitration agreement which forms or was intended to form part of another agreement (whether or not in writing) is not to be regarded as invalid, non-existent or ineffective because that other agreement is invalid, or did not come into existence or has become ineffective, and for that purpose it is to be treated as a distinct agreement. This principle of severability means that the invalidity or rescission of the main contract does not necessarily entail the invalidity or rescission of the arbitration agreement.

It is a practical perception when a construction contract is about to be signed after long drawn out negotiations, at times flexing the bargaining power and relative strengths of each other, the importance of the arbitration clause is overlooked. In any event the construction activity is a series of decisions and executions thereof and there is bound to be disagreements which may mature into disputes. Therefore, in the event of a dispute, in general it is the arbitration clause in particular that would come to one's recue as a last resort. If a simple question is asked whether: "Is it worth as a Builder, Contractor, Developer, Engineer, Architect or Quantity Surveyor to test the knowledge and temperament of the Arbitrator, Judge, Counsel or other Tribunal in the execution of one's profession, or instead, incorporate the arbitration clause properly at the inception in the main contract or as a separate agreement to arbitrate?". There is no doubt that everyone would agree to the latter.

7. CONCLUDING REMARKS

The awareness of the impact of incorporating Arbitration by reference in the contact agreements is very important since if a dispute arises between the parties to a contract and if it is not properly incorporated one party can challenge the validity or existence of an arbitration clause in the contract. This is seen in the number of case laws cited in the above literature review. It is also identified that an arbitration agreement must be properly incorporated by reference to another contract, in which the arbitration clause is spelled out provided specific reference has been made and the other party has notice of it. This way both parties have equal opportunity to resolve their disputes without a challenge. However industry research also shows that there are instances where incorporating the arbitration by reference has been challenged successfully and could be challenged in the future as well. However it is important for the construction industry stakeholders such as Builders, Engineers, Contractors or any other building professional not to venture into testing the common law, particularly English common law, and end up in difficulties. Also under varying degrees of uncertainties and mix of legal authorities, it may be not prudent to incorporate the arbitration clause by general reference but at the inception of the contract. One could reproduce the same clause, or alternatively include a well-tested arbitration clause, or enter into a separate contract to arbitrate or make a specific reference with notice to the other party so that parties do not fall into pitfalls with lack of awareness or understanding. It is believed that understanding of the ADR process very specifically the Arbitration process and its inclusion in the contract condition and in sub contract agreements will help build a less litigious construction industry.

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DISASTER RISK REDUCTION MEASURES IN BANGLADESH

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ABSTRACT

Disasters damage the entire economy of the country when they predominantly take place in developing countries. While no country in the world is entirely safe, lack of capacity to limit the impact of hazards has made developing countries being the most vulnerable nations to natural disasters. Bangladesh is being identified as a country that is vulnerable to climate change and subsequent natural disasters every year. Dense population and poverty has reduced the adaptability of Bangladesh in disastrous situations thus further increasing severity of impact from disasters. Owing to geographical settings, Bangladesh is currently ranked as one of the world's most disaster-prone countries in the world. The frequent natural hazards such as cyclones, storm surges, floods, droughts, tornados, riverbank erosions, earthquakes, arsenic contamination of groundwater and landslides account for significant losses in human lives and physical assets while effects are further reflected in social settings, ecosystems and the economic well-being of the country. This paper evaluates the types of natural disasters Bangladesh is subjecting to, how they have affected the Bangladesh community and existing disaster risk reduction strategies. Paper also evaluates four main domains of disaster vulnerability reduction measures namely physical, engineering, structural and organisational. Existing disaster risk reduction strategies adopted in Bangladesh are linked with the aforementioned four domains of disaster vulnerability reduction measures. A comprehensive literature review is used as the research method. Literature synthesis suggests that Bangladesh is being using a combination of disaster risk reduction measures ranging from technical to social measures.

Keywords: *Bangladesh, Natural Disasters, Risk Reduction, Vulnerability.*

1. INTRODUCTION

Natural disasters are no longer strange events for human. The entire world is facing an unprecedented scale of natural disasters and they appear to be increasing in both their frequency and intensity. The global cost of natural disasters has significantly increased in 14-folds between the 1950s and 1990s (Munich Re, 1999). 1990s and 2000s are remembered unforgettable 20 years in terms of losses occurred due to natural disasters all over the world. Japan earthquake (2010), New Zealand earthquake (2010), Italy earthquake (2009), tropical cyclone in Myanmar (2008), Kashmir earthquake (2005), Indian Ocean tsunami (2004), Bam earthquake (2003), Kobe earthquake (1995) are just a few out of that endless list of disasters.

It has been well-known that disasters damage the entire economy of the country when they predominantly take place in the developing countries. Despite the fact that the entire world is facing an unprecedented scale of natural disasters, most of the victims are reportedly from the poor developing countries (UN/ESCAP, 2006; Lloyd-Jones, 2006). While no country in the world is entirely safe, the lack of capacity to limit the impact of hazards and bounce back after major natural disasters has made developing countries being the most vulnerable nations to natural disasters. United Nations Development Programme (UNDP) reports that 24 out of 49 low-income developing countries face high levels of disaster risk and six are hit by two to eight disasters each year (Lloyd-Jones, 2006). Though only 11 per cent of people exposed to hazards live in developing countries, more than half of disaster deaths occur in these countries (UNDP, 2004 cited DFID, 2005a; DFID, 2005b). According to Moe *et al.* (2007), while Europe recorded the lowest number of victims from natural disasters, there is a higher frequency of disasters occurrence in Asia

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and the number of people who were killed and affected by natural disasters was highest in Asia. Proving the fact, Asia and the Pacific has become the world's most disaster prone region, accounting for 91 per cent of deaths from natural disasters in the past century and 49 per cent of the resulting economic losses (UN/ESCAP, 2006). There was a more than 700 per cent increase in the number of people affected due to both natural and man-made disasters in 1999 (41,244,335), in comparison to 1997 (4,698,656), in South Asia alone (IFRC&RCS, 2000 cited Ariyabandu, 2003).

Bangladesh is a South Asian country with total land area of 147,570 sq. km (Karim, 2004). It still remains a developing nation that faces variety of problems ranging from low income; lack of assets such as land and permanent housing to accommodate the people; shortages of clean water and adequate food; inability to participate in commercial activity; high population density (120 million people living in an area of 144 000 km2), human health, and illiteracy etc. (Maxwell, 1999 cited in Mclean and Moore, 2005; Ali, 1999). It has a huge population with recorded density of 855 per sq.km (Karim, 2004). All these long-lasting problems have been further exaggerated due to frequent natural disasters in the country and also have resulted in turning natural hazards into disastrous situations (Ali, 1999). Owing to geographical settings and environmental reasons, Bangladesh is currently ranked as one of the world's most disaster-prone countries in the world (Choudhury, 2002; Shimi *et al.*, 2010; World Bank, 2005) with 97.1% of its total area and 97.7% of the total population at risk of multiple hazards (World Bank, 2005). Bangladesh experiences natural disasters every year. The frequent natural hazards such as cyclones, storm surges, floods, droughts, tornados, riverbank erosions, earthquakes, arsenic contamination of groundwater and landslides account for significant losses in human lives and physical assets while effects are further reflected in social settings, ecosystems and the economic well-being of the country (Choudhury, 2002; Khan, 2008). Although Bangladesh has almost zero contribution to the greenhouse gas emission that affects global climate change, it has to suffer from the effects of climate change. Climate change is assumed to be a major force that would increase the future severity and frequency of natural disasters in Bangladesh (Khan, 2008; Ali, 1999), floods and cyclonic storm surges demand special attention because of their frequency of occurrence and damaging power (Khan, 2008). However, Ali (1999) claims that climate change is responsible for tropical cyclones, storm surges, coastal erosion, floods and droughts in Bangladesh to a greater extent.

This paper seeks to review disaster risk reduction strategies utilised in Bangladesh, in order to manage the risks of natural disasters. For the purpose of identifying the disaster vulnerability in the context of Bangladesh, natural disasters Bangladesh is at risk of and their impact on communities in Bangladesh is first discussed, eliciting evidence from past occurrences of such events. Approaches to disaster risk reduction in general are then discussed, identifying how these have been applied in Bangladesh at present.

2. METHOD

A comprehensive literature review was used as the research methodology for this paper. A key work search for natural disasters, hazards, vulnerability, disaster risk reduction, and Bangladesh was used to search literature from various sources such as electronic library data base, table of contents of journals, online journals, and e-books. Literature review was structured and presented within different categories of natural hazards and disaster risk reduction strategies used for natural hazards.

3. NATURAL DISASTER IN BANGLADESH

3.1. GENERAL OVERVIEW OF DISASTER RISKS

Current understanding is that the hazards give rise to disasters when they coincide with vulnerable populations and/or built environment structures. In other words, disasters are the disruptive and/or deadly and destructive outcomes of triggering agent(s) (in other words, hazards) when they interact with, and are exacerbated by, various forms of vulnerability (McEntire, 2001; DFID, 2005b; UN/ISDR, 2004a; UN/ISDR, 2004b). As far as the natural disasters are concerned, earthquakes, storms and torrential rains, are some of natural phenomena we refer to as 'hazards' and are not considered to be disasters in themselves. For example, an earthquake that occurs on a desert island does not trigger a disaster because there is no existing population or property affected (ADRC, 2005). In addition to a hazard, some 'vulnerability' to the natural phenomenon must be present for an event to constitute a natural disaster. While triggering agent(s) stand(s) as the independent component of a disaster that may originate from the natural environment, human activity or a combination of the two, vulnerability is considered as the dependant component that is determined by the degree of risk, susceptibility, resistance and resilience (McEntire, 2001). The following sections discuss the past and current trends of natural hazards in Bangladesh and community vulnerability to such natural hazards.

3.2. Past and Present Natural Hazards in Bangladesh

3.2.1. Tropical Cyclones and Storm Surges

Literature and statistics on natural hazards in Bangladesh affirm that tropical cyclones are the most devastating natural disaster in the country whilst floods are rated as the second most severe in terms of the number of death toll resulted in the recorded past (Asgary and Halim, 2011; Shimi *et al.*, 2010). The peculiar geography of Bangladesh where the Himalayas in the north and the funnel shaped coast touching the Bay of Bengal in the south resulted in monsoons, as well as catastrophic ravages of cyclones, tornadoes and floods (Choudhury, 2002). Bangladesh has suffered approximately 178 severe cyclones with wind speeds of more than 87 kilometres per hour (km/h) formed in the Bay of Bengal from 1891 to 1998 and 38 severe cyclones from 1970 to 1998 (Alam and Collins, 2010). The cyclones of 1970, 1985, 1991 and 1997 are some notable events in the recent past (Khan, 2008).

Cyclones and tidal surges caused major devastations in human lives and property in Bangladesh for generations (Alam and Collins, 2010). Major cyclones in Bangladesh have claimed thousands of human lives while millions of people being affected. 1970 major cyclone has killed 500,000 people and April 1991 major cyclone was responsible for human casualty of about 140,000 lives (Choudhury, 2002). The Cyclone Sidr hit Bangladesh in November 2007 affecting approximately 30 of Bangladesh's 64 districts, claiming more than 3000 lives, approximately 53,000 people reported missing and affecting 8.7 million people (IFRC&RCS, 2010). Moreover, storm surge, an unusual rise in seawater associated with a tropical cyclone originating in the Bay of Bengal, has also caused major devastation in the coastal region (Alam and Collins, 2010).

3.2.2. Floods

While floods are a devastating, worldwide natural disaster, Asian continent countries such as India, China, Philippines, Iran, Bangladesh and Nepal are recognised as highly vulnerable to floods (WWAP, 2006). Among other flood-prone countries, Bangladesh is in the forefront due to frequent floods reported in every year with varying magnitudes (Choudhury *et al.*, 2004; Hossain, 2003). Almost every year floods occur in the country, but the intensity and the magnitude vary from year to year. However, reportedly, Bangladesh experiences an increasing level of flooding (Mclean and Moore, 2005). Approximately 80 per cent of the land of Bangladesh is considered as flood plain areas and about 34 per cent of its land area is flooded for about five to seven months in every year (Islam, 2004 cited Shimi *et al.*, 2010). Approximately 20 to 25 per cent of Bangladesh's territory is inundated during the monsoon season (Choudhury *et al.*, 2004; Hossain, 2003).

It is reported that that annual flooding in Bangladesh affects 20 per cent of the landmass, and in the floods of 1992 over 50 per cent was under water (ISDWC, 2002 cited Mclean and Moore, 2005). Bangladesh has experienced 29 major floods during the past 50 years (from 1954-2004), of which 11 were classified as 'devastating' and six as 'most devastating' (Choudhury *et al.*, 2004). The floods of 1987, 1988, 1998 and 2004 are some remarkable floods took place in Bangladesh in the recent past (Khan, 2008).

Annual floods bring about significant disruption to Bangladesh economic and social activities by deteriorating the normal functions of life, affecting homesteads, daily activities, water supply and sanitation condition, washing away crops, polluting groundwater stocks and destroying the vernacular mud-brick and palm-leaf buildings (Shimi *et al.*, 2010; BSHF, 2001 cited Mclean and Moore, 2005).

Extreme events result in severe floods that bring damage to affected areas where the damage is higher if the event is prolonged (Rahman *et al.*, 2005 cited Khan, 2008). While floods can are broadly classified into 'normal' and 'abnormal' or 'extreme' events (Khan, 2008), Choudhury *et al.* (2004) identify four types of floods in Bangladesh: river floods, rainwater floods, flash floods, and cyclonic/storm-surge floods. While heavy monsoon rainfalls and melting snow in the upper catchment areas of the major rivers of Bangladesh result in river floods, rainwater floods occur due to heavy rainfalls that affect floodplains and other low-lying regions (Choudhury *et al.*, 2004). Flash floods are originated from heavy rainfalls that mainly take place in the eastern and northern hill streams in Bangladesh; Cyclonic/storm-surge flooding affects the coastal regions of Bangladesh which is formed due to tropical cyclones in the Bay of Bengal and (Choudhury *et al.*, 2004). River floods and flash floods are of utmost concern to Bangladesh (Khan, 2008). Although the normal river floods together with seasonal variability in flow and water level are somewhat beneficial to the ecosystem due to carrying alluvium, extreme floods have so far resulted in severe losses.

3.2.3. DROUGHTS

Drought is a hazard closely related to climate change and it is defined as deficiency of precipitation over an extended period of time, usually a season or more, which results in a water shortage for some activity, group, or environmental sectors (Habiba *et al.*, 2010). Although it is not a frequent hazard in Bangladesh, it forms a part of the natural disaster list in Bangladesh because droughts occur occasionally causing extensive damage to crops (Choudhury, 2002). It is said that drought is a recurrent phenomenon, afflicting the country at least as frequently as major floods and cyclones (Paul, 1998 cited Habiba *et al.*, 2010). Karim (2004) reports that Bangladesh experiences drought for 7 months, from November to May, when rainfall is normally low.

Bangladesh has undergone the effects of droughts approximately 20 times in the past 50 years (Choudhury, 2002; Habiba *et al.*, 2010). There had been a severe drought in 1998-1999 dry season in some areas of the north western, south western and central parts of the country (Karim, 2004). However, the severest drought in Bangladesh had taken place in 1979 (Choudhury, 2002). Karim (2004) reports droughts taken place in 1989 and 1994-95 as well.

Bangladesh being a country largely depends on agricultural production, drought results in significant economic, social and environmental problems in the country. For example, Karim (2004) notes that the persistent droughts in north western Bangladesh in recent decades had led to shortfall of rice production of 3.5 million tons in the 1990s. Droughts being closely related to climate change, the effects of global climate change predictions indicates that the dry seasons will become drier and hotter (Karim, 2004). Mirza and Pal (1992) and Das (1997) classify droughts in Bangladesh into three groups depending on their impact (cited Habiba *et al.*, 2010):

- Agricultural drought - Shortage of moisture in the soil for crop growth;
- Hydrological drought - Falling of the surface and subsurface water levels; and decreases in stream flow, ultimately affecting soil moisture; and
- Economic drought - A condition adversely affecting the economy at large.

3.2.4. EARTHQUAKES

While history of earthquakes in the world can be traced back to centuries, Bangladesh is prone to earthquakes as it lies in the seismic zone. Specially, the northern belt of greater Sylhet, Mymensingh and the eastern part of Rangpur Districts in Bangladesh are more vulnerable to earthquakes (Choudhury, 2001). The major earthquakes that have affected Bangladesh since the middle of the last century are the Cachar Earthquake of January 1869, the Bengal Earthquake of July 1885, the Great Earthquake of July 1897, the Srimangal Earthquake of July, 1918, the Dhubri Earthquake of July 3, 1930, the Bihar-Nepal Earthquake of January 15, 1934 and the Assam Earthquake of August 15, 1950 (Choudhury, 2001). The damages caused by these shallow focus earthquakes however were restricted to narrow zones surrounding the epicentres.

3.2.5. SOIL EROSION

Along the courses of the mighty rivers in Bangladesh, the Padma, the Jamuna, the Meghna, etc. erosion every year takes away chunks of land causing displacement of large number of people and losses of properties. Due to recurrence of such erosion, displaced people are forced to come to cities for their earning. In the last 34 years submerging of river side lands are 219286 acres in Jamuna, 69135 acres in Ganges and 95119 acres in Padma. To be concerned that, erosion in the Jamuna had caused 3408 acres of land, 543 localities, 3360 metres of embankment, 5160 metres of roads, 4 educational institutions, and 2 market place already been submerged by 2007. In the mean time, the Ganges had caused 1778 acres of lands, 136 acres of localities and 570 meters of roads while the Padma had caused 1600 acres of lands, 370 acres of localities, 3930 metres of roads, 9 educational institutions, 5 market places and 1 Union Council office have been submerged in the river by recent rate of erosion (Centre for Environment and Geographic Information Services, 2000).

Some rivers in Bangladesh cause erosion in large scale and high frequency due to their unstable character. These rivers assume a braided pattern consisting of several channels separated by small islands in their courses. During the last 200 years or so, the channels have been swinging between the main valley walls. During the monsoon extensive overbank spills, bank erosion and bank-line shifts are typical. The gradual migration or shifting of channels of the major rivers in Bangladesh amount to anywhere between 60m to 1,600m annually. In a typical year, about 2,400 km of the bank line experiences major erosion. The unpredictable shifting behaviour of the rivers and their encroachments not only affect the rural floodplain population but also urban growth centres and infrastructures too.

4. DISASTER RISK MANAGEMENT SYSTEMS IN BANGLADESH

As Jayaraj (2002) describes, disaster management cannot be seen in isolation but as a collection of various phases of management in addressing this particular issue. However, there cannot be a perfect/ideal system that prevents disaster damage, because then it would not be a disaster. Disaster management is in fact a systematic process of using administrative decisions, organisation, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impact of natural hazards and related environmental and technological disasters (UN/ISDR, 2009). This comprises all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation) adverse effects of hazards (OECS, 2007). While the entire world has realised the importance of employing appropriate disaster risk management systems, Bangladesh has also been implementing various disaster risk management programmes since long time but being a poor nation, cannot manage to meet the necessary resources to proactively and reactively meet the requirements of pre and post disaster needs.

4.1. DISASTER RISK REDUCTION: GENERAL OVERVIEW

The impetus for disaster risk reduction came largely with the severe loss of life, property and ecosystems due to both natural and human induced disasters and significant climate changes. UN/ISDR (2004b) defines disaster risk reduction as “the conceptual framework of elements considered with the possibilities to minimise vulnerabilities and disaster risks throughout society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development”. UN/ISDR (2009) defines the term as a “systematic development and application of policies, strategies and practices to minimise vulnerabilities and disaster risks throughout society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development”. DRR entails measures to curb disaster losses by addressing hazards and the vulnerability of people to them (DFID, 2005b).

McEntire *et al.* (2010) identify four ideal types for disaster vulnerability reduction: physical science school, engineering school, structural school and organisational school. While all four types possess their own strengths and weaknesses, two are categorised as technocratic (physical and engineering school of thoughts) and other two as sociological (McEntire *et al.*, 2010). According to McEntire *et al.* (2010) they are as follows:

- Physical science school - concentrates on living in safe areas and focuses mostly on exposure to hazards and risk reduction. This school relies heavily on the analysis of the physical environment
- Engineering school - concentrates on the built environment and ways to increase resistance through construction practices and methods of fabrication
- Structural school - concentrates on traditional notions of vulnerability more than the other three, and it stresses susceptibility based on socio-economic factors and demographic characteristics including race, ethnicity, gender, age, and other factors. This is a relatively new school of thought. The main idea is that the person is made vulnerable first and foremost due to social structure - and not necessarily by other choices they make in life
- Organisational school - stresses resilience or the effectiveness of response and recovery operations concentrates on stressing the importance of preparedness, leadership, management, and the ability to adapt, improvise, and be creative

'Organisational school of vulnerability reduction' does not assume that all disasters can be prevented and completely eliminated as the case with the other schools. This is one of the strengths of the organisational school (McEntire *et al.*, 2010). Moreover, McEntire *et al.* (2010) proposes strategies to overcome each school of vulnerability. Table 1 summarises these strategies proposed by them in reducing vulnerabilities to disasters.

Table 1: Strategies to overcome vulnerabilities (Adapted from McEntire *et al.*, 2010)

Disaster Vulnerability reduction school	**Strategies to overcome vulnerabilities**
Physical science school	Creation of warning systems Cautious development Environmental protection Complete relocation of vulnerable communities in extreme cases Land-use planning Careful settlement patterns General categorisation of a place's "hazardousness"
Engineering school	Ways to increase resistance through construction practices and fabrication methods Build structures and infrastructure adequately
Structural school	Improve socio-economic and demographic factors (e.g. race, ethnicity, gender, age, poverty) that usually increase a community's susceptibility
Organisational school	Effective response and recovery operations Effective preparedness Effective leadership, management, and the ability to adapt, improvise and be creative to help improve disaster activities

4.2. *Current Trend of Disaster Risk Reduction Measures in Bangladesh*

There are a number of disaster risk reduction strategies adopted in Bangladesh in terms of reducing risk of disasters and climate change adaptation. The following sub-sections discuss the internationally recognised disaster risk reduction measures and the existing measures within the Bangladesh context.

4.2.1. *Flood Risk Reduction Measures*

Due to high vulnerability to floods, flood management in Bangladesh is considered to be crucial to poverty reduction initiatives in the country (Hossain, 2003). Both public and individual actions have been taken in Bangladesh with regard to flood risk management (Thompson and Tod, 1998). The Flood Action Plan (FAP) came into action following major floods in 1987 and 1988 with a long-term focus on sustainable solution to flooding problem in Bangladesh. The main objectives of the FAP are to: safeguard lives and livelihoods, minimise potential flood damage, improve agro-ecological conditions for enhanced crop production, meet the needs of fisheries, navigation, communications and public health, promote commerce and industry, and create flood-free land for a better living environment (Khan, 2008). Further to that, the FAP provides guidelines for people's participation and environmental assessment for flood risk reduction (Khan, 2008).

Khalequzzaman (undated) articulates that flooding problems in Bangladesh must be analysed and necessary solutions must be taken in such a way to address three fundamental parameters called runoff, water carrying capacity, and land elevations. However, flood control measures in Bangladesh are mainly limited to building of earthen embankments, polders, and drainage (Khalequzzaman, undated). Strategies adapted by both public and individuals can be anyway classified into two groups as (Kates, 1962 cited in Thompson and Tod, 1998):

- Measure which adjust damages from floods to people (structures such as embankments);
- Measures where people adjust to floods ("non-structural" measures including flood proofing of buildings and settlements, flood warnings, land use restrictions, and adjusting crop calendars).

Since 1960s, Bangladesh government is involved in large scale flood control projects and by 1993 over 8,000km of embankments and other structures had been built at a cost of over US$5 billion (Haggart *et al.*, 1994 cited in Thompson and Tod, 1998; Khan, 2008). Loop embankments or polders have been built to protect major urban centres and coastal agricultural land while submersible embankments have been constructed for crop production and protection against flash floods in certain areas (Khan, 2008). Although certain measures like embankments and polders have been able to reduce floodplain storage capacity during floods, leading to an increase in water levels and discharges in many rivers, embankments tend to create a false sense of security among residence living within embanked areas (Khalequzzaman, undated). For example, there are several reported incidences on embankments breaching and erosion in Bangladesh such as breaching of Gumti embankment at Etbarpur during 1999 flood which caused substantial damage to the environment and property (Khalequzzama, undated). Moreover, earthen embankments can also be easily breach and can be damaged by riverbank erosion (Khalequzzaman, undated). These are evident of ineffectiveness of embankments as flood controlling measures. On top of that, adverse impact of construction of embankments is broadened to obstruction of fish migration routes and spawning grounds, and deterioration of floodplain ecosystem (Khan, 2008). Improving gravity drainage is another measure which adjusts flood extent to people (Khan, 2008). This is done through excavation and re-excavation of canals and dredging of rivers (Khan, 2008). Pumped drainage infrastructures have been constructed where gravity drainage is inadequate (Khan, 2008). Although pumped drainage infrastructure in urban loop embankments has been effective for mitigation of storm water flooding, it has not been cost-effective and resulted in channel sedimentation and adverse environmental impacts in rural flood control projects (Khan, 2008). Further to that, encroachment of storm water retention areas, obstruction of drainage routes and unplanned urban development usually weaken the effectiveness of pumped drainage infrastructure in urban areas (Khan, 2008). Construction of storm sewer and pump station is another measure adapted by the Dhaka Water Supply and Sewerage Authority to alleviate the internal drainage problems of Dhaka. The project has replaced many sections of the natural canals to concrete box culverts (Huq and Alam, 2003).

While Bangladesh government is mostly involved in taking actions to control floods, rural people are mostly keen on putting in measures to adjust to floods (Thompson and Tod, 1998). Hence, it can be argued that government of Bangladesh is using disaster vulnerability reduction measures within the Engineering school where as the community is following reduction measures within the Physical science school according to the classifications of McEntire *et al.* (2010). However, Khan (2008) claims that local people's traditional coping strategies to live with normal flood events such as river floods are far behind the required capacities to prevent, reduce and confront extreme floods. Regardless of such criticisms, it is argued that impact of flooding on households and communities are heavily reduced by flood proofing measures as well (Thompson and Tod, 1998). Flood proofing is relatively risk free and involves a minimum environmental intervention (Khan, 2008). In USA, flood proofing measure are significantly implemented through building codes as part of a set of floodplain management measures linked with floodplain zoning and compulsory flood insurance (Thompson and Tod, 1998). In Bangladesh, flood proofing measures include building homesteads on high grounds above the flood level (Khan, 2008), modifications to existing flood prone houses (retrofitting) through measure such as raising floors of homes (Laska, 1991 cited in Thompson and Tod, 1998), minor structural and non-structural measures, public or community measures such as providing flood shelters, designing roads to be above flood level, ensuring planning takes account of flood risks, and any measures to reduce the economic vulnerability of households to flood losses (Thompson and Tod, 1998). While traditional flood proofing measures such as raising of house floors and adjustments to flooding are widely used in rural Bangladesh, there has been limited official interest in flood proofing, except development of cyclone shelters in the coastal regions, and a few flood shelters in or adjacent to the char areas i.e. active floodplains (Thompson and Tod, 1998).

Flood forecasting is another measure where people adjust to floods. There had been a significant improvement in flood forecasting accuracy and lead-time of flood forecasting in Bangladesh (Khan, 2008). Although accuracy is reasonable, the need for a longer lead-time is emphasised for better preparedness and loss reduction (Khan, 2008). On top of that, appropriate use and interpretation of the forecasting information at the local level must be ensured (Khan, 2008). These disaster vulnerability measures fall within McEntire *et al.*'s (2010) Organisational school of thought.

4.2.2. EARTHQUAKE RISK REDUCTION MEASURES

A variety of earthquake risk reduction measures are proposed by practitioners and the researchers in order to reduce the earthquake vulnerabilities of people and built environment facilities. Bangladesh should develop adequate facilities for detection and study of earthquakes (Choudhury, 2001). Reja and Shajahan (2011) emphasise the importance of adequate sustainable land use planning with seismic microzoning mapping as because the land use pattern and the physical development of the built environment all affect the intense of the effects of an earthquake. Such measures fall within the Physical school of disaster vulnerability reduction measures (McEntire *et al.*, 2010). The link between land use master planning for earthquake protection and other urban planning protection measures and the control of building quality are so interrelated (Reja and Shajahan, 2011). Satellite Remote Sensing can easily identify earth's fault zones where the earthquake mainly occurs (Choudhury, 2001). Very high resolution satellites are being used for the detection of tectonic movement of the earth (Choudhury, 2001). Further to that, seismic vulnerability maps of the buildings and earthquake prevention plan for urban areas are some other useful measures for earthquake prevention (Reja and Shajahan, 2011).

4.2.3. CYCLONE RISK REDUCTION MEASURES

Bangladesh has many programmes and projects to minimise the impacts of cyclone disasters (Asgary and Halim, 2011). Moreover, a considerable amount of studies on disaster management and related issues have been undertaken in Bangladesh with particular focus on hazard analysis, coping and adjustment strategies, and loss and damage analysis from cyclones (Asgary and Halim, 2011).

Engineering measures such as cyclone shelter is one of the key cyclone mitigation measure adapted in Bangladesh. For effective employment and management of cyclone shelters, multipurpose versions have been built in carefully selected locations, identifying uses for both normal and disaster periods (Nizamuddin, 1997 cited in Alam and Collins, 2010). Cyclone shelters demonstrate an excellent dual purpose use during non-disaster periods and cyclones (Alam and Collins, 2010).

Alam and Collins (2010) categorises cyclone adaptation strategies as pre-cyclone, during cyclone and post cyclone strategies. Pre cyclone strategies include raising the height of the plinth, planting big-branched trees around the homestead, gathering crops from fields, hiding food and valuables in the earth, setting new poles diagonally around the house, endeavouring to reach cyclone shelters and other safe places etc (Alam and Collins, 2010). Strategies during cyclones include defining the role of the local youth with regard to saving the lives of children, women and older people during surge water; using cyclone shelters; and co-existence of humans, animals and wild species in different places throughout cyclonic surge (Alam and Collins, 2010). It is evident that some of the disaster vulnerability reduction measures within the Organisation school are used during post cyclone stage. Post cyclone strategies include searching for kith and kin and looking for housing utensils and means of livelihood, building a special tent-type of shed for those who have lost their houses, allowing women to become more active in the outside world in order to help cope with the devastation etc. (Alam and Collins, 2010).

4.2.4. DROUGHT RISK REDUCTION MEASURES

Having considered the nature and effects of droughts in the Colorado region, it is suggested that disaster vulnerability reduction measures within Organisation school improved communication and coordination between officials at the local level, as well as between the local officials and state or federal officials; and development of crisis management plans as key ways of reducing the effects of droughts (Wilhelmi *et al.*, 2008).

As far as the Bangladesh perspective is concerned, Habiba *et al.* (2010) classify drought risk management under physical, institutional and indigenous levels. At the physical level, Bangladesh Government has undertaken an irrigation project by installing deep tube wells in the region to increase agricultural productivity (Habiba *et al.*, 2010). The Barind Multipurpose Development Authority (BMDA) is actively involved in irrigating the northern district. Irrigation is necessary for many types of crops, especially for boro rice cultivation (Habiba *et al.*, 2010). There is a significant development of irrigation systems nowadays in Bangladesh compared to 1980s asserts Habiba *et al.*, (2010). At the institutional level, the Ministry of Food and Disaster Management (MoFDM) implements its mandate to coordinate all disaster management activities within Bangladesh (Habiba *et al.*, 2010). There are several of institutional arrangements have been built up from a national level to the union levels with the support of the Government of Bangladesh (Habiba *et al.*, 2010). Although Bangladesh has not yet been capable of establishing powerful institutions and systems to predict forthcoming droughts, they have established institutions at the national level such as the Space Research and Remote Sensing Organisation (SPARRSO), the Bangladesh Meteorological Department (BMD), and the Bangladesh Water Development Board (BWDB), for monitoring and forecasting disasters (Habiba *et al.*, 2010). At the indigenous level, households adopt various adjustments such as agricultural and non-agricultural adjustments (Habiba *et al.*, 2010). Agricultural adjustments include activities such as resowing crops, applying irrigation water, pond digging (Habiba *et al.*, 2010). Non-agricultural adjustments include activities such as sell and/or mortgage their land and livestock, sell their belongings to earn additional cash (Habiba *et al.*, 2010). At the community level, friends, neighbours, relatives, and affluent members may help the drought victims by providing cash, loans, food, and clothes (Habiba *et al.*, 2010) that comes under Organisation school of disaster vulnerability reduction.

Moreover, Ramamasy and Baas (2007) present various drought adaptation measures in relation to specific risks. If a few them are listed, they include re-excavation of traditional ponds; building of water control structures; check dams across the water ways; homestead gardening; mini Ponds for rain water harvesting; mango and Jujube cultivation etc.

5. CONCLUSIONS

Wide ranging impacts of natural disasters; including damages to infrastructure, built environment, and social impacts such as mortalities, highlight the importance of having effective disaster risk reduction measures in place, in order to prevent and mitigate the risks of such events. As elaborated via the review of existing literature, disaster risk reduction measures can be broadly classified as technocratic and sociological measures. Disaster risk reduction policy should entail a range of measures that best suits the context in concern and it is important that both technocratic and sociological measures are utilised therein, Availability of technocratic measures is imperative, as these physical and engineering interventions significantly contribute towards the protection of at risk communities. Sociological interventions can further limit the vulnerability of at-risk communities and enhance their resilience, coupled with technocratic interventions. Discussion on exiting disaster risk reduction measures in Bangladesh revealed that both the technocratic and sociological measures have been utilised thus far.

Although engineering and physical measures are required to prevent and mitigate disaster risk and impacts, such measures may not always be feasible due to resource constraints. Further, considering that majority of the country is at risk of natural disasters, it is inevitable that protection cannot be provided by technocratic measures alone in entirety. In this context, successful utilisation of sociological measures becomes important, in order to manage the risk of natural disasters. For example, effective management of communities, community awareness, and preparedness can play a major role in disaster risk reduction. Considering the economical and social contexts of a developing country like Bangladesh, it may be argued that there is scope for further utilisation of sociological measures for disaster risk reduction. Especially when it comes to a country like Bangladesh with a developing economy, community can be considered as a strength in addressing risks of disasters. Therefore, it can be argued that strengthening the social dimensions would lead towards better disaster risk reduction activities. Although the country may lack in physical and engineering related disaster risk reduction measures; use of the strengths of community can be better used to organise and act promptly and effectively during disastrous situations.

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USE OF RECYCLE GLASS AS A COARSE AGGREGATE IN CONCRETE

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ABSTRACT

Concrete is a composite material composed of sand and gravel, chemically bound together by hydrated Portland cement. It is the most widely used construction material in the developed world. As a result, the concrete industry is also one of the biggest consumers of natural resources specifically sand, gravel, rock and water. Numerous environmental problems and natural disasters are occurred because of the high extraction of natural resources. Due to that, researchers were focused on recycled materials for future development, while protecting the environment. Low cost, availability and simple process to recycle, glass concrete applications could be significantly applied in the construction industry. Therefore, primary aim of this research is to explore the applicability and adaptability of glass as a recycled material for concrete and concrete applications in Sri Lankan construction industry. This research problem will be approached through experimental studies. The empirical study will be conducted by testing the glass concrete applications in a laboratory. The results will be analysed to evaluate the concrete properties, which are made from glass coarse aggregates and glass concrete aesthetic applications. A total number of 10 cubes will be casted and tested for compressive strength, flexural strength, slump test, absorption test. It is expected that concrete which made of glass concrete aggregate 16% less strength in compression, flexure than conventional concrete. This paper intend to recommends that recycle glass can be used as an alternate coarse aggregate in concrete and will have wide applications in aesthetic workings.

Keywords: *Concrete, Recycled Materials, Glass, Glass Concrete, Glass Concrete Aesthetic Applications.*

1. INTRODUCTION

Concrete is a composite material composed of sand and gravel, chemically bound together by hydrated Portland cement (McGregor, 1997). According to McGregor (1997), concrete is the most used man made construction material, during the last century due to fire resistant, withstand for both dead and live loads, maximum safety, flexibility in design, exceptional aesthetic possibilities. According to Jayanandana and Jayasinghe (1998), aggregates include in-between 60 to 75 percentages of the total volume of concrete. Using high proportion of aggregate in concrete lead to value addition for concrete, because it is inexpensive, economical and govern the engineering properties (Jayanandana and Jayasinghe, 1998).

Most of the aggregates are obtained from the environment and numerous environmental problems and natural disasters are occurred due to high extraction of metal and sand. Therefore, the researchers focused on the future development, while protecting the environment. Limbachiya *et al.* (2000) declared that recycled materials can be used as aggregate in new concrete, which offer a viable route to convert the waste to a valuable resource. Govind (1989) stated that use of recycled materials as concrete ingredients has become popular because of the increased environmental legislation such as administrative, legislative support and fiscal assistance through direct and indirect tax incentives.

Glass can be recycled many times without changing its chemical properties NAHB Research Centre (2001). Further, NAHB Research Centre (2001) emphasised that due to the low cost, availability and simple process to recycle, glass concrete applications are significantly applied in the construction industry. Glass concrete applications are generally defined as concrete products which are prepared by the use of recycled glasses by replacing natural aggregates that extract from the environment.

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Sri Lanka hasn't still implemented a project to find the applicability of recycled glass as an alternative material for concrete and concrete applications. Thus, this research anticipates filling this research gap by exploring the applicability of glass concrete applications in Sri Lankan context.

2. CONCRETE

According to building researchers and scientists McGregor (1997); Bhattacharjee (2010); Cement Concrete and Aggregates Australia (2004); the most used construction material in the industry is concrete. Gambhir (2004) highlighted that for being the most used construction material, the properties and qualities of the concrete heavily affected. Common ingredients made the way to the popularity of the concrete and it is possible to gain the properties of concrete to meet the demands of any particular situation. Further, Gambhir (2004) expressed that, the advances in concrete technology have paved the way to make the best use of locally available materials by judicious mix proportioning and proper workmanship, so as to produce concrete satisfying performance requirements.

The use of concrete in buildings is not new, but it has increased enormously since the discovery and development of Portland cement. Handisyde (1995) mentioned that concrete's different uses might make quite different demands upon its qualities. In one case strength may be all important; in other appearance may be the essential requirement. The excessive demand for the concrete is the major clue to express that the concrete is the main essential building material for construction industry. Further, Cement and Concrete Institute Australia (2008) found in a survey that worldwide each year, the making of concrete consumes 1.6 Billion tons of Portland cement, 10 Billion tons of sand and rock and 1 Billion tons of water, making the concrete industry the largest user of natural resources in the world.

For studying about the concrete, definition for concrete is important to distinguish the world most used construction material with the other materials. Portland cement concrete is a composite material made by combining cement, supplementary cementing materials, aggregates, water, and chemical admixtures in suitable proportions and allowing the resulting mixture to set and harden over time (Nawy, 2008). Watson's (2005) perspective towards the concrete is, it's strength and qualities depend not only on the quality and quantity of the materials, but on the procedures used in combining these materials and the skills involved in the placing and curing of concrete. Further, Watson (2005) expressed that the required quality and performance of the concrete should be defined by the authorised engineer for the construction. For that purpose, in most of the countries have been published standard documents which state the most suitable concrete types for each construction. In that sense the knowledge on properties and categories of concrete is essential for the professionals who engaged in construction activities. Designers began to change the properties and ingredients of the concrete in order to fulfil the different types of construction requirements. This could result in plenty of concrete types in the modern world. Because of that, concrete categorisation also became more sophisticated. Santhakumar (2007) explained about three types of concrete Ordinary concrete, Standard concrete and High-strength concrete. The properties of the concrete in the plastic stage are important in the construction stage while the hardened stage properties are important for the remainder of the duration of the construction. Orchard (1962) mentioned that main properties of hardened concrete are strength, permeability, shrinkage and elasticity. Mehta (1986) expressed that strength of the concrete can be defined by the ability to resist stress without failure and failure is sometimes identified with the appearance of cracks.

2.1. CONCRETE AGGREGATES

American Concrete Institute (2007) defined aggregate as granular material such as sand, gravel, crushed stone, blast-furnace slag and light weight aggregates that usually occupies approximately 60-75% of the volume of concrete. Aggregates are the important constituents in concrete therefore they give body to the concrete, reduce shrinkage and effect economy. According to Neville (1995), aggregate content is a factor which has direct and far reaching effects on both quality and cost of concrete. Arum and Olotuah (2006) explained that aggregate properties significantly affect the workability of plastic concrete and also to the durability, strength, thermal properties and density of hardened concrete. Orchard (1962) stated that, concrete aggregates can be classified according to their petro logical characteristics and further it can be mainly divided into three categories as heavy weight, normal weight and light weight aggregates and normal and light weight aggregates. Moreover, it can be subdivided into natural and artificial aggregates. As the major ingredient for concrete mix, aggregate properties are being given a special consideration and importance for the construction applications. The significant effect of aggregate properties, both physical and mechanical towards the strength, quality and optimum packing configuration in concrete has also been scientifically proven and discussed by Rajeswari (2004 cited Mohammad, 2009). It is evident that, most characteristics of aggregates greatly influence the properties of both fresh and hardened concrete. Neville and Brooks (2004) had been showed how the properties of aggregates evaluate primarily. Many properties of the aggregate depend on the properties of the parent rock. Gambhir (2004) explained about two types of properties of aggregates which are namely "mechanical properties" and "physical properties". Bond, strength, toughness, hardness defined under the mechanical properties of concrete while specific gravity, bulk density, porosity and absorption, moisture content, bulking, thermal properties categorised under physical properties. In the past, almost all the materials which have used in the construction industry were entirely natural. Therefore, during this century, numerous environmental problems and natural disasters are occurred due to high extraction of metal and sand. Thus, the researchers have been focused on the alternative aggregates for concrete to the future development, while protecting the environment.

2.2. ALTERNATIVE AGGREGATES FOR CONCRETE

It is widely acknowledged that the use of secondary and alternative aggregates in construction products contribute sustainable construction. According to Oikonomou (2005), by replacing part of the natural aggregates, the need of both quarrying and waste disposal systems are reduced with the associated benefits of reduced environmental and social impacts. Mehta (2001) explained it further by saying that environmental impact of the concrete industry can be reduced through resource productivity by conserving materials and energy for making of concrete and by improving the durability of concrete products.

According to Cement and Concrete Institute Australia (2008), there is a critical shortage of natural aggregates for production of new concrete, further Cement and Concrete Institute Australia (2008) expressed that, the enormous amounts of demolished concrete produced from deteriorated and obsolete structures create severe ecological and environmental problems. Therefore, recycled aggregate usability for the concrete construction will be solving environment problems as well as the material shortage problems. Cement and Concrete Institute Australia (2008) had classified aggregates into manufactured, recycled and reused by-product aggregates for the easiness to the separation of alternative aggregate from other construction materials.

Table 1: Alternative Aggregate Types

Manufactured aggregates	Foamed Blast Furnace Slag (BFS), fly ash, manufactured sand, polystyrene, explanded clays, shale and slates.
Recycled aggregates	Recycled concrete aggregate, recycled concrete and masonry, reclaimed aggregate, reclaimed asphalt pavement, reclaimed asphalt aggregate, glass cullet, scrap tyres.
Reused by product aggregates	Air cooled (BFS), granulated BFS, electric arc furnace slag, steel furnace slag, fly ash, furnace bottom ash, incinerator bottom ash, coal washery reject, organic materials.

2.3. ADAPTABILITY AND APPLICABILITY FOR REPLACEMENT OF AGGREGATES

Winston and Yeung (2000) experiments shows that, most of the recycled aggregates can be used for construction activities without serious problems. However, the market force will dictate which kinds of materials can be recycled practically into products with commercial value. Akbari *et al.* (2011) perspective view is different to previous explanation where Akbari *et al.* (2011) argued that, Recycled Aggregate Concrete (RAC) obtained lower in workability compared to concrete using natural aggregate and for hardened concrete performance, it was recognised that RAC is lower in strength compared to natural aggregate. The potential for alkali silica reactivity in new concrete can be happened due to the inappropriate recycling.

There are five factors which can be lead to overcome with the problems of RAC to adopt and to be applicable to the concrete production. Those are development of appropriate specifications, opportunities in the pre-cast industry, and changes in legislation to use the RAC in constructions, quality assurance, improve and motivate research and development activities of RAC (Hyungu, 2011).

However, Carpenter (1994) stated that there is a price to pay for being eco-friendly and that potential uses of secondary aggregates are hindered by consumer tastes and strict construction specifications. At present, the cost of primary aggregates is not much expensive when comparing to recycled aggregates; therefore, material suppliers, contractors and the construction community not likely to accept the use of recycled aggregates in construction because of RAC's variability in composition and properties and lower performance. As an emerging developing country in South Asia, recent past Sri Lanka has undergone various attempts to find alternative aggregates for construction to the material shortage problem with solutions.

2.4. Current Alternative Aggregates Use in Sri Lankan Construction Industry

Annual sand demand for the construction industry in Sri Lanka is nearly 8 Million cubic meters and all are obtained from major rivers (Jayawardena and Dissanayake, 2006). The excessive excavation of river sand is becoming a serious environmental problem in Sri Lanka such as erosion and failure of riverbanks, lowering of river beds, damaging to the bridge foundations, saline water intrusion into the land and coastal erosion are the major adverse effects due to intensive river sand mining. At present private sector with the collaboration of government, alternative sources have been introduced to the Sri Lankan construction industry such as dune sand, offshore sand, manufactured sand (crushed rock sand) and quarry dust.

Except for the replacement of the fine aggregates, still there is a need of alternative coarse aggregates to replace natural coarse aggregates in Sri Lanka. Due to the low cost to produce natural metal and coarse aggregates, the process of finding the alternative coarse aggregates is slowed down. Replacement of natural coarse aggregate with recycled material is a need, to resolve environmental problem in Sri Lanka. Recycled glass can be introduced as one alternative for coarse aggregate for concrete.

2.5. Recycling Process of Glass Aggregate

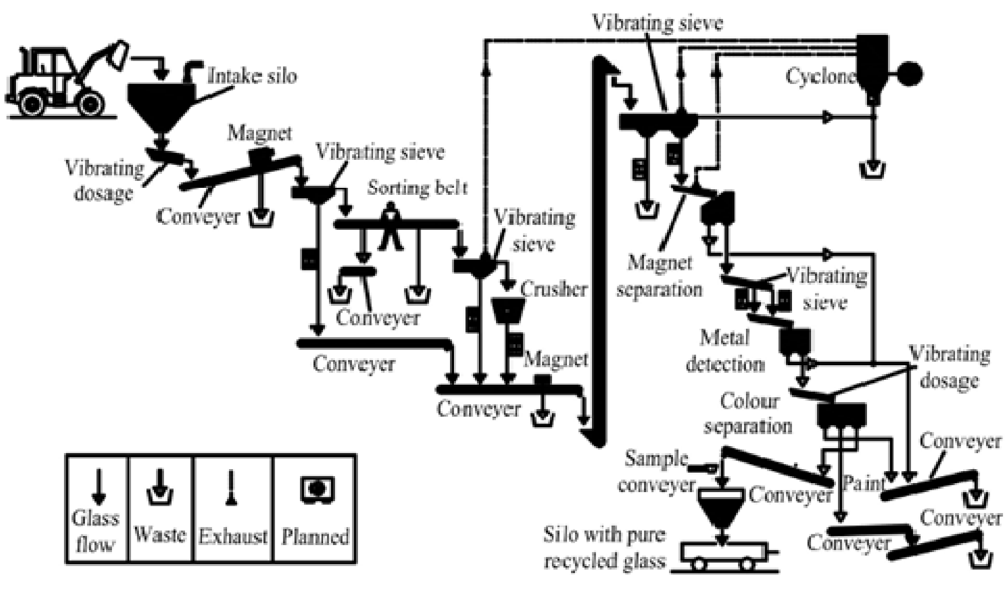

Figure 1: Recycling Process of Glass (Source: Meyer *et al.,* 2001, p.52)

2.6. Structural Strength of Glass Aggregate

Terro (2006); Shi and Keren (2007), and Sekar *et al.* (2011) experimented about the effect of replacement of coarse aggregates with recycled glass on the fresh and hardened properties of Portland cement concrete at ambient and elevated temperatures. Terro (2006) experiments indicated that the compressive strength of concrete made with recycled glasses decrease up to 20% of its original value. Shi and Keren (2007) expressed that concretes made with 10% glass coarse aggregates replacement to natural coarse aggregate replacement, had better properties in the fresh and hardened concrete states at ambient and high temperatures than those with larger replacement. Based on the studies conducted on strength characteristics of concrete made with utilising waste materials by Sekar *et al.* (2011), found that the compressive strength of concrete cubes made with glass concrete were found to be 16% and 26.34 % lesser respectively than that of conventional concrete. It was also found that the flexural strength and splitting tensile strength results were similar to that of compression strength test results.

2.7. Glass Concrete Architectural Applications

Glass concrete products can be categorised as "commodity products" and "value-added products" (Meyer *et al.*, 2001). "Commodity products" use as coarse and fine aggregate replacements in concrete and land filling. For "value added products", the aesthetic potential of the glass is utilised. Special aesthetic effects can be achieved with colour-sorted glass. Value added products are lead to substitute the expensive decorating applications such as granite and marble.

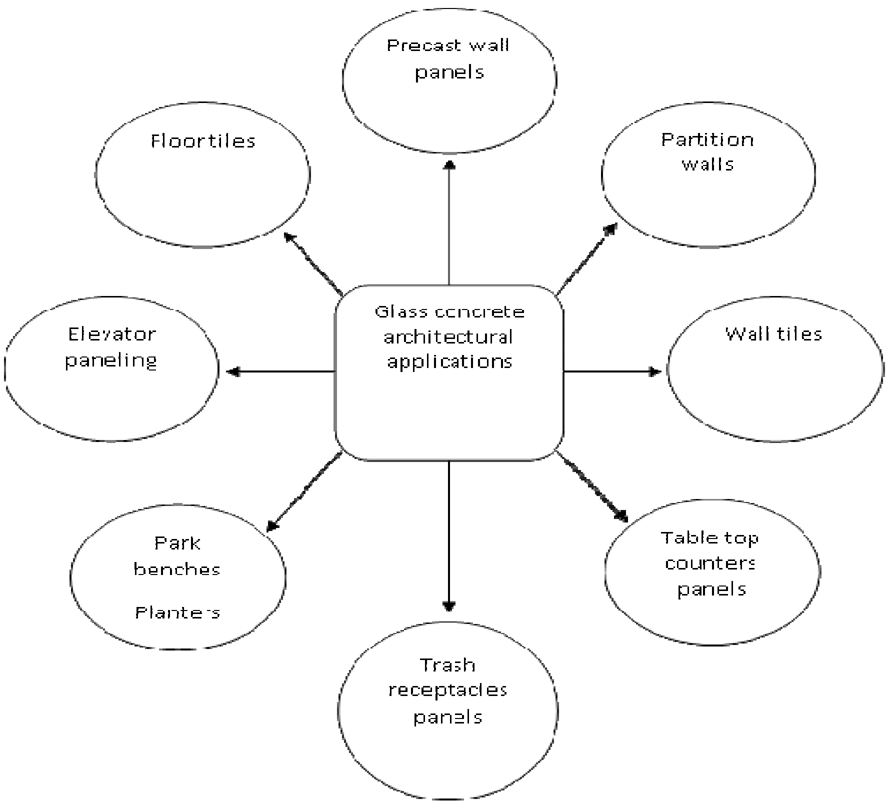

Figure 2: Glass Concrete Architectural Applications

3. Research Methodology

The research programme was divided into two parts. The first part was studying the impact of the presence of waste recycled glass as coarse aggregate replacement on plastic and hardened properties of concrete. In the second part studied the substitution of the aesthetic glass concrete to the expensive architectural items such as granite and marble.

3.1. MATERIALS

The materials used in this study include cement, sand, metal, glass, steel reinforcement. Each time a new aggregate sample was obtained, a new sieve analysis and slump test was performed. The following sections describe the materials used in the study.

CEMENT

Ordinary Portland cement had a strength class 42.5N according to the British standard BS EN 197 Part 1:2000. The alkali content (Na_2Oeq) was 0.58%.

COARSE AGGREGATE

Used different types of glass of varying sizes 12.7-25.4mm brown, white, green colours were used instead of the 5-10mm normal aggregate in traditional concrete control mixer. The specific gravity of glass is 2.50.

FINE AGGREGATE

River sand was used for all the experimental works.

3.2. EXPERIMENTAL PROGRAMME

First the Architectural use of the glass for concrete had been experimented. Secondly expect to carry out the experiment for the structural use of glass for the concrete instead of coarse aggregates. For the architectural aspect used two different experimental segments. One segment includes 100% pure glasses as coarse aggregates and other segment includes 60% glass and 40% metal. In this experiment other variables make as constants. Such as Aggregate / Cement ratio, Aggregate moisture state, Cement type and strength, Water / Cement ratio, Admixtures and additions, Mixing method, Compaction method, Curing method, Cast shape, Test method, Mix proportions. The proportions of the concrete mix are 1:2:4 for the two types of experiments.

3.3. LABORATORY WORK

CASTING

Two moulds were prepared 0.91x1.2x0.04 m using timber sheets. After the moulds were coated with a layer of oil (to help in the removal of the specimens) and steel reinforcement placed, concrete was placed within the moulds in. After adding concrete, the concrete was consolidated using a ramp. After the moulds were put in place, they were moved to an environmentally controlled place for get hardening.

CURING

Pre-cast concrete slabs with mould were cured using water up to 14 days by applying sand on the top of the concrete surface to remaining more water on the concrete surface. After curing, the specimens were allowed to dry in a controlled temperature and humidity environment.

3.4. EXPERIMENTAL RESULTS

Architectural glass concrete slabs strength checked by applying 50 kg weight for 24 hours and no deformation occurred. Concrete cubes, 150 mm in size, supposed to test in order to determine compression and flexural strength, absorption. Preparation and testing expected to do in accordance with British Standard procedures. Concrete cubes expecting to make using 100% natural aggregate as well as with 10%, 20%, 40% and 60% aggregate replacement by glass cullet are subjected to test. These levels of replacement were used for concrete made with Portland cement. The proportioning used for all concrete mixes was the same. All batching, including glass cullet replacement, was by volume. The free water content, cement content and aggregate content were 180, 350 and 1820 kg/m^3 respectively. Allowance for aggregate absorption permitted the same free water to cement ratio.

Figure 3: Glass Concrete Architectural Applications (Table Top)

Figure 4: Glass Concrete Table Top After Applying Loads (35kg)

4. CONCLUSIONS

For many years, the recycling and waste management industry has struggled with the problem of identifying or developing reliable markets for broken glass. To date, only low value applications are available, which do not utilise the physical and other inherent properties of the glass. Recent research has made it possible to use such glass as aggregate in concrete, either in commodity products, with the only objective being to utilise as much glass as possible, or in value-added products that make full use of the physical and aesthetic properties of colour-sorted crushed glass. Not only as a waste management solution for glass but also as coarse aggregate conservation in the environment applicability of glass in concrete had been discussed. Data presented in this paper show that there is great potential for the utilisation of waste glass in concrete in several forms, including coarse aggregate and architectural forms with concrete. It is considered that the latter form would provide much greater opportunities for value adding and cost recovery, as it could be used as a replacement for expensive materials such as granite, marble and terrazzo.

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STRATEGIES TO OVERCOME CHALLENGES FACED IN MANAGING CONSTRUCTION PROJECTS IN THE UNITED ARAB EMIRATES

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ABSTRACT

The problems faced when managing projects in the United Arab Emirates (UAE) are investigated and strategies to overcome the problems and improve project performance are recommended. The survey research design was adopted. The data collection instrument was a questionnaire. Data were collected via interviews with experienced personnel who have worked in the UAE construction industry. It was found that a high proportion of projects in the UAE experienced budget and schedule overruns. The findings show several unique challenges exist in managing projects in the UAE. The first is when foreign consultants fail to consider differences of language, culture, religion, customs and preferences, and this lead to disharmony and resentment. The second challenge is project-related issues such as contract documentation, technical details of construction, materials delivery and document approval and permits are not well-planned nor subject to rigorous risk analysis prior to project commencement. Finally, environment-related issues faced are extreme weather conditions which pose a challenge to foreign staff. It is recommended that foreign firms build closer relationships with clients and local authorities to establish trust that would help in a smoother process in obtaining approvals and resolving disputes. It is necessary to employ more foreign labour during Ramadan to compensate for the lower productivity on site due to fatigue and shorter working time. Protective measures must be taken to shield labourers from the intense heat and ultraviolet radiation. Cold water points and salt pills to replenish fluids lost through perspiration should be provided.

Keywords: *Challenges, International Construction, Multi-national Project Management, United Arab Emirates.*

1. INTRODUCTION

The Middle East has become an attractive market for foreign architecture, engineering and construction (A/E/C) firms. It is therefore timely to assess the challenges faced in managing construction projects in the Middle East and recommend ways to reduce or overcome them. The aim of this study is to examine the challenges and problems faced when managing construction projects in the United Arab Emirates (UAE). The specific objectives are to: (i) investigate the performance outcomes of construction projects in UAE; (ii) identify challenges and problems faced in these projects; and (iii) recommend ways to reduce or eliminate such issues. The UAE was selected because it emphasis on infrastructure development has resulted in a large number of projects here. Firms planning to undertake projects in the region will benefit from insights into industry practices and frequently faced issues.

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2. LITERATURE REVIEW

This study investigated outcomes of projects in UAE. Project outcomes may be measured by cost, schedule, quality and client satisfaction (Konchar and Sanvido, 1998), which are the basic and traditional criteria for measuring and benchmarking project outcomes.

The project management (PM) practices adopted in the projects were also investigated, based on the project management knowledge areas (scope, time, cost, risk, quality, human resources, communications, procurement management and their integration and management of externalities) defined by the Project Management Institute (PMBOK Guide, 2004).

Besides generic PM practices, in multinational construction management, cultural factors also need to be investigated. Understanding and managing cross-cultural factors is imperative for smooth project implementation (Ling *et al.*, 2007, Dulaimi and Hariz, 2011). Recognising and sensibly handling cultural diversity allows efficiency improvements and increases profitability of international projects (Chan and Tse, 2003).

Multinational PM is also subject to the legal framework of the host country. Studies have suggested that the UAE has an underdeveloped law enforcement system (Daoud and Azzam, 1999). This gives rise to out-of-court dispute resolutions that are sometimes enforced unfairly, creating injustices that may damage future relationships between parties. Contractors hesitate to sue clients and consultants who deal with them in an unfair manner, but this caused schedule delays and disputes to arise during project execution (Daoud and Azzam, 1999). Daoud and Hamdani (1988) also observed the misuse of family and political connections in contract award and administration.

Zaneldin (2006) found variances to be the most common problem in the UAE construction industry, caused largely by changed orders and owner-related delays. Faridi and El-Sayegh (2006) identified the top ten significant causes of construction delay to avoid recurring problems or mitigate their impact. El-Sayegh (2008) assessed the risks and recommended proper allocation of risk so that it can be managed proactively and consistently.

3. GAP IN KNOWLEDGE

Studies have been conducted to analyse critical determinants of project success in China (Ling *et al.*, 2009), Vietnam (Ling and Bui, 2010) and India (Iyer and Jha, 2005; Ling and Hoi, 2006). Projects in the Middle East have faced setbacks including time delays (Al-Kharashi and Skitmore, 2009) and cultural diversity issues (Dadfar and Gustavsson, 1992). However, no similar studies have yet been done on the UAE and no comprehensive examination yet exists on the challenges faced in managing projects in the Middle East. This research investigates management practices leading to good outcomes in the UAE, seeking to provide insights to help achieve successful projects.

4. RESEARCH METHOD

Research may be quantitative or qualitative in nature. This research adopted the qualitative method because understanding a phenomenon from the point of view of the participants and its particular social and institutional context may be lost when textual data are quantified (Kaplan and Maxwell, 1994). The data collection instrument is a specially designed interview questionnaire comprising open ended questions. The open ended questions allowed the interviewees to share their experiences and opinions without constrained alternatives. Data collection method for qualitative research includes interviews, observation and archival research. This study adopted the interview technique as this allowed for extensive discussion and clarification of the questions as well as responses. Respondents were asked to base their responses to the questions on a specific completed project in the UAE. Archival research and observation were ruled out due to the confidential nature of project information. Face-to-face interviews with Singaporean project personnel and e-mail interviews with UAE project personnel were conducted. Using convenience sampling, a list of samples was drawn up. After gaining approval for an interview, the questionnaire was sent to interviewees to prepare. Each face-to-face interview session lasted between 60 and 90 minutes. Interviewees not in Singapore were asked to fill up the questionnaire within three weeks of receipt.

5. CHARACTERISTICS OF THE SAMPLE

Twenty four requests were sent to Singapore firms with experience in the Middle East and three agreed to be interviewed. Seven requests were sent to UAE firms and five responded positively. All interviewees were from upper and middle management and had between 6 and 33 years of industry experience, averaging 18 years. All were personally involved in the projects they described. The positions, experience and location of the interviewees are described in Table 1.

Table 1: Characteristics of Interviewees

Interviewee Code	Interviewee Designation	Role of Firm in Project	Interviewee Construction Experience (Years)	Interviewee's Location During Project Implementation
S1	Quality Assurance Manager	Owner's Representative	33	UAE
S2	Senior Vice President (Architectural)	Consultant Project Manager	30	Singapore
S3	Contracts Manager	Consultant Quantity Surveyor	Not specified	UAE
L1	Deputy Project Manager	Main Contractor	18	UAE
L2	Deputy Managing Director	Subcontractor	6	UAE
L3	Head of Projects	Owner's Representative	16	UAE
L4	Design Manager	Main Contractor	6	UAE
L5	Branch Manager	Main Contractor	17	UAE

The interviewees provided information of their completed projects in the UAE, with Singapore firms handling projects in Abu Dhabi and local firms handling those predominantly in Dubai. Table 2 provides details of projects reported by interviewees. Diverse facility types are represented with construction areas varying from 114,093m^2 to 2,672,728m^2. Selective or invited tenders appear to be most popular as is the traditional design-bid-build (DBB) contract.

Nationalities represented among project teams include Austria, Australia, Canada, China, Germany, India, Lebanon, Malaysia, New Zealand, Pakistan, the Philippines, Singapore and the USA, demonstrating the importance of considering issues relating to communication, human resource management and cultural diversity.

Table 2: Project Details

Interviewee Code	Location	Facility Type	Appointment Method	Contractual Arrangement	Ownership
S1	Abu Dhabi	Infrastructure	Invited	Design and Build	Public-Private Partnership
S2	Abu Dhabi	Office Building with Basement	Selective	Design-Bid-Build	Public Sector
S3	Abu Dhabi	Office Building with Basement	Invited	Design-Bid-Build	Public Sector
L1	Al Ain	Infrastructure	Selective	Design-Bid-Build	Public Sector
L2	Dubai	Residential	Open	Supply and Install	Privately Owned
L3	Dubai	Commercial	Selective	Design-Bid-Build	Privately Owned
L4	Dubai	Hotel	Selective	Design-bid-Build	Privately Owned
L5	Dubai	Residential	Open	Design-Bid-Build	Privately Owned

6. Results and Discussion

The projects reported by interviewees cost between AED 335 million (AED1 ≈ US$0.27) and AED 2.1 billion, averaging AED 783 million. The first objective of this study is to investigate the performance outcomes of construction projects in UAE. According to the interviewees, the majority of projects met quality expectations, but this should be viewed with circumspect because interviewees may be biased. Five out of seven experienced project delays, and cost overruns, which may signify ineffective cost control or budget underestimation. Projects took between 23 and 54 months to complete, with a mean of 35 months. Five interviewees reported poor schedule performance and delays which led to cost escalations.

The second objective of this study is to identify challenges and problems faced in projects in UAE. The interviewees shared that the unique culture and work practices in the UAE and its internationally diverse workforce present considerable challenges. The interview findings are presented and discussed below.

6.1. Scope Management

Interference by owners despite their inexperience and lack of expertise is a contributor to scope variation, as are repeated changes in requirements to conform to local regulations or changes in owners' demands. Disputes often arise due to discrepancies in architectural drawings and bills of quantities with the local practice more focused on the latter. This results in delays in execution and avoidable rework leading to budget overruns.

6.2. Schedule Management

The local practice is to provide daily, weekly and monthly progress reports supplemented by Gantt charts and frequent meetings to track project progress. Many interviewees felt that they frequent progress reports, printed in hardcopy for wide distribution is environmentally unfriendly and waste personnel time in preparing them.

Extreme weather conditions in summer present a challenge to workers as do sandstorms. To protect workers from dehydration and heatstroke, work in the sun is prohibited between 12pm and 3pm by law and working hours vary by season, with summer timings beginning as early as 2am in two shifts. Concrete is usually poured at night during the summer. Extra rollers are used to compact asphalt in the winter to keep it from cooling too fast. Working hours are generally reduced during Ramadan because of fasting from sunrise to sunset.

6.3. Quality Management

Quality management is performed by having stringent criteria for contractor selection. Criteria for selection include financial capacity, experience, existing contract capacity, manpower and resource commitment and bid price. Soft skills are also an occasional consideration. In some instances, selection was not purely based on merit.

6.4. Risk Management

Financial hardship was faced in the UAE during the global economic crisis of 2008. When cash flow was affected, construction activities were halted or slowed down. Some clients were unable to raise funds to complete their projects.

Technical risks include variation in the practice of material use; for example, manholes in Singapore use reinforced concrete while in the UAE, fibre-reinforced concrete is used to prevent rusting and salt deposition. Public utilities not marked on drawings provided by local authorities were often damaged during construction, indicative of an underdeveloped regulatory mechanism in the UAE (Daoud and Azzam, 1999).

Foreign interviewees felt that political risk is substantial because the Middle East is politically volatile and the threat of war is ever-present. Interviewees relied on the Multilateral Investment Guarantee Agency (MIGA) which offers political risk insurance for foreign investments in developing countries.

6.5. HUMAN RESOURCE MANAGEMENT

Locals and expatriates are estimated by interviewees to be in the ratio of 10:90, described by one interviewee as a "mini United Nations", agreeing with Daoud and Azzam's (1999) observation. The low-paid labour force struggles both financially and psychologically to survive in a nation with one of the highest costs of living in the world. Conflict of opinion frequently arise due to this multicultural workforce and are usually dealt with through closed-door meetings until a mutually agreeable directive is reached for future use. Recourse to legal or contract solutions is not usually preferred. Cash incentives for good work and timely payments are used to keep employees motivated.

6.6. COMMUNICATION MANAGEMENT

While Daoud and Azzam (1999) noted that communication barriers were significant due to language constraints but this research does not support their findings, possibly because the English-speaking client and project team communicate with the site supervisors, who pass on the instructions to the foremen and workers in their native tongue. Although the use of English is widespread in the UAE, speaking skills generally outpace writing skills. Sign language, actions, illustrations, technical drawings and translation by workers who are more fluent are all methods adopted to communicate.

Singaporean interviewees shared that their project teams in UAE keep their headquarters updated through electronic communications media. At the personal level, the communication issue becomes acute when project durations stretch for long periods and foreign staff with little time or money to travel home are separated from their families.

Apart from language and communication tools, cultural differences in communication style have led to occasional difficulties. Westerners prefer problems to be verbalised and addressed rigorously, while locals tend to adopt a more quiet approach. Many foreigners mistake locals' quietness to passiveness when in many instances, this is not the case, but that locals do not like the fast and noisy approach. This has hampered the smooth working relationship in international teams. Experience in cross-cultural environments is definitely an advantage for international projects.

6.7. PROCUREMENT MANAGEMENT

Many interviewees reported that materials delivery is subject to arbitrary schedule changes to accommodate demands of more important projects, although extensions are granted when this happens. Importing materials already supplied from Abu Dhabi is prohibited. These factors affect both scheduling and cost. Late orders by contractors and delayed customs clearance also pose barriers to timely procurement.

Interviewees shared that foreigners need to establish close relationships with local decision makers to gain their trust first before they are awarded projects. Establishing good interpersonal relationships and trust with local project partners is very helpful since such ties are highly valued in the region.

6.8. CROSS CULTURAL MANAGEMENT

Dispute resolution is typically based on good faith practices rather than legal recourse. The interviewees shared that being late for appointments is a common phenomenon among locals. They reiterated the idea of verifying meeting times with local participants to ensure their attendance. Respect for local culture and practices, including prayer timings and abstaining from non *halal* food and alcoholic drinks, are appreciated and help gain trust. Long-term relationships with business partners are valued regardless of ongoing economic constraints. Interpersonal relationships help to get jobs done faster or better and contribute significantly to project success. Often, specific companies are selected to carry out tasks because of personal connections which indicate that trust had already been built up successfully. Because of these constraints, training and mentorship are challenging to come by, though experienced professionals may find promising career opportunities.

6.9. The Legal System and Approval Process

Interviewees noted that often, regulations change after contracts are awarded. Some new regulations that recently come into force affect travel times for heavy vehicles, fire safety and workers' welfare. The rapid modification and introduction of regulations without adequate notice shows an immature legal system. Often, international laws that are not entirely suitable for the UAE context have been significantly customised to serve local needs.

The interviewees shared that the application processes to obtain authorities' approval is lengthy. Interviewees observed that a personal approach is often more efficient. Prompt and persistent follow-up actions are important to obtaining permits and licences in a timely manner.

7. Recommendations

The third objective of this study is to provide recommendations on ways to reduce or eliminate challenges and issues faced in construction projects in the UAE. The interview findings on the recommendations are discussed below.

7.1. Recommendations to UAE Clients

The study found that many UAE clients do not have high level of understanding of project management practices and techniques. There was uninformed intervention in how work is done and extensive variations, which in turn contributed to project delays and rising costs. It is recommended that clients ensure that project objectives are well-defined from the inception stage and that these objectives are communicated to project team members so that all participants work towards a common goal.

The appointment of competent key players in the project is essential to increasing the chances of project success. Clients are recommended to select contractors and consultants based on merit and not relationship. The selection criteria for contractors could include their financial capacity, relevant experience, existing contract capacity, and manpower and resource commitment in addition to bid price.

7.2. Recommendations to UAE Consultants

Local consultants should make more effort to understand and prepare comprehensive and detailed contract documents instead of relying heavily on foreign consultants who are not familiar with local conditions. All parties involved in the project should be familiar with their contractual obligations to avoid ambiguous scope of work. As foreign players enter the construction market, local consultants should work towards upgrading their skills and professionalism to retain their competitive advantage.

7.3. Recommendations to Contractors

When dealing with the internationally mixed workforce in the UAE, failure to account for diversity of language, culture, religion, customs and preferences can create disharmony and resentment. Ambiguous or imperfect communication can hinder project progress, especially when language barriers exist. It is recommended that site supervisors who are able to converse in English with management and translate instructions in workmen's native tongue be employed in this multilingual setting.

Extreme weather conditions in the UAE may pose a challenge for foreign workers to adapt, especially in the initial stages of a project. Protective measures must be taken during the hot, dry summer season to shield the labourers on site from the intense heat and ultraviolet radiation. The welfare of workers is vital to maintaining high productivity and should therefore be addressed appropriately. In addition, workplace safety practices should account for *force majeure* situations such as sandstorms. It is recommended that salt pills to compensate for excessive perspiration, air-conditioned break areas, cold drinking water, sun protective materials, shaded areas and personal protective equipment (PPE) are all used.

It is important to factor in low output periods when scheduling construction work. These are the high summer and Ramadan. Omissions or miscalculations can result in undesirable cost and schedule overruns.

UAE contractors may find it necessary to employ more foreign labour to compensate for the lowered productivity on site during Ramadan.

Technical risks have to be carefully analysed and promptly addressed as the differences in geographical location and other physical factors may require changes to the materials or method of construction used. Familiarity with the FIDIC is recommended as this will be an advantage in getting a clear idea of the issues, such as the priority of award to be followed in the event of a discrepancy between drawings and documents.

7.4. RECOMMENDATIONS TO FOREIGN COMPANIES INTENDING TO OPERATE IN UAE

This study found that it is difficult to be awarded a UAE construction project without referrals. A good approach recommended to first-timers desirous of venturing into the UAE market is to work closely with firms that are already established in the UAE. Otherwise, it will be considerably hard to gain trust from clients.

Establishing interpersonal relationships and ties is also critical to advance smoothly in the resolution of disputes or getting work done. It is advisable to make use of political ties for assistance in obtaining permits and licences faster.

The UAE has a multicultural workforce and it is recommended that foreign personnel be sensitive to cultural differences, showing respect and consideration for the religious beliefs of others, going so far as to observe the same dietary restrictions if required as a show of good faith and to avoid conflicts between groups that could jeopardise the project.

8. CONCLUSIONS

Project outcomes in the UAE typically fail to meet satisfactory levels due to the high frequency of cost and schedule overruns. Only a handful of projects are completed within budget and on schedule with high output quality and owner satisfaction. A combination of human resource, project management and environmental factors affect the execution of projects in the UAE. The nine knowledge areas of project management practice are critical to improving the chances of project success. In addition, acknowledgement and adherence to cultural requirements in the region, including the building of more personal relationships, will significantly enhance the likelihood of project success and the ease with which foreign firms may enter and grow in the UAE construction market.

In conclusion, choosing the right team players from the start of the project is a determinant step in establishing a good working relationship that influences the project outcome to a large extent. Further, the establishment of this strong relationship not only leads to a successful project outcome and client satisfaction but is key to the extension of the relationship to future projects as trust builds.

The main limitation is the qualitative nature of the findings, and the primary data comprises interviewees' narrative answers. This made it difficult to provide empirical evidence to support the findings. Future research could consider a quantitative research involving many local and foreign firms operating in UAE.

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GREEN BUILDING CONCEPT TO FACILITATING HIGH QUALITY INDOOR ENVIRONMENT FOR BUILDING OCCUPANTS IN SRI LANKA

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ABSTRACT

Well-being is an important aspect determining the quality of life of an occupant. Hence, it is essential to have a good indoor environmental quality, as it affects the productivity and health of such occupants. Further, indoor air quality, acoustic, day-lighting and thermal comfort contribute to better indoor environment quality, and have a positive effect on an occupant's productivity and performance. Accordingly, many studies believed that the green building design will become more common practice once the human benefits are identified, primarily the productivity gains believed to be associated with the provision of high quality indoor environments. Hence, buildings are increasingly designed or required to be 'green' in recent years, giving the quality of the indoor environment new importance. Therefore, several green building assessment tools have been applied worldwide namely, Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM), Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) and Green Star etc in facilitating high quality indoor environment. Indoor Environmental Quality (IEQ) has considered as a major criteria in such tools. Thus, various IEQ factors relate to temperature and humidity, acoustic, ventilation, indoor air quality, day lighting and lighting quality, thermal comfort and access to views have been considered in these techniques. Similarly in Sri Lanka, GREEN$^{SL®}$ Rating System is applied for buildings in local context so as to obtain green certification. Even though, it emerges IEQ as an important aspect, it is considerably less compared to other domains. Thus, four green assessment tools were suggested which can be applied for buildings in Sri Lankan context through the review of key research papers. Accordingly, such green building tools can be considered for Sri Lankan buildings as a new concept/tool or even the existing system can be further enhanced so as to provide a better quality indoor environment for building occupants.

Keywords: *Indoor Environmental Quality, Building Occupants, Green Building Concept, Green Assessment Tools.*

1. INTRODUCTION

Well-being is an important aspect in determining the quality of life of an occupant (EU, 2007 cited Bluyssen, 2009). It can be taken as axiomatic that the majority of people spend most of their time indoors and that various aspects of the indoor environment affect their well-being and performance in this context (Kamaruzzman *et al.*, 2010). Since, there is a continuous and dynamic interaction between occupants and their surroundings that produce physiological and psychological effects on the person (Lan and Lian, 2009).

In recent years there has been an increase in public awareness about the effects of the indoor environment on people's comfort and health. It is widely accepted that the indoor environmental is important for public health and that a high level of protection against adverse health effects due to inadequate quality of the indoor environment should be assured (Kosonen and Tan, 2004). Further, in light of growing concerns about productivity, much more attention has focused on the indoor environment (Bluyssen, 2009; Mendell, 2003 cited Huang *et al.*, 2011).

This would be of major social and economic consequence, as a large fraction of the work force in modern societies spent the bulk of their productive time in office spaces (Mahdavi and Unzeitig, 2003).

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Once the occupants are satisfied with the overall environmental quality of their workspace are widely assumed to be more productive (Leaman and Bordass, 2007; Humphreys, 2007 cited Kim and Dear, 2011). In addition, it seems that "occupants are being regarded like consumers of the product (building) and as such, entitled to be satisfied with the indoor environmental product" (Kim and Dear, 2011, p.33).

Consequently, many ways, tools and concepts have been developed to determine performance indicators and criteria for healthy and comfortable buildings with high quality indoor environment, focusing in general on the prevention of health and comfort problems (Bluyssen, 2009). Green Building (GB) has emerged as a new building philosophy among other concepts for mitigating impacts of buildings on their occupants by encouraging the use of more environment friendly materials, the implementation of techniques to improve IEQ (Thormark, 2006 cited Lacouture *et al.*, 2008). LEED, BREEAM, CASBEE and Green Star are the most popular assessment tools used in green building concept which can be applied for facilitating high quality indoor environment. Therefore, this study is expected to convince about the importance of introducing green building concept to ensure high quality indoor environment for the building occupants with special emphasis on the application of green assessment tools. Hence, key research papers were reviewed for identifying green assessment tools used in worldwide, which can be applied for buildings in Sri Lanka in order to facilitate high quality indoor environment for building occupants.

2. LITERATURE REVIEW

2.1. INDOOR ENVIRONMENTAL QUALITY (IEQ)

The indoor environment is where people spend 90% of their time (Kosonen and Tan, 2004). Hence, the occupant exposure to microbial, chemical and building-physical factors in indoor environments can lead to a series of health symptoms ranging from discomfort to clinical disease (EPA, 1995 cited Prakash, 2005; Metzger, 1998). Further, this is incorporated in the human right to a healthy indoor environment as formulated in the World Health Organisation (WHO) 1985 Constitution (Kosonen and Tan, 2004). Consequently, enhancing the quality of indoor environment highly concerns in recent years.

The term Indoor Environmental Quality (IEQ) is referring to "the environmental qualities within a building, used especially in relation to the health and comfort of building occupants" (Hobday, 2011). Hence, IEQ refers to all aspects of the indoor environment that affect the health and well-being of such occupants (Levin, 1995). According to a studies by Prakash (2005), Portman *et al.* (2006 cited Lee *et al.*, 2009) and Lee (2010), IEQ is one of five categories of the LEED (Leadership in Energy and Environmental Design) building assessment system, developed by the Green Building Council of the United States of America including sustainable site, energy and atmosphere, water efficiency, materials and resources, and indoor environmental quality.

2.2. INDOOR ENVIRONMENTAL QUALITY FACTORS

Under the category of IEQ in the LEED checklist, IEQ comprises of indoor air quality (IAQ), including, environment tobacco smoke, Carbon dioxide monitoring, indoor chemical and pollutant source, thermal comfort, and daylight and views. According to a study by Levin (1995), among the other indoor environmental factors that must be considered are the quality of thermal, light, acoustic, privacy, security, and functional suitability. Henceforth, IEQ generally encompasses factors such as temperature, humidity, ventilation, indoor air quality, day lighting and lighting quality, thermal comfort and access to views. Indoor air quality (IAQ) concerns are among many indoor environmental issues that must be addressed to avoid adverse impacts on occupants' health and well being (Levin, 1995; Ning *et al.*, 2006). In addition to health problems, poor indoor air quality will also cause a decline in productivity for occupants who spend most of their workday in offices. Moreover, buildings perceived to have poor indoor air quality have noticeably lower overall occupant satisfaction, while buildings perceived to have good indoor air quality have higher overall satisfaction of the occupants (Kim and Dear, 2011). Therefore, indoor air should be of sufficient quality so that contaminants in the air are not at a harmful concentration level and the majority of people feel satisfied (ANSI/ASHRAE Standard 62-2007 cited Huang *et al.*, 2011).

Furthermore, Day lighting and thermal comfort contributed to better IEQ, and had a positive effect on occupant's perception of productivity and performance (Prakash, 2005; Lan and Lian, 2009). According to a study by Ramsey and Beshir (1998 cited Prakash, 2005), excessively hot or cold environments can affect motor and cognitive behaviour of individuals. Extremely hot conditions can lead to loss of performance capacity of the occupants and their slow production output, while excessively cold environments have affected on manual agility, and sometimes are associated with pain. As further verified by Atsusaka (2003 cited Edwin *et al.*, 2009), enhanced daylight and reduced toxicity in indoor environments can increase employee productivity by up to 16%. Kim and Dear (2011) declared when a building's lighting is perceived as comfortable there is a positive improvement in occupant overall workspace satisfaction (Kim and Dear, 2011). However, any dysfunction in the indoor environment potentially affects occupant health and well-being. When buildings fail to do what they are intended to do, indoor environmental pollution in the form of indoor air pollution, noise, glare, etc. cause occupant discomfort, health problems, and poor performance (Levin, 1995).

2.3. APPLICATION OF GREEN BUILDING CONCEPT FOR IEQ

As such environmental impacts of building activities on building occupants due to poor indoor climate become more apparent, a movement called "Green Building (GB)" is gaining momentum (Edwin *et al.*, 2009). Thormark, (2006 cited Lacouture *et al.*, 2008) verified that GB has emerged as a new building philosophy, encouraging the use of more environment friendly materials, and implementation of techniques to save resources and specially the improvement of indoor environmental quality, among others. Henceforth, GB practices are perceived by many construction industry professionals to be part of the solution to problems regarding indoor environment of buildings (Hashim *et al.*, 2011). Green, or sustainable building, is the practice of creating and using healthier and more resource-efficient models of construction, renovation, operation, maintenance and demolition (US Green Building Council, 2007; EPA GB, 2008 cited Edwin *et al.*, 2009). It offers an opportunity to create environmentally efficient buildings by using an integrated approach of design so that the negative impact of building on the environment and occupants' is reduced (Ali *et al.*, 2009 cited Hikmat *et al.*, 2009).

As a study by Edward (2007) mentioned that the concept of GB has applied in most of the countries as to reduce the impact of buildings on environment and human health. As Edward further stated that Green Building" is called "Environmental Co-Habitual Architecture" in Japan, "Ecological Building" or "Sustainable Building" in Europe and "Green Building in North American countries. Many fashionable terms such as "Green consumption", "Green living" and "Green illumination" have been broadly used. In Taiwan, currently, "Green" has been used as a symbol of environmental protection in the country. Edward (2007) further asserted that the GB policy is important and represents a positive first step toward reducing environmental impact and promoting sustainable development in countries with limited resources and a high-density population. According to studies by Edwards (1998), Lacouture *et al.* (2008) and Karkanias *et al.* (2010), other benefits of bioclimatic or green buildings include lower energy and operational costs, market advantages for the building developer, higher indoor environmental quality and therefore living quality or higher productivity and lower long-term exposure to environmental or health endangering factors thus, it reduces health cost. Consequently, a recent trend toward increased concern about the impacts of buildings on the larger environment has led many building design professionals to design so-called "sustainable architecture" or "green buildings" (Levin, 1995). Their efforts are intended to reduce harmful environmental impacts of buildings, especially to minimise indoor environment quality hazard on well-being of building occupants.

2.4. ASSESSMENT OF IEQ IN GREEN BUILDINGS

Once the evaluation and assessment of environmental impact of a building is carried out before it is built and when only the representation of the building is available, environmental impacts from that building could be prevented. In that case, knowledge about the environment has to be integrated with knowledge about the building. Environmental assessment tools for buildings are designed to provide objective evaluation of resource use, ecological loadings and indoor qualities (Cole, 2005 cited Wallhagen 2010) and make it possible to evaluate a number of different environmental aspects of buildings in a systematic way. Hence, key research papers were reviewed in order to identify green assessment tools available, their level of concern on IEQ among the other sustainable criteria and IEQ factors considered in different green assessment tools.

GREEN ASSESSMENT TOOLS

According to a study by Westerberg and Glaumann (2002) and McKay (2007), green assessment tools were primarily developed to assess, or measure specific aspects of a building, pertaining to sustainability goals. Once measured, buildings could be more easily compared with current and past building practices and other green buildings. Wallhagen (2010) further verified that the green assessment tools can also be used to produce guidelines, benchmarks, ratings and incentives to construct buildings with low environmental impact and to work as environmental management tools. The most representative and widely used green assessment tools are Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM), Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) and Green Star (Roderick *et al.*, n.d.; Boonstra and Pettersen, 2003; McKay, 2007).

- ***LEED***

LEED® is a U.S. national sustainable building benchmark as well as green building rating system adopted nationally and internationally (Roderick *et al.*, n.d; USGBC, 2007 cited Lee and Kim, 2008; InBuilt, 2010). The current version for new construction is LEED-NC v2.2 which is based on a set of prerequisites and credits. Each credit refers to one of following aspects; sustainable sites, water efficiency, energy and atmosphere, materials and resources, IEQ, and innovation and design process. LEED is available for a number of different project categories, but the LEED for new construction and major renovations is the most common (Lopus, 2011). As Roderick *et al.* (n.d.) and Lee and Guerin (2009) further mentioned that it is the most widely recognised building environment assessment schemes. Moreover, the interest in the LEED certification system became global. Hence, the registered projects have covered 24 different countries. Currently, many of LEED-certified projects are located in Asia including China, India, and Korea (InBuilt, 2010; Lopus, 2011).

- ***BREEAM***

BREEAM was launched by the U.K. building research establishment and is adopted by the U.K. government as a measure of best practice in environmental design and management. It is the most widely used in UK (Haapio, 2008). Although it is a voluntary standard, the energy performance assessment adopts the UK building regulation as a benchmark to rate the level of performance improvement. Latest version for office buildings is BREEAM offices 2008. It defines categories of credits according to the building impact on the environment including management, health and wellbeing, energy, transport, water, materials, waste, land use and ecology and pollution (Roderick *et al.*, n.d; Grace, 2000 cited Haapio and Viitaniemi, n.d.). According to a study by Haapio and Viitaniemi (n.d.), a variety of different BREEAM tools exist for building products, whole buildings and whole building assessment frameworks.

- ***CASBEE***

The CASBEE was introduced in 2002. It involves the evaluation of building quality and environmental impacts (Glaumann, 2010 cited Wallhagen, 2010). The categories are defined in accordance with hypothetical boundaries around a building site (Boonstra and Pettersen, 2003). Boonstra and Pettersen (2003) further described CASBEE tool comprises four assessment tools and a design process. Among the tools, only the "design for environment" tool has been completed. Others concern pre-design assessment, eco-labelling and sustainable operations and renovation.

- ***Green Star***

Green Star was launched by Green Building Council of Australia (GBCA) and is established as a national guide to evaluate the environmental design and achievements of buildings. All three schemes are based on rating system of collecting credits that applies to a wide range of building types, both new and existing buildings. All cover a range of environmental issues such as materials, energy, water, pollution, IEQ and building site (Roderick *et al.*, n.d). A most followed voluntary building environmental assessment scheme in Australia. It was developed to accommodate the need of buildings in hot climates where cooling systems and solar shading are of major importance. It has also been adapted in New Zealand and South Africa (Green Building Council Australia, n.d. cited Roderick *et al.*, n.d). Current version for new offices is Green star-office as design v3. The credits are organised in following aspects of the building and process: management, IEQ, energy, transport, water, materials, land use and ecology, emissions, and innovation (Roderick *et al.*, n.d).

2.5. GREEN ASSESSMENT OF IEQ

Assessment tools were primarily developed to assess, or measure specific aspects of a building, pertaining to sustainability goals. To develop the green assessment tools, the authors used existing sustainable practices, such as increased day lighting, operable windows, and native plants; improved efficiencies (energy and water use), monitoring and commissioning; and promoted biodiversity, material reuse, recycling and urban infill or densification (McKay, 2007). Among those sustainable factors, IEQ is a major concern in developing such green assessment tools due to its considerable impact on wellbeing of the building occupants. Thus, most of green assessment tools specially LEED, BREEAM, Green Star and CASBEE techniques have developed considering the IEQ as a major criteria towards sustainable buildings.

Table 1: Criteria Comparison between Green Assessment Tools
(Source: Boonstra and Pettersen, 2003; Haapio, 2008; Wallhagen, 2010; InBuilt, 2010)

	% of IEQ			
Criteria	**LEED**	**BREEAM**	**CASBEE**	**Green Star**
Management	04	16	05	09
Health and wellbeing/IEQ	**21**	**16**	**23**	**19**
Energy	23	15	18	18
Transport	06	13	00	19
Water	10	05	03	12
Materials	18	11	12	19
Land use	08	08	19	06
Pollution	10	15	20	07

As illustrated in the above Table 1, LEED, CASBEE, Green Star and BREEAM green assessment tools have shown a great importance of IEQ among the other factors. Specially, CASBEE and LEED assessment tools have considered that the IEQ is most significant criteria compared to other techniques. Furthermore, each assessment tool covers various IEQ factors in order to ensure high quality indoor environment within buildings through the green assessment. Thus, various IEQ factors under each technique can be clearly identified as mentioned in Table 2.

According to the comparison between green assessment tools namely, LEED, BREEAM, CASBEE and Green Star (Table 2) , indoor air quality, day lighting and lighting quality, are highly concerned IEQ measures in each technique while CASBEE contains many factors on temperature and humidity, acoustic and ventilation compared to other assessment tools. Furthermore, thermal comfort and access to views are considered in IEQ criteria of LEED, BREEAM and Green Star tools excepting CASBEE.

Consequently, different nations would be able to implement different green assessment tools in order to ensure high quality indoor environment for building occupants. Specially, LEED, BREEAM, CASBEE and Green Star are major assessment tools available in green building concept which can be considered in improving indoor environmental quality in buildings. However, the considerations for those rating systems can be changed as the environmental conditions; level of development and the availability of resources in different countries (GBCSL, 2010).

Table 2: Comparison of IEQ Measures Available in Different Green Assessment Tools
(Source: Boonstra and Pettersen, 2003; Malmborg, 2004; Haapio, 2008; Wallhagen, 2010)

IEQ factor	LEED	BREEAM	Green Star	CASBEE
Temperature and humidity	Controllability of systems	Local temperature control		Room temperature setting Variable loads and following-up control Zoned control Temperature and humidity control
Acoustic	Controllability of systems	Noise	Internal noise levels	Background noise Equipment noise Sound insulation of openings Sound insulation of partition walls Sound absorption
Ventilation	Environmental tobacco smoke control Co2 monitoring Ventilation efficiency	Operable windows Air intake Fresh air	Ventilation rates	Ventilation rate Natural ventilation performance Consideration for outside air intake Air supply planning
Indoor Air Quality	Indoor chemical and pollutant source control Minimum IAQ performance Construction IAQ management plan	Smoking Clean carpets	Air change effectiveness Co_2 and VOC monitoring and control Hazardous materials	Type of A/C Co_2 monitoring Control of smoking
Day Lighting and Lighting Quality	Low-emitting materials Day lighting	80% adequately day light Window antiglare Ballets Illuminance levels Independent lighting control	Daylight Daylight glare control High frequency ballets Electric lighting levels	Daylight factor Openings by orientation Daylight devices Glare from light fixtures Daylight control Illuminance level Uniformity ratio of illuminance Lighting controllability
Thermal Comfort	Thermal comfort	Thermal comfort	Thermal comfort	-
Access to Views	Views	Desks location	External views	-

2.6. *Application of Green Building Concept for IEQ in Sri Lankan Buildings*

Similarly in Sri Lanka, most of modern buildings have tended to be green certified building to obtain its vital benefits because of indoor environment quality is an important aspect which has received practically no attention in built environments (Ileperuma, 2000). Further, facilitating a high quality working environment for the building occupants is one of the major concerns of obtaining a green certification rather stays as a traditional building. Accordingly, GREEN$^{SL®}$ Rating System of Green Building Council Sri Lanka (GBCSL) has been introduced, with the main aim of fundamentally changing the built environment by creating energy-efficient, healthy, productive buildings that reduce or minimise the significant impacts of buildings on the environment. This is achieved through the allocation of different credits to the selection of a proper site, better and efficient design, material selection, construction, operation, maintenance, removal, and possible reuse, etc (GBCSL, 2010).

GBCSL (2010) further stated that GREEN$^{SL®}$ Rating System contains eight criteria namely, management, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation and design process, social and cultural awareness. Each domain category has number of aspects. The number and nature of aspects varies from one category to another according to the category itself and its importance matching the local context (Chandratilake and Dias, 2010 cited GBCSL, 2010). A study by Chandratilake and Dias further mentioned that 'sustainable sites' is the most important domain. And, energy and atmosphere, materials and resources, water efficiency and indoor environmental quality are respectively in the top order.

2.7. SUGGESTIONS ON GREEN ASSESSMENT TOOLS SUITED FOR IEQ IN SRI LANKAN BUILDINGS

Even though, the indoor environment quality is a major concern in many green assessment tools including LEED, BREEAM, GREEN STAR, CASBEE and GREEN$^{SL®}$ rating system, containing factors can be differ as mentioned in Figure 1. When specially consider about the GREEN$^{SL®}$ rating system in Sri Lanka, it has developed suited for local context. Thus, it contains some similar factors as the other assessment tools while some factors are not considered within Sri Lankan context (Figure 1). Minimum IAQ performance, smoke control, outdoor air delivery monitoring, increased ventilation, construction IAQ management plan, low - emitting materials, indoor chemical and pollutant source control, controllability of systems, thermal comfort, design, thermal comfort, verification, daylight and views can be identified as common factors among LEED, BREEAM, GREEN STAR, CASBEE and GREEN$^{SL®}$ rating system.

However, LEED assessment tool covers two factors as CO_2 monitoring and ventilation efficiency which are not mentioned in the local rating system in Sri Lanka. Further, local temperature control, noise, operable windows, air intake, fresh air, clean carpets, window antiglare, ballets, illuminance levels, independent lighting control and desks location factors were additionally included in BREEAM tool while Green Star and CASBEE tools contain many other several IEQ factors which have not considered within GREEN$^{SL®}$ rating system in Sri Lanka. Thus, in consideration of facilitating high quality indoor environment for building occupants, it is vital to go for another suited green assessment tools namely LEED, BREEAM, CASBEE, and Green Star or making possible enhancements in existing green rating system compared with another techniques.

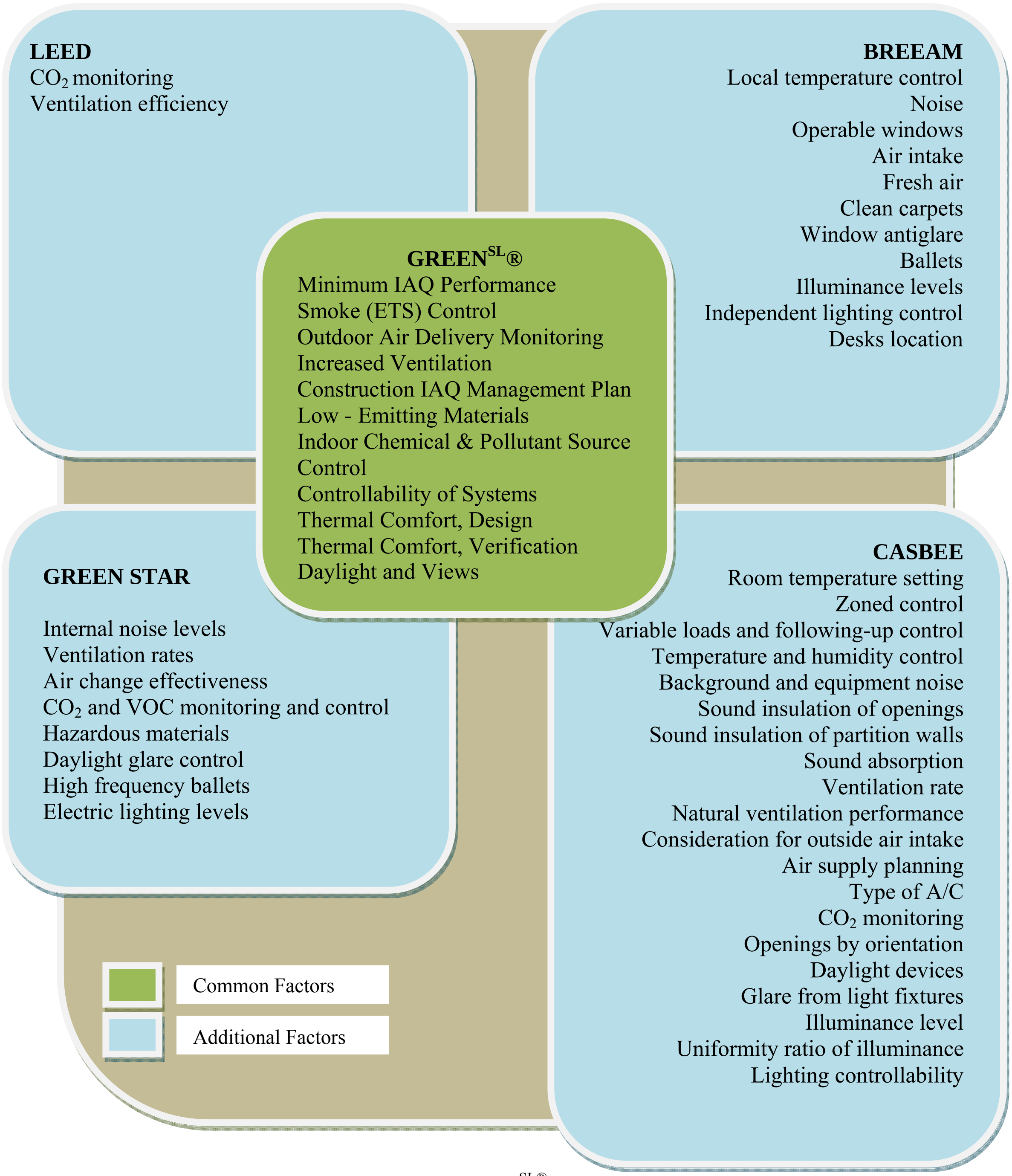

Figure1: IEQ Factors in GREEN$^{SL®}$ vs Other Green Assessment Tools

3. SUMMARY

Well-being is an important factor in determining the quality of life of building occupants. As majority of people spent their life indoors, it is widely accepted that the indoor environmental is important for public health and well-being of occupants. Hence, it emerges the importance of facilitating high quality indoor environment within buildings. Consequently, many tools and concepts have been developed to determine criteria for healthy and comfortable buildings with high quality indoor environment. Green building concept has emerged as a new building philosophy in order to provide better and healthier indoor environment for building occupants. There are several assessment tools of green building concept can be applied in facilitating IEQ namely, LEED, BREEAM, CASBEE and Green Star etc. This study was done for evaluating IEQ criteria and related factors of above mentioned tools so as to suggest implementation of new green building tool fulfilling the IEQ requirement of buildings in Sri Lanka. Even though, there is a local green rating system within Sri Lankan context namely GREEN$^{SL®}$, it only concern about few factors within the IEQ domain. However, within other tools, considerable attention has given for the IEQ in buildings. Thus, such green building tools can be considered for buildings in Sri Lanka as a new concept/tool or even the existing system can be further enhanced so as to provide a better quality indoor environment for their building occupants.

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PRESERVATION OF PRIVATE HOUSES IN FORT OF GALLE, SRI LANKA: A CASE STUDY

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ABSTRACT

Fort of Galle is a declared World Heritage under the Criteria (IV) since 1988, and, since then, several actions have been taken to preserve its historic built environment in its authentic form. Establishment of Galle Heritage Foundation (GHF) as an organ under the Ministry of Culture and National Heritage was one of the pioneering and very important move taken towards this endeavour. GHF, closely working with the Special Planning Unit of the Galle Municipal Council (SPUGMC); Department of Archaeology (DOA); and other stakeholders for preservation of historic built fabric of the Fort. GHF plays a vital role in monitoring development activities within the fort; assisting in planning development activities; assisting in scrutinising development plans by residents and others; and, submitting their recommendations to the Planning Committee of Galle Municipal Council. The role and functions of the GHF in preservation of the historic built environment of the fort in its authentic character is distinctive.

A GHF initiated socio-economic survey of the Fort of Galle, revealed that, although numerous preventive measures that include monitoring of building activities and control of developments through specific guidelines etc were effective, the historic fabric of the fort was fast deteriorating and degrading, mainly due to facts such as negligence, poor maintenance, illegal constructions, and dilapidation of uses etc. Further, it has been found that the deterioration of the southern sector of the fort, where there is a high concentration of private dwelling houses, is much rapid than its northern counterpart with public and institutional buildings.

The socio-economic survey of the University of Ruhuna brought into light many valuable facts about the condition of private dwelling houses in the Fort, and, probable causes of their deterioration etc. There were altogether 60 houses, some of them were depicting high architectural characteristics of the colonial period that are worthwhile to retain for the posterity. The other houses, which are possessing elements of colonial architecture or their generic architectural characteristics were in the verge of collapse due to negligence, poor maintenance, and, dilapidation etc resulted from the poor affordability of the residents. Having identified the necessity of preserving them for the posterity, GHF, through the Ministry of Culture and National Heritage, launched an international campaign to raise financial assistance for this endeavour.

In 2007, the Government of Sri Lanka received the Netherland Government Cultural Grant, mainly to preserve and maintain Dutch Heritage of the Country, and the Government, with the consensus of the donors, decided to allocate part of this grant for improvement of private dwelling houses, in order to regenerate traditional Dutch Streetscape of the Fort of Galle.GHF was entrusted with the task of implementing the project.

Having recognised the need of receiving expert advice from architect-conservators, GHF invited Centre for Heritage and Cultural Studies of the University of Moratuwa (CHCS), to assist them in preparation of plans for Refurbishment and Preservation of Private houses in the Fort. Necessary nitty-gritty's finalised, and CHCS was appointed as Consultants to advice the GHF. All preliminaries have been identified by the GHF based on the Socio-economic Survey conducted by the University of Ruhuna. About 60 private houses, which were eligible to receive financial assistance and technical guidance, too; had been identified. CHCS commenced the assignment, with an extensive Field Investigations and Preparation of Measured Drawings of selected houses. The cursory examination revealed that they had been renovated, modified and altered from time to time, without any records. Thus preparation of measured drawings and identifying original components had become a daunting task. A detail photographic recording completed the comprehensive documentation of Pre-refurbishment Stage.

This paper reports on a case study of the above project, elaborating on technical implications. Project, having recognised its contribution for preservation of Cultural Heritage, was awarded UNESCO-Asia Pacific Cultural Award 2010 (Merit Award).

Keywords: *Preservation, Refurbishments; Streetscape, Rescue Conservation.*

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1. INTRODUCTION

Fort of Galle, a World Heritage is the largest Dutch Colonial Township outside built and survives to date outside Europe. It had been a Dutch stronghold from 1640 until 1796, and thereafter a British Provincial Administration centre until 1948. After the independence, the township has been used continuously, and is considered as living monuments containing heritage from 1669 onwards. Due to those different phases of the History, the township possesses historic architectural remains belongs to all the periods since middle of the 17th century (Figure 1).

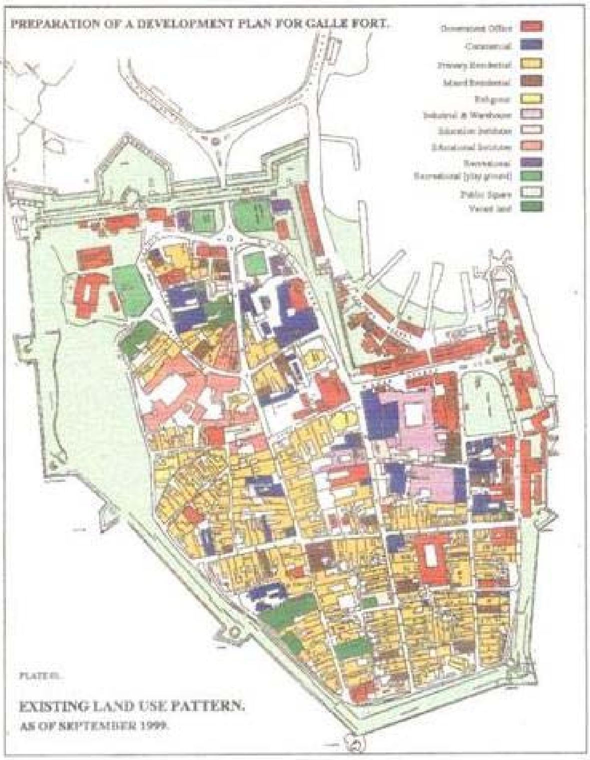

Figure 1: Fort of Galle and Its Heritage

The Fort contains many buildings, built during different eras to fulfil various requirements of regional administration as well as to service the community in and outside the Fort. Most of those buildings are concentrated in the northern segments of the Fort. Although there were not much ordinary residential facilities within it, during the latter part of the British period, it was opened up for ordinary communities too. They built their dwellings in the southern segment of the Fort, which had been comparatively low sense during the early periods.

After independence, very especially during 1960s, housing plots within the fort were fragmented into smaller plots, to accommodate extending families, mostly Muslim traders, and continue to living in their houses gradually decreasing in size.

With the passage of time, those houses became overcrowded, and at the same time, due to many reasons, their maintenance too was gradually neglected. At the turn of the millennium, majority of houses, especially in southern segment of the fort revealed impoverish characteristics such as poor maintenances, dilapidations, shabbiness etc. Project for refurbishment of private houses was a timely intervention in this regard.

Project for Preservation of Private Houses in the Fort of Galle comprised of several phases. First and foremost was the field investigation and documentation phase, aiming at preparation of a set of measured drawings of each and every house, which were selected to receive financial and technical assistance. Measurements and other supporting documentations were necessitated to prepare a draft conservation plan, which was the phase to follow. Draft plan was prepared in concurrence with residents as well as in consultation with other members of the project team, including Department of Archaeology, GHF, Central

Cultural Fund, and other stakeholders. Discussions on the draft conservation Plan were an indirect way of increasing awareness of the Fort Community.

Next Phase was for preparation of a detailed conservation plan, based on the outcome of discussions with the community, and, modifying draft conservation plan incorporating financial commitments as well as contributions promised by residents.

Penultimate phase was the project implementation, which was preceded by educating and training of a group of skilled labourers, including carpenters, masons and other artisans on conservation works.

Final phase, post-conservation documentation included comprehensive reporting on pre-; during-; and, post-conservation activities. Further, reporting on various studies and analyses; generic characteristics of houses; construction techniques; and, concept of planning too; are incorporated in the final report. This paper reports on a detailed case study of this project, which describes the lessons-learned during above phases followed by conclusions and implications for the construction industry.

2. FIELD STUDY AND DOCUMENTATION

CHCS commenced field investigation and documentation on identified houses for refurbishments, with assistance from students of the Department of Architecture, University of Moratuwa. Despite there were awareness programme for the community before commencement of the project, at the very inception, there were some resistance from them, and, no cooperation attitude was visible. However, when they were enlightened on merits of project, objectives, and, methodology to be adopted, resistances were transformed into enormous supports.

Some of the house owners, who were originally willing to take part in the programme and to receive financial assistance abiding with conditions laid down by Galle Heritage Foundation, later declared unwillingness, having believed on rumours. When positive improvements were visible in already implemented projects, the said owners returned to the programme, allowing investigations and documentations into their houses. Although those volatile decisions had some negative impacts on intended field investigations and preparation of measured drawings, they had no impacts on the final outcome mainly due to mitigating measures by the project implementers.

Another event, which had negative impacts on preparation of measured drawings, was the non-accessibility to some of the private properties; owners of them were living outside the fort, and their premises were closed most of the time.

However, with the dedication of all the stakeholders, project was successfully implemented as originally scheduled.

3. PROBLEMS ENCOUNTERED DURING FIELD INVESTIGATION/DOCUMENTATION PHASE

There were three main factors which resisted the collection of empirical data during site investigation and documentation, namely;

(1) Some residents were not original owners of houses, but living there for a considerable period of time. It seemed that they had knowledge to disclose history of their houses, at least for last few decades. But they failed to disclose origin and developments, apparently due to unknown reasons. Perhaps, they may not have received information from their predecessors and, occasionally, it appears that they were pretending to that effect due to unknown reason;

(2) Occasionally, there were legal disputes on ownership of premises. Current residents are either illegally occupied, or, have become owners as a result of prescriptive rights for living over a longer period in the same premises. Some of the properties are not divided among the legal heirs of original legal owners, and the residents there have become non-landholders; and,

(3) In some houses, unauthorised constructions have been carried out in recent past, and the present owners whether they are responsible or not, pretend that they have no knowledge of illegal

constructions, which could have done by their predecessors. They reluctant to disclose actual facts, pretending that there were no modifications since they became residents in that house.

These backgrounds prevented the CHCS collecting accurate information about original forms of house; their subsequent renovations; and, refurbishments etc. Therefore, alternatively, historic information was constructed based on structures; materials; and their construction technology.

Figure 2: Houses with Diverse Characteristics

4. ANALYSING EMPIRICAL DATA

The southern sector of the historic fort of Galle is congested private hosing with extremely high density, providing accommodation for more than 400 families. The cursory examination reveals a group building, in poor status of maintenance, with some hidden order in their architecture (Figure 2). 60 houses for refurbishment have been selected from this neighbourhood.

The large majority of houses that have been studied for refurbishment revealed that they had been either constructed or subjected to major repairs during latter part of British and Early Post-independence Periods. Very few houses could be antedated, but repetitive repairs also have affected their authentic characteristics over the years. None of the houses could be dated to Dutch origin, or early British Period, though they possess some generic characteristics sympathetic to buildings of those periods (Figure 3).

Irrespective of period of construction, ground plan of domestic buildings within the Fort has some common characteristics (Figure 4). Generic form of the Town House Architecture of a veranda; one or two rows of private and semi-private spaces; a rear veranda; and, utility spaces articulated in a linear form, overlooking an internal courtyard, either enclosed or semi-enclosed.

Generally they had an open veranda, adjoining the street with no open ground space or garden in between them. Veranda is generally colonnaded or arcaded depending on the period of construction and features of the street in which the building is located (Figure 4). Occasionally, a half-high wall, spanning between pillars, protects the veranda. Most common alteration of domestic houses is the encroachment of this open veranda by a high wall up to the roof level, with few windows to bring light and ventilation to the interiors (Figure 4). Occasionally the window or louvers span between the pillars and surmounted on the short wall to convert open veranda into a semi-enclosed veranda.

Behind the veranda is a hall, occasionally divided into two or three different spaces, depending on width the road frontage. Narrow properties have a single space and wider properties the space divided into three with lobby in the centre and two bedrooms symmetrically locating on either sides. The access is provided from the lobby, maintaining the symmetry, and windows are provided on veranda side to borrow lights and ventilation across the veranda.

Figure 3: Diverse Building Forms

In some of the houses, the second layer spaces are amalgamated with the veranda and restructured to have large bedrooms or larger living rooms.

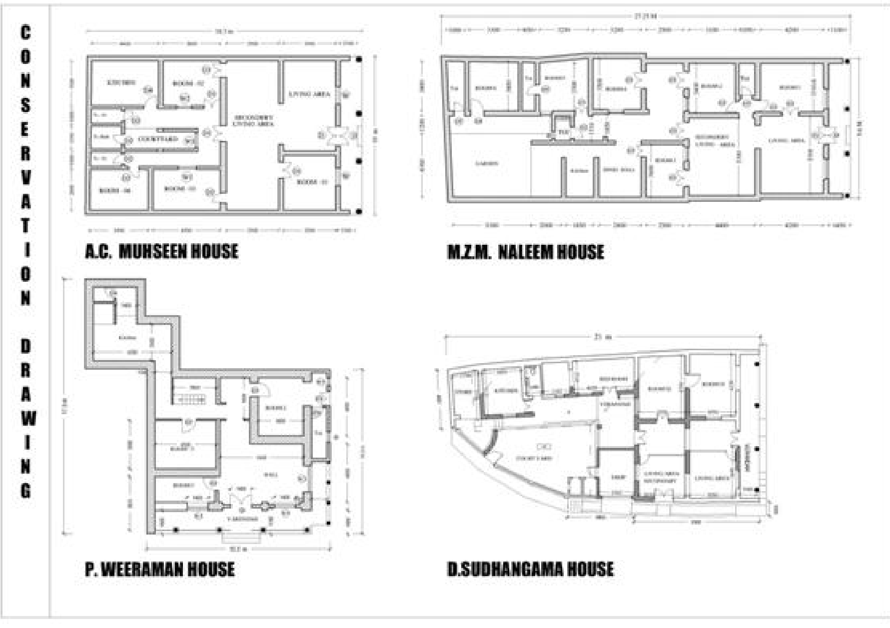

Figure 4: Generic Plan of Townhouse

Behind the bedroom layer, in older version of the houses, have a secondary living room, spanning the full width the house, thus ensuring access from other spaces in the second row. In smaller houses as well as in later period houses, the second veranda is missing (Figure 5).

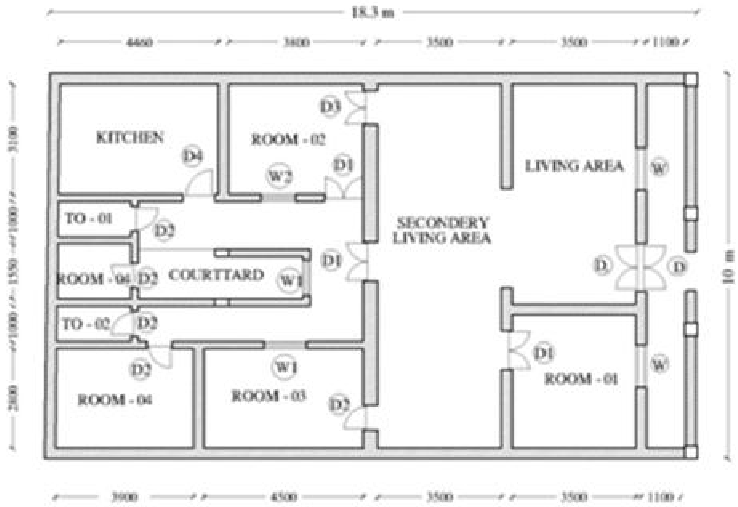

Figure 5: Generic Plan of Two Veranda House

Spaces accommodated in the main wing of the house are opened out to a rear veranda, in most cases spanning the full width of the house, and overlooking an internal garden or a courtyard.

In a typical house, one or two rear wings, depending on the width of the property, emanating from the rear veranda and runs up to the rear boundary wall, which is abutting a service alley. In case where there are no rear alleyways, the building ends up with leaving a rear space reservation, around two metres in depth (Figure 6).

In subsequent alterations, mostly illegal, rear space reservation and internal gardens had been encroached. A low pitch roof is constructed over the open space, preventing natural lights and ventilations in to the inner spaces. Though, approval from the local council is necessary for any development within the Fort, occupants are carrying out developments illegally, without informing any institution (Figure 7).

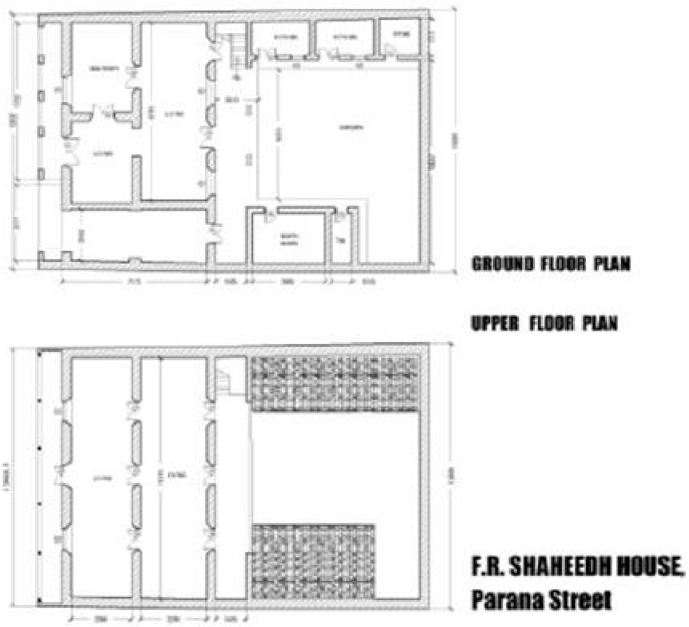

Figure 6: Typical two storied House

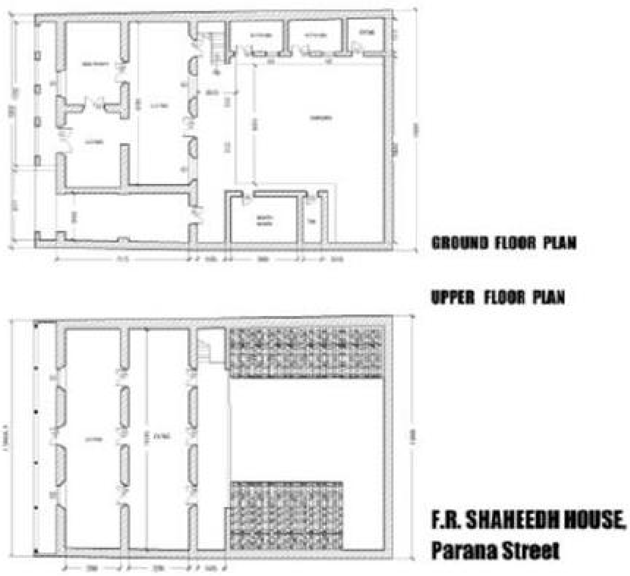

Figure 7: House with Encroachments

Few residents have encroached into the vertical space too; courtyard is covered by two-storied extension, preventing both natural lights and ventilation into the interiors.

One special characteristic of illegal renovations in recent past, especially after promulgation of new urban development and preservation regulations, is the methodology of carrying out them in series of unnoticeable small-scale works in hidden manner. In this manner, interior spaces are modified, altered and adopted, with no notice to the authorities, and, are not meeting the statutory requirements for lighting and ventilations of habitable spaces. Resultants interior architecture is one of the common characteristics of the majority of private houses in the Fort of Galle.

Summary of findings and their analyses lead for following comments, which will be the basis for determination of the Renovation Strategy for private houses, in Fort of Galle.

5. REFURBISHMENT STRATEGY AND PLANS

Since funds available for renovation of old houses were limited, main attention was focused on to use them optimally. Project was defined and scheduled as a Rescue Conservation programme. First priority was given for improvements of roof, which was identified as the primary cause for most of deteriorations. Reintegration of the lost streetscape accompanied the improvements to roof. A facade, sympathising with the architectural character of adjoining buildings were introduced to support the renovated roof, and helped in accomplishing the intended task of reintegrating the lost streetscape of fort (Figure 8).

Figure 8: Reintegrated Streetscape

Thereafter repairs were concentrated on consolidation of plaster works, rectification of cracks, prevention of deteriorated woodwork etc.

Changing attitudes of residents was considered as an intangible rescue conservation measure, and awareness programme has been used as an effective tool for the same. Further, it had become a strategy to discourage residents who were attempting to demolish their houses in order to rebuild them in an alien style, antithesis to historic landscape of the Fort of Galle.

A timeless style, which resembles Dutch-hybrid architecture of the Fort, was introduced as the key tool for refurbishment works. Though there were initial dislikes, when few houses were refurbished, majority of the residents acknowledged the type of architecture adopted for refurbishments (Figure 9).

Figure 9: Integration of Timeless Architecture

Refurbishment strategy for private houses is basically based on empirical data collected during site investigations, and, remedial measures were determined based on analyses of those findings.

- One of the key issues for residents to seek illegal construction and renovation as a console was due to the difficulty of obtaining statutory approval, as most of them have already violated light and ventilation regulations. Fear of receiving impractical recommendations from planning authorities, residents compelled to by pass them and seek easy way out, and to carry out their renovation works, without obtaining building permit from Galle Municipal Council or Galle Heritage Foundation.
- Having realised exorbitant cost incur in repairing historic structures, residents did not want to venture on their aged-old houses, spending considerable amount of resources. Further, buildings within the require renovations in compliance with conservation guidelines and regulations, and, thus no cheap conventional building materials can be used. According to owners, it is impossible to obtain value for money, thus investment on those houses are not fruitful. On the other hand, as a pull factor, there are better financial offers for old houses from foreigners, where the owners could obtain easy money.
- Due to repeated constructions, reconstructions, renovations, and modifications over the years, most of the house interiors have become uncomfortable for both physical usage of spaces as well as body comforts of inmates. Thus, there is a push factor to seek better accommodation outside Fort in a better and conducive living environment, if the urban conveniences are available. This desire also prevents owners spending on renovation of their houses.
- It was found that the most severe cause of deterioration of built environment was the ad-hoc renovations and modification of old houses. They had been constructed without permits and not follow set regulations and guidelines. Even the basic principles of building constructions have not been followed in later renovations and modifications. The whole attempts seem to be to get additional spaces, disregarding all environmental factors. Most visible result is the fast decaying roofs with poor roof drainage and leakages, which is the primary cause for most decays in old houses within the Fort of Galle.

6. Refurbishment Concept

Refurbishment concepts and the guideline have been prepared based on analyses of above facts. Basic principal of refurbishment strategy is to regenerate lost historic atmosphere of streets, by reintegrating generic characteristics of Town House Architecture of the Fort. When there are genuine evidences from history, with authentic information of their original characteristics, houses were reverted back to original architecture, with the consensus of their occupants. However, when there are no records of original form or no authentic information on the original character of the houses, the renovation principal adapted was a form of reconstruction sympathising with the existing general characteristics of the neighbourhood.

Reintroduction of the veranda, which had been one of the key element of Town House Architecture of the Fort of Galle during the foregone period, either fully opened or semi-enclosed, was one of the primary tool used in regeneration of historic atmosphere for streets of the Fort. For this purpose, the existing floor plan of each house was honoured as much as possible, without attempting a complete deviation, except where authentic information available for possible alterations (Figure 10). When the veranda is reviewed, it was guided by the remnants of previous floor plan, for which authentic information could be found from the site itself (Figure 11).

Figure 10: Before and After Veranda Review

Other major area of interventions was the roof. It is found that the cause for deterioration of most houses was the roof, and thus roof renovation is carried out in almost all houses. Since available resources for each unit was limited, most essential reparation works, in the form of rescue reparation only have been carried out.

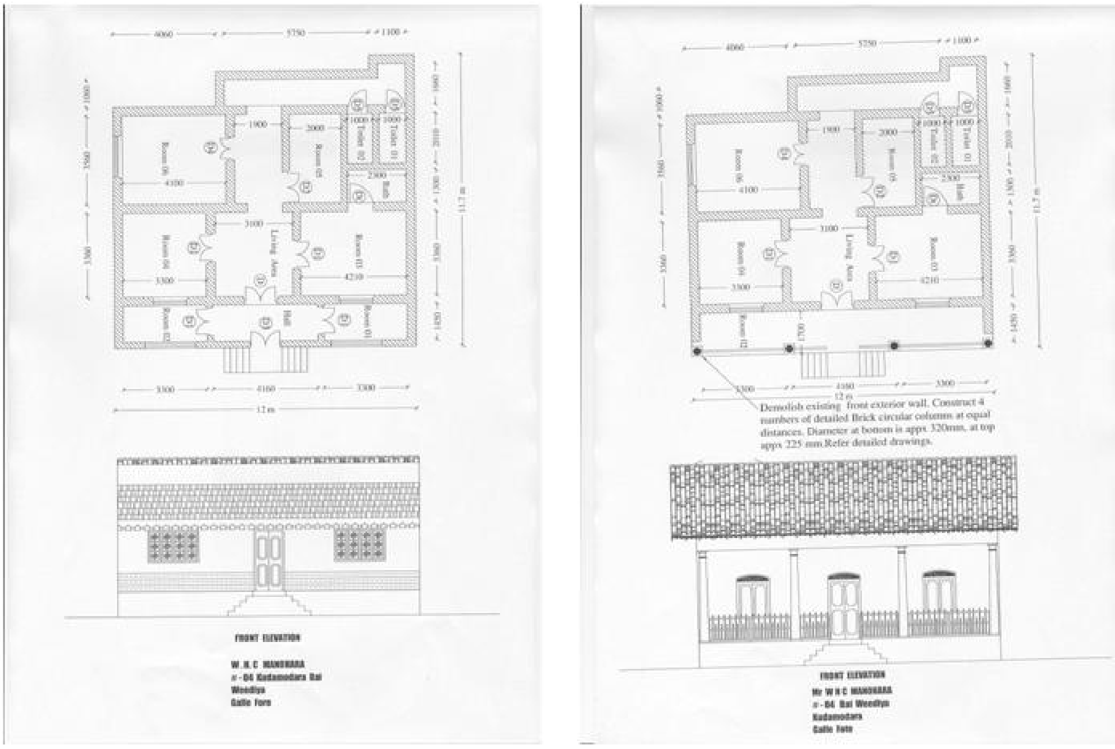

Figure 11: A House Before and After Intervention

Other remaining resources available were used to repair essential deteriorated works such as floors, walls, and veranda etc., mainly to prevent further decays.

7. CONSTRAINTS IN IMPLEMENTING WORKS

Although the Galle Heritage Foundation had conducted an awareness programme during the planning stage, some of the owners had distrust and doubts about the project. They were under the impression that houses would be subjected to various controls of statutory authorities; preventing them being used their ownership rights comprehensively. However, after completion of few projects, the mistrust disappeared and owners volunteered to take part in project.

Most notable constraint during implementation of the project was the finance. Majority of houses has not been renovated for decades, thus decays were extensive, and higher financial resources are required. And thus allocations for individual houses had to be restricted.

Lack of experienced and skilled labour, especially to handle repairs of historic buildings and renovation works, was another severe problem. Training staff under the guidance of Central Cultural Fund was a positive measure, which could mitigate the said problem.

Another difficulty anticipated was the renovation of a house which was being occupied by inmates. Limited space of house as well as non-availability of open spaces adjoining them further aggravated the gravity of implementation problem.

8. IMPLEMENTATION

Implementation of renovation works were commenced with appropriate solutions for previously identified setbacks, and thus it was able to complete the project as anticipated.

Financial constraints, one of the major hindrances in implementing the project, were mitigated by a strategic approach. The first priority was given to refurbishment of roofs, and rescue rectification works of damaged and decayed parts were first attended. Whenever, there is a large house, and allotted finances were insufficient to implement proposed renovation works, residents were encouraged to contribute making the project a public-private initiative in the full sense of the word. Under this scheme, some of the residents contributed to the project by supplying materials, and, others, occasionally provided cost of labour from their own resources. Galle Heritage Foundation in collaboration with the Central Cultural Fund took appropriate actions at the commencement to train skill workforce for deployment in Renovations works. Few carpenters and masons from the local area had been selected and were educated on implementation of works in historic buildings. Further, they were trained at preservation sites, in order to get familiarise with nature of works and how to deal with a building which has some historic relevance. Experience supervisors have been selected and trained to implement the project.

9. CONCLUSIONS AND IMPLICATIONS

Field study as well as interviews with present occupants revealed that there are three main causes threatening the survival of house, and had taken precautions to mitigate them in the future;

(a) Natural destruction as a result of age as well as impacts from natural elements had been further weakened by economic condition of occupation. Main threat to houses was from decayed roof, which had all elements of symptoms of a fast decaying building.

(b) Impacts of changes in adjoining streetscape have compelled owners to refurbish their houses by themselves, based on own designs and technology, embodying modern amenities and a new outlook.

(c) Strict conservation regulations and, urban development regulations etc to maintain historic streetscape and authenticity of the world heritage site, compelling residents to change their buildings by disobeying those rules and regulations, and engage in illegal reconstruction works.

Those factors were considered when setting the guidelines and recommendations for future interventions.

The maintenance of Refurbished Houses in their current form seems to be a difficult task. Ever increasing land prices as well as the demand for space within the township, accompanied by changing attitudes of the residents has become a severe threat to existing streetscapes. One of the primary forces behind these trends is the tourists' attraction to the city.

A suitable preventive measure, with consensus of the current owners, should be concluded no sooner the reparation works of old houses are completed. One of the attractive factors for preservation of private houses would be the exploitation of their hidden economic values. They could be used as museums, guesthouses or for any other activity, with adoptive and non-adoptive preservation of interiors. But it is essential to retain the exterior of those houses, which contribute immensely for maintaining the historic landscape and streetscape.

TEAMWORK IN FACILITIES MANAGEMENT

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ABSTRACT

Teamwork is essential to Facilities Management (FM) organisations due to the presence of various parties and multi-functional nature. However, there is a lack of published researches on teamwork with regards to FM. The consideration given in literature in discussing ways to adopt the concept of teamwork in FM was very insignificant. Therefore, the research question formulated was; "how the concept of teamwork can be adapted to FM in Sri Lankan Real Estate and Development sector?" The ultimate aim of the study was to develop a guide for teamwork by understanding the nature of teamwork in FM. The research question was approached through case study research method using three cases in the Real Estate and Development sector of Sri Lanka. Semi structured interviews were conducted with FM practitioners of the selected cases. The findings asserted that the ideal team concept in general management does not go with FM team. Instead, the composition of FM team required to be flexible depending on several factors, namely; task, method of performance, facility type and size. However, few key members, who were common to any FM team, were recognised in the research as well. Further, specific requirements of teamwork in FM were identified. Based on findings, a guide for teamwork in FM in Sri Lankan Real Estate and Development sector was developed. This will be useful to FM practitioners who operate in similar contexts.

Keywords: *Facilities Management, Teams, Teamwork, Case Studies, Sri Lanka.*

1. INTRODUCTION

Facilities organisations that are seeking not only to survive but also to maximise operational effectiveness in an ever-changing environment, need to identify factors such as senior management support, training, employee empowerment and teamwork as the key elements of innovation. Team-working stems from the simple recognition that a company's outputs are likely to be maximised when the people who make up that company act as a team rather than as a collection of individuals (Santa *et al.*, 2009). Empirical research on variables influencing teamwork is vast (Kozlowski and Ilgen, 2006; Salas *et al.*, 2004). Many researchers have demonstrated that the relationship between teamwork and its influencing factors is a complex one, and have called for more empirical research to draw more reliable conclusions regarding its nature and strength. More specifically, some relationships between influencing factors and teamwork appeared to be moderated by other variables such as diversity or task type or appeared to have a dynamic character (Zellmer-Bruhn and Gibson, 2006), therefore requiring longitudinal research.

When considering FM, no or very little research had been carried out covering this subject area. Thus, this research anticipates filling the research gap by exploring how the concept of teamwork can be adapted in Sri Lankan Real Estate and Development sector.

2. LITERATURE SYNTHESIS

2.1. FACILITIES MANAGEMENT: PRACTICE AND FUNCTIONS

The organisational objectives normally vary by different business environment (Lee, 2002). Hence, different organisations are differently reliant on their facilities and support services. In turn, facilities as well as FM function are prioritised differently to the core businesses of different organisations. Consequently, the function, role, scope and priority of FM functions need to be designed to fit with these contingent matters. Atkin and Brooks (2009) stressed that understanding the organisational needs is the

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key to effective FM, measured in terms of providing value for money. These authors agree that FM practice needs to be tailored to specific factors of given organisations. Since the organisational objectives and environment affect the use and management of the facilities, there may be no universal approach to managing facilities.

FM covers an extremely wide field of activities (Nutt, 2000), and is responsible for the provision of many varied services (Barrett, 1995). It has embraced broader range of services, more than building operations and maintenance (Aston, 1994). Both Alexander (2003) and Payne (2000) agreed that FM cannot deviate from functions like property management, administration, housekeeping, security, building services coordination and health and safety. When considering the functions of FM, it appears that Facilities Managers need to interact with various groups of people from different educational backgrounds and people with different expertise. Thus, adapting the concept of teamwork becomes a crucial factor for Facilities Management. Before moving on to teamwork, the significance of teams in organisations is explained in the next section.

2.2. SIGNIFICANCE OF TEAMS AND TEAMWORK

Cohen and Bailey (1997) defined team as a collection of individuals who are interdependent in their tasks, who share responsibility for outcomes, who see themselves and who are seen by others as an intact social entity embedded in one or more larger social systems and who manage their relationships across organisational boundaries. Further, according to Katzenbach and Smith (1993, p.9), "teams outperform individuals acting alone or in larger organisational groupings, especially when performance requires multiple skills, judgments and experiences."

Atkin and Brooks (2009) asserted that organisations consist of FM teams, which serve internal departments as well as external customers. According to Alexander (2003), key members of the facilities team will need the authority to match responsibility for managing the service delivered to customers. Nutt (2000) stressed the need of FM to widen considerably, with delegation of FM functions to working teams. Although none of them detailed the characteristics of a FM team, all these researchers implied that FM operates within a team in organisations. They provided enough evidence for existence of such a team. However, how they work as a team is not sufficiently addressed.

In general, the importance of high-quality teamwork for organisational success in today's economy is emphasised by many professional as well as academic publications (Glassop, 2002; Kozlowski and Ilgen, 2006). Dahlgaard *et al.* (1998) asserted that a culture of teamwork and co-operation must be developed throughout organisations. It is becoming a common practice in organisations to produce high productive results through ensuring effective teamwork. The next section attempts to identify the requirements of effective teamwork.

2.2.1. REQUIREMENTS OF TEAMWORK

Most researchers agree that there are a few distinct qualities that set apart the high-performance teams. Although the wording may be different, the ideas are the same. Hoegl and Gemuenden (2001) conceptualised teamwork excellence as a higher order construct with six facets classified into two groups: task-related facets (communication, coordination, and balance of member contributions) and social interaction facets (mutual support, effort, and cohesion). Gustafson and Kleiner (1994), being more definite, acknowledged eight distinct qualities that set apart the high-performance teams, namely: participative leaderships, shared responsibilities, definition of purpose, high communication, a focused future, focused tasks, creative talents and rapid responses. Some researchers perceived these requirements in a specific viewpoint. Dahlgaard *et al.* (1998, p.825) affirmed that "a culture of teamwork and co-operation must be developed throughout the organisation. Education and training will play a key role in this respect." This ascertains was further acknowledged and developed by Adebanjo and Kehoe (2001) by identifying education, training, facilitation, encouragement, recognition and reward as the five key change agents for teamwork.

Thus, most researchers have identified a common set of requirements of excellent teamwork. Table 1 denotes such a set of requirements which is essential for quality teamwork and effectiveness of teams.

Table 1: Requirements of Teamwork

Requirement	**Description**	**Researcher(s)**
Role clarity	The degree to which the team members' behaviour is specified by routines, procedures, and prescribed roles	Gladstein (1984)
Goal clarity	The degree in which the goal the team has to attain is clear	Gladstein (1984)
Job design	Task variety shall be identified and task significance should be specified.	Hackman (1987) and Campion *et al.* (1996)
Leadership	The degree in which task leadership, maintenance leadership was realised and the extent of leadership influence on higher management. Furthermore, the extent to which the leader shows monitoring, feedback, coaching and influencing behaviour	Gladstein (1984) and Kozlowski and Ilgen (2006)
Interdependence	Reliance and dependence on one another in performing duty	Guzzo and Shea (1992) and Campion *et al.* (1996)
Training	Employees need to be trained in the necessary tools and techniques, which make their attempts at teamwork, successful.	Dahlgaard *et al.* (1998) and Adebanjo and Kehoe (2001)

All these requirements or a selective few could benefit the teamwork in FM in Sri Lankan Real Estate and Development sector, thus, becoming enablers of teamwork in FM. Hence, these were focused in the empirical study with the aim of developing ultimate guide for teamwork in FM in Sri Lankan Real Estate and Development sector. The next section explains the research method.

3. RESEARCH METHOD

The study of phenomena in their natural environment is the key to the interpretivist philosophy which assumes that the reality is subjective and interior to the people (Easterby-Smith *et al.*, 2002). When considering the research aim and the nature of this research, it was obvious that this study needs cautious observation of human interactions and behaviours. Thus, this issue necessitated the researcher to assume that the reality which the research aim seeks was within the people who have to be observed. Hence, interpretivism research philosophy was adapted in this research.

Patton and Appelbaum (2003) stated that case studies are more suited for the studies where qualitative data predominate. This research also deals with qualitative data as generated through human interactions and behaviours in working as a team. By considering all of above reasons, case study research approach was selected for the research.

In this study, cases were selected from Real Estate and Development sector of Sri Lankan context. The three cases selected are briefed in Table 2.

Table 2: Case Briefing

Case	**A**	**B**	**C**
Core business	Real estate and property development	Property development and management	Property Development
Facility	Two towers with 36 levels per each. Lettable 700,000 sq.ft. and luxury apartment complex (256 apartments)	32 storeys with 598,321 sq.ft.	23 storeys with 430,000 sq.ft.
Procurement Method	In-house	In-house	In-house
Interviewees	1. Facilities Manager 2. Assistant FM 3. Civil Engineer 4. Procurement Manager	1. Manager Maintenance and Building Services 2. Electrical Engineer 3. Manager HR and Admin 4. Manager Security	1. Facilities Manager 2. Manager Electrical and BMS 3. Manager Finance 4. Procurement Manager

Cases were examined mainly by conducting semi-structured and face-to-face interviews. The interviews were conducted with four key participants of the FM team. Facilities Manager and three of the employee representatives involved in FM practice. These employee representatives varied with the cases as the selection was based on Facilities Managers' direction. Findings of this research are discussed in the subsequent section.

4. RESEARCH FINDINGS

Research findings arising from the three case studies are presented and discussed in this section.

4.1. NATURE OF FM TEAM

All the interviewees of the three cases strongly agreed without any hesitation that teamwork is an essential discipline in FM. Thus, on the whole it is clarified that FM is a discipline that requires teamwork to achieve efficiency, reasoned out by facts such as people being one of FM's main pillars, FM having a broader scope comparing to other professions and FM context comprising of different professionals from different disciplines.

According to the empirical study, it was apparent that FM cannot have a fixed team. Eleven out of the twelve respondents across the three cases agreed that it is unlikely to have a fixed FM team. It was revealed that FM team shall vary depending on the task and the facility. Further, when evaluating the people with whom Facilities Managers mostly interact in their practice, Manager – Maintenance and Building Services, Finance Manager, Security Manager and Procurement Manager were identified significant in all three cases. Further, Electrical, Mechanical and Civil Engineers are also significant. According to the empirical findings, they generally report to Manager – Maintenance and Building Services. Thus, keeping Manager – Maintenance and Building Services as a key contact person is more appropriate for FM.

The team composition of the entire FM team is not fixed as in an ordinary team. While having a few key members, the selection of other members shall be flexible according to the factors like type of facility, nature of the task undertaken and the method of performance. The key members or the people, with whom a FM keeps frequents tags, as identified in the empirical research are, Manager – Maintenance and Building Services, Security Manager, Procurement Manager and Finance Manager. Team composition identified for a FM team is presented in Figure 1.

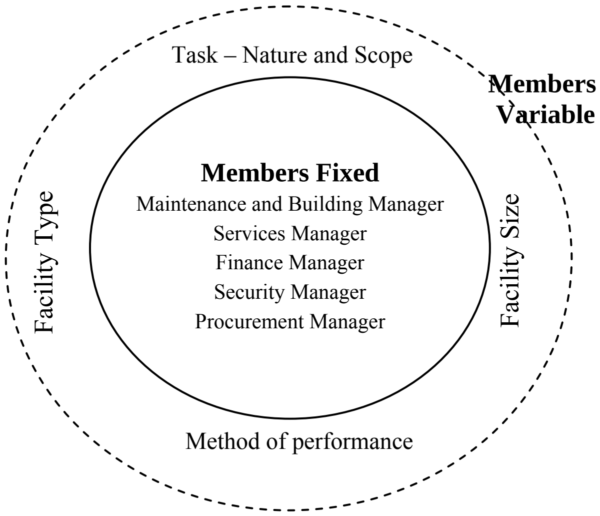

Figure 1: Facilities Management Team Composition

4.2. REQUIREMENT OF TEAMWORK IN FM

According to the empirical study, requirements of FM teamwork identified can be discussed under three main categories, namely; job design, facilitation and direction.

JOB DESIGN

The empirical findings suggested that designing the job in advance is a critical requirement of teamwork in FM. According to the respondents, by designing the job in advance as a collective effort of the members of the team, it is easier to build the team spirit within them. By clarifying what is to be done and how to do it before the commencement of the work, team members will have a clear idea about the job that they are involved in. Further, all respondents agreed that the *roles and goals of the FM team shall be very specifically placed* in order to increase teamwork. As per the assistant Facilities Manager of Case A, "*although an ordinary team may have a common goal to achieve, a FM team's common goal is the summation of specific individual goals*." Thus, when specifying roles, the scope of the work is to be considered to allocate accountabilities and responsibilities. The findings further suggested that goals should be very clear to reduce conflicts among the team members. It implied that a FM team might have groups within the team, especially when the scope of the work is larger. Hence, individual goals, group goals and the common goal of the team shall made clear to the members in terms of time and cost constrains as well.

FACILITATION

The term facilitation is broadly used to describe any activity which makes tasks for others easy. Thus, as per the empirical evidence, the organisation should act as a facilitator for the FM team in order to enhance the teamwork. This includes allocating necessary resources, top management support and reward and recognition for the team. As per Procurement Manager in Case C "*organisation should always support teamwork. For instance a team needs financial support of the organisation. Though they are assigned with a project but with insufficient budget allocation, it's impossible for us to proceed.*" This facilitation also includes good communication mechanisms, tools, technology and other resources which are necessary for the assigned FM tasks.

Need of a performance evaluation system for the FM team was suggested by Facilities Manager in Case A. This was further asserted by Facilities Manager in Case C. According to him, "*it is vital that the top management recognise the FM work and reward its success. Otherwise the entire team can be demoralised*" Hence, it is evident that the reward and recognition is important in enhancing FM teamwork.

Though provision for training and development was identified as a general teamworking requirement, respondents shared a subjective viewpoint on training as a requirement of teamwork in FM. Different respondents perceived the need of training to enhance teamwork in different ways. Some agreed that training helps to understand one another's perception and role in the team and therefore becomes an enabler of teamwork. But when considering the vast scope of FM and the different professionals who work in a FM team, providing FM training for the team members sounds impractical. This fact was asserted by several respondents over the cases. They suggested that as far as teamwork in FM is concerned, training the members with respects to behavioural skills is enough. However, comparatively most of the respondents stressed that a FM team needs sharing of up-to-date information of work that they are engaged in rather than training. They pointed out that it is important to brief the project to every team member before commencement.

DIRECTING

Empirical findings stressed that the effective directing is vital to enhance the teamwork in FM. This was discussed under three subtopics in the empirical study, namely; apt leadership, follow-ups and coordination.

The position of leadership in a FM team is not again fixed. It is evident that Facilities Manager shall not always lead the team. Based on the type of work and the skills required, the most suitable professional in the team shall take the lead. Further, the respondents demanded that whoever leads the team, they shall be competent, forward looking and inspiring. They also agreed that Facilities Manager should always keep the authority of coordination among the team members. Further, following-up the work having occasional progress reviews, looking into failures and celebrating success were also identified as important. As a FM project might involve people from different disciplines, respondents agreed that it is helpful to conduct frequent follow-ups and keep the team up-to-date with information about the ongoing project. They all stressed that without proper coordination no FM team can exist. As FM work usually deals with a vast set of information, if the coordination between the team members fail, the project will obviously be a failure and a waste of resources. It is the FM's job to coordinate among the team.

These requirements of teamwork in FM in Sri Lankan Real Estate and Development sector are comprehensively depicted in Figure 2.

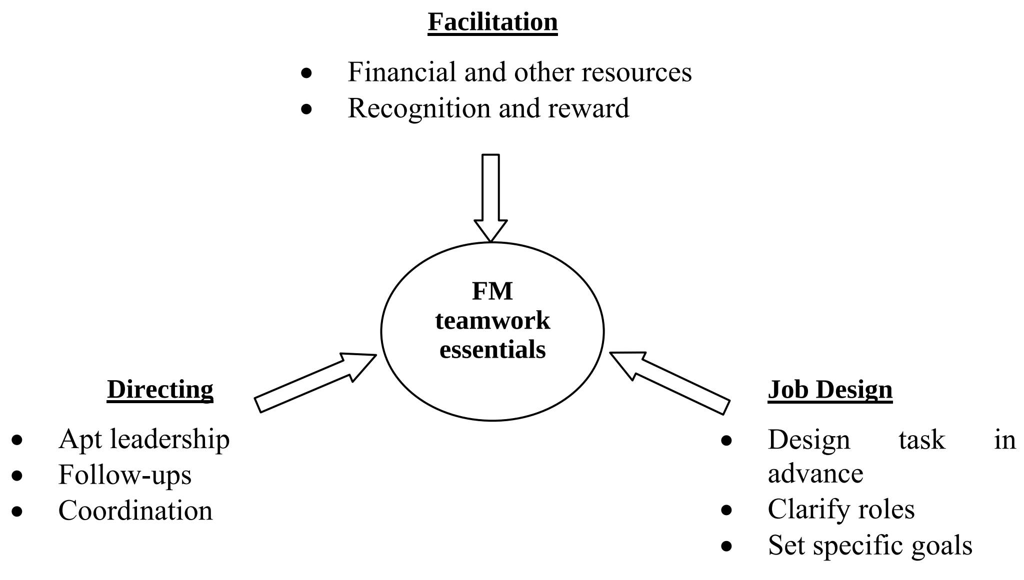

Figure 2: Facilities Management Teamwork Essentials in Sri Lankan Real Estate and Development Sector

5. CONCLUSIONS

The key findings of the research are summarised under this section in order to set up conclusions and recommendations. As far as the Sri Lankan Real Estate and Development sector was concerned, it was observed that no empirical studies had been undertaken to explore the way to adopt the concept of teamwork to enhance effectiveness of FM practice. This study, thus, was mainly focused on requirements of teamwork in FM.

The aim of this study was to explore the nature of teamwork in FM in Sri Lankan Real Estate and Development sector. The results indicated that the concept of FM team heavily deviate from the fixed concept of a generic team. A FM team has several permanent members and few variable members as well. These variable members depend on the task, its performance method and the facility in which they operate. The requirements of teamwork in FM are similar to the generic requirements of teamwork, but with apparent deviations. However, as a whole, it can be concluded that the concept of team or teamwork is not yet largely adapted in the context of FM in Sri Lankan Real Estate and Development sector. Though every member involved in FM understands and agrees that teamwork is an essential for FM practice, empirical results suggest that FM is more of a group of people who work together than an effective team.

Based on the findings, the following guide can be suggested for teamwork in FM in Sri Lankan Real Estate and Development sector.

Guide for Teamwork in FM in Sri Lankan Real Estate and Development Sector

Step 1: Study the Task
FM should first study task in terms of it's nature, scope, skills and expertise requisition and time, quality and cost constrains

Step 2: Job Design

The assigned task should next be designed in advance getting all member participation/contribution. There the most suitable method of performance shall be decided upon.

Then the team should be formed based on task, facility size and type and the method of performance

Step 3: Set Roles and Goals
Roles in the FM team shall be clarified to the team members. Responsibilities should be assigned and authorities should be laid down properly so there would be no confusions about the roles.
Goals should be clarified goals to each member of the team. - Every member should have a clear idea of the common goal, the individual goals and the time, quality and cost constrains of each goal

Step 4: Appoint Leader
Leader of the team should be appointed according to the task undertaken, required skills and expertise. However, the authority of coordination shall be kept with the Facilities Manager.

Step 5: Facilitate
Team should be facilitated in terms of financial and other resources, top management support, recognition and reward.

Step6: Follow-up the Work of FM Team
Before the commencement of each FM project, the task should be briefed to entire team. Conduct periodic progress review meetings is advisable. Evaluating individual performance as well as the team performance and sharing results and celebrating success are also essential.

This guide can be recommended to be followed in order to achieve effectiveness in FM as a team. But it should be taken in to consideration that the generalisation of the study is limited to the FM in Sri Lankan Real Estate and Development sector. Further, as all the three selected cases' procurement method of FM was in-house FM. Hence, the guide developed is mainly applicable to in-house FM in Sri Lankan Real Estate and Development sector. Moreover, as FM is still a new profession to Sri Lanka, the researcher was unable to study the research problem deeply within the empirical settings. In order to encourage and broaden research on this subject more case studies on different context are required. Further, the nature of FM team in a broader context and requirements of teamwork based on its impact could be considered as future research areas arising from this study.

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THE USE OF ALTERNATIVE BUILDING MATERIALS IN DEVELOPING COUNTRIES: ADDRESSING CHALLENGES FACED BY STAKEHOLDERS

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ABSTRACT

The rising concern on inefficient wood consumption associated with shelter development has led to policy and regulatory reforms to address such problems in most countries in recent years. The use of alternative building materials (ABMs) and technology, for example, have been proposed by decision makers as one of the ways of curbing deforestation hence promoting sustainable development. Although the use of alternative materials has enhanced housing stocks where these are appropriately employed, there are several problems faced by developers to embrace the proposed strategies more particular in developing countries. Focusing on the Sub Sahara Africa (SSA), this paper proposes strategies the decision makers would employ to promote the use of ABMs. In this paper, which is based on the extensive literature review of an ongoing academic research to find ways for promoting sustainability in developing countries, it is noted that cost of raw materials, flaw of sustainability definition as well as the lack of information related to the building sector are some of the limitations for building stakeholders to promote the use of ABMs. Therefore, the course of actions proposed is regarded as one of the possible ways for decision makers to take into consideration to improve the current situation in the building sector in SSA and beyond.

Keywords: *Alternative Building Materials, Building Challenges, Building Stakeholders, Developing Countries, Policy Strategies.*

1. INTRODUCTION

The increasing demand for wood for housing construction is considered to contribute severely to the adverse environmental effects attributed to the building sector in most countries. Although the effects vary from one country to the other, (Alam and Starr, 2009; Duguma and Hager, 2010) policy strategies and regulatory reforms have been proposed to encounter such problems in most developing countries. In Sub-Saharan Africa (SSA) particularly building developers and designers are encouraged to switch from the use of conventional clay burnt bricks to alternative building materials in order to minimise the inefficient wood consumption particularly for brick making (e.g. GoM, 2004).

The use of alternative building materials (ABM) has been advocated by the United Nations Commission for Human Settlement (UNCHS, 1993) since the early 1990s. Apart from the curbing of deforestation, the use of ABM is also considered as a means of enhancing the housing stock for low-income populations by using local and affordable materials and methods. However, the concept has highly been criticised by previous authors for a number of reasons. For instance, it is considered to have contradictory aims according to Myers (1999). That is, considering that most of the low income communities rely on the existing resources that also need to be protected this appears to be contradictory aims as highlighted by Myers (1999). Furthermore, the structures built of the ABMs are considered as structurally poor in terms of durability due to the lack of technological knowhow during material manufacturing or house construction process (Wells, 1993a; Wells *et al.*, 1998b). Although highly criticised in the early 1990's by several researchers for example, Wells, (1993b), the UNCHS strategies have highly been supported and promoted in a number of countries such as Kenya (Syagga, 1993). Furthermore, the need for the use of ABMs continues to rise with the housing demand in most countries. Consequently, the use of ABMs is gaining more favour as most of the problems highlighted earlier are being addressed through research and development.

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Among the several studies in the literature, Venkatarama (2007a and b) illustrate how the improvement in the shear stress and bonding strength of stabilised soil-cement blocks (SSBs) makes the SSBs suitable ABMs for the Indian context. Similar studies have also been conducted in several other parts (for example in Venezuela (Acosta, 2000) and Mozambique (Kuchena and Usiri, 2009). Consequently, as the improvements enhance the performance of the ABMs and methods this will also contribute to improving both quality and quantity of urban housing although other factor as those highlighted by Keivani and Werna (2001) and Lizarralde (2011) also need to be taken into consideration. Despite the improvements, most of which are technically oriented, building designers, developers and clients are still facing several challenges to embrace the proposed strategies.

This paper is based on an extensive literature review of an on-going academic research to explore ways of promoting sustainable construction in developing countries. Focussing on the SSA, the paper has three major objectives: (a) to establish the contributing factors to changes in building materials in order to augment the decision makers' understanding on the need for promoting of the use of ABMs and technologies; (b) to analyse the major limitations faced by building stakeholders in promoting the proposed ABMs in order to establish ways for addressing them; and (c) to recommend the course of action for the decision makers and other stakeholders to consider in addressing the existing challenges of sustainable construction in developing countries.

2. CHANGES IN BUILDING MATERIALS FOR URBAN HOUSING IN DEVELOPING COUNTRIES

2.1. OVERVIEW

The building sector has undergone a radical change in the type of building materials and methods used for urban dwellings over the past few decades in most countries. Alternative building materials are increasingly being employed to replace the conventional and traditional building materials. In some parts, though not widely common, earth based materials are modified with plant residues or animal dung to improve the durability and the architectural aesthetics. Depending on the local resources available and the level of affordability of the residents, industrialised ABMs such as cement and lime are also being widely employed. In most Sub Sahara Africa (SSA) precisely, earth, wattle and grass are being substituted by the conventional materials such as burnt bricks and metal sheets for walls and roofs respectively. Table 1 lists examples of materials classified for the purpose of this study. However, these will vary widely from one country to the other alongside with the factors contributing to the changes.

Table 1: Building Materials Classification
(Sources: NSO,1998, GoM, 2004 and Venkatarama Reddy, 2007)

Material classification	Masonry materials	Roofing materials
Traditional	Daub, mud blocks, rammed earth	Wattle and grass
Conventional	Burnt bricks, asbestos, cement blocks,	Metal sheets (galvanised iron sheets)
Alternative materials	Cement rammed earth, stabilised soil-cement blocks, waste recycled materials etc.	Cement roofing tiles

2.2. PRECEDING STUDIES ON CONTRIBUTING FACTORS TO CHANGES IN BUILDING MATERIALS

According to the existing literature, the scarcity of the traditional resources, international organisations' involvement, durability of the materials as well as policy and regulatory reforms are some of the main contributing factors to the changes in the building material types in most developing countries. In terms of scarcity of materials, Wells *et al.* (1998b) for instance, found that the increased distance from sources of traditional building materials such as poles fuelled the use of conventional materials for urban housing development in Dar es Salaam, Tanzania. Similar findings are also demonstrated in studies conducted in other parts of the SSA such as Mali (Wells *et al.*, 1998a), Ethiopia (Duguma and Hager, 2010). However, in other parts this has been due to the government initiated programmes. For instance in Ethiopia, the government's idea to ban the use of endangered wood species sourced from forest reserves since the 1990s has contributed to the scarcity of wood for housing construction hence affecting the quality of wood currently used for housing construction. In Egypt on the contrary, it was observed that the scarcity of good soil for red brick manufacturing was due to the construction of Aswan dam leading to the loss of the traditional raw material brought about from the Nile river hence contributing to the change in the type of building materials to cement, lime and gypsum based materials (Farag, 2004). Therefore, as suggested by Duguma and Hager (2010) the use of ABMs would solve such problems in respective countries.

Although some materials are always available, they are evaded due to their low durability and poor aesthetics hence contributing to the on-going changes. Earth for example, which is being promoted in other developed countries parts due to its low embodied energy, is regarded as a materials suitable for low-income societies who can hardly afford other options on the market. In Ghana for instance, laterite is regarded as a '*rural-ish'* material and not suitable for modern housing construction (UN-HABITAT, 2011a). Consequently, these traditional, affordable and resource efficient materials, which are shirked for urban housing construction, are losing popularity despite the several attempts being made to promote them (Hadjri *et al.*, 2007).

The changes are also exacerbated by the increasing knowledge on technical aspects as well as the health and safety issues related to various locally used materials. For example, due to the earth's poor structural strength against earthquakes, the Malawi Bureau of Standards (UN-HABITAT 2010), as it is also the case in Zambia (Hadjri *et al.*, 2007) do not recommend earth as suitable material for urban structures' development. Consequently, if such materials are to e used, this is based on the local assemblies' discretion when scrutinising the plans submitted for planning approval (Hadjri *et al.*, 2007). Furthermore, the widening of knowledge, as a consequence of globalisation has also contributed to the exploitation of foreign designs as well as building materials. As observed in Ghana, the use of imported materials by both local and foreign developers is contributing to the rapid change in the types of materials used for urban areas (UN-HABITAT, 2011a). Interestingly, the increase in knowledge also enables the developers to evaluate the best sources from where materials can be obtained hence improving the quality of materials even further (Ibid 2011a). Apparently, some imported building materials are purchased at a reasonable price compared to the locally manufactured counterparts. Therefore the changes towards imported materials will be the norm in countries like Ghana as long as the economic climate mostly based on the previous regulatory reforms continues to be favourable.

As noted previously, the role of the reforms in changes of building materials could be in twofold: that is, market liberalisation or policy and regulatory review. As noted by Wells and Wall (2003) in a study conducted in Tanzania and Kenya, market reforms enabled the small entrepreneurs to manufacture and supply building materials in urban areas. In this industry, which was originally dominated by large companies, the stone and timber artisans were able to produce the materials locally hence following the liberation of markets. The market liberalisation therefore, has led to price increase following the removal of subsidies for purchasing such items according to Wells (2003) hence encourage developers to use alternative modern materials. Beside the promotion of the small scale manufacturing of materials, the market liberation also has promoted the public and private partnerships in material supply as observed by Mlinga and Wells (2002) in another study conducted in Tanzania in 1999/2000. On the other hand, the policy reforms have led to the review of the old legislations and formulation of new policy strategies to encourage building developers to use resource efficient building materials. This is considered as one of the ways of increasing quantity of affordable housing for the low-income populations while minimising the use of scarce resources particularly where wood is used as fuel for brick making. However, follow-up studies are needed in this area to validate the changes with regard to the market and regulatory reforms.

Finally, the changes in building materials are also due to the international development organisations' concern on resource use as discussed below. Embraced by the international Non-Governmental and Community Based Organisations (NGOs, CBOs), the strategies have also contributed to the changes in building material types in most countries particularly the ABMs.

2.3. THE CALL TO USE OF ALTERNATIVE BUILDING MATERIALS

Since the past few decades, there has been a rising concern over the inefficient use of resources for building construction in most countries leading to the need for the use ABMs. In the Sub-Saharan Africa (SSA) in particular, the increasing demand for wood for housing construction is considered to contribute so severely to the adverse environmental effects attributed to the building sector. Apart from land degradation (Alam and Starr, 2009), the excessive use of wood and forest resources is considered to contribute to the effects of climate change although very little is so far known on the extent of the contribution. However, a number of efforts are being made to promote the use of ABMs.

The United Nations Commission on Human Settlements' report for instance, emphasised the need to promote 'appropriate technology' in the construction industry in developing countries (UNCHS, 1993) as one of the ways of promoting sustainable construction. The strategies aim to employ simple building blocks manufacturing technology which will not only reduce the building costs but also curb the environmental effects. Subsequently, policy and regulatory strategies have been made by decision makers in most countries based on the international proposals to promote sustainable development since the early 1990s. In Malawi for example, regulatory and policy strategies are in place as one of the ways of curbing deforestation as well as the effects of climate change. Section five of the Malawi National Environmental Policy (NEP) (1996), which was formulated based on the 1994 National Environmental Action Plan (NEAP) and the 1996 Environmental Management Act, highlights the policy objectives, principles and strategies for various sectors to adhere to in reducing fuel wood consumption and promote the use of renewable energy (GoM, 2004). Section 5.6 precisely, emphasises on minimising the use of petroleum fuels, in order to promote the renewable and energy saving technologies, to reduce the emission of green-house gases and minimise the dependency on fuel wood (GoM, 2004). Focussing on the building sector, Section 5.7 aims to promote *the "development of industries that are based on domestic raw materials and use of technology that is appropriate for the local environment"* (section 5.7.4, GoM, 2004). *It also encourages the "use of cement blocks in order to decrease use of burnt bricks to curb deforestation"* (section 5.7.10, GoM, 2004). In other words, the NEP urges the building designers and developers to switch from the conventional brick making to the use of options such as the stabilised cement blocks, concrete solid or hollow blocks and earth (adobe). Therefore, in order to meet the decision makers' set strategies, developers are required to comply with the recommended materials despite the problems associated with them.



Figure 1: Example of Alternative Building Material and the Related Structures: Stabilised Soil-Cement Blocks for Mass Housing Projects in Malawi (Photos by EC Mpakati Gama, May 2011)

Interestingly, the concept of ABMs commonly termed as appropriate technology, has highly been criticised by previous authors. It is not surprising though because according to Bhalla (1979), introduction of concepts in a society can be perceived in a number of ways. These include *"rejection of the concept, acceptance of the idea in principle, active involvement in knowledge and the willingness to apply"*. Myers (1999) for instance, considers the proposals made to have contradictory aims. That is, while the use ABMs aims to promote locally (natural) available resources and to enhance the inefficient consumption of the natural resources, it also aims to protect the excessive use of such resources on which most of the low income communities rely in most developing countries. Consequently, the balance to protect the resources and also utilise them for is not easy to achieve by many. In addition to that, Wells (1993a) also denotes that due to the use of manufactured raw materials in the production of most of the ABMs, this tends to reduce affordability of the materials by most of the intended groups. Consequently, the outcomes are more beneficial to the wider economy than the individual developers as previously noted by Wells (1993a) in a study conducted to assess the economic implications of the use of alternative technologies in Kenya and Senegal. Furthermore, the lack of durability due to their poor performance exacerbated by lack of technical expertise also contributed to the critics associated with the ABMs based on the studies conducted previously by Wells *et al.* (1998b) among others.

Despite the critics, alternative building materials for sustainable construction appear to enhance the building stocks where these are appropriately employed although the literature is almost silent on the quantities due to variation of materials being used. The use of ABMs is also considered as a way of curbing the environmental impacts attributed to the building sector although there are few empirical studies demonstrating the extent of environmental attributes associated with the building sector particularly in the SSA as previously elaborated by Mpakati-Gama *et al.* (2011). As discussed earlier on, several improvements have been made in materials such as the SSBs as presented in several studies such those conducted in India (Venkatarama Reddy (2007a and 2007b), Mozambique (Kuchena and Usiri, 2009) and Venezuela (Acosta, 2000) among others. However, there still several problems beyond structural failure associated with the use of ABM in most developing countries.

3. CHALLENGES FACED BY BUILDING DEVELOPERS TO EMBRACE ABM

Although there are several challenges highlighted in the literature with regard to the use of ABMs, a few of these are discussed here. However, attempts have been made to focus on the economic, technological and institutional factors affecting the building stakeholders in most developing countries.

One of the major hindrances to the use of alternative building materials is the rising cost of ABM or the raw materials for producing them. Taking cement as an example, which is commonly used for the production of ABMs, its costs are mainly associated with a number of factors. However, they vary from one country to the other hence cannot be generalised. In Malawi for instance, cement costs are associated with the high manufacturing costs due to the use of imported raw materials (U.S. Geological Survey, 2011). Transportation of raw materials as well as the finished product also contributes to the rising costs. While the two main cement companies continue to find ways to promote the production of locally found raw materials to reduce the production costs, hence promote affordability, cement prices continue to be relatively high due to low market competition in the country. This is also exacerbated by fuel scarcity affecting both production and transportation of cement in the country (UN-HABITAT, 2010) as it is also the case in other developing countries such as Nepal (UNHABITAT, 2011b). On the contrary, in Tunisia, where the manufacturing companies are able to produce adequate raw materials as well as cement to meet the national requirements, inflation is a major contributing factor to the rising costs of cement (UN-HABITAT, 2011c). Beside these factors, there are other hidden costs associated with the equipment used for material production as well as the maintenance costs in most countries (Syagga, 1993). Although some costs are reduced as the technology becomes widely spread and also taking the economies of scale in consideration, the ABMs remain unaffordable by most of the targeted groups. Hitherto, the use of ABMs, particularly those involving manufactured raw materials is regarded as one of the best options due to lack of other best suitable and affordable alternatives in most SSA countries. However, affordability remains one of the major challenges beyond the developers' control.

Besides cost, the lack of technical knowhow for the manufacturing and use of the new technologies also limits the probability f their usage by building professionals and developers. This is usually contributed by the lack of information dissemination in the use of such materials. In most SSA countries, where the small entrepreneurs and informal sectors dominate in housing development, most developers are not fully knowledgeable of the specifications of the ABM leading to poor performance of the finished products (UN-HABITAT, 2010, 2011a). On the contrary, where information exists, most of it is based on the imported technology. Consequently, where these are not compatible with the local construction climatic and physical conditions let alone building specifications, poor performance of the ABMs will always result as previously noted by Bhalla (1979). Some researchers such as Acosta (2000) suggested the need for locally based studies to suit the local building characteristics which will also augment the professionals and developers' understanding on the need for promoting ABMs.

Policy implementation failure is another major challenge faced by the building designers and stakeholders. As highlighted in previous studies (Mpakati-Gama *et al.*, 2011) policies, regulations and economic measures are commonly used as conventional tools for environmental monitoring in most SSA countries. However, these measures suffer severe limitations hence they are considered as not appropriate for promoting sustainable construction (Halliday, 2008). The major limitations of the frameworks, most of which are interrelated, include the lack of measurable targets, the poor structuring to suit local conditions and the use of flawed of data on which the strategies are based. Poor structuring of the policy strategies also provides loopholes for misinterpretation of the formulated policies hence encouraging the community's use of inappropriate alternative measures as commented in the Malawi National Environmental Action Plan (GoM, 1994). Interestingly, Ebohon and Rwelamila (2001) commented that poorly structured strategies are sometimes a result of the superimposed proposals most of which are influenced by other interested parties. This therefore, results in disintegration between the proposed policies and the local agenda. Although frequent restructuring could be one of the ways to improve the performance of such policies, Halliday (2008) highlights that such improvements are not always effective even in developed countries such as the UK. However, other authors suggest that the combination of the local and foreign policies, could encounter such problems (Urge-Vorsatz *et al.*, 2007; Liso *et al.*, 2007). Nevertheless, this will also depend on several other factors affecting the building sector as a whole in the country in question. Moreover, the policy related challenges affecting developers and designers' capability to embrace the use of ABMs include the lack of institutional capacity for the implementation of the policy strategies as observed in countries like Ghana and Malawi (Matope, 2000; UN-HABITAT, 2011a). This, therefore result in the lack of law enforcement where the regulations and policies are in place. On the contrary, the decision makers use their own discretion on what to give their priority to especially where enforcement of the policies leads to the draining government resources as highlighted by Tisdell (2005) and Shen (2006). That is, decision makers may deliberately overlook some proposals made especially where the financial implications or political interference outweigh the need for environmental conservation as denoted by Myers (1999) in a study conducted in Tanzania. In short, where regulations are in place but not respected or where the use of outdated National Building Regulations or even where they do not exist, the pose challenges to building stakeholders to promote the use of ABMs in most countries.

In addition to the flawed regulatory and policy frameworks, the lack of adequate information on environmental effects leads to flaw of motivation for developers to promote the use of ABMs. So far, there are a few studies conducted in most SSA countries on the extent of contribution the construction industry makes particularly with respect to deforestation. In Malawi for example, regulatory and policy strategies are in place forth the building sectors to comply with as one of the ways of curbing deforestation as well as the effects of climate change. Thus although the NEP urges the building designers and developers to switch from the conventional brick making to the use of options such as the stabilised cement blocks, concrete solid or hollow blocks and earth (adobe) it appears that there is not adequate information on which the proposals are based. For instance, apart from the preliminary study by Zingano (2005), little has been done to investigate the extent of the building industries' contribution to deforestation in terms of wood quantity, the type of wood utilised, and where the wood is sourced in order to justify the need for the use of ABM. On the other hand, the proposed alternatives such as those using cement are also associated with environmental effects which need to be evaluated. Therefore, by only focussing on one environmental aspect, this only leads to the shift from one environmental problem to the other as discussed in previous studies (e.g. Mpakati-Gama, *et al.*, 2011). Consequently, the absence of such guiding principles leads to inconsistency of laws used by the local councils in encouraging developers to embrace the use of ABMs. As a result, the building stakeholders are often in a dilemma on what standards to follow (UN-HABITAT, 2011a) more especially with the recent poorly defined concept of sustainability.

As the notion of sustainability continues to be an important factor for consideration in carrying out building development works in the 21st century, the concept also appears to be a hindrance to the promotion of the sustainable construction which includes the use of ABMs. The flawed definition of sustainability is one of the major contributing factors. The literature contains critics of the term which is often used to qualify other nouns making other more complex terms not easy to define. Du Plessis (2007), for example considers the term 'sustainable construction', is based on words that already complex to define. Therefore, it is even more difficult to understand the new phrase if it is not properly defined.

Although often embraced by decision makers when promoting the use of ABMs, the concept is ambiguous to the building designers and developers as it requires a thorough clarification within a specific context. Secondly, the contradicting aims and expected results of sustainability lead to poor understanding of the developers to embrace ABMs. For instance, the sustainable construction aims to promote the use of local materials which are considered as affordable by most individuals for housing development. Yet most of such materials are also considered to have very significant damage to the environment according to previous authors such as Myers (1999). Considering that there is a lack of measurable targets of sustainability at both the global and local settings this also contributes to the hindrances for the building stakeholders to embrace the proposed ABM in deferent countries.

In summary, although there are well established regulations and policies established in some countries, the presence of these and other challenges based on individual countries, it is not uncommon for developers to revert to the use of conventional materials. Therefore, some projects are abandoned before completion yet some of those completed, do not deliver the intended outcomes due to the challenges faced at design stage or at construction stage as the proposed use of ABMs are not favoured by many. Although several examples exist, most of them are not recorded in the literature hence there is need for further inquiry in this area based on individual country practices. However, a few recommendations made here provide the basis for further enquiry to promote the use of ABMs in developing countries, particularly the SSA.

4. Recommended Course of Action to Promote the Use of ABMs

In previous sections, the major contributing factors leading to the rising need for the use of ABMs and the challenges faced by developers in embracing ABMs in developing countries have been discussed based on the existing literature. This section highlights policy implications recommended for decision makers and the building stakeholders to take into consideration as some of the ways for addressing sustainable construction by promoting the use of ABMs.

Considering that most of the ABMs being promoted so far are cement based, though not affordable by the majority, one of the recommendations is to encourage researchers to come up with a wider range of ABMs from which developers can select the best options to use. Apart from earth, which neither meet the developers' aesthetical requirements nor the building specifications in most countries (UN-HABITAT, 2010; Hadjri *et al.*, 2007; UN-HABITAT, 2011a), there are several other opportunities to develop a variety of affordable ABMs. For instance, farm residues such as animal dung or plant husks (e.g. rice husks, groundnut shell and rice wheat straw) which are used to improve the structural strength of the earth based masonry materials, are considered as affordable and durable in other developing countries such as India (Pappu *et al.*, 2007) and a few parts of the SSA (Wells, 1995). However, this requires a sustainable supply of raw materials which could be a problem in most SSA countries where agricultural annual outputs vary significantly due to the effects of climate change. Nevertheless, other options highlighted in the literature include the use of solid and industrial waste as demonstrated by Pappu *et al.* (2007) and Singh (2007) among other researchers. Basically, further research is needed to utilise locally available resources which will not be able to meet the appropriate standards but are also sustainable. Therefore, these will not only provide better skills in promoting use of indigenous materials but also minimise the potential secondary environmental aspects.

Thus, the second recommendation is to urge the researchers to compile locally based environmental aspects of various materials for objective selection of ABMs to avoid shifting from one environmental impact to the other. As the different alternatives exist, further empirical research will also be needed to ensure the most suitable and affordable alternative ways are being promoted. Furthermore, the studies would need to include the indicators for sustainability based on a wider range of parameters as suggested by Singh (2007). For future prediction of sustainability indicators, further research would be ideal to evaluate environmental issues over the life span of the building materials in question. Moreover, health, aesthetical and safety issues as well as the economic aspects of ABM also need to be identified, addressed and revisited from time to time to encourage the developers' involvement in their usage. By involving the building stakeholders, at differs stages of the ABMs development process, it is expected that they will be more knowledgeable of the basis for their selection of materials at design and construction stages as appropriate. Therefore, with such information in place, appropriate policy strategies can be put in place although frequent revisions need to be encouraged relative to changes in local and global development challenges. It should be noted though that, it requires various stakeholders to contribute to these proposals although the building professionals need to take a leading role to get them established while policy makers need to promote the implementation.

Finally, monitoring and evaluation of projects previously undertaken is also required to ensure that appropriate standards are not only recommended but also used accordingly. However, project based assessments need to be prioritised in order to ensure appropriate materials and technologies are used as suggested by previous authors (e.g. Acosta, 2000). The learning institutions which will also act as a way of knowledge dissemination related to the use of alternative building materials to new professionals would contribute effectively in such developments. Accordingly, reference manuals can be developed and compiled by the building researchers alongside with the public and private sectors in the building industry. In short, it is a requirement for different sectors to work together to enhance the availability of such information vital for policy makers to determine the proper direction on how to tackle the environmental related issues attributed by the built environment whilst promoting the building stakeholders' participation. It is pitiable though that few empirical studies exist in this area due to inadequate financial support for evaluating the proposed projects. This therefore leads to low motivation for building professionals to pursue further application of ABMs for future projects. In contrast, several recommendations have been made by previous researchers yet only a few are addressed by decision makers as well as the international communities in supporting the efforts to promote further research and development for ABMs.

5. CONCLUSIONS

The rising concern on inefficient use of natural resources has led to policy and regulatory reforms to address the problems in recent years. In most developing countries, further changes in the type of building materials are being made not only to address the environmental related issues but also to meet the rising shelter need. Although it is not easy to predict the direction of the type of materials for future housing development, several efforts are required by to encourage the building stakeholders to employ the ABMs. It is therefore, expected that the use of simple manufacturing technology for building blocks production will not only reduce the building costs but also curb the environmental effects associated with similar materials produced using high technological processes. This work, which is based on an on-going academic research to find ways for promoting environmental sustainability in the building industry in Sub Sahara Africa, exhibits some of the challenges faced by building stakeholders in their efforts to embrace the use of ABMs.

Although the inefficient use of wood fuel is inevitable in most SSA countries a few studies demonstrate the associated environmental effects. One of the reasons is that such projects do not only require studies at a wider scale but also have financial implications that require political intervention hence avoided by decision makers. Interestingly, despite the little evidence on the construction industry's contribution to adverse environmental impacts, a number of government driven strategies as discussed earlier are put in place as possible ways to minimise them. Consequently, the ABMs are considered to contribute to the reduction of wood fuel consumption attributed to the construction industry if fervently employed. However, apart from the policy strategies proposed in various countries to enhance the use of alternative building materials (ABMs) and technology, decision makers need to address the other several problems faced by the building stakeholders in embracing the proposed strategies.

Based on the extensive pertinent literature of the study being undertaken, it is noted that only if the policy makers are able to intervene on the high costs of raw materials required for making the BMs, it is not easy for the developers to switch from the use of conventional materials to the proposals made. In addition, the misleading concept of sustainability and the flaw of knowledge with regard to building related environmental effects require further clarification through research and development to augment the building stakeholders' knowledge and understanding on the need to promote the use of ABMs. Otherwise, the promotion of sustainable construction through policy and regulatory frameworks appears to be rhetoric in most developing countries.

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INVESTIGATION OF BIM ADOPTION STRATEGIES IN INDIAN AEC INDUSTRY

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ABSTRACT

Building Information Modelling (BIM) is the process of creating digital parametric models for life cycle data management. Use of parametric modelling tools enables in integrating the building data from various stakeholders, on a virtual platform. On large-scale building projects with numerous stakeholders, a well-drafted strategy for BIM adoption becomes essential. This can be attributed to the complexity in the information exchange process between the various stakeholders. This paper focuses on investigating the strategies for BIM adoption in the Indian Architecture, Engineering and Construction (AEC) industry. What are the typical BIM goals on a project? What strategies can lead to effective BIM adoption? These are questions that this paper seeks to address. Case based investigation was carried out in three commercial building projects of comparable scale. A detailed investigation of the cases was carried out through interviews with the various stakeholders and documentation of the BIM adoption process. Case data were analysed to identify the strategies commonly adopted on projects. Further analysis enabled in developing a framework for BIM adoption strategies in the Indian AEC industry.

Keywords: *Building Information Modelling (BIM), BIM Adoption, BIM Goals, Strategy.*

1. INTRODUCTION

The exchange of information between participants on building projects is a complex process, particularly on large-scale commercial projects. Building Information Modeling (BIM), the process of creating digital parametric models of the building, integrates information on a virtual platform and hence eases such information exchange necessities between the various participants.(Eastman *et al.*, 2008; Smith, 2007) However, the use of BIM models and the process of creating the same varies across projects (Dossick and Neff, 2010). Why do BIM adoption processes vary from one project to another? What are the parameters to be considered while developing a BIM adoption strategy? These are some of the questions that this paper intends to address.

The objective of this paper is to investigate why the BIM adoption process varies across projects. This includes identification of the parameters that are to be considered while developing a BIM adoption strategy on Architecture, Engineering and Construction (AEC) projects. The scope of the work is limited to commercial building projects in the Indian industry.

2. BUILDING INFORMATION MODELLING

Building Information Modelling entails the development of integrated, parametric models of buildings. The process of developing BIM enables better design integration, constructability review, co-ordination for construction, building performance analysis and also facility management (Eastman *et al.*, 2008). Building Information Models (BIMs) are 3D parametric, virtual representations of the built environment. These models are capable of representing specific details to facilitate extended analysis as needed ahead of construction (Mulva and Tisdel, 2007).

One of the greatest advantages of BIM is the fact that all the information related to a project can be contained in, or linked to the virtual model of the building (Kymmell, 2008). In other words, Building Information Models function as repositories of project information, from design through construction to

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operations. It follows that BIM models can be built in a variety of ways and can be used for different purposes throughout the project lifecycle (Ning and London, 2010). One of the fundamental requisites of an organisation intending to adopt BIM is the definition of project-specific BIM-goals. BIM goals are a subset of the entire range of BIM uses that an organisation intends to pursue, depending on the project's needs.

Through an extensive literature review, we have identified the following as some of the most common BIM uses on a typical construction project, across the different phases of the project, shown in Table 1 below.

Table 1: Common BIM Uses on AEC Projects across Project Life-Cycle

DESIGN	**CONSTRUCTION**	**OPERATIONS**
Compare and analyse different design alternatives (Kymmell, 2008)	Replacement of fabrication shop drawings by 3D model (Gilligan and Kunz, 2007)	Generate "as-built" models (Manning and Messner, 2008)
Generate 2D drawings (Gilligan and Kunz, 2007)	Automated Quantity Take-offs (Brandon and Kocaturk, 2008)	Repair strategy development (Brandon and Kocaturk, 2008)
Visualisation/ walkthrough (Kymmell, 2008)	Cost tracking (cash flow analysis) (Kymmell, 2008)	
Clash detection/ design coordination (Gilligan and Kunz, 2007)	3D analysis of safety issues (Sulankivi *et al.*, 2009)	
Constructability analysis (Kymmell, 2008)	Installation procedures at congested areas (Brandon and Kocaturk, 2008)	
Cost analysis and estimation (5D) (Kymmell, 2008)	Analysis of construction sequences (Khanzode *et al.*, 2008)	
Construction schedule modelling (4D) (Brandon and Kocaturk, 2008;)	Purpose built models for specific problem solving (Kymmell, 2008)	
Energy/performance analysis (Eastman *et al.*, 2008)	Optimisation of crew(s) productivity (Gilligan and Kunz, 2007)	
Linking of methods statement to model (Brandon and Kocaturk, 2008)	Construction mobilisation procurement (Khanzode *et al.*, 2008)	
Planning of construction sequences (Eastman *et al.*, 2008)		
Resolution of coordination issues during regular coordination meetings (enhanced visualisation) (Khanzode, 2010)		

This paper intends to investigate how these BIM goals are achieved in various building projects.

3. RESEARCH DESIGN

We set out to investigate three commercial building projects of comparable scales, in order to ensure similar levels of complexity in the planning and design phases. Another important criterion for case study selection was that the projects must adopt BIM. A qualitative research methodology was adopted to explore the BIM adoption process on each of these projects (Scott, 1965). Case data was collected through unstructured interviews and through participatory observation. Unstructured interviews along a predetermined line of enquiry were conducted with each project participant. Participatory observation of the BIM adoption process was a major source of data that aided in the identification of parameters that affect the BIM adoption strategies on AEC projects. Standard axial and open coding techniques were used to analyse our data (Strauss and Corbin, 1988).

4. DATA COLLECTION – CASE STUDIES

4.1. CASE STUDY 1

The first case - an eight storied office building - was a traditional Design-Bid-Build project. Mechanical, Electrical and Plumbing (MEP) coordination in this particular case was very complex due to the number of service systems involved and the corresponding number of participants. This complexity motivated the use of BIM (Simonian *et al.*, 2008). The sole BIM goal on this project was MEP coordination.

We participated and observed the MEP coordination of above false ceiling works as a "fly on the wall" (Mahalingam and Levitt, 2007) for a period two months. The BIM adoption process was documented and participants were interviewed. Individual design consultants would develop drawings of their corresponding service systems and submit these 2D CAD drawings to the principal architect, who in this case was the MEP coordinator. Figure 1 below shows the BIM model developed for MEP coordination.

Figure 1: Integrated BIM of Above False Ceiling MEP Works

Following an integration of all the individual models developed, the architect identified problems that could be broadly classified under three categories namely, lack of adequate details, clashes between components and changes (in scope, specifications or system type). The identified problems were resolved during a coordination meeting.

Typically, the BIM model was projected, and the consultants were able to "see" the exact location of the problem. Although, the initial BIM goal was clash detection of MEP, it extended to enhanced visualisation for problem resolution as well.

4.2. CASE STUDY 2

Our second case - a multi-use retail facility - was a Design-Build project. In the case of a Design-Build project, design and construction are parallel activities. The EPC contractor decided to use BIM tools primarily for constructability review, apart from other uses. The BIM goals of the project included,

i. Visualisation / Client walkthroughs
ii. Clash detection / Design coordination
iii. Visualisation for regular coordination meetings
iv. Generating 2D drawings
v. Quantity take-offs for cost estimation

In this case, the BIM adoption was driven top-down. A co-located meeting space was part of the management's BIM agenda. As has been suggested in the literature, the primary purpose of this space was, to explore the potential of such a space to empower individual team members to communicate their design ideas to the rest of the team (Fernando, 2008).

Hence, the BIM team worked in a co-located workspace - referred to as a "workshop", meant for representatives from various disciplines to work collaboratively. Of the various BIM goals, clash detection required collaborative decision making and hence the objective of the workshop was, initially clash detection and design coordination alone. The workshop was headed by the design coordinator, assisted by one modeller from each design team. The layout of the workshop is shown in the Figure 2 below.

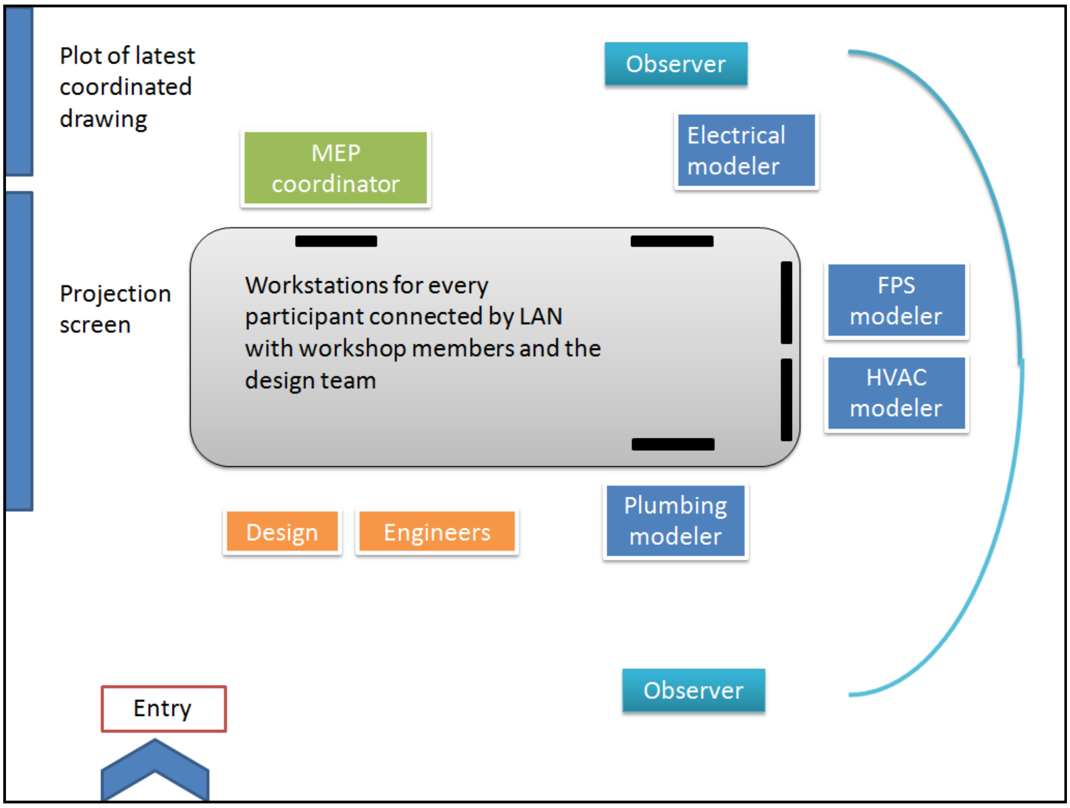

Figure 2: Co-located Workspace Layout

During the workshop, the coordinator integrated individual BIM models of each discipline, and performed an interference check. The results were reviewed, and critical clashes were projected onto a screen. Clash resolution was done either in the co-located workspace or in a coordination meeting depending on the magnitude of changes that would be required to resolve the clash. Coordination meetings were typically attended by all the chief engineers/architect. The workshop was the venue for every coordination meeting, during which, the coordinated BIM model was projected on the screen. This not only facilitated better visualisation, for the engineers/designers, but also provided scope for value engineering.

Over our three month observation period, interferences used to be resolved in such coordination meetings during the first few weeks. Progressively with time, the engineers visited the workshop frequently, suggesting changes to the modeller, wherever necessary to improve the performance of the system. After a couple of months at the workshop, the engineers realised that minor changes that would not affect the performance of the system could be done by the modellers. This resulted in saving the time lost in frequent visits to the workshop for the engineers.

The output from the workshop was the coordinated BIM model, which in turn was delivered to the construction team. 2D drawings generated from these models were issued to site, stamped as Good for Construction (GFC). The construction team utilised this model for quantity take-offs.

4.3. CASE STUDY 3

Our third case is a commercial facility in which the owner played the role of the contractor as well. Design was outsourced to various individual organisations while the construction team was in-house. The project brief was based on a specific construction methodology that involved the use of a particular type of formwork, novel to the Indian construction industry. The designs were conceived such that spaces were modular; to suit the specific needs of the formwork.

Initially the owner decided to use BIM for client presentations and modelling of architectural and structural components to check for dimensional compatibility with the formwork. This BIM goal can be broadly classified under the constructability analysis category. An in-house BIM team worked on model development of the architectural, structural and MEP components.

When MEP design was in progress, the MEP execution engineer of the construction team suggested that BIM be used for accurate modelling of the various MEP components. The dimensionally accurate coordinated BIM model, according to him, could be used by the piping and HVAC subcontractors to prefabricate and deliver in kits (Figure 3) for specific areas for a crew on site. The models were developed with a high level of detail, and hence the construction team started referring to the model for cross-checking their quantity take offs during estimation.

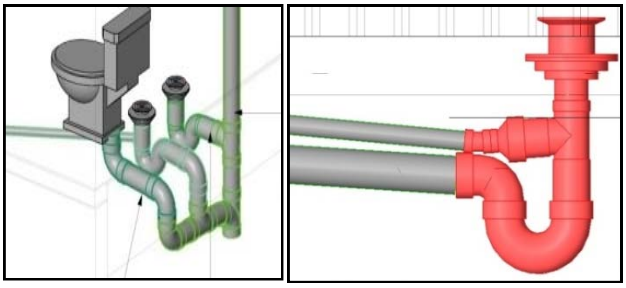

Figure 3: Example of BIM Models of Plumbing 'Kits'

While the construction team was developing the schedule they faced several hurdles, since they were unclear as to the construction methodology that was to be used for installing their new type of formwork. At this juncture, 4D simulation of the developed BIM model was resorted to, for quick review of the developed schedule. Therefore, we observed the development of a detailed BIM model that integrated structural, architectural, MEP components; took in construction related inputs, and was used for a variety of purposes throughout the design and construction lifecycle, in this case. The BIM team which was initially another department in the office slowly started becoming the nucleus of most activities in the office.

5. DISCUSSION

5.1. *COMPARISON OF CASES*

BREADTH OF BIM ADOPTION						
	DESIGN				CONSTRUCTION	
CASE 1	Clash detection/Design coordination	Generate drawings	Resoulution of coordination issues in meetings			
CASE 2	Clash detection/Design coordination	Generate drawings	Resoulution of coordination issues in meetings	Visualization	Automated QTO	
CASE 3	Clash detection/Design coordination	Generate drawings	Constructability anlaysis	Construction schedule development -4D	Automated QTO	Replacement of fabrication shop drawings by BIM model

Figure 4: Number of BIM Goals across the Three Cases

An interesting observation across the three cases was that the number of BIM goals progressively increased from one case to another, as shown in Figure 4 above. We then proceeded to investigate what factors influenced the same. Our analysis revealed that the "breadth of BIM adoption" represented by the number of BIM goals was dependent on the project structure. The project structures of each of the cases are illustrated below in Figure 5 below. The breadth clearly spanned some design goals in the first case, extended to design and construction goals in the second case, and increased to a larger set of visualisation, design and construction goals in the third case.

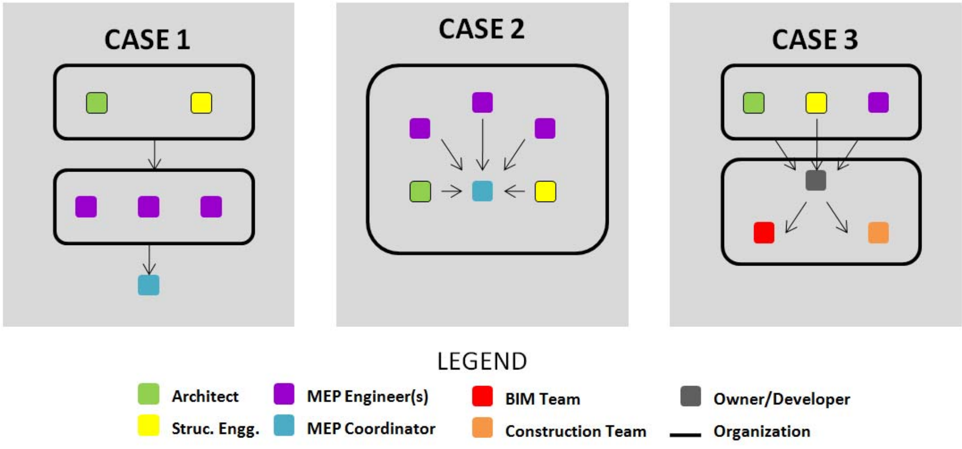

Figure 5: Project Structures of the Cases

The first case had a project structure with maximum fragmentation where participants of each engineering discipline were from a different organisation, and had the least breadth of BIM adoption. The third case had the least amount of fragmentation with the owner and the contractor being a unified entity, and had the greatest breadth of adoption. Hence, it appears that the breadth of adoption is inversely proportional to the fragmentation of the project organisation. The more integrated the contractual and project organisational structure, the greater the ability to collaborate and involve multiple trades in decision making, and consequently the greater the scope for exploring a variety of BIM applications. We thus state the following proposition:

Proposition: Integrated projects structures enable the use of BIM over a wide range of diverse BIM goals across the project lifecycle.

One of our research questions was to identify parameters that aid in achieving the BIM goals. In other words, we set out to identify factors that need to be considered while developing a BIM adoption strategy. We analysed our interview transcripts and documentation of the BIM adoption process on each of these cases to identify parameters that were considered in developing a strategy for the same. The three parameters that need to be considered while developing a BIM adoption strategy include assigning BIM roles to various participants, employing contractual innovations that specify the use of BIM and incorporating collaborative work procedures. Each of these parameters is discussed in detail in the section below.

5.2. Assigning BIM Roles to Various Participants

Kymmell (2008) identifies three primary BIM-related roles: the BIM manager, the BIM operator, and the BIM facilitator; and suggests that creation of such roles within a project organisation is necessary for successful creation and use of BIM models. Each of these three roles has specific responsibilities and skill-sets. The responsibility of the BIM manager is to plan and manage BIM processes at various levels. The BIM operator (modeller) has the skills to perform tool-related tasks. The BIM facilitator acts as an interface between the BIM team and the construction team on-site, who may not have enough skill to extract the required information from the BIM. Our investigation revealed that assigning appropriate BIM roles is significant to achieving the BIM goals on a project.

5.3. Contractual Innovations Specifying the Use of BIM

Contracts that specify the use of BIM and Integrated Project Delivery (IPD) contracts excluding litigation are examples of some possible contractual innovations that encourage BIM adoption. The IPD contract is a type of relational contract (AIA, 2007) that explicitly mandates collaboration between project participants. It is critical to ensure that contractual innovations aid in augmenting existing resources to achieve BIM goals.

5.4. INCORPORATING COLLABORATIVE WORK PROCEDURES

Collaborative procedures represent one set of organisational strategies that enhance the integration of the project team. For instance, Dossick and Neff (2010) highlight the need for communication innovations such as 'messy-talk' as a strategy to effectively adopt BIM. Regular coordination meetings that feature multiple disciplines are examples of collaborative procedures for effective BIM adoption. The BIM development team is an inevitable participant in such coordination meetings, and is either the contractor with BIM development capabilities or an external BIM consultant.

Collaborative work processes also include creative brainstorming sessions in "big rooms" and continuous co-located workspaces (Dossick and Neff, 2010; Homayouni *et al.*, 2010). Continuous co-location of a team composed of critical members sharing the same space improves access to one another, thus aiding in reducing the project latency while co-creating the BIM model, as was seen in case 2. Where continuous co-location might not be possible, one of the most efficient ways of achieving complete collaboration is to get critical participants in a "Big Room" where they brainstorm together and interact to resolve design and construction conflicts. Table 2 below compares and summarises our cases based on these parameters.

Table 2: Comparison of BIM Goals and Adoption Strategies across the Cases

	GOALS	ROLES	COLLABORATIVE PROCEDURES	CONTRACT TYPE
CASE 1	1.Clash Detection/Design Coordination 2.Generate 2D drawings 3.Resolution of coordination issues in meetings (enhanced visualisation)	MEP coordinator with additional responsibility of developing BIM models	Coordination Meetings: Periodic Coordination and Iteration	Design Bid Build
CASE 2	1.Clash Detection/Design Coordination 2.Generate 2D drawings 3.Resolution of coordination issues in meetings (enhanced visualisation) 4.Visualisation 5.Automated Quantity Take-Off	Design Coordinator: BIM manager Modeller: BIM operator	Workshop: Continuous co-location Workshop (Coordination meetings): Periodic coordination and Iteration	Design Build
CASE 3	1.Clash Detection/Design Coordination 2.Generate 2D drawings 3.Resolution of coordination issues in meetings (enhanced visualisation) 4.Visualisation 5.Automated Quantity Take-Off 6.Construction Schedule Development – 4D 7.Replacement of fabrication shop drawings by BIM	Dedicated BIM team: BIM operators, BIM managers, BIM facilitators.	BIM team: Continuous co-location	Design Build. Owner is the contractor

6. DEVELOPMENT OF A FRAMEWORK FOR BIM ADOPTION

The comparison of the cases eventually enabled us to develop a framework for BIM adoption, which is shown in Table 2 above. Our framework maps the potential BIM goals on a project against the BIM roles, contractual innovations and collaborative procedures. A cross mark on the framework indicates the set of BIM roles to be assigned, the contractual innovations required, and the collaborative procedures that need to be adopted in order to achieve a certain BIM goal. For instance, from the framework it can be inferred that to use BIM for clash detection/design coordination, one of the strategies that could be adopted is: A contract that specifies the use of BIM can be used thereby ensuring that all participants such as architect, structural engineer and MEP engineers provide respective models.

The framework was populated based on opinion from industry experts with experience in working with BIM. Using the framework, an appropriate BIM adoption strategy that suits the project structure can be resorted to, in order to achieve the project specific BIM goals.

Table 3: Framework for BIM Adoption

BIM GOALS	BIM ROLES							CONTRACTUAL INNOVATIONS		COLLABORTIVE PROCEDURES			
	BIM CONTRACTOR	ARCHITECT	STRUCTURAL ENGINEER	MEP ENGINEER	BIM MANAGER	BIM OPERATOR	BIM FACILITATOR	CONTRACTS SPECIFYING USE OF BIM	IPD CONTRACTS EXCLUDING LITIGATION	BIM CONTRACTOR	EXTERNAL BIM CONSULTANT	BIG ROOM	CONTINUOUS CO-LOCATION
DESIGN													
Compare and analyse different design alternatives		x	x	x	x	x							x
Generate drawings	x					x		x					x
Clash Detection/ Design Coordination	x	x	x	x	x	x		x	x	x	x		x
Visualisation/ Walkthrough		x				x				x			
Constructability Analysis	x		x	x	x	x			x		x		x
Construction schedule development (4D)	x				x	x		x	x	x	x		x
Cost analysis and estimation (5D)	x				x	x		x		x	x		x
Energy/Performance analysis		x		x		x		x					x
Linking of methods statement to model	x				x	x	x	x	x	x			x
CONSTRUCTION													
Resolution of coordination issues during regular construction meetings (enhanced visualisation)	x				x	x	x	x	x			x	x
Planning of construction sequences	x				x	x	x	x	x	x			x
Cost tracking (cash flow analysis)	x				x		x	x		x			
Replacement of fabrication shop drawings by 3D model	x				x	x	x	x			x		x
3D analysis of safety issues	x				x	x	x	x		x			x
Analysis of construction sequences	x				x	x	x	x	x	x			x
Installation procedures at congested areas	x					x	x	x	x	x			x
Purpose built models for specific problem solving	x				x	x		x	x		x	x	x
Construction mobilisation, procurement	x				x	x	x	x		x			x
Optimisation of crew(s) productivity	x				x		x			x			
OPERATIONS													
Generate "as-built" models	x				x	x		x	x	x	x		x
Repair strategy development	x				x	x	x			x	x		x
Emergency response planning	x				x	x	x			x	x		x

7. SUMMARY

This study has attempted to empirically investigate how BIM adoption varies across projects, and the factors that affect the same. By comparing and analysing our cases, we propose that the breadth of BIM adoption is directly proportional to the level of integration of the project structure. The exploratory study of the cases coupled with a detailed review of literature lead to the evolution of a framework for BIM adoption on various projects. The framework is a mapping of the various BIM goals and the means to effectively achieve these goals, by assigning BIM specific goals, through contractual innovations and choosing appropriate collaborative procedures. This framework would aid organisations in drafting a suitable strategy for BIM adoption. Hence, the framework needs to be coupled with forethought into the organisational and contractual structure prior to developing a BIM strategy.

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THE PURPOSE OF RETENTIONS: A REVIEW OF THE EXISTING LITERATURE

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ABSTRACT

Retention is a phenomenon practiced in the construction industry for well over a century. It is a contractual mechanism whereby a portion of money, due to the contractor/subcontractor is held back till the completion stage of the project. Half of it is released at the time of practical completion and the other half is released at the end of the defects liability or the maintenance period. Some countries have abolished this practice, others have tried to outlaw the practice but failed. Yet others seem to be content with the ongoing practice and find it useful, which is why it is important to understand as to why it is so. To achieve this objective it is first of all important to understand the 'purpose of retentions' or why are retentions used in today's construction industry even though the industry has undergone radical changes in the past century or so. A review of the current literature suggests that retentions exist for a variety of purposes. Hence there seems to exist some form of disconnect between the actual and the intended purpose of retentions. Perhaps it is important to understand whether retentions are actually serving the purpose they are set up for. In this paper the author through an extensive literature review has identified a number of purposes of retentions. Data has been collected from 27 publications including books, journal articles, magazines, reports etc. Ten main purposes/themes have been identified from the data. A matrix has then been formed with the purposes on one axis and author/publication on the other. This has been done to find out what most authors/publications have said regarding the purpose of retentions. Having found the numbers with the help of the matrix the purposes are numbered in the order of most recurring to the least recurring. The top three purposes of retentions are found to be performance security followed by defect rectification and motivation for early or timely completion.

Keywords: *Retentions, Construction Industry, Construction Contracts.*

1. INTRODUCTION

The payment mechanism of construction projects is different compared to other industries. For every payment made to a contractor or subcontractor a sum of money is held back which can vary from a low of 2% to as high as 10%. This deduction is a phenomenon peculiar to construction and is known as retention, retainage or hold back.

There have been debates and discussion on the merits and demerits of retentions (Fullerton, 2000; Abeysekera, 2003; Construction Manager, 2002). In the US the practice has been abolished (in public contracts of some states though) whereas in the UK they have tried and failed to have it abolished (House of Commons, 2002; Bausman, 2004).

Retentions are held both by the clients and the contractors. The clients hold retentions when they make payments to the contractors and the contractors when they make payments to the subcontractors. The contractor tries to achieve its profit margin by all means and it is the same case with the subcontractors. Therefore being focused on their profits contractors and subcontractors are generally seen compromising project performance. The reason for introducing retentions into construction contracts was to protect project performance. In the present day construction industry, retention is the most commonly used performance security.

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2. WHAT ARE RETENTIONS?

In its essential form, retention is a sum of money kept back from payment to a contractor or subcontractor until later in the contract (Hughes *et al.*, 1998). The accumulated money through retention is actually earned by the contractor as a part of the progress payment based on the interim valuation of the work completed. The retention is commonly between 5%-10%, of the total value of the contract, however the figure can be lower or considerably higher. It can also be ascertained differently, as it has become increasingly popular to set up retention as a fixed amount rather than a percentage (say $100,000) or to vary the absolute amount or percentage representing retention as the work progresses (Gilbreath, 1992).

The client holds on to the retention money until the completion stage of the contract. The retention sum is released once the client is reasonably assured by the architect/engineer that the project is completed as per the terms of the contract, and progress payments have been accurately prepared (Wyatt, 2003). The retention release mechanism is such that half of this is released to the main contractor once the project is certified practically complete whereas the other half is withheld until the end of the defects liability period or the maintenance period, during which the contractor must rectify any defects identified.

2.1. HISTORICAL BACKGROUND

The concept of retentions is at least as old as the Industrial Revolution (Wyatt, 2003). The original retention system began in Victorian times and was first utilised in railway construction during the 1840s. The rapid expansion of the rail network at the time created a high demand for construction labourers with an increase in the number of construction companies. Due to the increasing rate of insolvency (frequent at that time) among such construction companies and the consequent delays to building projects, the clients needed a mechanism to protect themselves and came up with a solution. The purpose of introducing retentions into construction contracts in those times was in order to be assured that there was availability of funds to help defray the cost of completion of project in case of insolvency of the contractor executing the project (Gilbreath, 1992). The practice spread to the rest of the construction industry, and until today, the retention system has become a vital part of any contract document for construction projects (House of Commons, 2002).

2.2. WHY HOLD RETENTIONS?

Retention is a phenomenon practiced in the construction industry for well over a century. It is a contractual mechanism enforced by legislation in most parts of the world. However some countries have abolished this practice finding other provisions of dealing with the risk, for which retentions exist. Others have tried to outlaw the practice but failed, yet others seem to be content with the ongoing practice and find it useful, which is why it is important to understand why it is so (Abeysekera, *et al.*, 2009). To achieve this objective it is first of all important to understand the 'purpose of retentions' or why are retentions used in today's construction industry even though the industry has undergone radical changes in the past century or so. According to Williams (2005) "given the volatile circumstances in which retainage originated, it is a historical oddity that retainage remains commonplace today when construction markets are so very different". Hence there seems to exist some form of disconnect between the actual and the intended purpose of retentions. The existing literature on retentions sets out a number of its uses; perhaps it is important to understand whether retentions are actually serving the purpose for which they were set up.

3. PURPOSE OF RETENTIONS

A review of the existing literature suggests that retentions exist for a variety of purposes. According to Champion (2005) retention provision is universally used by clients in the UK because it is understood by all. Also it provides a means of building small cash in hand fund during the course of the works which can be useful for cash flow. Using the retention provision avoids dealing with surety and it is already a part of the contract. The overriding reason Champion (2005) suggests for the use of retentions is administrative convenience. Retention terms are found in the standard forms of contract, the percentage to be withheld is set in advance and the retention amount grows subsequently by the month as part of the payment process. Interestingly no standard forms of contract define the purpose of retentions or what retentions are used for (Abeysekara, 2008). Therefore it may be contended that retentions are used only because the provisions exist in most of the standard forms of contract. This could well be a significant observation if it were demonstrable. As a conceptual rationale for use their existence as an option meaning that they should be used is very troubling.

Various authors and publications have identified a number of different purposes of retentions which have been tabulated in Table 1. All or most of the purposes stated in the table include a common element of performance security in one form or the other; be it to rectify defects or non-performance due to insolvency or simply to encourage good performance. Some of the uses of retentions are valid for the construction period whereas the rest are for the defects liability period or the maintenance period. The difference between the construction period and the defects liability period is that during construction the contractor/subcontractor is available on site whereas after practical completion the contractor is off site and the motivation to come back to site to rectify any defective or incomplete work has to be considerably high. The latter argument can be supported by the findings of Hughes *et al.* (1998) that the retention fund becomes limited after the payment of the retention money for practical completion. This amount may be insufficient in case of contractor or subcontractor not being able to perform due to serious defects and causing delays. Another argument in support of this notion by Wearne (1989) is that the retention amount may not be helpful in case the contractor determines that his resources can earn him more money if used in other contracts rather than to gain the retentions back.

3.1. RESEARCH METHODOLOGY

The objective of this paper is to identify the main purpose of the retention practice in the construction industry with a view to understand whether the practice is actually serving the purpose for which it is used in the industry. Although the retention system was introduced to protect the client from contractor insolvency, the periodic reform in the provisions of retention system fulfils many purposes. This paper reviews 27 publications including books, journal/conference articles, magazines and reports to identify the various purposes of retentions.

3.2. AN ANALYSIS OF THE PURPOSE OF RETENTIONS

An analysis of the purpose of retentions was carried out by using the data tabulated and presented in Appendix 1 (attached at the end of the paper). Appendix 1 sets out the different purposes of retentions identified in a total of 27 publications including books, journal articles, magazines, reports, etc. This has been done to gather the varied purposes of retentions as stated by different authors and organisations. From every publication the purpose/purposes of retention have been identified and subsequently the main theme stated. Ten main themes (purposes) have been identified from the tabulated data and presented in Table 1 below. The ten themes have been coded as P1, P2....P10 and the authors or publishers as A1, A2....A27 corresponding to the data in Appendix 1. A matrix has then been formed with the purposes on one axis and the publications/authors on the other as presented in Table 2 overleaf. This has been done to find out what these authors/publications have said regarding the purpose of retention. The last row of Table 2 shows by way of numbers the purpose identified by maximum publication followed by the rest. Having found the numbers with the help of the matrix as shown in Table 2 the purposes are ranked and numbered in the order of most recurring to the least recurring in column 3 of Table 1.

Table 1: Description of Purposes of Retentions with Ranks

Code	Description of Purposes of Retentions	Rank
P1	Rectify defects during construction	5
P2	Rectify defects during defects liability period	2
P3	Leverage to get defects put right	3
P4	Performance security e.g. to assure project completion or complete outstanding work or in case of non-performance or won't perform	1
P5	Motivation/Incentive for early or timely completion	3
P6	Protection against insolvency	4
P7	Financial security in case of over payment	5
P8	Administrative convenience	5
P9	Funds to pay mechanic's lien	5
P10	Quality assurance	5

Table 2: Retention Purpose Matrix

			Purpose of Retentions									
S No	**Type of Source**	**Article**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**
1	Conference proceedings	A1			✓	✓						
2	Book	A2			✓		✓				✓	
3	Report	A3		✓		✓		✓	✓			
4	Book	A4			✓		✓					
5	Journal article	A5								✓		
6	Book	A6		✓								
7	Report	A7		✓			✓					✓
8	Magazine	A8	✓			✓	✓				✓	
9	Book	A9		✓		✓	✓					
10	Report	A10			✓			✓				
11	Book	A11	✓	✓	✓	✓		✓		✓		
12	Journal article	A12		✓			✓	✓				
13	Book	A13				✓						
14	Book	A14		✓	✓	✓						
15	Book	A15			✓							✓
16	Book	A16		✓								
17	Magazine	A17			✓							
18	Book	A18				✓		✓				
19	Book	A19		✓		✓						
20	Book	A20				✓	✓					
21	Book	A21		✓								
22	Report	A22			✓		✓					
23	Magazine	A23		✓		✓						
24	Journal article	A24				✓	✓					
25	Book	A25		✓		✓						
26	Magazine	A26		✓								
27	Report	A27				✓			✓			
	Total		**2**	**13**	**9**	**14**	**9**	**5**	**2**	**2**	**2**	**2**

From this literature review analysis it can be concluded that most authors/publications have identified the primary purpose of retentions to be P4, i.e. "Performance Security" and P2, i.e. "Rectifying defects during the defects liability period". Out of the 27 publications 14 have identified performance security and 13 have identified rectifying defects during DLP as the primary purpose of retentions. This is followed by 9 each having identified P3, i.e. 'leverage to get defects put right' and P5, i.e. 'motivation/incentive for timely or early completion' as the secondary purpose of retentions. Next of importance is the use of retentions as a 'protection against insolvency' (P6) supported by 5 authors, followed by the remaining purposes P1, P7, P8, P9, P10 as shown in Table 1.

4. CONCLUSIONS

The conclusion drawn from this literature review analysis is that retention is perceived to be used for many different purposes. However the primary purpose identified for its existence in the construction industry seems to be performance security; be it to rectify defects or non-performance due to insolvency or simply to encourage good performance. Some of the uses of retentions are valid for the construction period whereas the rest are for the defects liability period. Retention originally was introduced into the construction industry as a measure to protect project performance however with the transformation that the industry has undergone in the past century or so the existence of retentions is rather questionable. Especially with the inclusion of a range of risk mechanisms and securities to deal with performance related issues it might be sensible to establish the exact purpose of retentions. The idea of holding retentions in these modern times is indeed a good one but the fact is that are retentions actually able to justify their existence. The way forward with this research would be to find out from the industry experts whether retentions are fulfilling the purpose for which they exist and if not then what is the rationale behind the continuation of the practice.

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Appendix 1

S No	Type of Source	Article/Reference	Definition/Purpose of Retentions	Main theme
A1	Conference Proceedings	Abeysekera, 2003	Head contractors (and clients) point out that as so long as industry produces defective work with performance related problems, retentions must and will remain. the function of retentions is that it guarantees the performance and quality of workmanship of the sub and main contractor	Rectify defects, performance security
A2	Book	Allensworth, 2009	The purpose of retainage is to preserve a fund of money that will be available to assure final completion and to correct defects in the work. Retainage also gives the owner, lender, and sureties extra security or protection against other issues that might arise, such as defective work, unpaid subcontractors, or liens filed late in or after the construction process.	Motivation to finish the job, Leverage to get defects put right. Funds to pay mechanic's lien.
A3	Report	Bausman, 2004	In addition to protection against contractor insolvency, proponents have encouraged its use to provide a 'buffer' for the valuation of work installed, remedy defects found during turnover of the facility, and encourage contractor performance.	Protection against insolvency, financial security in case of overpayment, remedy defects during defects liability period, encourage performance i.e. performance security.
A4	Book	Bennett, 2003	To provide an inducement to complete the work on time, because the retainage will be released upon completion, and to produce a quality project. So owners feel a need to retain moneys for such cases as contractor failure to remedy defective work or contractor-caused claims against the work that the owner may have to settle.	Motivation for prompt completion, Leverage to get defects put rights.
A5	Journal Article	Champion, 2005	Perhaps the overriding reason why retention provisions are used is administrative convenience.	Administrative convenience.
A6	Book	Chappell, 2003	This retention fund is also useful at the end of the job to ensure that making good of defects is carried out.	Rectify defects during DLP.
A7	Report	Council, 2007	Cash retention is the most prevalent form of protection against sub-standard work on a construction project. A 'fund' to put towards the cost of the contractor not finishing the job or the cost of correcting any defects in the finished building. The main purpose of retention is to give a client certainty that the contractor will complete the work and fix any problems that emerge within an agreed period of time after this.	Quality assurance, Rectify defects during DLP, Motivation for timely or early completion.
A8	Report (Magazine)	Fullerton, 2000	"The owners and the general contractors feel that retention is necessary to insure prompt completion of the project. Retention will motivate tradesmen to return to the project to complete small unprofitable punch-list items. Retention provides the owner and general contractor with money to correct defective work if a subcontractor abandons the project and provides funds to pay the mechanic's lien claims of unpaid suppliers".	Motivation for prompt completion, performance security, correct defects during construction, funds to pay mechanic's lien.
A9	Book	Gilbreath, 1992	1) To motivate the contractor to complete the work. 2) To cover the risk of latent errors or omissions. 3) To encourage contractors to return to the work after a planned demobilization.	Motivation for prompt completion, rectify defects during defects liability period, performance security e.g. complete outstanding work.

S No	Type of Source	Article/Reference	Definition/Purpose of Retentions	Main theme
A10	Report	House of Commons, 2002	"We note that, while construction clients felt that the use of retentions afforded them a degree of assurance and control over the rectification of faults and gave some level of insurance against insolvency by the contractor.	Leverage to get defects put right, protection against insolvency.
A11	Book	Hughes, Hillebrandt, & Murdoch, 1998	They are well understood, do not require any documentation apart from the contract itself and are by definition readily accessible. Hence where the client claims to have suffered from a contractor's mis-performance, a compensation fund is immediately available. Moreover, this may be the most powerful weapon in cases of "won't perform" – the view has been expressed that this is the lever which is most likely to bring a sub-contractor back to site to remedy defective work.	Administrative convenience, performance security, remedy defective work during DLP, remedy defects during construction. Leverage to get defects put right. Protection against insolvency.
A12	Journal Article	Hughes, Hillebrandt, & Murdoch, 2000	"The primary purpose of this retention is to provide a fund for the employer in the event that the contractor fails to perform because of insolvency. A secondary purpose is to motivate the contractor to complete any minor outstanding items and repair defects after the work are finished".	Protection against insolvency, motivation for prompt completion, repair defects during DLP.
A13	Book	Huse, 2002	"The employer may want to withhold a portion of each interim payment, an amount known as retention money, as a form of security of performance.	Performance security
A14	Book	Jones & Baylis, 1999	From the employer's point of view it is a useful system as it represents some protection against the inclusion of defective work in a valuation and which is therefore included in the amount of an interim certificate. It also provides security for the performance by the contractor of his obligations. Its main purpose, however, is to provide the employer with a fund during the defects liability period following practical or substantial completion, should the contractor fail to return and make good any defects of which he is notified"	Protection against defective work, security for performance, remedy defects during the defects liability period.
A15	Book	Kennedy-Grant, 1999	A fund from which to defray the cost of making good any default by the contractor in completion or in the quality of work.	Leverage to get defects put right, Quality assurance.
A16	Book	Knocke, 1993	There is normally a defects liability provision in building contracts which provides that the contractor shall make good defects or repair and maintain works for a certain period after completion.	Repair defects during the defects liability period.
A17	Magazine	Latham, 1997	It is supposed to be a mechanism whereby clients can build up a fund during the project that will act as an inducement to the contractor to remedy defects.	Leverage to get defects put rights.
A18	Book	McInnis, 2001	Retentions provisions empower the employer to retain an agreed percentage of each payment due to the contractor as security for performance of the works and as some protection against insolvency of the employer.	Performance security, protection against insolvency.
A19	Book	Murdoch & Hughes, 2002	"The retention fund is available to the employer for the purposes of underpinning contractual performance, in particular rectifying, or inducing the contractor to rectify, any defects in the work appearing during the defects liability period which starts from the date of practical completion to the date specified in contract"	Performance security, rectifying defects during defects liability period.
A20	Book	O'Leary, 1999	The purpose of the retainage is to provide the owner with a degree of financial protection in the event contractor fails to faithfully complete all of the terms and conditions of the contract. The retainage also provides a financial incentive to some contractors to remain on the job.	Financial security to the owner in case of non-performance. Incentive for the contractor to remain on the job or finish the job.
A21	Book	Pettigrew, 2005	"In Chapter eleven of his Report, Sir Michael identified the following 'The retention system is supposed to be a mechanism whereby a client can build up a fund during	Rectify defects during defects liability period.

S No	Type of Source	Article/Reference	Definition/Purpose of Retentions	Main theme
			the course of a project which will act as an inducement to the contractor to remedy any defect during the liability period.	
A22	Report	*Procurement strategy for construction-related services*, 2002	"Retention money has long been a feature of contracts. The concept is simple – a set proportion of the money due under the contract is withheld to encourage the contractor to complete the works and remedy any defects.	Motivation to complete work on or before time, Leverage to get defects put right.
A23	Magazine	Russel, 2002	– To provide the employer with funds to rectify a failure by the contractor to complete the work to the standard required. – To provide an incentive for contractors to return to site to remedy defects following handover of the works.	Performance security, rectify defects during DLP.
A24	Journal Article	Stockenberg, 2001	The legitimate purpose of retainage has always been to ensure owners that the contractors properly and timely complete the work.	Motivation for prompt or timely completion, Performance security.
A25	Book	Wearne, 1989	The amount is then 'released' (paid) if the contractor has completed his obligations such as rectifying poor work. The potential advantage to a promoter is that a contractor should have the incentive to complete his obligations.	Rectify defects during DLP, Performance security.
A26	Magazine	Wessely, 2002	The whole idea of retention is to safeguard against defects that may only emerge in a job after it's completed.	Rectify defects during DLP
A27	Report	Wyatt, 2003	Retainage is money withheld by an owner from progress payments due to the contractor to assure project completion. Retainage provides the owner a margin of financial security in case overpayment has been made for a portion of the work".	Performance security e.g. to assure project completion, financial security in case of overpayment

PREVENTIVE METHODS USED FOR HEALTH AND SAFETY HAZARDS IN HOTEL INDUSTRY IN SRI LANKA

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ABSTRACT

Occupational safety and health is a discipline which aims at the promotion and maintenance of the highest degree of physical, mental and social well-being of workers. It involves the protection of workers in their employment from risks resulting factors, which are adverse to their safety and health condition. If there is a safety and health issue in an organisation, it will lead to various problems and puts the worker, their families, other people in the community, and the physical environment around the work place at a risk. Literature reveals that health and safety matter in hotel industry is a very broad and critical concept that should be taken in to consideration. However, a study which has been carried on health and safety hazards in hotel industry is hardly found in Sri Lanka. Therefore, in order to address the above gap, this research aims at identifying the health and safety hazards, causes of those hazards and the preventive measures that can be adopted to minimise these hazards in hotel industry of Sri Lanka.

A three step approach; a literature survey, a preliminary study and a detailed questionnaire survey, was carried out in achieving the aim of this research. The study identified 'Cuts and Burns' and 'Electrical Hazards' as the most critical health and safety hazards in hotel industry. According to the study the most critical causes for those hazards are 'Open Flames' and 'Contact with Electricity from Machines' respectively. Further, 'Inadequate Instructions' and 'Inadequate Safety Education' could be identified as the most critical factors that affect the overall health and safety hazards in hotel industry. As the findings revealed, the usage of preventive methods to mitigate health and safety hazards in hotel industry in Sri Lanka, is at a very low level and using PPE and fire protection methods and maintaining a good housekeeping procedure are the mostly practiced preventive methods. Further, there are lot more to implement in order to minimise/eliminate health and safety hazards.

Keywords: *Health and Safety Hazards, Causes, Preventive Measures, Hotel Industry, Sri Lanka.*

1. INTRODUCTION

According to Wong *et al*. (2007) health can be defined as the state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Cooper and Phillips (2004) viewed safety as a snapshot of the prevailing state of safety in the organisation at a discrete point in time and may change over time. Health and safety hazards have a potential to cause harm to property, humans' health and even to their lives. Even though, earlier, safety and health hazard protection was not given an adequate consideration as a business success factor, nowadays it has become a major positive factor in favour of organisational as well as economic growth and productivity. Therefore, industries need occupational health and safety management systems that help them to prevent and mitigate health and safety issues by identifying and selecting the most critical hazards and managing them while adopting preventive measures.

Hotel industry is associated with various types of health and safety hazards and it has a major impact on profit. Therefore there is an imperative need to identify the ways of improving control of health and safety hazards at work in the local context in order to pursue better health and safety performance. In Sri Lanka, there is no national body to regulate and monitor the practice of health and safety hazard controls in hotel industry. Therefore obviously there is a need for a health and safety hazards mitigate programs in Sri Lankan hotel industry. Even though few numbers of researches (Munasinghe, 2011; Jayanthika, 2010;

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Perera, 2010; Ranasinghe, 2009) have been conducted in the area of health and safety in Sri Lankan context, a study which addresses the health and safety issues in hotel industry in Sri Lanka is hardly found. Therefore, an attempt was made in this research to identify the health and safety hazards, causes of them and preventive measures that can be adopted to minimise the health and safety risk of hotel industry of Sri Lanka.

2. HEALTH AND SAFETY HAZARDS IN HOTEL INDUSTRY

According to the International Labour Organisation (ILO) (2009), occupational safety and health is a discipline with a broad scope involving many specialised fields. In its broadest sense, it should aim at the promotion and maintenance of the highest degree of physical, mental and social well-being of works in all occupants, the prevention among workers of adverse effects on health caused by their working conditions, the protection of workers in their employment from risks resulting from factors adverse to health the placing and maintenance of works in an occupational environment adapted to physical and mental needs and the adaption of work to humans. In other words, occupational health and safety encompass the social, mental and physical well-being of workers that is the 'whole person'.

Hazard is a condition of changing a set of circumstances that presents a potential for injury, illness or property damage (Jekayinfa *et al.*, 2009). It is a source of potential harm to human health, property or environment, and under certain conditions hazards may lead to accidents which typically occur suddenly and unexpectedly causing immediate injuries and losses (Lind *et al.*, 2008). Further, many health and safety problems also can be slowly developed due to the exposure to these hazards (Lind *et al.*, 2008). If there is a safety and health problem in an organisation it will lead to sickness absence, high staff turnover, re-training of the staff, loss of production and subsequently it will increase the compensation (Phil and Ferret, 2008). In addition it will create poor working condition within the organisation. This means that worker, their families, other people in the community, and the physical environment around the work place, can all be at risk from exposure to health and safety hazards.

According to Hassanain (2009), a hotel is a facility that provides paid accommodation on a short-term basis. The International Code Council (2003) defined a hotel as any building consisting of six or more guest rooms intended or designed to be used or that are used rented or hired out to be occupied for sleeping purposes by guests. Health and safety of the hotel employment, staff, guest and other personal health and safety is concerned with protecting the safety, health and welfare of people engaged in work or employment.

There are various health and safety hazards associated with hotel industry. According to the Calvin and Joseph (2006), physical, chemical and mechanical are the main types of health and safety hazards happened in the hotel industry. Physical hazards include noise, vibration, heat and colds stress, dangerous machinery, electricity and fire safety and lighting. Chemical hazards include acids, bases, heavy metals, solvents, fumes and highly reactive chemicals. According to the Mill and Lin (2001), hazards resulting in physical hazards and fatalities in hotel industry can be broadly categorised into the basic groups as falling from heights, struck by falling objects, accident by operation of machinery/tools, electrocution, fire/explosion, failure of temporary structures and others (e.g. slipping on the same level, oxygen deficiency in confined spaces, lightning strike, etc.). As Hassanain (2009) mentioned, fire hazard is a main hazard type with regard to hotel industry. Further, as Lind *et al.* (2008) stated, main hazard types are poor ergonomics in operations and physical hazards. However, European Agency for Safety and Health at Work Organisation (2008) argued that, types of health and safety hazards are in terms of occupational accidents, slips, trips and falls, as well as cuts and burns represent the largest share.

3. CAUSES FOR HEALTH AND SAFETY HAZARDS IN HOTEL INDUSTRY

According to Mill and Linn (2001), major causes of occupational health and safety failures are inadequate safety education, instruction, housekeeping and wilful transgression. In addition, improper equipment and working platform, wrong safety attitude, lack of monitoring and supervision, lack of proper procedure and guideline and time constraints are the causes of fall accidents (Wong *et al.*, 2007). According to Cooper

(1998), some jobs require, for instance, a large degree of manual dexterity (e.g. electronic assembly work). Others require problem solving skills (e.g. a process control operator in a chemical factory). Some people are good at these tasks, others are not and therefore, inadequate training is also a factor that lead to cause health and safety hazards.

A research (Hassanain, 2009) revealed that the main causes of hotel fires are arson, open flames or smoking and cooking equipment. Further, according to this research hotels can be considered as a high risk type of facility regarding fire hazard due to several number of factors. These factors are high occupancy load present at the building, especially in banquet halls and conference centres, the high-fuel load present in hotel facilities, unfamiliarity with the building results in experiencing difficulty in finding the way out of the building in case of fire emergencies and the existence of high fire risk areas. Study by Hassanain (2009) identified the sources of health and safety hazards arise in hotel building are as guest rooms, hotel kitchen, laundry and etc. Potential fire hazards in guest rooms include smoking, candles, covered lamps, ash trays, coffee machines, irons, defective television sets, defective radios, and defective refrigerators, overheated hairdryers, electric blankets, fixed and portable space heaters, overloaded circuits and short circuits.

As Lind *et al.* (2008) viewed, there are two causes for ergonomics hazards. First, the workers may be unaware of proper working postures and methods and they may also be unwilling to give up unsafe routines, especially under pressure of time. Second, on many sites the design of machine and process or work environment is poor from the perspective of maintenance. Further, poor working postures head, neck, shoulders, upper and lower limbs, back and missing or misleading operational safety bulletins are also ergonomics related causes. In physical hazards, most typical injury risks are slipping, tripping and a person falling from height. Not using any Personal Protective Equipment (PPE) is also result in arising of physical hazards. Other risks of falling were related to occasional climbing to a high place. However, as Wlters (1998) argued, reasons for poor health and safety performance have been attributed to a variety of factors such as limited resources, limited knowledge of regulatory requirements, poor awareness of the economic advantages of health and safety, poor knowledge and understanding of safe working practices and absence of preventive services.

4. PREVENTIVE MEASURES FOR HEALTH AND SAFETY HAZARDS IN HOTEL INDUSTRY

A study by Wright (1998 cited Fuller, 1999, p.325) shows that non-controlling of health and safety hazards is often perceived as an area of operational management where costs exceed benefits. Further, poor health and safety performance has been reported to significant impact of organisations' profits (Davies and Teasdale, 1994). As Cooper and Phillips (2004) pointed out, safety behaviour will result in dramatic improvements in safety performance in terms of reductions in accidents, workers compensation costs, and insurance premiums. According to Ranasinghe (2009), health and safety hazards preventive methods are important for any industry as they would result in reduced risks and losses, reduced cost, reliable operations, systematic and efficient approach to health and safety at work, low turnover of people, positive company image, reputation and compliance to rates, legislation, company standards and practices.

According to Mill and Linn (2001), controlling health and safety hazards by practicing of health and safety management systems is one of the main foundations that lead to the success of a business. Hence, industries need occupational health and safety management systems that help them to prevent and mitigate accidents by identifying and selecting the most critical hazards and managing them while adopting preventive measures. The International Labour Organisation (2009) adopted a new convention on the prevention of major industrial hazards. This provides a framework for the establishment of a national major hazard system for the prevention of industrial hazards and to mitigate the consequences of such hazards. It requires the formulation, implementation and periodic review of a coherent national policy concerning the protection of employees, the community and environment, against risk from major hazards.

According to the literature findings, using Personnel Protective Equipments (PPEs) (Lin, 2001; OSHA, 2000), applying fire protection methods (Hassanain, 2009), conducting health and safety programmes (Hinze, 1988 cited Mill and Linn 2001), risk assessment (Lind *et al.,* 2008; Adebiyi *et al.*, 2007) and risk management (Cooper, 1998), forming a safety committee (Mill and Lin, 2001), adopting a health and safety management system (Lind *et al.,* (2008), practising good housekeeping (OSHA, 2000), maintaining equipment on schedule (OSHA, 2000), evaluation of health and safety hazards (OSHA, 2000) hazard identification (Mignanelli, 2000) and emergency procedures (Navon *et al.*, 2007) are the major health and safety preventive measures used in hotel industry.

Literature reveals that hotel industry health and safety is very broad and critical concept that should be taken in to consideration. Even though a few researches (Munasinghe, 2011; Jayanthika, 2010; Perera, 2010; Ranasinghe, 2009) have been conducted on health and safety issues in food manufacturing industry, construction industry and apparel industry in Sri Lanka, to date there is no research which addresses the health and safety hazards, their causes and the preventive actions that can be taken to minimise the health and safety hazard in hotel industry of Sri Lanka.

5. RESEARCH METHODOLOGY

The survey research was selected as the research approach for this research and followings techniques were used in data collection and analysis.

5.1. DATA COLLECTION TECHNIQUES

A three step approach was adopted for the data collection of this research. Three steps are; literature survey, preliminary questionnaire survey and detailed questionnaire survey. First, a comprehensive literature survey was carried out and then a model for mitigating health and safety hazards hotel industry was developed by identifying the health and safety hazards of hotel industry, causes, effects and preventive measures of mitigating them. A subsequent preliminary questionnaire survey was carried out and according to the findings, the proposed model for mitigating health and safety hazards was revised to comply with the in Sri Lankan hotel industry. The revised model was the basis in developing the detailed questionnaire. The detailed questionnaire survey was conducted to identify critical health and safety hazards, major causes for each hazard and to identify the current practice of preventive methods of health and safety hazards in hotel industry in Sri Lanka. A 0-4 Likert scale was used to collect the relevant data from the respondents. Further, the literature survey was carried out among sixty employees of randomly selected 10 hotels in Western province.

5.2. DATA ANALYSIS TECHNIQUES

Before analysing the detailed survey findings, Cronbach's Alpha was used to check the internal consistency of selected factors in this research. Statistical Package for Social Science (SPSS 16) was employed to carry out the reliability analysis. In analysing the findings of the detailed survey, 'Relative Important Index (RII)' for each factor was computed to rank and deliver an indication of the impact level of hazards and their causes. Percentage Analysis Method was used to identify the current practice of preventive methods.

6. DATA ANALYSIS AND RESEARCH FINDINGS

6.1. LITERATURE SURVEY FINDINGS

After a comprehensive literature survey, a model for mitigating health and safety hazards in hotel industry was developed by identifying the health and safety hazards of hotel industry, causes and preventive measures of mitigating them. Literature survey identified 15 major health and safety hazards. The identified causes of health and safety hazards were categorised into three groups as machine related causes, work environment related causes and material related causes. Further, nine effects of health and safety hazards and twelve preventive methods of mitigating health and safety hazards in hotel industry also could be integrated to this model.

6.2. PRELIMINARY SURVEY FINDINGS

According to the findings of preliminary questionnaire survey, changes were made to the developed model for mitigating health and safety hazards in hotel industry. New causes for health and safety hazards in hotel industry; less communication; poor monitoring and supervision; poor resource allocation; poor design of machines, process and work environment, etc. were identified and added to the revised health and safety model. Further, based on the preliminary survey findings, some factors which were in the conceptual model were removed and some factors were combined together where it was needed. In addition, a new category 'methods related causes' was identified according to the respondents' views. The newly identified causes; lack of new technology and poor permit license and approvals were included under this category. The revised model which was named as model for mitigating health and safety hazards in hotel industry in Sri Lanka is given in Figure 1.

6.3. DETAILED QUESTIONNAIRE SURVEY FINDINGS

The detailed questionnaire survey was used to identify the most critical health and safety hazards in hotel industry in Sri Lanka and also to identify the causes of those hazards. Further, questionnaire survey was employed to study about the current usage of identified preventive measures that can be adopted to minimise the health and safety hazards.

6.3.1. MOST CRITICAL HEALTH AND SAFETY HAZARDS IN HOTEL INDUSTRY

In identifying the most critical health and safety hazards in hotel industry, the respondents were required to use a 0-4 Likert Scale: where 4 represents severe impact, 3 represents high impact, 2 represents moderate impact, 1 represents little impact and 0 represents no impact. Here, the RII values come within the range of zero to one (0-1) and therefore, hazards which obtained more than 0.5 RII value were identified as critical health and safety hazards. Survey results showed that most critical hazard is cut and burns which has gained high impact level as 0.71. Further, as the Figure 2 shows, secondly and thirdly critical health and safety hazards are electrical hazards (0.66.) and heat (0.62.). Slipping and tripping, accidents happened due to machinery, chemical hazards, falling from heights, fire and ergonomics are also have received RII values over 0.5 and therefore, they are the next critical health and safety hazards respectively. The RII values of other hazards were less than 0.5. Therefore, biological hazard (0.49), cold stress (0.43), noise (0.33), inadequate lighting (0.32) and vibration (0.26) were identified as minor health and safety hazards in hotel industry in Sri Lanka.

6.3.2. MOST CRITICAL CAUSES FOR HEALTH AND SAFETY HAZARDS IN HOTEL INDUSTRY

In identifying the most critical causes for health and safety hazards in hotel industry, the respondents were asked to rank the causes in a 0-4 Likert scale: where 4 represents severe effect, 3 represents high effect, 2 represents moderate effect, 1 represents little effect and 0 represents no effect.

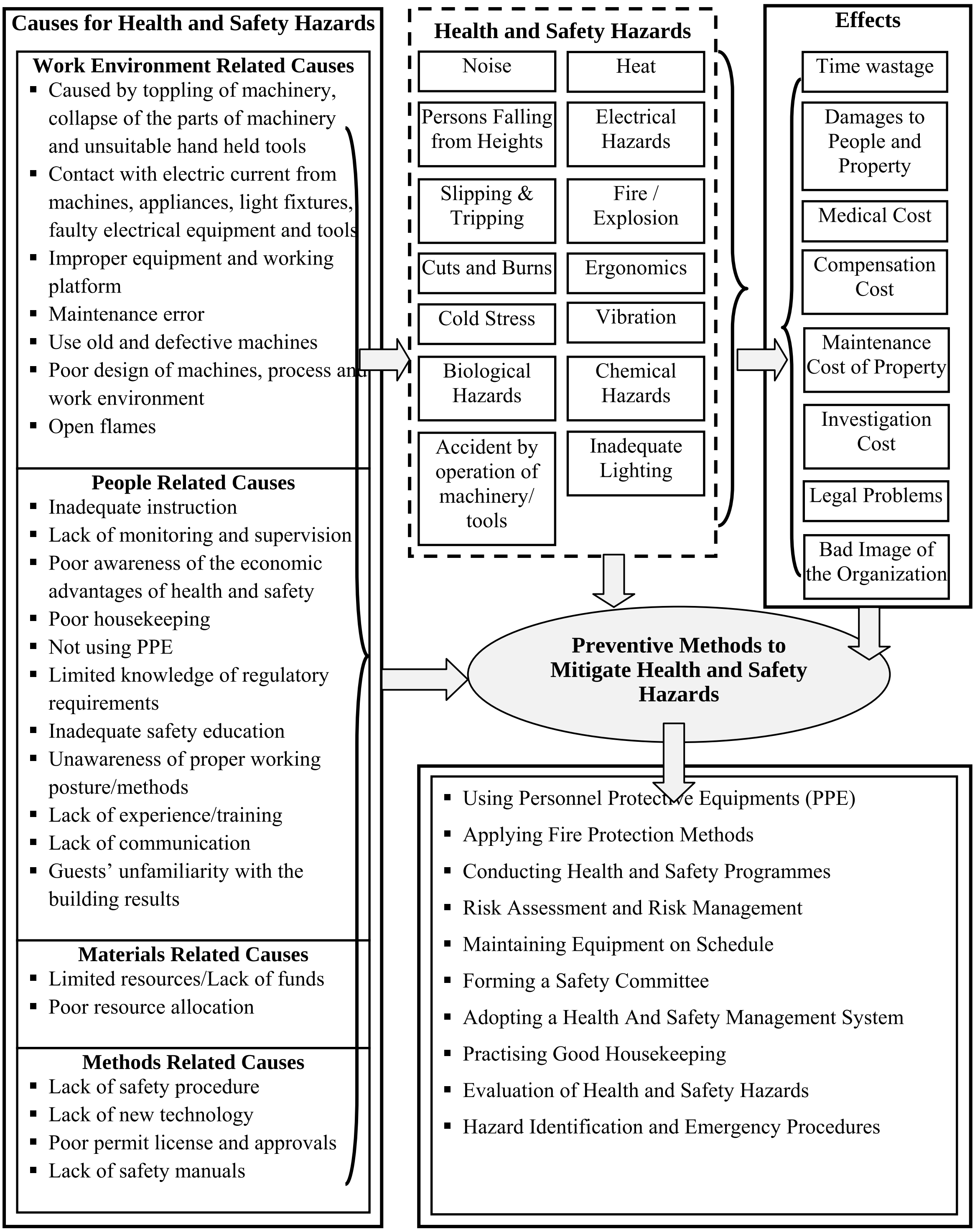

Figure 1: Model for Mitigating Health and Safety Hazards in Hotel Industry in Sri Lanka

The survey results revealed that inadequate instruction (0.601) as the most critical cause for overall health and safety hazards. Inadequate safety education (0.598) and poor design of machines, process and work environment (0.566) are secondly and thirdly critical causes. Lack of proper procedures and guidelines (0.546), lack of monitoring and supervision and not using PPE are also major causes for health and safety hazard in hotel industry in Sri Lanka. Awareness of economic advantage of health and safety (0.41), less communication (0.34) and poor housekeeping has (0.31) could be identified as minor causes for overall health and safety hazards.

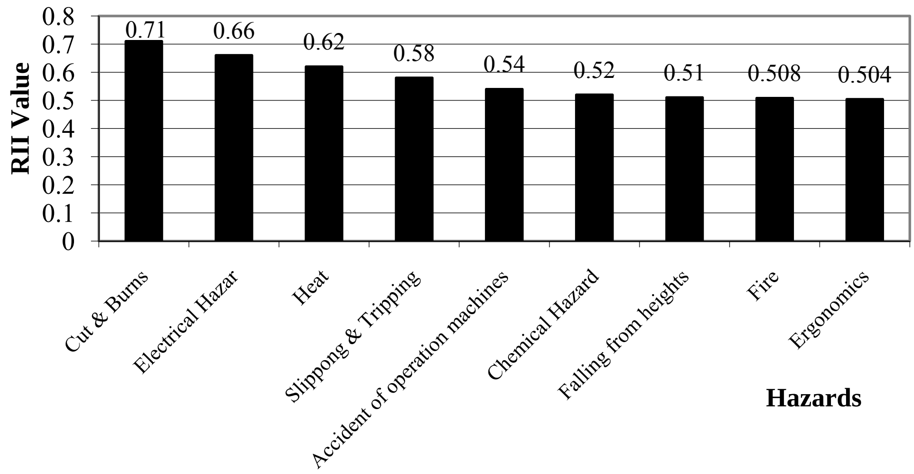

Figure 2: Critical Health and Safety Hazards in Hotel Industry

As it was mentioned above, cut and burns, electrical hazards, heat, slipping and tripping, accident by operation of machinery/tools, chemical hazards, falling from heights, fire/explosion and ergonomics were identified as the most critical health and safety hazards in hotel industry in Sri Lanka. According to the survey findings, open flames (0.77), contact with electric current from machines (0.71) and toppling of machinery, collapse of parts of the machinery (0.704) have a significant impact to cause cuts and burns. Generally, a large amount of electric machinery and equipment are used in hotel industry. Open flames can be largely found in kitchen equipment. Hence, due to these causes, cuts and burns have become a critical health and safety hazard in hotel industry. Similarly, contact with electric current from machines (0.75) and open flames (0.608) badly affect to cause electrical hazards as well. In addition, inadequate safety education (0.679) also has a significant impact on electrical hazards. The most significant cause for Heat hazard is Open Flames and its RII value is 0.72. Workers in the kitchen have to expose to this hazard because, most of kitchen equipments are open flames and generate more heat. The next critical cause for heat hazard is lack of usage of PPE (0.68). Workers should wear PPE such as gloves, goggles and special uniforms to protect from the heat. Contact with electric current from machines (0.66) is also a critical cause for heat hazard. Poor housekeeping (0.766), lack of monitoring and supervision (0.725) and lack of proper procedure and guideline (0.7125) are the most significant causes for slipping and tripping hazard respectively. If smooth floor areas in rooms, swimming pools and bath rooms are not properly cleaned and these activities are not properly supervised it will lead cause this hazard. Further, proper guidelines and standards are also required to ensure the elimination of slipping and tripping hazard.

The next critical hazard is accidents that can be happened while operation of machinery. The results revealed that Contact with electric current from machines (0.595), inadequate instruction (0.595), inadequate safety education (0.591) and poor design of machine, process, and work environment (0.587). If the employees are not trained on operating procedures of the machinery in advance and if they are not educated on safety practices accidents can be happened while they are operating the machinery. Further, a poorly designed work environment, machine or a process itself contains the risk of happening accidents. The chemical hazards include exposure to gases, fumes, liquids, solids, vapor, acids, etc. As the study identified, the critical causes of these hazards are inadequate instructions (0.737), inadequate safety education (0.666) and not using PPE (0.637). If the employees are exposed to gases, fumes, liquids, solids, vapour, acids, etc. They should be provided with proper instructions and safety education. Absence of such education leads to cause chemical hazards in a hotel facility.

Most of the hotels are high rise buildings and most of the time hotel employees have to engage in works such cleaning windows in upper floors, installing the instruments in high rise places (antenna, satellite) and work in high rise temporary structures. When engaging in such works there is a high probability for people falling from height. The critical causes for this hazard are poor design of machinery, process, work environment (0.604), not using PPE (0.591) and inadequate instructions (0.587) respectively. In hotel industry fire/explosion hazard has been identified as a critical hazard because damages causes by fire hazard is very high. According to the respondents' view most affected cause for fire hazard is open flames

(0.777). Contact with electric current from machines (0.741) and lack of proper procedure and guidelines (0.65) are the critical causes of fire/explosion hazard. According to Hassanain (2009), kitchen is a primary area in hotels, where fire hazards are occurred. Poor design of machine, process, and work environment is the most significant cause for ergonomics hazard (0.733). Further, improper equipment and working platform (0.675) and unawareness of proper working postures and methods (0.67) were the next critical causes. Poor designs of workplace and machines will cause muscular pains. Poor work environment result in mental stress and aches in body parts. In addition improper postures also result in ergonomics hazards.

6.3.3. Current Practice of Preventive Methods of Health and Safety Hazards

According to the research findings, the current practice of preventive methods of health and safety hazards of hotel industry in Sri Lanka is given in Figure 3. The study revealed that the practice of preventive methods to health and safety hazards in hotel industry in Sri Lanka is at lower level. According to the findings, using PPE and fire protection methods are the mostly used preventive methods in the hotel industry and have percentage of 100%.

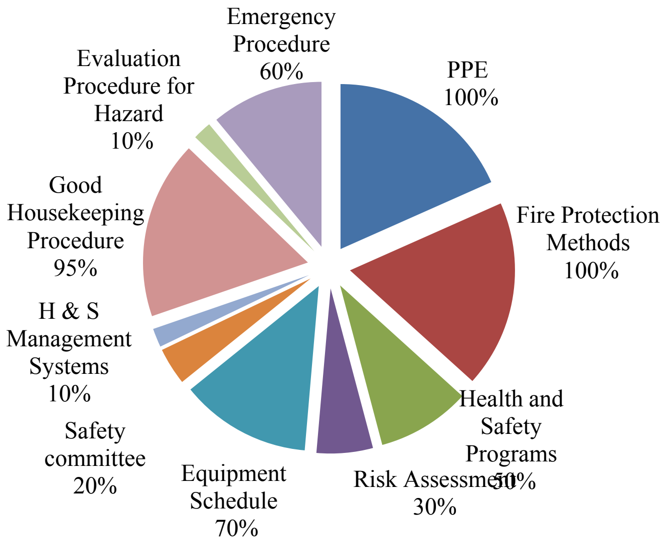

Figure 3: Current Practice of Preventive Methods of Health and Safety Hazards in Hotel Industry in Sri Lanka

Maintaining a good housekeeping procedure is practiced by 95% of hotels. Further, equipment schedules and emergency procedure are currently practiced by 70% and 60% of hotels respectively. In addition to above preventive practices, all the other preventive measures have been given a less priority by the hotel industry in Sri Lanka. As the research found, most of respondents have given less priority for health and safety programs (50%), conducting risk assessment (30%), appointing safety committee (20%), maintaining health and safety management systems (10%) and evaluation procedure for hazards (10%). Preventive methods of health and safety hazards enable an organisation to mitigate health and safety issues that can be occurred in the future. Less practice of these methods will cause health and safety issues in future. Therefore, preventive methods should be implemented and properly used to mitigate health and safety hazards in hotel industry in Sri Lanka.

7. Conclusions

Occupational safety and health is a cross-disciplinary area concerned with protecting the safety, health and welfare of people engaged in work or employment. It ensures a safe and healthy work environment and protects workers, their family members, employers, customers, suppliers, nearby communities and other members of the public who are affected by the workplace environment. Health and safety hazards lead to workers' illnesses, pain, anxiety, depression and various other health and safety issues. Further, it creates great losses to an organisation in terms of cost, time and management efforts. A hotel is a commercial establishment that provides paid lodging, meals, and other guest services. The problem of health and safety hazards is very detrimental to the hotel industry and it has become a major burden as well. Even though workers' health and safety is becoming an increasingly more important part of modern management, managing health and safety hazards is a challenging process.

In managing the health and safety hazards in hotels, the identification of actual hazards, their causes and preventive actions is important. Even though such necessity is there, no research has identified above factors in Sri Lankan context. Therefore this study aimed at identifying the health and safety hazards in hotel industry, their causes and preventive actions. In achieving the above aim, first, a model for mitigating health and safety hazards in hotel industry was developed through a comprehensive literature review by identifying the health and safety hazards, their causes, effects and the preventive measures. The developed model was revised through a subsequent preliminary survey and it was named as the model for mitigating health and safety hazards in hotel industry in Sri Lanka. The revised model comprises of 14 health and safety hazards; noise, heat, fire/ explosion, slipping and tripping, persons falling from heights, electrical hazards, cuts and burns, ergonomics, cold stress, vibration, biological hazards, chemical hazards, accidents happen due to operation of machinery/tools and inadequate lighting. Further, number of causes for these hazards and preventive measures also could be identified and integrated to this model.

The detailed questionnaire survey was carried out to study the impact of identified health and safety hazards to a hotel and the effect of each identified cause to those hazards. Further, it aimed at identifying the current practice of identified health and safety hazards preventive methods in hotel industry in Sri Lanka. According to the findings, the most critical hazard was cut and burns. Further, electrical hazards, heat, slipping and tripping, accidents happened due to machinery, chemical hazards, falling from heights, fire and ergonomics are also identified as critical health and safety hazards respectively.

As the study revealed, open flames, contact with electric current from machines, open flames, poor housekeeping, contact with electric current from machines, inadequate instructions, poor design of machinery, process, work environment, open flames, and poor design of machine, process, and work environment were the most critical causes for above health and safety hazards respectively. The findings show that similar causes have led to create several health and safety hazards. However, according to the survey results, inadequate instruction was the most critical cause for overall health and safety hazards. Inadequate safety education and poor design of machines, process and work environment are became secondly and thirdly critical causes for overall health and safety hazards. Moreover, the preventive methods; PPE and fire protection methods are used by almost all the hotels. Good housekeeping procedures are practiced by 95% of hotels and equipment schedules and emergency procedure are currently practiced by 70% and 60% of hotels respectively. The research further identified that important preventive methods; health and safety programs (50%), conducting risk assessment (30%), appointing safety committee (20%), maintaining health and safety management systems (10%) and evaluation procedure for hazards (10%) are practiced by limited number of hotels.

As the occurrence of health and safety issues harm the people and property, reduce the performance of the organisation, lead to increase the cost and minimise the profitability. Going for preventive measures is very much important to sustain in the market. This research provides the hotel management with major health and safety hazards of hotel industry in Sri Lanka and their critical causes. Therefore, the necessary preventive actions should be taken by management in order to minimise the health and safety hazards and improve the safety performance.

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SIGNIFICANCE OF MEANINGFUL BUILT ENVIRONMENTS IN SUSTAINABLE DEVELOPMENT WITH SPECIAL REFERENCE TO AYURVEDA-ECO TOURISM IN SRI LANKA

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ABSTRACT

Scarcity and the rapid decline of earth's natural resources is an outstanding global issue in the present context. Construction industry is highly responsible for utilising these resources at large. Therefore Eco-friendly Sustainable approach has become a key consideration and a current trend in present day Construction sector. In this arena, the words Green, Sustainable, Eco-friendly, Environmental, energy efficiency, Carbon-zero, Climate responsive and so on are interchangeable. All in all, the ultimate motive is to raise the living condition of our lives and protect the earth for today and tomorrow. In uplifting the living condition, physical aspects as well as psychological aspects often play significant roles. At present, professionals involved in construction sector are very much concerned about physical sustainability achieved through green technology and often tends to ignore psychological sustainability that could be achieved through conceptual or meaningful architectural approach.

Therefore, this paper focuses on the Architects approach to sustainable development through creating meaningful built environments. This is approached by relating architectural theories such as Psychology of Sustainability, Sensual Architecture and Conceptual Architectural theories to selected case studies. The selected case studies would focus on the current development projects in Sri Lanka, related to Ayurveda-Eco Tourism.

Keywords: *Ayurveda-Ecotourism, Conceptual Architecture, Meaningful Built Environments, Psychology of Sustainability, Sensual Architecture.*

1. INTRODUCTION

Among many significant global challenges identified at present in the construction industry, achieving sustainable development is significant and outstanding. The concept of Sustainable development is vast and has many dimensions. Although it is criticised for being too vague, there is a considerable agreement among different scientific fields that it should remain the main aim to be pursued in the management of natural and human resources. This management is known to be in two folds such as technical and non-technical. Many professionals in the construction industry mainly address sustainability through technical solutions such as the use of a wide variety of Green technology and tend to ignore non-technical humanistic approach.

According to Mirilia Bonnes (2002), sustainability is a trans-disciplinary concept which calls into question issues that are central in several social and human sciences and disciplines, ranging from economics, legal

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sciences, philosophy, psychology, etc. In this regard, within social and environmental psychology in particular, some authors have recently proposed the term "psychology of sustainability" or "new ecological psychology" (Bonnes and Bonaiuto, 2002). These terms identify those theoretical and empirical contributions aiming at better understanding the psychological processes involved in the development of a positive environmental awareness and concern in people's use of natural resources.

Having come out of the thirty year civil war, Sri Lanka is heading towards rapid development in many numbers of spheres. Contributions made by the Construction industry in to this development are crucial and outstanding. Development of a country would be holistic if it caters not only to the physical environment but also to the human factors. Therefore it is the responsibility of professionals involved in the construction industry to detect and address issues and needs relevant to the wellbeing of not only the physical built environment but also its users.

2. SUSTAINABLE DEVELOPMENT THROUGH PSYCHOLOGY OF SUSTAINABILITY

Though most people who are concerned about environmental issues and sustainability understand that the Environment is not something “out there,” a significant number of people think of “the environment” as a separate entity, like “the moon” or “the trade deficit” (Manning, 2009). Therefore it is crucial to make the humanity aware of the fact, that the environment is not something separate from us; but humans are an integral part of the environment.

Alice Jones(1996), a pioneer in field of Psychology of Sustainability, expresses her personal views on the subject as follows; “I call it loosely ‘the psychology of sustainability’, and it has to do with the very personal, individual, and sometimes conflicting experience of talking the talk of sustainability and then trying to walk the walk. My take on this is that we can't have a meaningful discussion about a national sustainability policy, or even a community sustainability policy without explicitly considering the very personal nature of what is implied”.

The focus below is to follow Alice Jones with respect to the 'very personal nature of what is implied', which denotes the hidden or disguised humanistic version of perceiving sustainability. Therefore the emphasis here is on understanding how any ability to act in the environment in a sustainable manner is intimately dependent on the ability to act in a sustainable manner with respect to one's own internal psychological environment. Indeed it could be argued that unless experiential understanding of one's psychological environment consciously embodies analogous cyclic patterns and processes, it is unlikely that social behaviours with respect to the environment will themselves be sustainable- however strong the declarations of intent or the initial commitment to sustainable patterns of action. The built environment holds immense responsibility in providing this personal experiential understanding of the cyclic patterns, processes of the natural ambient environment and thereby align it with the inner psychological needs in order to achieve optimum equilibrium in sustainable development.

3. NEED OF MEANINGFUL BUILT ENVIRONMENTS IN SUSTAINABLE DEVELOPMENT

One of the side effects of our modern stressful and hurried lives is that we tend to lose track of the things that make living meaningful and significant, such as our connections to close friends and family or our desire to make a difference in the world. Rushing through our days on autopilot, not really thinking through the impacts of our decisions, we sometimes do things that we later realise are incompatible with our values(Manning, 2009, p.20). In the context of reframing environmental messages, Kaplan (2000) has suggested emphasising deeper values and reminding people how sustainable actions (or sustainable living) can contribute to things like being needed by connected to others, making a difference in the world, being competent, and creating a good life. At least two separate areas of research confirm this link between activated personal values and sustainable behaviour, particularly when personal values are ecologically friendly. First of all, in a series of studies investigating the values and motivation, Verplanken and Holland (2002) found that people preferred ecologically friendly options if their personal environmental values had been primed. In a second set of studies, Vohs and colleagues (Schmeichel and Vohs, 2009) found that people who took a moment to reaffirm personal core values were better able To practice self-control in a consumer task compared to people who were not prompted to think about their values.

Reflecting on the above research findings, it would be acceptable if said that the built environment people live in has direct influence on stimulating, motivating and promoting the above mentioned aspects of environmental values and personal core values. In the field of Architecture, built environments of this nature are broadly titled as 'Meaningful Architecture'. This nature of built environments emerges if they are appropriately approached from its early inception stages. Therefore concept formulation could be considered as significant in this regard. There are many approaches in creating Meaningful Architecture, and selected two are;

- Sensual architectural approach (more contextual)
- Conceptual architectural approach (theme, function)

Sensual architecture is more context related, where human senses are enhanced through forces of nature. This is learning from nature. A similar theory was discussed by Alice Jones and Steven Gordon (1997) on understanding the cyclic process of nature in order to promote sustainable storm water management. The point of doing so is to obtain an intimate sense of what is important to one's psychic well-being in such processes that may then give new meaning to caring for processes in the external environment. Few example activities Jones and Gordon dictate in this regard are as follows;

- wind, wind storms - possibly in the light of experience with sailing and hang-gliding
- water, waterfalls, rain, rivers and flooding - possibly in the light of kayaking and white water rafting
- earth, dust, sand and landslides - possibly in the light of gardening, rock climbing, and caving
- wildfires, volcanoes - possibly in the expectation of light sailing

Conceptual architecture responds mainly to the function or the theme of the project and communicates the 'big idea' of the project through the composition of design elements. This is significant in conveying a message to the building user and thereby changing the mode of behaviour and line of thinking appropriately. Authors believe that when sensual architecture and conceptual architecture are combined, the built environment becomes meaningful and effective and thereby could easily achieve the intension of sustainable development. In order to achieve this 'Architects Thought Process' during the work stages of inception, concept formulation and designing stages are significant.

4. AYURVEDA-ECOTOURISM

4.1. UNDERSTANDING AYURVEDA

Ayurveda translates into English as the Science of Life (Ayur - life, veda - science). Ayurveda, originated in India, is the oldest and most developed life science of natural healing in the world. Life is the outcome of the union of body (Sharir), sense organs (Indriya), Psyche (Mana) and Soul (Atma). Ayurveda is not merely a system of Healing, but an entire way of life that aims to bring about the perfect balance of the entire personality - body, mind and spirit. Ayurveda is based on theory of tridosha of the three Biological forces - Vata, Pitta and Kapha. Disease arises when there is an imbalance among the three Doshas and aim of the therapy is to bring about the required equilibrium.

Ayurveda not only refers to the positive health of individuals but also the protection and balancing of universal masses. Response to the five basic elements of the earth (Panchamahabuth) is one such principle in Ayurveda. These elements are; Air (Akasha), Space (Vayu), Fire (Theja), Water (Jala), Earth (Pruthvi). Therefore Ayurveda promotes universal balance by responding to the forces of the earth. It is a medical system which emphasise that all being comes out of nature. That we are integral part of a whole universe and therefore have a responsibility to our source. It is a system which recognise that the five elements comes together in each individual in different combination and proportions marking each person unique in their composition of elements with their own path to balance. These differences need to be recognised and honoured, and live in harmony with the environment in order to maintain health and wellbeing in a holistic way. Healing ensures by the grace of the absolute acting through the law of nature. Many benefits could be drawn if people assist nature by living a life of balance in accordance with her law. The massage of Ayurveda is to bring about harmony between the individual and nature from which he or she arises.

The concepts which are used in Ayurveda by contrast do not originate from scientific concepts or experiments, but comes from 'direct observation of nature'. According to the wisdom of Ayurveda the mind-body has the intelligence to heal itself. The same intelligence which operates in the nature which governs the yearly migration of birds, the changing of the seasons, the flow of the tides, the orbits of the planets, also operates at the functioning of the human physiology. It is the sole function of Ayurveda to promote the flow of this great intelligence through each and every human being and the universe as a whole.

4.2. DEFINING ECOTOURISM

Ecotourism is defined by The International Ecotourism Society as "responsible travel to natural areas that conserves the environment and improves the well-being of local people" (TIES, 1990). Ecotourism is about *uniting conservation, communities, and sustainable travel*. This means that those who implement and participate in ecotourism activities should follow the following ecotourism principles:

- Minimise impact.
- Build environmental and cultural awareness and respect.
- Provide positive experiences for both visitors and hosts.
- Provide direct financial benefits for conservation.
- Provide financial benefits and empowerment for local people.
- Raise sensitivity to host countries' political, environmental, and social climate.

4.3. THE CONCEPT OF AYURVEDA-ECOTOURISM

As discussed previously on the concept of Ecotourism, it is broadly connected with conservation and sustainable development. 'Conservation' could be considered as a key point in ecotourism, where environment, bio diversity and local communities are protected and positively developed. In the arena of development, Green Economy is becoming the outstanding income source of many developing countries, where flora and fauna are used to generate money and wealth. Herbal plants are one such group of flora that plays a significant role in the green economy. If this green economy is not managed properly it would harm the bio-diversity and the universal balance of the nature.

Many numbers of Herbal plants with numerous astounding medical values are found in tropical forests of the Asian region. Sri Lanka is one such region with a vast variety of identified and unidentified medical plants. At present these herbal plants are exploited in large scale for local and international industrial purposes without proper supervision and management. Scientists and naturalists' research indicate that many plants of great value are endangered and are heading towards extinction unless taken immediate action to conserve. Therefore conservation of Herbal plants and thereby the biodiversity as a whole has become not only a national concern but a global concern.

After the three decade war, Sri Lanka is heading towards rapid development and has become an attractive destination to many international tourists. Among many reasons for being a popular tourist destination, Sri Lanka is internationally well known for the Ayurveda medical treatments. These treatments are organic and herbal plants are widely used. Therefore, the time has come to combine Herbal Plant Conservation with Ayurveda and Ecotourism and orientate development towards sustainability through the concept of Ayurveda-Ecotourism.

Along with the present day Sri Lanka National Development Policy, Ministry of Indigenous Medicine and the private sector investors are promoting many development projects that are aligned with the concept of Ayurveda-Ecotourism. As discussed in the section 1.0 above, it is important to respond to these projects not only through physical sustainability but also through psychological sustainability. The projects discussed in the section 4.2 below are viewed in this perspective.

5. CASE STUDIES

Above discussed ideas and concepts are explored through two case studies- two ongoing Architectural projects as described below:

(1) Development at Bandaranaike Memorial Ayurveda Research Institute, Navinna, Sri Lanka

Client - Ministry of Indigenous Medicine, Sri Lanka

(2) Ayurveda - Herbal Park Tourist Centre at Habarana, Sri Lanka

Client - Dr Rohan Karunarathne, AKK Engineers (Pvt.) Ltd., Battaramulla Sri Lanka

Both projects are about promoting awareness on Ayurveda and healthy living, while addressing commercial revenues and sustainable development. Architects involved in these projects have concerned the sustainable approach from the inception and the concept formulation has played a significant role in this regard. Further the projects are sensitive towards the Psychology of sustainability and therefore more focused on the primary and secondary users of the project. In both projects meaningful architecture is approached through the combination of Sensual and Conceptual architectural concepts.

5.1. CASE STUDY 1: DEVELOPMENT AT BANDARANAIKE MEMORIAL AYURVEDA RESEARCH INSTITUTE, NAVINNA, SRI LANKA

The site Navinna is in close proximity to the city of Colombo, Sri Lanka and reflects urban characteristics with a mixed development. The site is 15 Acres in extent and is lush green with a rich variety of Herbal plants. The existing Ayurveda Research Institute (under the Ministry of Indigenous Medicine, Sri Lanka) was first established sixty years ago on this site and is functioning today with a small hospital and research laboratories. In the year 2010, with the new national development policy a proposal was made to reface this institute in response to 'Ayurveda-Ecotourism' concept.

Scopes of work of the project are as follows:

A. Entrance gate development
B. Development of the foot paths/landscaping
C. Development of the pond and Buddha statue
D. Meditation Pavilion
E. Development in and around the existing main administration building
F. Development in and around the hospital
G. New five story hospital building

In response to the above discussed theories on creating meaningful architecture, Architects had put lot of effort to formulate an appropriate concept that focus on the psychology of sustainable development. The Architects "thought process" in this regard is as follows;

STEP 1

Task interpretation:

- Promote awareness about Ayurvedic and Indigenous medicine (Enhance imagery)
- Promote research on Ayurvedic and Indigenous medicine (Provide facilities)
- Promote good habits in people and uplift health (Physical and psychological)
- International attraction

STEP 2

Define the project aims and objectives:

a) "Ayurveda for All"
   - Futuristic approach to Ayurveda

b) "Urban oasis"
   - Located amidst densely built busy urban context.
   - Proposed development to cater to recreational and spiritual needs of urban residences. (morning exercise, yoga, family walk, etc.)

STEP 3

Function, user and context analysis:

It is very important for the designer to have an ample knowledge on the function, user and the context of the project. In this case, the architect studied and gained a good knowledge on basic principles of Ayurveda and its involvement in the society. Further, the Architect conducted a survey on the intended primary and secondary users of the project derived an insight to the ultimate needs of the society. Physical context was analysed in terms of the sun path, wind direction, level differences, existing plants, potential views, etc.

STEP 4

Inspirations and analysis of Precedence;

a) The theory of five basic elements - Panchamahabutha (refer section 4.1.1 above)
b) Traditional buildings in Sri Lanka (court yard houses, ancient monastic architecture, etc)
c) Green buildings in the world
d) Monumental modern buildings in the world
e) Function specific buildings (Ayurveda buildings, spas, meditational pavilions, etc)

STEP 5

Understanding the Architectural qualities to be achieved in the project:

a) Fusion of tradition and modern characteristics (sentimental yet attractive/impressive to new generation)
b) Stability, long term effect and mysterious qualities of Ayurveda
c) Reflecting/symbolising five basic elements (Panchamahabutha)
d) Sensual architecture that evoke sensational experience of the user

STEP 6

Concept formulation:

After going through the entire thought process above the Architects main concept was to create architectural qualities that reflect 'Ayurveda' with the fusion of water, fire, earth, air and space and create an attractive place with intimate spatial qualities that make a positive impressions on 'Ayurveda'.

Figure 1: Entrance Gate of the Bandaranaike Memorial Ayurveda Research Institute, Navinna

The entrance gate shown in the Figure 1 above, reflect the above mentioned concept through the composition of design features. They are as follows;

- Air and space(Akasa, Vayu) - Lightness of the roof structure and its composition to embrace air movement
- Water (Jala) - The water cascade behind the ticket counter (internal courtyard) catches the attention of the approaches through the noise of falling water
- Earth (Pruthvi) - The stone pillars on the either sides of the gate reflects the heaviness, long lasting effect and the stability of Ayurveda
- Fire (Agni) - Engraved Copper plates (Ayurveda scripture) embedded on to the timber (Kumbuk) strips on the gate reflects heat and light

Further, the overall composition of the entrance reflects the fusion of traditional and modern elements. The design not only visually communicate with the user but also address all the other senses such as the touch (variation in textures), hearing (falling water), Smell (Aroma of herbal plants), etc. Therefore, the message of Ayurveda is communicated through each and every component of the design in a holistic way.

Likewise this concept is reflected in other sections of the development to communicate the total idea of the significance of healthy living style.

5.2. Case Study 2: Ayurveda-Herbal Park Tourist Centre at Habarana, Sri Lanka

The second project is located in the dry zone in close proximity to the world heritage sites of Sigirya-the rock fortress and Polonnaruwa- the ancient medieval capital of Sri Lanka. The 14 Acre land is covered with lush greenery and has access to natural spring water during the wet season. This site has a rich biodiversity with a variety of dry zone fauna and flora and is close to an Elephant corridor.

The proposed project has three sections such as; a) Herbal park, b) Spa and Boutique resort with seven Cabanas and c) 18 room hotel.

The project is invested by the private sector with the intention of responding to concept of Ayurveda-Ecotourism. The project not only aims to obtain financial benefits but also the holistic sustainable development in the country through the wellbeing of individuals intact.

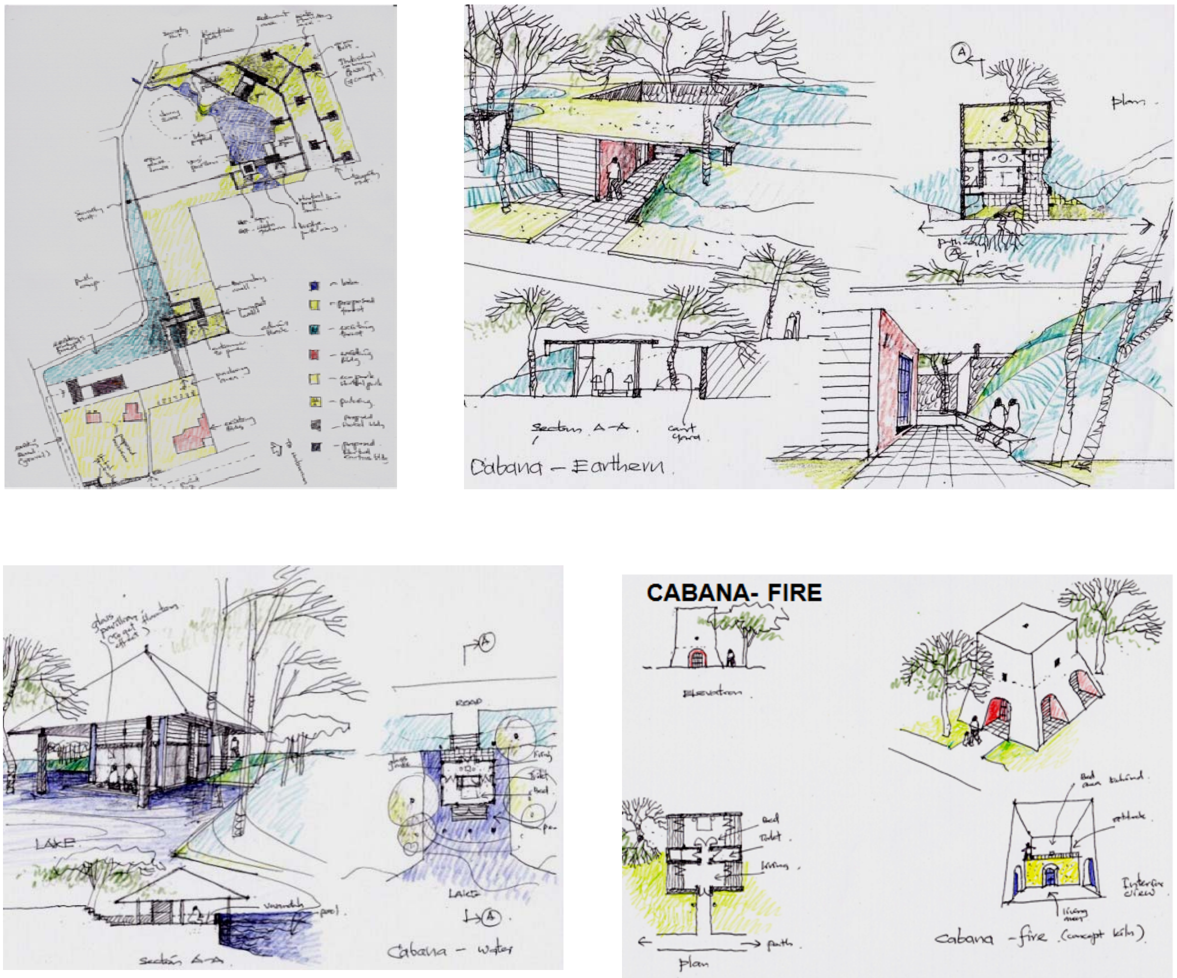

Figure 2: Habarana Site and the Proposed Master Plan

This paper would focus only on the entrance to the spa and the cabanas. Similar to the above discussed project in 4.2.2, this project also had made lot of effort to explore an appropriate concept that would make a positive impact on user psychology and on the sustainable development as a whole. Therefore the Architects thought process in this assignment was very much similar to the previously discussed project.

In addition to the inspirations drawn from the previously discussed Panchamahabuth, this project drew inspirations from the activities in the ambient environment. Few examples are as follows;

- Watch-huts on tree tops
- Elephant Kraals to keep out elephants
- Dambulla cave temple- drip ledge and the water caldron
- Kumara pokuna, Polonnaruwa – bathing pond

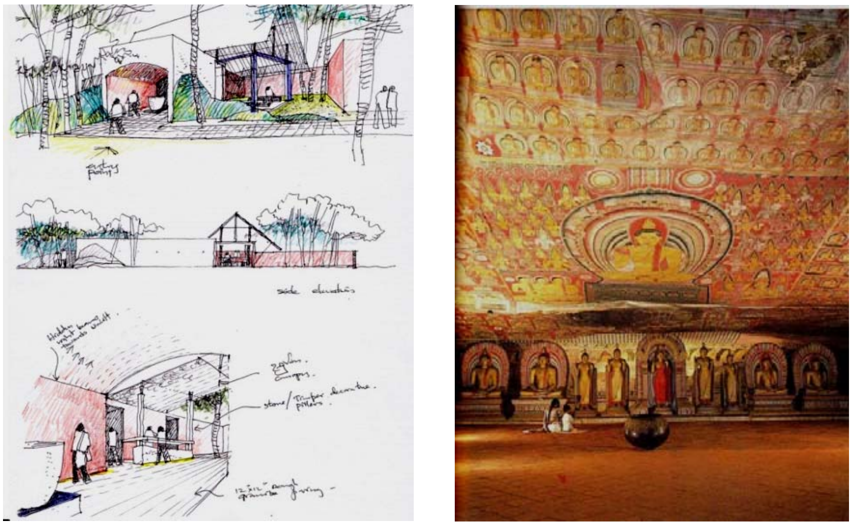

Figure 3: Proposed Entrance to the Spa and Boutique Resort was Inspired by the Spatial Qualities in the Cave Temples at Dambulle, Sri Lanka

The sound created by water drops falling in to the caldron, the cave vault, low lighting levels with mysterious qualities, unique aroma, etc found in the Cave temples of Dambulla inspired the designing of the entrance. The entrance is designed in such a way that it addresses all the four senses of the user and evokes the inner conscience that brings ultimate harmony with the ambient environment.

Figure 4: Theme Cabanas Representing Panchamahabutha Principle

Cabanas were designed to provide a variety of experiences to the user and were drawn inspiration by the five basic elements in Ayurveda.

Reflecting on this project proposal, it could be said that in this project, sensual architecture and conceptual/ theme architecture were combined to create a meaningful built environment.

6. CONCLUDING REMARKS

Meaningful built environment is significant in the process of sustainable development. This is mainly because when the created environment is meaningful and thought provoking it changes the behaviour of its user towards not only the physical sustainability but also the psychological sustainability. The creation of meaningful built environments emerge during the very early stages of inception and Architects thought process in formulating a concept plays a significant role in this regard.

This idea is explored in two on-going Architectural projects that communicate the concept of Ayurveda-

Ecotourism. Both case studies reflect the Architects approach to sustainable development through creating meaningful built environments, which demonstrate effective application of architectural theories such as Psychology of Sustainability, Sensual Architecture and Conceptual Architectural theories.

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UNDERSTANDING PROJECT CULTURE IN CONSTRUCTION: A LITERATURE SYNTHESIS

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ABSTRACT

Construction industry being a project-based industry, understanding nature of project culture is of paramount importance. Culture at project level seems less researched; possibly due to understanding of project culture seems a tedious task since it is being shaped through different levels of cultures; national, industrial, organisational, professional and many other factors situational to a given project team. However, recent past shows some studies attempting to elaborate project culture in construction context. Some researchers tend to identify construction project culture through theories of organisational culture. This paper attempts to understand nature of project culture in construction through these extant literatures and also reveals limitations of these studies. Further, the study identifies some unique features related to a construction project, which challenges identifying a unique culture at project level in construction. These main unique features include: the fixed duration of the project; adoption of traditional method of procurement; entrance of key members to the project from time to time and effective communication. Further research will aim to explore this aspect fully in the light of these challenges.

Keywords: *Project Culture, Construction, Project Team.*

1. INTRODUCTION

Construction project culture is a less researched area and, therefore, a proper definition for construction project culture has not much discussed within extant literature. An early definition given by Newcombe (1997 cited Kwan and Ofori, 2001) refers project culture as the set of shared values, beliefs and assumptions of stakeholders involved in a project. Zuo and Zillante (2005, p.357) further explains construction project culture as;

> "the shared values, basic assumptions and beliefs that the participants involved in a project hold that determine the way they process the project and the relationship with each other in the project environment."

Among several attempts to explain project culture, Kumaraswamy *et al.* (2001, 2002 cited Ankrah *et al.*, 2009) and Zuo (2008) offer some models to identify components of project culture while Ankrah *et al.*(2009) has identified some factors affecting the project culture. However, most of these studies are divergent and have their own limitations. For example; the model developed by Kumaraswamy *et al.* (2001, 2002 cited Zuo and Zillante, 2005) is very complex to understand which incorporate several components at different levels of culture. Zuo's (2008) model for construction project culture is limited to relationship contracting such as partnering and alliancing projects which are still emerging procurement methods in many countries. This paper aims to study these studies in-depth and explore possibilities of converging diverse perspectives to get a clear understanding of construction project culture. Further, this is a part of a large study intended to carry out on role of project culture on construction project performance.

This paper is structured in six sections, initially the importance of culture in construction is explained and then, the complexity of culture in construction is discussed. Next, an insight into the project culture through the study of impact of different sub-cultures is given following an explanation on project culture through organisation cultural models. Thereafter, the challenges in identifying a unique construction project culture are explained and finally, the conclusions have been drawn.

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2. IMPORTANCE OF CULTURE IN CONSTRUCTION

The construction industry is having its run through different human interactions along the design and construction phases of a construction product. Hence, behaviour of each and every individual within a project is significant to its success. 'Culture' is believed to create these differences in behaviour of the people involved. Cultural differences could create misunderstanding between people and between businesses creating risk for conflicts and dissatisfaction between construction project participants (Tijhuis, 2011). Ankrah and Langford (2005) also believe that conflicts related to human interaction could occur with cultural differences and negatively affect achieving project objectives.

Kendra and Taplin (2004), who studied on project success in IT organisations, highlighted that it is a must to develop a project management culture based on shared cultural values of the organisation's members. Accordingly, it could be argued that project culture has a role to play in success of project management. Quality management being one of the nine areas of project management, Thomas *et al.* (2002) highlight the importance of project culture in achieving quality outcomes in construction. In that, they elaborate that clan type of a culture within the project team can achieve better quality outcomes on construction projects provided that the project manager acts as a mentor by placing a premium on teamwork, participation and consensus. Project culture as explained above is not only important to achieve project success and quality outcomes, but also for knowledge management and innovation. For example, Egbu (2001) states that a favourable project culture and environment are vital if tacit knowledge are to be exploited for the purpose of innovation. Ngowi (1997 cited Pheng and Yuquan, 2002) depicts that a construction project team with members from different cultural backgrounds are more innovative than team members from similar cultural backgrounds. He highlights the importance of understanding the cultural background of project team members in project management to create a conducive environment for innovation.

Hence, diverse culture could in one hand lead to innovation and learning, while on the other hand could lead to conflicts as argued before. This will become more complex with multi-national construction projects where team members not only come from different organisations and backgrounds, but also from different countries. Therefore, it could be argued that project culture has an important role in project management and managing a project culture is important in several ways such as to manage conflicts, for quality outcomes and to promote innovation. However, understanding culture in construction is a complex task due to several reasons as discussed next.

3. COMPLEXITY OF CULTURE IN CONSTRUCTION

Both culture and construction are considered as complex. Culture is considered to be governing complex human behaviours while construction involves many and complex human activities throughout its design, production, occupation and disposal processes (Fellow and Liu, 2010). As described by Tijhuis (2011), individual human beings have collective values and behaviours creating a culture which can be recognised by analysing the social groups to whom they belong. Further, related to construction industry, he elaborates that such a social group may be considered as an industry segment, companies within the industry segment, geographical region of an industry segment or individuals within it. Analysing each of it unveil the professional culture, industry/business culture, national or regional culture and family culture respectively. These different levels of culture create a complex arena in which cultural issues are emerging and influencing behavioural interactions within construction.

Fellow *et al.* (2007) further describe that projects in construction are seen as temporary multiple organisations where members from different organisations are brought together. Hence, the projects they involve present mixes of cultures of constituent organisations and nations as well. These cultures are of complex nature due to the combination of underpinning values, manifestations of behaviour, and language. Therefore, the complexity seems to have created through the existence of different levels of culture on a construction project, which is discussed in detail next.

4. UNDERSTANDING PROJECT CULTURE THROUGH ITS SUB-CULTURES

The project culture seems to be affected by different cultures at different levels including national culture, industry culture, organisational culture and professional culture. Ofori and Toor (2009) identify the importance of understanding levels of culture and their relationship in defining the culture in a cross-cultural construction project setting. They explain that in a major construction project when members from different countries participate, it would be inappropriate to define a culture at national level because, although foreigners from different countries adopt the local culture, they still maintain some ties with their roots. This shows the impact of national culture on project culture. A similar argument has been brought forward by Evaristo and Scudder (2000) that the project culture may borrow national cultural characteristics of its team members and of its different locations. Further, Zuo and Zillante (2008), who have done a preliminary study on national culture and project culture argue that there is a clear possible link between national and project cultures while a strong project culture would override the national culture of project team members.

When a construction project team is formed with different participants from different organisations, mainly; consultants, contractors and other stakeholders, many difficulties seem to arise due to the conflicts of different business objectives and lack of sensitivity and tolerance of difference between participants which highlight the importance of understanding of organisational culture for successful project management (Fellow *et al.*, 2007). Further, Rameezdeen and Gunarathna (2003) elaborate the cultural differences between contracting and consultant organisations in Sri Lanka. According to them, consultants believe that their success depend on the development of human resources for achieving specific goals of the organisation which emphasises on a culture with loyalty, value traditions and openness. Further in contrast, contracting organisations are driven towards output maximisation where they encourage a competitive work environment and culture. Moreover, Ankrah and Langford (2005), who studied on architectural and contracting organisations, explain that major differences exist in these two organisation types not only in its structure but also in people issues. Hence, it is apparent that organisational cultures have an impact on the project culture.

Kumaraswamy *et al.* (2002 cited Ankrah *et al.*, 2009) have attempted to define construction project culture by looking at these impacts from different levels of culture. They identified 'organisational', 'professional', 'operational' and 'individualistic' sub-cultures as the principal elements that come together to evolve the culture within a construction project as depicted in Figure 1. Here they argue that **'organisational sub-cultures'** is mainly influenced by national culture and industry culture. At the same time, project culture could be affected by three other cultures: professional, operational and individual. **'Professional sub-cultures'** are influenced by factors such as the type of members, origin and history and type of task/function. **'Operational sub-cultures'** could comprise of quality culture, safety culture, and learning culture. **'Individualistic sub-cultures'** are influenced by factors such as national culture, ethnic factors, social status and religion.

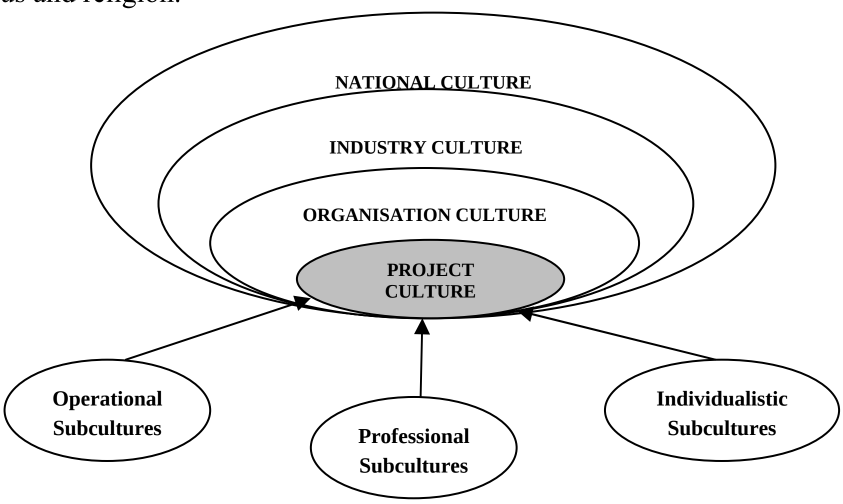

Figure 1: Sources of Typical Construction Project Culture (Adopted from Zuo and Zillante, 2005, p.357)

As explained by Kumaraswamy *et al.* (2002 cited Zuo and Zillante, 2005), a number of components contribute to each sub-culture, where one or more sub-cultures may dominate, depending on their ‘relative strengths’. Thereby, Hofstede’s cultural model (1980, 1991) could be first used to assess the culture in each sub-culture and then to assess the whole project culture. Though the aforesaid framework seems insightful, it does not make the task of identifying and investigating the drivers of culture within the project easy. Some researchers have tried to understand project culture through organisational culture models as discussed in detail in the next section.

5. UNDERSTANDING PROJECT CULTURE THROUGH ORGANISATION CULTURAL MODELS

Thomas *et al.* (2002) tried to understand cultural orientation of thirteen Australian construction projects using one of the most popular organisation culture models; Competing Value Framework (CVF) developed by Cameron and Quinn (1999). According to Oney-Yazici *et al.* (2007), the CVF is based on two major dimensions. The first dimension emphasises the organisational focus (internal versus external), whereas the second one distinguishes between the stability and control and the flexibility and discretion. These two dimensions form four quadrants (refer Figure 2), each representing a major type of organisational culture; ‘clan’, ‘adhocracy’, ‘market’ and ‘hierarchy’ which are respectively support-oriented, innovation-oriented, rules-oriented and goals-oriented.

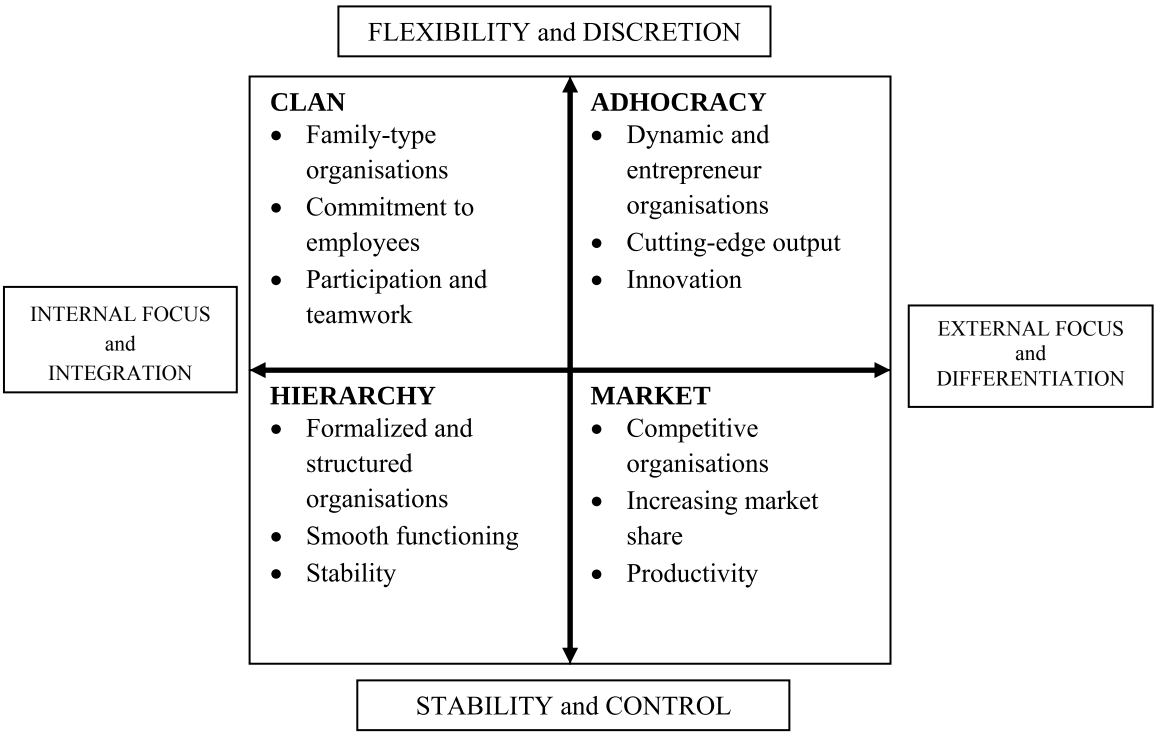

Figure 2: The Competing Values Framework
(Source: Oney-Yazici *et al*., 2007, p.522, Adopted From: Cameron and Quinn, 1999)

Using this framework, Thomas *et al.*(2002) found that projects achieving below average performance showed a strong orientation towards ‘market’ forms of culture, which are ironically, results orientated. The management styles (implicitly) inherent within this culture are focused on short-term goal attainment and project managers are ‘hard-driving’ and competitive. This type of culture focuses on the individual and his/her ability to produce. These forms are not favourable to developing co-operative, open, team environments, but rather, adversarial, conflict-ridden projects concerned with individual, or organisational, self-preservation.

Conversely, projects that produced above average results exhibited considerably weaker market characteristics while possessing strong traits associated with Clan types of organisation. These are organisations that place a premium on team cohesion, consensus and morale and are led by managers with a mentor or facilitator style where they were people-orientated. They recognised and were open and listening to the needs of the individual and the team as a whole. It logically follows that this approach to managing projects is most likely to take care of an environment conducive of proactive, committed, and open team working (Thomas *et al.*, 2002).

However, use of CVF in analysing project culture, which has originally been developed to assess the organisational culture has been criticised by several other researchers. As argued by Zuo and Zillante (2005), general management derived organisational culture models such as Competing Values Framework, have little consideration for the specific characteristics of construction projects. For example, the integration between the functional departments of one organisation, which is stressed in numerous organisational cultural models, should be modified to suit construction projects with the integration of the different functions (services) in construction projects.

Zuo (2008) has carried out research studies on project culture in Australian and Chinese construction industries combining some popular organisational culture models (e.g. Cameron and Quinn, 1999; Hofsted *et al.*, 1990 etc.) to suit construction project context. According to his proposed project culture model (refer Figure 3), project culture consists of five dimensions as; Integrative, Cooperative, Goal oriented, Flexible and People-oriented.

Project Culture	**Integrative**	Inputs of various contributing parties (e.g. design, construction, consultant. etc) are encouraged in the early stage of project process.
	Cooperative	There are few conflicts during the course of projects. Emphasis is placed on aligning the objectives of different participants and organisations to a common goal the objectives of the project. Teamwork is popular. The project participants collaborate with each other.
	Goal-oriented	More attention is given to getting the job done. The process of the project tends to be tolerated.
	Flexible	The way a project is processed is very flexible and easy to change. Innovative approaches, which include risk-taking, are encouraged and rewarded in the project process.
	People-oriented	It is high priority to develop team members' skills. No blame and celebrating achievements.

Figure 3: Proposed Project Culture Model (Source: Zuo, 2008, p.274)

However, this model has been developed for relationship contracting projects only. As described by Zuo (2008), relationship contracting or collaboration contracts are to achieve a common project objective which results in win-win situations for client and all other parties involved in the project including major features as all the parties sharing the risk and everyone being responsible for the success or failure of the project. Moreover, they explain that project culture tends to be different in different procurement methods. However, it is the traditional procurement method (where design and construction is carried out in two separate phases of the project) which is the most popular procurement method adopted in most of the construction industries (Love, 2002; Skitmore and Love, 1995). Therefore, whether the proposed project culture model is a fair representation of project culture is questionable.

Having identified specific research on construction project culture with their limitations, the next section looks into to challenges of understanding a unique project culture.

6. CHALLENGES IN IDENTIFYING A UNIQUE CONSTRUCTION PROJECT CULTURE

Numerous attempts to identify culture in construction project context are apparent in construction research arena. These include some explanations for construction project culture through the effect of different subcultures (refer Section 4) while some studies identify project culture with the aid of existing organisation cultural models (refer Section 5). However, these elaborations have their own deficiencies and assumptions. On the other hand, unique features of the construction project team setting challenges in identifying a unique project culture in construction context. This section attempts to discuss these challenges in detail.

The differences between a project and an organisation make it difficult to relate organisational cultural theories to project to understand the culture of the project. Zuo (2008) depicts some differences between a project and an organisation related to time span, uniqueness, stakeholders, team and membership hierarchy.

Among these differences, time-span seems to be affecting most to the creation of a unique culture within the project. As depicted by Tyron (2003), a general project team could take three forms; ‘Continuing Efforts’, ‘Repeating Efforts’ and ‘Single-Time Efforts’ which seems common to the construction industry as well. Real organisations are with continuing efforts where strong cultures are visible due to the nature of life time which is perpetuity. Further, Palmer (2002) describes the effectiveness of adopting a project culture in Kimberly-Clark; one of the world’s largest manufacturers of packaged goods which are adopting ‘Continuing Effort’ type of project teams. However, most of the projects in construction take the look of a ‘Single-Time Efforts’ type of projects with a fixed time span. Further, Turner and Muller (2003, p.7) provides a definition for a project as follows:

> “A project is a temporary organisation to which resources are assigned to undertake a unique, novel and transient endeavour managing the inherent uncertainty and need for integration in order to deliver beneficial objectives of change.”

Here, they also identify a construction project as a temporary organisation highlighting the characteristic of a fixed time span. Meudell and Gadd (1994), who argue on culture in general management, depict that ‘history’ is the key influence which affects culture where time allows for relationships to be built up, there is time for top management to exercise influence and for values to be created and transferred. Thereby, cultures are clearly visible with organisations due to their life span, but somewhat unlikely with a project. Further, this is an issue which seems valid for construction projects with fixed life spans. However, Zuo and Zillante (2005), in their proposed project culture conceptual framework suggest that long-term relationships with project participants is a key component of project culture in construction where there could be continuous relationships between project participants and further, clients are willing to use the same project team in their future projects as well. This challenges the common procurement methods such as separate contracts used in construction industry.

Entrance of key members from time to time is another challenge in identifying a unique construction project culture. When a new member enters to the project team, the team development process is reversed back to the earlier stages (refer Senaratne and Hapuarachchi, 2009) which is a barrier to the development of a positive culture. Further, Zuo (2008) argues that creation of a culture is deterred by key members entering the project team by time to time. Within a construction project with traditional procurement arrangement, due to its nature of the design and construction phase being separated, entrance of project team members from time to time is unavoidable. The contractor, who becomes one of the major stakeholders to the construction project team, enters to the project only after the design phase of a traditional procurement arrangement and the sub-contractors at their particular trade. Therefore, creation of a culture within such a project team is highly questionable.

Ankrah *et al.* (2009) identify that the client and contractor as dominant participants influencing project culture. Even, Zuo (2008) highlights the influence of client in creating the culture within the project team. Mainly the client's involvement is essential in relationship contracting to allocate resources throughout the project process. Further, it is highlighted that the capacity and the level of resources of the client (such as funds) directly impact the level of influence the client can exert on the project members. Moreover, Zuo (2008) depicts that this influence would not be visible in traditional procurement methods because in such procurement arrangements client will engage in the primary consultation only later the architect or the project manager will manage the project. However, Ankrah *et al.* (2009) do not indicate project manager as an influencing character for project culture in construction industry in United Kingdom. Nevertheless, Zuo (2008) identified that project manager has to take the responsibility in creating the culture within the project team. Further, Marrewijk (2007) elaborates in detail the two dominant cultural episodes in the Environ Megaproject in Otherlands, due to change of the project manager. Therefore, it is a real time example for the implementation of strong project culture by a project manager. Even as previously highlighted by Zuo and Zillante (2008), a strong culture could override the national culture.

Further, Zuo (2008) mentions that a strong culture could be created through effective communication between parties mainly through project meetings hold face-to-face. Even, Song (2008) depicts the importance of information and communication technology in creating a good team culture. In addition, Meudell and Gadd (1994), researching on the hospitality sector projects argue that a strong culture could be created in projects through proper recruitment and training. This is a further challenge considering that construction project teams are formed mainly based on technical capabilities and contractual relationships.

The next section offers the conclusions of these literature findings.

7. CONCLUSIONS AND WAY FORWARD

This review of literature aimed to understand a culture at project level in construction through the existing literature. According to the prevailing literature, it is Kumaraswamy *et al.* (2001, 2002 cited Ankrah *et al.*, 2009) who made the initial attempt to develop a model to define the culture at project level related to construction industry. However, this model is heavily criticised by other researches for being complex and difficult in adopting. In addition, there are some other researchers who have carried out different studies related to culture at project level with certain limitations such as ignoring construction project as a temporary organisation and sticking to rare procurement approaches. This is common in the work done by Ankrah *et al.* (2005, 2009); Thomas *et al.* (2002); and, Zuo (2008). Thomas *et al.* (2002) directly used the Competing Values Framework in evaluating the quality outcomes in construction project context with the underpinning assumption that construction projects possess the features of an organisation. However, Ankrah *et al.* (2005, 2009) and Zuo (2008) have tried to incorporate some of the unique features of the construction project teams during their studies. Zuo (2008) has made a fair attempt to bring forward a model for culture. However, it is limited to procurement approaches like relationship contracting which takes the nature of partnering and alliancing practices while ignoring common methods such as the traditional (separated) procurement which is more popular in construction industries in most of the countries.

It is evident through literature that there are some specific characteristics pertaining to construction projects which have been disregarded in defining the project culture by above researchers. These features of the construction projects challenge the worth of identifying a culture at construction project level. These features include: the fixed time span of a construction project; traditional method of procurement being the most popular within the industry with minimum involvement of the client; entrance of key members to the project from time to time; and, lack of appropriate recruitment and training initiatives. These features within the construction project challenge the existence of a unique culture within the project level.

However, as discussed in Section 2, it is important for construction project managers to understand the culture of their project team to improve project team performance. Hence, this study calls for more research into this aspect which considers overcoming the challenges identified due to construction project features. This will be the focus of the future research arising from this literature review.

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THE ECONOMIC COST OF LANDSLIDES IN HALI-ELA DIVISIONAL SECRETARIAT OF SRI LANKA

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ABSTRACT

Landslides which cause degradation of slopes through soil loss is one of the major climate related disasters in Sri Lanka and the highest number of landslides was recorded in Badulla district. This study attempts to identify the economic costs of landslides in Hali-Ela Divisional Secretariat Division (DSD) which recorded the highest number of displaced people in recent landslides in the Badulla District.

Primary data collected through a questionnaire was used for this study. Two stage cluster sampling technique was used to select 160 households in six Grama Niladhari (GN) divisions including Bogahamadiththa (20), Spreenweli (40), Panakenniya (20), Kandana (25), Bulatwatta (25) and Ketawala (30) from the 57 GNs in Hali-Ela DSD and the systematic random sampling technique was used to select households. Descriptive statistics, simple regression and chi-square test are used for the analysis.

Majority of the sample are in high (46.8%) and medium risk (34%) areas of landslides. Mean distance between house and the nearest recent landslide is recorded as 478m. Landslides have both direct and indirect economic costs. Regarding direct costs, mean damage cost and mean replacement cost for last five years are recorded as Rs.115,790.91 and Rs.78,954.55 respectively showing that only half of the damage is recovering. Regarding indirect economic costs, land value has been deteriorating due to landslides as found by the positive relationship between the land value and the distance to the nearest landslide using hedonic pricing approach. The uncertainty created by the risk of landslide reverses the overall development of the household (62%) including delay of housing construction (62%), agricultural activities (21.6%), road construction (9.3%) and getting electricity (5.2%).

Keywords: *Disaster, Economic Costs, Landslides, Hali-Ela, Sri Lanka.*

1. INTRODUCTION

Landslides which cause degradation of slopes through soil loss is one of the major climate related disasters in the world and it is responsible for huge physical, human and economic losses. According to Centre for Research on the Epidemiology of Disaster (CRED) (2010; cited in Akinci *et al.*,2011), landslide is the third leading disaster faced by the people in the first half of the year 2010, reporting 10% of the total disasters in the world, while flood and storms comes first and second in the disaster profile. According to United Nations University (2006; cited in Asch *et al.*, 2007), Asia reported 220 terrible landslides in past century.

Poor composition in geological structure, rock or soil formation, heavy rain, changing ground water levels are some natural causes for landslides, while changing natural slopes due to unplanned construction activities without proper engineering inputs, unplanned farming and deforestation are reported as some man-made causes (Sri Lankan-German Development Corporation, 2006). Global warming and anthropological actions are identified as important causes of landslides by Schuster (1996; Cited in Asch *et al.*, 2007).

According to Department for International Development (2005), economic losses of landslides are categorised as direct, indirect costs as well as micro level and macro level economic costs. Direct costs include physical and human capital losses, cleaning, re-establishment, reconciliation and administrative costs, while indirect costs include production and investment losses due to macro economic instability,

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reduction of the land value of the risk areas, reduction of income taxes imposed on property values, reduction of tourism income and the opportunity cost of government expenditure due to sudden disaster recovering expenditure. Micro economic cost of landslides includes the losses of household, houses, vehicles, furniture and other property equipments and cultivation. Macroeconomic loss includes influence on gross domestic product, unemployment, consumptions, savings and business.

According to Sassa *et al.* (2005; cited in Popescu and Sasahara, Undated) the economic losses caused by landslides sometimes equal or exceed the gross national products of developing countries. Economic losses of landslides recorded nearly 1-2% of the gross national products in many developing countries (Schuster and highland, 2001; cited in Asch *et al.*, 2007). Direct and indirect losses generated by landslides in Japan exceed four billion dollars (Schuster, 1996; cited in Popescu and Sasahara, Undated), while United States, Italy and India spend an annual cost between one to two billion dollars due to landslides (Sassa *et al.*, 2005; cited in Popescu and Sasahara, Undated).

According to Sri Lanka National Report on Disaster Risk, Poverty and Human Development Relationship (Draft Report for Review), during 1974 to 2008, l,174 landslide events were recorded in Sri Lanka (UNDP, 2009). Nearly nine percent of total natural disasters were landslides in Sri Lanka. There is a seasonal impact of landslides simultaneously with the two monsoons faced by Sri Lanka. Therefore, November, December and January are the months reporting higher incidents of landslides. Considering spatial distribution, the highest impacts of landslides were recorded in Badulla, Nuwara-Eliya and Ratnapura. The highest numbers of deaths due to landslides were–recorded in years 1989 and 2003. Nuwara-Eliya district recorded the highest numbers of death due to landslides (UNDP, 2009). Destruction of buildings is another impact of landslide and the highest numbers of such incidents were recorded in 2003 and 2007.The highest agricultural or crop related loss was recorded in 2007. Destruction of buildings and crop loss were high in Badulla and Kandy districts (UNDP, 2009).

This study selected Badulla district to study the economic cost of land slide, since it reports the highest property and agricultural loss (UNDP, 2009). According to the disaster information report of January and February 2011 at Badulla district, 3645 of displaces families, 13312 of displaced persons, 3 deaths, 5 injured, 1 missing person, 294 of fully damaged houses, 2517 of partly damaged houses, 70 displaced camps, 1620 of families displaced at camp, 6069 persons displaced at camps were reported due to natural disasters including landslides. Badulla district has 12 divisional secretariat divisions which are affected by landslides including Badulla, Hali-Ela, Bandarawela, Haputhale, Soranathota, Uvaparanagama, Welimada, Lunugala, Passara, Mahiyanganaya, Haldummulla and Migahakiula. Hali-Ela divisional secretariat was selected for this study, because it reported the highest number of displaced people in recent landslides in the Badulla District according to the Disaster Management Centre situated at Badulla (2011).

Accordingly, the aim of this study is to identify and to quantify the economic costs of landslides in Hali-ela DSD. Economic cost includes both direct and indirect costs. Supplementary, this study analyses the socio economic vulnerability of the people living in land slide risk areas.

2. METHODS

The study used primary data collection through a questionnaire survey. The questionnaire includes basic information on the household including monthly family expenditure, and changes in living conditions, education, employment and income profiles, information on landslides including risk of landslides, number of times affected and nature of landslide, distance to the landslide from home, knowledge and the steps were taken to prevent landslides, information on the cost of landslide including direct costs of property, agricultural and business losses and indirect cost due to risk and uncertainty created by the landslides.

Hali-Ela DS division was selected for the survey due to having the highest record of displaced people by landslides among other DS divisions in Badulla District. Two stage cluster sampling was used to select the sample. Six GNs out of the 57 GNs in the Hali-Ela DSD were selected first representing high, medium and low risk areas to the landslides. The selection was as follows: Bogahamadiththa (20), Spreenweli (40), Panakenniya (20), Kandana (25), Bulatwatta (25) and Ketawala (30). The systematic random sampling technique was used to select the final entities (160 households) from each cluster as given above. A

Sample Survey was carried out in September 2011.

Descriptive statistics were mainly used for the analysis including frequencies, cross-tabulations and means. The hedonic pricing approach was further used to see the indirect cost of landslides through the reduction of land value in the affected area. The hedonic pricing method is commonly used to see the reduction of property values (economic costs) due to natural disasters. The simple regression between land value per perch (as dependent variable) and the distance to the land slide or landslide mark (as independent variable) was applied to see the indirect cost of landslides through the reduction of land values due to landslide risk according to above approach. Chi square test is further used to see the relationship among the variables of distance to landslide, nature of risk, total cost; self stated life status, knowledge on landslides, delay of the family development and willingness to pay to prevent landslides in future.

3. RESULTS

Results and discussion is mainly consisted with sample characteristics including household and family profile, land use, climate and land slide profile, direct and indirect cost of landslides and the impact of landslide on land value.

3.1. SAMPLE CHARACTERISTICS: HOUSEHOLD AND FAMILY PROFILE

The sample includes 160 households with 593 family members. Out of the total number of households, 133 (83%) have faced landslides, while 27(17%) have not faced any within the last five years. Considering the distribution of sample among races, 59 percent of the sample is represented by Sinhalese, while 34 percent and 7 percent are Tamils and Moor respectively. The proportion of landslide victims among the Sinhalese community is lower than that of the Tamil and Moor communities. Considering the household and family profile of sample, the mean age of the household head is 47 years and according to the sample the mean number of family members is 4 persons (Table 1).

The educational level of the household head is another important consideration in relation to the vulnerability of people. The percentages of pre-secondary and post-secondary educated household heads (35 percent in each category) are higher than in other education categories. While 22.3% of household heads are primary educated, 5 percent and 3 percent respectively belong to no schooling and tertiary groups of education (Table 1).

The economic profile of the family is further taken into consideration by this study. Per capita income and per capita expenditure are some important economic variables considered in the study. In terms of the research sample, 68 percent of the sample has Rs. 6000 or less per capita income, while 92 percent have reported Rs. 6000 or less per capita expenditure. Poverty lines are normally derived by using per capita expenditure because the accuracy of expenditure data is believed to be higher than the income data (Table 1).

Table 1: Sample Characteristics

Ethnic Group	%	Education of the head of the household	%	Per-capita income/ per capita expenditure	Income	Expenditure %
Sinhala	59	No Schooling	5	2000 or less	16	23
Sri Lanka Tamil	26	Primary	22	2001-4000	29	57
Indian Tamil	8	Pre- Secondary	35	4001-6000	23	12
Muslim	7	Post-Secondary	35	6001-8000	19	3
Total	100	Tertiary	3	8001-10000	5	2
Family members	%	Total	100	More than 10000	8	3
1	6	Employment Status of household head	%	Total	100	100
2	13	Employment	58			
3	26	Unemployment	13	Mean values in Sample profile		Mean
4	29	Self Employed	21	Mean Age of the Head of the household		47
5	19	Retired or economically inactive	8	Mean Number of family members		4
6 or more	7			Mean Per capita income (Rs)		5334
Total	100	Total	100	Mean Per capita Expenditure(Rs)		3232

According to the per capita expenditure, poverty in the area was identified. The Poverty line for Badulla district (DCS, 2012) derived by the Department of Census and Statistics in September was used to categorise poor and non poor group. This poverty line was Rs. 3217 of per capita expenditure. According to this expenditure, 64.4 percent of the sample is in poverty, and 42.4 percent of poor are living in highland risk areas. In order to consider the relative poverty of the family, a direct stated question on the nature of the change in life status was asked. Nearly half of the sample (48%) responded that their living status has been deteriorating or stagnating during the last 5 years (Table 2), while 39 percent of the sample believed that the living status of their family is better than that of other families in the same living area.

Table 2: Absolute and Relative Poverty

Poverty	Criterion	%
Absolute Poverty according to per capita expenditure (Less than Rs. 3217)	Non Poor	35.6
	Poor	64.4
Relative poverty (Living status in last 5 years)	Increase	51.9
	Decrease	29.4
	Stagnating	18.8

Regarding employment status of the household head, 58 percent of household heads are employed, while 21 percent were self employed and 13 percent unemployed. Moreover, 81 percent of employed household heads represent private sector employment (formal private-27% and informal private-54%), while 19 percent represent government or semi government sector.

3.2. LAND USE, CLIMATE AND LAND SLIDE PROFILE

Land use pattern in the area is an important phenomenon regarding the risk of landslide. Land use of the selected area was basically classified for agriculture, livestock production and for construction. Construction is the prominent land utilisation in selected area, while half of the lands in the area was utilised for agriculture (Table 3). Tea, Paddy and the mixed crops are the leading crops, out of which mixed crops were the leading component. There is a high risk of landslides in the areas with high soil erosion and crops like tea would affect high soil erosion in the mountain areas. Crops cultivated in neighbour lands could also resulting landslide risk. Mixed crop and tea cultivation are the leading agricultural activities in the nearby area (Table 4). Regarding climate, rainfall is an important factor dealing with landslides in the area. According to people, the duration from November to February has the highest rainfall in the area, and the risk of landslide is also high during this period. The natural slope of the land is also a significant factor in relation to the frequency of landslides. Out of the land in the selected area 25 percent were very steep, 15.2 percent steep, while 50 percent of lands have low slopes and 9.8 percent have very low slopes.

Table 3: Land Use Pattern

Land use Patterns	Each from 100%
For Crops	48.8
Livestock Production	7.5
Constructions	98.1
Other	0.6

Table 4: Types of Crops

Type of Crop	% of land from selected households	% of land from nearby
Tea	8.1	40.8
Paddy	15	10.9
Mixed crop	21.9	48.3

Distance to the most recent land slide is another key indicator of landslide risk. Among the sample, 78.1 percent lives closer to landslide risk; within half kilometre from the landslide feature. Mean distance between house and the nearest recent landslide is recorded as 478m. Therefore the selected sample reports very high risk of landslides (Table 5).

According the Figure 1 topples and lateral spreading are the leading types of landslides in the selected area, while 21 percent of people have experienced a mix of several types of landslides.

Table 5: Distance to Recent Landslide Features

Distance to the Recent Landslide or land slide sign in Meters	%
500 or less	78.1
501-1000	8.8
More than 1000	13.1
Total	100.0

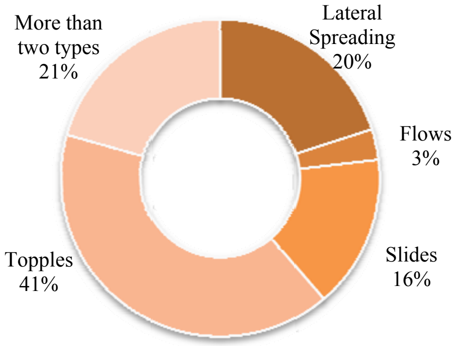

Figure 1: Type of Landslide

Terms of incidence shows the probability of the landslide disaster. According to Figure 2, 87 percent of people have faced landslide incidence once within the last five years. However the situation of the rest is very pathetic with a high frequency of such disaster incidences. According to the ideas of the residents, majority of the sample are in high (46.8%) and medium risk (34%) areas of future landslides.

Landslide risk is pre-identified by using several clues, which is apparent in the area related to the physical resources. The most common feature seen in the area is wall cracks in many houses, while 56.6 percent of households have identified landslide risk using wall cracks. Leaning lamp posts were seen in some places. However this was not much a prominent clue in the area. Two or more of such marks related to landslide give a sign of landslide risk to 29.2 percent of people (Table 6). With such a higher risk, people in the area still live in the risk area and have no expectation of leaving the area.

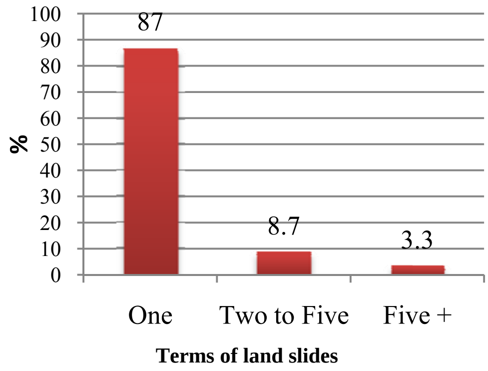

Figure 2: Terms of Landslides within Last 5 Years

Table 6: Method of Pre Identification of Landslide Risk

Method of pre identification of landslide	%
Leaning lamp posts	4.7
Wall cracks	56.6
Other	9.4
Two of the above	29.2

Land use, climatic and landslide profiles were comprehensively discussed in this section to see the nature of landslide risk in the selected area.

3.3. *Direct and Indirect Cost of Landslides*

The economic costs of landslides are identified as macroeconomic and micro economic costs and as direct and indirect costs. This study is basically based on micro economic cost analysis in relation to household level information. Total direct cost of the landslide includes total damage cost, total replacement costs and total preventive costs. Out of the sample, 52.5 percent of households have responded for the cost or expenditure due to landslides during last five years, and majority of them have (45.5%) expenditure equals or less than Rs.20,000. 32.1 percent of the households spent more than Rs.100,000 due to landslides last five years (Figure 3).

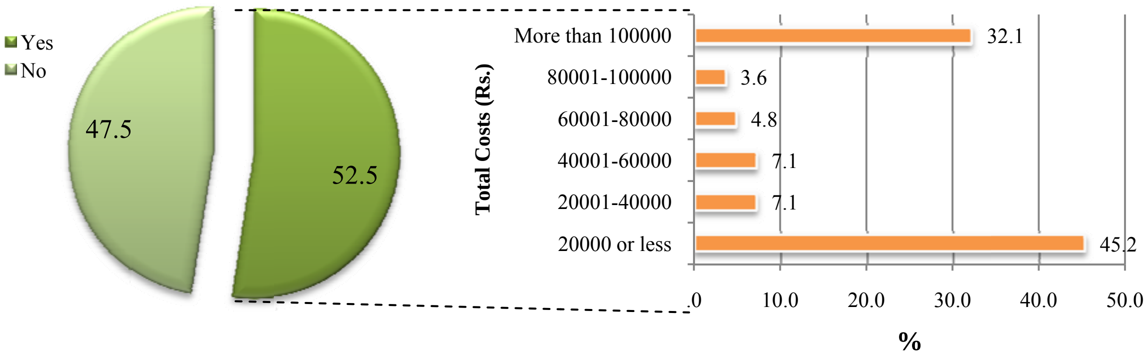

Figure 3: Total Direct Costs of Landslides

Self stated damage costs given by the respondents, which are divided as property damage (including all damages for housing and related constructions, vehicles, furniture, electronic and other equipments), agricultural damage (including the loss of harvest and damages for the field setting of the cropped area) and damage for businesses during last five years were given in Table 7. Then highest number of households stated on property damages and the highest mean cost of damage were also recorded in relation to property damages, while damage for businesses come second.

Table 7: Type of Damage and Replacement Costs Due to Landslides During Last Five Years

Type of Damage	Damage Value		Replacement Value	
	% Yes	Mean Rs.	% Yes	Mean Rs.
Property Damage	31.3	125580.00	18.8	83850.00
Agricultural Damage	3.8	9083.33	1.9	13333.33
Damage for Businesses	1.3	17500.00	0.6	50000.00

Table 8: Preventive Cost Due to Landslides

Type	Preventive Cost Yes %	Mean Rs.
Construct drain and stone ridges	16.3	58884.62
Concrete	5.0	9062.50
Other	8.1	7846.15

Table 9: Total Cost Due to Landslides

Type	Stated Costs Yes (%)	Mean Rs.
Total Damage Cost	34.4	115790.91
Total Replacement Cost	20.6	78954.55
Total Preventive Costs	28.8	37076.09

Replacement costs included all recovery expenditure to retain damaged items. Highest percentage of replacement costs are related to property replacements. When comparing mean damage and replacement costs, nearly half of the damage cost was replaced by the households in the area for property. The pattern of highest mean replacement cost is very similar to damage costs, while property replacement is the leading component (Table 7).

Regarding expenditure for preventive techniques, 16.3 percent have spent on construction of drain and stone ridges. Putting concrete and some other techniques were further used in the area in order to prevent landslides. The highest prevention cost was spent for the construction of drain and stone ridges for last five years (Table 8).

According to Table 9, the highest percentage of households faces the damage cost while the second highest expenditure is reported as preventive costs. 68% of the mean damage costs were spent for the replacement, and nearly half of the mean replacement has been spent as mean preventive costs.

In terms of willingness to pay to prevent landslide risk, 49 percent of households express their consent to do so. The majority of this group like to spend Rs 1001-1500 as Willingness To Pay (WTP) while the second highest group of people mentioned that they would like to pay more than 2000 rupees per year to prevent landslide risk (Figure 4).

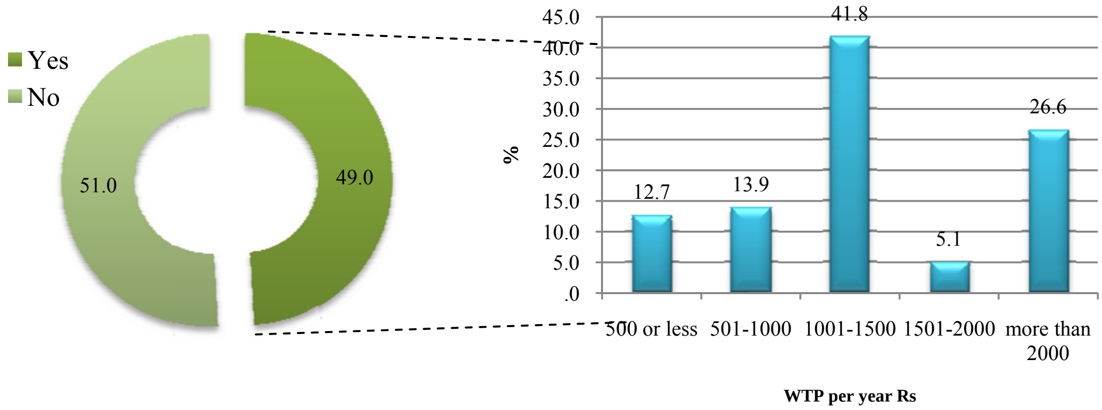

Figure 4: Annual Willingness to Pay (WTP) to Prevent From Landslide

Indirect cost of landslides included the cost of uncertainty, insurance cost and the reduction of land values. The uncertainty created by the risk of landslide causes to reverse the overall development of the household (62%) including delay of housing construction (62%), agricultural activities (21.6%), road construction (9.3%) and getting electricity (5.2%) (Figure 5). Most of the people have the uncertainty if they will be resettled by the government in another area which is safe or if the government would make safer environment for them in the same area. When they planned for the new construction or cultivation this has become a problem and this uncertainty always has a huge opportunity cost of waiting time for a solution for the disaster they faced.

Regarding life insurance, only 7.7 percent of respondents have such insurances (Figure 6), while half of them were covered from Ceylinco insurance packages. Monthly instalments of most of them are less than 1000 rupees.

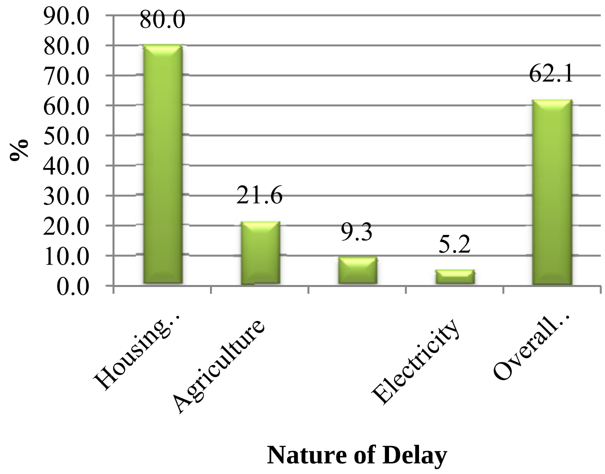

Figure 5: Delay of the Development of Household Due to Risk and Uncertainty of Landslide (Each from 100%)

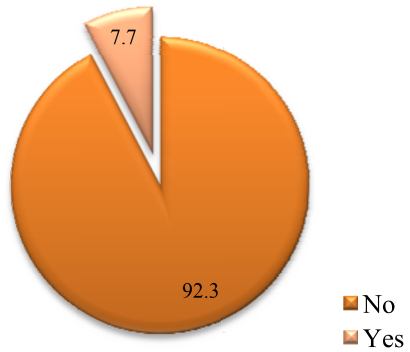

Figure 6: Having Insurance

The reduction of land value is a key indirect cost due to landslide disaster. That is explained in section 3.4.

3.4. Impacts of Landslide on land Value: Hedonic Price Approach

Table 10: Simple Regression of Distance to Recent Landslide in Meters on Land Value per Perch

Variable	Coefficient	Standard Error	P Value
Constant	15456.792	961.397	0.000
Distance to recent landslide in meters	3.083	1.039	0.003

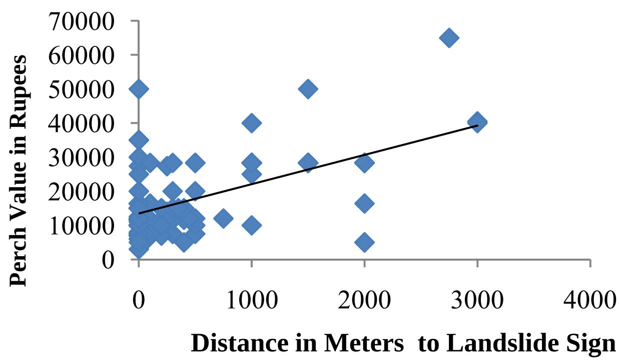

Figure 7: Scatter Plot

$Land\ Value = 15456.792 + 3.083\ Distance$

The relationship between the land value and distance to nearest landslide is derived as given above by using the simple regression model. The scatter plot drawn by using the selected variables is given in Figure 7 to see the relationship between two variables. According to Table 10, the model explains a positive significant relationship between land value and distance to the landslide. The land value decreases from Rs.3083 when distance is decreased by one kilometre to the landslide.

3.5. REASONS TO LIVING WITH LANDSLIDE AND FUTURE EXPECTATIONS OF VICTIMS

Although 83 percent of the households in the sample have faced a land slide within the last five years, they are not willing to leave the risk areas due to various reasons. The majority, 79.3 percent of households according to Table 11 are not willing to leave risk areas due to the unavailability of a land to shift, while 37 percent and 6.4 percent have financial problems and influence of relations respectively for being in the risk areas.

Table 11: Reasons for not Leaving Risk Area

Reasons for not leaving the place	Yes%
Influence of Relations	6.4
No land to shift	79.3
Financial problems	37.9
Other	9.2

Table 12: Future Expectations to Live in the Same Area

Future Expectation To live in the area	Yes (%)	No (%)
Household head	81.0	19.0
Children of the household	71.8	28.2

According to Table 12, 81 percent of the current generation as well as 71.8 percent of future generation expect to live in the same risk areas.

3.6. FACTORS RELATED WITH LANDSLIDE RISK, TOTAL COST AND WTP

Chi-square tests, which are further used to identify important factors related to landslide risk, total cost of landslides and willingness to pay to prevent from landslide risk is given in Table 13.

Table 13:Chi-Square Test to Seek the Factors Dealing with Landslide Risk, Cost and WTP

Relationships between variables	Chi square Value	p
Distance to the landslide and ethnic group	25.195	0.000
Distance to the landslide and delay of the family development	15.635	0.000
Distance to the landslide and knowledge on landslide	6.096	0.047
Nature of risk and total costs	24.417	0.007
Nature of risk and ethnic group	31.817	0.000
Nature of risk and self stated life status	29.592	0.000
Nature of risk and knowledge on landslide	16.394	0.000
Nature of risk and delay of the family development	5.641	0.060
Nature of risk and delay of agricultural development	5.055	0.080
Nature of risk and delay of road construction	10.422	0.005
Nature of risk and the nature of crop in the land nearby	32.345	0.000
Total cost and knowledge on landslide	15.911	0.007
Total cost and delay of the family development	11.194	0.048
Total costs and number of terms affected last year	20.062	0.029
WTP for landslide and self reported life status	18.827	0.016
WTP for landslide and Slope type	29.956	0.003

Table 13 gives significant factors related to land slide risk, cost and WTP using chi-square test at 5% and 10% significant levels. Distance to landslide has significant associations with ethnic groups, delay of the family development and knowledge of the landslide. Nature of risk is related to various factors such as total cost, ethnic groups, self stated life status, knowledge of landslides, delay of family and agricultural development, delay of the road construction and the nature of crop in the land nearby. The knowledge of land slide, delay of family development and number of terms affected in last year are related to the total cost during last five years, while self reported life status and slope type are related to WTP.

4. SUMMARY

The aim of this study is to identify the economic costs of landslides in the Hali-Ela DS division in the Badulla District of Sri Lanka. Out of the total sample, 83 percent has been facing landslide risk. Tamil and Moor communities live in high risk areas to landslide than the Sinhalese in the selected sample. This should be further concerned in policy making. Out of the total sample, 64 percent are poor and live in more vulnerable areas to landslides. Land was mainly utilised for agriculture, livestock production and for constructions. Mixed crops were leading among agricultural land. Moreover, 78 percent of people live very close to landslides; within half a kilometre. Topple and lateral spreading are the common types of landslides in the area. The key sign to identify the risk of landslides is wall cracks. Both direct and indirect costs are considered here regarding economic costs of landslides. Damage costs are higher than replacement costs and prevention costs are nearly half of replacement costs. Property damages are leading in damage and replacement costs, while the cost of the construction of drains and stone ridges is the key component in preventive costs. Nearly half of the households have willingness to pay to avoid landslide issues. Regarding indirect cost, the cost of uncertainty due to landslides is a key issue in the area. When distance to the landslide increases from one kilometre, the value of one perch of the land will increase from Rs.3083 showing the indirect cost of landslide through land value. The main reason for not leaving the area is the absence of land to shift. Most people in the current generation and the children representing future generation do not expect to leave the area due to this risk. Total costs, knowledge, development of the household were highly affected by nature of risk to landslide and the total cost was dependent on knowledge and the frequency of incidence last year. WTP was affected by the slope of the area and the life status of selected household.

The above findings of the study have important implications for disaster management practice and procedures in Hali-Ela Divisional Secretariat Division in Badulla District with high landslide risk. Since the majority of them are poor people, they have less empowerment to have self decision to shift from the risk area. Therefore disaster management authorities should directly involve for the process of resettlement of these communities. Even though people are vulnerable with the risk, the majority of them do not like to move there since their economic activities are located in the same area. Therefore, the resettlement process should further consider the economic resettlement of people. Dissemination of knowledge on landslides should be further enhanced to reduce damage caused by landslides, while disaster management authorities should further consider ways in which it could obtain community participation for risk reduction.

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LEAN CONSTRUCTION IN LARGE CHINESE CONSTRUCTION FIRMS: A SWOT ANALYSIS

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ABSTRACT

In recent years, there has been a growing trend in applying lean principles outside of manufacturing. In the construction context, lean construction has become an established theme since the early 1990s. However, very limited studies are reported about its implementation in Chinese construction industry. This study undertakes a SWOT (strengths, weaknesses, opportunities, and threats) analysis of large Chinese construction firms, evaluating their potential strengths, perceived weaknesses as well as external opportunities and threats associated with the application of lean construction. This study is qualitative in nature. Using interview questions, face-to-face interviews were conducted with 27 Chinese building professionals from large construction firms in China. It highlights several constraints, ranging from lack of understanding of lean construction; to hierarchical organisational structures that discourage empowerment, use of low skilled workers and a high tolerance for an untidy workplace, and others. The opportunities are realised through government's push to upgrade firms' standards; role of jianli, collaboration with foreign construction firms, and promotion of prefabrication. Furthermore, intense competition, highly-demanding clients, rising material prices, and others are some of the foreseen threats to the adoption of lean construction. This study concludes with some suggestions to improve lean construction implementation in China. These include the establishment of a long-term philosophy and organisational culture that would call for leaders to be more pro-active on the jobsites, to understand the work flow, and to encourage foremen to be committed in work plans. It is also important to introduce, educate and reinforce the lean knowledge to the employees at all levels as they are the real implementers of lean construction.

Keywords: *Lean Construction, SWOT Analysis, Chinese Construction Firms.*

1. INTRODUCTION

In line with China's GDP growth, China's construction industry is booming. During a boom period, concerns about poor quality, inefficient operations, low profitability and others are however frequently heard. Reportedly, the performance of many Chinese construction firms is behind that of international counterparts (Xu, *et al.*, 2006). Lean construction, which aims to eliminate wastes from the construction process and to maximise value to clients, is worthwhile to be promoted at this point. It is an innovative construction management approach which is linked closely to the overall life of the project to ensure project success. The purpose of this study is to examine the strengths, weaknesses, opportunities, and threats (SWOT) affecting large Chinese construction firms which are considering implementing lean construction. This paper concludes by providing technical and management viewpoints on the subject.

2. FROM LEAN TO LEAN CONSTRUCTION

Simply put, lean construction is an attempt to apply lean production principles to the construction industry. The principles of lean production originated in the Toyota Production System (TPS), which can be traced back a few decades. It then became a popular recipe which revolutionised the manufacturing industry through its management philosophy and practices. Not only manufacturing companies, but also construction firms have begun to embrace lean thinking concepts and strategies (Egan, 1998) and the associated tools (Salem *et al.*, 2006; Höök and Stehn, 2008). Generally, there are two schools of thought which have emerged in association with the development of lean construction. One view has largely relied on Koskela's (2000) work, which makes use of production views (i.e. transformation, flow, and value

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generation) in the construction context and in order to conceptualise lean construction. The other school of thought is led by Ballard (2000) and his colleagues, who developed the Last Planner System™ (LPS) to encourage the use of lean principles in a more practical way at the project level. For example, LPS demands planning actions from the frontline foreman or last planner who "pulls" the work, depending on their actual capacity to perform. In addition, there are other works of lean construction based on lean thinking (see Egan, 1998), as originally outlined by Womack *et al.* (1990) and further elaborated in the book Lean Thinking (Womack and Jones, 1996), in which the guiding principles of lean thinking are summarised as value, value stream, flow, pull, and perfection.

1. Value: value can be defined by the end customer, where the customer can be considered to include all downstream operations. It can be applied in the construction context by focusing on client's value. Diekmann et al. (2004:92) outlined that customer focus has little to do with the commercial terms of the contract, but to do with the concept that the customer receives value both from the product and the process of construction.
2. Value stream: the value stream involves analysing three types of actions, namely activities creating value, activities creating no value but determined to be unavoidable, and activities creating no value and determined to be avoidable.
3. Flow: flow is the next step to be considered once waste and variations have been eliminated, and the value stream has been streamlined. Flow is the opposite of batch and queue. The goal of flow is to have a product move from concept to customer, without interruption or delay. In construction, Koskela (2000) developed a number of heuristic practices from the flow principle, including reducing variability (standardisation), increasing process transparency (visual control), and others.
4. Pull: pull is closely related to the "pull system" that is another important aspect of Just-in-time. The end user pulls the production, such that a product is only produced to suit the requirements, and thus avoids overproduction and reduces inventory.
5. Perfection: this indicates that there is an end to how much better a process can become through the constant application of lean methodology. This is very similar to the Japanese concept of *kaizen*, which is often interpreted as continuous improvement in the West.

3. THE CHINESE CONSTRUCTION INDUSTRY

Much has been written about China's construction industry and its leading contractors. In contrast to the West currently in recession, China is still undergoing huge infrastructure growth and urbanisation processes, aimed at building a moderately prosperous society. Projections suggest that the Chinese construction market will be worth almost US$ 2.4 trillion in the next decade, which represents 19.1 per cent of global construction output (Xinhua, 2009). Leading Chinese construction firms are expected to play bigger roles. Although the number of state-owned enterprises (SOEs) has decreased in recent years (Wang *et al.*, 2006), during the transition period, they have continued to maintain their leading positions in the domestic market. These state-owned construction enterprises have fully demonstrated their leading positions by the fact that, despite their smaller numbers and their fewer employees, they achieved 36.5% of the total output of construction value, and contributed 27.5% of the total taxes paid to the central government (National Bureau of Statistics of China, 2009:43). In the international market, according to Reina and Tulacz (2011), Chinese construction firms, including the China Railway Group, China Railway Construction Corp, and China State Construction Engineering Corp continued their reign at the top in the rankings of ENR's top 225 global contractors in 2010, and also reappeared on the 2011 list. Among these large construction firms, this study focuses on general contractors with the capability of planning, designing, and research and development, because these capabilities are similar to those of a typical manufacturing company, in which lean concepts might be applied.

4. SWOT METHODS

4.1. SWOT ANALYSIS

SWOT analysis is widely accepted as an important methodology in guiding a company to formulate a competitive business strategy. It aims to identify the company's strengths and weaknesses, as well as the opportunities and threats to it in the external environment. Generally, SWOT analysis is done by benchmarking, that is, comparing one's performance with the best in the industry, or with the best anywhere in business (Johnson and Scholes, 2002). Hence, it is appropriate to use SWOT to analyse the large Chinese construction firms in the lean construction context.

4.2. SWOT IN CONSTRUCTION

SWOT has become an increasingly popular analytical tool adopted by researchers in the construction industry. For instance, at the firm level, Lu *et al.* (2009), Zhao and Shen (2008), and Ling *et al.* (2009) used SWOT methods to examine Chinese international construction companies, foreign construction companies in China, and Vietnamese A/E/C firms, respectively. Moreover, there are also reports that used SWOT to investigate individual construction firms. For example, one of the largest Chinese construction firms, China Communications Construction Company (CCCC)'s SWOT analysis was published in Datamonitor*'s (2011) database. At the project level, Milosevic (2010) undertook a SWOT analysis from both the investor's and the contractor's viewpoint in the planning, contracting, and construction of a project. In the following section, a similar SWOT methodology will be employed to investigate the gaps which exist in large Chinese construction firms, based on lean construction practice. SWOT is an appropriate approach to use, given that lean construction is known to be associated with change, both organisationally and culturally (Egan, 1998; Höök and Stehn, 2008). SWOT analysis can be an effective tool in a timely manner to identify the specific strengths and weaknesses of the firm, which may be relevant to changes taking place, and capable of dealing with them (Johnson and Scholes, 2002). It is also important for Chinese construction firms to reflect upon their strengths and weaknesses when they decide to implement new management initiatives such as lean construction. Furthermore, SWOT is normally employed in qualitative research (see Zhao and Shen; 2008 and Ling *et al.*, 2009). Lu *et al.* (2009) assert that the widespread survey fatigue as well as the requirement of in-depth information is the reason to pursue SWOT research in the construction industry through interviews and/or case studies. This is the case too in lean construction research, where researchers like Senaratne and Wijesiri (2008), Diekmann *et al.* (2004), and others used survey to explore the applicability of lean in construction. This study however evaluates the SWOT factors, which were derived from the interviews to also serve the same purpose.

5. RESEARCH METHODS

Interviews with open-ended questions were the main method used in the SWOT analyses in other earlier studies (Zhao and Shen, 2008; Ling *et al.*, 2009). This was also adopted in this study. This is because in the process of probing questions, respondents were required to provide in-depth answers. Given that the interview was semi-structured with open-ended discussions, the interviewees were encouraged to explain in more details if an individual aspect is of particular important. The data collection began with interviewing several Chinese building professional who are known to the researchers. At the end of the interviews, they were asked to recommend others with the same criteria to participate in this study. The recommended candidates were then contacted and interviewed. This method of sampling is known as snowball sampling in qualitative research. When agreement to a meeting was secured, face-to-face interviews were conducted in the interviewees' offices. The interviews were conducted separately. As a result, 27 participants from 16 large Chinese construction firms were contacted to participate in this research between March and April, 2011 in China (see Table 1). A majority of the Chinese building professionals interviewed are from Chinese State-Owned Enterprises (SOEs). The sample consists of 17 site staff (e.g. project managers and engineers) and 10 management staff (managing directors, deputy managers, and vice presidents).

* Datamonitor is a leading business information company specializing in industry analysis.

Table 1: Profile of Interviewees and Their Firms

No.	Code	Designation of interviewees	Grade	Ownership
1	A	1 Project Manager	Premier	SOE
2	B	1 Engineer-in-Charge	Premier	SOE
3	C	1 Engineer-in-Charge, 1 Site Engineer, and 1 Commercial Manager	Premier	SOE
4	D	1 Project Manager, 1 Managing Director, and 1 Contract Manager	Premier	SOE
5	E	1 Project Director and 1 Deputy manager	Premier	SOE
6	F	1 Manager, 1 Head of Engineering Management Department, and 1 Project Manager	Premier	SOE
7	G	1 Vice President	Premier	SOE
8	H	1 Manager	One	SOE
9	I	1 Regional Manager	Premier	SOE
10	J	1 Project Manager	One	Private
11	K	1 Vice President	Premier	SOE
12	L	1 Site Engineer	Premier	SOE
13	M	1 Project Manager	Premier	Private
14	N	2 Project Manager and 2 Site Engineers	Premier	Private
15	O	1 Site Engineer and 1 Quality Engineer	Premier	SOE
16	P	1 Project Manager	Premier	SOE

Note: 27 interviewees in total.

6. FINDINGS OF THE SWOT ANALYSIS

This section presents the findings of the SWOT analysis, highlighting constraints, potentials, and challenges for implementing lean construction for large Chinese construction firms. Based on the literature review and the structured interviews during the fieldwork in China, the SWOT analysis brings out some of the peculiar features in terms of lean construction practices in China (see Table 2).

Table 2: SWOT Analysis of Large Chinese Construction Firms when Implementing Lean Construction

Strengths	**Weaknesses**
• Skilled and capable management teams (i.e. at project level) • Sufficient resources (materials, labour, etc.) • Meeting of client expectations, and firms becoming more customer oriented	• *The short-term oriented firm culture* • *The use of "guanxi" to solve problems* • Hierarchical organisational structures discourage empowerment • A lack of awareness of lean construction among practitioners • *Use of low skilled workers and a high tolerance for an untidy workplace*
Opportunities	**Threats**
• Government support and calls for change • Role of *jianli* • Collaboration with foreign construction firms • Slow adoption of prefabrication	• The intense competition among construction firms • The highly-demanding clients • Rising raw material prices • The separation of design and construction • Employee resistance • High turnover

It is acknowledged that some of the attributes presented in Table 2 are in the first instance more generic in nature for both the construction industry as well as the construction firms. Nevertheless, prior consideration of these generic attributes is vital to better understand why certain lean construction practices are viewed as more significant than others in China. The reasons why some firms have implemented lean construction practices cannot be isolated from generic happenings in the construction industry to affect the Chinese construction firms.

6.1. STRENGTHS

The term "strength" identifies resources or capabilities of a firm in implementing lean construction practices. The strengths of the large Chinese construction firms in terms of implementing lean construction practice lie in the following areas:

- Skilled and capable management teams (i.e. at project level)
- Sufficient resources (materials, labour, etc.)
- Meeting of client expectations, and firms becoming more customer oriented

In the first place, the large volume of construction undertaken every year in China allows many project teams to understand technology and construction management in a meaningful way. It is worth mentioning that a number of mega-projects have been undertaken by some of the responding firms, including Olympic games venues and Shanghai's World Expo, to name a few. Through participating in big projects like these, they acquired and enhanced their management skills in planning, quality control, design coordination, and others. With their leaders' enhanced skills, the likelihood is increased for lean construction to be successfully implemented.

Secondly, all the responding firms highlighted that they have a database of qualified suppliers, subcontractors, and vendors across China, and the number of their working partners is increasing. A multi-sourcing strategy is prevalent, which ensures that the contractors enjoy a sufficient supply of materials or equipment, even if one supplier fails to meet the requirements, so others can then be quickly counted on as a backup. Additionally, in the case of the frontline workforce supply, several of the interviewed firms claimed that endeavours have been made to establish relationships with selected Chinese counties which are well known for labour outsourcing. Training centres were set up in such places, where basic skills are provided before workers are sent to the projects. Besides, they also built their labour sources into three layers, based on the ability and skill sets. In other words, they maintained appropriate level of skilled, semi-skilled, and average-level workers, respectively. Such a flexible labour resource structure can easily accommodate the varying needs of projects.

Lastly, the interview results revealed that client expectations are the top priority of most of the firms interviewed. This is not simply because clients exert power over them, but most firms realised that meeting their requirements is the key to winning future projects from the clients. Given that clients are satisfied with the performance of the responding firms, several of the interviewees pointed out that their firms have therefore become the clients' long-lasting working partners, and continued to receive business from these clients.

6.2. WEAKNESSES

Despite the above-mentioned strengths, it is easily recognised that some notable weaknesses still exist in large Chinese construction firms concerning the application of lean construction. These include weaknesses in firm culture, organisational elements, and people. Five key weaknesses are particularly evident:

- The short-term orientation of firm culture
- The use of "guanxi" to solve problems
- Hierarchical organisational structures discourage empowerment
- A lack of awareness of lean construction among practitioners
- Use of low skilled workers and a high tolerance for an untidy workplace

To begin with, a core difference between the firms implementing lean and Chinese construction firms rests in the firm culture (i.e. short-term or long-term). It is worth mentioning that the success of lean construction is dependent on a firm culture that encourages training, teamwork, commitment, and long-term relationships, and that is able to support and sustain the implementation of such concepts. It should be very clear that implementing lean is an on-going journey, which requires the commitment of top management. On the Chinese side, however, things might be quite different. As highlighted by a few interviewees, several so-called new management initiatives including Just In Time (JIT), TQM, PDCA thinking, and others have been proposed and implemented, but ended up as unsuccessful experiences. The biggest problem is the lack of a long-term philosophy. This is again confirmed by the interviewees that short-term thinking somehow prevented construction firms from investing in people through training and skill development. Firms may take the lowest price offer from the suppliers without considering whether to establish long-term relationships with them.

Secondly, using "guanxi", or the Chinese practice of building relationships in problem-solving slows down the implementation of lean construction. In a lean environment, such as in Toyota, the culture encourages the workers to expose problems. They treat problems as opportunities, and so they then decide to halt production and not let the problem pass into the next process (*jidoka*); they examine the root causes and quickly fix it in a way that will prevent repeat occurrences in future (Liker, 2004). In Chinese construction firms, as revealed by several interviewees, the attitude towards problems is usually understood as "*turn big problems into small ones, and small ones into no problems at all*". In parallel to Paolini et al.'s (2006) observation, project managers may adopt a quick solution rather than to investigate the root causes. In addition, it is more important for the managers to find a person to take responsibility and to be blamed, than to focus on problem-solving countermeasures.

Thirdly, implementing lean construction involves exercising a great deal of empowerment. The adoption of the LPS self-evidently shows that empowerment is the key here, as the contractor needs to allow the frontline workers to make their own commitments as to what they can deliver, and to highlight them in weekly plans with the relevant participants. Yet, in China, traditional organisational structure is still hierarchical, which prevents empowerment to be widely adopted. This is in line with Tang et al.'s (2009) finding where empowerment was poorly rated as a key factor to the successful implementation of TQM in China's construction industry. This is confirmed by several interviewees that at the project level, project managers do not often empower their frontline workers to undertake planning work, but demand them simply to execute what have been planned from the top.

Furthermore, low awareness of the lean construction concept among practitioners is yet another problem, not only among construction firms, but also among the suppliers, subcontractors, and clients. The main reason is that they may not be aware of the concept and the associated lean tools, but in reality, they are actually practicing some of the underlying principles, just that was known under this different vocabulary in the Chinese context. This therefore requires more efforts to promote lean construction principles in the same language, and to ensure that all the practitioners understand, especially those regarded as belonging to the extended firms (e.g. suppliers, subcontractors) of the main construction firms.

Lastly, lean construction in China faces equally challenging workforce issues, especially in the case of frontline workers who work only temporarily on project sites. As pointed out by most interviewees, unlike the workforce in the developed countries such as USA or Japan, where the workers are very skilled in various trades, the Chinese construction industry is staffed by low-skilled workers who picked up their skills informally, or even commenced their works without any formal training. If a firm's skill development and training is absent, it is close to impossible for them to effectively identify the non-value-adding activities, and to continuously improve the construction process as their Japanese counterparts can. Instead, they just cut corners and make things easier in their work. Apart from the low skills set, Chinese frontline workers have no problems working in an environment which makes an overall impression to the public of being dirty, messy, and chaotic. This is partly due to their high tolerance for an untidy and disorganised workplace, which is counter to the principles of 5S, a visual control programme that is essential to any lean initiatives, and which is also promoted by lean construction.

6.3. OPPORTUNITIES

There are opportunities stemming from the assumption that lean construction practices can be implemented within large Chinese construction firms. These include:

- Government support and calls for change
- Role of *jianli*
- Collaboration with foreign construction firms
- Promotion of prefabrication

Firstly, as noted, a large number of large construction firms are state-owned enterprises (SOEs), which have close association with the central government. The strategies and plans of such firms are overseen by the government. If lean construction is appreciated by top management, the chances are high that it will benefit from government support, so that specified allocations of funds and materials can be received from official government sources. Moreover, the government has put forward an agenda for improving the management level of firms, and has highlighted that the business and project management of Chinese construction firms must be standardised, normalised, and fine-tuned at all stages of the management process (Ministry of Housing and Urban-Rural Development, 2008:40). Such a strong call is an opportunity for construction firms, as the principle of standardisation - also a key element of lean initiatives - is evidently part of the government's agenda.

Secondly, the role of *jianli* – known as supervision firms – is very unique in China that became compulsory in 2001. This aims to ensure that the construction work is carried out according to relevant stipulations, laws, and regulations (Wang et al., 2009). The main duty of *jianli* is to monitor whether a contractor's quality programmes, safety plans, and others are put in place (Wang et al., 2009). Although extensive quality controls are now widely adopted, which is actually counter to the principle of "building in quality" in any lean initiative, *jianli* has somehow gained experience in assisting construction firms to put quality management into practice. This has laid a much-needed foundation for the adoption of lean construction, because it shares some similarities with TQM (i.e. customer focus and continuous improvement). It is worth noting that all the firms interviewed have already implemented quality management programmes, and with that added supervision from *jianli*, they may find it less difficult to adopt lean construction, since their previous experience can serve as a valuable exercise. Moreover, this opens an opportunity for *jianli* to upgrade their skills and to take on a role as a lean champion or an agent for change in assisting construction firms to promote the lean construction concept in the industry.

Thirdly, the increased involvement of international construction firms in China represents another opportunity. As the interview results revealed, three responding firms have had experience in working with their Japanese counterparts, and they were deeply impressed by the authentic Japanese management style, which pays much attention to details, commitments to quality, schedules and other elements. It is said that these international construction firms have brought not only competition, but also management know-how from the developed countries into China.

Furthermore, another opportunity for lean construction in the Chinese context is the growing adoption of prefabrication methods, especially in the housing sector. Prefabrication minimises on-site operations, while promoting more construction works to be pre-constructed in a manufacturing environment, where lean principles can be applied to a larger extent. On the brighter side, both the prefabricated materials and the methods related to them are being heavily promoted in China. One video clip, titled "*30-story building built in 15 days – construction time lapse*", from YouTube in January, 2012, showcases how a 30-storey hotel can be built by a Chinese construction firm in 15 days (Broad Group, 2012). Moreover, it is also comforting to see that several responding firms have strategically invested heavily in prefabrication; one private firm (firm N) states that their focus on prefabrication is reflected in its firm mission, which is set out as "*from construction to manufacturing*". This ambitiously reveals their next move and their commitment to prefabrication technology. In a more practical way, this firm has set up a research centre for prefabrication. But, the threat here is that clients or construction firms may resist change, so much so that conventional methods of construction are still being widely adopted.

6.4. THREATS

Impediments to the future implementation of lean construction practice in China's construction industry need to be evaluated and analysed. The interviews with Chinese building professionals revealed several common threats in implementing lean construction practices, including:

- The intense competition among construction firms
- The highly-demanding clients
- Rising raw material prices
- The separation of design and construction
- Employee resistance
- High turnover

Firstly, a majority of the interviewees pointed out that fierce competition is one potential threat. Several interviewees from private firms especially acknowledged that strong competition from large SOEs and others have eroded their market share and therefore forced them to seek out the emerging market in the western region of China. Competition indirectly threatens large construction firms in adopting lean construction, since their revenues and profits are affected. In order to win the work, it is common to see some bidders deliberately lowering their costs by compromising on quality, and increasing revenue later through claims or by subcontracting some portions of the project to unqualified subcontractors at a price that is much lower than the contracted price (Wang, *et al.*, 2009). The greatest threat comes from their working partners (e.g. subcontractors) who are short-sighted in the corporate sense. It is particularly true that some subcontractors may not be competent for the works and, worse, may have different philosophies of conducting businesses, including less commitment to quality, schedule, and the customer. This will quickly hinder the implementation of lean construction.

Secondly, almost all the firms interviewed pointed out that highly demanding clients have become another serious threat too. The root problem is that the binding force of contracts in China is so weak that clients can exert their power intentionally. It is not uncommon to see clients changing the contract even when everything was already "agreed" earlier. For example, clients drastically reducing the project delivery time is a common occurrence in China's construction industry. Even large construction firms can do nothing but to accept this practice, because they are afraid of jeopardising their relationships with the client. In order to deliver the project on time under such time pressure, the "locked milestone" strategy is widely adopted for specific portions of the project. This gives subcontractors and specialised trades locked-in deliverable dates in which the given tasks or packages must be completed. If these are not completed, large penalties would be imposed. In such cases, some interviewees pointed out that it is not possible to "pull" the work from the workers, and the majority agreed that their commitments at this point are unreliable. Hence, a top-down approach is preferable, and the plan is generated from the project team in the absence of any concerns from the frontline workers and foremen.

Thirdly, the interviewees also pointed out that the unstable prices of raw materials, including steel, cement, and others have been a cause of concern in more recent years. Similar to the stock market, the prices of some of these materials fluctuate even on a daily basis. Even so-called long-term partner suppliers or vendors will demand price increases on materials, in order not to lose money. Because of this, construction firms are largely discouraged from adopting the "pull" concept. Rather, in order to minimise the risk of price increases, most responding firms preferred to stockpile materials, and this explains the large piles of materials stocked on the site.

Fourthly, several interviewees also pointed out that less in-house design, or limited design and build process is another potential threat that needs to be addressed. An absence of design and build is generally regarded as reflective of a slow adoption of lean construction (Johansen and Walter, 2007). Under design-bid-build, the contractor is generally appointed at a very much later stage where it has much less opportunity to influence the design. This eventually leads to more communication and coordination being required in the construction stage between the Chinese design institutes (CDI) and the contractor to verify the design specifications, and to evaluate these in greater details.

The last two threats identified are employee resistance and high turnover. The success of lean construction, like any other lean initiatives, requires a culture change within the firm. For example, lean construction may change the way the current planning process is conducted at the project level. It may also bring about more workloads if the concept of multi-skilling is introduced, or in order to minimise the non-value-adding activities by employing prefabrication techniques. One manager from firm B mentioned that,

"In the case of prefabrication techniques, the client should be on board and that is the key. In addition, given that our trades are so similar with what they are currently doing at the site, it might need a long time for them to accept the change and take the prefabrication method."

The later concern involves the turnover of employees, including frontline workers. The interviewees revealed that large Chinese construction firms, especially SOEs are perfect workplaces for fresh graduates to begin their career, and after a while they typically use it as a stepping stone to seek a more respected position elsewhere. Moreover, the turnover at the site level is more frequent, as frontline workers are tempted by higher wages, even if this is a minor increase. This creates serious threats to the continuity of implementing lean construction since training is required for employees and workers. Several interviewees highlighted that their projects have suffered from productivity loss as a result of this high employee turnover. In addition, when workers leave, they take away the value of the firm's training.

7. DISCUSSION

The SWOT analysis highlights an overall picture of the positive aspects of implementing lean construction, as well as the key challenges that may hamper its implementation in the Chinese construction industry. The rule of thumb is to take advantage of the strengths that large Chinese construction firms currently possess, eliminate the weaknesses as much as possible, seize the opportunities, and counter the potential threats. At first glance, some of the SWOT results appear to be generic, to even overlap with other research. However these do reflect the practices of large Chinese construction firms that are relevant to lean construction. "Sufficient resources" identified in the "strengths" is one such example. Hence, "sufficient resources" become one of the strengths of large Chinese construction firms since endeavors have been made to enhance their database of qualified suppliers, vendors, and subcontractors, so that a sustained supply of cheap materials, manpower and other resources can be assured. By the same token, it should be noted that the pull system is not able to work effectively when there are inconsistencies in material supply. Despite the strengths highlighted, there are clearly some tough decisions for large Chinese construction firms to make before they can truly embark on their lean construction journey. Since the negative aspects (mainly weaknesses and threats) have been addressed, what follows is a call for strategies which should facilitate the implementation of lean construction in China. In the case of weaknesses, these have generally been categorised into three areas: firm culture, organisational elements, and people. For instance, the establishment of a long-term philosophy depends on management's commitments and actions that consistently reinforce the objectives deriving from it. These objectives must be elevated to the same level of priority as the financial and profits oriented objectives which enterprises hold today. Strategies here may call for leaders' frequent *genchi genbutsu* or the Japanese way of "go and see for yourself" to visit site at the project level, to ensure that objectives are well understood and executed. Moreover, it is very challenging to ask managers to empower their workforce and subcontractors to make daily plans under time pressure from clients. This is not simply because of management leadership style, but because the culture is such that the project managers do not want to be blamed for the empowerment that results in project delays. If this is the case, it again requires project managers and their teams to be more proactive on the site, to understand the work flow, labour productivity, among other things, to monitor more diligently how the project progresses, and to ensure that tasks only commence on the condition that all necessary inputs are already in place. Lastly, in response to the low skill levels of workers, although training may sound cliché at this point, for the large number of the workers who are unskilled, the construction firms must introduce, educate, and reinforce basic lean knowledge to their employees and workers, starting from waste elimination, or build-in quality, or cleanliness practices (5S). The *jianli* can also be utilised to assist in facilitating the awareness of lean, rather than simply focusing on quality control and health and safety issues. The important notion here is that the implementation of lean construction comes from the people – the employees who should be aware of implementation, should care about it, and should be committed to it. Moreover, as employees' skills improve, so should their pay, especially in the case of frontline workers. This is because they are most concerned about their daily paycheck. If this is satisfactory to them, it will become an effective way to retain the workforce, and efficiency improvements can be expected.

Fundamentally, the threats existing in China might be more complicated than elsewhere, and therefore may require extra efforts to handle them. Implementing lean construction can easily be a long-term endeavour, since several factors pertain to the industry's inherent problems and structural issues. It requires government support and promotion, as well as efforts on the part of the firm. For example, in the case of the separation of design and construction, this has in fact drawn serious attention from the government. Earlier in 2007, an investigation by a taskforce from the Ministry of Housing and Urban-Rural Development (MOHURD, 2008) has pointed out the low levels of adoption of design and build (DB) in China's construction industry. Meanwhile, it is necessary for contractors to develop their in-house design capacity, and to call for the early participation of the relevant stakeholders. Moreover, to successfully implement the lean construction initiative, it is necessary that employees support it and not resist it. A stable workforce is also an essential factor. Chinese construction firms need to re-evaluate their human resource management strategies, and to find ways to minimise resistance and retain their workforce.

8. CONCLUSIONS

Despite the significant achievements of large Chinese construction firms in recent years, in the current economic recession, it is important for them to adopt advanced management practices, such as lean construction, in order to improve project performance. Understanding the strengths, weaknesses, opportunities, and threats of large Chinese construction firms helps them to look at the prerequisites for the implementation of lean construction. It is worth mentioning that although the interviews were conducted separately, the overall analysis must of necessity be conducted collectively to provide consolidated findings at the industry level. Hence, the SWOT analysis highlights the overall responses from the large Chinese construction firms. Nonetheless, in the case of assessing the importance and/or urgency of issues in each of the SWOT components, different results may technically be possible for each and every one of the leading Chinese construction firms. Despite all the weaknesses and threats highlighted above, the SWOT results are not intended to discourage the practitioner from implementing lean construction practice until all prerequisites have been met and the time is ripe. In contrast, it is still strongly recommended that large Chinese construction firms consider giving immediate attention to lean construction practice, with efforts targeted at working on the weaknesses identified. Lean construction is not a destination; it is a journey.

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A PRELIMINARY LITERATURE REVIEW INTO LEAN CONSTRUCTION IMPLEMENTATION

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ABSTRACT

Although all activities expend cost and consume time, Lean Principles state that only conversion activities add value and these should be made more efficient, whereas non value adding flow activities should be reduced or eliminated. Research into these lean principles in construction has found that considerable waste lies in flow processes of construction. By eliminating waste activities, processes can become 'lean' which provide 'more with less' resources. These flow wastes are recognised as a major weakness, which hinder performance and efficiency in the Construction Industry. Previous studies conclude that the construction industry workforce is ignorant of these flow activities that create waste and hinder construction performance.

However, the industry lacks an implementation framework to implement lean principles into the construction processes. This research aims to develop such an implementation framework through action research study for Sri Lankan construction contractors and achieve long-term sustainable benefits by becoming lean. The research is in its initial stage and the aim of this paper was to explore the literature on how LC is implemented in different contexts in construction industries in the world.

The findings reveal several benefits when applying lean principles in construction such as reduce sharing of non-value adding activities increase the output value through systematic construction of customer requirement and reduce process variability. The paper finally identifies the few barriers for implementing lean principles and provides some guidelines on how to overcome the identified barriers for effective implementation of lean principles.

Key words: *Implementation, Lean Principles, Construction Industry, Literature Review.*

1. INTRODUCTION

Construction project delivery system consists of three domains; the contract, the project organisation and the project operating system (Thomsen *et al*., 2010). Within the typical project structure the parties involved in a project such as Client, Contractor and Designer generally worry about their own interests and communication which usually occur along contractual lines. Singleton and Hamzeh (2011) stated that over the past 20 years, innovations have brought major changes to the project organisation and commercial terms, such as Design and Build and Partnering. However, these changes have done very little to improve construction in terms of efficient use of labour, equipment, and material. The project operating system has been largely neglected in construction. Thomas *et al*. (2010) revealed that this situation contributes significantly to inefficiency and waste and lead to construction's low productivity rates. In recent past, researches have put greater focus on developing ways in which a construction project operating system can be improved and one such method is known as Lean Construction (Singleton and Hamzeh, 2011).

First, the paper explains the implications of the lean principles, and how when taken together they result in different ways to manage construction activities. Second, the literature on lean construction

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implementations are explored in different construction settings. Third, their effectiveness together with benefits offered and implementation issues are investigated. Implementing lean in construction in any setting then becomes a matter of developing and acting on this already available knowledge and good practices. It is hoped that the key literature findings arising from this stage, will assist to develop a conceptual implementation framework using lean principles for the construction process.

2. LEAN CONSTRUCTION

Although all activities expend cost and consume time, Lean Principles state that only conversion activities add value and these should be made more efficient, whereas non value adding flow activities should be reduced or eliminated (Koskale, 1992). Similarly, Ballard and Howell (2003) stated that lean constriction is aimed to maximise value and to minimise waste of money, time and materials. Lean construction is a concept still new to many construction industries in the world (Senaratne and Wijesiri, 2008). All construction activities can be divided into two; *conversion activities* which produce tangible and flows activities which bind such conversion activities during the delivery process of the output. Research into these lean principles in construction has found that considerable waste lies in flow processes of construction. By eliminating waste activities, processes can become 'lean' which provide 'more with less' resources (Womack and Jones, 2003). Further, Salem and Zimmer (2005) defined that lean construction is a continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire value stream and pursuing perfection in the execution of a constructed project.

2.1. UNDERSTANDING WASTE

When focusing on waste, attention is on what is not needed. So, it is easy to lose sight of value what the customer wants (Mossman, 2009). Further, he states that when there are more demanding problems or emerging waste, the initial waste that was aimed to eliminate can re-emerge. The waste emerging cycle demonstrated in Figure 1 illustrates when focused on waste elimination, how it gets into an oscillation in which the amount of waste increases and decreases. This pattern can be seen very clearly on construction sites. For example, when one trade falls behind, a special pressure is put on to catch up. Pressure is then reduced as attention shifts to another trade that is now more behind. Now in the first trade things slip again and the, pressure is increased again. Therefore, Mossman (2009) stressed that value should be focused rather than waste. Focusing on the value is more rewarding and more effective. Value is delivered and waste is eliminated or perhaps not even created in the process.

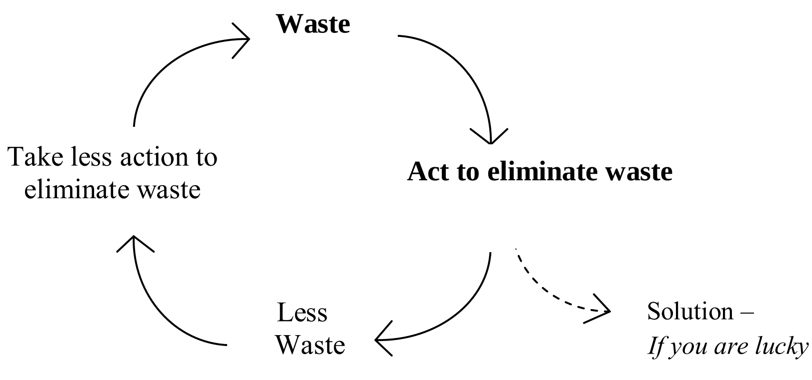

Figure 1: Waste Elimination Cycle (Source: Mossman, 2009)

Waste that generate in flow activities are recognised as major weakness, which hinder performance and efficiency in constriction activities. Several authors including Cornick (1991), Austin *et al*. (1994), and Koskela *et al*. (2001) have discussed the main causes for the poor performance of building design process are poor communication; Lack of adequate documentation; Deficient or missing allocation; Lack of co-operation between disciplines; Unbalanced resource allocation; and, Erratic decision making. Lean principles argue that waste could be eliminated by certain techniques which provide more value with fewer resources. These are discussed in the next section.

2.2. *Lean Techniques And Their Implementation In Construction*

Several lean techniques were developed for Manufacturing Industry by many authors. These are summarised in Table 1 and their implementation in construction industry is discussed next.

Table 1: Lean Construction Techniques

Lean Techniques	Definition	Application
Last Planner (LP)	Production Planning and Control system implemented on construction projects to improve planning and production performance (Hamzeh, 2009)	LP has been created to maximise reliability of the work /material / information flow to minimise waste in time / money in project processes and to maximise customer value (Ballard and Kim, 2006)
Just In Time	JIT is a Japanese management philosophy which has been applied in practice since the early 1970s in many Japanese manufacturing organisations. It was first developed and perfected within the Toyota manufacturing plants by Taiichi Ohno as a means of meeting consumer demands with minimum delays (Monden, 1993)	JIT manufacturing has the capacity, when properly adapted to the organisation, to strengthen the organisation's competitiveness in the marketplace substantially by reducing wastes and improving product quality and efficiency of production. (Cheng and Podolsky, 1993)
3D Models	3D modelling is the process of developing a mathematical representation of any three-dimensional surface of object via specialised software. The model can also be physically created	The use of 3D models for improving constructability has typically included model based design and coordination by combining multiple models into one and running clash detection (Staub-French and Khanzode, 2003)
Increased Visualisation	The increased visualisation lean tool is about communicating key information effectively to the workforce through posting various signs and labels around the construction site. Workers can remember elements such as workflow, performance targets, and specific required actions if they visualise them (Moser and Santos 2003).	This includes signs related to safety, schedule, and quality. This tool is similar to the lean manufacturing tool, Visual Controls, which is a continuous improvement activity that relates to the process control
Value stream mapping	A value stream map is a comprehensive model of the project that reveals issues hidden in current approaches (Howell and Ballard, 1998)	Value stream maps can be identified as Process Flow Charts that identify what action releases work to the next operation.
Stopping the line	Stopping the line in manufacturing prevents the release of defective work down stream	Planning at the assignment level is the place to “stop the line” in construction to assure a reliable flow of work and no defective assignments are released downstream (Howell and Ballard, 1998)
Reverse Phase Scheduling (RPS)	RPS is a pull technique is used to develop a schedule that works backwards from the completion date by team planning (Ballard and Howell, 2003)	Phase scheduling is the link between work structuring and production control, and the purpose of the phase schedule is to produce a plan for the integration and coordination of various specialists’ operations.

Huddle Meetings	Two-way communication is the key of the daily huddle meeting process in order to achieve employee involvement.	As part of the improvement cycle, a brief daily start-up meeting was conducted where team members quickly give the status of what they had been working on since the previous day's meeting, especially if an issue might prevent the completion of an assignment (Schwaber, 1995).
Make it flow	Product components should be in constant motion, that is without stopping	In construction, this may mean repackaging work so that parts of the project can proceed without completion of others (Howell and Ballard, 1998)
Kaizen	Kaizen is a system of continuous improvement in quality, technology, processes, company culture, productivity, safety and leadership	Kaizen implicates cost reduction and zero defects in Final Product
Five S	5S is a set of techniques providing a standard approach to housekeeping within Lean (Kobayashi ,1989; Hirano, 1998)	Visual work place: a place for everything and everything in its place It has five levels of housekeeping that can help in eliminating wasteful resources
Fail Safe Quality	Shingo (1986) introduced Poka-yoke devices as new elements that prevent defective parts from flowing through the process. Generation of ideas that alert for potential defects.	Fail safe for quality relies on the generation of ideas that alert for potential defects. This approach is opposed to the traditional concept of quality control, in which only a sample size is inspected and decisions are taken after defective parts have already been processed
Off site manufacturing (OSM) **Prefabrication**	OSM is largely seen as offering the ability to produce high-volume, high-quality products based on the efficiencies of general manufacturing principles common to many industries (Cooperative Research Centre for Construction Innovation, 2007)	Manufacturing and assembling process, whereby, construction components are made at a location different from the place of final assembly, under specialised facilities with different materials. May lead to better control of the inherent complexity within the construction process
Target Value design	TVD is a management practice that seeks to make customer constraints drivers of design for the sake of value delivery (Ballard, 2011)	TVD is a method that assures customers get what they need (where it is valued by customers) and also a method for continuous improvement and waste reduction (Ballard, 2011)

Last Planner is a lean technique that has four main processes: Master Schedule, Phase Schedule, Look ahead plan, and Weekly plan (Hamzeh, 2009). Many researchers have proved reducing plan variability helps increase productivity. Alarcon *et al*. (2006) suggested a regression line between plan reliability and production and Alarcon *et al*. (2006) showed difference in productivity after implementing Last Planner. In construction, the effective point of intervention has proven to be the Weekly Work Plan, because that is where work is selected and commitments are made, and the key to reduction of uncertainty is improving the ability to keep commitments through better selection of work to be done (Howell, 1994).

With **the pull approach**, the concept of **just in time** is utilised in construction wherein the inventories are kept to the bare minimum and new inventories are ordered based on the current demand (Ballard and Howell, 1998). Stocking of material is wasteful. Its implementation requires good relationship with suppliers.

According to Egan (1998), Pacific Contracting of San Francisco, a specialist cladding and roofing contractor have used the principle of lean thinking to increase their annual turnover by 20% in 18 months. The key to this success was improvement of the design and procurement process in order to facilitate the construction site. They used a computerised ***3D design*** system to provide better, faster information provides isometric drawings of components and interfaces, fit co-ordination, planning of construction methods, motivation of the work crews through ***visualisation***. Further Khanzode *et al*. (2005) states that having a constructible design, reduces the amount of contractors' requests for information and change orders related to field changes. Additionally, MEP (Mechanical, Electrical and Plumbing) contractors are able to use more prefabrication which improves productivity on site and improved safety. And also, Staub-French *et al*. (2003) revealed that 3D models can be used for accurate quantity takeoff. When quantities are taken off manually there is lot of waste in construction process because quantity takeoff needs to be performed each time the design is updated. **3D models** can produce quantities automatically based on a means and methods database.

In the building sector, it has been customary for architects to work with customers to understand what they want, then produce facility designs intended to deliver what's wanted (Ballrad, 2011). The cost of those designs has then been estimated and too often, found to be greater than the customer is willing or able to bear, requiring designs to be revised, then re- estimated. This cycle of design – estimate – rework is wasteful and reduces the value customers get for their money. Cho and Ballard (2011) further stressed that cost, time, location and other constraints are conditions that must be met in order to deliver value to customers and implementation of ***Target Value Design*** has also consistently resulted in the delivery of projects faster and under budget, both market benchmarks and project targets.

Current practice in construction generally ignores or accepts large inventories or backlogs as the natural consequence of the commercial situation. According to Howell and Ballard (1998), lean works to eliminate those places where value adding work on material or information is interrupted. The Lean principle ***Make it Flow*** says that value development and therefore product components should be in constant motion that is without stopping. In construction this may mean repackaging work so that parts of the project can proceed without completion of others and / or assure that resources are delivered in order required directly to the installation location.

According to Kobayashi (1998); Hirano (1989) Seiri (Sort) refers to separate needed tools / parts and remove unneeded materials (trash). Seiton (Straighten or set in order) is to neatly arrange tools and materials for ease of use (stacks/bundles). Seiso (shine) means to clean up. Seiketsu (standardise) is to maintain the first 3Ss and develop a standard ***5S's*** work process with expectation for the system improvement. Shitsuke (sustain) refers to create the habit of conforming to the rules. Spoore (2003) indicates that 5S is an area-based system of control and improvement. The benefits from implementation of 5S include improved safety, productivity, quality, and set-up-times improvement, creation of space, reduced lead times, cycle times, increased machine uptime, improved morale, teamwork, and continuous improvement (kaizen activities).

Howell and Ballard (1998) revealed that ***Value stream mapping*** brings choices to the surface and raises the possibility of maximising performance at the project level. Normally maps are prepared at the project level and then decomposed to better understand how the design of planning, logistics and operations systems work together to support the customer value.

According to Koskela (1992), a specialist who transforms his/her perception on the client requirements i to Design Decision Previous researches confirm that the adoption of lean principles facilitate manufacturing through increasing productivity, reduction of manufacturing space, improving quality and safety, reducing lead time, reduce human effort, reduce investments in tools, reduce engineering hours to develop a new product and ultimately increasing of sustainability values. Vilashini *et al*. (2010) argued that many problems persistent with ***Prefabrication*** Production Process can be solved or reduced by adopting lean principles.

Terry and Smith (2011) state that taking a construction company, lean involves two significant paths; best people and the systems in place to control them. Figure 2 illustrates theses two paths.

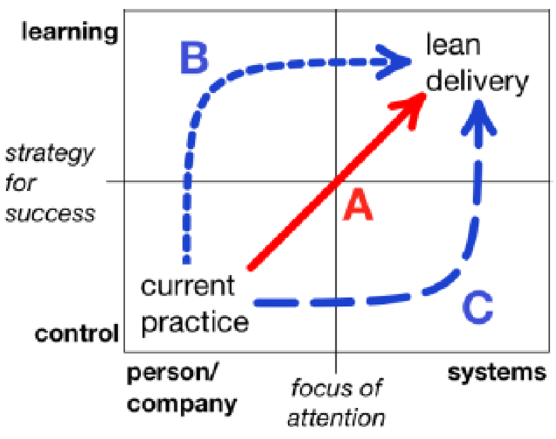

Figure 2: Paths to Implementation (Terry and Smith, 2011)

However, Howell (2011) argues that "successful transformations in my experience begin with action and study and lean construction focused on improving systems instead of individual motivation and training rather than control". According to Howell and Ballard (1998), both construction and manufacturing require prototyping that is the design of both product and process. Thus, implementing lean production does not require making construction manufacturing by standardising products, rather implementation starts by accepting the ideal of perfection offered by lean and understanding the application of each principle and technique to construction. Implementation of lean means adopting a "project-as-production-system" approach to construction.

On the whole, there is sufficient evidence on implementation of above discussed lean techniques in construction. However, some are implemented without the awareness on 'lean philosophy' and as a requirement of a quality assurance procedure. Hence, it is important that construction companies rethink about implementing lean techniques consciously to reap the real benefits of lean applications by avoiding general construction issues as discussed next.

3. BENEFITS AND BARRIERS OF LEAN CONSTRUCTION IMPLEMENTATION

Significant variations generally occur at every stage of construction process. Plans change and materials are late. Howell and Ballard (1998) stated that in compressed circumstances, variation becomes more apparent and critical as it exposes the interdependence between activities. When lean construction is implemented and the work environment is stabilised through modifying the planning system, it becomes possible to reduce variation in flows that improve the downstream operations. However, many researchers concluded that there is lack of interest among construction parties to sit for a weekly review meeting to solve the problems causing the plan failures (Salem *et al.*, 2005 and Tzortzopoulos and Formoso, 1998). The other major problem which lies in the way is to make people change their mindset and be open to new ideas about managing construction projects. Salem *et al.* (2005) revealed that changing mindsets and behaviour with lean thinking become a challenge and to eliminate this barrier contractor need to offer training and recognition.

Howell and Ballard (1998) believed that lean production is a new way to coordinate action that rests on a new mental model and as problems are solved by "lean" the non-value adding flows would be recognised as problems in construction. Tzortzopoulos and Formoso (1998) stated that some clients have their needs which are not explicitly represented and some important aspects of design are abstracted away in the conceptualisation. Further, persisting problems in conversion may be identified as: not all requirements are identified at the beginning of the project, design errors are detected in later phases leading to costly rework and time delays. Lean thinking can address these problems.

Formoso *et al.*(1999), identified other general benefits when applying lean principles in construction; i) Reduce sharing of non-value adding activities, ii) Increase the output value through systematic construction of customer requirement, iii) Reduce process variability, iv) Reduce cycle times, v) Simplify by minimising the number of steps parts and linkages, vi) Increase output flexibility, vii) Increase process transparency, viii) Focus on complete process, ix) Build continuous implement into the process, x) Balance flow improvement with conversion improvement, xi) Benchmarking.

However, Alarcon *et al*. (2006) revealed that there are barriers in implementation the lean construction. These barriers are; ***Time***: The main difficulty is lack of time for implementing new practices in the projects, ***Training***: Lack of Training, ***Organisation:*** Challenge to create organisational elements, ***Self Criticism***: Lack of self criticism to learn from errors, respond to some deficiencies, ***Low understanding*** of the concepts, Low use of Different elements, Inadequate administration, Weak Communication and transparency and ***Lack of integration*** of the construction chain.

Further, Koskela *et al*. (2010) stressed that the application of lean construction principles offer ***key benefits*** to prefabrication such as increase productivity, increase quality, increase sustainable values, provide better value to the customer and reduce human effort. On the other hand, Koskela *et al*. (2010) concluded that there are issues in implementing lean construction techniques, especially in prefabrication such as: waiting times, inventorying, moving, high quality controlling, requirement of efficient testing, stock keeping, less flexibility to varying design, standardisation and requirement of well trained people and resources.

Further, some researchers have attempted to apply lean principles in different construction delivery methods to get higher benefits. For example, Singleton and Hamzeh (2011) and Eagan (2004) have attempted to apply lean principles play a crucial to integrated project delivery (IPD) approaches such as in partnering and strategic alliances in order to maximise value and minimise waste on such projects. Further, Lamming (1996) relates lean principles to construction supply chain and Howell and Ballard (1998) to design process protocol and showed how benefits such as reduce variation in flows that improve the downstream operations and change people's attitudes could be achieved. Next section discusses suggestions offered by researchers in implementing lean principles in different construction contexts.

4. SUGGESTIONS OFFERED BY RESEARCHES ON SUCCESSFUL LEAN IMPLEMENTATION

Koskela and Siriwardena (2009) founded out that changes are needed in terms of the proper implementation of lean principles such as top management commitment to the implementation, sufficient technical experts regarding the lean production, a quest for a culture of continuous improvement the company, fullest dedication of workers towards the implementation, awareness of employees regarding the lean principles, change people's attitudes and sufficient management expertise to induce the changes in the production flow process. Further Salem *et al*. (2005) stress that the commitment of the top management of the construction firms for implementation of these lean tools may prove to be most important factor in successful implementation.

Some other studies offer guidelines for effective implementation of lean approaches. For example, Singleton and Hamzeh (2009) offer the following guidelines when implementation Integrated Project Delivery linking lean.

(1) Avoid a segmented and rigid sequence of design activities

(2) Explicit internal Client supplier relationships between sub processes

(3) Involve designers in joint solutions

(4) Work with a set of design alternatives

(5) Introduce control focus on flow activities

Further, Ballard and Kim (2006) offer guidelines for implementing lean;

(1) Select partners or suppliers who are willing and able to adopt lean project delivery

(2) Structure the project organisation to engage downstream players in upstream processes and vice-versa, and to allow money to move across organisational boundaries in pursuit of the best project – level returns

(3) Do target costing: define and align project scope, budget and schedule to deliver customer and stakeholders value

(4) Encourage thoughtful experimentation; explore adaptation and development of methods for perusing the lean ideal

(5) Celebrate breakdowns as opportunities for learning rather than occasions for punishing the guilty

(6) Do set based design: make design decision at the last responsible moment, with explicit generation of alternatives, and documented evaluation of those alternatives against stated criteria

(7) Practice production control; in accordance with lean principles such as making work flow predictable and using pull system to avoid over production

(8) Build quality and safety in to the projects by placing primary reliance by acting to prevent breakdowns

(9) Implement Just In Time and other multi organisational processes

(10) Use 3D modelling to integrate product and process design

These lean implementations and guidelines on different context could be useful in exploring lean implementation in Sri Lankan construction industry. Next section discusses Lean construction approach in Sri Lanka and the research problem of the study.

5. CONCLUSIONS AND WAY FORWARD

The aim of this paper was to explore the literature on how lean construction is implemented in different contexts in construction industries in the world.

The findings revealed several benefits when applying lean principles in construction such as;

- Reduce sharing of non-value adding activities
- Increase the output value through systematic construction of customer requirement
- Reduce process variability
- Reduce cycle times
- Simplify by minimising the number of steps parts and linkages
- Increase output flexibility
- Increase process transparency
- Focus on complete process
- Build continuous implement into the process
- Balance flow improvement with conversion improvement and benchmarking

The paper identified few barriers for implementing lean principles as ***Time***: The main difficulty is lack of time for implementing new practices in the projects, ***Training***: Lack of Training, ***Organisation:*** Challenge to create organisational elements, ***Self Criticism***: Lack of self criticism to learn from errors, respond to some deficiencies, ***Low understanding*** of the concepts, Low use of Different elements, Inadequate administration, Weak Communication and transparency and ***Lack of integration*** of the construction chain. Finally, the paper provided some guidelines on how to overcome the identified barriers for effective implementation of lean principles. These lean implementations and guidelines on different context could be useful in exploring lean implementation in Sri Lankan construction industry.

There are few studies conducted in Sri Lanka on lean construction. For example, through an opinion survey of construction workforce, Senaratne and Wijesiri (2008) establish that lean construction is suitable and acceptable in the Sri Lankan context. Further, Ekanayaka and Senaratne (2011) and Vilashini *et al.* (2011) have applied lean to Sri Lankan prefabrication production processes. Also, Ekanayake and

Senaratna (2010) discussed the sustainable benefits in application of lean in prefabrication production process. All these studies show that the Sri Lankan industry is behind in effectively implementing lean in construction processes. The industry lacks an implementation framework to implement lean principles into the construction processes. This research aims to develop such an implementation framework through action research study for Sri Lankan construction contractors and achieve long-term sustainable benefits by becoming lean. It is expected that the key literature findings arising from this stage, will assist to develop a conceptual implementation framework using lean principles for the construction process.

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APPROPRIATENESS OF LEAN PRODUCTION SYSTEM FOR THE CONSTRUCTION INDUSTRY

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ABSTRACT

The manufacturing industry has been a constant reference point and a source of innovation for construction over many decades. The lean concept is one of such strategies adopted by the construction industry from the manufacturing industry to improve performance. In order to take benefit of lean techniques developed in the manufacturing industries, it is important to identify which categories of manufacturing systems are best applicable to construction. Many research studies have identified construction as a lean resistant industry because it differs from manufacturing due to site production, temporary multi-organisation and one-of-a-kind nature projects. The main objective of this study is to find different characteristics of construction processes and how lean techniques can be adopted to them. The method used for this study is a practice oriented research approach where it compares the characteristics of two construction processes with manufacturing process characteristics. In the attempt of visualising the existing process, value stream mapping techniques were used. It is identified that the construction process is a combination of fabrication and assembly processes with different characteristics such as layout, material flow, information flow, and work element. It can be concluded that certain construction techniques like pre-fabrication soften the construction peculiarities.

Keywords: *Assembly, Construction, Fabrication, Lean, Manufacturing.*

1. INTRODUCTION

The manufacturing industry has grown significantly through increasing productivity and product quality while reducing product lead time (Diekmann *et al.,* 2004). The improvements in the manufacturing sector have been achieved through process management strategies. These strategies stress the significance of basic theories and principles related to production management (Koskela, 1997) involving technology, employee, process, product, material and management based techniques (Kumar, 2006). They include reduction of human efforts, space, engineering hours, lead time and inventory and increase of quality, product variety and operation flexibility (Diekmann *et al.*, 2004). With the development of a tripartite view of production, transformation-flow-view by Koskela, the construction industry was inspired with a new process management approach (Elfving, 2008). Different methodologies have also been introduced to the industry and they include total quality management, time based competition, lean and concurrent engineering (Koskela, 2000). Earlier, these developments were beneficial to the process management in manufacturing (Polat and Ballard, 2004). Same practices have been promoted as productivity improvement strategies in construction to reduce waste and maximise value.

Based on the results of lean transformation developed by Womack and Jones as cited in Taguchi (2004), it can be seen that lean implementation derives great benefits within manufacturing and other industries. However, the implementation of manufacturing concepts in construction has often been unsuccessful due to peculiarities of construction projects compared with the manufacturing processes (Bjornfot and Stehn, 2007). Koskela (2000) come to a similar conclusion that long production time and cyclical nature is the major peculiarity in the construction sector. Distinct characteristics of the construction sector continue to isolate it from other industries and sustain the belief that it is quite different from the other sectors (Dos

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Santos and Powell, 1999). As a result the performance of construction in terms of productivity, quality and product functionality is low compared to other industries. The low rate of innovation has been the major cause for this situation (Winch, 2003). Furthermore, construction workers also experience a higher incidence of non-fatal injuries than workers in the other industries (Cain, 2004). Due to the unique nature of the construction sector, adopting the manufacturing practices directly into construction may not be appropriate. This uniqueness results from properties of construction projects.

The primary objective of this research is to assess the differences and similarities between a construction project and a manufacturing process. Similarities between the manufacturing and the construction cases can use to explain the suitability of the lean concept in construction. Furthermore, the differences between manufacturing and construction can use to show why the lean concept does not fully suit to construction. To support these two claims, the two distinct construction cases are identified and the study examines process characterises of two construction cases in order to identify the production type of these construction processes. Then, the most relevant techniques of lean manufacturing and lean construction are reviewed.

The paper is divided into five sections including this introduction section. The next section explains the main principles underlying performance improvement initiatives in construction and the comparison between the manufacturing and construction process characteristics. The third section illustrates the methodology adopted for this study and fourth section assesses the process characteristics of two process studies conducted in the case study project. The final part assesses the similarities and differences between process studies and manufacturing process characteristics identified in the literature review and states the extent to which adaptability of lean concepts in construction projects.

2. LITERATURE REVIEW

Given the origins of lean thinking in the automotive sector, the application of lean without appropriate adaptation for construction sector has been widely questioned. This is due to the specific characteristics of the industry. Therefore this section discusses the main differences between construction and manufacturing sector by considering its nature of operation. Construction is a project centric industry operating within an environment of considerable complexity and uncertainty (Koskela, 2000) due to the fragmented structure of the supply chain (Picchi, 2001) and short term , adversarial trading relationships (Barret, 2005). Contrary to manufacturing, the final product has its very own nature because construction projects are unique, static and big in size (Koskela, 2000) whereas manufacturing produces repetitive, large volume and movable products. Furthermore, the workforce in manufacturing has regular workers with high employment security. Due to the long term nature of the employment contract and the long lifecycle of a product, the employees gain job specialisation with high experience. On the other hand, in the construction industry, job security is low and workers perform a range of tasks during a project (Salem *et al.*, 2006).

The scope of operations in manufacturing is well defined from the beginning and operations plan is in great detail based on many trials. However, construction operations are partly defined and details are un-examined (Howell and Ballard, 1997). This is mainly due to the short term nature of the projects. Unlike manufacturing activities where the rhythm of production is fundamentally governed by the machines used in the manufacturing processes, construction depends on the management of information and resource flows of mainly labour and non-stationary equipment (Alarcón, 1997). In construction, contractors generally prefer to rent or lease their machineries (Clough *et al.*, 2000) due to short project duration, temporary nature and high investment cost. However, in manufacturing, it is preferred to purchase machineries because of the long product life cycle and repetitive nature of production. Unlike manufacturing, there is less protection from environmental conditions for construction work since it usually operates outdoor (Koskela, 2000) which causes interruptions to construction works.

Quality in manufacturing is achieved through controlling the processes while quality of construction is primarily related to product conformance based on specifications and drawings (Salem *et al.*, 2006). In manufacturing, defective products are largely discarded rather than reworked due to the simplicity and flexibility of the product. In construction, rework is a common practice since only one final product is delivered (Salem *et al.*, 2006). Moreover, the labour intensity increases the risk of human error and quality issues are widespread in the industry. In manufacturing, manufacturer-supplier relationships are clear, more manageable and open to repetition. However in construction, these relations are more dynamic and complex. Subcontracting is a common practice in construction. The subcontractor performance can highly affect a finished product in construction due to the interrelations between processes. The incapability to improve the productivity level of construction projects is mainly perceived by people in the industry due to project characteristics (Koskela, 2000) and identified differences are summarised in Table 1.

Table 1: Differences between the Manufacturing and Construction Work Characteristics

Features	**Manufacturing**	**Construction**
Type of industry	Process centric	Project centric
Type of work	Discrete components	Assembly
Mode of production	Machine intensive	Labour intensive
Production volume	Large and repetitive	Single and unique
Production rate	Depend on machines used	Depend on information and resource flows
Operations	Well defined	Evolving, learning from the initial stages
Product quality	Assures from process quality Less rework	Conforms to specification High rework
Workers	Regular and long term	Irregular and short term
Supplier relationship	Clear, manageable and repetition	Dynamic and complex
Layout	Static	Dynamic
Environment	Mainly indoor, factory setup	Mainly outdoor, site setup

In the recent past, other industrial sectors have made significant progress through the adoption of “lean thinking” but research investigations show that several obstacles account for the low uptake of lean principles in construction. Many practitioners are resistant to lean principles due to the fact that the industry as a whole is unique (Hook and Stehn, 2008). Therefore they believe that extension of specific manufacturing techniques such as lean to construction is uncertain. However, most of the studies consider the short term nature and unique project. Conversely, researchers have listed a number of similarities between the two industries such as both industries consist of socio-technical systems (the combination of human and technical elements) and construction is similar to the manufacturing area of new product development (Kagioglou *et al.*, 1999). Koskela (1999) states that lean construction shares the same goals of lean production: elimination of waste, cycle time reduction, and variability reduction. Therefore before generating a range of theories related lean implementation for the construction industry, it is worth to consider the ability to transfer of lean manufacturing practices and theories to the construction industry. There is a lack of studies that explicitly address the above issue.

To gain an understanding of the differences in lean principle between manufacturing and construction, the fundamental differences between manufacturing and construction had to be investigated. Before converting the principles and techniques, it is good to look at the construction process characteristics through real examples. The direct transfer of knowledge from manufacturing to construction could be possible for some particular types of construction. While previous studies related to lean construction provide some insights, they are inadequate for understanding what actually happens in the construction site particularly in infrastructure, long term project. Therefore, this study has compared two case studies conducted at infrastructure construction project sites and identified the situation in the construction.

3. METHODOLOGY

The study reviews the position of the construction industry from a theoretical and practical point of view. The research methodology adopted for this study basically follows two distinct and independent investigation steps, which are literature review and a case study approach. The literature review is based on published literature in construction management to analyse the difference between construction and manufacturing industries in theory. Then the study used participant observation as a research technique from a series of site visits at two construction processes to identify characteristics of each process. Consequently, the identified process characteristics compared with different resource inputs required for construction. The participant observation acts as a data collection tool as well as an analytic tool. Therefore, it enhances the quality of the data obtained during fieldwork and interpretations of data. It helps to find answers to 'how' questions (Robson, 2002). This research approach was supported by process mapping tools to get a clear picture of the process flow of selected case study processes namely pre-cast segment production and parapet construction of a motorway project.

4. ANALYSIS

In a construction environment, there are multiple resource inputs or conditions that need to be satisfied simultaneously for a task to be able to be started and completed (Fearne and Fowler, 2006). It can be identified that there are nine common inputs that are required to carry out a single task in construction projects. They are:

(1) Materials

(2) Output from preceding task (Work in progress)

(3) Labour

(4) Plant and machinery

(5) Information – what needs to be done

(6) Space – access to the working area and space in which to work

(7) Method – as in how the works are done

(8) Permissions – in terms of planning, building regulation and statutory authority approvals

(9) Environment - as in weather conditions

Two construction process studies are compared with the above nine input factors in order to determine the characteristics of these construction processes.

4.1. PROCESS DETAILS

4.1.1. PROCESS STUDY 1

The pre-cast concrete segment construction process was selected for the first case study. The data collection was started from the raw material receiving bay and it continued through each of the individual processes identifying the linkages between the states of production and establishing the flow of information and material resources. The overall process mainly consists of re-bar fabrication, mould set up, concrete pouring and remedial work and process maps for the main activities is shown in Figure 1. The pacemaker of the process is the mould setup task and only one product can fit into a machine at one time.

4.1.2. PROCESS STUDY 2

This study focuses on a parapet construction of a bridge. The process consists of pre-cast element installation, parapet formwork installation and concrete pour and removal of formwork. The process map for the main activities is shown in Figure 2. The pacemaker for the process is the parapet formwork installation operation and the aim was to produce two units at once. This is mainly determined by the number of formwork available at the site.

Process photo					
Operation description	Rebar fabrication	Rebar cage lifting	Mould set up	Survey (segment, pre pour, as built)	Concrete pouring
Process photo	No photograph				
Operation description	Crack segment	Remedial work	Transfer to yard	Final inspection& sign off	

Figure 1: Process Map for Process Study 1

Process photo				
Operation description	Lifting pre cast barrier	Tie reinforcement and lighting duct	Prepare stop end	Install temporary hand rails
Process photo				
Operation description	Clean and apply release agent in the formwork	Install formwork	Pour concrete	Remove formwork

Figure 2: Process Map for Process Study 2

4.1.3. COMPARISON BETWEEN TWO STUDIES

The two process studies are compared with the nine input factors as shown in Table 2. In the first process, the material flows through workstation to workstation and the material flow is transparent. During the production, two material flows can be clearly visible namely main raw materials and intermediate components. Frequent production stoppages are happening due to the absence of verification against the delivered materials. In this process, there is a permanent storage place for required materials and they are placed at the best possible location to reach all the workstations. On this site, the product is movable and it flows through different workstations where fixed and stationary worker-teams are engaged in a particular task. Therefore, it has a fixed position layout throughout the operation.

In the second process, the material also flows through workstation to workstation with two material flows namely main raw material and intermediate components. But due to moving workstations around the site, the material flow is complex and invisible. Since workers and workstations are moving as the work proceeds, most of the input materials and equipment are stored in temporary storage positions. Sometimes this improper storage results double handling of materials and it has been observed that the materials were manually moved from one workstation to another which causes a productivity reduction. This dynamic nature of the layout causes workstation congestion. In this study, it is found that the worker idling time is mainly caused by poor layout. In this process, the final product is stationary and it proceeds through different assembly tasks.

Table 2: Comparison of Two Construction Processes in Terms of Construction Inputs

Input factors	Process 1	Process 2
Materials	Flow through workstations Flow is transparent Interruptions due to material shortage Stores in permanent location	Flow through workstations Flow is less transparent Less interruptions due to material shortage Stores in temporary location
WIP	Product moves through workstations Product movable One piece flow	Product proceeds through assembly phases Product immovable Multiple piece flow
Labour	Stationary team One team is working on the product Defined work with specialisation Temporary and regular	Team moves throughout the process One part worked with several work teams Different work elements Temporary and irregular
Plant	Production depends on machine capacity High setup time and some breakdowns	Production depends on labour efficiency No setup time and breakdowns
Information	Design drawings, production schedule. Information displayed at fixed positions and near to workstations	Design drawings, production schedule. Need to move information display boards as work proceeds
Space	The site is not an input resource to final product Fixed position layout Less congestion and obstruction from material and WIP	The site is an input resource to final product Dynamic layout High congestion and obstruction from material and WIP
Method	Sequential work Structured improvements Unclear production methods at the beginning of the production	Flexibility in out of sequence work Very little structured improvements Clear production methods at the beginning of the production
Permissions	Requires inspection acceptance	Requires inspection acceptance
Environment	Less effect from the weather No traffic related issues	Direct effect from the weather Need to consider traffic related issues

In the first process, the pacemaker activity is an equipment intensive process and therefore the production rate is restricted by the machine capacity. Machine breakdown and setup time are relatively frequent and cause variability in the process cycle time. Furthermore, "right at first time" is important to this process since the process follows a one product sequential flow. As quality defects will cause bottleneck conditions, it is necessary to assure quality at the source which is a distinct feature of this process. Therefore workers detect any visible deviation and attend to quick rectification to reduce any interruption that could cause quality rejections. Since one team is working on one product at one time, it is easy to visualise quality defects and reduce quality issues.

In the second process, the pacemaker activity is a labour intensive process. Therefore the production rate is dependent on the labour efficiency. Since there are no process restrictions, the production follows multiple unit flows with multiple worker teams. Most of the time, this process performed out-of-sequence due to its flexibility in the operation sequence and product design. Therefore, several different work teams work on one product unit at a time and it provides less opportunity to assure the quality at source due to lack of transparency. The first process was new to the workforce and they have no experience in such a production. Workers learn from the initial production runs and streamline the production process and planning. Even though the second process contains clear production methods at the beginning of the construction and it is a familiar process to the workforce, they go through a rapid learning curve starting from the initial assembly phases.

Both the processes require design details and production schedule details to start with. However, the information required for workers to conduct their work could be displayed closer to the workstation. Unlike in the first process study, it is difficult to allocate specific permanent locations for the second process due to its dynamic layout. In the latter case, the site is a necessary input resource for the final product and the initial case site is not an input resource for the final product. Due to the lack of shelter on the site area, the second process is disturbed by the environmental conditions but the first process is not affected by weather conditions since most of the activities are conducted under a roof. Since the second process study is conducted at the highway construction, some activities are carried out during night time. This is mainly to reduce the impact on the travelling public if the work is carried out during daytime hours. However, the first process does not need to consider these traffic related issues since it operates in a separate, isolated place similar to a manufacturing setup.

5. DISCUSSION AND CONCLUSIONS

The identified characteristics of two construction processes are synthesised into the factors used to compare the two sectors namely manufacturing and construction. By analysing the above two processes as shown in Table 3, it can be found that the first process is similar to a fabrication type process with product layout arrangements while the second process is similar to an assembly type process with a fixed position layout. Even though most of the literature mentions that the construction industry is distinct from the manufacturing industry, the above study found that the construction process contains a mix of fabrication and assembly type work. Containing the characteristics of both “fabrication” and “assembly" processes, lean manufacturing techniques with or without further modifications depending on the characteristics can be accommodated.

In the illustrated process study one has eliminated the construction peculiarities mainly site production and therefore external uncertainties (example: weather changes) and internal uncertainties (example: layout changes) could be controlled. These kind of processes is mainly found due to the use of a pre-fabrication technology where major parts of the construction work are transferred to a manufacturing set up to simplify the assembly process. Therefore, most of the lean manufacturing techniques could be applied to such construction processes without any modifications since they are similar to a manufacturing environment. For example, due to the fixed position layout nature of work centres facilitates the application of visual management tools for without any changes. Moreover the repetitious nature of pre-cast segment production eliminates one- of- a- kind peculiarity in the construction process and it enhance the possibility of continuous improvement. In these cases, the techniques are very similar to the lean manufacturing techniques. It can be concluded that pre-fabrication is a good strategy to ease the lean implementation in construction.

With reference to the second process study, due to the dynamic nature of the layout particularly in assembly type construction processes, several waste activities can appear due to inefficient material handling and less transparency. Therefore in this type of construction process, the direct transfer of knowledge from manufacturing to construction is not possible under the lean construction initiative. For example, due to the dynamic nature of the site layout the application of visual management tools for material and process flow may not be sustained. Therefore efficient handling and storing of materials, standardisation of material storage and work standardisation are vital to such processes. Moreover, the particular process may not be repeated in the next project, due to the large scale of the project it is feasible to implement continuous improvements. In that case, it could be concluded that the peculiarities of construction act as a barrier for lean implementation. However, the implementation of lean manufacturing techniques could be appropriate and advantageous with relevant customisations to the context.

Through considering the differences and similarities between the two construction processes we have shown that for some particular types of construction, the direct transfer of lean manufacturing techniques to construction has been evidenced. Consequently, the application of the lean construction seems to be easy in this kind of processes because the lean manufacturing techniques can be applied directly. The findings of this study present an opportunity to understand how the construction processes deviate from the manufacturing processes and appropriateness of lean manufacturing with certain modifications.

Table 3: Summary of Comparison of Two Construction Process

Description	Process 1	Process 2
Type of process	Process centric	Project centric
Type of work	Fabrication	Assembly
Mode of production	Labour intensive	Labour intensive
Production volume	Large and repetitive products Unique to the project	Single and unique Repetitive tasks
Production rate	Depend on machines capacity	Depend on information and resource flows
Operations	Well defined; learning from the initial stages	Evolving, learning from the initial stages
Product quality	Conforms to specification High rework	Conforms to specification High rework
Workers	Regular and short term	Irregular and short term
Supplier relationship	Dynamic and complex	Dynamic and complex
Layout	Static	Dynamic
Environment	Mainly indoor, factory setup	Mainly outdoor, site setup

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IMPACT OF GREEN CONCEPT ON BUSINESS OBJECTIVES OF AN ORGANISATION

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ABSTRACT

Today, the world is moving towards green concepts which focus on increasing efficiency of resources while reducing impact on human health, productivity and environment. As a result, many companies are incorporating the green practices into their daily operations. Whereas, the rest of the world moves towards sustainable development, a very few number of green buildings are functioning in Sri Lanka. Within this emerging culture, this research has addressed, how green building concept influences in achieving the business objectives of an organisation with many aspects than conventional buildings.

The research method used for this study was qualitative. Case studies were conducted to ascertain the research aim and objectives. Two green buildings were selected from apparel industries. Semi-structured interviews were conducted among a selected experts panel and mainly content analysis was used to analyse data. The results discussed compatibility of the green concept for Sri Lankan organisations and deliberated how the green process achieves the cooperative objectives of organisation and sub-objectives of individual departments. Moreover, it was found that there is a positive impact of green building concept to achieve business objectives of an organisation and discussed the benefits gained in terms of financial, social, environmental and technical aspects.

Key words: *Green building, Organisational Objectives, Sustainability.*

1. BACKGROUND TO THE RESEARCH

Global warming and depletion of natural resources cannot be ignored by any one because it affects to environmental degradation (Mezher, 2011). To response the society's growing expectations, organisations are increasingly revealing social, environmental, economic, safety and health performance (Fonseca *et al.*, 2011). The biggest challenge facing the world today is how to balance the economic growth and development with sustainable development (Mezher, 2011). The best definition of sustainable development was made in 'Our Common Future', the report of the World Commission on Environment and Development (1987) as 'the development that meets the needs of the present without compromising the ability of future generations to meet their own needs' which involves with environmental responsibility, economic profitability and social awareness and achieving the right balance between them (Smith and Pitt, 2011).

Green buildings are important for a sustainable development (Waheed, 2010) which use resources such as energy, water, materials, and land more efficiently than conventional buildings (Kats, 2003). In the last decade, attention on green buildings was mostly focused on ecological benefits, and to some extent cost savings associated it decreased the operational cost but now it is moving beyond its establishment stage by focusing on the benefits to occupiers working in a green workplace (Armitage *et al.*, 2011). Green buildings typically contribute to improve employee health, comfort and productivity (Kats, 2003) on the other hand it is linked to gaining success through improving quality of work life, enhancing relationships with stakeholders and community liability, and ability to market pro-environmental consumers (Brown *et al.*, 2010). Moreover, the same authors explained that organisational and green building objectives are highly interrelated. However, according to Kats (2003) green buildings are commonly perceived to be more expensive than conventional buildings.

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1.1. *PROBLEM STATEMENT*

Green Building Council Sri Lanka (GBCSL, 2010) stated that improper understanding and misinterpretation of different domains and aspects in different localities have created inadequate measure of sustainability, which would not reflect the magnitude of the local interpretation of sustainability. Apart from that still green concept has not become a major and pressing requirement for Sri Lanka especially in building construction. Therefore, in Sri Lankan context, there are only few buildings which have been applied the green building concept yet. Less awareness, lack of knowledge about the green building concept among the industry practitioners and insufficient funds can be considered as some preliminary reasons behind this scenario. On the other hand, many practitioners do not have enough confidence to implement the green concept, assuming that high risk involvement in recovering their investment. Therefore, this research will be addressing "how the green building concept impact on the business objectives of an organisation" and facilitate solutions for the above mentioned problems in Sri Lankan context. A brief foreword to the study was given in this section and next section explained the key literature findings.

2. LITERATURE REVIEW

2.1. *SUSTAINABLE DEVELOPMENT IN AN ORGANISATION*

Since the last quarter of the twentieth century, environmental issues have reached the status of a global problem (Faria *et al.*, 2009). According to Gandhi *et al.* (2006) the modern man started exploiting the natural resources and economic activities changed the status of natural resources, finally it led to the natural resources depletion on one hand and the environmental degradation by dumping pollutants on the other. Despite some improvements over the past decade, future generations will continue to face serious environmental problems unless significant attention is given, and investments are made to reverse the current state of environmental degradation (Hussein, 2008).

According to the Sigma Guidelines (2003) the adoption of sustainable development principles can result many benefits to the organisation including improved operational efficiency, enhanced reputation, customer attraction and retention, enhanced human and intellectual capital, building and sustaining shareholder value, improved management of risk, generating increased revenues, attracting and retaining talented staff and identification of new opportunities. Many managers have had difficulty in getting along with sustainable development requirements (Hall and Vredenburg, 2003). It is to be noted that failing to care about the community and organisational sustainable development roles will create a negative image of the organisational brand, and negatively affect in the long-term (Cruz *et al.*, 2006). According to Richardson and Lynes (2007), sustainability targets are important pre-requisites to the construction of green buildings. Today green building concept has become a main factor contributing to the sustainable development in this century that endures the responsibility of balancing long-term economic, environmental and social health (Ali and Nsairat, 2008).

2.2. *THE CONCEPT OF GREEN BUILDING AND BENEFITS*

Environment degradation has conspired to create an increasing awareness of sustainability issues and demand for green construction practices in general (Lavy and Ferna´ndez-Solis, 2009). Paumgartten (2003) stated that, buildings continue to have an enormous impact on resource use and the environment. It is pointed out that "green buildings" is a relative concept and not an absolute one. This is because even the best green buildings built today are not 100 per cent sustainable (Kats, 2003). Six fundamental principles concerning sustainable construction should persist in a green building (National Institute of Building Sciences (NIBS), 2009) which are needed to optimise site/existing structural potential, optimising energy use, protection and conservation of water, use of environmental friendly building materials, enhancing indoor environmental quality and optimising operational and maintenance practices.

According to Richardson and Lynes (2007) green buildings have four key benefits over to design and construction of conventional buildings. Such as environmental benefits, reduction of costs to the owner or occupier over the operational life-cycle of the building, better indoor working environment and construction of green buildings provides benefits to contractor by presenting a positive image and reputation towards that company by practically demonstrating green approach. On the other hand, Kats (2003) pointed out that many of the benefits of the green approach cannot be easily expressed in dollar and cents. However, green buildings could yield up to 30 per cent savings in energy consumption through green features such as building envelope designs and use of more energy efficient air-conditioning systems and light fittings (Building and Construction Authority (BCA), 2009). Moreover, Heerwagen (2000) stated that benefits of both organisational and green building factors are more likely to occur when the building and organisation are treated as an integrated system from the outset.

2.3. OBJECTIVES AND FUNCTIONS OF AN ORGANISATION

Moynihan (1993) defined, organisation sets out to achieve certain objectives while interacting with the environment, people and resources to make products or to provide services. Moreover, the same author stated that, organisations are formed to pursue particular fundamental objectives of a business which are an essential starting point for all business planning and differed from organisation to organisation according to individual vision and mission statements and the main function of that organisation. According to Agarwal (1982), organisational objectives are survival in the market, growth of organisation, profit maximisation, efficiency and productivity, innovations, employee development and social responsibilities. Furthermore, Moynihan (1993) stated that main business functions of an organisation can be identified as finance, personnel, production, and marketing. In addition, information technology, administration, purchasing, engineering and maintenance, legal, research and development support the success of a business. Considering all the facts discussed by the various authors, organisational objectives can be grouped into financial, productivity, employee turnover and health, engineering and market value.

2.4. GREEN BUILDING CONCEPT IN AN ORGANISATION

Paumgartten (2003) explained that high performance green buildings effect on changing the direction of businesses. According to Arif *et al.*, (2009) the major drivers behind adaptation of green are regulations, cost savings through reduction in energy costs, waste minimisation, promotion of corporate green image, and corporate social responsibility. To achieve a competitive advantage in the global business environment, companies must have a capability for continuous adaptation to the markets and for renewal capability (Junell and Stahle, 2011). However, there is a trend towards achieving organisational growth by exploiting understanding of the relationships between an organisation and its environment (Holland and Salama, 2010) rather than continuing wasteful spending on inefficient buildings, owners and operators are looking at green buildings not just as an environmentally responsible alternative, but as a smart, financially responsible business strategy as well (Paumgartten, 2003). Richardson and Lynes (2007) mentioned that financial benefits are divided into two categories as result in money savings and result in money earnings. The National Canadian Energy Code states that life cycle costs of green buildings can be reduced by 25% at the very least using an integrated team (Paumgartten, 2003).

2.5. STATUS OF GREEN BUILDING IN SRI LANKA

Sri Lanka, like other countries around the world, is facing an immense challenge to build sustainable buildings for the future. The Green Building Council of Sri Lanka came into existence as a result of an emerging trend towards applying the greener concepts for built environment in November 2009 as a non-profit organisation that is committed to developing a sustainable building industry for Sri Lanka by encouraging the adoption of green building practices (GBCSL, 2010). Furthermore, the same report mentioned that the green building concept is quite new to the current Sri Lankan context but it is rapidly expanding all over different industries. Since Sri Lanka didn’t have a clear framework and governing body for green rated buildings in the past there is an extreme necessity for such an institution for Sri Lanka and it was introduced as GREEN$^{SL®}$ Rating System in 2010 which encourages the design of buildings in an environmentally acceptable manner.

3. RESEARCH METHODOLOGY

The unit of analysis for this study was the organisations from apparel industry that already received the LEED (Leadership in energy and environmental design) green certification because today apparel industry moving towards the green concept. While selecting organisations, special concern was given for organisations which have separate departments for financial, productivity, human resource, marketing and engineering. A brief description about the selected cases was given in Table 3.

Table 1: Brief Description about the Selected Cases

Organisation	Organisation A	Organisation B
Area of the building	80,000 ft^2	96,000 ft^2
Number of Employees	1200	1200
Type of green certificate	LEED-NC - Platinum	LEED-NC - Gold
Products	Lingerie	Knit clothing

The interviews conducted among the professionals representing each department in both case. Therefore, all together ten professionals were interviewed. The professionals selected from the top management level employees who lead the organisation and have knowledge about how the organisation going to achieve their objectives towards sustainable approach. The data collection instrument used in this research was face to face semi-structured interviews. Code-based content analysis was used in this study to capture significant findings from the transcripts and for effective interpretation of those. The QSR.NVivo ® - version 7.0.281 computer software was used in this study to simplify the works relating to content analysis.

4. RESEARCH FINDINGS

4.1. BACKGROUND TO THE ORIGINATIONS

The organisations ‘A’ and ‘B’ had taken the LEED-NC certification in year 2008, from the United States Green Building Council. ‘Organisation A’ has ‘platinum’ award and ‘Organisation B’ has the ‘gold’ certification. According to the respondents, the green building concept plays a major role within a building to convert the building operation more towards the sustainable development. Organisations use different strategies to achieve the business objectives in the different stages. This research tries to identify the impact of green building concept on achieving organisational objectives. One of the interviewees of organisation ‘A’ stated that *“Objectives of any organisation changed by time to time since objectives based on SMART concept therefore objectives are built up with the time constrain. Moreover, those objectives are based on mission of the organisation and some objectives are pre-established and specified areas of the organisation”*. Table 2 shows the mission and some pre-established objectives of organisations ‘A’ and ‘B’. Almost similar objectives could be seen from the both organisations and which are aligned with the mission of the organisation.

Table 2: Mission and Pre-Established Objectives of Organisations 'A' and 'B'

Mission of Organisation A	**Mission of Organisation B**
To provide an unparalleled range of industrial services, enabling investors the most feasible environment for seamless activity, within a climate promoting intra and inter-generational equity, based on the commitment for continuous growth for the company and its shareholders.	*To offer quality customer service through innovation, leadership and excellence while being responsive to change in a competitive global environment. Further, to instil professionalism by embracing a positive spirit of enterprise within the group, to increase global market share.*
Pre-established cooperate objectives	**Pre-established cooperate objectives**
• Earning profit from satisfying customers • Committed to principles of sustainable development • Dispense good quality products and business activities • Generate job opportunities	• Maximising profit • consistently provide meticulous, high quality products • Upholding the highest standard of customer service • Promote entrepreneurship

4.2. Green Building Practice in Sri Lanka: Positive and Negative Aspects

As found from interviewees, since last five years, many organisations in Sri Lanka aware of the green building concept and try to implement it to their organisation and work for the green buildings. However, still a few organisations received the LEED- NC certification, and at present the green building council has been formed in Sri Lanka in 2010 as the legal body to issue green certificates.

Most of the respondents disclosed that green buildings provide many benefits to the organisation, its employees, and to the whole society over to its initial cost and which assists to achieve the organisational objectives clearly. One of those is financial benefits such as low operational cost, low energy bill, profit maximisation, low motivation cost for employees, low compensations for health issues of employees and low advertising cost. Another benefit highlighted was human resource related benefits such as high employee health, safety and satisfaction, self-motivated employees, attract, encourage and retain the best employees. On the other hand these increase the employees' productivity and the product quality. Moreover, the findings show that green building concept adds value to the building and its product. Other than that makes some competitive advantage within the market and increase the market value of the organisation as well as the product. At the end, this helps to increase the customer satisfaction, goodwill and image of the organisation which opened a way to new market opportunities. Perspective of employees, it provides comfortable environment to the employees within the work stations and it ensures health and safety of the employees.

Sri Lanka is a 3rd world country which undergoes through economic situation within the country and most of the construction projects inside the country use foreign loans which were provided by the funding organisation or foreign countries. According to the empirical evidence gathered from the interviews show that even there are many benefits over to its initial cost, many organisations specially in the private sector face on lack of funds and do not ready to take risk of payback of investment in green projects. Moreover, many respondents emphasised that in order to overcome some issues identified there is a big role for the green building council in Sri Lanka to assist organisation to ensure sustainable development towards the future generation.

4.3. The Impact of Green Building Concept on Achieving Organisational Objectives

In order to achieve the research aim, all the departments: financial, production, human resource, marketing and engineering departments were analysed separately. Main objectives of the selected case studies were achieved by incorporating all sections of the organisation towards the cooperate objectives and each department has their own sub objectives which have been broken up from main objectives. The following sub-sections elaborate the foremost findings revealed through the interviews conducted in the organisation 'A' and 'B'.

4.3.1. FINANCIAL DEPARTMENT

Financial benefit is one of the crucial and mostly concerned by any organisation. The financial executive of the organisation 'A' stated that *"This building had consumed 10% more initial cost than a conventional building, but it is gaining many financial benefits as a whole". Moreover, the respondent emphasised that* "*Now our company operates in profit margin and it takes only 4 and ½ years to recover the initial cost because of the special features of this building. Electricity consumption is considerably low since evaporator cooling system consumes low energy compared to the conventional system. If someone expends Rs.100 for the conventional A/C system, this system only consumes Rs.40. Other things are energy efficient lighting system, natural lighting system and electricity gaining from solar panel system which contributes 10% to the total electricity consumption. All above factors effect to reduce the energy bill of this organisation"*. On the other hand "w*ater consumption is also 50% less because this factory building has rainwater harvesting system and that water is used for the flushing system. Another thing is toilets have dual flushing system which reduces the water consumption*". Another significant fact stated by the financial manager of organisation 'B' was *"implementing green building concept, life time of the building cannot increase but easily we can achieve the expected life time"*. Furthermore, he explained that "t*he operation cost of this organisation is considerably low compared to the conventional buildings since building maintenance cost, energy bill, other garden maintenance cost are small amount compared to conventional buildings*". All above facts give the positive impression on the green building concept, which are some of the financial benefits mentioned by the interviewees.

4.3.2. PRODUCTION DEPARTMENT

The production executive of organisation 'B' stated that, *"production is the main function of any organisation in apparel industry and there is an indirect effect of green building concept on productivity of this organisation"*. Moreover, he specified "e*mployee productivity is the main fact that contributes to increase the total productivity. This building maintains comfortable air conditioning level, natural lighting level, and comfortable indoor air quality. Those factors effect on the productivity of employees because people like to work in comfortable environment"*. In addition, the production manager of organisation 'A' explained that *"in a conventional building, the work stresses of employees are high because they work in an environment which is fully covered from the building. But in this organisation all worksites are opened to the natural environment. The theme used here is "this building is for people not for machine". Every person can see the natural environment from their work station. Then they can work without any stress and increase individual productivity of the production flow"*. Moreover, he mentioned that *"workers in this factory are always motivated, they work without any stress and they are satisfied with this environment. Therefore, the quality of the product that they produce is very high because they can fully concentrate on their work because of this comfortable environment. Here employee productivity is 51%. But in the conventional factories in the Sri Lankan garment industry, productivity is around 40%*". This signs that green building concept indirectly effects on quality of the product through employee satisfaction.

Production executive of the organisation 'B' stated that "*employee attendance of the organisation is good and employee turnover rate is also in low level because of employee satisfaction and that ensures their high productivity and continuous operation of the production. Then that will affect to achievement of target on time and do the on time delivery for the buyers"*. That means the green building concept has an effect on the on time delivery to their buyers. And he further emphasised that "*There is no direct effect on machines of this building by the green concept, but it indirectly support to enhance the life time of machines*". All above mentioned facts give evidence to prove that green building concept assists to achieve production objectives of both organisations.

4.3.3. ENGINEERING DEPARTMENT

Many facts mentioned by the engineers of both organisations revealed that there are many direct impacts on achieving objectives of engineering department by incorporating green building concept. The plant engineer of the organisation 'A' stated that "*this building had built-up with bricks which are not burnt and* *it acts as the building envelope of this building which gives good appearance to the building as well and also no painting cost. Therefore, the maintenance cost of the building is very low compared to the other buildings and here all plants are native trees they are grownup by themselves".* The above statement supports to show that green buildings contribute to reduce the maintenance cost some extent. Furthermore, he highlighted that *"use of bricks has some effect to keep inside the building coolness, therefore A/C consumption little bit less than other conventional buildings, on the other hand, orientation and height of the building also contribute to keep the building cool. Those facts help to reduce the energy consumption of the building".*

Another significant factor mentioned by the executive engineer of organisation 'B' was *"there is a positive impact on the environment since there is no carbon dioxide emission to the environment from this building*. Plant engineer of organisation 'A' also stated that *"indoor air quality is good, because here CO_2 level is below the 600 ppm where work around 300 workers".* All the factors highlighted by the interviewees of engineering department ensure that there is a positive impact of green building concept on engineering aspects of both organisations.

4.3.4. HUMAN RESOURCE MANAGEMENT DEPARTMENT

The executive HRM of organisation 'A' stated that *"Human resource is most critical factor which has influence on many sections of the organisation and it is very difficult to control. Specially, in garment industry has higher employee turnover rate and it is difficult to attract employees. Most of the people motivated from financial benefits and some motivated from recognition expect from other people".* The information collected form interviewees of human resource departments in both organisations give evidence that the green building concept has direct impact on employee satisfaction and motivation, employee health and safety and employee attraction and turnover. The executive HRM of organisation 'A' mentioned that *"This is an environment friendly system and air quality of this building is high as well as CO_2 level is also below 600ppm and no harm to the employee health".* Furthermore, Human Resource executive of organisation 'B' explained that *"all the employees in this factory are self-motivated and they do their work without any stress since the natural environment around their workstation assist to increase the employee satisfaction of this factory. Therefore, no issue with salary increments and motivation cost to retain employees because they are well motivated to work".* Moreover, he mentioned that *"The employee turnover of this factory is less than other conventional buildings and it is easy to attract employees".*

4.3.5. MARKETING DEPARTMENT

Marketing department which is market the products of the organisation and target to attract customers within the competitive environment. During the survey, it was identified that some factors contribute to achieve marketing targets especially in organisation which has implemented green building concept. Marketing executive of organisation 'A' explained that *"customer satisfaction of this organisation is 99.9% and there are no customer complaints against us. Nowadays people like to buy products from companies which have green certification. Therefore, demand for our products is very high and on the other hand there is a competitive advantage for the market having our products because of green concept.* Moreover, the respondent proudly mentioned that *"new opportunities are there in the foreign market for our products from some countries like Pakistan, Japan and China already came to visit this factory and they hope to buy our products in near future since the image and goodwill of our organisation in the foreign market is good".* The interviewee of the organisation 'B' also stated that "*customer satisfaction of our organisation is very high because today people are more concerned about the environment and they are satisfied with our products. Therefore demand for our products is also higher than other garment factory products".*

All the facts identified through the interviews conducted among the two case studies supported to prove that there is a positive impact of green building concept on achieving the objectives of both organisations. The summary of findings is depicted in a cognitive map as shown in Figure 1. It shows sub-objectives of each department which are supported by the green building concept. Apart from that some cross relationships between each department are also indicated in the Figure 1. Finally, all sub objectives support to achieve the main business objectives of an organisation.

5. CONCLUSIONS

The green building concept spreads all over the world as a positive approach to build up a sustainable environment for the present generation as well as for the future generation. This study mainly focused to identify the impact of green building concept on achieving organisational objectives which was conducted using two case studies in apparel industry. It can be assertively stated that there is a positive impact of green building concept to achieve the individual objectives of each department in an organisation. The findings supported to prove that the benefits of green concept directly and indirectly assist to achieve the organisational objectives. Important thing highlighted by the interviewees was green buildings provide many benefits to organisation, its employees and to the whole society over to its initial cost. The findings made through this research direct to think, it is time to awake and try to catch up the world new trends in this changing world and go for more green buildings in Sri Lanka to protect the natural resources and to build healthy and financially viable sustainable environment for future generation.

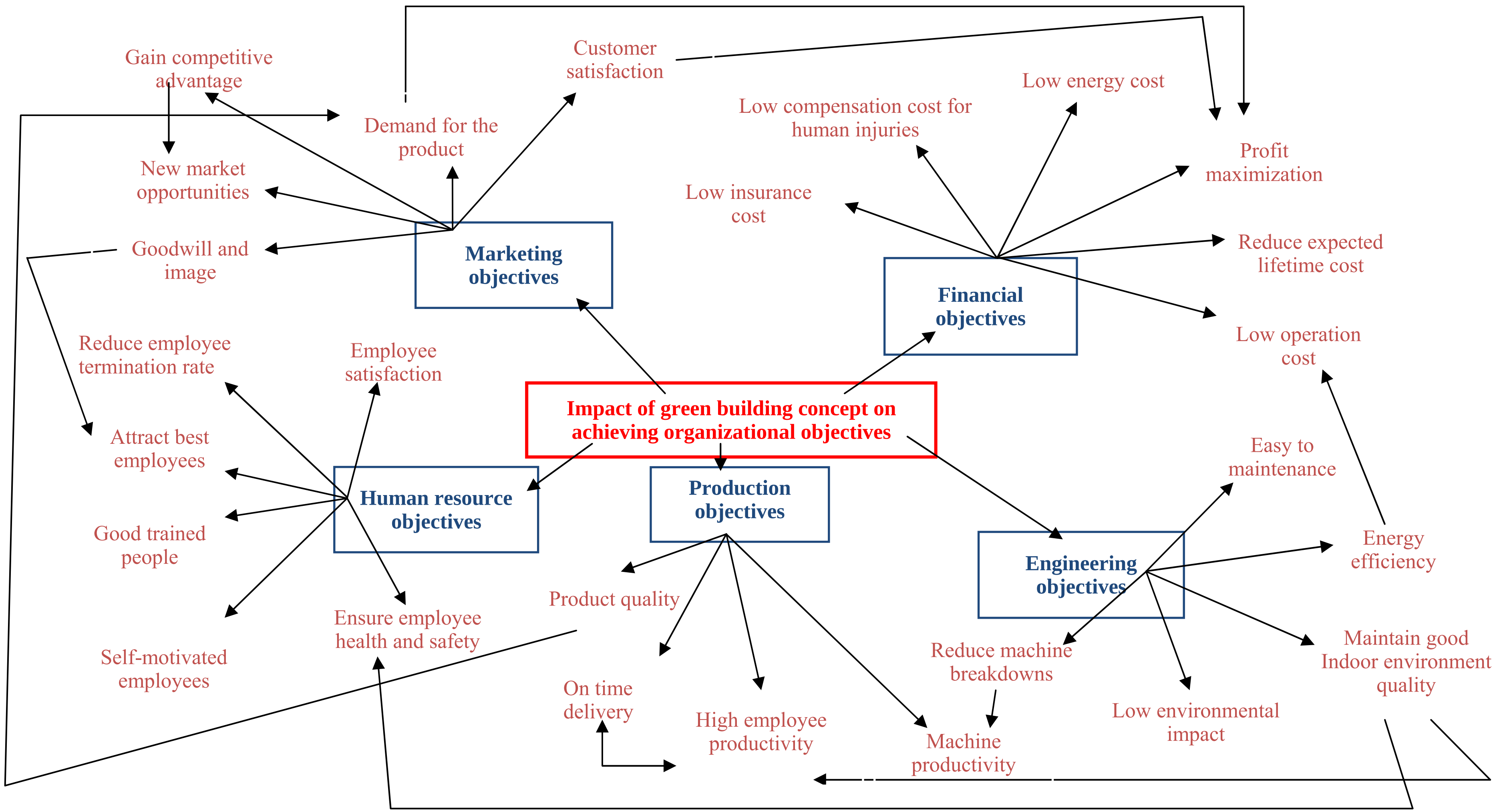

Figure 1: Cognitive Map of Impact of Green Building Concept on Achieving Organizational Objectives

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RISK MANAGEMENT IN ELECTRICAL DISTRIBUTION SYSTEM IN SRI LANKAN HOTEL INDUSTRY

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ABSTRACT

An uninterrupted service throughout the facility is a must for building services in the hotel industry because a large part of guest satisfaction with the hotel depends on building services. However, building services face many different types of failures due to various risk factors. Therefore, a risk management framework is an essential part of the building services of a hotel. In case of hotel buildings, the literature suggests electrical power distribution system (EPDS) to be the key building service which governs all other building services and failure in the EPDS can happen due to maintenance risks, operational risks, assets specific risks and human errors. This research was commenced through a study of three leading five star hotels in Sri Lanka. Based on the research findings, a risk management framework was developed to address risks in EPDS of a hotel facility. The risk management framework was developed based on these findings reveals effective practices that could be used to reduce failure in EPDS. The research also pointed that maintenance risk, unplanned operational risk, asset-specific risk and human errors as the main internal risk factors that lead to failures in EPDS. On the other hand, weather conditions was identified as the uncontrollable external risk factors in the hotel industry, a preventive and a predictive maintenance schedule, planned operations, training and development, and proper asset selection criteria were identified as the main risk management strategies used in the hotel industry. The paper proposed a risk management framework to overcome the identified risks in EPDS in hotel industry which consist of failure mode effect analysis, power monitoring panel and a risk mitigation plan to maintain continuous operations in the EPDS. The findings and recommendations of the study will be useful to those responsible for EPDS operations in the hotel industry for the purpose of reducing services failures.

Key words*: Electrical Power Distribution, Risks, Service Failure, Risk management Framework.*

1. INTRODUCTION

Hospitality is indubitably a people-centred business, which provides both security and physical and psychological comfort for an appropriate fee. In hotels, both the owners and staff therefore are concerned with the condition and sustainability of constructed facilities as well as intangible aspects and ambience of the hotel premises. These form a major part of the product sold to guests, (Okoroh *et al.*, 2002). Nowadays, hotels therefore offer a range of facilities for the purpose of providing high levels of comfort and services for the guests. These include building services, catering facilities, function rooms, meeting and conference facilities etc. (Mohammad, 2009). However, according to Phau and Baird (2008), guests at hotels are more concerned about satisfaction derived through building services.

Studies have identified key building services that directly impact the service quality provided in a hotel as air-conditioning, electricity, cold water distribution system, hot water and steam distribution system, fire detection and prevention system, lighting, internal transportation system, security system, and telecommunication system (Heimonen *et al.*, 2003; Malatras *et al.*, 2008; Phau and Baird, 2008).

However, most of the key building services identified are generally regarded as major electricity consumers (Yu and Chan, 2005). For example air-conditioning, ventilation and lighting systems cannot operate without electricity (Yu and Chan, 2005). Kamaruzzaman and Edwards (2005) highlighted that, total operations of the building services are based on the electrical power distribution of the hotel. It mainly consumes the high voltage power to run the operations. Also as Yu and Chan (2010) highlighted, high electricity demand of a hotel is very critical to maintain, because the guests who are in the hotel use

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different types of services which run based on the electrical system within 24 hours. Therefore, electrical power distribution system is identified as the key and essential system to the proper functioning of the hotel building.

Every process is susceptible to fail and for the electrical distribution system there's no difference. The electrical power distribution system can failed in different location from the main sub-station to minor circuit breaker. However, these electrical system failures may lead to the overall system performance degradation and also it can cause to congest the total operation of the hotel building as electricity is the main power source of most other building services (Chan *et al.*, 2001). As a result the good will, brand loyalty and market share of the hotel can decline due to guest dissatisfaction (Oh and Parks, 1997). Therefore, it is necessary to have a system to identify the risks which can cause failures in the EPDS beforehand. Accordingly, this study was the aimed to propose a risk management framework for the EPDS in hotel buildings.

2. THE ROLE OF ELECTRICAL POWER DISTRIBUTION SYSTEM IN A HOTEL

Energy consumed by hotels includes electricity, gas and diesel, but the energy consumption is dominated by electricity in terms of both rate of consumption and the cost (Yu and Chan, 2005). Therefore, electricity takes a major role for sustaining the hotel in the current situation. According to Yu and Chan (2005) electricity is used mainly for air-conditioning, ventilation and lighting in a hotel building.

2.1. COMPONENTS OF AN ELECTRICAL POWER DISTRIBUTION SYSTEM

The EPDS comprised of six main components with different functional requirements (see Figure 1).

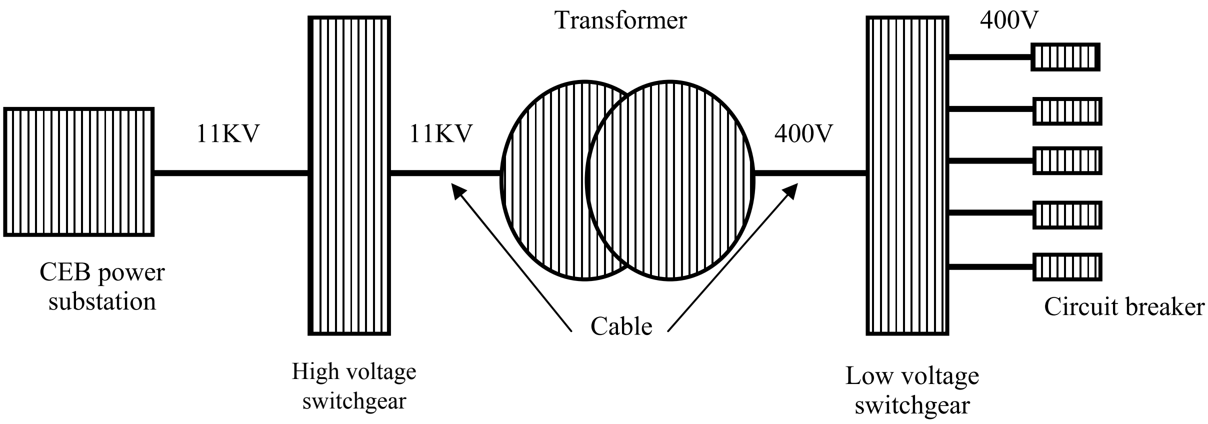

Figure 1: Electrical Power Distribution (Source: Kazibwe and Sendula, 1993, P.10)

2.1.1. POWER SUB-STATION

Electricity is generated in the power station alternator at 25kV. This electrical energy is fed into a transformer to be stepped up to a very high voltage for transmission on the grid network at 400kV, 275kV or 132kV. The electricity leaves the local sub-station and arrives at the consumer's mains intake position (Linsley, 2007).

2.1.2. HIGH VOLTAGE SWITCHGEAR

High voltage power supply directly comes to the high voltage switchgear. It works as the main safety component of the total electrical distribution and power levels and voltages rapidly escalated, making open manually-operated switches too dangerous to use for anything other than isolation of a de-energised circuit (Harrison, 1996). Oil circuit breaker, vacuum circuit breaker and gas (SF6) circuit breaker can be identified in the high voltage switchgears.

2.1.3. TRANSFORMERS

A transformer is device, which use to phenomena of the mutual induction to change the values of alternating voltages and currents and in face one of the main advantages of the AC transmission and distribution is an alternating voltage can be increased or decreased by transformers (Harrison, 1996). This component is used in the electrical distribution to step down the high voltage in to the low voltage.

2.1.4. LOW VOLTAGE SWITCHGEAR

Harrison (1996) explained, low voltage switchgears (fuses, air blast circuit breaker, minimum oil circuit breaker and oil circuit breaker) use after converting the high voltage current to the low voltage current. Main function of low voltage switchgear is protection, which is interruption of short-circuit and overload fault currents while maintaining service to unaffected circuits. Switchgear also provides isolation of circuits from power supplies.

2.1.5. ELECTRICAL SERVICE SHAFT (CABLES AND ENCLOSURES)

Power and lighting circuit conductors are contained within cables or enclosures. Part 5 of the IEEE Regulations (2008 cited Linsley, 2007) explained that electrical equipment and materials must be chosen so that they are suitable for the installed conditions, taking into account temperature, the presence of water, corrosion, mechanical damage, vibration or exposure to solar radiation.

2.1.6. CIRCUIT BREAKERS

A circuit breaker is an automatically-operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and, by interrupting continuity, to immediately discontinue electrical flow (Weedy, 1972). Mainly circuit breakers are installed in the electrical distribution for the protection of equipments.

2.2. RISKS ASSOCIATED WITH THE ELECTRICAL POWER DISTRIBUTION SYSTEM

Risk is the potential that a chosen action or activity (including the choice of inaction) will lead to a loss or an undesirable outcome (Booty, 2006). Depending on the building or type of operation, electrical failure can cause a loss of goods, data, equipment, property damage, potentially even life that will require unbudgeted time and money to repair or replace, if possible (McPhee, 2010). Just because everything is working today doesn't necessarily mean that potential problems aren't there. The more power the building operation uses, the greater the risk of failure and the warning signs of these risks are invisible to the untrained eye. If it is left unchecked, failure happens suddenly and the results can be catastrophic (Chan *et al.*, 2001). Therefore, it is critical for the reliability of the EPDS operate without any failures. However, number of researches identified that EPDS can face with several risks which can be discussed under maintenance risks, operational risks, asset specific risks and human errors (Yu and Chan, 2005; Schneider *et al.*, 2006; Michel *et al.*, 2009).

2.3. MAINTENANCE RISK

According to Lam (2006), when a building is put to use, its building services including the EPDS must perform its operations in an efficient and effective manner round the clock during the life-span of the said building. Therefore, to attain optimum levels of efficiency, all service systems require both proper design and proper maintenance. However, as Narayan (1998) has pointed out, improperly maintained systems will deteriorate over time, increasing the likelihood for malfunction. For example, normal electrical cycles create thermal expansion and contraction that naturally loosen, connections, accumulated dust and dirt can produce a high resistance path (these paths are responsible for more than 30% of all electrical failures annually), moisture is another culprit that causes 17% of all electrical failures (McPhee, 2010). Therefore, risks can arise due to improper maintenance of the EPDS.

2.4. OPERATIONAL RISK

Operational risk can be identified as mistakes in process or procedure that cause losses (Chapman, 1997). According to Flanagan and Norman (1993), operational risks which affect the EPDS can be identified as staff unawareness, management systems failure, technology failure, model failure, technology obsolescence and inadequate internal controls. For example due to lack of awareness a staff member can trip a circuit breaker in the electrical distribution which can result in part of the building to lose power (Flanagan and Norman, 1993).

2.5. ASSET SPECIFIC RISK

According to Schneider *et al.* (2006), asset-specific risks mostly occur at the stage of selecting equipment or components of the EPDS since selection is the key to the life-cycle of assets. According to the explanation of BPA Manual (2009), asset risks of an electrical distribution system typically include;

- Risk of system or system component failure
- Risk of capacity inadequacy
- Risk of equipment/component/system obsolescence
- Risk of environmental damage or noncompliance
- Risk of security breach or noncompliance
- Risk of health issue or safety injury

Accordingly, risk of system or system component failure risk of capacity inadequacy, and risk of equipment/component/system obsolescence can be identified as risks which directly impact the failure or malfunction of the EPDS.

2.5. HUMAN ERRORS

According to Hollengel (1983), human error cannot be considered as a function, an activity, nor the result of an intention. It is simply a contradiction of any reasonable definition to say that a person can make an error intentionally. According to Dahlgaard *et al.* (2008), human errors may become a serious risk factor in the engineering service. They also point out how a system can fail due to a minor error on the part of the human. Therefore, human errors can be considered as a major risk factor that affects the continuous operations of the EPDS.

3. GAP IN KNOWLEDGE

Electric power is at the root of almost every services of a hotel building, yet electricity is almost always the most overlooked and under-appreciated utility in day to day operations of any building. Without it, almost everything stops, including the business. According to BPA Manual (2009), electrical losses continue to top the list as the equipment category with the most premature breakdowns, which cost business and industry through extra expense, disruptions and lost profits. According to literature findings studies have been conducted in determining what are the risks associated with EPDS in foreign context. However, the perception of risk is subjective while also being affected by the unique political, economic, environmental and cultural conditions of a country (Han and Diekmann, 2001; Andi, 2006 and El-sayegh, 2008). Also, no similar research has yet been carried out in Sri Lankan context in relation to risks associated with EPDS in relation to Sri Lankan hotels. Therefore, this research focused on investigating the risk factors that affect the electrical distribution system and mitigation strategies for the identified risks in relation to Sri Lankan hotel industry and finally aimed to develop a risk management framework for EPDS in Sri Lankan hotels.

4. METHODOLOGY

The study is of exploratory nature and requires an in depth understanding of risk in electrical distribution systems in Sri Lankan hotels, it has been argued that, when a phenomena of interest requires detailed in depth information, a qualitative research can provide distinctive advantages (Yin, 2003). Therefore, this research is based on qualitative research. The study resorted to the case-study method in order to study risk factors that affect the EPDS and mitigation strategies for the identified risks in relation to Sri Lankan hotel industry. Hence, the unit of analysis of the study will be 'risks in EPDS in hotel industry'. Three five star hotels were selected for the study based on access and time limitations (See Table 1). Interviews were the primary data collection technique in this study while organisational records such as guidance documents, registers, manuals, handbooks supplemented data-gathering efforts. Content analysis and cognitive-mapping techniques were used to draw conclusions.

Table 1: Details of Cases

Organisation	Case A	Case B	Case C
Type of Hotel	Five star City hotel	Five star Business hotel	Five star City hotel
Life span (Age) of the building	28 years	22 years	18 years
Interviewees	Maintenance Engineer	Assistant Chief Engineer	Assistant Chief Engineer
	Shift Engineer	Shift Engineer	Electrical Supervisor

5. RISK FACTORS ASSOCIATED WITH ELECTRICAL POWER DISTRIBUTION SYSTEM IN HOTEL BUILDINGS

5.1. INTERNAL RISK FACTORS

Figure 2 illustrates the main risk factors and sub-risk factors which were identified in the empirical study. The diagram was developed based on the data derived from the three selected cases. The findings show that there are four key risk factors affecting EPDS. Poor maintenance (maintenance risks), unplanned operations (operational risks), bad equipment (asset specific risks) and negligence (human errors) were identified as the main risk factors. Out of the four, the maintenance risk and unplanned operations were identified as the most critical risks which affect the EPDS because in all the three cases selected, identified poor maintenance and unplanned operations as critical risk factors. In addition, the asset-specific risk and human error were also mentioned by the respective interviewees.

According to the research findings, the maintenance risk depends on the different sub-risk factors. A poor maintenance plan, inaccurate maintenance strategies and failures in the maintenance schedule were identified as the main sub-risk factors in the case of the maintenance risk. The maintenance risk is also affected by some of the other common sub-risk factors. Low awareness, low level of training and unskilled persons was seen as the common sub-risk factors because most of them have a direct impact on all the main risk factors.

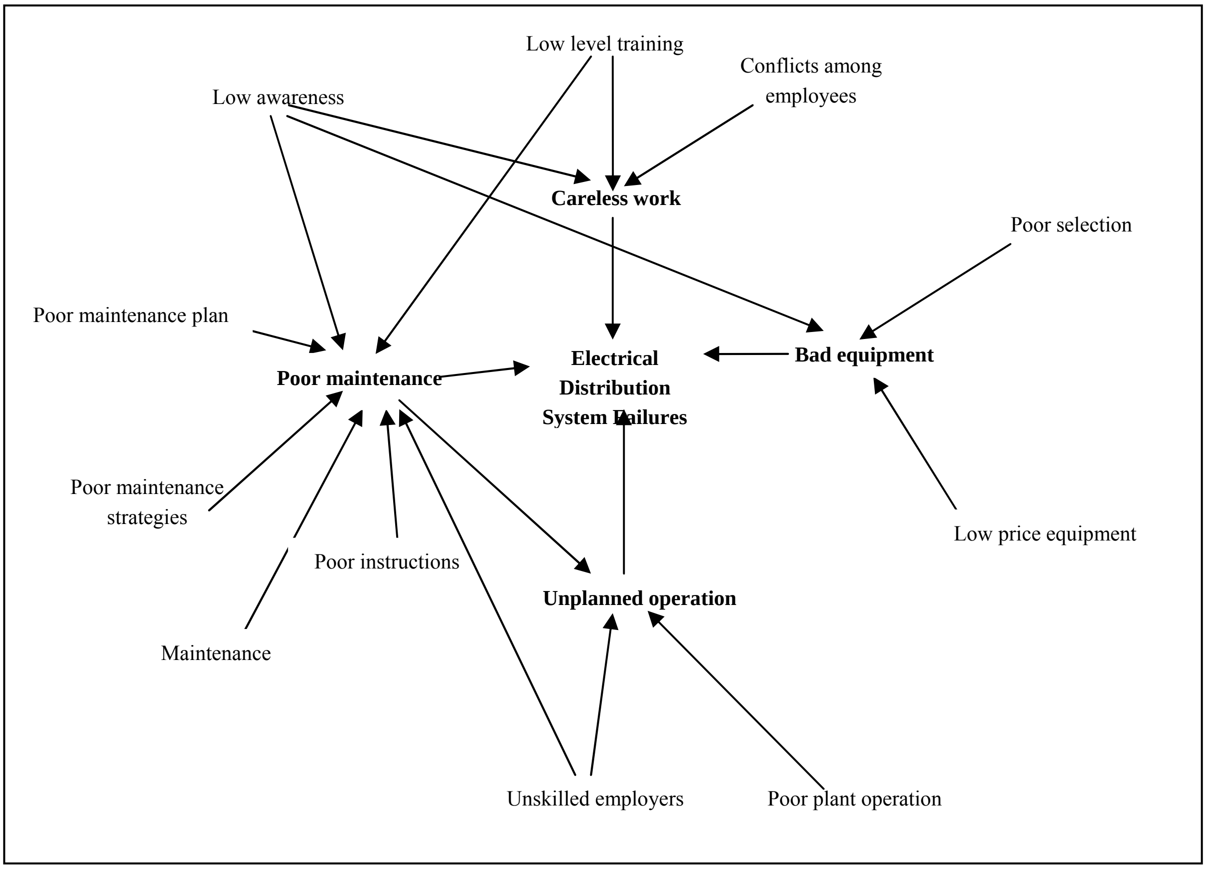

Figure 2: Different Type of Risk Factors which Affects the Electrical Distribution System

On the other hand, it was identified that some risks depend on another risk. For example, as the data shows, of poor maintenance may be the result unplanned operations.

5.2. EXTERNAL RISK FACTORS

External risk factors are another considerable fact which was identified through the interviews done by the researcher. External risk factors were emphasised by most of case representatives as the uncontrollable risk factor which they are faced during the operation. This point was emphasised by the representative of the Case A, "*weather condition may affect to the building services*". He emphasised whether condition as the uncontrollable external risk factors in the present situation. Further, he expressed that, "*mainly electrical system affect by the weather condition. High moister situation may cause to short circuit*". EPDS are highly sensitive to moister condition because it may spark due to higher moister situation. Therefore, weather condition directly affects the EPDS and it can cause to failures in the hotel EPDS.

5.3. HIGHLY RISKY EDS COMPONENTS

The case study findings revealed that there is highly risky equipment in the EPDS. Representative of the Case A identified transformers and generators as high risk equipment in the system. Further, he stated that, "*transforms can fail due to the small changes in the moisture condition and generator can fail due to the irregular maintenances*". With respect to the ideas of the Case B Representative, "*MCCB and generators are high risk equipment in the electrical distribution. MCCB are fail due to the very small problem in the voltage*". He further stated that, "*because of the high risk in the generators, we have an agreement with the generator company to do the generator maintenance and related services*". According to the representative of case C, "*High voltage switchgear and generators are the high risk equipments in the electrical distribution. High voltage switchgear can be easily failed due to the spark and heat of the switchgear*". He further explained about the maintenance and service procedure, which was required for the proper operation of the system. Based on the empirical data, it can be identified there are components in the EPDS which can fail easily due to factors such as changes in moisture conditions or slight change in voltage.

6. MITIGATION STRATEGIES OF RISKS IN ELECTRICAL POWER DISTRIBUTION SYSTEM

The empirical data gathered revealed several risk mitigation strategies namely; mitigation strategies for maintenance risk, operational risk mitigation strategies, mitigation strategies for bad equipment and mitigation strategies for careless work. These will be discussed in the following section.

6.1. MANAGEMENT STRATEGIES FOR MAINTENANCE RISK

According to the empirical data poor maintenance can be identified as a key main risk factor which affects the EPDS. Therefore, maintenance schedule comprising with preventive and predictive maintenance strategies is a good way to prevent the occurrence of maintenance related risks. As an example representative of the Case B stated "*we follow preventive maintenance schedule to prevent any failure of the building services including EPDS. Preventive maintenance was done for the electrical system weekly, monthly and yearly*". Further, he clearly mentioned that, special testing called "hot pot tests" for maintain the main point of the electrical system is used. It is evident that having preventive predictive maintenance schedule to control maintenance risk is important. According to empirical findings maintenance system should be capable of preventing any fault which occurring due to the maintenance activities.

6.2. MANAGEMENT STRATEGIES FOR OPERATIONAL RISK

Operational risks are one of the critical risk factor which causes to fail the EPDS. According to the collected data, different management strategies are used to avoid the operational risk which occurring in the EPDS. Representative of the Case A emphasised that, "*each and every function in the hotel is done with the proper plan*". Representative of the Case B explained the importance of the proper plan. For example Most of the instances electrical power distribution system overloads due to the unplanned operation. He stated that, "*we identify the maximum load which can be able to bear in the each switchgear. Then we train people to consider about maximum load in the operation. It helps to prevent the operational risks of the system*". According to that, unplanned operations are identified as the main problem and proper planning is identified as the most suitable strategy for controlling the risk.

6.3. MANAGEMENT STRATEGIES FOR BAD EQUIPMENTS (ASSET SPECIFIC RISK)

Empirical findings showed that there are asset specific risks in relation to EPDS Although, The interviewees are more concerned about this issue and suggested management strategies for this risk factors. According to the explanation of the Representative of Case A, "*when we are selecting equipments; we go for the best equipment in the industry. It can help in preventing failures due to faulty equipment*". In addition the empirical findings showed proper equipment selecting criteria should be adapted to avoided asset specific risk.

6.4. MANAGEMENT STRATEGIES FOR HUMAN ERROR (CARELESS WORK)

According to empirical findings most of representatives emphasised that, human error was difficult to manage with strategies because; most of the human errors happen due to personal attitude. Representative of the Case A stated that, "*we have training programs to educate the people to manage the emergency situation without any problems*". He emphasised that, people are educated with the use of training programs. With respect to empirical findings, employees training and development were identified as the management strategy for the human errors.

7. THE RISK MANAGEMENT FRAMEWORK FOR ELECTRICAL POWER DISTRIBUTION SYSTEMS IN SRI LANKAN HOTELS

The aim of this research was to develop a risk management framework for EPDS in Sri Lankan hotel industry. As the research findings revealed, once the risks were identified, they can be addressed via the risk management framework. The developed risk management framework for EPDS is as illustrated in Figure 3. It was developed based on the research findings and the analysis of data generated through the literature review, interviews and the review of organisational records of the selected cases.

The first and second objectives of this research were identifying the key building services in hotel buildings and identifying the risk factors associated with the failures of building services. These objectives were achieved through the literature review. The third objective was to identify the risk factors related to EPDS failures in hotels in the Sri Lankan context while the fourth objective were to identify the strategies used for mitigating the risk factors associated with EPDS failures. These objectives were achieved form the data which were gathered through interviews and organisational records of the selected cases. The final outcome of this research was to develop a risk management framework in terms of EPDS which was realised from the critical analyse of the literature and interviews details (See Figure 3).

According to empirical data the maintenance risk, operational risk, human error and asset-specific risk were identified as the internal, controllable risk factors. In addition, weather condition considered as external uncontrollable risk factors. The risk management framework uses different strategies to minimise the internal and external risk factors. The research findings showed the failure mode effect analysis method as the most appropriate tool for use in the risk identification process. According to a representative of case B the results from the failure mode effect analysis can provide the required risk management strategies to control the effect of failure. Therefore, in the proposed risk management framework, this method is recommended to prioritise and evaluate the risk factors in the building services.

The risk management strategies were identified as offering control methods for internal risk factors. As explained by a representative of Case B after identifying and prioritising the risk factors through the failure-mode effects analysis method, risk management strategies were used to control the risk factors. For example preventive predictive maintenance schedule, planned operations, employee training and asset-selection procedures were identified in the research findings as the main risk management strategies in EPDS. However, according to the interviewees uncontrollable risks such as changes in weather were difficult to control through the risk management framework.

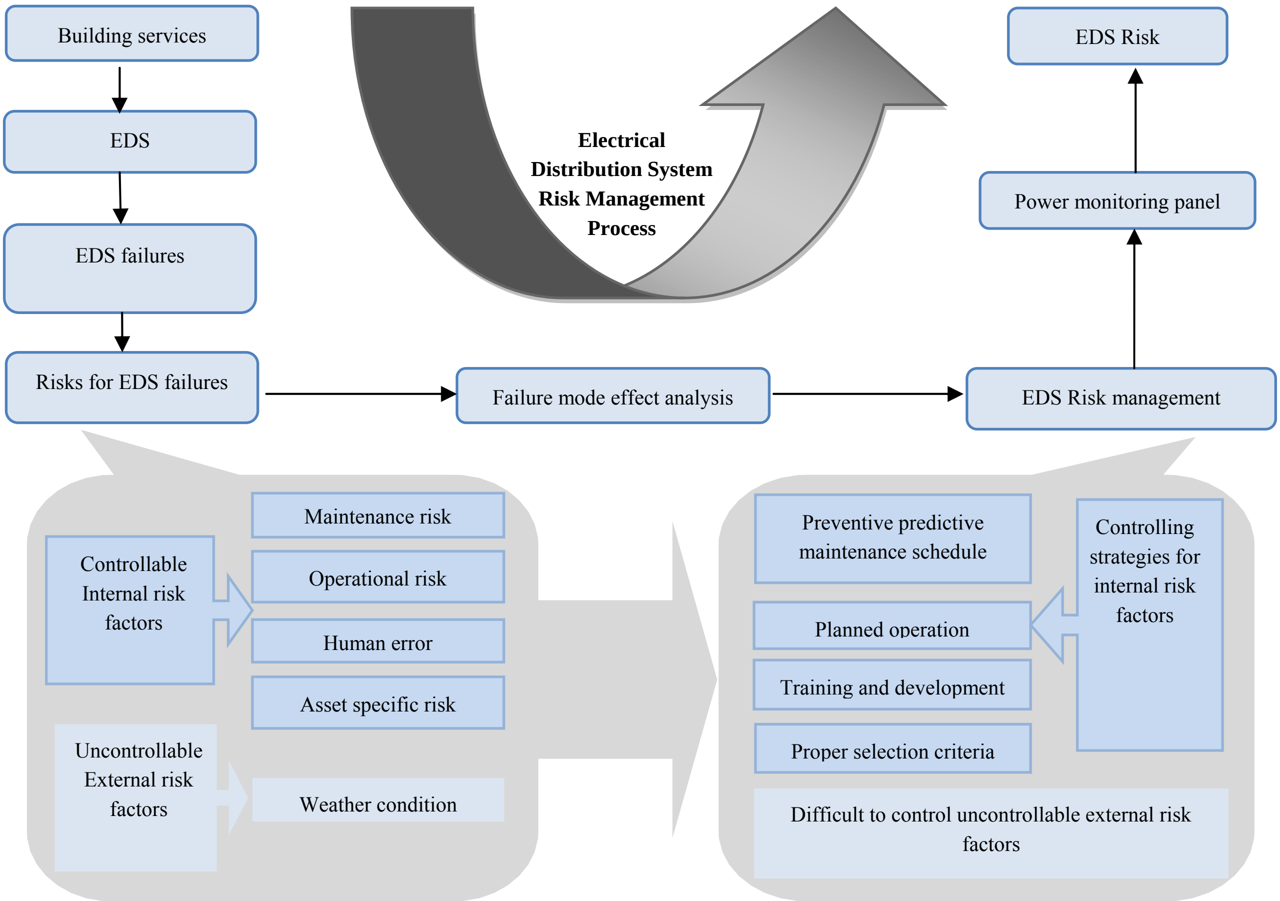

Figure 3: Proposed Risk Management Framework for Electrical Distribution System

Monitoring the process implemented is an important aspect in any system. According to empirical data, the power monitoring panel was identified as the monitoring method most used in the electrical EPDS risk management framework. According to the explanations offered by representatives of Case C and Case A, the power monitoring panel helps them to identify the location of the fault and to provide mitigation strategies for the fault.

The reactive risk management strategies may not be enough to control risks that occur in EPDS. According to a representative of Case A, it is necessary to have a pro active as well as reactive risk management system as the hotel is responsible in providing uninterrupted and quality service to their customers. Some failures can also occur due to external uncontrollable risk factors. Therefore, a pro active risk mitigation plan was emphasised as the final step in the risk management framework. The research findings emphasised that a risk mitigation plan addressing different aspects was required to manage emergency situations. Each and every critical aspect of the system is addressed in the risk mitigation plan in order to control the damage due to the failures.

8. Conclusions

The prime aim of this study is to develop a risk management framework for EPDS in Sri Lankan hotel industry. Since guest satisfaction was identified as the most important consideration in a hotel, continuous operation of the different building services has to be assured. From the many different building services installed in a hotel building EPDS was identified as the key building service because the operations of all other services depend on the EPDS. Thus, power failure would inevitably lower guest satisfaction.

Both the literature review and interview data revealed the different risk factors associated with EPDS. These risk factors were categorised as internal and external in the interview data. While the maintenance risk, operational risk, human errors and asset-specific risks were identified as the main internal controllable risk factors, weather conditions was identified as the uncontrollable external risk factors.

The final objective of this research was to develop a risk management framework for EPDS in the hotel industry. Based on the research findings, a risk management framework was developed as shown in Figure 3. The proposed risk management framework was developed addresses the risks in the EDPS in the hotel. The risk management framework comprises the failure-mode effect analysis, risk management strategies, power monitoring panel and risk mitigation plan. It should also be noted that each and every step addresses critical points in the risk management process of EPDS. The findings and recommendations of this study will be useful to those responsible for EPDS operations in the hotel industry for the purpose of reducing EPDS failures.

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IMPORTANCE OF DESIGN PHASE STAKEHOLDER MANAGEMENT FOR SUCCESSFULLY ACHIEVING OBJECTIVES OF BUILDING PROJECTS: A SRI LANKAN PERSPECTIVE

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ABSTRACT

Contribution of the building design process for achieving the project objectives with a higher degree of success has been highlighted in several researches worldwide. Conventionally, success of a building project is judged in terms of, completion within the scheduled time, completion within the budget, and fully complying to the clients' satisfaction with minimum subsequent modifications and reworks. In achieving these, design phase of a building project alone offers the greatest scope. Irrespective of this awareness, instances are not rare to find, where clients are facing various difficulties in completing/ operating their buildings. Research and many case studies from the industry have provided evidence for cost overruns, delay in completion, mismatch between the delivered product and the clients' expectations, and high cost and time expenditure on variations and modifications in building projects. The aim of this paper is to present the outcomes of a research, which identified the importance of acquiring the timely contribution of design phase stakeholders and effective coordination amongst them, throughout the design phase for better achievement of the project objectives. The discussion is based on findings of a comprehensive questionnaire survey carried out in Sri Lanka on a sample of design phase stakeholders who holds hands-on-experience in building trade. Based on findings recommendations are made to encourage higher investment on stakeholder management during the design phase.

Keywords: *Design Phase, Design Stakeholders, Effective Coordination, Success of Building Project, Timely Participation.*

1. INTRODUCTION

Design process is intense in human involvement. It is performed by several design specialties (architecture, structures, building systems, etc.) that develop solutions with increasing levels of details (Fabricio *et al*., 1999). It also involves a large number of stakeholders whose voices must be heard and whose needs are often conflicting (Ballard and Koskela, 1998). However, their contribution is essential in the thousands of decisions to be made, with numerous interdependencies, within a short period of time relative to the total project duration, in a highly uncertain environment. Clients and developers/ investors are not only interested in value for money in relation to the investment in project development but also in costs associated with operation and maintenance over the period of lifecycle (Doloi, 2010). The design professionals are supposed to deliver the best alternative which would fulfil this requirement. Further, to be competitive, they need to adhere to the time constraints stipulated by the overall project duration which greatly depends on clients' business schedules. Hence, understanding at early stages, the complexity of design in both functional and operational context is important in defining the appropriate end facility (Kohler, 2008; Doloi, 2010).

In addition, increasing complexity of modern building also demands incorporating novel technologies, innovative applications and new concerns such as sustainability and green building concepts (Austin *et al.*,1994; Doloi, 2010). During the last three decades, the expectations of clients have changed

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considerably from the conventional frame, resulting in complex and fascinating building forms with various superior features. These have put more pressure on design teams to come up with better solutions. Consequent is an enhanced challenge exerted on the design professionals. They are supposed to be more conscious on the degree that their design meets the project objectives and clients expectations, completely and comprehensively. The project managers / lead consultants are supposed to form design team which include all important design stakeholders, ensure timely appointment and participation of each design professional and maintain proper coordination amongst them throughout the design phase of the project.

This paper focuses on the importance of design phase stakeholders involvement in achieving the project objectives, successfully. It argues that identifying all stakeholders who are important for the design process, planning their contribution in an effective manner and maintaining proper coordination among them have a significant impact on the success of a project.

1.1. DESIGN PHASE IN A BUILDING PROJECT

The increased emphasis for keeping the construction project on time and within the budget requires effective management of project scope and defining its limits clearly (Goldschmidt, 1992). It is an important fact that properly managed, systematic approach to the whole building design process is essential to ensure smooth and harmonious progress into construction (Austin, *et al.*, 1994). Design phase in a building project alone offers the greatest opportunity to add maximum value to the end-product and reduce overall project cost (Doloi, 2010). It is the phase during which the client's requirements are conceptualised and developed into various design drawings and engineering specifications, which ultimately would be used to build up the facility. It usually starts with a barely defined set of requirements, which usually does not describe client's needs explicitly. Right from this point, it is the design team's responsibility to develop a comprehensive design brief, develop alternatives, evaluate and detect the best option suited for client's requirements, develop it through integration of contributions from various disciplines, re-evaluate and improve through iterations, submit for various approvals from client and other corporate bodies and finally deliver a set of designs and specifications which explicitly comply with the client's need. This is essentially a team effort that needs effective and thorough planning and control within and among all disciplines. Hence successful design process of a large multidisciplinary project requires close coordination to ensure that all parties are constantly aware of every changing status of the project, if it is to eliminate design errors and limit design alterations. However, lack of design planning is often noticed in the architectural, engineering and construction (AEC) projects largely due to the fragmentation of the industry (Pekta and Pultar, 2006).

In the majority of projects the planning work that has to be carried out during the design phase is generally performed in a perfunctory fashion (Austin, *et al.*, 1994). It is not because that the designers are poor in planning but because that the 'design' being largely a creative process, it is difficult to plan at its early stages. Usually the planning is done on a disciplinary by disciplinary basis, with each discipline trying to accommodate the inputs from the others (Austin *et al.*, 1994). However, cross-discipline information flow is not continuous and results in conflicts at deep levels of details. Many intermediate decisions taken within these disciplines are reciprocally independent, which may or may not be communicated to or identified by other parties during the design phase. Any such unidentified decision could lead to variations and many other issues during subsequent phases of the project. Galvan and Tucker (1991) have shown how the minor design-related problems significantly affect the construction performance.

In addition, deficient planning of stakeholder involvement leads to lack of in-time response, lack of communication, poor understanding and cooperation between parties and poor understanding about the project objectives, in overall. This results in considerable reviews and rework. Reviews enhance quality and accuracy. However, rework absorbs considerable amount of useful time available for conceptualisation and design development. Most of the time, with poorly planned stakeholder involvement, overall effort does not ensure a satisfactory design.

1.2. STAKEHOLDER CONTRIBUTION ISSUES DURING DESIGN PHASE: WHAT LITERATURE REVEALS

Josephson and Hammarlund (1996) in a study carried out on seven building projects in Sweden, found that when measured by cost, design-caused defects were the biggest category among all defects of a building. Of the design caused defects, those originating from missing coordination between disciplines formed the largest category. In the study carried out in United States, on causes for quality deviations in design and construction, Burati, *et al.* (1992), found that the design deviations account for 78% of the total number of deviations, 79% of the total cost of deviations, and 9.5% of the total project cost. Poor communication, lack of adequate documentation, deficient or missing input information, unbalanced resources allocation, lack of co-ordination between disciplines and erratic decision making have been pointed out as the main problems in design management (Lyren and Sundgren, 1993; Sverlinger, 1996; Tzortzopoulos and Formoso,1999). In a study on management of design documentation, carried out in Australia, Gardiner (1994) says that he encounters many design consulting firms, who do not allocate a project manager or dedicated staff to the project and assign them roles that are clearly understood. Those observations are supported by Swedish studies on design management by Arnell, *et al.* (1996) and Koskela *et al.* (2002), where one central problem found was that the involved persons perceive uncertainty in what has to be done, who has to do it and when it has to be ready. Common consequences include slow approval from clients, late appointment of consultants, conflicts between details from different disciplines and inadequate time to complete design documentation carefully (Sverlinger, 2000).

2. TOWARDS BETTER MANAGEMENT OF DESIGN STAKEHOLDER INVOLVEMENT

As the methodology, this research utilised an experience survey conducted in Sri Lanka using a questionnaire as the tool on a carefully selected group consist of expert design professionals, building construction and maintenance professionals, quantity surveyors, clients and end-users who possess considerable experience in the building trade. The study was structured on a meaningful sub-division of the design phase.

2.1. IMPORTANT DESIGN STAKEHOLDERS

The important stakeholders were identified based on authors' past and present experience in building projects and from the findings of previous researches by Fabricio *et al.* (1999), Tzortzopoulos and Formoso (1999) and Koskela *et al.* (2002). Accordingly, conventional stakeholders; Client, Project Manager, Architect, Structural Engineers, and Building Services Designers (Electrical Engineers, Mechanical Engineers, Water Services Engineers, IT and Telecom Engineers) and few nonconventional stakeholders; Developers/ Investors, Quantity Surveyors, Facilities Managers (FM) / Maintenance Engineers (ME), End Users/ Tenants of previous building projects, were identified as stakeholders important for the design phase.

2.2. STAGES OF DESIGN PHASE

The collaborative building design process is viewed as an iterative flow of interdependent decisions of different design professionals (Pekta and Pultar, 2006). It can be split into meaningful sub stages. It is argued in this research that understanding the depth of involvement of each stakeholder at each stage gives better grounds to understand the exact time to consult them. Selection of the best depth of division influences the ease and practicality of implementation of outcomes of this research. As such, the design phase was subdivided into five stages based on the specific, important deliverable that those produce.

Stage 1 - Functional Brief setting stage

Stage 2 - Conceptual design preparation stage.

Stage 3 - Council drawing preparation stage.

Stage 4 - Tender drawing preparation stage.

Stage 5 - Construction drawing preparation stage.

3. Relationship of Design Stakeholders' Participation and Coordination with Achievements of Project Objectives

The survey results revealed that over 87% of the participants agreed to the fact that the difficulties in completing the project within the contract duration and the budget, scope creep and problems associated with it, and many cost variations could have been avoided if all necessary stakeholders were consulted in the appropriate stages of the design process. Over 82% of them agree that such shortfalls could have been avoided if effective coordination among stakeholders is maintained throughout the design phase.

Further, 75% of the participants agreed that the scope creep is directly associated with incomplete designs delivered at the tender stage, which has a direct relationship to stakeholder participation and coordination amongst them. 55% agreed that the cost variations in building projects are generated mostly due to the inefficient contribution of design stakeholders during design phase. 45% and 37% voted respectively for and against on the fact that the reasons for time extensions were originated due to incomplete deigns and subsequent additions and amendments.

On the whole, the statistics revealed that obtaining the participation of all necessary design stakeholders during appropriate stages of the design phase and maintaining coordination amongst them would contribute highly in overcoming critical problems associated with achieving the core objectives of building projects. However, obtaining and maintaining the participation of all stakeholders, in all stages is practically impossible and costly. The degree of contribution in terms of inputs, comments and feedbacks from each stakeholder obviously vary throughout the design phase. In order to develop proposals for optimum arrangement, further investigations were carried out to query the importance of each stakeholder's participation in the identified phases of the design process.

3.1. Timely Participation of Stakeholders in the Design Process

Figure 1 illustrates the average of the responses received on a five point scale for the importance of participation of main design professionals, during the five stages for the successful achievement of overall project objectives.

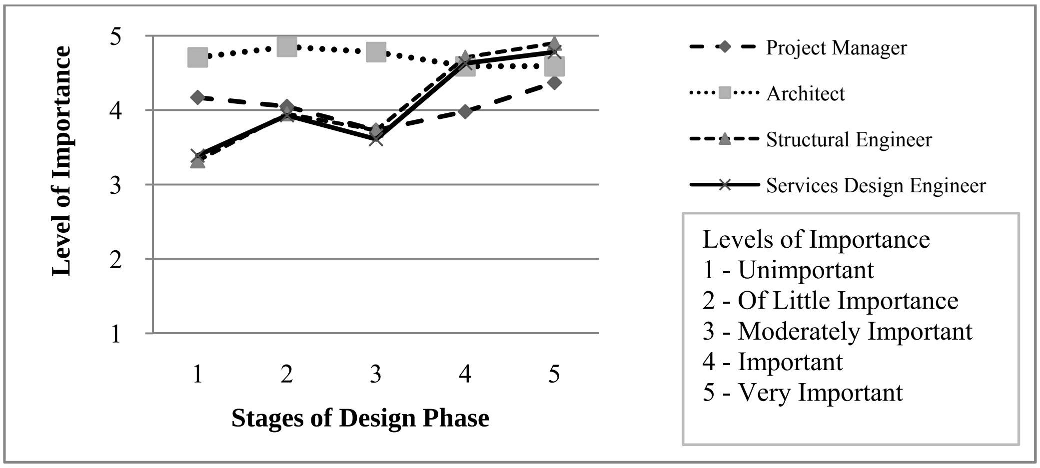

Figure 1: Importance of Participation of Main Design Professionals

The analyses show that the participation of all four categories of stakeholders is ranked above moderately importance. This follows the usual industrial trend, which shall be obviously visible in this kind of survey. However, beyond this, the analysis gives a better picture on the variation of the importance of participation of each professional category, during each stage of the design phase.

Figure 2 illustrates the averages of the responses received on the same scale, for participation of clients, developers and end users/tenants as stakeholders during the five stages, for the successful achievement of overall project objectives.

In Figure 2, clients' participation is ranked above moderate, in the three initial stages of the design phase. Developers' and end-users'/ tenants' participation is also placed above moderate, in the first two stages. Usually, the participation of these three stakeholders is more or less limited to the initial stages, as conceptual and layout design development is mostly completed during these stages. However, it does not give evidence to conclude that the availability of these three categories, during the rest of the design phase, is insignificant. Averages of the total responses made by all participants of the survey on the participation of these three categories are above scale point 2 for all design stages. This indicates that in the subsequent stages their presence is valued by the building experts against the convention, though with a lesser degree of importance.

In general, at the stage of council drawing preparation, the design development is mostly completed. However, between council drawings and tender drawings, there would be considerable refinements to reach the final design, which clients, developers and end-uses would like to be aware of. This is an iterative process, which ultimately produces the final design that would be handed over for construction. Furthermore, these designs would be used for procuring the builders and would be a part of the legal contract. Therefore, the participation of this stakeholder group would still be important, in the remaining stages where they can comment on subsequent essential modifications. Hence, the observation illustrated in Figure 2 has sound underline reasons. The surveyed sample has accepted the need of the participation of the three categories of stakeholders in all five stages for the successful achievement of overall project objectives.

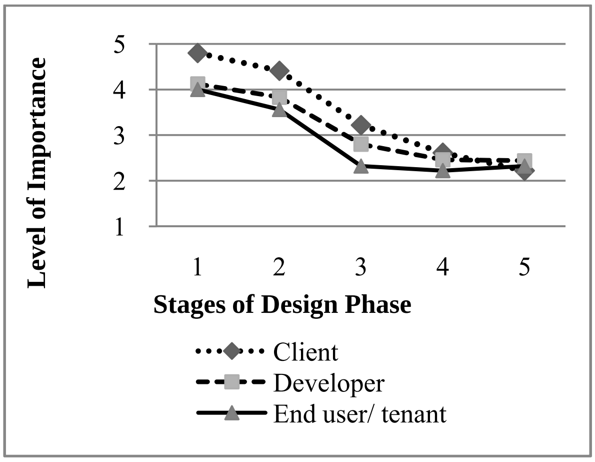

Figure 2: Importance of Participation of Clients, Developers, End Users/Tenants

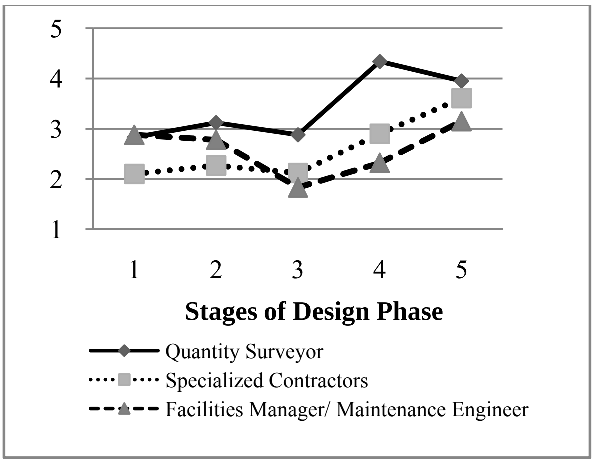

Figure 3: Importance of Participation of Quantity Surveyors, Specialized Contractors, and FM/MEs

The importance of participation of another three non-conventional stakeholders is illustrated in Figure 3. The results show that the importance of participation of quantity surveyors, in all the design stages is near or above moderate. At the stage of tender drawing preparation, this has received a significance level over 4 which is in the range of main design professionals. The survey brought the participants attention on their previous experience of cost variations and cost overruns. They confirmed with over 55% agreement that, 'subsequent cost variations of building projects have a relationship with the stakeholders' contribution during design phase'. Quantity surveyors play a major role in preparation of bills of quantities and specifications, parallel to the design development, which fix the price of the project. These two documents describe the work detailed in all designs completely and comprehensively. Any discrepancy between tender designs and these documents could lead to a dispute according to the contract document. Hence, continuous updating of these documents for all design alterations even at the last moment is of utmost importance from the point of the contract. On the other hand, quantity surveyors possess the capacity to provide advice and guidance in terms of cost implications of the various decisions taken while those are being made, which could be of great importance for clients and developers of the project. It is with this background the quantity surveyors were included in as a category of design stakeholders which had been accepted by the sample (Figure 3).

Participation of professionals who possess facilities management and/or building maintenance experiences were also proposed as design stakeholders in the study (Figure 3). These professionals possess experience in post occupancy issues of buildings, who in turn could provide valuable inputs during design phase of future works. The great advantage is that the issues related to operational and maintenance costs could be addressed in advance by effectively incorporating the lessons learned. Participation of these professionals has reached a level near or above moderate, in design brief setting stage, conceptual design preparation stage and construction design preparation stage.

Figure 3 also shows the importance of participation of the specialised contractors, who form another non-conventional stakeholder proposed in this research. Usually, specialised contractors in different trades are procured to the project team during the construction phase. Analysis of responses shows that, they also would be a category who could contribute in the design process for the successful achievement of overall project objectives. They possess considerable experience in issues arising during the construction phase, defect rectification period and during the post-occupancy stage of previous building projects. They also have a better idea of how those problems would originate and what is the best time to take precautions to reduce the chance of repeating the same problem in future projects. Hence the acceptance of their participation as design stakeholders by the survey participants has strong underlying reasons.

The above analyses show that it is needed to rethink on the organisation of design team stakeholders based on the new demands of the design process. It also illustrates that various design stakeholders hold different levels of importance of participation during different stages of the design phase. These findings could be used as a guideline in planning design teams for consultancy bids, scheduling design stakeholder participation during the design development process and optimising the stakeholders' involvement for profitable design projects.

3.2. EFFECTIVE COORDINATION AMONG DESIGN STAKEHOLDERS

Importance of maintaining the coordination among design stakeholders for better achieving project objectives was accepted with over 82% agreement by the respondents, as earlier. However, *the degree of importance* of coordination among each stakeholder category for all combinations remains a question to be answered. Maintaining the same level of coordination among all stakeholders, at all time is impractical and would not be the requirement for a successful design development. The coordination is required to minimise reworks in all disciplines during design development and minimise conflicts between different disciplines in the final designs. In this process, obviously, the main design professionals may need a higher level of coordination amongst them, but it would not be the same among all stakeholders. Usually the coordination among different disciplines takes place through periodical meetings and/or when queries are made upon issues aroused. However, depending on these and voluntary requests for coordination alone, has not been trustworthy enough for a large investment like a building project. Hence, coordination among design stakeholders cannot be left to occur in the way it comes, or in an arbitrary way. Instead, it needs to be planned and managed throughout the design phase.

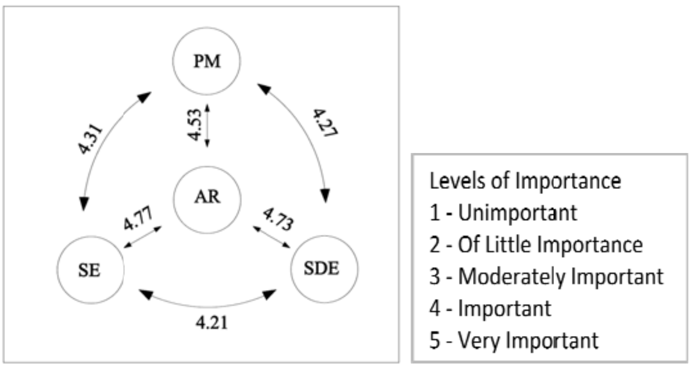

Figure 4: Importance of Coordination among Main Design Professional.
(PM – Project Manager, AR – Architect, SE – Structure Engineer, SDE – Services Design Engineer)

The study examined the variation of the degree of coordination among different stakeholders depending on the role they play in the team. In order to develop proposals for optimum arrangement, further investigations were carried out to query the importance of coordination among each stakeholder pair considering the entire design process.

Figure 4 illustrates the averages of the responses received on a five point scale for the importance of coordination among main design professionals during the design phase for the successful achievement of overall project objectives. It clearly indicates the high importance of coordination that needs to be maintained between them throughout the design phase. Usually, one could say that this is already secured in practice to a considerable extent. However, as highlighted in the literature, the cost and time variations resulting from the conflicts between design details of different disciplines cannot be taken casually. The scale values indicated in the figure stress the attention that needs to be paid on each relationship when it comes to integrating the contributions from different disciplines. The study proposes that these results trigger a necessity of higher and closer attention even on the conventional coordination relationships, in the effort exerted to develop the design that best fit to the project objectives.

Table 1: Importance of Coordination among Client/ Developer/ End User and Other Important Design Stakeholders.

	Client	Developer	Project Manager	Architect	Structural Engineer	Services Design Engineer	Quantity Surveyor	Specialised Contractor	Facilities Manager/ Maintenance Engineer
Client	-	4.27	4.19	4.82	3.55	3.85	3.24	2.77	3.19
Developer	4.27	-	4.55	4.44	3.55	3.40	3.29	3.15	2.89
End user/ tenant	4.15	3.06	2.89	3.94	2.29	2.63	1.90	2.48	3.76

Table 1 illustrates the averages of the responses received on the same scale, for the coordination of clients, developers and end users/tenants with all important stakeholders identified in the study, for the successful achievement of overall project objectives.

The zone highlighted shows the averages of the responses received on the five point scale for the expected coordination between main design stakeholders and the group under discussion. It shows that the importance of coordination of main design stakeholders with client and developer is above moderate importance (value of 3.0) for all combinations. This is as high as 4.82 between the client and the architect for the obvious reason of coordination required for the development of the project brief and the conceptual architectural design. However, the results reveal that clients direct coordination with services design engineers and structural engineers cannot be regarded of lesser importance. In the current context, clients and developers are concerned about the nature of building services that could be made available in their new facility, structural aspects such as performance of the building in natural disasters, economy of services and structural solutions adopted, possibilities of adopting the latest technologies available in the industry, and many such engineering aspects, in addition to the layouts of spaces and aesthetics. In addition clients are also interested on trade-offs made between different disciplines during design development and optimisations. Almost all of these are dealt during the design phase itself and successful achievement of them could be ensured if coordination among the clients/ developers and design engineers are maintained at a strong level. This is justified by the survey results.

Further, coordination between clients/developers and quantity surveyor has received an importance above moderate. This further strengthens the argument developed on quantity surveyor's involvement as a design stakeholder, discussed in the previous section. Coordination with quantity surveyor, who could advice the client/developer, in terms of cost implications of the various decisions taken while those are being made, is valued by the survey participants with a higher level of importance. In addition, clients/ end-users/developers coordination with building maintenance experts has also received reasonable level of importance. Also, the coordination of developers/clients with specialised contractors, and architect with end-users also have been accepted with moderate values by the survey participants.

The importance of coordination between quantity surveyors, facilities management/ building maintenance experts and specialised contractors with the remaining design stakeholders are illustrated in Table 2. The results show that the importance of coordination of quantity surveyors with main design professionals, specialised contractors and facilities mangers/maintenance engineers is near or above moderate.

Table 2: Importance of Coordination among Quantity Surveyors, Specialised Contractors, and Facilities Mangers / Maintenance (FM/ME) Engineers and Other Important Design Stakeholders.

	Project Manager	Architect	Structural Engineer	Services Design Engineer	Specialized Contractor	Facilities Manager/ Maintenance Engineer	End user/ tenant
Quantity Surveyor	4.21	4.15	3.81	3.71	3.60	2.47	1.90
Specialised Contractors	4.00	3.76	3.65	3.94	-	3.39	2.48
Facilities Manager/ Maintenance Engineer	3.53	3.29	2.87	3.82	3.39	-	3.76

Coordination between the main design professionals and the group under consideration in Table 2, have received near or above moderate importance for every combination. In section 3.1 above their participation as design stakeholders in various design stages was discussed. Coordination between specialised contactors, and structural and services design engineers during design phase could improve constructability aspects of the building which would enhance the chance of completing the construction work within the planned duration. In addition, this would facilitate the use of proprietary systems (e.g. form-work systems) and ready-made products, which would reduce construction and operational wastage, which in turn would be beneficial for the project. This has been accepted according to the research findings. Importance of coordination between project manager/ architect with facilities managers/ maintenance engineers, during design phase also had received higher regard. Close coordination among these parties would be essential to improve the current designs using the lessons learnt in previous projects.

In summary, the research results shown in Table 2 reveal that obtaining the coordination of these non-conventional stakeholders, during the design phase, could considerably contribute to better achieving project objectives.

4. CONCLUSIONS

Building projects are capital investments of which the degree of success has serious implications on the investors' life. Design phase of a building project, not only finalises the building design, but also defines and fixes majority of the project parameters, boundaries and constraints in terms of scope, cost, time and quality. It requires intense involvement of various stakeholders. The aim of the study was to find out the importance of timely participation and effective coordination of the design phase stakeholders for successfully achieving the project objectives. The research findings show the varied importance of timely participation of different design stakeholders during various stages of the design phase. Those confirm the involvements of main design professionals and highlight the importance of involvements of the other non-conventional groups as design stakeholders, which were proposed by this study. The participation of, and coordination among the Developers/ Investors, Quantity Surveyors and Facilities Managers (FM) / Maintenance Engineers (ME), in design phase has been accepted with high importance. The research methodology also facilitated the numerical expressions of the variations of the importance of participation and coordination of each stakeholder. These could be used as a guideline in planning design teams for consultancy bids, scheduling design stakeholder participation during the design development process and optimising the stakeholders' involvement for profitable design projects.

In addition, the research highlights the importance of higher coordination between client – design engineers, client – quantity surveyor, architect – quantity surveyor, design engineer – quantity surveyor and architect – building maintenance expert, for successful design process, which throws a light on project managers/ design managers who plan and monitor the coordination between various design disciplines.

The findings reveal that success of a project has a strong relationship with the design stakeholders' involvements during the design phase. The research also highlights the need to rethink on the conventional design stakeholder lists and managing their involvement throughout the design phase for greater success of building projects. Overall it concludes that the decision on higher investment on stakeholder participation and management during design phase would considerably increase the degree of success of building projects.

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STUDY ON SICK BUILDING SYNDROME IN OFFICE ENVIRONMENT

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ABSTRACT

Prevalence of harmful natural and artificial substances combined with poorly ventilated interiors can lead to various building related health problems among those who spend long periods indoors. A group of symptoms of unclear etiology divided into mucous membrane symptoms related to eyes, nose, throat, dry skin, together with general symptoms of headache and lethargy due to poor indoor air quality is defined as Sick Building Syndrome. Literature revealed many evidence of indoor air quality and other symptoms that affect to staff in office buildings in Sri Lanka. Thus purpose of this study is to appraise the impact of sick building syndrome on building occupants in an office environment.

Case study was selected as the research approach. Semi structured interviews were conducted with responsible parties on indoor air quality and occupants of three selected office buildings. Case studies revealed that uncomfortable indoor environment and unsystematic maintenance of existing indoor air caused prevalence of symptoms related to sick building syndrome among building occupants, such as lethargy and eye irritation. Results showed that occupants in three office buildings bore many common symptoms while working in same premises in same timing pattern. Further, findings showed that three office buildings that are already affected with sick building attributes have in fact complied with existing Indoor Environment Quality standards. This study discusses approaches to identify sick building syndrome in working environments and standards to mitigate unhealthy conditions in buildings. This study enhances the comprehension on sick building syndrome and attributes that can be applied to evaluate impact of poor indoor environment quality on sick building syndrome.

Keywords: *Building Occupants, Indoor Environment Quality, Office Environment, Sick Building Syndrome, Symptoms.*

1. INTRODUCTION

The ultimate objective of comfort of work place is to acquire better productivity at work place in any culture (Lloze, 2001). Complaints about discomfort and health effects at non-industrial workplaces have increased during late eighties (Skov *et al.*, 1990).

Health problems are usually divided as Building Related Diseases and Sick Building Syndrome (SBS) (Burge, 2004). Furthermore, Burge (2004) mentioned that building related diseases include infectious diseases spreading from building services such as Legionnaires' disease and diseases spreading from worker to worker within a building, such as viral infections. As defined by World Health Organisation (WHO) sick building syndrome "comprises a collection of non-specific symptoms including eye, nose and throat irritation, mental fatigue, headaches, nausea, dizziness and skin irritation, which seem to be linked with occupancy of certain workplaces" (Hedge and Erickson 1995). These symptoms are common in places of large populations and may vary from one building to another (Morris and Dennison, 1995). Lack of personal control of working conditions, indoor climate, work load and interpersonal relationships at work also aggravated SBS symptoms (Bachmann and Myers, 1995). In SBS, symptoms appear when a person is at work and disappear when he is away from the building (Morris and Dennison, 1995).

According to Hedge and Erickson (1995), symptoms prevailed more among workers who work in an air conditioned building than naturally ventilated buildings. According to Burge (2003) SBS symptoms occur in office buildings, particularly schools, hospitals, care homes, residential and hotels. Among these office workers are the mainly affected community as they work in the same place for long durations (Hedge and

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Erickson, 1995). Complaints on discomfort and health effects in non-industrial workplaces increased during the past few decades (Skov *et al.*, 1990).

Central Bank Reports (Annual report, 2007) prove that office workers in Sri Lanka play a significant role in the Sri Lankan economy. However, it was revealed that many workers get absent from work in office buildings due to symptoms such as eye, nose and throat irritation, mental fatigue, headaches, nausea, dizziness and skin irritation they felt whilst engaging in work. Thus, this study attempts to find how SBS affects employees in office environments of Sri Lanka.

2. LITERATURE REVIEW

2.1. SICK BUILDING SYNDROME

SBS symptoms occur in an increasing frequency since 1970s and the most energy efficient, "airtight" buildings are more affected than older naturally ventilated buildings (Redlich *et al.*, 1997). Most researchers extracted the WHO definition to define SBS. Fisk *et al.* (2009) illustrated that many studies appraise health symptoms such as eye, nose or throat irritation, headache and fatigue as common to SBS. Morris and Dennison (1995) demonstrated that these symptoms usually develop on the first day back at work after a break, often in the same afternoon where it can become severe in evening and night after the person has left work. Because of these effects SBS is a major problem at many organisations. Skov *et al.* (1990) mentioned that there was a rapid increase of complaints about discomfort and health effects in workplaces and prevalence of diseases that affect during working time.

Personal factors, job category, type of work, psychosocial factors, building factors, building related factors such as high indoor temperatures, little or no outdoor ventilation, poor individual control of temperatures and lighting, air conditioning and especially poor maintenance, poor office cleaning regimes and water damage are main factors that affect SBS, as identified through previous research. Table 1 demonstrates factors identified by several researchers.

Table: 1 Factors Affecting SBS

Year	Factors affecting Sick Building Syndrome					
	Personal factors	Job Category	Type of work	Psychosocial factors	Building factors	Building related factors
Skov *et al.*(1990)	√	√	√	√	√	√
Morrice and Dennison (1995)					√	√
Redich *et al.* (1997)	√			√		√
Bholah and Subratty (2002)	√					√
Runeson *et al*. (2004)	√					√
Fisk *et al* (2009)				√		√
Crock and Burton (2010)	√			√	√	√

Personal, psychosocial and building related factors were identified as common factors affecting SBS from 1990 to 2010. Among these indoor air quality has been included in to building related factors.

2.2. INDOOR AIR QUALITY (IAQ)

As per a study of Llozor *et al.* (2001) prevalence of harmful natural and artificial substances combined with poorly ventilated interiors lead to various health problems among those who spend long periods indoors.

Table 2 illustrates factors affecting SBS in which indoor air quality related aspects were identified as main factors.

Table 2: Indoor Air as a Main Factor

Research	**Factors affecting on SBS**
Skov *et al.* (1990)	Sex, Job category, photocopying, handling of carbonless papers and **indoor climate factors**.
Bachmann and Myers (1995)	Personal factors, work organisation, gender roles and **indoor climate**
Redish *et al.* (1997)	**Air contaminants, ventilation,** work organisation, host factors
Runeson *et al.* (2004)	Personal factors, physical factors in **indoor environment**
Wong *et al.*(2007)	**Indoor air chemicals**, and high stress during work
Fisk *et al.* (2009)	**Indoor environmental conditions**, psychosocial conditions
Crook and Burton (2010)	Personal factors, female gender, lower Status, Building factors, office Dust, cigarette smoke, paper dust and other factors, **high indoor temperature, air conditioning**, outdoor air ventilation.

As per above studies, indoor climate is a major and common factor that affects SBS.

IAQ refers not only to comfort, which is affected by temperature, humidity and odours, but also to harmful biological contaminants and chemicals in the conditioned space. Illinois Department of Public Health (IDHP) consistently ranked indoor air pollution among top five environmental risks affecting public health. According to Bholah and Subratty (2002), IAQ leads to increased health related symptoms. Though being a tropical country Sri Lanka is expected to have good indoor ventilation, limited data suggest that indoor air is more polluted than outdoor (Nandasena *et al*., *2010).*

Indoor climate is not a characteristically unique factor that causes several diseases. Skov *et al.* (1995) stated that indoor climate consists of several other factors, too.

Internationally, organisations observe certain IAQ standards to prevent prevalence of SBS. Summary of such standards published by IDPH, ASHRAE and OSHA are shown in Table 3.

Table 3: IAQ Standards (Source: Arnold, 2010)

PARAMETER	IDPH	ASHRAE	OSHA
Humidity	20% - 60 %	30% - 60 %	N/A
Temperature	68 - 75 (winter)	68 - 75 (winter)	N/A
	73 – 79 (summer)	73 - 79 (summer)	
Carbon Dioxide	1,000 ppm	1,000 ppm	5,000 ppm
	(<800 ppm preferred)		
Carbon Monoxide	9 ppm	9 ppm	50 ppm
Hydrogen Sulfide	0.01 ppm	N/A	20 ppm
Ozone	0.08 ppm	N/A	0.1 ppm
Particulates	0.15 mg/m^3 (PM 10) (150 µg/m^3) 24-hr 0.065 mg/m^3 (PM 2.5) (65 µg/m^3) 24-hr	50 µg/m^3, annual average (PM 10)	15 mg/m^3 (total) 5 mg/m^3 (resp.)
Formaldehyde	0.1 ppm (office)	0.1 ppm (office)	0.75 ppm
	0.03 ppm (home)	0.04 ppm (home)	
Nitrogen Dioxide	0.05 ppm	N/A	5 ppm
Pressure relationship with Zones	N/A	Restroom mechanically exhaust with no recirculation	N/A
Outdoor air floor rate	N/A	10 L/s (20 cfm) per person	N/A

2.3. IMPACTS OF SBS IN OFFICE ENVIRONMENT

Office, physical and behavioural environments must match with workers' needs as they make an impact on workers' productivity (Wong *et al.,* 2009). In an office environment workers have to work in the same working area for many hours continually in the same premises. Studies found that quality of an office building has a direct relationship with productivity. Unalterable evidence on above was contained in a survey submitted to UK Parliament by Burge (2004). It revealed statistics related to days of sickness absence per year attributed to sick building syndrome and hours per month dealing with or complaining about indoor environment. Thus many studies reveal that productivity depends on working conditions of the office building and a main factor affecting such conditions is indoor air quality.

2.4. STATUS OF SBS IN SRI LANKAN OFFICE BUILDINGS

In Sri Lanka, measuring air quality is a difficult task as costs of measurement of indoor air quality is very high and few experts realise that measurement of indoor air quality is essential. These demonstrate that health effects of occupants are not a concern of the industry. Literature reveals that measurement of indoor air quality is essential for productivity of workers.

Some researchers have illustrated symptoms that affect people in the same place due to poor indoor air quality. But they do not identify those buildings as sick buildings as they usually define these illnesses as building related illnesses. When considering all these factors in Sri Lankan context, there is a high probability that affect of SBS is prevalent in Sri Lanka.

3. METHODOLOGY

To conduct the research, case study approach was selected. The unit of analysis of this research was air conditioned office buildings located in urban areas of Sri Lanka. Three cases of fully air conditioned office buildings in urban areas of Sri Lanka were selected to conduct the multiple case study related to the research problem. Those three cases are briefly described in Table 4.

Table 4: Brief Introduction on Selected Cases

Office	Office A	Office B	Office C
Number of floors	34	7	7
Number Employees	3000-3500	700	1800
Ventilation system	Mechanical ventilation system	Mechanical ventilation System	Mechanical ventilation system
Type of office	Customer service	Customer service	Customer service

Office buildings with mechanical ventilation systems were selected since it is easy to measure indoor air quality components and maintenance aspects. All selected buildings provide customer services where more than five hundred employees provide services day to day from morning to evening. Table 5 illsutrates the interview profile of the research.

Table 5: Profiles of Case Studies

Case	Type	Interview
Case 1	Maintenance Engineer	1
	Occupants	4
Case 2	Chief Technician Officer	1
	Occupants	4
Case 3	Facility Manager	1
	Occupants	4

As a data collection technique interviews were conducted face-to-face, in a semi structured manner. Interview structure was developed using interview guidelines formed to capture data related to the research problem. Two sets of interview guidelines were prepared for two sets of people in office buildings. One was prepared to evaluate existing indoor air quality, with those who are responsible for indoor air quality systems either as facilities managers or mechanical engineers and the other was prepared to identify occupants' symptom patterns with two male and two female occupants who work day to day in same premises, within age group of 21 to 28. Altogether, 15 interviews were conducted, each lasting for about 45 minutes to one hour.

Code-based content analysis was used to capture significant findings from transcripts and for effective interpretation. The QSR.NVivo® - version 9 (copyright© 2009 Qualitative Solutions and Research Private Limited); computer software was used to conduct content analysis, using below illustrated coding structure.

Figure 1: Coding Structure to Evaluate Existing IAQ System

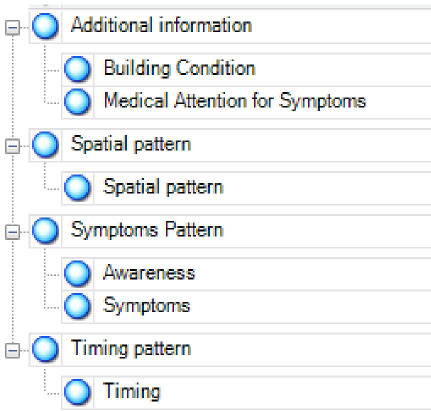

Figure 2: Coding Structure to Evaluate Occupants Structure to Evaluate Existing IAQ system

This research considered networks over matrices as a data displaying tool. Cognitive mapping was selected for data displaying within the study.

4. Findings

Findings of interviews along with observations are discussed under seven sub headings. Three office buildings were selected to identify SBS in office environments Sri Lanka.

4.1. Indoor Air Quality in the Components

Empirical study revealed current practices of indoor air quality components through three cases. Table 6 discloses common tendencies of practice of IAQ components in office buildings.

Table 6: Impact of Symptoms

Components	Common tendency of the Buildings
Humidity	Measure
Temperature	Measure
Carbon Dioxide	Measure
Formaldehyde	Do not measure
Particulates	Do not measure
Nitrogen Dioxide	Do not measure
Carbon Monoxide	Do not measure
Ozone	Do not measure
Outdoor air floor rate	Do not measure
Pressure relationship between zones	Measure
Total Volatile Organic Compound *Comfort range* *Discomfort range* *Toxic exposure range*	Do not measure

Findings reveal that humidity, temperature, carbon dioxide and *pressure relationships between zones are measured in office buildings in Sri Lanka and components such as Formaldehyde, Nitrogen Dioxide, Carbon Monoxide and others are not measured.*

4.2. INDOOR AIR QUALITY MEASUREMENTS

Table 7 illustrates comparison of empirical findings of three case studies with standards for IAQ, sourced from Illinois Department of Public Health (refer Table 3).

Table 7: IAQ Measurements in Office Buildings of Sri Lanka

Components	Standard IAQ Measurement	Common tendency of the buildings
Humidity	30% - 60 %	47%-70%
Temperature	73 - 79 (summer)	73- 79
Carbon Dioxide	1,000 ppm	600-1000 ppm
Pressure relationship between zones	Restroom mechanically exhaust with no recirculation	Circulate
Particulates	50 µg/m^3, annual average (PM 10)	51- 53 µg/m^3
Formaldehyde	0.1 ppm	-
Nitrogen Dioxide	0.05 ppm	-
Carbon Monoxide	9 ppm	-
Outdoor air floor rate	10 L/s (20 cfm) per person	-

Accordingly, all three buildings measured humidity, temperature and carbon dioxide, maintaining them at a satisfactory level. However, it does not prove that these office buildings are safe from SBS.

4.3. RECORD KEEPING AND MAINTENANCE

Table 8 illustrates the common result of record keeping in three selected buildings.

Table 8: Record Keeping and Maintenance

Records	Common tendency of the buildings
As-built construction documents	Yes
HVAC system commissioning reports	Yes
HVAC systems testing, adjusting and balancing reports	Yes
Operations and maintenance manuals	No
Water treatment logs	Yes
Operator training materials	No

Results show that common record keeping systems prevail at selected three buildings. OSHA standards of IAQ state that above records need to be updated to maintain a good indoor environment. Further, findings revealed that operation and maintenance manuals and operator training materials are not maintained properly. Thus, it is concluded that three buildings maintain proper records as far as record keepings for IAQ is concerned.

4.4. OCCUPANT'S COMPLAINTS AND SYMPTOMS

OSHA regulations of IAQ introduced in 1994 declare that to provide a friendly environment, entertaining written complaints of employees related to building related illnesses is mandatory. All three selected cases maintain proper written records of employee complaints. Table 9 illustrates common occupants' complaints.

Table 9: Impact of Symptoms

Symptoms		**Common tendency of the buildings**
Eyes	Itching/irritated	Reported
	Dry eyes	Not reported
	Itching eyes	Reported
	Watering eyes	Reported
	Eyes strain	Reported
Nose	Blocked or stuffy nose	Not reported
	Running nose	Reported
	Other itching/irritation	Not reported
Throat and Chest	Sore throat/cough	Not reported
	Dry throat	Not reported
	Dry/irritated throat	Not reported
	Chest tightness	Not reported
	Breathing difficulty	Reported
	Flu-like symptoms	Not reported
Skin	Itching face without rash	Not reported
	Rash or irritated skin	Not reported
	Other dry skin symptoms	Reported
General	Feeling heavy-headed	Reported
	Lethargy or tiredness	Reported
	Forgetfulness and/ or lack of concentration	Not reported
	Other symptoms	Not reported

As illustrated at Table 9, nine symptoms out of twenty one affected occupants who work day today in the same premises. Numerically it is 42.86%. It shows that symptoms such as itching/ irritated eyes, watering eyes, running nose, breathing difficulties and feeling heavy-headed widely affect occupants who work in the office buildings in Sri Lanka. Numerically it takes a high value. Above mentioned symptoms are defined in SBS as common symptoms that can be identified in sick buildings. Thus in Sri Lanka, 42.86% of symptoms affect the office buildings.

4.5. OCCUPANTS' SYMPTOMS PATTERN AND AWARENESS

Table 10 presents symptoms that affect the selected four occupants in the three office buildings.

Table 10: Symptoms Patterns

	Symptoms	Office A				Office B				Office C			
		M_1	M_2	F_3	F_4	M_1	M_2	F_3	F_4	M_1	M_2	F_3	F
Eyes	Itching/irritated	✓	✓										
	Dry eyes												
	Itching eyes	✓		✓	✓		✓			✓		✓	
	Watering eyes				✓		✓	✓					
	Eye Strain		✓	✓					✓				
Nose	Blocked or stuffy nose			✓	✓		✓						
	Running nose	✓	✓					✓					
	Other itching/irritation												
Throat and Chest	Sore throat/cough	✓	✓		✓				✓				
	Dry throat						✓						
	Dry/irritated throat												
	Chest tightness												
	Breathing difficulty	✓	✓										
	Flu-like symptoms												
Skin	Itching face without rash						✓						
	Rash or irritated skin			✓					✓				
	Other dry skin symptoms	✓		✓	✓	✓							
General	Feeling heavy-headed	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	
	Lethargy or tiredness	✓	✓	✓	✓	✓							
	Forgetfulness and/or lack of concentration												
	Other symptoms												

M – Male F – Female

Results reveal that occupants of two office buildings are highly affected by symptoms such as heavy-headedness, lethargy or tiredness, itching/ irritated or running nose and blocked or stuffy noses. Thus, it is possible to state that most occupants who work day to day at same premises in office buildings are highly affected by such symptoms.

Empirical study revealed that interviewees' awareness of similar symptoms among other occupants of the same building is also high.

4.6. TIMING PATTERN

Research findings revealed that symptoms are overcome when affected occupants leave the premises. Further, most symptoms occur during morning hours from 9 a.m. to 11 a.m., generally getting worse between 12 a.m. to 2 p.m. Thus, findings show that majority of office staff are stained from symptoms that defined SBS and all these symptoms appear within a same timing pattern.

4.7. SPATIAL PATTERN

To discover spatial patterns, empirical data mainly focused on places where occupants experience discomfort and place where occupants spend most of time in a building. The empirical data revealed that occupants spend most of their working time at the same place.

5. CONCLUSIONS

The ultimate objective of comfort at the work place is to obtain better productivity. However, many health problems occur among occupants specially Building Related Diseases and Sick Building Syndrome (SBS). Symptoms of SBS are common among large populations such as office buildings, schools, hospitals, care homes, hotels etc. Office workers are the people mainly affected by SBS, as they work in the same place for long durations.

Similarly in Sri Lanka, several experts revealed that absence of workers from office buildings is at a considerable level due to symptoms such as eye, nose and throat irritation, mental fatigue, headaches, nausea, dizziness and skin irritation that they feel whilst engaging in work. This research unearthed impacts of SBS on occupants of three office buildings in Sri Lanka and also factors that cause SBS. As findings revealed few IAQ components such as humidity, temperature are measured in such office buildings whilst other factors such as Formaldehyde, Nitrogen Dioxide etc were not measured. Anyway, most buildings maintain proper records. Occupants in most office buildings were affected by many common symptoms while working in same premises during same timing patterns. Approaches to identify SBS in working environments are also illustrated. Standards to mitigate unhealthy conditions of buildings by identifying prominent IAQ standards were added to knowledge. Further, this study widened limits of health and safety standards and drew attention to new research areas.

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RISKS AND RISK ASSESSMENT METHODS IN INDUSTRIAL MAINTENANCE IN SRI LANKA

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ABSTRACT

Studies on industrial maintenance operations worldwide have identified several maintenance specific risks such as working at heights, the pressure of time, etc. However, there is a dearth of published research on risks and risk assessment methods in industrial maintenance in the case of Sri Lanka. This study therefore aims at identifying the risks and risk assessment methods in industrial maintenance in Sri Lanka. The main objectives of the study were to identify the occupational risks and safety issues in maintenance work and the risk assessment methods in place in the Sri Lankan context. This was undertaken through a study of three manufacturing organisations which are involved in producing fast-moving consumer products. According to the findings, the risks which affect maintenance work can be categorised as organisational risks, unsafe acts and local workplace risks. The findings indicate that the most typical risks associated with maintenance are cuts, slips and falls, with severe or fatal injuries the result of worker disregard for standard operating procedures and/or failure to use the protective equipment provided. It was also found that check lists, brainstorming, and decomposition techniques are the preferred methods in maintenance for risk identification while a risk-rating matrix is used for risk analysis. The findings of the study highlight the safety risks entailed in the maintenance operations of manufacturing organisations and the risk assessment tools used in identifying the risks. The findings of the research will be useful for those in industrial maintenance operations for the purpose of managing risks effectively by designing work environments that are risk-fee and for educating workers on the importance of paying due attention to risks and the need to follow instructions that are in place on safety procedures in the workplace.

Keywords: *Maintenance, Risk Assessment, Risk Analysis, Safety Risk, Sri Lanka.*

1. INTRODUCTION

The proper maintenance of properties and facilities in the workplace is essential for the efficient functioning of any organisation (Booty, 2006). A recent study by Lind (2009) asserts that maintenance, in the case of a company, has the direct and indirect aim of supporting production as well as management processes. The term “maintenance” can encompass all the work relating to the economic preservation of facilities, equipment and systems at a satisfactory level for the purpose of performing their designated functions (Lewis and Payant, 2007). Such preservation entails for the workers charged with maintenance a variety of work-related risks as well as working-environment-related risks (Lind *et al.*, 2008). Risk, however, can have different meanings. Alexander (2000), for instance, defines risk as a hazard, an unsafe practice, a peril capable of being insured, or a statistical probability. Risks, normally, can be defined as the probability or likelihood of someone being harmed by a hazard (Barnard, 1998). Most studies on safety risk in maintenance focus on the aspect of human performance and the risk it poses to the maintenance process (Lind, 2008). But, although there has been much focus in maintenance-related research on the system’s post-maintenance condition, there has not been up to now a systematic and methodical approach to examining the impact or risk of maintenance operations on the humans who perform maintenance-related functions (Kelly and Mc Demid, 2001; Lind, 2008).

However, since work tasks and the working environment vary in industrial maintenance, companies need occupational health and safety management systems in order to enable them to prevent and mitigate accidents by identifying and prioritising the most essential hazards and to manage the hazards and to adopt

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preventive measures (Lind *et al.*, 2008; Papadopoulos *et al.*, 2010). Thus, there is a clear need for companies to place emphasis on establishing risk assessment methods that are clearly linked to the implementation of practical risk reduction measures (Kogi, 1997). Therefore, risk assessment is a structured and systematic procedure which includes the accurate identification of hazards and the appropriate estimation of the risks arising from them for the purpose of making inter-risk comparisons in order to control or avoidance them (ISO 31010, 2009). There are various risk assessment tools and methodologies available to help enterprises and organisations assess their health and safety risks (European Agency for Safety and Health at Work, 2010). According to Hughes (2008), risk assessment methods are used to decide on priorities and to set objectives to eliminate hazards and to reduce risks. As the European Agency for Safety and Health at Work (2010) states, the most common risk assessment tools are checklists, guides, guidance documents, handbooks, brochures, questionnaires and free interactive software, including downloadable applications which are usually sector-specific.

Risk assessment provides the foundation for successful health and safety management and is a key to reducing work-related accidents and occupational diseases, which in turn helps improve work place health and safety as well as business performance (Payne, 2000; European Agency for Safety and Health at Work, 2009). Therefore, the implementation of a safety risk assessment system which is designed specifically for maintenance-related activities may enhance the efficiency of the maintenance process and will in turn aid the business organisation to achieve its ultimate goals and objectives effectively and efficiently.

2. INDUSTRIAL MAINTENANCE

The term "maintenance" can be defined as all the work relating to the economic preservation of facilities, equipment, and systems at a satisfactory level in order to perform their designated functions (Lewis and Payant, 2007). In an organisation, the maintenance activities can be divided into three main elements as the technical, the human and the economic aspects to and consequences of maintenance (Thorsteinsson and Hage, 1992 cited Lind, 2009).

The maintenance operations of an organisation directly and indirectly support its production and management processes. For example, the promotion of economic efficiency by ensuring the trouble-free use of process equipment and minimising downtime contributes indirectly to economic efficiency, process reliability and product quality by enhancing overall production safety (Lind, 2009). Failure in maintenance operations can jeopardise all such benefits and become the source of accidents, which would be dangerous to human health, production and/or the environment.

Maintenance operations can be examined in various ways. Lewis and Payant (2007) has categorised maintenance operations into two main groups as corrective maintenance, which is also called breakdown maintenance, and preventive maintenance, which is also called time-directed maintenance. Dhillon (2002), on the other hand, has grouped maintenance into three types based on the underlying motivation for maintenance. According to him, maintenance can therefore involve preventive (i.e., planned, periodic, and specifically-scheduled maintenance work), corrective (i.e., unscheduled maintenance or repair work) and predictive maintenance (i.e., modern measurement and signal-processing methods to accurately diagnose the item/equipment condition during operation).

Maintenance is important not only to ensure dependability but to reduce the cost of operation throughout the systems' life and for accident prevention. Thus, maintenance is also performed to increase safety since incorrect maintenance performances can cause extensive losses (Holmgren, 2005; Mobley, 1990). Previous studies have typically identified human performance as the threat to post-maintenance reliability. However, as Lind (2008) has pointed out, it should be presumed that industrial maintenance operations can also include several risks for the maintenance worker, which should be examined and managed.

3. RISKS IN INDUSTRIAL MAINTENANCE

Maintenance operations include repairs, inspections, preventive maintenance, calibrations and testing as discussed in Section 2. Further, maintenance may include work that is performed in exceptional conditions such as when high priority repairs are carried out while machines are still running or in operation (Nag and Patel, 1998). Thus, maintenance operations may include risks to the machinery, the company and the human carrying out operations (Lind *et al.*, 2008). This section therefore discusses the maintenance-related risks and hazards and their sources.

3.1. RISKS AND HAZARDS

Risk can have different meanings. For example, risk can be defined as the probability or likelihood that someone will be harmed by a hazard (Barnard, 1998; Lind *et al.*, 2008). Occupational Health and Safety Advisory Services (OHSAS) (2008) defined risk as the product of the probability of a hazard resulting in an adverse event multiplied by the severity of the event. Alexander (2000) has further expanded the scope of the term 'risk' by describing it as not only a hazard but as an unsafe practice, a peril capable of being insured or a statistical probability. However, regardless of their contradictions and limitations, most definitions suggest that risk is simply the probability of a hazard happening.

In risk management, the term "hazard" is used to mean an event that could cause harm (BS 8800, 2004). Hazards are sources of potential harm to human health, property or environment, which may, under certain conditions, lead to accidents (Lind *et al.*, 2008). In general, accidents often happen suddenly and unexpectedly causing immediate injuries and losses (OHSAS 18002, 2000; British Standard 8800, 2004). On the other hand, many health problems may also develop slowly over time (Lind *et al.*, 2008). Accidents can also be seen to be an organisational problem (Booty, 2006). Supporting this view, some scholars have looked at accidents as the outcome of unsafe actions, error-provoking conditions, and organisational factors (Reason, 1997 cited Lind *et al.*, 2008).

Thus, owing to the diversity in work tasks and working environments, industrial maintenance operations can be challenging. However, in addition to risks that are connected with industrial working environments, maintenance operations also include several maintenance-specific risks (Lind, 2008) which will be discussed in Section 3.2.

3.2. MAINTENANCE-RELATED RISKS

Maintenance is associated with a range of management processes, such as safety management, environment management and quality management as discussed in Section 3.1. When it comes to managing safety and environmental impacts in industry, the role of successful and effective maintenance is important because of the very high demands and expectations for retaining a system's inherent safety (Edwards, 2005). Further, reliability is also important for environmental safety as failures and accidents in high-risk industries such as the chemical industry can cause major environmental impacts (Acosta and Siu, 1993 cited Lind, 2009; Aneziris *et al.*, 2010). Thus, from a task-based perspective, industrial maintenance poses several risks for the maintenance worker (Lind *et al.*, 2008).

Studies by Lind (2008) and Lind and Nenonen (2008) have grouped maintenance-related accidents under two categories as fatal and severe non-fatal accidents. The most typical type of fatal accidents in industrial maintenance involves falling, and accidents caused by falling objects. In the case of severe non-fatal accidents, the types of accidents are the same. Lind (2008) also regarded fatal accidents as generally involving the working environment and structures while severe non-fatal accidents involve machinery or devices.

A recent study by Lind (2009) further argues that risks in maintenance can be divided into three categories as organisational risk factors, local workplace risk factors and unsafe acts. According to Lind (2009), there are fewer organisational factors and unsafe acts compared to local workplace risk factors. The most typical risks, as revealed by this study, involve physical ergonomics as demonstrated in Table 1.

As Table 1 shows, the risks included are actual hazards such as unsafe working surfaces and error-provoking conditions such as missing or misleading operational safety bulletins or green-painted fields, which can contribute to unsafe acts and, thereby, indirectly undermine maintenance safety. Unsafe acts can arise during task planning and execution and also due to organisational risk factors such as management and supervision.

Table 1: Risks in Maintenance (Source: Lind, 2009)

Organisational Risk Factors	Local Workplace Risk Factors	Unsafe Acts
▪ Pressure of time ▪ Defects in customer corporation ▪ Aging of skilled maintenance crew members ▪ Working on changing sites ▪ Large variety of maintenance tasks	▪ Unsafe walking/surfaces, slipping, tripping, falling ▪ Missing safeguards or shields ▪ Missing/misleading operational safety bulletins ▪ Cold or hot objects ▪ Falling objects ▪ Working outdoors ▪ UV radiation ▪ Lack of oxygen ▪ Site-specific safety challenges and requirements ▪ Defects in the working environment ▪ Working on changing sites	▪ Non-use of Personal Protective Equipment (PPE) ▪ Conscious / unconscious risk-taking ▪ Risks relating to ergonomics (heavy lifts/ carrying too much weight, poor working postures) ▪ Poor safety attitudes

It is well known that the most effective way to improve safety performance is through the prevention of accidents and through reducing uncertainties before accidents happen (Cooke, 1997; Gambatese *et al.*, 2008). This makes safety risk analysis the foundation upon which safety management is built and makes risk assessment a crucial task in a safety management system (Longford *et al.*, 2000; Jung *et al.*, 2008). The next section therefore discusses risk assessment in the industry.

4. Risks Assessment in Industrial Maintenance

Risk assessment includes both hazard identification and estimation of the probability and expected consequences of the observed hazard (Lind and Nenonen, 2008). Risk assessments have traditionally been based on the identification of hazards in the workplace (Lind *et al.*, 2008). However, according to Booty (2006), risk assessment is not merely a tool to calculate the probability and expected consequences of a hazard; it is also the phase in which the appropriate actions to minimise the probability of risk occurrence is determined and the cost of resource allocation to manage the impact of the harm, in the event of its occurrence, is established.

In general, risk assessment should consist of hazard identification, evaluation of preventive safety measures and their functionality, estimation of exposure to the hazards, and the evaluation of consequences and tolerability of the risk (Booty, 2006; BS 8800, 2004) since risk assessment serves as a basis for controlling intolerable risks.

5. Methodology

The study resorted to the case-study method in order to study safety risk assessment in industrial maintenance. Hence, the unit of analysis of the study will be 'risk assessment in industrial maintenance'. Three multinational manufacturing organisations where the products were fast-moving goods were selected for the study based on access and time limitations. Interviews were the primary data collection technique in this study while archival records supplemented data-gathering efforts. Content analysis and cognitive-mapping techniques were used to draw conclusions (See Table 2).

Table 2: Details of Cases

Organisation	Case A	Case B	Case C
Type of Manufacture	Fast-moving consumer goods	Fast-moving consumer goods	Fast-moving consumer goods
Scale of the Organisation	Multinational Organisation	Multinational Organisation	Multinational Organisation
Interviewees	Supply Chain Manager	Supply Chain Manager	Supply Chain Manager
	Environmental Health and Safety Manager (EHS)	Environmental Health and Safety Manager	Environmental Health and Safety Manager
	Maintenance Engineer	Engineering Manager	Maintenance Engineer

6. RESULTS

6.1. MAINTENANCE-RELATED RISKS

The empirical data gathered reveals several maintenance-related risks: namely, management-related risks, workplace-related risks and unsafe acts. These will be discussed in the following section.

6.1.1. MANAGEMENT-RELATED RISKS

The empirical data reveals management of work-related issues such as pressure of time and workload can be identified as risks. A majority of the interviewees said that when people work under pressure they tend to overlook or omit crucial aspects which can result in the occurrence of hazards. Thus, although the pressure of time is not a significant risk in itself, it could cause cognitive overload in workers in the long run. But it could also increase the magnitude of hazard of the existing risks and even create new ones such as workers resorting to inappropriate methods or shortcuts when working under pressure to perform or complete a task on time. Thus, both work planning and resource allocation play essential roles in preventing accidents during maintenance. For example, the Maintenance Engineer of Case A stated "*more errors can happen when the workers are in a hurry*." In the words of the EHS Manager in Case B, "*once we had a unplanned breakdown of a machine and the whole maintenance staff had to work twenty four hours to get it fixed so that the production would not be delayed. During this time two of our workers cut their arms and got badly injured. What they said was the blade slipped from their hand when they hurried to cut the metal pipe*." Therefore, pressure of time can be considered a risk to maintenance workers.

6.1.2. WORKPLACE-RELATED RISKS

The local workplace-related factors often relate to insufficient system- or workplace-maintainability such as factors impeding maintenance task execution. In addition, various site-specific risks, along with the organisation's safety demands, form a group of challenges to the workers. The local workplace factors can also include outdoor conditions such as weather and other environmental conditions such as temperature, humidity, etc.

With regard to maintenance-related risks, the empirical data revealed that bruises and minor cuts were the most frequent during the maintenance process. Mostly, the accidents occurred work was in progress or when working at the workshop during the day. According to the Maintenance Engineer of Case A, "*these cuts and bruises are not even considered as first-aid injuries*." However, there were situations when near-fatal outcomes did occur. EHS Manager of Case A cited an example: "*an employee who worked on the* *roof of the building had got into contact with a high tension electric cable and almost died*." The EHS Manager of Case B cited a fatal accident: "*a 45-year-old worker was crushed by a pallet falling from a vehicle tail-lift. He was helping a driver to unload a pallet from a lorry when the load fell on top of him*." Thus, the empirical data on maintenance-related risks consists of a majority of workplace-related risk factors. As the Maintenance Engineer of Case A stated: "*we cannot ignore anything as not being a risk, Due to uncertainty, any workplace factor can turn out to be a risk to health and safety*." Therefore, local workplace-related risk factors have a significant impact on the safety of maintenance workers.

6.1.3. UNSAFE ACTS

From the three categories identified as maintenance-related risks, unsafe acts are the most dangerous. According to the empirical findings, unsafe acts can be risks as well as causes of risks. For example all three interviewees in Case A cited the example of a godown being opened after two days of fumigation although it is a must that the godown be closed for at least three weeks after fumigation. This in fact caused some of the employees to collapse due to inhalation of poisonous gases. As the EHS Manager of Case A pointed out: "*because of disregarding the standard operating procedures and non-use of PPE the employee received injuries though their lives were saved*." Thus, disregarding the standard operating procedures and the non-use of PPE not only caused a chemical risk, but also led to near fatal injuries. This shows how unsafe acts can cause risks as well as be a risk in itself.

Based on the empirical data, the risks in industrial maintenance can be tabulated (See Table 3) in the following manner.

Table 3: Summary List of Risks

Management Related Risks	Workplace Related Risks	Unsafe Acts
▪ Pressure of time ▪ Work load	▪ Physical hazards ▪ Environmental conditions ▪ Biological hazards ▪ Chemical hazards ▪ Electrocution ▪ Missing safe guards ▪ Lack of oxygen ▪ Cold /hot objects ▪ Fire ▪ High pressure air and fluid	▪ Non-use of PPE ▪ Conscious/unconscious risk-taking ▪ Ergonomics risk ▪ Defects in safety attitudes ▪ Ignoring work instructions ▪ Disregarding Standard Operating Procedures (SOP) ▪ Negligence

6.2. SAFETY RISK ASSESSMENT METHODS USED

Several risk assessment methods have been designed for industrial workplaces. However, these methods typically focus on general working environment hazards or are designed for a certain process or specific equipment. These methods can be either qualitative methods or quantitative methods. Further, different methods were used for specific types of risk identification and risk analysis as shown in Table 4. These will form the basis for the following discussion.

All the interviewees stated that they did not have a particular risk assessment procedure for industrial maintenance. However, in all three cases, risk assessment methods were practiced which were applicable to the whole organisation. In this section, the empirical data relevant to the types of safety risk assessment methods identified will be discussed. The risk assessment methods used can be discussed under two headings: methods used to identify risks and methods used to analyse the risks (Table 4).

Table 4: Methods Used in Risk Assessment

Risk Identification Methods	Case A			Case B			Case C		
	SCM	EHS	ME	SCM	EHS	MM	SCM	EHS	M E
Checklists	√	√	√	√	√	√	√	√	√
Brain-storming	√	√	√	√	√	√			
Decomposition Technique	√	√	√	√	√	√			
Root-cause Analysis							√	√	√
Semi-structured Interviews							√	√	√
Risk Analysis Methods	**Case A**			**Case B**			**Case C**		
	SCM	EHS	ME	SCM	EHS	MM	SCM	EHS	M E
Risk Calculator (Semi-Quantitative)	√	√	√						
Risk-rating Matrix (Qualitative)				√	√	√			
Risk-rating Matrix (Semi-Quantitative)							√	√	√
SCM - Supply Chain Manager ME - Maintenance Engineer MM - Maintenance Manager EHS – Environmental Health and Safety Manager									

6.2.1. METHODS USED FOR RISK IDENTIFICATION

In all three organisations, the first step in risk assessment would be to identify the risks because an unidentified risk cannot be managed effectively other than in a reactive way.

- ***Checklists***

All the interviewees said that they used checklists for identifying the risks. According to the EHS Manager of Case A, "*we use experiences from past incidents to make a check list of risks*." For example, the Maintenance Engineer of Case A stated that "*we use the check-lists to identify hazards and risks or to assess the effectiveness of controls. They can be used at any stage of the life cycle of a product, process or system. They may be used as part of other risk assessment techniques but are most useful when applied to check that everything has been covered*." Thus, checklists can be identified as the simplest form of identifying hazards, risks or control failures. These have been developed usually from experience, either as a result of a previous risk assessment or as a result of past failures.

- ***Brainstorming***

As per empirical data, brainstorming is another popular method for identifying the risks. For example, the Supply Chain Manager of Case B stated that "*for brainstorming we used a team of people with knowledge of the organisation, system, process or application being assessed. Normally this technique is used when assessing the risk involved in implementing something new like a Building Management System*." Thus, it is used in high-level discussions where issues need to be identified for a more detailed review of a particular problem.

- ***Decomposition Technique***

At the same time, the empirical data shows that decomposition techniques are also useful in identifying risks. For example, the EHS Manager in Case B stated that "*whenever we do a maintenance activity, let's say replacing a pipe, we breakdown that process into small tasks and, for each task, the potential risks involved are identified*." Therefore, decomposition techniques allow risks to be identified in a structured manner.

- ***Semi-structured Interviews***

The empirical findings suggest that semi-structured interviews can also be used to identify risks. For example, the EHS Manager of Case C stated that "*having a brainstorming session is very difficult as it is difficult to bring the members together. So we carry out semi-structured interviews*." The Maintenance Engineer of Case C further stated that "*we prepare a set of questions as a guide and appoint a suitable person to carry out the interviews and gather the relevant data*." Thus, semi-structured interviews can be used as input to risk assessment.

- ***Root-cause Analysis***

The empirical data from case-studies also showed that root-cause analysis can be used to identify the root or original causes of an incident instead of dealing only with the immediately obvious symptoms. For example, the Supply Chain Manager of Case C stated that they used root-cause analysis for accident investigation. "*Once there was a fire in one of our labs. To identify what was the cause of it we used root-cause analysis*." Thus, root-cause analysis can be used as a reactive risk identification technique.

Thus, the empirical data shows that there are various risk-identification methodologies available to help organisations to identify risks. The findings show checklists, brainstorming and decomposition techniques to be the most widely used risk identification techniques. Further, checklists are used in conjunction with either the brainstorming or decomposition technique. However, the empirical findings also show that root-cause analysis and semi-structured interviews can also be useful in identifying risks.

6.2.2. METHODS USED FOR RISK ANALYSIS

Once a risk is identified, it is analysed and evaluated with the aim of prioritising the identified risks for further actions. According to the empirical findings, the most widely used risk analysis method is the risk rating matrix. As the Maintenance Manager of Case B stated, "*in our organisation we use the risk rating matrix for identifying the likelihood of occurrence, the consequence of the risk event and the level of risk. If we take a person falling from a ladder, the probability of occurrence is likely. The consequence of the risk maybe major because the employee can get injured. So the level of risk is very high. Here we use relative measures rather than numerical values*." Therefore, the risk rating matrix allows those responsible for risk management to determine the severity of the risk of an event.

However, the empirical findings also showed that some organisations prefer the use of weightings to determine the probability and consequence labels. For example, the EHS Manager of Case C said that "*they prefer defining the consequence labels as a percentage of the project or activity cost and the probability as a percentage*." Their reason for using such a method was to eliminate the bias created through the use of relative measures. For example, the Maintenance Engineer of Case C stated that "*the relative measures vary according to the experiences, knowledge and attitudes of the decision maker; however, with the weightings, we can reflect the relative magnitude of probability and consequences and it is consistent for all projects*." Therefore, risk rating matrixes are used in qualitative as well as semi quantitative analysis.

At the same time, the empirical findings also showed that risk levels can be calculated on the basis of Probability/Likelihood, Exposure and Consequences using the risk calculator. For example, the EHS Manager of Case A stated that "*the risk calculator illustrates the probability, exposure to hazard in percentage of time, consequences and the risk level. Once the inputs for probability, exposure to the hazard in percentage of time, and consequences are given, the risk level is shown automatically whether it is high risk, medium or low risk*." Therefore, the risk calculator can be considered as a semi quantitative risk analysis tool.

Prevention of accidents is based on risk analysis. According to the empirical findings reported above, it involves the identification of the hazards and the consequences and the likelihood of occurrence of each hazard. Based on these findings, the most preferred method for capturing the nature and degree of risk in industry is the semi-quantitative analysis. Hence, the risk calculator and the semi-quantitative risk rating matrix can be identified as the most preferred methods of risk analysis.

7. CONCLUSIONS

This study adopts the case-study approach in order to demonstrate what the risks and risk assessment methods are in industrial maintenance in Sri Lanka. The empirical data showed that maintenance-related risks consist of a majority of workplace risks and a fewer number of management related risks and unsafe acts. However, from the three categories of identified maintenance-related risks, unsafe acts are the most dangerous because the empirical findings show unsafe acts to be both risks as well as causes of risks.

The risk assessment methods identified in the empirical findings can either be qualitative methods or quantitative methods. Moreover, the risk assessment methods used can be discussed under two headings: namely, methods used to identify risks and methods used to analyse risks. While risk identification methods consist of qualitative methods, risk analysis methods consist of qualitative as well as semi-qualitative or quantitative methods.

These findings from the Sri Lankan manufacturing industry show that various risk-identification methods are used to help the organisations identify risks. The findings show checklists, brain-storming and decomposition techniques to be the most widely used risk identification techniques. It was also revealed that these techniques are mostly used for their simplicity and for their ability to identify risks in a broader sense. However, the empirical findings also show that the root-cause analysis and semi-structured interviews can also be useful in identifying risks. While the root-cause analysis is used for reactive risk identification, the other methods are used for proactive risk identification.

The prevention of accidents is based on risk analysis which involves the identification of the hazards, and the consequences and likelihood of the occurrence of each hazard. Semi-quantitative analysis is the most preferred method for expressing risk in industry. Hence, the risk calculator and the semi-quantitative risk rating matrix are used as the most preferred methods in risk analysis. Further, qualitative risk rating matrixes are also used. The reason for the use of a semi-quantitative risk rating matrix and risk calculator over the qualitative risk rating matrix is that qualitative measures can vary according to the experiences, knowledge and attitudes of the decision makers. In semi-quantitative analysis, on the other hand, the relative magnitude of probability and consequences can be reflected with the use of weightings and it is consistent for all projects.

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SUSTAINABILITY EVALUATION FRAMEWORK FOR ENERGY POWER PLANTS IN SRI LANKA

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ABSTRACT

Energy is essential for economic and social development of a country. Ever increasing energy demand forces public and private sector to install energy power plants without giving much attention to the sustainable issues. Existing power plants evaluation mechanisms were limited to few factors such as energy efficiency, economic aspects and quality of life. Therefore, the aim of this study is to develop a multidimensional framework to evaluate sustainability of energy power plants in Sri Lanka.

A comprehensive literature review and a preliminary survey were carried out to identify sustainability criteria and indicators. The study identified eight sustainability criteria and 37 indicators. Eight criteria include economic aspects, technological aspects, air quality, water quality, waste management, health, safety and social issues, energy resource, and land, forest and wildlife issues. Structured interviews with industry practitioners were used to prioritise the criterion and indicators. Data was analysed using Analytic Hierarchy Process (AHP) tool and the findings were used to develop a multidimensional framework to evaluate sustainability of energy power plants in Sri Lanka.

Results obtained from the survey showed that, 'economic aspects' followed by 'technological aspects' and 'air quality' are the most important criteria and 'land, forest and wildlife issues' is the least important criteria among the eight sustainability criteria studied. Survey findings further revealed 'availability of renewable energy resources' followed by 'plant process efficiency' as the most critical sustainability indicators among the 37 indicators. This multidimensional framework can be used to evaluate the sustainability of energy power plants and also in the approval granting process for the power plant projects in Sri Lanka.

Keywords: *Energy Power Plants, Sustainability Evaluation Framework, Sustainability Criteria, Sustainability Indicators, Analytic Hierarchy Process Tool.*

1. INTRODUCTION

Energy is a vital commodity to eradicate poverty and to improve present day human welfare and living standards. Further to Jovanovic et al. (2010), energy is essential for economic and social development. There are many environmental costs associated with the generation and utilisation of energy, ranging from the loss of a local wild river to the potentially enormous effects of global warming (Wright, 1991). As a result, current energy usage and supply patterns are considered unsustainable (UN, 2001).

Sustainability has been reinvented as the key word to describe a political discourse concerning quality of life issues, limitation of natural resources and the sense of commitment to the future generations (Afgan and Carvalho, 2008). Conversely, many major environmental problems are derived from the production and consumption of energy. Wright (1991) exemplified that, it is extremely critical to measure the impacts of energy use on the 'sink' functions of the environment.

Athanasios and Pilavachi (2007) claimed that the operation of a power plant causes both positive and negative effects on employees as well as on local communities and have shown that harmful phenomena such as the release of gases, soil and water contamination and radioactivity were ignored or undervalued while economic aspects were given higher priority, disregarding the concept of sustaining towards future.

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In order to complement the effort of the commission on sustainable development and to provide a higher resolution on energy, the International Atomic Energy Agency (IAEA) commenced a long term programme addressing Indicators for Sustainable Energy Development (ISED) in 1999 (Vera *et al.,* 2005). Energy indicators are defined as combination of basic economic data, social activities, technological characteristics and measurements or estimates of energy production and consumption.

Many organisations and institutions across the world have emphasised on the consideration of sustainable issues in electricity power generation. Sustainability in power generation has not been highlighted in power plant evaluation processes or processes of giving approvals for the establishment of electricity power plants. Conversely, the main concern thus far was about energy usage and energy efficiency. Decision making on developing new power plants should not be just driven by the demand, but sustainability and impacts from each and every alternative should also be thoroughly considered.

There is therefore a need to introduce a multidimensional approach to evaluate sustainability of energy power plants in Sri Lanka. Thus, the aim of this paper is to introduce a generic and multidimensional framework to evaluate sustainability of energy power plants with prioratised sustainability criteria and indicators.

The paper structure begins with an introduction to the study and followed by a literature review on sustainability of energy power plants. Section three presents the five-steps approach of developing the multidimensional sustainability evaluation framework including data collection carried out using survey method and data analysis using Analytic Hierarchy Process (AHP) tool. The final section summarises conclusions derived from the research findings and presents recommendations.

2. SUSTAINABILITY OF ENERGY POWER PLANTS

Sustainability is a concept emerged with the establishment of the World Commission on Environment and Development (WCED) by the United Nations in 1983. One of the first and the best definitions of sustainable development were made in "our common future", the report of the WCED (1987) as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The general concept of sustainability is often introduced in the literature using Brundtland statement; which is "humanity has the ability to make development sustainable, to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs'' (Carew and Mitchell, 2008).

Michelle *et al.* (2008) stated that sustainability assessments range from single indicators to prescribed sets of multi-disciplinary indicators focusing on either the whole system or parts of the system, such as the economy, society or environment. Each of these approaches has advantages and limitations. For example, single indicators, such as the ecological footprint (Wackernagel *et al.*, 1993), are able to provide information about the sustainability of part of the system, highlighting specific sustainability issues. The five sustainability assessment methods are ecological footprint, wellbeing assessment, quality of life, ecosystem health and natural resource availability (Michelle *et al.*, 2008).

The sustainability evaluation framework provides a structure for developing a valid and reliable system that achieves sustainability through institutionalisation (Robert *et al.*, 2006). Many approaches for measuring sustainable development have led to very detailed frameworks, where long lists of indicators have been derived. United Nations Department for Policy Coordination and Sustainable Development (UNCSD) indicator set comprises over 130 indicators (UNCSD cited Andreas and Daniel, 2006). UNCSD further stated that the indicator set developed by UNCSD have the advantage of covering most sustainable development issues and providing detailed insights. However, due to the large number of indicators, these sets are complex, difficult to interpret, and cannot provide a concise general overview of system behaviour.

Energy production is one of the vital areas to be concerned and utmost priority should be given to the aspects of economical sustainability. Three types of power plants considered in this research study are hydro power plants, thermal power plants and wind power plants. As a developing country, Sri Lanka is rapidly increasing the energy supply through both government and private sector. At present, the total primary energy requirement of the country is met with biomass (47.4%), hydropower (9.5%) and imported petroleum (43.0%), while electricity remains the main secondary energy source (Sri Lanka Energy Balance, 2007). Further, the total amount of electricity generated during 2007 was 9,901 GWh out of which 60% was from oil burning thermal power plants while the balance 40% was almost entirely from hydropower. Share of electricity generation from nonconventional sources remained very small.

The necessity of power plant development and operation in our everyday life cannot be argued, but a balance between development and sustainability should be found, so that electricity production no more harms public health and its negative effects are minimised (Athanasios and Pilavachi, 2007). In 2007, Athanasios and Pilavachi built a hierarchy to evaluate power plants by considering living standards respect to power plants. In following year, Athanasios and Pilavachi (2008) built another hierarchy model to evaluate power plants. In this model earlier key aspects were removed and new parameters (technology and economic) ware introduced. Further, in 2009, Carrera and Mack developed some key indicators to evaluate power plants. However, the study was mainly focused on limited parameters like quality of life, socioeconomically impacts, political stability and continuity of energy service. However, the power generation efficiency and environment impact due to air and water pollution are not considered in their study.

3. Steps of Sustainability Evaluation Framework Development Process for Energy Power Plants

A five step approach was adapted to develop the sustainability evaluation framework for energy power plants as follows;

(1) Identify of key sustainability criteria and indicators with related to energy power plants
(2) Refine identified sustainability criteria and indicators
(3) Develop an energy power plant sustainability evaluation hierarchy integrating sustainability criteria and indicators
(4) Data analysis using Analytic Hierarchy Process (AHP) tool
(5) Develop a framework for multidimensional evaluation of sustainability of energy power plants

3.1. Step 1: Identification of Sustainability Criteria and Indicators

A comprehensive literature review was conducted using journals, conference proceedings, books and web sites to identify the sustainability criteria and indicators. According to the literature review sixteen sustainability indicators were identified under seven main criteria namely economic aspects, technological aspects, social aspects, air quality, water quality, land requirement and waste issues. Given the ambiguity surrounding the terminologies used by the different authors, the best judgment has been used in categorising the sustainability indicators.

3.2. Step 2: Refine Identified Sustainability Criteria and Indicators

A preliminary survey was conducted to refine the criteria and indicators identified through literature survey and to identify new sustainability criteria and indicators applicable to the Sri Lankan context. Semi structured interviews were carried out with eight (08) industry practitioners who are having remarkable experience at power generation authorities and approval granting authorities in Sri Lanka.

Importance of the criteria and indicators was obtained depending on relevance of the indicators and preference of the respondents to use the sustainability criterion and indicator to evaluate the sustainability of energy power plants. Most of the criteria and indicators were recommended by the industry practitioners as important when evaluating the sustainability of power plant. Few criteria and indicators were removed due to less applicability and few were added and altered according to the suitability to the Sri Lankan context. 'Energy Resource' criterion was added to the model, while 'social aspects', 'land requirement' and 'waste issues' were changed as 'health, safety and social issues', 'land, forest and wildlife issues' and 'waste Management', respectively.

3.3. Step 3: Develop an Energy Power Plant Sustainability Evaluation Hierarchy

Based on the results of the critical literature review and the preliminary survey findings, hierarchy was developed to evaluate sustainability of energy power plants. Figure 1 is the hierarchy developed to evaluate sustainability of energy power plants which consists with 37 sustainability indicators under the eight criteria.

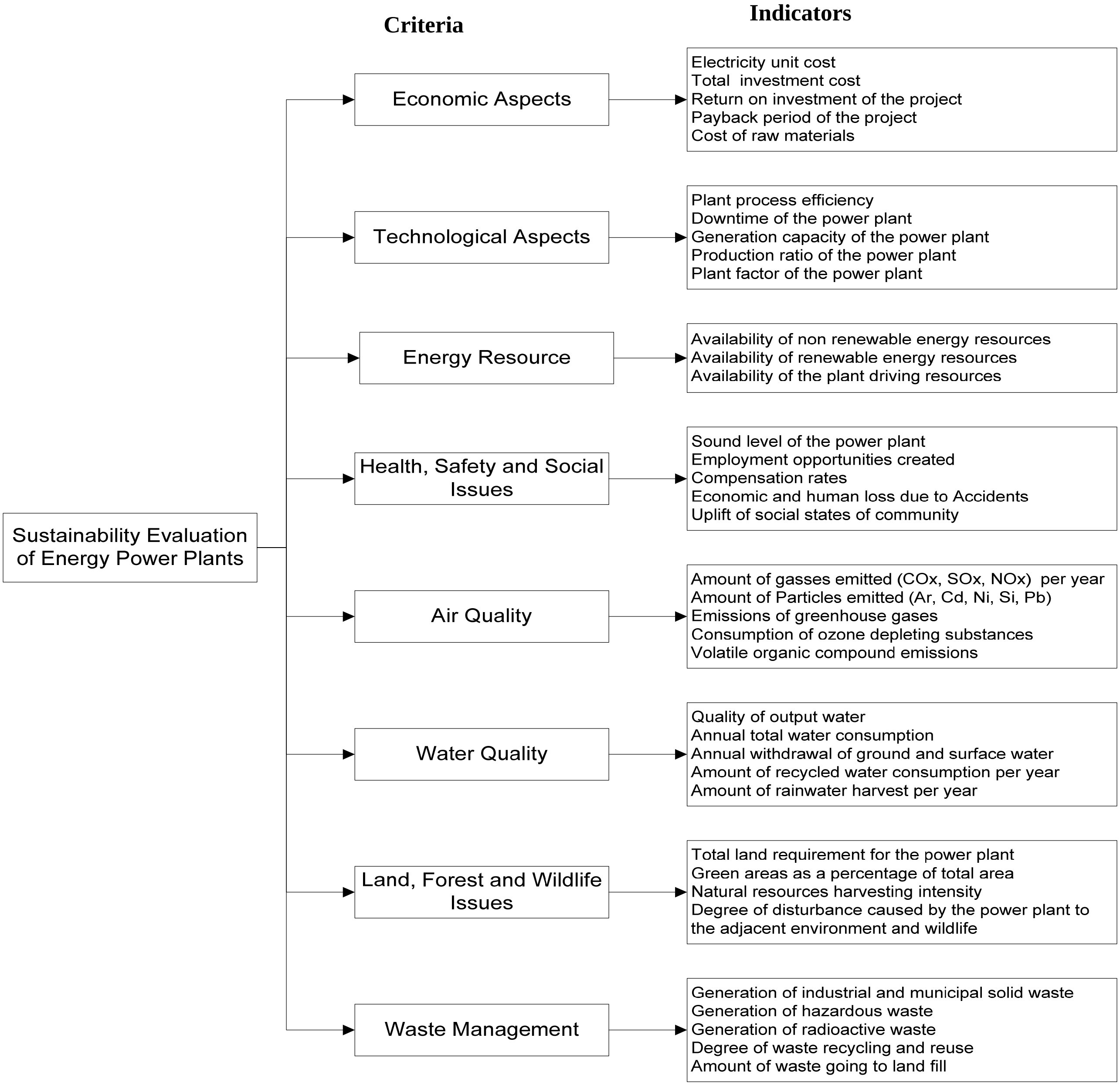

Figure 1: Energy Power Plant Sustainability Evaluation Hierarchy

3.4. STEP 4: DATA ANALYSIS USING ANALYTIC HIERARCHY PROCESS (AHP) TOOL

Analytic Hierarchy Process (AHP) is a multi-criteria decision making tool, which provides a room to select the most important criteria between two folds (Saaty, 1994). In the manufacturing industry, Partovi (1992) presented a methodology and corresponding model for the strategic selection of processes for benchmarking in a manufacturing setting. Wu *et al.* (2007) applied AHP to determine the priority of the accessibility criteria. Teo and Yng Ling (2006) used AHP method to assess safety management in construction industry. Having considered the research context and objectives of the study, AHP tool was selected for data analysis.

The structured questionnaire was prepared based on the AHP hierarchy and the survey was performed among various disciplines related to power generation authorities and approval granting authorities. The purposeful and snowball sampling was used in this study. Questionnaires were distributed among 40 respondents and were asked to give their individual opinion and to indicate the magnitude of the importance placed on each criterion and indicator using the one-to-nine ratio scale.

Indicator in each level was compared pair wise with respect to their importance to a criterion in the next higher level and starting at the top of the hierarchy and working down. For all decision alternatives, geometric mean was calculated from the allocated weights by the participants; the mean for each alternative was considered in the analysis. Comparisons in a matrix may not be consistent as in eliciting judgments. This gives rise to multiple comparisons of an element with other elements that leads to numerical inconsistencies. Cheng and Li (2001) concluded that the consistency calculation is a critical component of AHP, and it makes AHP more reliable and useful as decision-making tool.

Table 1 shows pair wise comparisons of the sustainability criteria. The weightings of Table 1 are then normalised and presented in Table 2. The comparison matrix is normalised by dividing each entry by the sum of the entries in relevant column. After normalising the entries in the pairwise comparison matrix, sums of each row will be calculated. The averages of each row will be calculated in order to obtain the "sustainability score", which will allow the researcher to compare and prioritise each sustainability criterion and indicator. The consistency calculations are given in Table 3 and Eq: 01.

Table 1: Pair-Wise Comparisons of the Main Sustainability Criteria

Main Criteria	Economic aspects	Technological aspects	Energy resource	Health, safety and social issues	Air quality	Water quality	Land, forest and wildlife issues	Waste Management
Economic aspects	1.00	0.92	1.80	2.21	1.32	1.30	2.14	0.54
Technological aspects	1.09	1.00	0.97	1.70	1.04	1.07	2.54	1.18
Energy resource	0.55	1.03	1.00	1.11	0.96	0.87	0.65	0.36
Health, safety and social issues	0.45	0.59	0.90	1.00	0.96	0.89	1.05	1.52
Air quality	0.76	0.96	1.04	1.04	1.00	1.30	1.80	3.00
Water quality	0.77	0.93	1.04	1.13	0.77	1.00	1.64	3.80
Land, forest and wildlife issues	0.47	0.39	1.53	0.95	0.56	0.61	1.00	1.70
Waste management	1.87	0.85	2.78	0.66	0.33	0.26	0.59	1.00
SUM	**6.96**	**6.67**	**11.06**	**9.79**	**6.94**	**7.31**	**11.41**	**13.10**

Table 2: Pair-Wise Normalised Comparisons of the Main Sustainability Criteria

Main Criteria	Economic aspects	Technological aspects	Energy resource	Health, safety and social issues	Air quality	Water quality	Land, forest and wildlife issues	Waste Management	SUM	Sustainability Scores
Economic aspects	0.14	0.14	0.16	0.23	0.19	0.18	0.19	0.04	**1.27**	**0.16**
Technological aspects	0.16	0.15	0.09	0.17	0.15	0.15	0.22	0.09	**1.18**	**0.15**
Energy resource	0.08	0.15	0.09	0.11	0.14	0.12	0.06	0.03	**0.78**	**0.10**
Health, safety and social issues	0.07	0.09	0.08	0.10	0.14	0.12	0.09	0.12	**0.81**	**0.10**
Air quality	0.11	0.14	0.09	0.11	0.14	0.18	0.16	0.23	**1.16**	**0.15**
Water quality	0.11	0.14	0.09	0.12	0.11	0.14	0.14	0.29	**1.14**	**0.14**
Land, forest and wildlife issues	0.07	0.06	0.14	0.10	0.08	0.08	0.09	0.13	**0.74**	**0.09**
Economic aspects	0.27	0.13	0.25	0.07	0.05	0.04	0.05	0.08	**0.93**	**0.12**
SUM									**8.00**	

Table 3: Consistency Calculations for the Main Sustainability Criteria

Main Criteria	Economic aspects	Technological aspects	Energy resource	Health, safety and social issues	Air quality	Water quality	Land, forest and wildlife issues	Waste Management	SUM	SUM ÷Sustainability Scores
Economic aspects	0.16	0.14	0.18	0.22	0.19	0.19	0.20	0.06	**1.33**	**8.40**
Technological aspects	0.17	0.15	0.10	0.17	0.15	0.15	0.24	0.14	**1.26**	**8.54**
Energy resource	0.09	0.15	0.10	0.11	0.14	0.12	0.06	0.04	**0.81**	**8.32**
Health, safety and social issues	0.07	0.09	0.09	0.10	0.14	0.13	0.10	0.18	**0.88**	**8.78**
Air quality	0.12	0.14	0.10	0.10	0.15	0.18	0.17	0.35	**1.31**	**9.01**
Water quality	0.12	0.14	0.10	0.11	0.11	0.14	0.15	0.44	**1.32**	**9.23**
Land, forest and wildlife issues	0.07	0.06	0.15	0.09	0.08	0.09	0.09	0.20	**0.83**	**8.95**
Economic aspects	0.30	0.12	0.27	0.06	0.05	0.04	0.05	0.12	**1.01**	**8.74**

$$CR = \{(\lambda_{max} - n) / (n - 1)\} \times (1/ RI) = \{(8.75- 8) / (8 - 1)\} \times (1/0.11) = \mathbf{0.08} \quad \text{(Eq: 01)}$$

Where *CR* is Consistency Ratio, *n* is size of matrix (e.g.: Number of sustainability criteria), λ_{max} is the average of SUM/Sustainability Score column and *RI* is Random Index for *n* number of matrices.

According to Saaty (1994), consistency ratio of 0.10 or less is a positive evidence and acceptable, and therefore above data can be considered as consistent and valid.

A similar exercise was applied towards the sustainability indicators in each sustainability criterion and responses were collected from the parties related to each criterion.

3.5. STEP 5: DEVELOP A FRAMEWORK FOR MULTIDIMENSIONAL EVALUATION OF SUSTAINABILITY OF ENERGY POWER PLANTS

The final step in this approach is to develop a prioritised framework to evaluate sustainability of energy power plants. The results of all pair-wise matrices were synthesised to achieve the overall ranking of the sustainability criteria and indicators. The results of this analysis are presented in Table 4.

Table 4: Prioritised sustainability evaluation framework for energy power plants

Main Sustainability Criteria and Indicators	Sustainability Scores	Overall Sustainability Scores	Rank
Economic Aspects	**0.1583**		
Electricity unit cost	0.2323	0.0368	**5**
Cost of raw materials	0.2243	0.0355	**6**
Return on investment of the project	0.2015	0.0319	**10**
Payback period of project	0.1772	0.0281	**14**
Total investment cost	0.1647	0.0261	**17**
Technological Aspects	**0.1471**		
Plant Process efficiency	0.2597	0.0382	**2**
Plant factor of power plant	0.2107	0.0310	**11**
Plant production ratio	0.1930	0.0284	**13**
Power plant downtime	0.1741	0.0256	**19**
Plant Generation capacity	0.1624	0.0239	**23**
Air Quality	**0.1452**		
Emissions of green house gases	0.2532	0.0368	**4**
Consumption of ozone depleting substances	0.2231	0.0324	**9**
Amount of Particles emitted	0.1923	0.0279	**15**
Volatile organic compound emissions	0.1734	0.0252	**21**
Amount of gasses emitted	0.1580	0.0230	**26**
Water Quality	**0.1425**		
Annual total water consumption	0.2605	0.0371	**3**
Amount of recycled water per year	0.2312	0.0330	**7**
Annual withdrawal of ground and surface water	0.1888	0.0269	**16**
Amount of rainwater harvest per year	0.1783	0.0254	**20**
Quality of output water	0.1413	0.0201	**31**
Waste Management	**0.1157**		
Generation of radioactive waste	0.2221	0.0257	**18**
Generation of industrial and municipal solid waste	0.2130	0.0246	**22**
Generation of hazardous waste	0.2025	0.0234	**24**
Amount of waste going to land fill	0.1917	0.0222	**27**
Degree of waste recycling and reuse	0.1707	0.0197	**32**
Health, Safety and Social Issues	**0.1007**		
Employment opportunities created	0.2304	0.0232	**25**
Uplift of social states of community	0.2101	0.0212	**30**
Economic and human loss due to Accidents	0.1943	0.0196	**33**
Sound level of power plant	0.1900	0.0191	**35**
Compensation rates	0.1752	0.0176	**36**
Energy Resource	**0.0976**		
Availability of renewable energy resources	0.4921	0.0480	**1**
Availability of the plant driving resources	0.3106	0.0303	**12**
Availability of non renewable energy resources	0.1973	0.0193	**34**
Land, Forest and Wildlife Issues	**0.0928**		
Total land requirement for the power plant	0.3537	0.0328	**8**
Degree of disturbance caused to the adjacent environment and wildlife	0.2316	0.0215	**28**
Natural resources harvesting intensity	0.2287	0.0212	**29**
Green areas as a percentage of total area	0.1860	0.0173	**37**

The second column of Table 4 presents the local priorities representing the relative weights of sustainability indicators with respect to relevant sustainability criterion. The overall ranking, shown in the third column of the table, were obtained by multiplying the performance scores of the each sustainability indicator by the sustainability scores of the relevant sustainability criterion.

According to Table 4, the highest sustainability score (0.16) has been obtained by the 'economic aspects' becoming the most significant criterion in the framework to evaluate sustainability in power plants. At the same time 'technological aspects' and 'air quality' have obtained an equal second highest score (0.15). Further, 'water quality' has become the fourth with a score of 0.14.The fifth, sixth and the seventh places have been obtained by 'waste management' (0.12), 'health, safety and social issues' (0.101) and 'energy resource' (0.098) respectively. According to the research the least important criterion was the 'land, forest and wildlife issues' with 0.093 sustainability score.

According to the sustainability scores, 'electricity unit cost' has become the most important sustainability indicator in the 'economic aspects' criterion where 'total investment cost' has become the least important indicator within the criterion. In 'technological aspects', 'plant process efficiency' and 'plant factor of the plant' have obtained the highest sustainability scores and 'plant generation capacity' has become the least important indicator among 'technological aspects'. According to findings, 'availability of renewable energy resources' indicator has become the most significant indicator among 'energy resource' with 0.49 sustainability scores. That weight is almost half of the total weight of 'energy resource'. 'Availability of non renewable energy resources' has become the least important indicator with 0.20 sustainability score. Results emphasise that importance of 'availability of renewable energy resources' indicator is two times more important than 'availability of non renewable energy resources' indicator in measuring sustainability of energy power plants.

'Employment opportunities created' has become the most significant indicator while 'compensation rates' has become the least important indicator from all the five indicators in determining the sustainability of power plants in 'health, safety and social issues'. In 'air quality', 'emissions of green house gases' has become the most important indicator in evaluating sustainability of power plants with sustainability score of 0.25 where the least important indicator is 'volatile organic compound emissions' with 0.16 sustainability score. Most important 'water quality' indicator to evaluate sustainability of electricity power plants is 'annual total water consumption' with 0.26 sustainability score. 'Amount of recycled water per year' has become the second important one with 0.23 importance level. 'Quality of output water' level has graded as the least important indicator with about more than 200% less important from the 'amount of recycled water per year' indicator.

'Total land requirement for the power plant' has become the most important indicator to evaluate the sustainability in power plants in aspects of 'land, forest and wildlife issues', while 'Green areas as a percentage of total area' has become the least important indicator. 'Generation of radioactive waste' has become the most important indicator in 'waste management' sector with 0.22 sustainability score level. 'Degree of waste recycling and reuse' has become the fourth important indicator with 0.19 sustainability score and 'amount of waste going to land fill has become the least important aspect with 0.17 sustainability score.

According to the overall sustainability scores, 'availability of renewable energy resources' is the most significant indicator with relative sustainability score of 0.048. Since the world is moving towards renewable energy sources the utmost importance should be given to the renewable energy provisions. Second most importance indicator is the 'plant process efficiency'. Plant process efficiency has been identified as a primary indicator in previous studies on power plant evaluations namely Afgan and Carvalho (2008), Athanasios and Pilavachi (2008) and Carrera and Mack (2009). 'Annual total water consumption' has been rated as the third important sustainability indicator to evaluate sustainability of energy power plants while 'emissions of green house gases' and 'electricity unit cost' have been rated as fourth and fifth respectively.

'Availability of non renewable energy resources' has become the 34th indicator in framework, where it can be identified as the 4th most insignificant indicator to evaluate sustainability of power plant. The 'Availability of renewable energy resources' indicator can be identified as 150% important than this indicator. This indicator will de-motivate the developers and investors to use fossil fuels as primary energy source.

Third most insignificant indicator is 'sound level of power plant'. Most of the times hydro plants are constructed at country sides and the disturbances occurred may very less concerned to other sustainability aspects. Although studies like Afgan and Carvalho (2008), Costa and Pagan (2006) used 'compensation rates' as a power plant evolution criterion, it has become the 2nd most insignificant indicator in framework. 'Green areas as a percentage of total area' has become the most insignificant indicator among the all 37 sustainability indicators. This is nearly 180% less significant than the first ranked sustainability indicator. As a tropical country most of the power plants are developed on country side green areas. Only few thermal plants are located in urban areas due to ease of fuel transportation. Hence, in most of the power plants, additional green plots are not necessary since they are located in green plots surroundings.

4. Conclusions and Recommendations

Energy is the source of survival of human life. Energy conservation and management has become the key inspirational practices in many industries in 21st century. Contemporarily sustainability development has also gained extraordinary attention with the recent environmental changes. Power plant evaluation involves great number of criteria whose selection and weighting is decided in accordance with the socioeconomic and political framework or the area in which they are established. Though there have been over 500 adhoc sustainability indicators were found, none of the studies were concentrating on multidimensional aspects of sustainability related to the generation of electrical power. Thus, the aim of this study was to develop a multidimensional framework to evaluate sustainability of energy power plants in Sri Lanka.

Five-step implementation approach was used to develop the sustainability evaluation framework for energy power plants. The evaluation hierarchy was developed according to the findings of the literature review and preliminary survey. The hierarchy consisted of eight sustainability evaluation criteria namely economic aspects, technological aspects, health, safety and social issues, air quality, water quality, land, forest and wild life issues and waste management and 37 sustainability indicators.

The identified sustainability criteria and indicators were then prioritised using AHP tool. According to survey findings, 'economic aspects' was ranked as the top most important criterion and 'technological aspects' and 'air quality' were ranked as the second and third with close relative sustainability score levels. 'Water quality' became the fourth main sustainability criterion with higher sustainability scores. 'waste management', 'health, safety and social issues' and 'energy resource' were ranked at fifth, sixth and seventh important criteria respectively. The framework ranked 'land, forest and wildlife issues' as the least important criterion from the eight criteria in evaluating sustainability of energy power plants in Sri Lanka. According to the overall sustainability scores, 'availability of renewable energy resources' became the most important indicator while 'green areas as a percentage of total area' became the most insignificant indicator among the 37 sustainability indicators.

The developed framework can be used to categorise sustainability of different power plants in Sri Lanka and to measure the sustainability of existing plants in order to grade their level of sustainability.

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COMPARISON OF KEY COMPETENCES OF CLIENTS AND DESIGN-BUILD CONTRACTORS IN THE CONSTRUCTION MARKET OF THE PEOPLE'S REPUBLIC OF CHINA (PRC)

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ABSTRACT

Clients and Design-Build (DB) contractors are two key stakeholders in DB projects, and contribute significantly to the successful project performance. This study aims to identify and compare such key competences in the construction market of the PRC. After the survey of available literature and face-to-face interviews, a two-round Delphi questionnaire survey was conducted to identify the key competences of clients and DB contractors in DB projects. Relative importance of these identified competences were ranked and compared. The questionnaire results indicated distinct differences between the key competences of clients and that of contractors. The contractor's key competences emphasise on DB experience, corporate management capability, building and design expertise, financial capability, enterprise qualification and reputation. While the client's competences focus on the ability to clearly define the project scope and requirements, financial capacity, contract management ability, adequate staff, effective coordination with DB contractor and similar DB experience. Both clients and DB contractors should clearly understand the competence requirements in DB projects and possess all the necessary competences for the successful outcome of DB projects. The identification of these key competences provides clients and DB contractors with indicators to assess their capabilities before going for the DB option. Furthermore, the comparison of competences for clients and DB contractors will result in better understanding of DB system and improve the communication between these stakeholders.

Keywords: *China, Competence, Delphi Method, Design and Build.*

1. INTRODUCTION

As key stakeholders in DB projects, both clients and DB contractors contribute towards the project success (Songer and Molenaar, 1997, 1998; Mo and Ng, 1997; Leung, 1999; Pearson and Skues, 1999; Chan *et al.*, 2001; Ling, Chan *et al.*, 2004; Lam *et al.*, 2008). Although both clients and DB contractors play a critical role in the project, they are required to possess different competences. DB client's responsibilities are mainly commissioning and financing (Kamara *et al.*, 2000). They should, for example, be able to develop clear definitions of project scope, express their requirements clearly in project briefs, and possess the ability to manage design changes (Kometa *et al.*, 1995; Mo and Ng 1997; Songer and Molnaar 1997, 1998; Leung 1999; Deakin, 1999; Pearson and Skues 1999; Chan *et al.*, 2001; Gransberg *et al.*, 2006; Lam *et al.*, 2008); while the requirements for DB contractors mainly focus on techniques of design and construction, track record, and adequate skills in project management (Mo and Ng 1997; Songer and Molenaar, 1997, 1998; Hemlin, 1999; Pearson and Skues 1999; Chan *et al.*, 2001; Ling *et al.*, 2004; Ling and Liu, 2004; Lam *et al.*, 2008). It is clear that clients and DB contractors have different responsibilities; and therefore, both should clearly understand the competence requirements in DB projects accordingly.

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However, in the DB market of the PRC, many clients and DB contractors lack clear understandings of requirements for their DB competences. According to the survey conducted by China Construction Industry Association (CCIA), many clients do not clearly define the project scope or objectives before handing over projects to DB contractors. Even though many DB contractors lack the sophisticated design expertise to fully integrate the design and construction functions, they still try to assert greater control of DB projects (Wang *et al.*, 2004). As a result, conflicts of interest arise among project stakeholders.

Furthermore, most of Chinese clients and DB contractors lack the adequate competences to execute DB projects successfully (Xia and Chan, 2008). The DB system has not been widely used in the Chinese construction industry, with only less than 10 per cent of the construction projects delivered in DB method in 2006. Given the unique characteristics of the domestic DB market, the requirements of DB competences for clients and DB contractors in the PRC will probably be different from those required in other countries.

Therefore, this study aims to identify and compare the required competences of clients and DB contractors in the PRC construction market. It is expected that the identification and comparison of those competences will provide clients and DB contractors with measures to evaluate their DB capabilities and further promote their understanding of the DB system.

2. LITERATURE REVIEW

Clients and DB contractors are two key stakeholders in DB projects. Previous studies have identified key competences of clients and design-builders for the success of DB projects (see Table 1).

Table 1: Summary of Required Competences of Client and DB Contractor

Authors	Geographical locations	Client's required competences	DB contractor's required competences
Songer and Molenaar (1997)	U.S	The owner should precisely understand and define the project scope, and have adequate staff dedicated to the project.	The contractor should have the design-build related experience.
Mo and Ng (1997)	Hong Kong	The owner should have the ability to develop high quality client brief, and have DB experience.	The contractor should have the Design-build related experience
Molenaar and Songer (1998)	U.S	The owner should clearly define project scope, have the DB experience; construction sophistication and enough staff	Track record
Pearson and Skues (1999)	Hong Kong	Abilities to develop clear project scope, owner's requirements and client's brief; mange the design process and design changes.	Experienced in design-build projects and familiar with local industry and regulatory system
Leung (1999)	Hong Kong	The ability to clear define the project scope; have comprehensive employer's requirements; thoroughly assess the bidder's qualification and technical proposal.	The contractor should be familiar with the local construction industry and have the experience in design-build concept.
Chan *et al.* (2001)	Hong Kong	The client had a good capability of managing DB project; a precise understanding of the DB project scope; and clearly articulated end-user's needs.	Construction technology capabilities; project management capabilities; and design capabilities.
Ling and Liu (2004)	Singapore	The client should have a high level of construction sophistication and construction experience, and have handled DB projects in the past.	Adequate human resources and skill set, track record for project execution
Lam *et al.* (2008)	Hong Kong	The client or his representative has the project management skills, technical skills, active involvement in the project, decision-making power, and DB experience and capability.	Project management skills, construction and design capabilities

As shown in Table 1, the key competences of design-builders mainly focus on previous experience on DB projects and building and design techniques; while the key competences of DB clients emphasise on the ability to clearly define project scope and end users' requirements.

In the DB market in PRC, most of the clients and design-builders lack the aforementioned competences. It constitutes barriers to entry into the PRC DB market (Wang *et al.,* 2004; Xia and Chan, 2012). Nevertheless, although the DB system has not been widely used in the PRC, it will bring benefit to the PRC construction industry. The advantages of the DB system, such as single-point responsibility, shortening duration time, leading contractors to keep on technological upgrading, can provide solutions to many problems in the current construction market (Xia and Chan, 2008). Consensus on the effectiveness of DB system has been reached among many owners and government officials. It is anticipated that the DB system will be widely used in the PRC construction market in the future. In order to take full advantages of the DB system, owners and design-builders should understand and possess all the necessary competences to ensure the smooth delivery of DB projects.

3. RESEARCH METHOD

Xia and Chan (2009) and Xia and Chan (2010) developed the key competences of DB clients and design-builders and their relative importance in the Chinese construction industry via semi-structured interviews with five DB professionals, followed by a three-round Delphi survey distributed to 20 construction experts.

The semi-structured interviews were conducted to identify a list of potential key competences of DB clients and contractors. All the interviewees had sufficient DB experience and knowledge in the construction industry. They were requested to list any key competences of DB clients and contractors according to their understanding. Considering the DB system has not gained the popularity in China, the key competences of DB clients and contractors may be different from those identified in the literature review. After the data collection from these interviews, all the transcripts were coded and analysed. Then, similar meanings and expressions were incorporated and rephrased, and different themes were categorised. Finally, a list of potential key competences of DB clients and design-builders has been finalised as shown in Table 2.

Based on the results of semi-structured interviews, a two-round Delphi questionnaire survey was conducted to validate and prioritise these competences. According to Chan *et al.* (2001), the Delphi method helps to extract the maximum amount of unbiased information from a panel of experts. With the features of anonymous response, iteration and controlled feedback and statistical group responses, the Delphi method can produce reliable and more objective outcomes (Masini, 1993; Adnan and Morledge, 2003).

A list of 20 experts was invited in this Delphi study in two rounds. All these experts have extensive DB knowledge and experience. In Round 1Delphi Questionnaire survey, all the respondents were asked to give ratings to the key competences of DB clients and contractors, which were finalised in the face-to-face interviews. A 10 points Likert scale was used for the rating system as it is more familiar to the Chinese experts than the 7-point or 5-point scales. 17 experts completed the Round 1 of the Delphi survey. In Round 2, respondents were asked to reconsider their ratings on each competence with a reference to the consolidated results from Round 1 Delphi survey. Finally, 16 experts completed the round 2 of the Delphi survey.

Most of Delphi studies involve two and seven rounds of survey (Rowe and Wright, 1999; Adnan and Morledge, 2003). A large number of rounds would render high rate of dropout and waste respondents' time and energy. By contract, stopping the process too soon could not produce reliable results (Schmidt, 1997). According to Ludwig (2001), the majority of Delphi studies have involved between 15-20 respondents. Moreover, if the panel experts share similar research background and relevant expertise, the Delphi study can obtain good result even with a small panel with 10-15 individuals (Ziglio, 1996). With the careful selection of the panel members and close interaction with them, the final opinions solicited from the 16 experts are considered adequate enough to provide reliable findings. The prioritised key competences of DB clients and contractors are presented in Table 2.

Table 2: Key Competences of Client and DB Contractor

Rank	Key competences of DB clients	Key competence of the contractor
1	Ability to clearly define project scope	Experience with similar DB projects
2	Financial capacity for the projects	Capability of corporate management
3	Capacity in contract management	Building technique and design expertise
4	Adequate staff or consulting team	Financial capability for the project
5	Effective coordination with contractor	Enterprise qualification and scale
6	Experience with similar DB projects	Reputation and credit record in the industry

4. DISCUSSION

For the DB clients in China, they should possess the ability to clearly define the project scope, have sufficient financial capacity, adequate staff and experience for the projects, and manage the contract and communication effectively. While for the design-builders, they are required to have sufficient DB experience, corporate management capability, building and design expertise, financial resources and enterprise qualification, and good credit record in the industry. Project stakeholders should have a clear understanding of their own responsibilities and roles in DB projects, and cooperate closely to achieve satisfactory project performance.

DB experience is undoubtedly the most important key competence for DB contractors in the PRC construction market. It echoes the research findings of previous studies that hat DB projects should be delivered by experienced DB contractors (Song and Molenaar 1997; Molenaar and Songer, 1998; Mo and Ng, 1997; Pearson and Skues, 1999; Leung, 1999). As the single entity taking the total responsibility of DB projects, the design-builder should have sufficient experiences to not only construct, but also to design, manage and coordinate the whole project. Especially in the construction market of China, where the DB system have not been widely used, DB clients only hand over their projects to the experienced contractors with sufficient evidence track record.

For DB client, although the DB experience is still one of its key competences, it is considered less important than others. This is mainly because inexperienced clients can leave most of the project and responsibilities to DB contractors. In addition, external consultants can be employed to provide sufficient specifications, clear project definitions, and all the necessary service to protect the client’s interests. In the construction market of the PRC, owing to the close relationship between clients and design consultants in the traditional delivery method, most clients prefer to work with their design consultants to finish most of the design work before engaging the DB contractors. As a result, the risk of project failure, which may be attributed to a lack of DB experience, will be reduced. However, providing too much design work will prevent the innovation input from design-builders as most of the design solutions have been determined by the clients.

So far as clients are concerned, the competence to clearly define project scope and objectives/requirements is ranked as the most important DB competence. According to Quatman and Dhar (2003), only when the client can clearly articulate the project scope and objectives at the early stage, then the DB system will work to the owner’s benefit. Even though DB clients can leave most of the project responsibilities to design-builders, they should establish the project requirements before the contractor selection. Otherwise, they may not obtain the final project as expected. In the DB market of China, considering most of the DB clients lack the ability of project definition at early stage, they tend to work with traditional design consultant until the phrase of design development, and then leave the remaining detailed design and construction to the successful design-builders.

According to participants of this study, the capability of corporate management is another key competence of DB contractors, been ranked second of the list. Although the current literature emphasises on design-builders' project management rather than the corporate management skills (Hemlin, 1999; Chan *et al.*, 2001; Ling *et al.,* 2001; Ling and Liu, 2004; Lam *et al.*, 2008), the Delphi panel experts in the PRC considered the capability of corporate management as the key competences of design-builders. This is mainly due to the fact that there is a very competitive market structure associated with the Chinese construction industry. All the construction companies have to face fierce market competition and low level of profit in the construction industry. In 2007, the total profit of the construction enterprises takes up only 3.0 percent of the product value, and the ratio of liability to assets is as high as 65.5 percent (National Bureau of Statistics of China, 2008). As a result, DB contractors should first survive and strengthen their competitive advantages in the fierce competitive construction market.

Apart from having DB related experience and corporate management capabilities, DB contractors are required to have building techniques and design expertise, financial capability for DB projects, and enterprise qualification and scale. These key competences echo the high requirements of modern DB projects. The execution of DB system is different from the traditional way. It requires the fully combination of design and construction functions. Cheng (1995) asserts that a DB contractor should develop a good design with appropriate construction method. Therefore, DB contractors should have both building techniques and design knowledge to conduct the DB project and coordinate a variety of professionals. In DB projects, most of the construction work starts before the total completion of shop drawings, thus causing large fluctuation in the labour force and material supply (Ernzen and Schexnayder, 2000). It will, in turn, require huge capital scale of DB contractors. Only the big scale companies with corresponding qualification levels can afford the financial cost and gain competitiveness at the bidding stage.

Among the key competences of DB clients, the financial capability is considered the second-most important. In DB projects, although clients can leave most of the responsibility and risk to the design-builders; at the same time, they should fulfil their obligation to provide sustained capital supply. Otherwise, the DB contractors will increase the bidding price or resort to continuous claims to compensate the extra risk. Additionally, most of DB projects in the Chinese construction industry are from the public sector with large scale and complex, which are naturally capital intensive. DB clients should have sufficient financial resources to support the smooth delivery of the project.

The following key competences of clients, namely, contract management skills, adequate staff or consulting team, and effective coordination ability, reflect the requirements of mutual communication between clients and DB contractors in DB projects. Effective communication between DB clients and design-builders contributes to the success of DB projects (Ng and Aminah, 2006). The DB system requires the client to engage more active and effective ways of communication with DB contractors to express its ideas and solve the problems. In the contract management process, clients should clearly understand and convey the terms and conditions of DB contracts and make sure that specification and terms of contracts are fully met. In order to conduct efficient contract management and effective coordination with design-builders, clients should have sufficient staff to answer the design and construction related questions and provide instant feedbacks to contractors.

It is clearly demonstrated that DB projects have different requirements for clients and DB contractors. DB contractors should mainly possess the ability to integrate the design and construction functions and get the project under control. In order to acquire these abilities, experience with similar types of projects and according qualification levels are necessarily required. The key competences of clients, on the other hand, focus on defining project scope and objectives clearly, having sustained capital supply, and coordinating effectively with DB contractors to guarantee that DB projects will meet their requirements.

5. CONCLUSIONS

The DB system has accounted for an increasing proportion of the construction market worldwide. Although it does not receive the same popularity in the construction market of the PRC, it will bring benefits to the construction industry and have great potential in the future (Xia and Chan, 2008). As key stakeholders in DB projects, both clients and DB contractors should possess certain competences to ensure the success of DB projects. The purpose of this study is to identify and compare the key competences of clients and DB contractors in the construction market of the PRC. The research findings indicate that the key competences for DB clients in the PRC are: (1) clear articulation of project scope and objectives; (2) financial capacity for the projects; (3) capacity in contract management; (4) sufficient staff or consulting team; (5) effective coordination with contractor and (6) experience with design-build related projects. To DB contractors, the key competences include (1) experience with similar design-build projects; (2) the capability of corporate management; (3) building techniques and design expertise; (4) financial capability for the project; (5) enterprise qualification and scale and (6) reputation and credit record in the industry. It is concluded that the contractor's key competences emphasise more on the capability to integrate the design and construction, and get the DB project under control. While the client's competences focus more on the ability to clearly define the project scope and requirements, to finance DB projects adequately, and to communicate effectively with DB contractors.

The findings can furnish stakeholders of DB projects with indicators to assess their DB competences. This study provides useful inputs to decision making process that helps to complete a DB project successfully and help to yield better project performance. For example, it can facilitate the clients to select appropriate DB contractors; at the same time the contractors can also assess the competences of DB clients to decide whether or not to accept the bid invitation. It is worth noting that stakeholders may interpret the competence differently. Therefore, future research opportunities exist to establish a comprehensive evaluation system providing quantitative interpretations/indicators for each competence. Furthermore, a large sample in the face-to-face interviews and the Delphi questionnaire survey should be conducted when the DB market matures in the future.

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IMPLEMENTING ENTERPRISE RISK MANAGEMENT IN A CHINESE CONSTRUCTION FIRM BASED IN SINGAPORE

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ABSTRACT

Despite the booming domestic construction market, an increasing number of Chinese Construction Firms (CCFs) have ventured overseas for market expansion, and thus are simultaneously exposed to higher business risks. Hence, they require not only project risk management (PRM) but also a more holistic and integrated approach to managing risks on an enterprise basis, which is known as enterprise risk management (ERM). The objective of this study is to examine ERM implementation in CCFs based in Singapore. As part of a larger research project, this current study adopts a case study approach in the first instance to understand the ERM implementation of a relatively large CCF based in Singapore. The information is collected through in-depth interviews with the senior management of the firm and document review. The empirical findings suggest that the firm has initiated an ERM program and established clear ERM ownership, a regular risk communication mechanism, and a risk-aware culture. However, the firm does not have a risk management information system, which may create inefficiency and hinder the involvement of staff at a lower level of the firm. The findings of this study provide valuable information about current ERM implementation status for practitioners and researchers.

Keywords: *Risk Management, International Construction, Construction Firms, Singapore.*

1. INTRODUCTION

Construction businesses, especially those conducted outside home countries, are risky ventures. Venturing into the international construction markets involves not just the typical risks at home, but also the risks peculiar to international transactions (Han and Diekmann, 2001). Inadequate overseas environmental information and construction experience also contribute to a higher risk exposure and possibility of losses in the international market than that in the domestic market (He, 1995). Hence, risk management is critical for construction firms to survive and remain profitable in the international construction market.

The construction industry is a project-based industry where construction firms typically depend on their construction projects to earn revenues and profits. Although risks inherent in projects have been emphasised, construction firms are also exposed to the risks outside the projects, which tend to impact both project objectives and corporate objectives. Overemphasis on project risk management (PRM) tends to result in low efficiency in risk management, lack of transparency across multiple projects, inappropriate resource allocation among projects and difficulties in achieving the corporate strategic objectives. The recent trend has regarded risk management as an enterprise-wide process that collectively considers the risks that various projects face and links these events to the corporate strategy (Adibi, 2007). This approach agrees with the modern portfolio theory. This theory states that it is possible to build a reasonably safe portfolio even though it contains a number of uncorrelated or negatively correlated high-risk investments (Lam, 2003). Thus, as a holistic and integrated approach to risk management, enterprise risk management (ERM) can be adopted by construction firms (Druml, 2009).

The huge investments in infrastructure projects and urban development make the Chinese construction market continuously boom, thus enabling Chinese Construction Firms (CCFs) to have got soaring revenues in recent years. Despite the booming domestic construction market, an increasing number of CCFs have ventured overseas for market expansion. The National Bureau of Statistics of China (NBSC,

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2011) indicated that CCFs in Singapore obtained a turnover of US$2.27 billion from contracted projects in 2010, which made Singapore the 12th largest overseas market for CCFs.

Although previous studies investigated ERM implementation in the financial, insurance, manufacturing, energy and chemical industries, there have been few studies on ERM in the construction industry. This study aims to fill the knowledge gap in ERM implementation of construction firms by adopting a case study approach to provide an in-depth understanding of the ERM implementation of a relatively large CCF based in Singapore. Thus, it will provide valuable information about current ERM implementation status in CCFs for practitioners and researchers.

2. LITERATURE REVIEW

2.1. DEFINITION

ERM is most frequently defined with reference to the guidance document Enterprise Risk Management-Integrated Framework published by the Committee of Sponsoring Organisations of the Treadway Commission (COSO). COSO (2004) defines ERM as "a process, effected by an entity's board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risk to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives (p.2)." The definition is adopted in this study as it is applicable to various industries, including the construction industry. Also, it reflects that ERM should be implemented by all levels across an enterprise and applied in strategy setting to assure the achievement of corporate objectives in one or more but overlapping categories, rather than an attempted eradication of the risks.

2.2. FACTORS AFFECTING ERM IMPLEMENTATION

Previous studies found that ERM adoption was driven by a series of legal compliance and corporate governance requirements (Kleffner *et al.*, 2003; Liebenberg and Hoyt, 2003; Gates, 2006). These requirements are from the mandatory laws or regulations, non-mandatory reports or standards creating public pressures and benchmarks for sound management practices, and the rating agencies that included a company's ERM system in their rating methodology. In addition, Pagach and Warr (2011) indicated that firms also carried out ERM for potential benefits. ERM implementation can improve firm performance (Nocco and Stulz, 2006; Gordon, *et al.*, 2009; Hoyt and Liebenberg, 2011) through bettering decision-making, maximising shareholder value, increasing accountability and risk reporting, improving earnings and profitability, as well as providing firms with sustaining competitive advantages (Meulbroek, 2002; Kleffner *et al.*, 2003; Lam, 2003; Gates, 2006; Nocco and Stulz, 2006). Moreover, a broader scope of risks from globalisation, market and greater risk interdependence were believed to drive firms to embrace an integrated approach to risk management (Liebenberg and Hoyt, 2003). Furthermore, technological advancement was also considered as a major external driver (Liebenberg and Hoyt, 2003) because advances in information technology (IT) enabled firms to gather better data for certain risks, model complex risks, and analyse risks faster, and better understand risk interdependence across a firm (Davenport and Bradley, 2000; Jablonowski, 2001; Segal, 2011). The above external forces would result in the request of the board and senior management for ERM implementation, which was seen as an internal driver for ERM adoption by Gates (2006).

Besides these drivers for ERM adoption, ERM implementation also faces some hindrances. Previous studies have identified a number of hindrances to implementing ERM in various industrious. These hindrances include:

(1) Insufficient resources (e.g. time, money, people, etc.) (Bowling and Rieger, 2005; Gates, 2006; Roth, 2006; Rao, 2007; AON, 2010; Beasley *et al.*, 2010; KPMG, 2010);

(2) Lack of a formalised ERM process (Rao, 2007);

(3) Lack of risk management techniques and tools (Rao, 2007; Segal, 2007; Muralidhar, 2010);

(4) Lack of internal knowledge, skills and expertise (Rao, 2007; AON, 2010; KPMG, 2010);

(5) Lack of a risk management information system (RMIS) (Ross, 2005; Muralidhar, 2010);

(6) Unsupportive organisational structure (Kleffner *et al.*, 2003; Rao, 2007);

(7) Unsupportive organisational culture (Merkley, 2001; Kleffner *et al.*, 2003; de la Rosa, 2006; Rao, 2007; Kimbrough and Componation, 2009; Muralidhar, 2010);

(8) Lack of a common risk language (Nielson, *et al.*, 2005; Muralidhar, 2010);

(9) Lack of risk awareness in the organisation (de la Rosa, 2006; Muralidhar, 2010);

(10) Confidence in the existing risk management practices (Roth, 2006; Beasley *et al.*, 2010);

(11) Perception that ERM adds to bureaucracy (Beasley *et al.*, 2010);

(12) Inadequate training on ERM (Gupta, 2011);

(13) Lack of an ERM business case (Aabo *et al.,* 2005; AON, 2010; KPMG, 2010);

(14) Lack of perceived benefits (Roth, 2006; AON, 2010; Beasley *et al.*, 2010; KPMG, 2010);

(15) Lack of commitment from the top management (Roth, 2006; AON, 2010; KPMG, 2010).

Because of these hindrances, only 11% of the US respondents possessed a complete formal ERM management system (Beasley *et al.*, 2010). Nonetheless, the status was better in Singapore as another survey indicated that 81% of the 203 respondents had ERM programs in place, and that approximately 53% had implemented ERM for more than three years (KPMG, 2010).

2.3. ERM OWNERSHIP

Due to the centralised nature of ERM, ERM needs a risk oversight of an enterprise's entire risk profile at a high level rather than different overseers managing specific risks (Banham, 2004). A chief risk officer (CRO) position can be created to take responsibility for risk oversight, and thus signals the firm's emphasis on ERM to its employees and investors (Cendrowski and Mair, 2009). Some firms may choose to form a stand-alone risk management committee at the board level, or include the ERM responsibility in the C-level executives, such as chief executive officers (CEOs) and the chief financial officers (CFOs). Gregory (2003) claimed that it would be appropriate for small organisations to have the CEO function as CRO, but this was not practical for larger ones.

2.4. RISK-AWARE CULTURE

A supportive culture is crucial to the success of ERM efforts (Cendrowski and Mair, 2009; Brooks, 2010). Such a culture is called a risk-aware culture (Brooks, 2010), risk management culture (Santori *et al.*, 2007), or risk culture (Collier, 2009; Zou *et al.*, 2010). A risk-aware culture improves vigilance of employees (Cendrowski and Mair, 2009) and enables employees to speak up and then be listened to by decision makers (Brooks, 2010). Explicit expression and deliberation about the expected behaviours within the organisation is also required to create and sustain a strong risk-aware culture (Brooks, 2010). In addition, as recommended by the UK Health and Safety Executive (HSE), the components of a risk-aware culture encompass leadership, involvement, learning, accountability and communication. Lastly, the risk-aware culture should be embedded into the corporate culture, which can encourage management at all levels to be aware of the potential project and enterprise risks. Hence, due to the pervasiveness of risk awareness throughout the firm, risk management becomes a critical part of the corporate culture (Barton, Shenkir and Walker, 2002; Kimbrough and Componation, 2009).

2.5. RISK COMMUNICATION

Risk information obtained from various sources should be communicated transparently across multiple projects and departments of a firm. Transparent risk communication allows and encourages individual comments and expert views during the development of cross-functional understanding of risks and risk management strategies (AON, 2010). There should be a mechanism in place to ensure that critical risk information is reported to the top management (Dafikpaku, 2011), and clear communication lines to ensure that line managers, project managers and staff are promptly notified of critical information (Barton *et al.*, 2002). In addition, a RMIS can improve risk communication through providing an information platform for risk information distribution across an enterprise, and facilitate data-based risk reporting, which leads to rapid and accurate evaluation of risk and timeliness of reporting (Duckert, 2011). Furthermore, a common language, which clearly explains terminologies and methods to be used universally in the organisation, can save time of risk management staff in resolving communication issues at the expense of their primary responsibilities (Espersen, 2007).

3. RESEARCH METHODOLOGY

The case study approach was adopted in this study to understand the current ERM implementation in a CCF based in Singapore. A large CCF operating in Singapore (hereinafter referred to as Firm A) whose management staff agreed to participate in the interview was selected. The data was collected through reviewing past documents and semi-structured interviews. Prior to conducting the interviews, a number of past documents, including non-confidential internal documents about ERM and reports in the mass media, were reviewed. The semi-structured interviews were conducted in March and November 2011, and guided by a questionnaire consisting of six groups of questions. The first group was used to collect the basic information relating to the firm and interviewee. The following five groups of questions were used to collect the information regarding the factors affecting ERM implementation, ERM ownership, risk communication, the risk-aware culture, as well as the ERM process in the interviewees' firm, respectively. Most questions in the questionnaire were open-ended for the interviewees to supply their own answers without being constrained by a fixed set of possible responses. New questions were also allowed to be raised during the semi-structured interviews.

4. CASE STUDY

4.1. PROFILE OF THE FIRM

Firm A was a Singapore-based subsidiary of Firm B. By the end of 2010, Firm B had established 16 overseas subsidiaries. Besides them, other domestic subsidiaries can also contract overseas projects. Firm B was a state-owned central enterprise, and has been a listed corporation in the Shanghai Stock Exchange since 2009.

Since its foundation in 1992, Firm A has completed approximately 150 projects in Singapore. Firm A has been registered under CW01 with a financial grade of A1, and under CW02 with a financial grade of B1 with the BCA. Hence, this firm enjoyed unlimited tendering capacity in all types of building projects, and had a tendering limit of S$40 million in civil engineering projects. Firm A has become the largest building contractor in Singapore in terms of turnover value. It attained a turnover of S$561 million in 2008, S$569 million in 2009 and S$677 million in 2010. Its net profits had doubled from S$10 million in 2008 to S$20 million in 2010. At the time of this study, Firm A had over 700 staff and over 4,500 skilled workers. A matrix organisational structure was adopted by Firm A. The board of Firm A consisted of six members, including the Managing Director, who actually took charge of the business and operations of Firm A. The Chairman of Firm A was also the Vice President of Firm B, and the General Manager of the Overseas Business Department in the headquarters of Firm B, which meant he took charge of the entire overseas business of Firm B.

4.2. FACTORS AFFECTING ERM IMPLEMENTATION

ERM implementation in Firm A was closely related to directions from its parent company. As a listed enterprise, Firm B had to comply with the internal control rules in the Shanghai Stock Exchange. As a state-owned central enterprise, Firm B had to comply with the Guidance to ERM for Central Enterprises, which was issued by the State-owned Assets Supervision and Administration Commission (SASAC) of the State Council of China in 2006 after a great loss by China Aviation Oil (Singapore) due to futures trading. The SASAC is responsible for the supervision and administration of the existing state-owned central enterprises and has already taken ERM implementation into the performance evaluation system of central enterprises. To comply with the requirements from SASAC, Firm B took the following steps:

(1) In March 2008, Firm B established an ERM leadership group;

(2) In December 2008, Firm B issued the Firm B Guidance to ERM Implementation;

(3) In 2009, Firm B issued the Guidance to ERM Implementation in Subordinate Enterprises;

(4) In 2009, ERM implementation was included in the Firm B Internal Control Manual, and its annual Sustainability Report.

These steps also drove the ERM implementation in Firm A, because the Firm B Guidance to ERM Implementation requires all its subsidiaries to adopt ERM and report implementation status to the headquarters of Firm B in Beijing at the end of each year. Based on the ERM implementation in its subsidiaries, Firm B developed a comprehensive annual report and submitted it to the SASAC. Hence, the ERM implementation in Firm A was directly driven by the compliance requirements from Firm B, and indirectly driven by the requirements from the SASAC.

Increasing and more complicated risks that Firm A faced was another factor that drove its ERM implementation. The recent uncertain political situation in the Middle East and North Africa, the devastating earthquake, tsunami and nuclear meltdown in Japan, as well as the post-war reconstruction in Libya would increase the volatility of prices of raw materials, and bring about some uncertainties to the international construction market. The risks whose origins were perceptibly far away from Singapore might also threaten the profitability and even the survival of the firms in Singapore. Although Singapore has a stable political situation, the firms should still emphasise risk management with the management having a strong risk-aware culture. Hence, Firm A implemented ERM to proactively control the risks within its risk appetite.

The compliance requirements from Firm B and a broader scope of risks caused the board and senior management to encourage ERM implementation in Firm A. The Chairman of Firm A was a member of the ERM leadership group in Firm B, and thus had to commit to ERM implementation. Influenced by the Chairman, other senior executives were therefore committed to ERM implementation. The request and encouragement from the board and senior management drove the ERM implementation and ensured that risks were considered in strategic decision-making within the firm.

Lack of perceived benefits of ERM would hinder ERM implementation in Firm A. According to the interviewees, employees needed to perceive the underlying benefits to themselves and the enterprise, before the firm adopted ERM as a new risk management paradigm to complement the existing PRM practice. Otherwise, they would regard ERM implementation as an additional burden. In addition, although the Chairman did not stay in Singapore, the lack of the leadership of the Chairman appeared to have little negative influence on ERM implementation in Firm A.

4.3. ERM OWNERSHIP

In Firm A, the Chairman was ultimately responsible for ERM, but the Managing Director actually took charge of ERM. The top management made decisions concerning ERM. Because projects were the only revenue source, the top management was involved in risk management at all stages of the projects of Firm A, especially the large-scale ones. The decisions relating to tendering strategies, material procurement and measures to deal with cost overrun were made by the board because these decisions were related to both project revenue and the profitability of the firm.

There was not a position dedicated to ERM in Firm A. The ERM responsibility was actually included in the function of the Managing Director. In addition, there was no specialised risk management department or risk management committee of the board in Firm A, even though the Firm B Guidance to ERM Implementation suggested establishing such a department or committee in the subsidiaries. In reality, in the operations of Firm A, the board itself had served as a risk management committee, and was involved in critical decision-making at both project and firm levels. The board also oversaw the entire risk profile of the firm, and centralised the risk management practice of each project team. Moreover, it is worth reiterating that construction firms are project-based and the construction projects that they are engaged in are their only revenue source. PRM was still emphasised in Firm A and was considered as a critical part of ERM. Each project has its own project team comprised of people with the necessary management skills and experience.

4.4. RISK-AWARE CULTURE

The Firm B Guidance to ERM Implementation emphasised creating the risk-aware culture and incorporating the culture into the corporate culture. Hence, the senior management should be committed to cultivating the risk-aware culture throughout the firm. According to the interviewees, Firm A had cultivated a risk-aware culture through training and instituting clear accountability.

Firm A emphasised training its staff and workers. The staff from middle management (e.g. project directors and managers) to frontline managers (e.g. quantity surveyors, and engineers) needed to attend various training courses held inside or outside Firm A. The workers employed by Firm A needed to accept safety training before working on site. These training programs, which also served as an organisational learning mechanism, involved the staff at middle and lower levels and the workers on site, and helped to embed risk awareness into the minds of the staff and workers.

Besides training programs, accountability also facilitated cultivating the risk-aware culture in Firm A. ERM implementation was included in the key performance indicators (KPIs) of the senior management. To attain the KPIs, the senior management had high-level risk awareness. At the middle level, project directors and managers signed accountability pledges, which clearly announced their responsibility for achieving safety, cost, quality, and schedule objectives, and linked their bonuses to these objectives. Failure to attain these objectives would lead to reduction in bonuses, while surpassing the objectives or getting BCA rewards can bring about additional performance bonuses. Thus, the accountability pledges made project directors and managers aware of potential risks, and contributed to relatively high-level risk awareness among the middle management. Hence, the accountability established in Firm A motivated the management at senior and middle level to be vigilant against risks and to consider risks in decision-making.

4.5. RISK COMMUNICATION

Within Firm A, the monthly Operating Meeting acted as a platform for communicating risk information. The Managing Director presided over such meetings. The board members, heads of all the departments, as well as project directors and managers of all the on-going projects attended this meeting at the headquarters of Firm A. At this meeting, the progress status of the on-going projects was reported to the board, which could thus have a clear perspective of the entire risk profile of the firm. Risk information collected from various sources was communicated at this meeting, and the decisions made by the board were notified to the leaders of the departments and projects. Besides the regular meetings, emails and telephone calls were the main communication methods across projects and departments in Firm A. Although every computer in Firm A can access the Internet, there was neither an intranet in Firm A, nor a RMIS in place. In each project team or department, there was a local area network (LAN) for sharing documents, but communication between projects and departments greatly depended on emails and telephone calls.

Firm A was supervised by Firm B and had to report its operational status to Firm B to account for all its losses or profits every year. In order to ensure the accuracy of the annual reports and to implement internal control, Firm B audited Firm A twice a year. Such internal audits from Firm B began in 2006, just after SASAC issued the Guidance to ERM for Central Enterprises. Actually, the control of Firm B over Firm A was relatively strong because the Chairman of Firm A was also the Vice President of Firm B. In addition, Firm B identified the macroeconomic risks by cooperating with consulting companies and collected the risks identified by all its subsidiaries. Based on all the available information, Firm B identified the major risks and issued them to all the subsidiaries, including Firm A.

To ensure the effectiveness and efficiency of risk communication, Firm B provided a glossary of risk terms in the Guidance to ERM Implementation. This glossary included explanation of 27 risk terms that would frequently be used in risk communication, and would facilitate forming a common risk language. As the interviewees revealed, these risk terms was understood by the middle and senior management, and widely communicated at Operating Meetings. However, the staff at lower levels may be unfamiliar with the risk language.

4.6. ERM PROCESS

Firm A adopted an ERM process recommended in the Firm B Guidance to ERM Implementation, which consisted of initial risk information collection, risk identification and evaluation, response plan for major risks, risk response plan implementation, and review and improvement.

Firm A collected risk information from all available sources, which helped to identify potential risks. Firm A had a risk checklist, which listed the potential risks they had identified in previous projects. This risk checklist was reviewed and updated every year. The renewed risk checklist was then reported to Firm B. After collecting risks identified from its subsidiaries, Firm B identified the major risks. By the end of 2010, Firm B had identified 1,314 risks and six major risks in 2010: macroeconomic risks, strategic management risks, investment risks, receivables risks, overseas operational risks, and quality and safety risks. Firm B also issued the risks identified, the response plans for the major ones, and the lessons learned to all the subsidiaries in the forms of the Annual ERM Report of Firm B (confidential) and the Risk Monitoring and Analysis Report. Then, Firm A updated its checklist by using the information from Firm B at the beginning of the year.

Firm A depended on experience and subjective judgments, rather than software, to evaluate risks. However, Firm A had to be more serious in safety and health risks for compliance with the Workplace Safety and Health (Risk Management) Regulations in Singapore, which stipulated that a record of risk assessment should be kept for at least three years from the data of the assessment.

The top management, who was very experienced in dealing with risks in the international construction market, made decisions for developing and implementing risk response plans. In addition, Firm B provided guidance to risk response, thus contributing to better-informed decisions in Firm A. For instance, Firm B issued the Guidance to Engineering Contract Review Risk Management in 2010, which identified the potential risks in contract review and tendering decision-making, provided applicable risk response measures, and thus improved decision-making in tendering.

Firm A reviewed its ERM practice every year and reported the review results and plans for improvement to Firm B. ERM implementation in Firm A was also reviewed and audited by Firm A twice a year. The Risk Monitoring and Analysis Report issued by Firm B also provided lessons of some successful risk management practices in other subsidiaries, which would help Firm A to improve its ERM implementation.

4.7. DISCUSSION

Firm A had effective PRM practice in place, which appeared to be supported by the increasing annual turnover and net profits in recent years. The effective PRM practice also set a foundation for ERM implementation. In terms of time, ERM implementation in Firm A was still at its infancy stage because the ERM initiation in Firm A was only announced at an Operating Meeting in early 2010 after its parent company issued a series of guidance relating to ERM.

ERM implementation in Firm A was directly driven by the compliance requirements from its parent firm, indirectly driven by the compliance requirements from the SASAC. ERM adoption was also externally driven by the increasing and more complicated risks, and was internally driven by the request and encouragement from the board and senior management. The findings were consistent with the previous studies that recognised legal and regulatory requirements as a major external driver (Kleffner *et al.*, 2003;

Liebenberg and Hoyt, 2003; Gates, 2006), that found complex risks as an external driver (Lam and Kawamoto, 1997; Liebenberg and Hoyt, 2003), and that regarded the board request as a primarily internal driver for ERM implementation (Kleffner *et al.*, 2003; Gates, 2006). In Firm A, the benefits from ERM implementation were not evident enough to the interviewees. Lack of perceived benefits of ERM would hinder ERM implementation (AON, 2010; Beasley *et al.*, 2010; KPMG, 2010). A significant increase in benefits can be achieved as firms move along the maturity continuum of ERM (KPMG, 2010). Thus, top management may adopt training programs to emphasise the short-term benefits of ERM implementation, such as more turnover and less losses.

In Firm A, the Managing Director actually took charge of ERM and the board itself acted as a risk management committee to oversee the entire risk profile and centralise the risk management practice of each project team and departments. The effectiveness of such ERM ownership was backed by the increasing turnover and profit even though there was not a CRO position in Firm A because firms without CROs could also have successful ERM programs (Barton *et al.*, 2002).

The traditional communication methods, such as regular meetings, emails, and telephone calls, were used for risk communication and were considered to be convenient and effective. However, lack of a RMIS may lower the efficiency of ERM implementation, and hinder the involvement of staff at a lower level of the firm for ERM implementation. Thus, lack of a RMIS would hinder ERM implementation (Ross, 2005; Muralidhar, 2010). The low level of IT applications for construction management or decision-making was seen as a weakness of CCFs, which would constrain them from achieving better performance outside of China (Lu *et al.*, 2009). According to the Firm B Guidance to ERM Implementation, a RMIS is highly recommended. Firm B has set out to establish such a system for ERM implementation and its subsidiaries can also benefit from this RMIS.

In addition, risk-aware culture was created in Firm A through training programs and accountability. The findings agreed with Hopkin (2010) who identified involvement of organisational individuals and organisational learning as approaches to creating risk-aware culture, and with AON (2010) that found instituting clear accountability as a successful approach to creating a risk-aware culture.

Furthermore, the management staff in Firm A highly depended on their experience, knowledge and subjective judgments to identify, evaluate and respond to risks, which was recognised as a common practice in risk management in the construction industry (Kartam and Kartam, 2001; Raz and Michael, 2001; Thevendran and Mawdesley, 2004; Wang and Yuan, 2011). However, the subjectivity in risk management has limitations and would lower risk management effectiveness. The RMIS to be established in Firm B may contribute to the effectiveness of risk management in all its subsidiaries, including Firm A.

5. CONCLUSIONS AND RECOMMENDATIONS

This study presents a case study to demonstrate how a CCF in Singapore implemented ERM. The findings indicated that this firm had initiated an ERM program, and had clear ERM ownership, a regular risk communication mechanism, and risk-aware culture. However, the lack of a RMIS would lower the efficiency of the risk communication and hinder the ERM implementation. ERM practice is an on-going process (Bowling and Rieger, 2005; Simkins, 2008), and will demonstrate more benefits when it becomes mature (KPMG, 2010). Therefore, Firm A still has a long way to go before achieving a mature ERM program, which echoes the "step-by-step principle" in the Firm B Guidance to ERM Implementation.

Although the objective of this study was achieved, there are some limitations. One of them is that this study investigates the ERM implementation in a large firm because ERM implementation would be different in small and medium construction firms. This is because firm size has been identified as a variable positively related to ERM adoption (Beasley *et al.*, 2005; Hoyt and Liebenberg, 2011) and significantly affecting ERM system design (COSO, 2004) and the improvement of firm performance (Gordon *et al.*, 2009). Nevertheless, this study still contributes to filling the knowledge gap in ERM implementation in the construction industry by conducting a case study on how a specific construction firm implemented ERM, and sets a foundation for further studies in this area. Further studies would be conducted to develop a set of ERM best practices and an ERM maturity assessment model for construction firms, and to identify the critical factors that drive and hinder ERM implementation in construction firms. This is because an ERM maturity model is required for construction firms to assess their current ERM maturity and based on which, the firms can improve their ERM implementation, using a set of ERM best practices as a benchmark.

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CONCEPTUAL FRAMEWORK OF DECISION SUPPORT MODEL FOR THE SELECTION OF STRUCTURAL FRAME MATERIAL TO ACHIEVE SUSTAINABILITY AND CONSTRUCTABILITY IN SINGAPORE

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ABSTRACT

The construction industry plays a significant role not only in economic growth, but also in environmental impacts. As the global recognition on sustainable development, the construction industry is now highly challenged from high material consumption, energy consumption, CO_2 emission, and social problems. In addition, Singapore government has launched buildability appraisal system and productivity enhancement scheme to encourage construction industry improve productivity. Under the pressure of reducing environmental impacts and increasing productivity, economic goal is not the only factor that should be considered when doing decision making. There is a clear need for a link between economic performance, environmental performance and productivity performance. Sustainability philosophy and constructability philosophy are useful when establishing such a link. However, little has been done on the connection between constructability principles and sustainable development. This paper presents a holistic framework to show the factors that affect the decision making on selecting structural materials. Based on the framework, a decision support model is established using Multi-attribute value technique. The weights of 1st level factors and 2nd level attributes have been computed using AHP method and 1-5 likert scale method. The rating method is offered as well.

Keywords: *Building Structural Material, Multi-Attributes Value Technique, Sustainable Construction.*

1. INTRODUCTION

Constructability is a unique and important target that should be achieved by the Singapore construction industry. Constructability is defined by Construction Industry Institute of Australia (1993) as "a system for achieving optimum integration of construction knowledge in the building process and balancing the various project and environmental constraints to achieve maximisation of project goals and building performance". As Singapore is a city state boasting a 5 million population with a land area of about 700 square kilometres, one problem occurs in this city is the confliction between progressive tightening on supply of foreign workers and increasing demand for better quality make. Hence, it is necessary for the Singapore construction industry to adopt labour-efficient designs and construction techniques.

In recent years, as global environmental problems, such as the depletion of natural resources, environment pollution, earth warming, sea levels raising, and biodiversity endangering, attract the attention of many countries and organisations, sustainability has become an essential concept in many countries' strategies for both economic and environmental development. For a small country like Singapore, developing in a sustainable way is not an option but a necessity. Subsequently, the Sustainable Singapore Blueprint (Inter-Ministerial Committee on Sustainable Development, 2009) was announced by the Singapore government in April 2009.

The building and construction sector, being one of the key drivers of Singapore's economy, will be at forefront of this national effort, Sustainable Singapore. This means sustainable construction should be strongly encouraged in the building industry because half of the total of raw materials extracted from the planet is used by construction and more than half of the waste produced comes from this sector (Mourão, 2007).

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Nowadays, building and construction industry is under great pressure of reducing environmental impacts and increase productivity. Therefore, economic goal and constructible performance are no longer the only targets that should be pursued by this industry; environmental sustainability should be highly considered as well. The challenge lies in achieving the right balance between economic performance, environmental performance and constructible performance. There is a clear need to establish the connection between these three aspects. The implication and existing applications of sustainability philosophy and constructability philosophy will be useful when establishing such a link. However, little has been done on the connection between constructability principles and sustainable development.

In order to take a good starting to establish such a connection, three considerations should be noticed. Firstly, from the economic perspective, building structure accounts for 20%-25% of total construction cost (Elnimeiri and Gupta, 2008). Secondly, in the environmental aspect, according to the report by Canada Wood Council (CWC, 1997), materials of building structure (concrete and steel) have high environmental impacts such as resource consumption, green house gas emission, etc. Thirdly, for constructability performance, building structure occupies half of the total score in Buildable Design Appraisal System (BDAS) in Singapore (BCA, 2006), and half of the total score in Constructability Appraisal System (CAS) (BCA, 2011b). It is obvious that selection of frame materials in a sustainable and constructable way is a proper point to take the first step to build the link between economic sustainability, environmental sustainability, and constructability. Therefore, this paper aims to develop a framework to help decision makers select structural frame in a more sustainable and constructable way.

2. THE DEVELOPMENT OF THE FRAMEWORK - DSSSSM

2.1. PREVIOUS STUDIES ON ECONOMIC, ENVIRONMENTAL SUSTAINABILITY AND CONSTRUCTABILITY

In building investment, traditional cost-accounting methods are widely used as the core indicators for investment decision as well as alternative making. However, as it becomes increasingly more important to consider environmental sustainability and constructability, decision makers will need to pay more attention to these two dimensions when seeking to attain profit goals. Life Cycle Cost (LCC) methodology is proved as a good solution to evaluate the real economic performance when considering environment issues (Aye *et al.*, 2000; British Standard Institute, 2008; Kaenzig and Wüstenhagen, 2010; Smith and Jaggar, 2007). In this study, the cost categories of LCC defined by British Standard Institute (2008) was adopted. The BSI LCC system is composed by 6 categories: construction costs, maintenance costs, operation costs, occupancy costs, end of life costs, and non-construction costs. In these categories, operation costs and occupancy costs are mainly affected by the materials and size of envelop elements, usages of buildings, and air-condition systems etc. Structural materials have little effect on operation costs and occupancy costs. Therefore, operation costs and occupancy costs are not evaluated in this study.

To investigate the environmental impacts, the authors have reviewed the Building Research Establishment (BRE) Environmental Assessment Method (BRE, 2011), Leadership in Energy and Environmental Design (USGBC, 2011) and Singapore Green Mark (BCA, 2011a) systems. It was found that these systems have provided the following indicators to assess the environmental performance associated with structural materials: percentage of reuse materials (reuse rate), percentage of recycle materials (recycle rate), waste, CO_2 emission, water consumption, noise and etc.

BDAS and CAS, encouraged by Singapore Building and Construction Authority (BCA) to improve buildability and constructability, are mainly focus on labour saving improvement (BCA, 2011b). However, other than labour saving, there are several aspects are implied in constructability concept, such as resource accessibility (Trigunarsyah, 2007), construction quality and safety (Ugwu *et al.*, 2004).

In order to develop an integrated model for material selection, considerable works have been done. For example, Castro-Lacouture *et al.*(2008) and Paya-Zaforteza *et al.* (2009) developed their models for selection of structural material by integrating the environmental and cost goals where constructability criteria were absent. Elnimeiri and Gupta (2008) and Giudice *et al.* (2005) developed their models for selection of structural materials by integrating the environmental and constructability requirements where economic factors were not considered. Sirisalee *et al.* (2004) developed their model for selection of structural material by integrating the cost and constructability goal where environmental factors were excluded. Despite the growing awareness of the importance of pursuing both sustainability and constructability in building and construction industry, there is still no model which synthetically assesses economic sustainability, environmental sustainability and constructability performance for structural material selection between RC and steel. In this paper, a synthetically conceptual framework is given below.

2.2. CONCEPTUAL FRAMEWORK

Based on the literature review, it can be hypothesised that building structural material selection is determined by the synergies of the economic sustainability performance, the environmental sustainability performance, and the constructability performance. The conceptual framework is shown in Figure 1, which indicates how these factors function in the decision system.

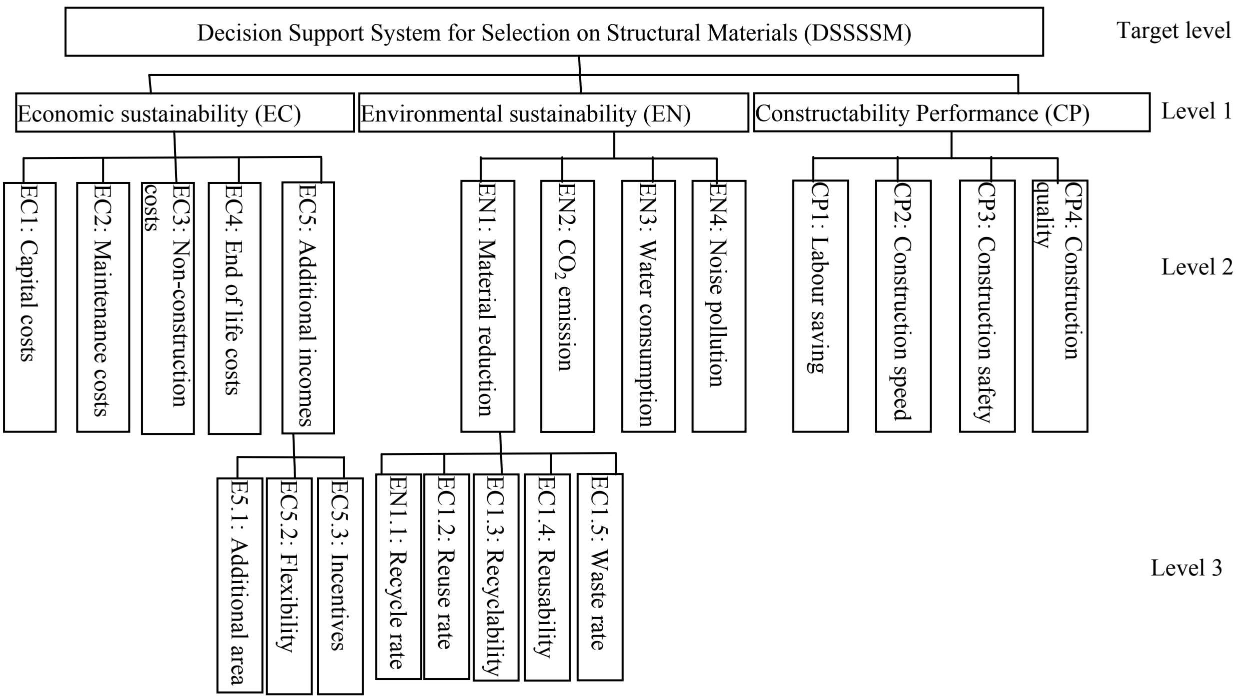

Figure1: DSSSSM Conceptual Framework

In this conceptual framework, 5 attributes indicate economic sustainability applied for structural material: capital costs (including costs of substructure, costs of superstructure, contingency costs, preliminary costs, and design costs), maintenance costs (including fire protection costs and corrosion protection costs), non-construction costs (including financial costs and taxes), end of life costs (including disposal costs and demolition cost), and additional income (including benefit from addition using area, benefit from flexibility of internal space, and possible incentive from BCA productivity enhancement scheme). 4 attributes indicate environmental sustainability applied for structural material: material reduction (including material recycle rate, material reuse rate, material recyclability, material reusability, and the material waste rate), CO_2 emission, water consumption and noise during construction. Another 4 attributes indicate constructability performance applied for structural material: labour saving, construction speed, construction safety, and construction quality.

3. RESEARCH METHODOLOGY

3.1. RESEARCH PROCESS

The research process is shown in Figure 2. Following the identification of research problems (step 1), literature review (step 2) was conducted to form the conceptual framework (step 3) of this study, as well as the questionnaire (step 4). After refining the questionnaire (step 6) from pilot studies (step 5), data collection (step 7) was conducted. Following statistical analysis, those data were used to develop the decision support system for the selection of structural materials (step8) using multi-attributes value technique (MAVT). The establishment of the DSSSSM is composed by two elements, weighting of all factors and attributes (section 4.1) and rating of attributes (section 4.2) Validation of the model (step 9) is currently conducted before making the conclusions and recommendations (step 10). This paper mainly reports the model construction, which including step 3, step 7 and step 8.

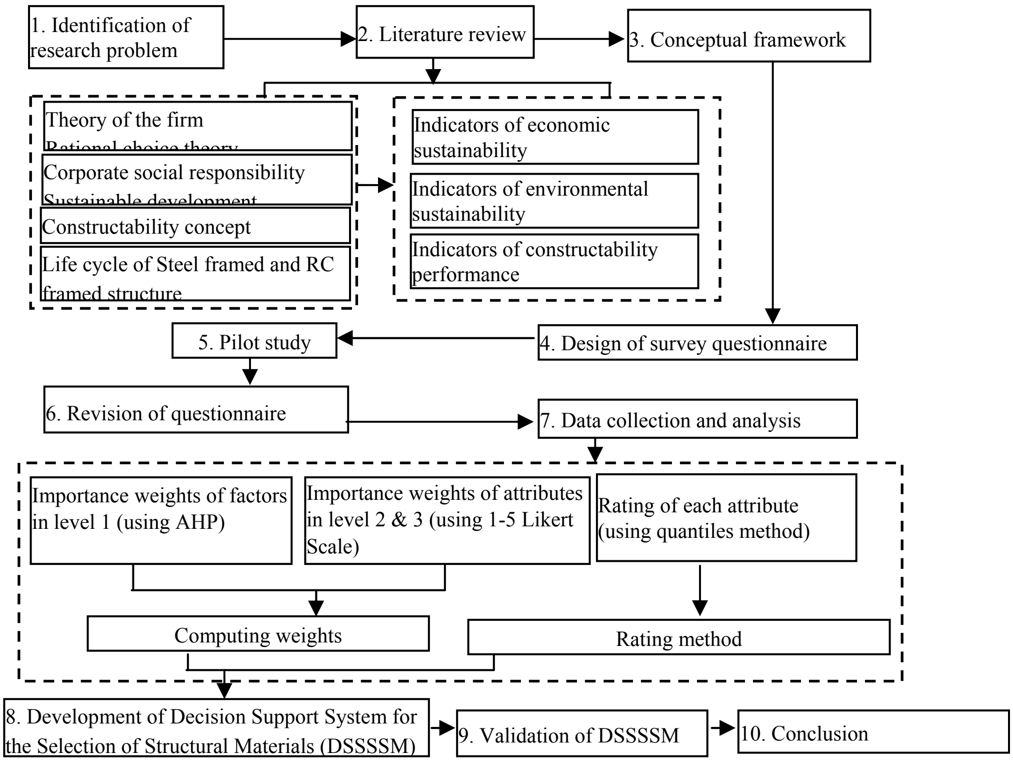

Figure 2: Research Progress

3.2. SURVEY

This research aims to investigate decision makers' perception of the impacts of those pre-addressed factors and attributes on selection of structural frame materials. Survey method is proper for achieving this aim because survey may reflect respondents' attitude and beliefs (Royse, 2008) and is efficient in collecting information from the population (Tan, 2004). The data was collected by face to face interview using a structured questionnaire. In this study, 30 Reinforced Concrete (RC) framed buildings and 9 Structural Steel (SS) buildings had been investigated. RC projects were randomly selected from those projects constructed in recent 3 years in Singapore, while SS projects were selected with wider range of 10 years due to limited numbers of SS buildings in Singapore. These projects consist of residential buildings, commercial buildings, institutions and official buildings. The information of each project was collected by interviewing a group composed by 2-3 experts who involved in that project. In order to obtain comprehensive information of each project, these experts were allocated to multi-discipline of contractors, architects and engineers.

4. MULTI-ATTRIBUTES VALUE TECHNIQUE (MAVT)

4.1. WEIGHTING

The first part of MAVT is to computing weights of criteria and attributes. Weights reflect the priority of each factor and attribute. In this study, it is shown from the decision hierarchy in Figure 2 that there are three level weights need to be determined.

The weights of the three factors (EC, EN and CP) make up the first level weighs (refer to Figure 1). The first level weights are obtained by using Saaty's Analytic Hierarchy Process (AHP) technique (Saaty, 2005). The participants were asked to compare each factor against one another based on Saaty's 1-9 point scale using pair wise comparison method to establish their relative importance. In Saaty's 1-9 point scale method, 1 means equal importance, and 9 means absolute importance. In order to minimise the possibility of bias, all participants were asked to select the number in accordance with their experienced judgments.

All of the data from the pair wise comparison were used to compute the weights of first level factors (ω_i). It was not practical to use AHP technique to obtain the weights of those attributes on level 2 and 3 due to large number. Therefore, the 1-5 Likert Scale was used to investigate the weights of those attributes in 2nd and 3rd level, where 1 means not important, 3 means neutral and 5 means very important. All of the respondents were asked to tick the extent to which each attribute contribute to the selection on structural frame material.

The weight for each attribute (ω_{ij}) is obtained using the Eq: 01.

$$\omega_{ij} = a_{ij}\omega_i \qquad \text{(Eq: 01)}$$

Where a_{ij} is the weight of attribute j under factor i.

$$a_{ij} = \frac{a_j}{\sum_{j=1}^{m} a_j} \qquad \text{(Eq: 02)}$$

$$a_j = \frac{1(n_1)+2(n_2)+3(n_3)+4(n_4)+5(n_5)}{n_1+n_2+n_3+n_4+n_5} \qquad \text{(Eq: 03)}$$

Where a_j is the mean importance rating of an attribute. $n_1,\ n_2,\ n_3\ ,\ n_4,\ n_5$ are the numbers of subjects who rated the attributes as *1, 2, 3, 4, 5*. j is the attribute reference and there are m numbers of attributes under factor i.

4.2. RATING

The second part of the MAVT is to rating each attribute, which assist decision makers to allocate score to each attribute in an objective and straight forward manner. To enhance the accuracy of the performance of each attribute, exact information of particular project were asked in the questionnaire for those participants to provide (for example, the construction duration for structural works, the CONQUS score for structural construction, and etc.). Once the data having been collected, T test was conducted to test the significance.

After the statistic analysis, the performance values of each attribute were classified into 5 groups using quantiles method (Hyndman and Fan, 1996). The rating method is shown in Eq: 04. Score 10, 7.5, 5, 2.5, and 0 represent those points from located in the range of the group with the best performance (G1) to the group with the worst performance (G5).

$$r_{ij} = \begin{cases} 10,\ if\ the\ performance\ value\ of\ an\ attribute\ \in\ G1 \\ 7.5,\ if\ the\ performance\ value\ of\ an\ attribute\ \in\ G2 \\ 5,\ if\ the\ performance\ value\ of\ an\ attribute\ \in\ G3 \\ 2.5,\ if\ the\ performance\ value\ of\ an\ attribute\ \in\ G4 \\ 0,\ if\ the\ performance\ value\ of\ an\ attribute\ \in\ G5 \end{cases} \qquad \text{(Eq: 04)}$$

Where r_{ij} is the rating given to the j^{th} attribute of i^{th} criteria. Due to the model is still in the validation stage, the actual rating ranges are not shown in this paper.

After rating an attribute, the score for each attribute is computed by multiplying the weight and the rating score. The additive method of aggregation was used to calculate the selection on structural material (SSM) score. The value function is given in Eq: 05:

$$SSM_k = \omega_1 \sum_{j=1}^{5} \omega_{1j} r_{1j} + \omega_2 \sum_{j=1}^{4} \omega_{2j} r_{2j} + \omega_3 \sum_{j=1}^{4} \omega_{3j} r_{3j} \qquad \text{(Eq: 05)}$$

Where SSM_k is the total score for structural material k. The option with higher SSMscore is more preferred for decision makers.

5. DATA ANALYSIS

The data collected were analysed using the Statistical Package for Social Science software (SPSS). One sample t-tests of the mean were carried out to check the entire population's response to the addressed attributes in the survey. The null hypothesis (H0) was set as: μ=μ0 and alternative hypothesis (H1) was set as: μ≠μ0, where μ was the sample mean; μ0 was the population mean. μ0 was fixed at the value of 3 according to the definition given in the rating scale 1~5. If μ is less than 3, it means the corresponding attribute is not important on the determination of selection of structural frame materials. H0 would be rejected and μ would be less than μ0 if the value of significance at 95% confidence level was less than 0.05 with negative mean difference.

Respondents were asked to tick the importance of each attribute when making decisions on selection of structural materials. Then the collected 39 sets of data were input into SPSS to conduct sample t-tests. According to the results of sig (2-tailed) value and mean difference, those attributes were regarded as not important when H0 was rejected with negative mean difference. To refine the decision support model, those non-important attributes will be removed from the model.

6. CONCLUSIONS

This study offers a new framework to assist decision makers to select building structural frame material to achieve sustainability and constructability in Singapore. It explored the factors that affect the decision making on selection of building structural materials, revealing that the determination on building structural materials is integrally affected by 3 factors: economic sustainability (EC), environmental sustainability (EN) and constructability (CP). Furthermore, these 3 factors are determined by 13 attributes (EC1~5, EN1~4, and CP1~4). A series of survey had been conducted to test the hypothetical framework.

It should be noted that there are two limitations in this paper. First, although the DSSSSM model is flexible for application in other countries, this model is based on projects in Singapore. If decision makers want to use this model overseas, they have to build a new database by investigating the local projects in that country. Secondly, due to this study is still in the validating stage, the statistical results are not available for this paper right now. The further results will be reported in the near future. This study has taken the first step in addressing the link between economic sustainability, environmental sustainability, and constructability in terms of selection on building structural materials. In addition, the DSSSSM framework might be helpful for decision makers to choose a more sustainable and constructable structural frame.

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DEVELOPING SUSTAINABLE RELATIONSHIPS THROUGH PUBLIC PRIVATE PEOPLE PARTNERSHIP (4P) PROJECTS

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ABSTRACT

Public Private Partnership (PPP) are sometimes used to procure public infrastructure, if deemed useful in mobilising private finance and expertise for generating innovations and enhanced 'value'. However, when delivering desired 'value' to specific end-users, we should not neglect 'overall value' for the sustainable development of the parent community/society. To address such holistic issues in suitable broader-based projects, wider-ranging 'Public Private People Partnership' (4P) arrangements are proposed to invite and integrate contributions from societal stakeholders through relevant bodies, e.g. social enterprises, NGOs, academia and professional institutions.

Selecting and integrating such stakeholders in a properly structured 4P procurement and operational framework can help formulate more widely acceptable and sustainable designs and mobilise more resources for procurement, construction, maintenance and operation of built assets. This will also help to address grass roots aspirations and concerns earlier, rather than try to resolve conflicts later. However, a major barrier to involving more stakeholders in already complex projects arises in managing their inputs, and relationships, while optimising outputs.

Based on literature review and structured interviews, this paper presents pros and cons of using 4P in selected scenarios such as post-disaster reconstruction. Initial findings confirm that a 4P approach requires superior relationship management. This paper also draws on another study that highlighted the often neglected importance of relationship management in 'traditional' PPP projects. Combining these findings, a case is made for improving relationship management by mobilising the additional P ('people') to appropriate extents in selected PPP projects, so as to identify, prioritise and harmonise diverse stakeholder objectives and target optimal 'overall value' with sustainable relationships aimed at common goals.

Keywords: *Public Private People Partnership, Relationship Management, Stakeholders, Sustainable.*

1. BACKGROUND AND INTRODUCTION

Public Private Partnership (PPP) projects have increasingly covered a wide range of public projects including economic infrastructure such as transportation, telecommunication, power and energy; and social infrastructure such as hospitals, schools, prisons and sewerage. The most significant difference between traditional procurement and a PPP approach is that PPP purchases services, rather than assets only (Grimsey and Lewis, 2004). Successful PPP projects should deliver the required public services and outcomes to the levels specified by the government and should also achieve better value for money compared to traditional approaches.

Since the essential missions of public projects are fulfilling the needs of targeted end-users, as well as the broader community and the people in general, it has been widely acknowledged that representatives of the 'people' should be integrated into the whole procurement process from planning, construction to operation, in order to fully achieve the ultimate goals of public projects – improving living standards in a sustainable manner that would also facilitate continuous improvement.

In order to address this issue, a 4th P in Public Private People Partnership (4P) projects has been introduced in this research. The 4th P is 'people' which would formalise, if not legitimise the participation of important stakeholders in PPP projects. People could be represented for example, by Non-Governmental

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Organisations (NGOs), the community, academia, media and so on, the appropriate choice being made according to project nature and needs. The authors hypothesise that multiple synergies could be generated across but only after the missing link – the 4th P - is formally incorporated in the partnership and their contributions injected into the planning, development and operations.

Drawing on the research that highlights the often neglected importance of relationship management (RM) in 'traditional' PPP projects, this paper first presents pros and cons of 4P in more obvious special scenarios such as post-disaster reconstruction where various 'people' necessarily get involved over time, but currently in an ad hoc informal manner. Initial findings from literature review and structured interviews confirm that a 4P approach in such special scenarios also requires superior RM. Based on these findings, a case is made for improving RM by mobilising the additional P ('people') to appropriate extents in other types of PPP projects as well.

2. RESEARCH METHODS

Our initial research on 4P focused on the application in one particular scenario, which is post-disaster reconstruction. Post-disaster infrastructure reconstruction projects require engagement, participation and contributions from multiple stakeholders, such as NGOs, local communities, professional organisations and media. In fact, these parties do get involved in recovery activities, but always in ad hoc and hence inefficient modes. Therefore, reconstruction projects provide particularly high potential for benefiting from the 4P proposition of integrating 'people'- these key stakeholders into the development and operation of the reconstructed facilities and services. Following an initial literature review, this proposition was tested and confirmed through semi-structured interviews and two parallel questionnaire surveys. Questions asked in the interviews and questionnaires were mainly derived from the literature review that integrated relevant threads from previous research on post-disaster reconstruction, the role of 'people' in disaster management (DM) and the nature of PPP. Interviewees were practitioners and scholars with either PPP experience or DM/post-disaster reconstruction experience from the construction industry, renowned NGOs, public sectors and university academia in Mainland China and Hong Kong SAR. The findings presented in this paper are consolidated mainly from 12 first round interviews. The profile of the 12 interviewees is shown in Table 1.

Table 1: Profiles of Interviewees

Working area	Profile
Disaster management	3 (1 senior manager from an NGO + 2 'Hong Kong Humanity Award' winners)
Post-disaster reconstruction	6 (3 civil engineers + 2 academics +1 officer from Hong Kong Development Bureau with relevant experience)
PPP	3 (1 senior manager from Hong Kong Airport Authority + 2 academics)

Two types of questionnaires were distributed separately among (1) PPP professionals and (2) DM professionals, since there are few experts with deep knowledge and experience in both fields. PPP based questionnaires were sent to members of NCPPP (National Council for Public-Private Partnerships) in USA, Partnerships Bulletin, NZCID (New Zealand Council for Infrastructure Development), Partnerships Victoria (Australia) and other such PPP organisations through emails. 41 responses were received. DM based questionnaires were sent to DM government agencies and NGOs around the world and 40 responses were received on this other questionnaire.

This paper also draws on relevant findings from a recently finished PhD study that focused on RM in PPP infrastructure projects (Zou, 2012). Space does not allow description of the structured methodology, but the main research methods included a critical literature review, structured interviews, two rounds of questionnaire surveys and a case study, followed by a validation exercise.

3. LITERATURE REVIEW AND INITIAL FINDINGS

3.1. PUBLIC PRIVATE PEOPLE PARTNERSHIP (4P) PROJECTS AND DISASTER MANAGEMENT

Construction projects, especially public infrastructure projects would have socio-economic, environmental and other impacts on the broad society and communities during their life cycle. Therefore, other stakeholders' interests should also be considered and protected. Furthermore, these stakeholders could, given appropriate opportunities, also contribute and benefit the project or the broader society through their participation. Viewing this from a value perspective, beyond the traditional concept of 'value' that merely focuses on a clients' perspective of cost/quality/time and profitability, a broader perspective of 'overall value' encompassing wider issues such as environmental and social impacts is being increasingly emphasised. To identify and target appropriate 'overall value', numerous scholars suggest that it is imperative to involve key stakeholders in the process of both decision making and project delivery, especially in large, complex and high-value projects (Thabrew *et al.*, 2009; Achterkamp and Vos, 2008; Boddy, 2002). In the specific context of disaster mitigation, aiming at achieving better performance and services from rebuilt facilities and enhancing 'overall value' over the long term, a 4P approach to integrate 'people' upfront in 'ex-ante frameworks' was proposed by Kumaraswamy (2008).

In the proposed 4P approach tailored for ex-ante disaster mitigation and post-disaster reconstruction projects, 'people' refers to NGOs, local communities, professional groups, academia and media. NGOs provide professional assistance and services in both short-term rescue/response and long-term recovery/reconstruction. It is accepted world widely that local communities should be proactively involved in planning and decision making processes of reconstruction and throughout the DM cycle. Professional organisations, especially those engaged in civil engineering practices, contribute numerous modalities such as establishing technical groups to assess building damages and sending expert consultants to assist in reconstruction. Based on this, the following question was asked in both interviews with construction industry professionals and in the PPP-based questionnaire: 'In this research project, people (communities, NGOs, professional organisations and media etc.) are proposed to be integrated into a PPP to form an expanded holistic 4P approach for better DM. Do you think it is necessary to build such 4P structures and mechanisms beforehand?' The responses summary is in Table 2.

Table 2: Necessity of Building 4P Mechanisms

	Necessary	**Not necessary**
Interviewees	100%	0%
Respondents from PPP-based questionnaire	77.2%	22.8%

The above summary suggests that most of the interviewees/respondents believe it is necessary to build ex-ante frameworks with 4P mechanisms for post-disaster reconstruction. The reason that the perceptions of 'necessary' from interviewees is higher than from the questionnaire could be that the researcher could explain the background and possibilities in more detail to interviewees than is possible in the questionnaire introduction. Therefore, the interviewees would have probably understood the proposed 4P mechanisms better.

In addition, the importance of 'people' was further emphasised by interviewees with reconstruction experience after the 2008 Sichuan Earthquake in China. They said for example, that:

'The role of people in Sichuan reconstruction is very prominent. Since the disaster affected area is a minority gathering region, it is essential to understand and protect local culture and customs in reconstruction.'

'Different from usual construction projects, reconstruction projects have a stronger social nature and much broader impacts. The objective is not only recovering but also improving the life quality of affected victims. There are hundreds of projects waiting to proceed after a destructive disaster, it is critical to make the right decision of which projects to go first and how to do so. The decision making process needs the participation of various related organisations and groups.'

Despite the imperatives for, and benefits from involving 'people', the obstacles and barriers to achieve successful partnerships between these various parties cannot be under-estimated. According to the international questionnaire survey findings, the effectiveness of the various ad hoc partnerships between multiple parties in post-disaster reconstruction is already very unsatisfactory. There is a woeful lack of relevant policies, regulations and standard contracts or agreements to clarify, safeguard and implement the partnerships between the many involved parties. The mutual trust, collaborative team culture, effective communication and transparency especially needed in partnerships are not easy to build and achieve. In addition, conflicting interests will arise from inconsistent objectives of multiple parties. The responses to the following question are presented in Table 3: 'Please rate the current practice/status of the following identified factors to achieve successful partnerships between public, and private sectors and people (communities, NGOs, professional organisations and media)'.

Table 3: The Current Practice of Partnerships in Post-Disaster Reconstruction

	Very inadequate	**Inadequate**	**Adequate**	**Good**
A. Establishing relevant policies and regulations	6.7%	53.3%	26.7%	13.3%
B. Formulating formal contacts and agreements	6.7%	66.7%	13.3%	13.3%
C. Transparency	21.4%	57.1%	14.3%	7.1%
D. Checks and balance	13.3%	60.0%	20.0%	6.7%
E. Effective communication	6.7%	53.3%	33.3%	6.7%
F. Mutual trust	13.3%	46.7%	33.3%	6.7%
G. Commitment from senior managers	0.0%	66.7%	26.7%	6.7%
H. Collaborative team culture	6.7%	46.7%	33.3%	13.3%
I. Long-term sustainable development perspective	13.3%	66.7%	13.3%	6.7%
J. Consistent objectives	13.3%	40.0%	33.3%	13.3%

The above results show that the current status of most ingredients of successful partnerships are seen as 'unsatisfactory', e.g., the combined rating of 'Very inadequate' and 'Inadequate' for all identified factors range from over 50% to 80%. Therefore, superior relationship management (RM) is required for building successful partnerships in such 4P projects. Although the above initial findings are extracted from the questionnaire survey on post-disaster reconstruction projects, it is proposed that the importance of better RM in any 4P project can be extrapolated or at least hypothesised from the above discussion, given the multiple partners and potentially conflicting diverse interests involved.

3.2. RELATIONSHIP MANAGEMENT AND PPP

The inadequacy of traditional project management to deal with conflicting agendas as well as uncertainties, had driven industry focus towards relational contracting, partnering, joint risk management and other collaborative arrangements, which target efficiencies through team working, softer skills and mobilising good relationships (Rahman and Kumaraswamy, 2002; Walker and Hampson, 2003).

This suggests a relationship approach, based on relationship building and management, as an emerging construction management paradigm (Pryke, 2004). Whilst broader than relational contracting and relationship management (RM), the relationship approach can also include mobilising social capital and better relationships for developing synergies, core competencies and added value. It shows how to create and sustain effective inter-team and intra-team relationships between the client and the project team. Extending this further, stakeholder RM is also important (Cleland, 1986; Jergeas *et al.*, 2000). Efficient management of the relationships between the project management team and other project stakeholders is an important key to project success, given potential risks and extra costs that often arise later e.g. from excluding end-users, neighbours and relevant interest/pressure groups (Zheng *et al.*, 2008).

Based on the above, construction industries are currently in transition from innovations in procurement and project management approaches, in particular, moving towards collaborative contracting and technologies with partnering relationships between project actors, based on relational contracting principles and procurement initiatives e.g. in framework agreements, alliances and 'relationally integrated value networks' (Pryke, 2004; Cheung and Rowlinson, 2011; Anvuur *et al.*, 2011).

Traditional PPP goes through several quite distinct stages, therefore the relationships move from building 'internal' bidding team (SPV) relationships to bidding/development team (SPV)/procurer relationships, and finally to delivery team/customer/end-user relationships, whilst still maintaining the SPV/procurer agency relationship. The principal relationships in a PPP change in relative intensity and importance during these various stages – before the financial closure, the development/design and construction phase and the operational phases. However, good RM is clearly needed at all stages for any successful PPP. This was studied and established in a recently completed PhD thesis (Zou, 2012).

The findings presented in Table 4 were extracted from one part of one of the questionnaire surveys in this PhD study. Based on 42 responses from a cross-section of experienced participants from public and private sectors in a range of PPP project types, the summary indicates that: RM is more important in PPP because of the longer term contracts; successful RM will help to improve the performance of the present PPP; RM can help maintain and improve relationships between PPP parties; and future PPP business can also be increased by effective RM. Of particular interest to the present integrated study/paper is the dominant view that RM should include 'internal and external relationships'.

Extending the above findings on PPP in general, to the 4P scenarios developed and described in sub-section 3.1, the additional dimension and complexity of shareholders involved in 4P projects calls for even better RM. From the social network perspective, the whole 4P network includes many criss-crossing direct and indirect relationships between all stakeholders of the project, from government departments, private companies, consulting companies, contractors, banks and insurance companies to the multiple representatives of the 4^{th} P.

Table 4: Characteristics of RM in PPP

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
RM is very important for PPP because it involves long term contracts	61.5%	28.2%	7.7%	0.0%	2.6%
Successful RM will be helpful in improving the performance of the present PPP	54.1%	43.2%	2.7%	0.0%	0.0%
RM is to maintain the relationship between PPP parties	35.3%	44.1%	14.7%	5.9%	0.0%
RM is to improve the relationship between PPP parties	45.7%	40.0%	11.4%	2.9%	0.0%
RM should include internal and external relationships	42.9%	34.3%	14.3%	8.6%	0.0%
Effective RM will increase chances of future PPP contracts	51.4%	34.3%	11.4%	2.9%	0.0%

4. IMPROVING RELATIONSHIP MANAGEMENT BY MOBILISING THE 'PEOPLE'

Having identified the above challenges and needs for better RM in 4P scenarios, suitably injecting the 4^{th} P can on the other hand, provides opportunities for improving RM, since 'people' can provide the 'missing link' that cements the partnership.

A 4P approach can mobilise important stakeholders via a well-structured strategy, so they could play significant roles and make positive and synergistic contributions to certain types of PPP projects. This could yield positive impacts in reconciling the relationships between public and private parties, particularly with the current focus on sustainability in project delivery. On the other hand, this could also trigger 'negatives', such as more complex negotiations, decision making processes and personal/ relational disputes. The practical issues in injecting the 4th P into PPP are therefore: (a) how to select and engage them, and manage expectations; while minimising potential disputes in general; and (b) particularly, how to structure the formal partnership and develop the relationships across the 4P.

Clearly, the integration of multiple stakeholders into the already relatively complex PPP projects raises questions on which stakeholders should be involved, when and to what extent, how to involve them and the balance between the 'inputs' of efforts and costs to involve them and the 'outputs' in improved performance levels. 4P is certainly not a panacea for all procurement scenarios; not even for those (the sub-set) that merit considerations for PPP. Comprehensive research should be done to test and justify the use of 4P for certain types of projects that are suited for PPP to start with.

Public projects normally include both 'hardware' construction like for power supply, water supply, school buildings, hospitals and roads, as well as related 'software' building like for education or medical services. It is recommended that where more 'software' is needed in a public project, then more inputs and 'buying in' is required from 'people'. In general terms, social infrastructure requires more inputs from 'people' than purely physical infrastructure. These inputs became indispensable especially when social infrastructure extends to the provision of certain types of social services.

In this 4P approach, in terms of core contributions, the government can provide an overall enabling environment; the private sector can contribute financial resources and commercial expertise and efficiencies; and NGOs can help formulate, implement and propagate the social development agenda more realistically and efficiently at the grass roots level; professional bodies can mobilise relevant special expertise; the media can raise public awareness and help harness opinions and social capital. All these can help to inject better value into project design, mobilise and optimise more resources for procurement, construction and operation and maintenance; as well as reinforce commitments and sustain relationships to meet agreed objectives more efficiently. Significantly, this transforms a less effective two-party partnership (PPP) into a more representative integrated three-party partnership (4P). The following case example suggests where earlier mobilisation of the 4th P could arguably have helped reduce the initial disruptions to the planning and launching of this mega project.

5. CASE EXAMPLE OF WHERE 4P COULD HAVE BEEN BETTER THAN PPP

The West Kowloon Cultural District Project is one initiative in a strategic thrust to make Hong Kong 'Asia's World City', in this case through world-class cultural infrastructure (Lee and Haque, 2006). However, this megaproject suffered from a number of false starts from soon after its initial announcement in 1998 (An *et al.*, 2011). An international design competition was organised in 2001, and a massive single over-arching 'Canopy' design scheme won the competition. However, the process was aborted after intense public criticism of potentially exorbitant costs, as well as allegedly perceived needs for either a single property developer to handle this, or even if split up, what were widely seen to be potentially excessive benefits for property developers. After more stop-start interruptions, the government established a high-powered West Kowloon Cultural District Authority (WKCDA) in 2006, to take over responsibility for developing the project. Two public consultations were held in 2009 and 2010 (An *et al.*, 2011). In late 2010, a new design competition was held and three reputed companies submitted conceptual design proposals. The WKCDA also held a series of exhibitions to solicit public opinions. The overall concept has finally been finalised and the project is now awaiting the approval from the Town Planning Board (West Kowloon Cultural District Authority, 2012).

According to a joint report by APCO Asia *et al.* (2005), this project was then criticised for its limited public consultation, misinterpretation of public sentiment and lack of transparency. It was alleged that the project planning process lacked broad public consultation, with inadequate involvement of stakeholders and the general public. It was said that the consultation process did not allow for in-depth discussions and favoured the developers by letting them answer the questions they chose. It seemed that key stakeholders were not identified, resulting in mistrust and misperceptions. Furthermore, it was alleged that the Government mistook media reports to represent the public voice.

In hindsight, a 4P approach could have been useful, by which the government could have gauged and mobilised support for an appropriately structured project. This could have improved the project's 'overall value' and minimised the initial conflicts among different stakeholders. Moreover, it would have avoided the abortive stop-start interruptions that marred the initial phase of this project.

The project development process needs to include key stakeholders from the public sector, urban planners, constituents, arts groups, the general public as well as media. Public buy-in would minimise some resistance and suggest ways the community could monitor and be involved in the project (Parker and Hartley, 2003). Besides, given the characteristics and objectives of the project, the 4th P should have also included the arts community upfront, to assess their needs and to enable the future facilities to meet their aspirations from the outset.

6. CONCLUSIONS

Apart from the basic benefits inherent in upfront integration of relevant stakeholders, the proposed 4P approach could help improve RM by providing the fundamental links for harmonising the different objectives of public and private sectors in a PPP, resolving their differences faster, developing and reinforcing stronger commitments and cementing the partnership. In short, 4P can create a healthy environment for developing and continuously improving sustainable relationships. Like any long-term relationship, it is best to keep these congenial, transparent and balanced, resolving small problems before they could turn into big ones. However, when formally 'injecting people' into PPP processes, an optimal balance should be targeted between 'inputs from the 4th P' and 'real and intangible costs of including more people'. If not, the planned net benefits from expected synergies and overall long-term whole-life value may well 'back-fire' in a 4P arrangement. Further research is needed to develop, detail and test the above initial findings. The present propositions are based on the integration of relevant results from two studies as above, and also set the stage for a specific and more focused study. It is also expected from parallel research, that improved RM could in turn increase productivity and lead to better industry practices in general.

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