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Abstracts

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Analysis of Air Void Variations in Hot Mix Asphalt Wearing Course Mixtures used in Sri Lankan Roads

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Over the past decades, the road construction with hot mix asphalt (HMA) has been increased significantly. However there were many concerns of the durability of the recently constructed asphalt concrete roads. Therefore, impotency of introduction of new quality control measures is arisen these days.

The properties of the asphalt mixture as well as the construction practices are also important for the quality and the durability of asphalt pavements. The present Sri Lankan practice is measure and control of (1) Thickness, (2) Density, (3) Bitumen Content and Aggregate gradation and (4) Roughness Index (IRI) of the laid asphalt mat.

The objective of this research is to find out the impotency of measuring the air void of the laid asphalt mat and the need of a combined index of the important parameters to improve the quality and durability of asphalt concrete roads. Core samples were tested at 12 locations with various initial compaction levels at two aging levels, 100 days and 225 days. In addition performance was evaluated of the road sections with various levels of initial compaction after 5 years to check the long term aging of asphalt concrete. It was found that initial air void content significantly decreased under traffic in a short period and long term performance of HMA roads cannot be evaluated by initial air void content alone.

Key words: Air Voids, Marshall Density, Degree of Compaction

Effect of Fine Percentage on Properties of Sub base Material

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With the huge infrastructure development in Sri Lanka, construction of roads plays a vital role. Massive quantities of construction materials required for these highway and expressway constructions. Finding sub base material as per specification is a major issue in most part of the country. Therefore, in some road construction projects, crushed stone has been used as an alternative material to replace sub base material. Due to the scarcity of good quality material, there is a need of research to use marginal materials for sustainable development in the highway industry.

Standard Specification for Construction and Maintenance of Roads and Bridges (SCA/5) (SSCM) (ICTAD, 2009) used as a road construction specification in Sri Lanka. Liquid limit (LL), plastic limit (PL), maximum dry density (MDD), California bearing ratio (CBR) and sieve analysis are specified in selection of gravel sub base material. According to sieve analysis requirements in SSCM, percentage of passing 75 μm sieves should be 5-25 percent by weight. This grading limit for sub base material was adapted to the specification in second edition of SSCM in 2009. Questionnaire survey conducted among senior engineers has expressed that one of the least important parameter in material selections was grading (84% of the participants) and 16% of the engineers have expressed grading as the most difficult parameters to meet. This study was conducted to see the possibility of relaxing the passing percentage of fine fraction.

Experimental study was conducted altering the fine fraction of soils varying from 0-40%. Properties of those samples were tested. It was found that there is a linear relationship with high correlation factor between fine fraction of the material and it's properties (CBR, MDD, OMC). Only three samples out of ten samples were within the grading band requirement and nine samples out of ten samples satisfy CBR requirements. By scrutinizing the findings and available literature, it can be recommended that grading band of No.200 sieve passing can be relaxed up to 35% if soil sample satisfy the specified CBR requirement (30), PI value is less than or equal to 10 and swell percentage is less than 2%. Further, a linear regression model was fitted to assess the CBR of the material with reference to fine fraction

(Percentage passing of 425 μ m, 300 μ m, 75 μ m sieves). Statistical analysis shown that material passing 425 μ m & retained on 300 μ m, and 75 μ m passing percentage are the significant parameters are when predicting CBR of the selected soil in this study.

Key words: California Bearing Ratio, Grading Band, Fine Fraction

Energy Optimization in Compaction of Unbound Material in Road Construction

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Compaction of Unbound Material in road construction projects, plays one of major role, as it directly contributes to project cost, quality, time and natural environment. Compaction effort is optimized significant amount in soil compaction according to its moisture content. But unfortunately this is not applied to Aggregate Base Course (ABC) compaction in most cases. Water is used as lubricant in traditional practice of macadam base construction & Optimum Moisture content (OMC) concept is not applicable there as it compacts until fines come out with water. Based on that practice, ABC is compacted at high moisture level disregarding compacting effort. In order to achieve the optimum energy level, the relationship between OMC, Maximum dry density (MDD)& Compaction effort (Compaction Energy) should be identified. Understanding of the importance of this concept is a question in present Sri Lankan context.

Questionnaire survey was done to collect information of current compaction practice, which are the compaction effort& moisture levels they compact in order to achieve the compaction. Lab and field studies were done to observe the compaction behavior of ABC at different moisture conditions &energy levels. The lab study was performed at four difference energy levels(Standard proctor, Modified proctor, Standard mould with 52 blows & Modified mould with 25 blows), while field was done at six different energy levels (2,4,6,8,10, & 12 roller passes by 11 ton single drum vibratory roller) & at five different moisture levels. Furthermore sieve analysis tests were done after compaction at some selected locations in order to compare the variation with its initial gradation.

By analyzing questionnaire survey results, it is reviled that ABC compaction is done at higher moisture levels. Based on the field trial results it is observed that higher compaction effort is ineffective, when compacts at moisture level which is not closed its OMC. Furthermore, it shows that dry unit weight is increased rapidly with lesser no. of roller passes, when it has

moisture content lower than the OMC. Finally dry densities are reached to constant value after higher no. of roller passes in all range of moisture levels.

It can be concluded that selection of compaction effort mainly depends on its moisture content. But field in charge officers are trying to get required compaction only at higher MC. Therefore ineffective compaction procedures should be brought to end by convincing field officers. Thus appropriate compaction effort should be identified after testing its moisture content prior to compaction, in order to achieve cost effective, better quality, timely completion & environment friendly job.

Key words: Compaction, Energy Optimization, Moisture Content, Dry Density

Estimation of Penetration Requirements for Prime Coat

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Prime coat application is a necessary activity in road construction and it has a purpose in the pavement construction process, yet many times prime is misused during the project. The main function of prime coat is to prevent moisture infiltration to the base and underneath layers by sealing the road base. So the prime penetration into the road base is the most important consideration. When it comes to Sri Lankan context, the application of prime has been a common practice in road construction projects though there is no basis for penetration requirements. This is an issue of concern as there should be a basis for selecting the best type of prime coat in terms of the penetration and penetration requirement for respective type of processed bitumen as well. Commonly used types of processed bitumen for prime application in Sri Lanka are MC-30 (Medium Curing cut back bitumen) and CSS-1 (Cationic Slow Setting). The experimental research was done using both types of bitumen and the Aggregate Base Course (ABC) specified in the ICTAD-2009 specification as the road base. Specimens were casted in AASHTO specified CBR moulds at selected degree of compaction and sprayed each types of bitumen at selected rate under typical defined Sri Lankan conditions. Penetration requirement and required curing time were selected for each degree of compaction and rate of application, and then the penetration requirements for respective required curing time were plotted on a graph against the base compaction and rate of application. There is no significant difference of required penetration for both type of bitumen but MC-30 has shown a bit higher penetration at few time intervals to make it arguably the best to select in terms of the penetration into the base among the two types of bitumen tested. The penetration requirements for MC-30 and CSS-1 with the time are presented and can be used to make decisions on the best type of bitumen to use in terms of penetration and required penetration for a selected type of bitumen with curing time.

Key words: Prime coat, Penetration requirement

Pedestrian Crash Analysis in Uva Province: Case Study at Wellawaya, Buttala and Monaragala Cities

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Road crashes in Sri Lanka is becoming a major social, economic and health issue with rapidly increasing number of vehicles, road kilometers and vehicle kilometers travelled. Despite the significant increase in road infrastructure development in recent years (post war period), number of pedestrian related accidents remains at a very significant level. One of the reasons is not having due attention towards the pedestrian related infrastructure development such as pedestrian walkways, safe pedestrian crossings and safe and efficient public transport services, etc.

As a result, the probability of a pedestrian being exposed to unsafe road conditions has been increased giving way to the increased risk of pedestrian casualties from road crashes. Adverse effects of this were evident with comparatively higher number of pedestrian casualties all over the country. The impacts of these crashes are comparatively high due to the higher probability of these crashes being a fatal or grievous than other types of crashes. In the year 2013, 7004 pedestrian casualties were recorded while 10% of them being fatal making it the highest rate of fatalities from all the categories of casualty.

In parallel to the aged friendly city concept introduced in Moneragala District and considering severity of the problem of pedestrian crashes that affect elderly and disabled significantly, a case study was conducted to assess and find out the contributory factors caused by the deficiencies of roadway conditions towards pedestrian crashes in Sri Lanka taking Monaragala, Buttala and Wellawaya DS divisions. Total accidents and pedestrian related accident details for the past decade (2004-2013) in these areas were extracted from 'Sri Lanka Police Accident Database' and analyzed using descriptive statistics. The existence of a relationship between all crashes and pedestrian related crashes were checked using chi-square test. Spatial distribution of pedestrian related crashes within the study areas was

analyzed to find out hot spots for pedestrian crashes and then a site visit was made for those locations to collect information about the background.

It was found that less than 6% of the pedestrian related crashes occurred at junctions where limited pedestrian facilities are available while the rest of the crashes have occurred in mid-block sections (road stretches with no intersection within 10m). More than 55% of these crashes have taken place where there is 'no pedestrian crossing within 50m' or 'on road without side walk' depicting the inadequacy of pedestrian related infrastructure. Population wise, the portions of elderly people (age ≥ 60 years) and young people (age ≤ 14 years) within these three divisions are 9% and 27% consecutively and the pedestrian crash involvement of the above age categories are 15% and 20% respectively. The elderly people had significantly higher percentages of crash involvements than the elderly population proportion (9%) at locations where 'no pedestrian crossing within 50m' (19%) and at 'roads without sidewalks' (15%) in rural conditions. This points out the fact that elderly people are more susceptible for crashes especially at locations in rural condition. Site visits for the fatal pedestrian crash hot spots revealed mainly poor visibility due to geometric constraints such as sharp bends, rolling terrain (change in vertical alignment) and unavailability of pedestrian walkway nor enough hard shoulder compelling pedestrians to occupy carriageway increased the risk for pedestrian related crashes.

Key words: Pedestrian Crashes, Crash Hot Spots, Pedestrian Infrastructure, Aged People

Extent of concerns over Human Limitations in existing road design standards – A Literature review over the “Status of Adequacy”

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Analysis of technically unexplainable accidents has confirmed that accidents could occur not only due to the user misbehaviors but also due to the lack of purpose designed field of vision including road courses without adequate contrast to increase alertness. These findings imply that without a comprehensive understanding of the human limitations a self explaining road design with low accident risk cannot be achieved. Our current design standards need to be systematically improved to integrate principals of spatial perceptions in order to manage user needs and expectations. In the context of Sri Lanka and of many Asian countries user misbehaviors certainly the most significant contributory factor for the alarming accident rates they experience at present, yet the fact that lack of purpose designed field of vision though would be secondary, certainly will aggravate the end repercussion of a misbehaved user.

The duration taken by an average driver to adapt from one traffic situation to the next or to adjust to a new environment is much longer than the standard reaction time duration between 2.0-2.5 seconds stated in most of the current design standards. This is particularly so when information is difficult to find or when users are confronted, with situations demanding complex decisions.

A critical review of pertinent research and related provisions within road design standards of US, Canada and UK has revealed that concerns over human limitations have not yet been satisfactory incorporated in to the standards (G. KANELLAIDIS, 1997) [3].Birth S IBYLLE, 2013[4] reviewed design standards of nine western countries and found that none of the standards explicitly considers the aspects related to the management of field of vision of drivers.

This paper submits a comparison of “extents of considerations” of human factor concerns over the geometric design standards of Sri Lanka, with other standards including AUSTRROADS[2], AASHTO[1] & Chinese based on findings of previous studies. At the end a framework is discussed allowing the integration of human aspects related to the management of field of vision of road users into the geometric standards of Sri Lanka.

Key words: Field of vision, spatial perception, expectation logic

Study on the effects of overloading on Sri Lankan Roads

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With the increasing demand for transport means, new technological vehicles and heavy loads carrying vehicles are used by people, in order to take the financial advantage. Consequently most of the commercial vehicles plying on Sri Lankan National Highways are overloaded. Previous studies show that overloaded vehicles are carrying as much as double weights than its maximum permissible load. Limits for standard legal axle loads and gross vehicle weight have been already imposed by Minister of transport as a part of Motor Traffic Act. But they are violated oppressively by the transporters but not enforced stringently by road agencies or Motor Traffic Department.

Designing of flexible road pavements is mostly based on the cumulative number of equivalent standard axles which is significantly subscribed by the heavy vehicular traffic including overloaded vehicles. Construction cost of road pavement is hence directly incurred by above and it results in extensive, costly pavement designs. Furthermore the damage by overloaded vehicles to the pavement is exponential. Continuous overloading of vehicles reduces the design life of pavement resulting premature failures and induces additional cost to road agencies for maintaining them.

In this study, actual axle load survey data at selected locations to cover the national road network were analyzed and assayed in different aspects. Overloading of vehicles and its effects were identified in accordance to several pavement design methodologies such as Road Note 31, AASHTO & Austroads. Overloaded zones and roads were identified and design details of existing pavements were assessed for two scenarios; (1) at actual loading and (2) at legal loading limit.

Results of the preliminary assessment include Percentage of overloaded vehicles, extent of overloading, overloading trends based on the vehicle type, commodity type & travel direction. Further average equivalent standard axle loads (Average ESAL) were calculated and contribution of overloaded and non overloaded vehicles was distinguished. Cumulative number of equivalent standard axles (CNESA for 15 years) for current overloading scenario

and non-overloaded scenario were computed. It was found that the additional cost incurred with pavement construction for current overloaded scenario of each road.

It was concluded that, limits for maximum permissible axle loads should be reviewed in order to make them realistic and enforceable. Further necessity is emerged for immediate effective enforcement against the transporters who violate the stipulated rules and regulations. Huge economic loss due to extensive pavement designs would have been reduced upon effective enforcement and great attention of relevant road agencies on this regard.

Key Words: Vehicle overloading¹, standard legal axel loads limits², effective enforcement³

Development of PCU Factors for Four lane Roads under Sri Lankan Context

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Passenger Car Unit (PCU) or Passenger Car Equivalent (PCE) is a metric used in Transportation Engineering, to assess traffic-flow rate on a road or an intersection. A Passenger Car Equivalent is essentially the impact that a certain mode of transport has on traffic variables compared to a single passenger car.

Roads in Sri Lanka carry heterogeneous traffic, where road space is shared among many traffic modes with different physical dimensions and prevailing loose lane discipline.

PCU factors used in Sri Lanka at present are somewhat older and do not reflect static and dynamic characteristics of modern vehicles, road conditions or driver behavior.

Data collection was done on various four lane road segments. Location for the study is identified based on uniformity of road characteristics in terms of pavement width, shoulder type, etc. There should be no visual obstructions to traffic because of bus stops, road side developments, etc. No intersection or side roads along the road stretch so that there are no changes in the traffic volume over the entire stretch. No signalized intersection for 3km road length.

Traffic volume data was collected using video camera to record vehicles in both directions during peak hours. These video footages were observed and the traffic volumes, speeds and 85% value of road width used by traffic volume were calculated.

Then using modified density method proposed by Tiwari (Tiwari, Fazio, & Pavitravas), the PCU factors were derived.

$$PCU_{xi} = \frac{k_{car}/W_{85car}}{(q_{xi}/u_{xi})/w}$$

The results obtained, showed that there is a variation from homogenous conditions to heterogeneous conditions. These results can be used for traffic volume analysis, capacity calculations, road network planning and design purposes, etc. in Sri Lankan four lanes roads. Further research can be carried out to evaluate PCU factor for 6 lane roads, different highways and intersections.

Keywords: PCU, PCE, Road capacity

Applicability of Rational Formula for Larger Size Catchments in Highway Drainage Design

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The rational formula has been used for the peak flow estimation over 150 years and still remains as the most widely used flood estimation technique. The method is applied assuming that rainfall intensity and storm duration is uniform over the study area; storm duration is equal to the time of concentration of the catchment; and the runoff coefficient is constant during a storm. The assignment of precise upper limit on the catchment area for reliable application of rational method varies from country to country and among literatures. As many literatures indicated, it has been specified that rational method is appropriate for small catchments. However, the definition of small catchment is not consistent across practitioners.

The peak flow estimation of drainage structures would be a vital design consideration in evaluating the capacity adequacy of existing drainage system and to propose extension/new addition to the present drainage system, if it failed to satisfy the anticipated peak flow of a structure.

The hydrologic model determines the runoff that occurs following a particular rainfall event. The primary output from the hydrologic model is quantity, rate and timing of stream flow that results from rainfall events. The Hydrologic Modeling System (HEC-HMS) originally developed by the U.S. Army Corps of Engineers is used to simulate precipitation-runoff processes of dendritic watershed systems. It includes many of the well-known and well-applicable hydrologic methods to simulate rainfall-runoff processes in river basins.

The study focuses on the hydrologic design of cross drainage structures of road sections located in different hydrological and geographical zones in Sri Lanka. The topographic maps of 1:10,000 and 1:50,000 together with google terrain maps were used to identify the respective catchment areas and catchment characteristics. The peak flow corresponds to return periods of 25,50 and 100 years determined by the rational formula and comparison of

these values with the outputs derived through HEC – HMS model were then used for the determination of upper limit of the catchment area where the rational formula can be applied.

Key words: Rational Formula, HEC-HMS

Identification of Accident Black Spots on Roads in Jaffna District and Identification of Possible Root Causes

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Road accidents and the consequential fatalities have become a national tragedy in Sri Lanka. According to the records in the Police Department 37,881 road accidents occurred in the country in 2013 of which 2,363 were fatal. Fatal accidents of 2,436 were also reported in year 2014, out of total 38,481. The number of fatal accidents is rising yearly and the alarming rate warrants some meaningful steps to be taken by the authorities concerned to reduce them now and to create an “accident free road environment” in future. The vehicular traffic in Jaffna peninsula has increased steadily with the restoration of peace in 2009, but on the other hand that leads to increased number of accidents. Road accidents have been increased in the recent past in Jaffna according to Jaffna Teaching Hospital sources. 2,224 accident victims were admitted in Year 2013, but in the year 2009 only 454 accident victims were admitted in Jaffna Teaching Hospital. Meanwhile, the records in Motor Traffic Department, Northern Province indicate the number of vehicles registered in Jaffna district has increased significantly from 45,763 to 101,931 between years 2009 and 2013. Unlike in the past, the fuel prices have also been brought in par with the prevailing prices in rest of the country and the rehabilitated high ways and other main roads in the peninsula has contributed to this increased vehicular traffic. Therefore outcome of this Case Study on accidents in Jaffna District would be a pragmatic approach in the present context.

Main Objectives of this research study are to identify the accident black spots in Jaffna peninsula, and to investigate possible causes for such accidents in order to propose mitigation measures. The road network is depicted in the GIS map of the Jaffna peninsula. Based on the accident data collected from the Police Department, the vulnerable unsafe spots were located in the GIS map of Jaffna Road Net Work. “Kernel Density” was calculated based on the frequency of accidents that was shown in the map by using “Spatial Analysis Tool”, and the high density accident zones are termed as “Accident Black Spots”. There are around fifteen of such accidents intensive junctions and seven accident intensive

sections found within the Case Study Area. It was observed that more than 50 percent of traffic accidents were occurred on roads due to high speeds beyond the specified limits and nearly 30% of drivers were found without driving licenses. It was also found that 35 % of accidents occurred between 18:00 Hours and 20:00 Hours. Out of the fifteen accident intensive junctions, twelve junctions were posing poor visibility. Moreover “Human Behaviors”, “Lack of Street Lighting” and “Poor Geometric Designs at Intersections” are the major causes for these accidents. Therefore awareness on the accidents and causes need to be educated among public, especially to drivers and riders. Geometry of major intersections shall be designed with re-alignment improving the visibility for road users. Cycle lanes shall be constructed with proper lane marking for the use of pedestrians and motorcyclists. In conclusion the implementation of above mentioned mitigation measures would reduce the accident rates and severity of injuries.

Key Words Accident Black Spots, Spatial Analysis, Root Causes for the Accidents

Identification of Accident Causing Factors through Detail Analysis of Road Accident Records in Sri Lanka

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Road traffic accidents in a country are inevitable and these accidents can be caused due to several different factors. They can vary from place to place and time to time and are in no particular order: excessive speed, inattention, fatigue, alcohol/drugs, behavior, vehicle defects, weather, road environment, road design etc.

The study involved review of police accident records in police divisions (detail report prepared by the police officer including accident sketch) to identify the contributing factors that led directly to the accident, through detail analysis of road accidents. Accident records (More than 200 accident records) were obtained from various police divisions of the country particularly in 2013 and 2014 for a selected week. The collection and use of accurate and comprehensive data related to road accident is very important to road safety management. Detail analyses of accidents were conducted by thorough examination of all elements contributing to the accident, resulting in a well-founded explanation of the series of events which occurred based upon the factual data. Its objectives were to determine; what happened? Where the accident occurred? When the accident occurred? Why the accident occurred? and who was involved?. Analysis was based on two distinct phases found as precipitating factor (14 numbers) and contributing factor (54 numbers).

No method of collecting contributory factor data will be perfect. Precipitating and contributory factors were identified is based on the report of police officers collecting data at the scene using their best judgment from evidence gathered after the accident. However, certain information is not reported in the summary sheet prepared for accident reporting. Inevitably some factors may be harder to determine and it is difficult to attribute a single precipitating factor to one participant in the accident.

Human factors are supposed to be the leading contributory factor in any accident analysis and road and environmental factor were found to have a potential effect on road crashes whilst vehicle factor makes the lowest impact (less than 5%) compared to the human factor (nearly 90%) and road and environmental factors (more than 5%). The visibility, geometry,

lane markings, surface condition and street lighting facilities, weather, have a potential influence on the drivers and react in a dynamic driving condition. The interaction of the road and environment is quite complex with driving behavior and performance.

Key words: Traffic accident; contributing factor; precipitating factor

Study of Accidents at Mid-Block Pedestrian Crossings

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All Pedestrian accidents in Sri Lanka in last four years from 2010 to 2013 are 20.89%, 17.65%, 17.53% and 18.51% of total accidents respectively. Among these, pedestrian crossing accidents are 17.89%, 15.20%, 17.85% and 18.17% respectively. In which, mid-block pedestrian crossing accidents are 81.88%, 79.56%, 81.20% and 77.08%. Thus, mid-block pedestrian crossing accidents are more than 75% of the pedestrian crossing accidents. This study focus on identifying factors that have contributed to such high numbers of accidents such as the design of road and vehicle, factors affecting pedestrian crossings visibility and attitude of drivers and pedestrians. The method used to evaluate this is quantitative, which analyses mid-block pedestrian crossing accidents for four hundred kilometers from A03, A12, A09 and A20 roads and interview of hundred drivers and pedestrians.

At presents 40% of the 'A' Class roads in Sri Lanka have wider and asphalted pavements. Maximum allowed speed in these roads is 70 km/hr. Most of the vehicles at present are in good condition than that of in the past. Speed control mechanisms are not strictly followed in Sri Lanka compared to developed countries. Thus, 70% of the interviewed drivers drive more than allowed speed. Therefore, they face difficulties to control speed in Pedestrian crossing. In this research, 100% of the pedestrian crossing constructions are not suitable for handicapped people and 65% haven't proper stud and material. Based on interviewed data, 50% of the drivers and 45% of pedestrians do not use pedestrian crossing properly. Due to the head and dim light elimination, visibility of pedestrian crossing is affected. Some of the vehicles such as three wheelers head light brightness is higher that of other vehicles. This also affects the visibility of pedestrian crossing. 10% sign boards in my research are not constructed in proper location. Visibility of these signboards is affected by obstacles such as trees and poles. 15% pedestrian crossing visibility is affected by sag, crest and super elevation. White colour road markings visibility is higher at night than yellow colour markings used for pedestrian markings.

The results indicate that mid-block pedestrian crossings accidents are influenced by combination of design of road and vehicles, factors affecting visibility of pedestrian crossings and attitude of pedestrian and drivers.

Key Words: Accidents, pedestrians, mid-block crossings

Study on Work Zone Management in Highway Rehabilitation Projects in Urban Areas

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The safe and efficient flow of traffic through work zones is a major concern to transportation officials (government authorities, contractors), the public, businesses, and road users. Key areas for performance measures of work zones include delay/queues, user costs, exposure, safety, and public perception.

This paper presents an investigation on current work-zone practices in Highway rehabilitation projects around Colombo and sub-urbs. The prevailing guidelines adopted in Sri Lanka were compared with the guidelines and manuals of USA, Canada and Ireland for the major differences. Five (05) road rehabilitation projects have been identified out of which four (04) currently being ongoing, and the remainder is being recently completed. Separate questionnaire surveys were carried out on Road Users, Nearby Residents, and Contractor's representatives to identify the major difficulties and inconveniences borne by the road users and residents and the probable reasons. The major issues identified are; Dust and Noise pollution, Lack of advanced signage, Increment in travel time, Access and utility disturbances, and Drainage issues. The root causes identified are; Lack of focus on guidelines, Non availability of experienced and qualified officers, Lack of space, Higher traffic volume throughout the day, and Political, Police and public interferences. With the reference with the guidelines of other countries, some alterations to the prevailing RDA guidelines are suggested at the conclusion.

Key words: Work-zone Management, Traffic Management, Road User Safety

Modeling Transport and Land Use in Micro-Level (A Case Study of Colombo DS Division, Sri Lanka)

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In transport planning, two major approaches can be seen: namely, micro-level (local, intra-city) and macro-level (regional, inter-city) planning. The different nature of the micro-level and macro-level travel behavior is well acknowledged in the literature. Therefore, to make informed transportation planning decisions on micro level, planners and engineers have to be able to predict travel characteristics and usage of transport services under different socio-economic scenarios, transport services and land use configurations comparing macro-level travel demand estimations (Litman, 2008). Therefore, separate transport and land models also need to be prepared to micro-levels as well.

In micro-modeling aspect, absorbing the minor level data is a difficult task. The task becomes harder in areas where a complex interaction of transport and land use is visible. Further, micro models needs to incorporate the macro-models' outputs to a certain extent. Therefore, the modeling process, which comprises the collection of data, preparation of maps and databases, development of algorithms becomes more multifaceted.

This paper explains the modeling process involved in an attempt made for the development of micro-level transport and land use model for the Colombo DS Division. The Colombo DS Division has the most complex interaction between transport and land use in the western region as well as in the whole country and further, this model has been developed using the activity based modeling process in the micro-simulation approach. Here, household interview travel surveys, railway passenger origin-destination surveys and GIS analysis were primary used for supporting the modeling process. Moreover, matters and questions encountered while developing the model were also included in the paper.

Key words: Transport and Land Use, Modeling, Micro-Level, Interaction

PARK & RIDE: Factors Affecting to the Public Acceptance

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Colombo, the Capital of Sri Lanka, being the hub of commercial activities with the Port and other key business establishments, the vehicle fleet entering the city has increased steadily over the past decade. As a result the traffic congestion in Colombo has increased now to a higher level that is too intense within the city limits causing uneasy in travelling and inconvenience to road users. Further it was revealed that new registrations of the motor vehicles have been on the significant rise during the recent past and many of them added to the Colombo traffic fleet. [http://www.sundaytimes.lk/120212/News/nws_18.html] On the other hand traveling speed has reduced during peak hours and thus travelers wasting time on the roads, burning more fuel, as the number of vehicles on the roads keep increasing.

Park and Ride is a concept used in developed countries in which the car travelers who enter the city center (or congestion area) park the cars in the designated peripheral zone and then reach the destination by using public transport. This model believed to be helpful to reduce the car traffic flow into the city center, relieve the traffic density and perfect the urban traffic structure.

“City Liner” was the first Park and Ride operation in Sri Lankan context implemented in 2009. It was proved to be unsuccessful due to various reasons. The operation was then reviewed and shortcomings were analyzed through a series of research and development and the idea had emerged with Park and Ride operation integrated with a Mass Rapid Transit (MRT) system for Colombo city.

The aim of this research paper is to analyze the major causes that contribute to a sustainable Park and Ride operation with integrated Mass Rapid Transit for the Colombo metropolitan region. In order to analyze the relationship between the public perceptive factors and the Park and Ride behavior intent, it is necessary to understand the perception levels of the related influencing factors of travelers through surveys. The study consists with distribution of a questionnaire to travelers and the feed-back from them, who travel to the Colombo city at least once a week. The survey was conducted both online and manual basis.

The Park & Ride system will operate along with a MRT concept but that would not solely address the car commuters. Hence over the phone interviews and questionnaires were focused on all categories of commuters who travel to Colombo. In addition the questionnaire focused on user preferences, drawbacks issues of existing system and expectations of proposed system.

In the analysis stage, acceptability of Park and Ride Scheme and expectations on improvements and characteristics were studied through frequencies, percentages, and other basic statistical methods to outline a generalized profile of daily travelers to Colombo city based on daily travelers personal travel behaviour. Meanwhile Chi-square tests were also performed to obtain a deeper understanding of peoples' personal background, Traveling behaviour and Park and Ride acceptability. However, if the assumption of Chi-squared test was found not to be satisfied the Fisher's exact test was used.

According to the survey results there were 112 daily travelers out of 136 samples collected. In general, for all modes of transport, daily travelers were highly concerned about the travel time to Colombo city. Meanwhile public vehicle users were unhappy with the safety, comfort and reliability of their service whilst private vehicle users were struggling to find suitable parking slots in the City.

According to the result of statistical analysis, daily traveler's income level, vehicle ownership, age, and education level play a vital role to the acceptability of new Park and Ride Scheme. But present transport conditions (mode of transport, travel time, travel distance and entering time to Colombo city) don't affect much to the user perception for the Park & Ride. New scheme must be designed to cater these major factors.

As per the survey results, it is evident that the daily travelers are expecting high assurance of passenger safety, parking vehicle safety and reliability of service to accept new scheme. Further, it is revealed that they are much concerned about the cleanness, operating frequency and availability of cross-city transit but not the seating facilities, terminals/parking sites facilities and cost of service.

Findings of this research about the user's perceptions can be helpful to design a successful and sustainable Park and Ride scheme to the suburb of Colombo city.

Key words: Park and Ride, Daily Travelers, Chi-squared test, Fisher's exact test, SPSS

Explore the Possibilities of Reducing Train Delays between Colombo Fort and Maradana

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Sri Lanka Railways (SLR) is operating around 300 passenger train movements daily across its 1400 Km rail network. About 90% of train movements out of this have Maradana or Colombo as the destination or the starting point. It further leads to a figure that around 50 trains which amount to more than 30% of the Colombo reaching train service is reaching either Colombo Fort or Maradana daily within the morning peak time. All these train movements are using the Colombo – Maradana block section which comprises of only four rail tracks, hence causing a reasonable delay for the morning peak hour train service.

Delay in this particular section is commonly identified as caused by the lack of infrastructure which includes less number of Platforms, inappropriately arranged service feeders (depots) and low flexibility in the signaling system. In addition to this the overlap operation between Colombo and Maradana, that is by always keeping the further station as the destination point has also created additional train movements which leads the situation to an even worse.

Objective of this research is to find out the root cause for the delay in the Colombo Fort – Maradana section and explore the possibilities of reducing train delays. In this view, the delay portion pertaining to this section is quantified through a survey and it confirms the worthiness of the research. It was then continued to check the actual requirement of continuing the overlap operation and in results, sufficient evidence found for a service restriction. Actual line and platform utilization at present were calculated to find out whether any alterations are required to the systems and operational practices. Train feeding arrangements are also studied for suggesting modifications for the practices in order to catch up the delays. Mainly the issues in reducing the number of train movements in the section and reshuffling the feeding arrangements to achieve this target are addressed in this in this research.

Key words: travel time delay, passenger train movement

Implementing Cycle Lane Facilities in Eastern Province in a Sustainable Manner

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Commuting by bicycle is a sustainable transport strategy and has advantages over other modes of transport, both for the commuter and for society. The social cohesion that cycling can bring through recreational opportunities also promotes wellbeing. A diverse range of people choose to cycle, including school-aged children, regular commuters, weekend recreational cyclists and sporting cyclists. Cycling does not emit greenhouse gas, cause air or water pollution or rely on fossil fuels.

Road Development Authority (RDA) has taken a policy decision to incorporate a separate lane as cycle lane to encourage the non-motorized transport of this country. But it is observed that these bicycle lanes are not used for its intended purpose. Especially in Colombo area, there are very few bicyclists on the roads and bicycle lanes are always empty. So, it is seen that the bicycle lanes are used to overtake vehicles in wrong side, for illegal roadside parking etc. While the situation is such, Road Development Authority is planning to extend its new policy to the areas where there are higher numbers of cycle users.

Trincomalee is one of the districts in Eastern province having higher numbers of cycle users and the terrain condition also well suited for cycling. More than 50% of the road users are identified as cycle users and almost 60% of car, three wheel & motorcycle trips are less than 4 kms, a distance that is easily cycled in less than 20 minutes. These data were collected during field observation. Although cycling is an option for many commuters, a considerable number of them choose to use other forms of transport. Especially school children & office staffs, they use three wheel or motorbike as transport mode.

In order to underpin policies that promote commuting by bicycle, this research investigates the determinants for commuting to work, school or their other purposes and studies about the public opinion in existing road conditions to use bicycles and their concern in cycling facilities to be provided in the future road developments. A questionnaire survey was conducted among 200 road users in different part of Trincomalee district. Accordingly, it was

understood that existing road conditions such as non availability of continue route network dedicated for Cyclists, mixed traffic without proper safety measures and parking facilities discouraged the commuters to use bicycle as their transport mode and commuters in Trincomalee district are really willing to use cycle as a sustainable transport mode for the short trips up to 4kms, if the cycle lane facilities are provided with safety and comfort.

Key words: Cycling, Bicycle lanes, Non-Motorized transport

Development of a fares structure for the three wheelers

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Three wheelers have a significant contribution towards the road transportation as a popular para-transit mode in the country. Three wheeler transports is highly unregulated at present and is mainly criticized for its “unfair” fares structure. Many three-wheeler users feel that they are often exploited by drivers who over-state distance and charge higher fares. It is also observed that the fares are usually inconsistent and may vary from operator to operator in addition to the distance travelled and journey time. Further three wheeler meters are calibrated arbitrarily by operators.

This study is an attempt to explore the cost recovery in three three-wheeler transport and thereby to develop a systematic fare structure. Absence of a proper fare structure for three wheelers causes inconvenience to both operators and passengers. Therefore development of a fares structure would lead to minimization of imbalances and inefficiency in the service under prevailing fares structures. At present, passengers are charged with a minimum fee of Rs. 50 up to the first kilometer and henceforth each kilometer is charged at a rate of Rs. 40 per km. There is no systematic procedure to charge for two way trips and waiting time and there is no systematic procedure available at present for the revision of fares with fluctuation of major cost components. In order to revise three-wheeler fares with frequently fluctuating input price levels, such as fuel price, percentage contribution of each cost component in the total operational cost (Rs/km) were calculated. A reasonable fare structure is proposed considering share of each cost component with profit mark up.

First step is identifying variants of three wheeler operation and the second step is identifying different cost components. Three wheeler types are major variant and ten different cost components have identified such as Fuel cost, Operator’s salary, Service cost, Tires cost, Tube cost , Repairs and maintenance cost, Annual overheads ,Depreciation , Interest on capital and Risk on enterprise (for profit mark up).

After quantifying identified cost components Questionnaire survey was conducted. The cost of operating a three wheeler over one km distance was computed based on the information collected. Each cost component is quantified for each three wheeler type and then the actual

distribution of each cost component was studied. Finally operational cost was calculated using the average value of each component and each cost component was calculated on the basis of rupees per kilometer.

A fares structure should be transparent, simple and understandable by each party to be effective and fares structure is the instrument to recover cost and it acts as the communicator between operator and the passenger of the transport service. After considering the present operational cost and cost recovery of a three wheeler including the profit markup a new fares structure is proposed for the convenience of both operators and passengers.

Key Words: fares structures, para-transit mode

Evaluating the Impacts of Coordinated Traffic Signal Systems

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Traffic congestion due to ever-increasing number of vehicles and pedestrians is one of the major problems that need to be tackled especially in metropolitan areas. Numerous methods are available to reduce delays and financial losses as well as environmental problems caused by road traffic in major cities. Signalizing is one of the main methods to control traffic at intersections. Most of the signalized junctions Sri Lanka are isolated fixed-cycle type.

Signal coordination is considered as one of the cost effective and successful strategies to reduce congestion problems worldwide. When traffic signals work together (or are coordinated), they provide a greater opportunity for motorists to travel through adjacent traffic signals without making unnecessary stops. This reduces fuel use, saves motorists travel time, diminishes wear and tear on vehicles, and cuts vehicular emissions.

Sri Lankan road development and management agencies are in their planning stage to implement this system for signalized intersections. However, little has been done to quantify the benefits that can be obtained from coordinated traffic signal systems. Although it is important to have quantified measure of the benefits compared to prevailing system, such measure is not yet available in Sri Lankan context. Therefore, objective of this research is to evaluate the benefits from Traffic signal coordination in reducing delay and reducing travel time to vehicles.

As a case study, closely spaced three signalized junctions are selected at for the analysis. The junctions selected are Park Road Junction, Narahenpita Junction and Kirimandala Mawatha Junction on Baseline Road. SIDRA, Signalized (and unsignalized) Intersection Design and Research Aid is used to generate the timing plans for each junction. Each junction is analyzed considering as a non-coordinated isolated junction and also as an individual junction of a coordinated system. Travel time, delay, effective stop rate and proportion queued are identified as important parameters to evaluate the benefit/impact of the coordinated system. Data related to above parameters taken from the SIDRA output is used to calculate the travel time and delay of the coordinated system and in the isolated system separately. Using the evaluation results, travel time saving, reduction of delay and

reduction of stop rate are presented as percentages, as quantified measures of the benefits of the signal coordination. Limitations of signal coordination such as time for pedestrians, non-uniformity of intersections are identified and evaluated to take a quantified measure of the negative impacts of the system.

Key words: traffic signal systems, intersection



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