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Abstracts

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Dr. Beshan Kulapala is the Director of Vega Technologies and chargeNET Pvt Ltd, and a Research Scientist at CodeGen International, Sri Lanka. He is also the Director of Vega Innovations and ChargeNET Pvt Ltd. In this role Dr. Kulapala is leading Vega's and CodeGen's efforts to expand in to electronic and mechatronic product development.

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1. Traffic Engineering

An Observation Study on Un-signalized Marked Midblock Crossings in Colombo Suburban

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Abstract

A pedestrian crossing is a place designated for pedestrians to cross a road where they can cross safely across the flow of vehicular traffic. It also makes the pedestrians easy to be spotted by motorists, by keeping them together, and Mid-block pedestrian crossings are marked crosswalks placed between intersections. Before crossing, pedestrians check the traffic in right side, left side, then again, the right side. Drivers must slow down and stop when a pedestrian steps onto a marked crossing, giving way to him/her. Crossings with poor visibility have zigzag white lines marked in the middle of the road to warn drivers. The aim of this study is to investigate the pedestrian road crossing behaviour at uncontrolled midblock locations in Sri Lanka which operate under a mixed traffic condition.

It was identified that all the unsignalized midblock crossings from Malabe to Kaduwela in B263 roadway of Sri Lanka operate under a mixed different traffic flow. The data on the gender and approximate age of the pedestrian, crossing pattern, mobile phone usage of pedestrians while crossing, the fact whether a weight is carried or not, and the crossing's geometry, were collected. All these data were collected from Malabe end towards Kaduwela end, using a video survey method, covering all the pedestrian crossings. Each and every video footage was recorded during 8:00 am to 9:00 am in weekdays during the months of July and August, 2017. Each and every characteristic of crossing and pedestrians were compared using the statistical inference theory.

The overall average waiting time at the road segment considered was 6.54 seconds. When investing the waiting time by age category, it was observed that waiting time of children is lower than other categories. Elders opposing to children had more waiting time than others. This showed that middle aged people were paying more attention when crossing the road than children or elderly people. Therefore, children need to be given more attention. Most people were willing to cross the road as groups. It may be due to safety reasons. When considering the crossing speed, results showed that crossing speed of children was higher than that of adults. Statistically significant speed differences between males and females were also observed. When a person individually crossed the road, the crossing speed was higher than when crossing as a pair or a group. Straight crosswalks are designed to minimize the pedestrians' crossing distance and pedestrians are expected to walk straight. However, about 48% of pedestrians did not walk straight on the crossing.

This study revealed pedestrian characteristics and differences between pedestrian groups at the uncontrolled midblock locations in Colombo suburban. The results of this study can be used for traffic safety improvement programs. For an example, advanced warning messages and higher slight distance could be suggested in the crosswalks where more children are expected, as children did not pay much attention in crossings. Awareness and education programs could be prepared, encouraging pedestrians to walk straight when crossing as 48% did not walk straight.

Keywords: Pedestrian, Mid-block pedestrian crossing

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Motorcycle Accident and its Severity Analysis in Ampara District

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Abstract

Nearly 30% of the total traffic flow on most highways in Sri Lanka comprises of motorcycles. It is a popular mode of transport of middle income families, as well as the youth, due to the lower cost in transport and being readily available. In Ampara district, the motorcycle population keeps on increasing as the officers who works within and closer to the district, return home the same day. However, the rapid increase in motorcycles caused accidents and fatalities to increase as well. This caused motorcycle riders to be the most vulnerable road users on Sri Lankan roads as they are left unprotected in the case of a crash.

The objective of this study is to identify the risk factors involved, and to investigate the rate of the usage of motorcycle helmets. The representative sample of the motorcycles was observed using the mobile observation method in rural roads and through periodical observation, carried on in national roads and the township area of Ampara district. The accident data were obtained from police headquarters and the Ampara divisional traffic police, while injury severity data were obtained from the base hospitals of Kalmunai & Akkaraipattu, general hospital-Ampara and Ashraff memorial hospital.

In 2013 motorcycles were responsible for 33% of total accidents, by 2017 it had increased up to 45%. In Ampara district it increased up to 61% in 2017 from 54% in 2016. It can be observed that in Ampara district the cases and crashes related to motorcycle accidents keep on increasing as 31.95% was recorded in 2015 while in 2017 it had increased up to 32.15%. According to the observational data, the average helmet usage rate of the rider & pillion was 95% in national roads where they travel on A & B class roads thus proved they were more likely to wear safety helmets, on the other hand, the usage rate was 15% among riders and pillion in rural roads like C, D & E class roads. Children sitting on the tank with no helmets were observed. The riders & pillions engaged with the town area were observed with helmets in the rural area. As per the hospital data, it was revealed that around 70% of those admitted to the hospital were victims of motorcycle accidents, in which 45% were youngsters. The treatment days were averagely 265 patient-days and in which 75 cases were just admitted and treated within one day.

One major limitation in the availability of accident data is that the police accident data does not provide sufficient information on pre-crash factors contributing to accidents. The study shows that young riders are at a great risk of meeting accidents. These provide useful insights to risk factors related to the safety of motorcycle users and effective countermeasures that could be implemented to reduce motorcycle related accidents.

Key Words: Road safety, motorcycles, accident analysis, helmet use

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Development of a Personal Vehicle Type Choice Model for Sri Lanka

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Abstract

Vehicle ownership is a key determination factor in any country's economy. In the Sri Lankan context, it has been identified that vehicle ownership rate has expressively increased over the last decade. Apparently, the road congestion in urban and suburban areas also have increased significantly. As controlling measures of reducing new vehicle imports, and promoting environmental friendly vehicles, the government has introduced new taxes as well as some increments in the tax level on private passenger vehicles.

The overarching object of the research was to examine how a new vehicle choice may vary in the context of household socio – economic characteristics (eg. income level, number of households, age of the user, gender of the user etc), and the regime of new pricing reforms for annual and variable charging on the vehicle price itself (eg. fuel, insurance and other operational aspects and change of user requirements such as enhancing the vehicle seating capacity, shifting vehicle operating method etc). The respondents participating in the survey, 'household choice of a new personal vehicle, must have purchased a new vehicle, as the survey is designed accordingly.

This paper examines the development of a type of vehicle ownership model using a sample of people living in the Western Province of Sri Lanka. A sample survey is being conducted in the Western Region to collect household data in 2013. ALOGIT software is used to obtain the results of this research. This research considers several potential determinants of vehicle choice, including socio-demographic status.

This study primarily attempts to identify how to recognize the family's monthly income, age, occupation, social status, and number of drivers in the family, and their influence on the ownership of the car. The main objective of this research is to help planners and traffic designers to solve the planning and traffic problems in the Western Region. In addition, the result of this research is to assist the Sri Lankan government in imposing the required taxes, and providing as much funding as possible to maximize a sustainable and environmentally friendly transportation system in Sri Lanka.

Keywords: Choice Model, Vehicle Ownership, Logit Model, ALOGIT, Household

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Development of Service Quality Index for Sustainable Bus Transport

A.H.S. Sharic [1] and J.M.S.J. Bandara [2]

Abstract

Sustainable transport is essential for achieving most, if not all, of the proposed Sustainable Development Goals (SDGs). Improvement of public transport service quality is one of the best alternatives to achieve sustainable transport goals in any part of the world. Transportation agencies can better integrate the concepts of sustainability into their planning, programming, and project development activities through performance measures. The purpose of this paper is to propose a service quality index for sustainable bus transport (SQISBT) which would enable to see how a country or region is progressing towards sustainability in transport.

Reliability, convenience, comfort, safety, security and environmental standards have been identified as the main domains of service quality, in public transport. The relevant performance indicators found were waiting time, travel time, walking time, in-bus environment and station environment. Waiting time was used to reflect the domain of punctuality and reliability. Both waiting time and walking time were the indicators to reflect convenience. Comfort, safety, security and environmental standards were reflected by both in-bus environment and station environment.

Waiting time refers to the time spent at a bus stop/terminal to get on a bus. Average excess waiting time (AEWT) is proposed as an indicator. AEWT is estimated as the difference between the average of actual waiting time, and scheduled waiting time. Schedules of all the bus routes in operation are to be collected, and a weighted average of a scheduled headway for bus trips are to be calculated. The schedule adherence can be monitored either using Geographical Positioning System (GPS) or bus dispatchers' records. Average scheduled waiting time is taken as half of the average headway for frequent bus service routes which have one bus at least every twelve minutes. Decreasing score is always positive. Walking time refers to the time taken for the passengers to get access to a bus from their trip origins and the time taken to reach their trip destinations on foot, after taking the bus. This can be measured by the proportion of households within an acceptable (e.g. 500 meters) walking distance to bus stops/terminals from their trip origins. Buffer zones are to be drawn for all the bus stops/terminals and the proportion of population can be averaged for a certain district. Increasing score is always positive and the score would lie between 0 to 100 percent. The travel time means the time taken in bus travel. The average travel time per unit distance will be found out by the GPS or using published schedules, if no vehicle tracking is available for the certain locations. The weighted average travel time based on number of buses operated, is calculated, taking into consideration different routes and different times. Here, the decreasing score is always positive. In-bus environment refers to the level of comfort expected by the passengers inside bus. This can indirectly be measured by the age of the buses. Year of manufacture of buses and number of years in operation are to be collected from all the buses in an area. The weighted average value will

be used as an indicator. The decreasing score is always positive. Station environment refers to the needs and expectations of the passengers at the station or halt. This can be measured by the perception on the levels of which these needs are met. Theory of Maslow's Hierarchy of Needs was used to derive possible levels of passenger needs inside a bus while traveling. Availability of toilets, washroom, availability of seats and shelters, availability of television and entertainment, availability of categories of counters and availability of one room with all these facilities for a passenger to himself/herself are the identified indicators for measuring the perception on station environment that represent the elements of Maslow Hierarchy of Needs such as physiological, safety, love and belonging, esteem and self-actualization respectively. The score will be 1 to 5 for the respective needs. The perception should be collected from a sample of passengers representing various trip purpose, gender, level of income etc.

It is proposed to normalize the above scores using weightages for these service quality parameters obtained in a previous study (Sharic,2016) and the following equation, where Z is the normalized indicator value, Xmin is the 'worst' value of the indicator in actual units, whereas Xmax is the 'best' value. Xi, c are the values to be received for the identified indicators for a certain city.

$$Zi,c=Xi,c-(Xmin,i)\ Xmax,i-(Xmin,i)*100$$

Likewise the normalized values for the indicators will be found notated by Zwalking time, Zwaiting time, Ztravel time, Zin=bus environment and Zstation environment respectively. Then the sustainable bus transport service quality index (SBTSQI) for the certain city/village would be found by the following equation.

$$SQISBT=5Zwalking\ time*Zwaiting\ time*Ztravel\ time*Zin\ bus\ environment*Zstation\ environment$$

Keywords: Sustainable Bus Transport Service Quality Index, Performance Measurement, Sustainable Transport

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2. Highway Engineering

Modified 3 Parameter Model Incorporating Particle Shape, Texture and Vibration to Predict Packing Density of Binary Particulate Mixtures

H.A.C.K. Hettiarachchi [1], W. K. Mampearachchi [2]

Abstract

Particle packing density is one of the most important parameters in materials engineering. Ultra-high-performance concrete (UHPC), lightweight concrete, porous concrete, advanced ceramic materials, porous asphalt, filter materials are some of the major applications based on the packing density. Determination of packing density of a particulate mixture is a complicated and a laborious process. Hence, many researchers investigated the behaviour of particulate systems in a confined space in order to develop mathematical relationships to predict particle packing density. Several particle packing models have been developed so far such as Toufar model (Toufar, Born, & Klose, 1976), Compressible packing model (CPM) (Sedran & De Larrard, 1999) , 3-Parameter model (Kwan, Chan, & Wong, 2013), Linear packing density model (Stovall, De Larrard, & Buil, 1986) etc. However, due to the complexity of the particulate systems, many of these models are based on several basic assumptions; spherical shape, random loose packing method, smooth particles etc. A study carried out by Hettiarachchi and Mampearachchi (2017) revealed that the packing models can be effectively utilized to improve concrete mixtures for Interlocking concrete block pavers (ICBP). Nevertheless, the study also revealed that the packing models do not accurately predict the packing densities and 3-parameter model predictions are showing a close relationship with the actual packing densities.

Hence, the objective of this study was to modify the 3-parameter model incorporating particle shape, surface texture and vibration frequency. A vibration table and a vibration hammer were used to apply vibration to the particles. Spherical glass beads were quoted with sand dust of various sizes to achieve different surface textures. Aggregates of various shape factors were taken to investigate the effect of shape. Each effect was isolated, and the packing density of the mixtures were measured varying the large particle volumetric fraction. Effect of the size ratio was also investigated by varying the size of the two particle classes of the mixture.

The variation of packing density with vibration, shape and texture were analysed and the combined effect was modeled using regression analysis. The 3-parameter model was then modified using back calculation techniques to develop relationships with each effect. The modified 3-parameter model was validated using over 300 experimental data. The modified 3-parameter model found to be in correlation with the experimental data with a correlation coefficient of 0.95. In conclusion, the developed model will be able to predict the packing density of complex mixtures with high accuracy to provide more realistic outcomes which will benefit the materials engineering greatly.

Key words: Particle packing models, Packing density, Vibration, Shape, Surface texture, 3- parameter model

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The Effect of Water to Cement (W/C) Ratio on Workability of Internal Curing Concrete in the Development of High Strength Concrete with Required Workability and Cement Content (ICBP)

M.M.H. W Bandra[1], T. Anojan[2], and W. K. Mampearachchi[3]

Abstract

The escalating demand for highways and other related structure development of any country may lead to the introduction of fast and sustainable construction techniques and materials. Internal curing is an emerging technology in the cement concrete industry, and will outperform in the road construction industry than conventional curing methods, due to it being convenient to use under harsh envirpoonmental conditions.

Generally, after the placement of concrete pavements, concrete is subjected to evaporation and hydration, which causes a significant loss of moisture. That will reduce the relative humidity of concrete and increase the internal stresses. This may form micro cracks throughout the concrete, subsequently, cementitious particles may not hydrate properly. As a result of that, the durability and strength of concrete will reduce significantly. Normally, external curing methods such as immersion, ponding, fogging and wet covering are used to provide excess water, to avoid the aforementioned problems. However, those external curing methods will be effective only up to a certain thickness from the concrete surface while internal curing provides water throughout concrete using prewetted aggregates. The water will distribute uniformly throughout the concrete and reduce the humidity drop and hydrate the cement paste. The main problem in internal curing concrete is that the water added through the aggregates will affect the water cement ratio and reduce the compressive strength.

This study was conducted to investigate the effect of the water cement ratio of internal curing concrete on compressive strength and workability. Concrete is cured internally by providing the required amount of water using pre wetted aggregates. These pre wetted aggregate will spread all over the concrete and help to cure the cementitious matters uniformly. Here, pre wetted burnt clay chips (internal curing concrete aggregates) are used as water reservoirs which will provide water for cement hydration. Thus, additional water added through the fine aggregates will increase the expected workability. Results are obtained by adjusting the water content and then workability, and compressive strength values are compared. Results showed that water/cement ratio reduces, and compressive strength increases with ICCA for all grades of concrete, tested in the study.

Key Words: (ICCA) internal curing concrete aggregates

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Application of Level of Service Facilities for Sidewalk Assessment

Chamali Hewawasam[1], Shamain Saparamadu[2]

Abstract

The model share of pedestrians, in developing cities has the tendency of being very high, as opposed to developed cities. For example, between 25-50% of trips in major Indian cities, and about 50% of all trips in major African cities, are made entirely on foot. However, though such is the case, in majority of developing cities, pedestrian infrastructure, amenities, and services are often neglected in municipal planning and budgets (Fang, 2005). Improved walking facilities not only will generate new pedestrian flows, but will also increase the comfort of the current walking population. Consequently, it will result in an increase in the public transit usage and a decrease in private vehicle trips. Accordingly, a need has arisen to measure the performance of pedestrian facilities for improvements and priority setting. Traditionally, pedestrian facility operations were evaluated on the basis of the level of-service (LOS) concept. Therefore, the LOS methods used in the assessment of pedestrian facilities are to be examined in detail, to identify what is to be added or improved in the South Asian context.

In response, this paper aims to study the current status of the sidewalks in Sri Lankan urban areas for the estimation of the sidewalk level of service. It reveals that the current level of services methodologies are lacking, as they address western conditions rather than the prevailing conditions in Sri Lanka. So, this study intended a review of existing methodologies by evaluating the existing sidewalks, and a combination of most appropriate factors for Sri Lankan conditions were selected.

As for the review of existing methodologies, recent methodologies that developed at an international level have been selected. They are included in Table1. This study is at the initial stage and is to be developed as an “all-inclusive pedestrian facilities Level of Services methodology for South Asian Countries”.

Key words: Concrete mix design, Interlocking Concrete paving blocks, Sustainable concrete

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Study on Soil Stabilization Using Natural Rubber Latex for Road Construction in Sri Lanka

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Abstract

Soil stabilization technology is extremely important to the road construction industry. In order to utilize the local soil resources effectively, soil stabilization can be adopted in the construction of the roads. However, the traditional soil stabilization techniques cannot be applied for all types of soil, as environmental impacts are considerably high. Therefore, an investigation was carried out to use natural rubber latex as a stabilizer and its ability to increase the bearing capacity of the soil, which is an indicator of the strength characteristics. This research focuses on the effects of the treatment on the physical properties of soil. For this research, Clayey Sand (SC) type of soil from a highway construction site was used. Preserved field latex was selected due to its low cost, low viscosity and non-toxicity when compared to other types of latexes. Further, air curing and oven dry curing methodologies were adopted for the soil-latex mixed samples during the CBR testing. Additionally, oven dry curing samples were analysed in soaking and non-soaking conditions in this research. In the soaking condition, the California Bearing Ratio (CBR) of the soil reduced drastically in comparison to the non-soaking condition, but it was higher than the CBR of normal soil at 3% of dry rubber content. Optimal percentage of latex to be used was selected by adding 2%, 3%, 4% and 5% of dry rubber content to the soil. The stabilized soil yielded the highest maximum dry density and CBR values for 3% of the dry rubber content. With the increase of latex more than 3%, the maximum dry density and CBR values showed a reduction because the increase in latex content leads to a reduction in the bond between soil particles. Validation was carried out using hypothesis testing, and statistics analysis was used to estimate the improvement rate. Even though there are benefits in this research method, few limitations exist in the application to the road construction in Sri Lanka.

Key words: Soil stabilization, Natural rubber latex, Road construction, Soaking, Curing method

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Performance Evaluation of Waste Fillers Admixed Asphalt Mixes

Jayvant Choudhary[1], Brind Kumar[2], Ankit Gupta[3]

Abstract

Ever increasing growth of various sectors has led to the continuous usage of natural resources and the generation of huge quantities of solid waste. Currently, world cities produce around 1.3 billion tonnes of solid wastes annually, which is expected to increase to 2.2 billion tonnes by 2025. Besides environmental concerns, inflation in the cost of virgin material and the gradually declining amount of natural resources have obliged the decision-makers to utilize waste/secondary materials as replacements to conventional construction materials. Global pavement network primarily consists of flexible pavements, which utilize asphalt mixes as their base and surface courses. Mineral filler is an integral part of asphalt mixes which influence mix's cost and performance against various distresses. This study investigates the suitability of seven different waste materials as fillers in place of conventional material in the asphalt concrete mix. Waste materials under consideration are; glass powder (GP), bauxite residue or red mud (RM), brick dust (BD), copper tailings (CT), dimension limestone slurry dust (LD), carbide lime (CL) and rice straw ash (RSA). Whereas, conventional dolomite stone dust was adopted as a conventional filler.

Detailed physical, geometrical and chemical characterization of fillers was carried out. Physical characterization parameters such as specific gravity, plasticity index, particle size distribution and fractional void content were assessed using a specific gravity test, plasticity index test, particle size analysis, and German filler test value, respectively. Harmful clay content was determined as per methylene blue value test. Morphological and mineralogical analysis were performed using Scanning electron microscope (SEM) and X-Ray Diffraction (XRD) techniques. Apart from these, affinity of fillers towards asphalt was assessed using the pH value and hydrophilic coefficient tests. Thereafter asphalt concrete mixes containing waste fillers and stone dust were prepared, and their Optimum Asphalt Contents (OAC) were determined. The stability, flow, volumetric and performance parameters such as the Marshall quotient (MQ) and indirect tensile strength (ITS), were evaluated to compare the performance of mixes against rutting and cracking, respectively. The resistance of the prepared mixes against moisture damage was evaluated using retained Marshall Stability ratio, active and passive adhesions test values.

At their optimum bitumen contents, all waste modified mixes delivered satisfactory mechanical and volumetric performances as demanded by paving specifications. However, the performance of each waste filler modified mixes was found to be largely influenced by the physical and chemical characteristics of the filler incorporated in it. Fillers like limestone dust and copper tailings formed economical mixes with lower OBC which was attributed to the bitumen extender action and lower porosity of these fillers, respectively. Mixes with finer fillers (red mud and limestone dust) displayed superior stiffness and cracking resistance. Similarly, carbide lime and limestone dust admixed mixes have

displayed superior adhesion and moisture resistance due to the predominance of calcium based water insoluble minerals like calcite and portlandite in their composition which ensure superior aggregate bitumen adhesion.

Keywords: Filler, Waste materials, Asphalt mixes, Sustainability, Waste management, Moisture resistance.

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Improvement of aggregate packing model of Interlocking Concrete Block Pavement (ICBP) mixture using Fly Ash

I.P.Batuwita[1], W.K.Mampearchchi[2]

Abstract

Use of concrete paver blocks is becoming increasingly popular. They are used for paving approaches, paths and parking areas, including their application in pre-engineered buildings and pavements. Interlocking Concrete Block Pavement (ICBP) has been extensively used in a number of countries for quite some time as a specialized problem-solving technique, to provide pavements in areas where conventional types of construction are less durable due to many operational and environmental constraints.

This research is conducted in order to improve aggregate packing model of ICBP by using Fly ash. In Sri Lanka, Lak Vijaya Coal Power Station at Norocholai, Puttalam generates large amount of fly ash per day as a by-product. It was considered a waste & an environmental hazard, thus its use was limited. Within this research, this waste & hazardous fly ash is used as a filler material in paving block mixture to optimize the packing of aggregate. These fly ash samples & control samples were tested for compressive strength, water absorption and Scanning Electron Microscope Analysis. Experimental results showed that 23 and 21 percent of cement can be replaced by Fly Ash in Grade 15 & 20 mixtures respectively. Fly ash has reduced the cement needed for ICBP mixtures. Optimization of packing of aggregate is the process of determining the most suitable aggregate particle size and distribution, to minimize the voids content of an aggregate mix. An optimized aggregate mix will have a lesser amount of voids which need to be filled with cement paste. Further, fly ash has improved the workability of the mixture due to the special nature of the particle. The use of fly ash in concrete paver blocks has reduced the cement content, and heat of hydration, leading to better economy and durability.

It will also help safeguard the environment from the adverse effects of CO2 emissions from the cement industry, and provide a solution for the disposal issue of fly ash produced by thermal power plants.

Keywords: Fly Ash, Interlocking Concrete Block Pavement, packing of aggregate, Optimization, Compressive Strength, Scanning Electron Microscope.

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Develop Material Systems for Next-Generation Infrastructure

Asanka De Silva[1], Prof. Sanjaya Senadeera[2]

Abstract

The demand for construction materials continues to rise as the infrastructure development spreads. There is a looming crisis for raw materials used in construction running low due to this high demand, and the material-intensive nature of the current construction practices adds to this. The use of novel materials and their potential applications are no longer limited to highly technical areas. The computer power developing exponentially adds another dimension to material engineering which makes it possible to develop and characterize novel materials for the next generation infrastructure.

Novel materials can be in the form of novel fibers, memory materials, and bio-inspired materials. Research has been carried out to investigate the suitability of natural fibers, such as cotton, in composite construction, and how the strength properties of structural elements can be improved using carbon fibers. The potential and limitations of shape conscious materials (shape memory materials) have been studied recently. The application of such materials to enhance structural performance, and mitigate natural disasters is being investigated, and the construction industry will benefit significantly upon it being proved acceptable. Bio-inspired materials are synthetic materials whose structure, properties or function mimic those of natural systems. For example, physical properties of a material such as adhesion can embody attributes of a gecko, and self-cleaning surfaces may be inspired by the super-hydrophobic nature of a lotus leaf. They make use of the logical argument: if it works in nature, it could be scaled up to develop infrastructure.

These novel materials often have improved performance aspects, and they make sustainable structural concepts feasible. For example, a novel adhesive material could offer a possibility for instruments to be attached and detached easily and self-cleaning surfaces will reduce the maintenance cost of infrastructure and also the use of chemical cleaning materials. However, developing and characterizing a novel material is a time-consuming task which represents a large commitment of resources. The operational implications such as maintainability and resilience of infrastructure built with such novel materials are to be fully understood and accepted before their implementation.

Design of Precast Concrete Cover Slab for Pedestrian Walkways

C.J.Athapaththu[1], I.M.H.Perera[2], W. K. Mampearachchi[3]

Abstract

Pedestrians need to experience safety, comfort, accessibility, and efficient mobility. Walkways are often needed in rural and suburban areas to provide access to schools, parks, community centers, local businesses, employment centers, transit stops and stations, and Residential areas. In some areas, when no sidewalks, walkways, or shared use paths are available, pedestrians might be seen walking on roadside shoulders. Sidewalks and walkways separated from the roadway contribute greatly to pedestrian safety. Therefore whenever possible, it is necessary to furnish a sidewalk or walkway for the safety and convenience of the pedestrians.

According to the Federal Highway Association, sidewalks require a minimum width of 5.0feet if set back from the curb, or 6.0feet if at the curb face to meet the minimum requirements for people with disabilities. For any two people to walk together, 5.0 feet of space is the bare minimum. According to RDA regulations minimum width of sidewalk is 1.5m.

In most of the urban areas in Sri Lanka, drain area also has used as a part of the sidewalk. Sidewalks have been constructed with tactile and interlocking blocks along with precast concrete cover slabs as to cover the drain and for the mobility of pedestrians. This is mainly due to the lack of land in Sri Lankan Roadways. The existing precast concrete cover slab is designed with a hollow at the edge of the slab as to make a lengthy void when two slab panels are interconnected together. Surface water is drained out through this void strip. However the problem is these holes may be a disturbance for the pedestrians because some valuable things may fall through the voids. After having some reviews from Municipal councils and RDA, it was confirmed that more than 10 inquiries were reported weekly. Therefore people tend to cover these holes using gunny bags or some other material to avoid these disturbances. And there is a possibility of entering surrounding solid waste which would cause to block the drainage. Then the rain water will get collected on the roads and the sidewalks, and will lead to a flood. In this research, our aim is to modify the existing cover slab so as to give a safe and convenient mobility to the pedestrians.

The research presented in this thesis is aimed at a novel design of a cover slab, which is being developed as a composite section of reinforced concrete and a porous concrete layer. Then the problem of draining out rain water and the inconvenient mobility of pedestrians will be solved. A cover slab model was designed using SAP2000 and the stress development was checked. Then samples were casted and tested for strength and permeability at the laboratory.

Porous concrete exhibits reduction in permeability due to clogging by particulates, which severely limits service life. This research also includes the clogging mechanism and mitigating strategies of porous concrete. Samples of new cover slabs with different sized aggregates were casted using different types of compaction methods. Clogging potential of

the cover slab was determined by the infiltration test (ASTM C1701). Infiltration was tested on a series cover slab samples which were clogged with topsoil, collected from the field, landscape fine compost and silt clay slurry, to simulate worse case clogging in the field. Comparison of surface texture was done according to the results of the sand patch test and clay patch test. Construction methods and practical issues related to application and mitigation techniques are discussed in this thesis

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3. Intelligent Transportation Systems

Evaluation and Improvement of Toll Collection System in Sri Lankan Expressways - Case Study for Colombo-Katunayake Expressway

H.B.N.S.Kumara[1], G.L.D.I. De Silva[2]

Abstract

With the latest development, three expressways were opened to the public in Sri Lanka and the number of users of the expressway network is expected to rise. The pay toll system in the road is based on the traditional method, which is the collecting of the toll by road barriers installed at the entrance & exit points of expressways. Although in this system the toll is collected directly from the drivers, the existence of barriers causes increased travel time, increased fuel consumption and consequently increased pollution in the road environment. For a more continuous flow of traffic, an Electronic Toll Collection (ETC) system was introduced in Colombo – Katunayake Expressway (CKE) since June 2015 to help alleviate traffic congestions, reduce environmental pollution, reduce cash circulation, integrate the financial system, elevate passenger comfort, and specifically reduce the service time at Toll Plazas.

This research focuses on the economic and technical analysis of the existing toll collection systems in the Colombo-Katunayake Expressway. The study is aim to evaluate the newly established ETC Toll collection System CKE.

In detail, the objective is to assess the amount of delay of the individual lanes dedicated for MTC and ETC, their service time, lane capacities and the forming of the queue in each lane and compare with the different modes of toll systems used in other countries. The study also aims to find out the specific factors that affect the delays experienced at Toll plazas & decrease the system performance, and recommend ways to improve the service. Not only that, the study is focused on the evaluation of the economic loss caused by the delays in toll lanes and level of lane utilization by each mode of vehicles. The analysis of the current toll systems in CKE under the system, financial, traffic, environmental, infrastructure and socio-economic aspects would be conducted using SWOT method.

Then, the different toll collection methods & technologies are to be studied under this research and characteristics and performances of each individual technology is to be compared. Analysis would be done to identify the appropriate ETC toll collection method for Sri Lankan Expressways. Consequently, short-term and long-term recommendations, for the Sri Lankan road tolling system, will be proposed, in terms of transportation.

Key words: ETC, MTC, Service Time, Delay time, Toll - Lane Capacity, SWOT Analysis

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IRoads: Smartphone-Based Road Condition Monitoring

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Abstract

Measuring and monitoring road conditions are essential to ensure public and vehicle safety, prompt maintenance, as well as fuel and time savings. While developed countries use sophisticated devices installed on specialized vehicles to measure and monitor the road conditions, it is cost prohibitive for countries like Sri Lanka. Moreover, the diversity of road types and non-standard physical properties, make it impractical for specialized vehicles to travel on roads in Sri Lanka and many other countries. Therefore, a system that is low cost and practically usable on roads with non-standard physical properties will be a useful solution for road condition monitoring.

Sensors such as 3-axis accelerometer, gyroscope, GPS, and magnetometer in most smartphones could be used to detect potholes and bumps, as well as to estimate International Roughness Index (IRI) at a much lower cost. Related work has shown that acceleration data from smartphones have a linear relationship with road roughness. Hence, it opens the way to the development of a system to measure the road roughness using smartphone sensors. While the accuracy of such a solution is relatively low, with the increasing number of motorists with smartphones, crowdsourcing could be used to collect data at a high spatial and temporal resolution that has been hitherto impossible. Such a massive volume of data collected through crowdsourcing could be processed using machine-learning and signal processing algorithms, such that the limitations and low accuracy of a single smartphone could be overcome by data analytics of the same road condition again and again.

A crowd sourced mobile app is proposed, to measure the road conditions such as potholes, bumps, speed breakers, and estimate IRI at a high spatial and temporal granularity. The proposed solution collects data over a broadband connection to a cloud-computing-based backend where machine-learning and signal processing algorithms are used to determine different road conditions and estimate IRI. Moreover, the solution provides visualization of this information using a map-based dashboard.

3-axis accelerometer is used as the main source for road profile monitoring. However, in a crowd sourced model, many practical problems need to be solved in addition to technical problems, as motorists may use vastly different types of smartphones with varying features and accuracy. For example, they may mount the smartphone in various orientations or orientation may change as the trip progresses. Therefore, a reorientation mechanism is essential to convert accelerometer data from any arbitrary smartphone position to the vehicle's axis. The solution implements two reorientation mechanisms. The first mechanism is using Euler angle-based algorithm. The second mechanism uses magnetometer and GPS bearing readings to reorient the acceleration vectors of the mobile device. Signal processing techniques are used to filter out the sensor noise for more accurate data gathering. Moreover, the magnitude of sensor reading tends to correlate with

acceleration and deceleration of the vehicle. Thus, vehicle speed data are also needed to capture road conditions accurately. Therefore, the proposed app connects to an OBD2 (On-Board Diagnostic) ELM327 adapter to collect vehicular data such as fuel consumption and speed of the vehicle. OBD2-based vehicle speed estimation is more effective than GPS-based estimation due to the low resolutions and slow sampling in GPS.

Random-forest algorithm is used in the backend to detect road anomalies (e.g., pothole or bump), while pulse calculating algorithm is designed for estimating IRI values. Road segments are classified based on IRI and a map is annotated based on the IRI values. Due to varying accelerometer accuracy levels, as well as low resolution and slow sampling in GPS, it is difficult to estimate the exact location of the road anomaly. Therefore, a clustering algorithm is used to identify the location of an anomaly by clustering GPS locations estimated from different trip data provided by users. Moreover, vehicular data will be used in the future to estimate the relationship between fuel consumption and IRI of Sri Lankan roads. Furthermore, the visualization of bad road segments could provide insights to drivers to bypass bad road segments while the authorities could use the dashboard to prioritize maintenance and policy marking.

An Android-based mobile app, namely iRoads, is developed and already used with a few data collection trails. The research currently focuses on calibrating the mobile app and related algorithms to accurately estimate IRI and detect road anomalies. For example, efforts are currently underway to calibrate estimated IRI values with the IRI readings from a ROMDAS Bump Integrator. The goal is to improve the accuracy to such a level that iRoads could measure roughness like a class-3 road profiling instrument. Another app is also developed to label road anomalies on the go, such that a large, labelled training dataset could be gathered for training and evaluation of machine-learning and signal processing algorithms. Based on this, dataset model parameters are to be tuned to more accurately estimate road anomalies.

Keywords: IRI, road anomaly, accelerometer, signal processing, machine learning

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Applicability & Design Requirements of an Intelligent Pedestrian Crossing

Hasini Godawita[1], Nadika Jayasooriya[2], Saman Bandara[3]

Abstract

Pedestrian crossing is one of the places where pedestrians and vehicles interact each other. This interaction often causes delays to both pedestrians and vehicles and increase possibility of accidents between vehicle-pedestrian and vehicle-vehicle. In order to manage these interactions, controlling mechanisms such as traffic signals are used. This research looks into the possibilities of making these interactions safe and less delay causing to both pedestrians and vehicles, by means of appropriate controlling mechanisms with the help of present technical capabilities. The objective of this research is to come up with a design guideline for an intelligent pedestrian crossing and to compare its effect on minimizing delays and reducing risk of accidents as compared to standard zebra or signalized pedestrian crossing. Only the isolated pedestrian crossings are considered for this study.

End purpose of the research is to identify the applicability of intelligent pedestrian crossings and to identify design requirements for an intelligent pedestrian crossing at places where it is needed. Design requirements are characterized based on four main parameters; vehicle flow, vehicle speed, pedestrian flow and safe stopping distance for vehicles. The proposed design requirements allow intelligent pedestrian crossing to decide to whom to give the priority based on traffic & pedestrian flow condition and the location of pedestrian crossing.

Main findings of the research include identification of different design requirements; signal operation strategies for different traffic conditions and analytical solutions to identify appropriate timing requirement of the traffic signal. Four different situations based on pedestrian flow and vehicle flow have been analysed. Intelligent pedestrian crossing will be suitable for all except the situation where both pedestrian and vehicle flows are high. It is proposed to vary amber time considering whether a vehicle can be safely stopped or whether it is allowed to pass through the pedestrian crossing. The decision is based on the approaching speed of the vehicle and its safe stopping distance. Red time and Green time could vary depending on the crossing ability (speed) of pedestrian and the crossing length.

Key words: Intelligent Pedestrian Crossing, Delays, Safety, Isolated

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Queue Dissipation at Signalized Intersection under Mixed Traffic Conditions

S. Mondal[1], A. Gupta[2]

Abstract

The complexity in discharge pattern through the intersection in developing countries is mainly due to its mixed properties of traffic stream where both motorized and non-motorized vehicles are traveling in the same stretch without any lane discipline. In a mixed traffic stream, no single vehicle dominates the traffic stream consequently prediction of saturation flow is more sensitive for that mixed traffic. Therefore, it is essential to convert all categories of vehicles into a single unit to integrate their effects on traffic stream called passenger car unit (PCU).

Moreover, vehicles headway is one of primary microscopic parameter, which contributes major impacts on discharge rate estimation for a signalized intersection. It is the time gap between two consecutive vehicles with some reference line during the queue dissipation in green time, called discharge headway.

The methodology for data collection is being adopted as per the guidelines of Highway Capacity Manual (2010). Initially, five four legged signalized intersections from the city of Delhi, Chandigarh and Allahabad were selected for the data collection purpose. All the selected intersections are free from pedestrian activities with a pre timed signal characteristics. Video graphic technique was used to capture the vehicular movement through the intersection. The camera was installed and focused to a particular approach to capture its discharge pattern during the green time. The recording was done during the morning (9 am to 12 pm) and evening (4 pm to 7 pm) peak hours.

An optimization approach is used to find out discharge rate of vehicles during queue dissipation. Dynamic PCUs are estimated through reducing the Theil's coefficient. The obtained flow value is compared with the ideal flow profile provided by HCM 2010.

The discharge pattern of vehicles during the queue dissipation is analyzed using the graphical representation of departure headway with queue position. It shows a generalized trend where departure headway decreases with increase in vehicle position in the queue with a saturation headway of 2.05 sec/veh.

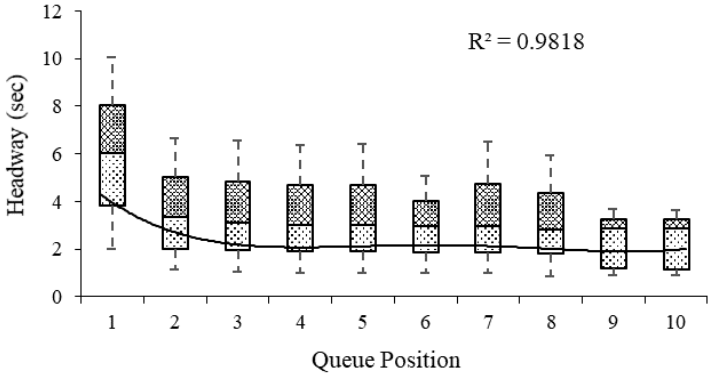

Fig. 1: Departure headway pattern of vehicles

Several distribution models are tested to find out the distribution of departure headway. The hypothesis result obtained by Kolmogorov-Smirnov (K-S) test shows that the departure headways follow a particular log-normal distribution for each vehicle position in a queue.

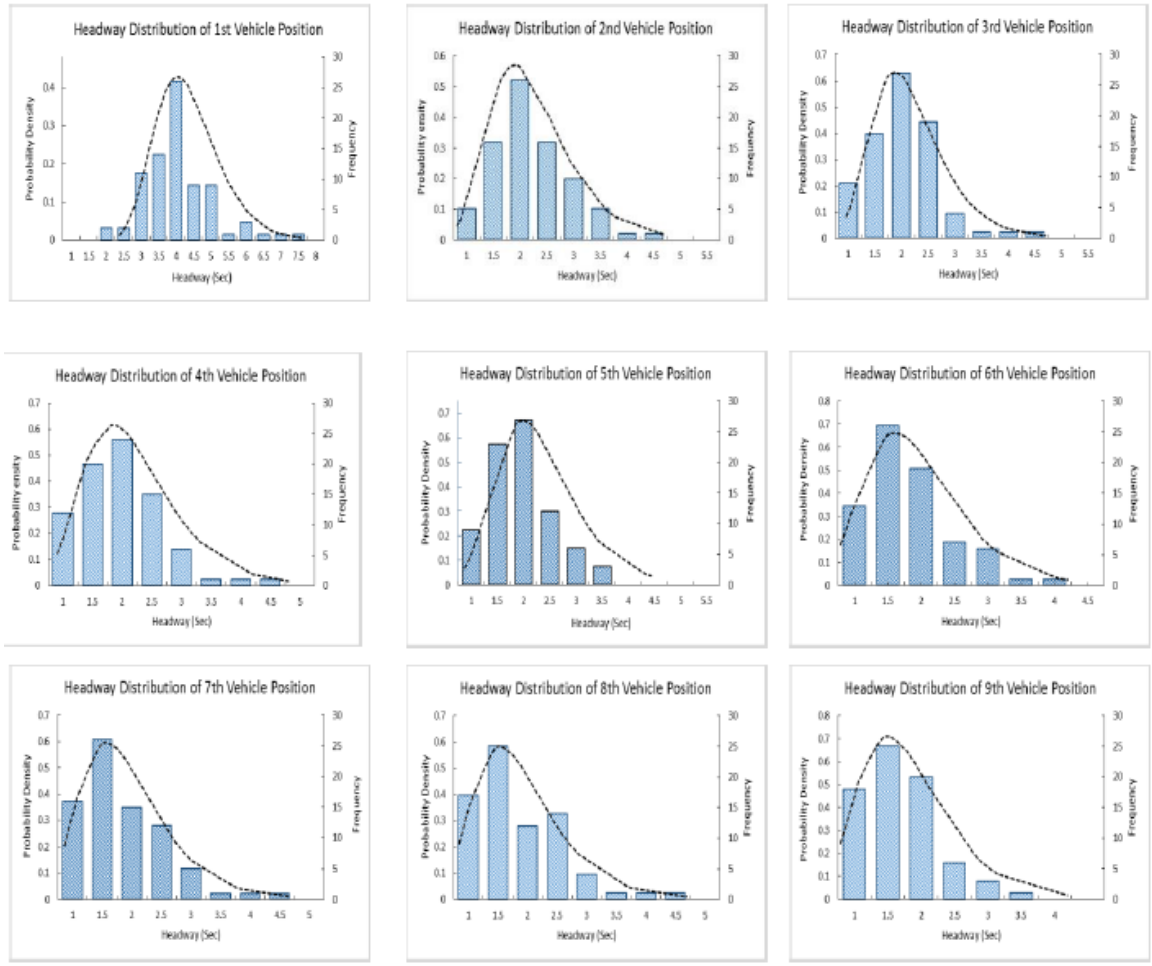

Fig. 2: Histogram of the empirical departure headway for each vehicle position

The optimization technique is applied during the saturated green period, obtained by one way ANOVA for each successive pair of green slices. The dynamic PCUs of vehicles are estimated through minimizing the Theil's coefficient value by taking the PCUs as decision variable with several constraints of PCUs.

$$Z_{\min} = \frac{\sqrt{1/N\sum_{i=1}^{N}(S_b - S_i)^2}}{\sqrt{1/N\sum_{i=1}^{N}(S_b)^2} + \sqrt{1/N\sum_{i=1}^{N}(S_i)^2}}$$

$$S_i = \sum_{j=1}^{m} n_j P_j \ , \ P_j \geq P_{j\min}$$

The primary function of the optimization is to minimize the difference between the observed and ideal flow profile provided by HCM 2000. The DPCUs are used to estimate the discharge rate.

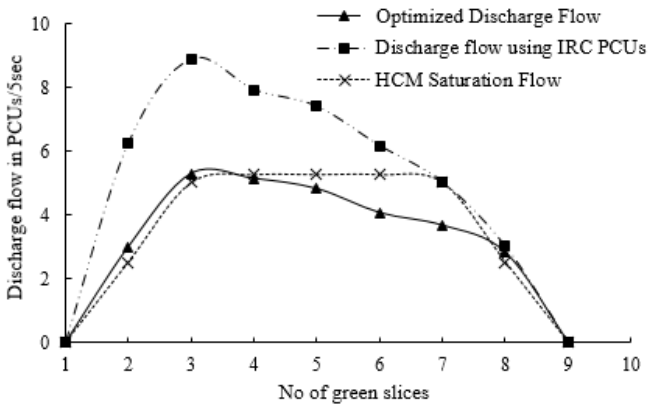

Fig. 3: Discharge profile using optimized PCUs

Result gives a flow value of 1908 PCU/hr/lane which is almost near to the ideal profile proposed by the Highway Capacity Manual 2000. Therefore, the current methodology can effectively be used to evaluate the dynamic PCUs and discharge value for a non-lane based mixed traffic stream.

Key words: Departure headway, Discharge rate, Mixed traffic, Passenger car unit, Signalized intersection

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4. Transport Planning and Road safety

Competitive Assessment of Container Port Development in Sri Lanka

C.A. Kavirathna [1], S. Hanaoka[2], T. Kawasaki[3]

Abstract

Owing to the strategic location of Sri Lanka with the world maritime networks, Colombo port is developed as a main transshipment hub port, given that majority of containers throughput being represented by transshipment cargo. Within this context, the expansion of Colombo port and the development of Hambantota port were initiated by Sri Lankan Port Authority. This paper discusses the container port developments related to Colombo and Hambantota ports considering both domestic and transshipment container handling. Total domestic laden container throughput is disaggregated into 25 districts in Sri Lanka for domestic cargo flow analysis. For the transshipment cargo flow analysis, twelve selected feeder ports in the Indian sub-continent are considered, which are grouped into three feeder markets namely, Indian East-coast, South-coast and West-coast feeder markets.

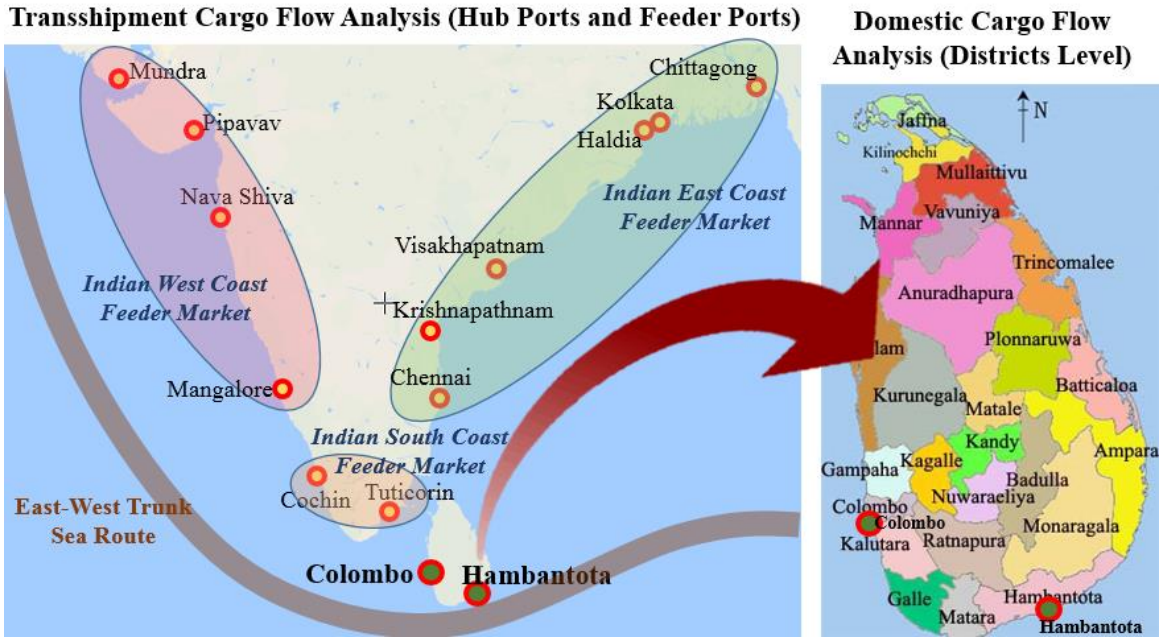

Figure 1: Study Area

A discrete choice model together with the generalized cost approach, is used for modelling the gateway port choice behaviours of local shippers/consignees considering basic container haulage cost, detention fee, transport time cost, waiting time cost, and terminal handling charges. Transshipment hub port choice of shipping lines is quantified considering the range of hub port selection criteria discussed under monetary, time, port traffic, location, operation and liner related categories, according to the context of current study. The autoregressive integrated moving average model is used to forecast container volumes in 2040, which is considered as the target year. The liner programming simplex optimization method is used to calculate the additional generalized cost of

shippers/consignees with the given slot capacity constraints at Colombo. Sensitivity analysis is carried out to analyse impacts from the split of liner services.

High attractiveness of Colombo port for domestic container handling and Hambantota for transshipment container handling, was revealed. Scenario analysis indicates the significance of accessing the road development and incentive scheme at Hambantota port to reduce generalized cost of local shippers/consignees. The impacts from additional waiting time for liner services and slot capacity constraints at Colombo port are analysed, where a significant negative impact on local shippers/consignees was revealed. Recommendations are made considering the impacts on local shippers/consignees, shipping lines, the port authority and maritime competitiveness of the country.

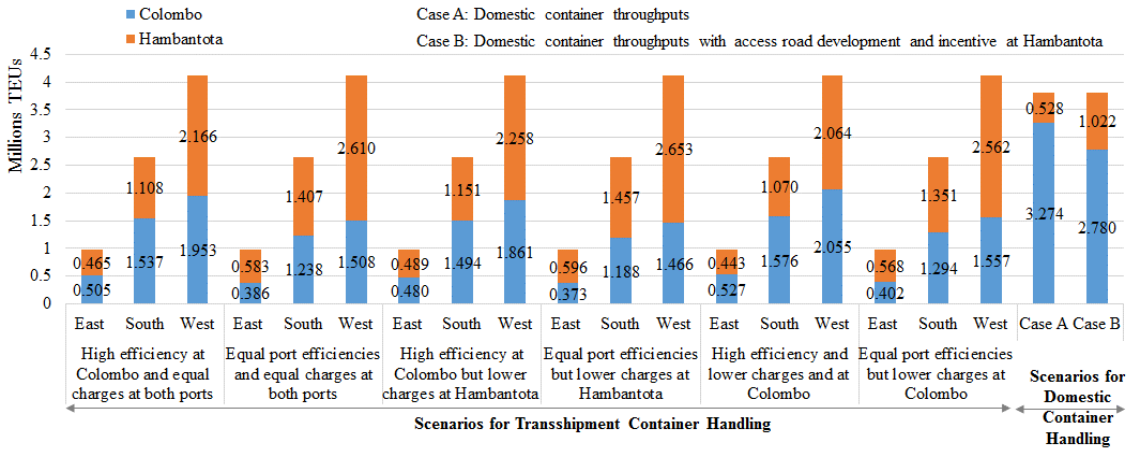

Figure 2: Domestic and Transshipment Container Handling

Keywords: Port Developments, Transshipment, Competition, Generalized cost

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Development of a Choice Model for School Trips

Indunil Sannasooriya[1], Dimantha De Silva[2]

Abstract

The school bus service has become more of a necessity due to two major reasons: it engages with the most sensitive crowd in the society, and operates at the most crucial time of the day. A high quality bus service is one of the most important parts of the transportation system as it will reduce the congestion by a large number.

Currently it can be clearly seen that many school bus services are not up to the required standard in Sri Lanka with the lack of safety and efficient conditions. Moreover, the dissatisfaction of both parents and their children with the service, has made people switch to the alternative of using the private vehicle to commute to school. Therefore, the transportation industry is in dire need of a high quality school bus service. This study focuses on the attributes of a high quality bus service, compared to the existing transport modes for school trips. Analysis on desired attributes in a high quality school bus service and the model shift from the existing system to the new system, will be stressed.

Stated Preference (SP) theory will be the main methodology utilized in the study to find out all the required data. Stated Preference survey or self-stated preference is an efficient method to analyse consumer's evaluation of multi attributed services, specifically when there are hypothetical choice alternatives and new attributes. In the case of Colombo, Sri Lanka there are no revealed Preferences (RP) data for the high quality school bus service as it is only a Megapolis proposal. Therefore, a Stated Preference survey must be well designed and implemented. There are few objectives defined for this study such as the quantification of sensitivity to the level of service, by varying values of access time, waiting time, travel time and cost etc. to measure the willingness to pay, and to investigate effects of attitudes and perceptions.

There are few most probable choice sets to commute to school around Colombo, such as using the private car, school vans and Sisuseriya or other public bus services which have numerous attributes to be considered. Furthermore, the new high quality bus service includes door to door arrivals and drop offs, information services such as Internet, telephone, and GPS navigation, a tracking system and air condition etc. The process of developing the SP survey is categorised in few major steps;

I. Defining important attributes
II. Designing the questionnaire of SP survey
III. Experimental Design
IV. Testing the Synthetic Data
V. Pilot study and Analysis
VI. Revising SP Survey
VII. Implementing an Internet survey and supplemental presentable survey

When defining important attributes, a focus group discussion will be conducted to collect data. And the questionnaire of the SP Survey will include social-economic information,

current travel behaviour, attitudes and perceptions. Model Estimation will be conducted for the travel data. Different model specifications will be compared in this regard. In general, discrete choice models based on a maximum likelihood estimation technique will be used. Further, logit models will be used throughout the analysis. These models capture the influence of attributes and characteristics on the decision makers' preferences.

Key words: Stated preference theory, travel behaviour, mode choice model

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Evaluation of Roadway-Railway Level Crossings in Main Line from Colombo to Polgahawela

Kulasingham Ragulan[1], Niranga Amarasingha[2]

Abstract

When a railway line crosses a road or a path at the same level, it is called a Level Crossing (LC). The total length of the railway lines in Sri Lanka is approximately 1930 km (SLR, 2011). 1047 crossings have been reported. Out of these, 128 crossings are protected by electrical barriers and 139 are protected by mechanized barriers. A great amount (758) is manned by barriers while an amount as low as 17 are manned by farm type gates. About 151 gates have a bell and flash light system. There are about 457 unprotected gates in the country, accounting for 37%. The main objective of this study is to evaluate the railway-roadway LC safety, because a significant number of rail crashes are being reported in Sri Lanka at LC.

Four years of railway crash data, LC characteristics, rail line characteristics, and highway characteristics, were collected at the main rail line from Colombo to Polgahawela. Special attention was paid to different types of LCs, focusing on their methods and their functional capacity. Furthermore, the shortcomings found in the system were analysed using data pertaining to the 62 LCs found between Colombo to Polgahawela. The details regarding these LCs, their nature, construction, location, and intermittent distances were obtained directly from the Railway department. Then linear regression models were used to identify whether these predictor variables, which successfully predict an outcome, crashes.

The locations which had appalling shortcomings such as the unavailability of barriers found in the LC, the prolonging of the bell sound for a considerable time, the elderly being employed in unprotected LCs without their basic facilities or wages being ensured, LCs and roadways running parallel and road traffic getting entangled in the LC, and the view of approaching trains getting blocked by towering buildings and trees, were successfully identified. Based on the data collected, the locations that needed immediate attention were pointed out. Statistical analysis further showed that the distance to the nearest curvature from the direction of Colombo and Polgahawela, the sight distance from the upside and the bottom, availability of a passive protection system, have a significant influence on the occurrence of crashes.

The main intention of this research is to minimize the number of accidents that occur at the crossing of main line. The sample taken for the study is convenient, due to the fact that the population can be accessed appropriately. The results can be considered as general, though there might be slight variations that could arise, as some of the LCs, especially in the rural areas of the country, have less trains and vehicles on roads. Furthermore, some solutions and recommendations have been put forward, taking into consideration the modern methods utilized in this field.

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Keywords: Level Crossings, Railway Safety, Crashes, Crash Modelling

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Studying pedestrian's personal space in mass religious gatherings

A case study of Kumbh Mela

Karthika P S1, Dr. Ashish Verma2

Abstract

Personal space can be defined as the physical distance between two individuals in a social environment. Studying personal space includes the ability to recognize the various zones of involvement and the activities, relationships, and emotions associate with each zone. This paper tries to formulate and define personal space in high density crowd situations in Kumbh Mela, one of the world's largest mass religious gatherings. It is found that the average speed of the individual, the group size, and the gender ratio of group members have a significant effect on the personal space of an individual.

Keywords: Inter-personal distance, Personal space, Mass religious gatherings, Stampede

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An Overview of Motorcycle Crashes in Sri Lanka with a Comparison between Public Opinion and Police Crash Data

J.M.S.B Jayasundara[1], T.W.K.I.M Dias[2]

Abstract

Road safety is being a major topic discussed all time, focused studies are not much carried out to identify factors affecting the road traffic crashes. Among the huge number of road traffic crashes, motorcycles are one of the most vulnerable vehicles on roads. In this research, motorcycle crashes happened at the urban areas was analysed. A descriptive data analysis about motorcycle crashes is a very important to develop the public opinion about motorcycle crashes. There are so many road rules and regulations in Sri Lanka. A study about those road rules and regulations related to motorcycle crashers, motorcycle riders were carried out here. The road rules and regulations and a brief description about driving license examination were carried out here. A questionnaire survey was conducted to find out the public opinion about road user's disciplines and motorcycle crashers. To find out the motorcycle congestion of the urban roads, a traffic count was carried out. Also, the police crash database was obtained from the Traffic Police Headquarters Colombo. Some other motorcycle crash data were obtained from the Ceylinco Insurance PLC to find out the most unsafe motorcycle type available on the road. Results of the questionnaire, police crash database, and crash data obtained from Insurance Company were analysed. A descriptive analysis was carried out with the comparison between questionnaire survey results, police crash data analysis and Insurance crash data analysis. When the fatal crashes are considered, motorcyclists are ranked number one. Most vulnerable vehicle category presented on the road, most driver/rider fatal vehicle category, most vulnerable vehicle type that caused more accident to pedestrian can be identified as the motorcycle. The major outcome of this research was identify a list of factors that involves with increasing of motorcycle crashers. Some major factors identified for motorcyclist's safety are:

"Helmet is the most important safety equipment for motorcyclists; wiser and strap use is more important to reduce the severity of fatal crash",

"Multiple road junction, 4-leg junction and T junction are the more unsafe locations for motorcyclists according to the responses, but stretch of road, no junction within 10m is more unsafe because most of past motorcycles crashes happened at that location",

According to the responses slippery surface, flooded with water surface, wet surface are unsafe road surfaces for motorcyclists, but dry road surface has more crashes, because of the hidden factor of "exposure". According to the responses, rain and fog/mist weather types are the most unsafe for motorcyclists but clear weather type is more unsafe than other weather types, because most of motorcycle crashes happened at clear weather type.

According to the responses, night, no street lighting is the most unsafe lighting condition for motorcyclists, but daylight is the most unsafe lighting condition for motorcyclists, because most of motorcycle crashes happened at daylight lighting condition.

According to the responses, brake system of motorcycle is the most considerable factor related to motorcycle safety. No traffic control system is more unsafe than others for motorcyclists. Because most of motorcycle crashes happened at no traffic control. Aggressive/negligent driving and speeding is more unsafe human pre-crash factor contributing to an accident

Keywords: Road safety, Motorcycle crashes, Public opinion, Questionnaire

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5. Pavement Maintenance

A Simple Method to Evaluate Subgrade Resilient Modulus for Pavement Overlay Design using FWD Parameters

S.A.S.B.Samarasinghe[1], H.R.Pasindu[2]

Abstract

Subgrade soil characterization expressed in terms of resilient modulus (M_R) is one of the most important parameters in pavement overlay design with Falling Weight Deflectometer (FWD) data. The subgrade M_R can be determined by several methods such as laboratory testing, back calculation with FWD data or estimation from correlation studies. In order to obtain M_R from laboratory testing, a dynamic triaxial testing equipment is required. But in Sri Lanka, only static triaxial testing apparatus is available, hence we cannot obtain M_R from laboratory testing. Empirical relationships with California Bearing Ratio (CBR) is the most widely used method to estimate subgrade M_R, since CBR is not an expensive and easy to obtain parameter. Although it is convenient to obtain M_R from these simple empirical relationships, these relationships are not tested for the soil condition in Sri Lanka, hence the results obtained may not be accurate.

AASHTO 1993 guide provides an equation to calculate resilient modulus from FWD data, however it not widely used because Engineers always prefer to use simple CBR-M_R empirical relationships to obtain subgrade M_R. It is very important to analyse FWD deflection data obtained from all the sensors, since it provides valuable information of the pavement subgrade condition. But one of the problems in the AASHTO equation is, it only uses one deflection sensor (D300 or D450), to calculate M_R in order to satisfy the minimum distance criteria. Hence the non-linearity characteristics of subgrade is not identified in AASHTO method.

Hoak and Emery (7) reported that in the deflection basin obtained from FWD data, at relatively large distances (generally more than 600 mm up to 900mm) from the loading plate, all compressive strain will occur only in the subgrade. Also they have reported that deflections obtained from sensors D300 to D900 will represent the combined effect of both subbase layer and subgrade.

When the pavements are selected for rehabilitation work, from the test pit investigation, it can be observed that it is difficult to distinguish between subbase material and subgrade of those aged pavements. So that it is not unreasonable to consider deflections obtained from sensors D300 to D900 in order to calculate a representative M_R for the aged pavement sections. Two factors, central deflection (D0) and subgrade non-linearity characteristics are considered, to decide a one M_R from D300 to D900 as the representative value.

Measured central deflection (D0) also provides an indication of the condition of the subgrade. Hoak and Emery (7) reported that of all structural layers of the pavement, contribution of subgrade to the central deflection (D0) is about 70%. M_R is calculated from the equations proposed by Boussinesq and the method proposed in Transit New Zealand Report No. 117 (6) is used obtain non-linearity characteristics of calculated M_R.

This study proposes an improved method to calculate subgrade resilient modulus (M_R) while analysing condition of the subgrade and its non-linearity characteristics. The results are compared with the resilient modulus obtained from AASHTO method.

Key words: FWD, Subgrade, Resilient Modulus

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Performance Evaluation of Night Time Visibility (Retroreflection) & Skid Resistance of Road Pavement Markings with Ceramic Beads

B. H. T. Ariyarathne[1], H.L.D.M.A. Judith[2], K. L. I. Ranasoma[3]

Abstract

Pavement markings play an important role by providing visual guidance to motorists, to improve road safety and road networks, to meet the social aspiration of people. In order to function properly, pavement markings must be visible under all weather conditions to any driver in any age category. In general, most pavement markings provide a satisfactory performance under dry conditions. However, under wet night conditions, the visibility of these materials degrade significantly as the marking surface gets covered with water, leading to the partial or complete disappearance of the marking.

Currently in Sri Lanka thermoplastic paint is being used for road marking intermixed with glass beads, in order to give the retroreflection promoting night time visibility. However wet night visibility of these materials are not in a satisfactory level due to these glass beads having a refractive index ranging from 1.5 to 1.9. A higher refractive index is needed to be able to reflect in wet weather conditions (Paul J. Carlson, 2007).

Therefore, this study was focused to evaluate the performance of thermoplastic road marking paints, applied with ceramic beads which have a refractive index over 2.4, and to evaluate the improvement of visibility (especially night time retroreflectivity under wet condition) & skid resistance values.

At the initial stage, retro reflectivity (dry & wet) was measured for newly applied road markings on several locations to get an idea about the current values. Lower values were reported under wet conditions.

Thereafter, laboratory investigations were carried out to evaluate the variation of retroreflection values & skid resistance, by varying the amount of glass beads & ceramic beads, 250 g/cm^2 to 400 g/cm^2. It was observed that retroreflection can be improved up to a certain level by amplifying the number of glass beads. However, further increasing of the glass beads beyond this point seemed to result in the reduction of the skid resistance value.

Subsequently a field trial was done with ceramic beads to study the improvement in visibility. In this study, road marking were made on Kotte-Bope Road (B240) over the pedestrian crossing, and night time visibility in dry & wet conditions and skid resistance were evaluated for over 9 months.

High values (622 mcd.m^{-2}.lx^{-1} - dry & 420 mcd.m^{-2}.lx^{-1} – wet) of initial retroreflectivity & (85) skid resistance were noted from the section applied with ceramic beads. However discoloration was observed in this section, compared to the conventional glass bead section.

Further performance evaluation needs to be carried out, especially for the expressways which have visibility issues during rainy periods with high speed & safety. The edge line of expressways are proposed to be evaluated at the preliminary stage. At the second stage, center lines need to be evaluated giving due consideration to possible improvements in staining due to traffic movements.

This research enabled the drawing of few conclusions: ceramic beads could be used to gain high retroreflection, it is necessary to introduce and implement quality control checking of the retroreflection under wet conditions and introduce these high quality materials, to gain high visibility. Also retroreflectivity should be specified based on the type of the road (Highway/Expressway), to be visible under all weather conditions, favouring all road users, since the speed of the vehicle and age will determine the most prominent factors of visibility of these markings.

Keywords: Thermoplastic Pavement Marking, Night time visibility, Skid resistance, Glass Beads, ceramic Beads

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Use of Reclaimed Asphalt Pavement (RAP) for Road Construction in Sri Lanka

S.Kajugaran[1], W. K. Mampearachchi[2]

Abstract

Recycling technologies on maintenance and rehabilitation of asphalt pavements have been amplified in many countries. Because cost and energy consumption are minimized using Reclaimed Asphalt Pavement (RAP). In this study, the suitability of RAP materials for Sri Lankan roads was analysed by Marshall Mix design. Different percentages of RAP were mixed with virgin aggregates and binder, to conduct the Marshall Test. The gradation of the total combined aggregates and properties of the binder from RAP can have an impact on the results of the Marshall Test. Methods to find the effective specific gravity of RAP and specific gravity of RAP binder were derived from the manual series-2 (MS-2), asphalt mix design methods of asphalt institute. Results of air voids, voids in mineral aggregates, stability, and flow were investigated for each percentage of RAP mix specimen. Natural oxidation of RAP binder was analysed under Fourier Transform Infrared Spectroscopy (FTIR) using the presence of carbonyl bond and sulphur oxide bond. The range of 20% - 30% RAP content of asphalt concrete would be recommended to fulfil the requirements of the Institute of Construction Training and Development (ICTAD) specification for asphalt wearing course and this is one of the sustainable solutions for road construction practices in Sri Lanka.

Key words: RAP, Asphalt, Gradation, Marshall, FTIR

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Effect of Mat thickness for the Degree of Compaction of Asphalt Pavements

K. K. S. M. Gunasekara[1], W. K. Mampearachchi[2]

Abstract

Compaction of the hot mix asphalt (HMA) is a very important process in road construction. The ability of the load bearing greatly depends on the degree of compaction of the hot mix asphalt pavements (Finn, & Epps, 1980). The degree of compaction depends on various factors. The thickness of the hot mix asphalt mat is a major factor that affects the degree of compaction. Temperature of the hot mix asphalt is very much important for proper compaction. It is mainly governed by the layer thickness. According to the previous research, it is shown that temperature in layers with a low thickness rapidly drop down rather than in the layers with a high thickness.The research aims at finding out, the optimum mat thickness of the asphalt pavements, suitable for Sri Lankan conditions.

In the process compaction of the hot mix asphalt layers, maximum aggregate affects the layer thickness. In general, it is about 2.5 times of the maximum aggregate size. According to the guidelines of the Road Development Authorities (Sri Lanka), most of the asphalt pavements are constructed with layers the thickness of 50mm or lesser (40-50mm).

For the purpose of the investigation, two road projects (Jaffna-Pannai-Kayts road project and AP4-Integrated road package of Anuradhapura) were selected, to find out the optimum mat thickness. Thickness of the asphalt cores and their degree of compactions were obtained from the above projects. The cores within a certain range of breakdown temperatures, were selected to maintain the uniformity. Maximum day time temperature and average monthly velocity details were obtained from the Department of Meteorology. The graph of core thicknesses versus degree of compaction is plotted and optimum compaction range is measured using the graph.

As per the investigation, it shows that, mat thicknesses within the range of 55-60mm have the highest degree of compaction. It is recommended to have a mat thickness about 55-60mm thick, instead of having 50mm or lesser mat thicknesses.

Keywords: Mat, thickness, hot mix asphalt, degree of compaction, maximum aggregate size, core sample

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6. Poster Presentation

Analysis of Defects Liability Period for Different Type of Defects Identified in Road Construction Projects

W.A.H Chathuranga[1], H.R Pasindu[2]

Abstract

In any type of construction work there is a possibility for defects. Defects in road construction can be of many categories: road surface defects, base or sub base defects, drainage issues, design failures or construction failures. Failures can be identified using many methods. Visual observation, accident analysis, public complaints, re-testing etc are among the most common ways of identifying these defects.

To minimize these construction defects, in the construction field, contractors have to use high quality materials, better construction techniques and proper machinery. Competitiveness in the construction field leads contractors to try and win the bids by bidding at a low cost. After the lowest bidder is awarded the contract, he tries to generate profits within their budget. Because of this, the contractor might tend to use low quality materials, poor construction techniques and improper machinery to make profit. To mitigate such situations and defend the client against poor construction works, the construction industry has the Defects Liability Period. Defects liability period is a set period of time after a construction project has been completed, during which a contractor has the right to return to the site to remedy defects. A typical defects liability period lasts for 12 months.

However different types of defects appear after different time periods from the completion of the road construction. In common practice, Sri Lanka has one year defects liability period for all the defects in road construction projects. However, some defects may occur after one year, so contractors tend to use of low quality materials and poor supervision in road construction. Therefore employers should give carefully consider the wording and requirements of the defects rectification provisions. Where the client considers hiring another contractor to fix the original contractor's mistakes it will lead to the cost a considerable amount for the rectification of these defects. Therefore the analysing of the defects liability period for different type of defects is very much needed in road construction projects.

In the recent past many roads have been re-constructed all over the country. These works were carried out by different types of contractors using different types of method statements and methodologies. Most of these contracts have had one year defects liability period. It creates many problems to relevant authorities, even though road surfaces were black top.

Also few road construction projects entertain performance based contracts; such a type of contract contractor should maintain the rehabilitated road section for an agreed time period. These types of project rates of bidding items are too high compared to the normal contracts. This cost, sometimes cannot be bared. This may lead to the completion of the project far before their schedule scope due to the unavailability of funds. But most of the developing countries, including our neighbour India, focus on increasing this Defects Liability Period

according to the type of defects.

This study is an attempt to analyse the defects identification period in road construction, and thereby enabling the proposal of a systematic defects liability period for road construction projects. Absence of a proper defects liability period for road construction causes inconvenience to both contractors and clients. Therefore identification of the DLP would minimize imbalances and inefficiency in the construction industry.

The first step is to identify the variants of defects identification. The second step is to analyse different defects with the time of identification. Road construction projects are a major variant and ten different defects components have been identified: such as road surface, base failures, sub base failures, subgrade failures, low quality materials, drainage issues, design failures, construction failures, road marking and signalling issues.

To identify those defects a questionnaire survey was conducted within the Executive Engineers' division in Kalutara District of Road Development Authority. This sample space includes three EE divisions, Kalutara, Agalawatta and Horana. Within these three EE divisions, a 450 km of national highways were maintained. In the last decade 90 percent of the road lengths were upgraded to black tops, in these divisions. Based on the results of the questionnaire, survey charts were developed for these defects, against their occurrence. This will help to identify the DLP for different type of defects in the road construction.

Keywords: Defects Liability Period, failures

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The Study of Aging Characteristics of Road Marking Material

R.A.D.M.P. Ranawaka[1], J.M.S.J. Bandara[2]

Abstract

Road Safety is a major component of the highway sector, and it should be considered well in highway planning, designing, construction and maintenance. The visibility of road marking is essential for efficient traffic flow and road safety. There are complaints that road markings of many roads in Sri Lanka have poor visibility and no effective re-marking processes within a sufficient time period. The major reason for the poor visibility is the low reflection level of road markings. The performance of the road marking can be affected due to the embedment of glass beads, water on road way, driver's eyesight, position, and quality of headlamps, and road surface debris. The adequate noticeable area of road marking, directly affects the visibility of road marking. This noticeable area of road marking decreases due to traffic with respect to time, after applying. It is necessary to repaint the road marking to improve safety to road users.

There is no guideline or methodology available for road agencies in Sri Lanka to follow, when deciding the road marking and repainting period. It is difficult to manage funds, material stock, manpower and machinery in a most effective manner, without guidelines.

The main objectives of this research are to understand the aging characteristics of road marking material with respect to traffic and other environmental parameters, identify the optimum frequency of time for repainting urban roads and introduce guidelines for the repainting of the road marking while integrating it as a program, to a road database in highway management tool, as a future implementation.

Preliminary measurements will be taken on selected high volume traffic roads that have shown a considerable reduction of visibility with time due to traffic. Colombo - Galle – Habantota – Wallawaya road (A002, Rawatawatta ADT - 42711) and Colombo – Horana (B084, Werahera ADT - 40910) road can be considered as examples for roads. Galle road consists with newly painted road marking (2017) and old road marking (2014). It can be seen a considerable quantity noticeably fading within the period of 3 years. These noticeable area of road marking will be compared, with time periods, to many road sections. A relationship between the reduction of visibility and traffic, is to be developed based on these photo based measurements. It is a ranking method based on weightages given to a visible area of a photo view. Newly finished road marking photos with the best visible area will be 10 and it may decrease as per visibility of marking. By comparing many samples, the relationship between the visibility of marking and aging of marking, using these weightages, is tried to be established. It can be possible to identify the frequency of the repainting of road marking.

Keywords: Road safety, Road marking, Visibility, ADT, Photo base, Frequency of remarking.

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Analysis of Road Accidents in "A9" Roads in the Northern Province

M.M.M. Munas[1], J.M.S.J. Bandara[2]

Abstract

A9 (Kandy-Jaffna Highway) is the most popular road in Sri Lanka, and was opened for traffic after the renovation of the section from Vavuniya to Jaffna, in 2013. Even though several safety precautions have been provided, most number of accidents reported along the highway have occurred in the district of Jaffna, Kilinochchi and Vavuniya. Therefore, identifying locations that may lead to accidents, the cause for the accidents, and where majority of the accidents take place are essential, for immediate safety measures and improvements.

The main research objectives are to identify accident prone locations, identify possible reasons for the accidents and calculate the accident rate based on vehicle travel kilometre.

According to this research, fifteen most critical accident-prone locations were identified in the A9 road section from Vavuniya to Jaffna. Accident locations were grouped into the nearest 100m distance, and the fifteen most critical locations are 171+100km, 176+100km, 177+100km, 180+200km, 183+200km, 212+800km, 252+100km, 299+100km, 300+100km, 302+100km, 303+100km, 305+100km, 309+100km, 311+100km and 312+200km. Main causes of the accidents, as per the accident records, are the driving speed and the poor road environment(light condition). Driver fatigue also acted as a key factor for some accidents. Accidents that happened during day time were twice as higher than that of the night time in some locations while some were equal. However, this trend was the same in each section along the road.

The highest accident rate that was around 1.31 x 10^{-6} veh km, was noted from Palai to Meesalai east section. Accident rates in each section have increased from year 2012 to 2014. When comparing A9 road section from Vavuniya to Jaffna with A9 road section from Kandy to Vavuniya with the same corridor geometry in 2014, A9 road section from Vavuniya to Jaffna shows a higher accident rate (0.68 x 10^{-6} per vehicle kilometre travelled) than other corridors (0.47 x 10^{-6} per vehicle kilometre travelled). In addition, fatality rate in A9 road section from Vavuniya to Jaffna has increased from 2012 to 2014, which is considerably a higher value than the fatality rates of road accidents in most of the other countries.

Key words: Fatality, Safety, Accidents, Vehicle kilometre travelled

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Weighted Plasticity Index (WPI) as a Screening Tool for Quality Control Measures

K.D.I.U. Kannangara[1]

Abstract

Expansive soils are one of the most problematic materials in road construction. Soil expansiveness is generally assessed by the Plasticity Index (PI) test. But PI test discards the fraction coarser than the 425μm test sieve as part of the test procedure. Therefore PI test does not well represent the whole sample. In Sri Lanka, residual soils are very common, with a high granular content in "clayey" soils. Therefore PI value often provides error in classification of residual clays.

Weighted Plasticity Index (WPI) is another parameter which can be used to assess the expansiveness of the soil. WPI is defined as the product of the PI and the percentage passing in the 425μm test sieve. Therefore WPI is accounts for both PI and percentage used in the test.

The objectives of the study are to find out correlations to WPI with soil CBR and CBR swell and then establish the WPI boundaries for soil materials such as embankment soil, shoulder soil & sub-base soil.

Soil data on different soil samples were collected and analyzed to find out above mentioned correlations. A soil classification method is developed for the subgrade soil based on the correlations obtained from the data analysis carried out and is given in the table 1 below.

Table 1: WPI Classification for subgrade soil

Soil Class	**WPI**	**CBR Swell**	**Potential for Volume change**
A	<1100	<1%	Low
B	1100 ≤ WPI<2250	1% ≤ CBR swell<2%	Medium
C	≥2250	≥2%	High

Further a case study was done using the soil data collected from the Outer Circular Highway (OCH) phase III project in order to validate the above mentioned WPI boundaries for subgrade soil.

Soil classification based on WPI provides meaningful solution to overcome the misclassification arises in PI test due to the usage of percentage passing in the 425μm test

sieve. Also WPI classification leads to significant savings while qualifying significant quantities of marginal material for road construction.

Keywords: Weighted Plasticity Index, Plasticity Index, Expansive soil

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Study of Behaviour and Impacts of On-Street Parking in Kandy Town

U.A.Gopallawa[1] and J.M.S.J. Bandara[2]

Abstract

Parking considered as one of the most important transport facilities in the urban area. The availability of parking, is related to the parking location, parking price, parking regulations and parking space available.

In a city, parking spaces are required by residents, employees, visitors and the moving traffic. With the increase in car ownership, parking is becoming a serious problem in cities, especially in the historical cities which were not designed for automobiles. This creates a tremendous pressure on parking, resulting in an increase in the demand for on-street parking in major arterial roads. Even though, the local government and regulatory bodies have introduced various initiatives with a number of policies and solutions, for parking in the city, the problems still exist due to inadequate understanding about the root cause of the parking problem.

For this study the historical city, Kandy, is taken as a case study, to analyse the major problem of on-street parking and to find out the root cause through the analysis of the behaviour, impact of the parking and the factors that influence drivers when parking.

As part of the methodology, on-street and off-street parking data, together with traffic volume data were collected and analysed, to identify the relationship between the on-street and off-street parking with the traffic volume. Further, GIS tools combined with the statistical analysis were used to find the demand for the two types of parking, at the same time determining the on-street parking attraction area and average walking distance to the on street attractive area, from the off-street parking area. Results show that motorists tend to park their vehicles on street in the morning hours. Also, results represents that users are attracted to park on the street without parking their vehicles in an off street car park, to reduce the walking distance to their destination.

In addition, impact of the on street parking of vehicles travel speed were analysed using a Google map related program, which calculates the travel time in pre-assigned road segments developed by the Planning Division, Road Development Authority. The data were analysed for three parking categories, based on the width of the road segments as narrow, medium and wide. The results show that a 10% rise in the on street parking caused the reduction of the speed of the traffic flow by 1Km/h and this is evident in all parking categories. This may be useful for policy makers to consider the role of on-street parking as part of their local area speed management strategies.

The study also presents a discussion on the policies of parking regulations and possible solutions for parking, in the area the study was conducted. The study envisaged that this would provide a more logical framework that could be adopted in decision making, and finding suitable solutions for traffic problems in similar situations.

Keywords: Parking, On-street parking, Off-street parking, Travel speed, parking behaviour

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Bitumen Emulsions as a Stabilizer for Substandard Soil

P.M.A.K Udayakantha[1], Prof W.K Mampearchchi[2]

Abstract

Sri Lankan road construction sector is dealing with an ever depleting construction material problem, specially finding good quality soil is becoming more and more difficult for projects over the past few years. The accelerated development demands a lot of natural resources and the extraction of resources like soil in mass scale also poses a great threat to the environment. Improving the substandard materials which are otherwise disregarded, can be a viable solution for the material shortage and may help environment conservation.

Stabilizing the soil is a well-known practice used to improve the engineering properties of the soil. There are many ways from which the stabilization can be achieved. But a reluctance to implement it has been developed because of the time consumption, expenses, the need for expert knowledge and the need of special machinery has developed. The research is to find the possibility of using bitumen emulsions, a product which can be handled and applied rather easily as a stabilizing agent for soil. The bonding characteristics of bitumen are expected to facilitate the extra cohesion between particles, inhibit permeability and result in improved engineering properties. The idea is to find out the viability of bitumen emulsion as a soil stabilizer for Sri Lankan road projects and whether materials marked as unusable can be used for road shoulders, sub base or embankment construction after improving.

To determine the characteristics of bitumen emulsion as a soil stabilizer, trial mixes, mixing bitumen contents varying from 2% to 6%, have being carried out, and the outcomes were observed. First the compaction was done soon after the mixing was finished and CBR was determined after 4 days of soaking. Since the results were not promising, the samples of the next approach were kept for five hours under normal conditions, and then compaction was done and 4 day soaked CBR was determined. The strength improvement characteristics may vary with the soil type and the construction steps followed .The curing time and the curing stage (after compaction or before compaction) has a significant effect on the strength gain. Also analysing the soil matrix at a micro level also should be done in order to get an idea about the strengthening mechanism.

Emulsion is not new to road construction. It is being used extensively for other purposes such as priming and cold mixes and is a very familiar substance for the industry. Using it on the site has many advantages over other stabilizers. Therefore, finding the possibility of the applicability of bitumen emulsion as a soil stabilizer is important.

Key words: Soil, Stabilization, Bitumen Emulsion

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Evaluation of Rheological Properties and Performance of Asphalt Binder Modified With Nano Clay

Y.G.P.B. Shantha[1], W. K. Mampearachchi[2], S.U. Adikary[3]

Abstract

The rheological behaviour of bitumen is very complex and it can vary from purely viscous to elastic, depending on the loading time and the temperature. Bitumen plays a major role in many aspects of road performance. Various investigations have been carried out related to the modified bitumen, to improve the performance of bituminous mixtures. Most of the Roads have failed due to the rutting and cracking of the bituminous layer, which is mostly due to the poor performance of bituminous binders. So, the modification of the bitumen is a major approach, and modified bitumen has been effectively used in many countries to construct pavements during the last three decades. This research presents a laboratory scale evaluation of the conventional and the fundamental rheological characteristics of modified binders with micro clay and Nano clay contain 2%, 4%, 6% & 8% by its weights.

Engineering fields widely use montmorillonite (MMT) Nano clay for a wide range of applications. In Sri Lanka also, there had been research about the usability and characterization of MMT clay available at Mannar area near the Giant tank. The clay powder prepared from the original samples taken from the above area were added to the original bitumen of 60/70 penetration grade binder to prepare the modified binder.

Modified bitumen samples were prepared at a mixing time of 25 minutes by adding Nano clay mixed at 160^0C. The properties of the modified binders with Nano clay were evaluated in terms of penetration, softening temperature, ductility and dynamic viscosity tests. Finally each sample of modified bitumen was evaluated for rutting and fatigue resistance for fresh and aged samples with the Dynamic Shear Rheometer (DSR) test.

It was observed by the results obtained from the tests that the softening point and viscosity increased up to 4% clay, penetration and ductility had decreased with the increasing of clay percentage. Rutting resistance had not improved compared to conventional bitumen and it showed that modified bitumen and the original sample showed PG 70 grade with 2%, 4%, 6% and original bitumen sample.

It can be concluded that the montmorillonite clay modification helped to improve some characteristics of the bitumen binders. But at this level they are not at a stage enabling the verification of their application at a large scale.

Key Words: Nano clay, Montmorillonite, Viscosity, Penetration, Softening point, Dynamic Shear Rheometer

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Potential of Applying Built-Operate Transfer (BOT) System for Sri Lankan Highways- Case study on Colombo-Katunayaka Expressway (CKE)

M.A.P. Perera[1], Dimantha De Silva[2]

Abstract

The Sri Lankan transport network had a massive development during the last decade, experiencing highway infrastructure with the utilization of foreign concessions and local government funds of the country. The Road Development Authority holds the pioneer authority to operate and maintain the system periodically. The user benefits generated with these highways include travel time saving, developed infrastructure and living standards, also social benefits which are not counter measured quantitatively.

As a developing country, the lack of financial stability for infrastructure of the government may lead to foreign loans and concessions. The concessions lead to rapid involvement in the fund involvement for mega infrastructure projects as the necessity and demand of the country. The Build - Operate and Transfer (BOT) concession model is becoming a major trend in the privatization of the infrastructure projects, the concession period and interest rate are the critical parameters for BOT contracts.

A model for the evaluation of the potential of applying BOT system for the highways is developed in the study. The demand estimation, operation and maintenance cost, and toll income are used as the inputs for this model and financial viability is observed with different scenarios. The concession period, interest rates and optimality of the selection of BOT are decided with different criterions based on financial viability. As the Colombo-Katunayake Expressway (CKE), meets the highest demand for traffic in the Sri Lankan highway network, it is used to demonstrate the applicability of the proposed methodology. To minimize the ridership guarantee, the gap in-between the accumulated revenue and accumulated costs, optimum subsidy level is eliminated by differentiating acceptable criterions. Also, the BOT model is further expanded with risk assessment with the current trends, applying the suitability of applying to the expected income gain interconnecting with the Outer circular highway (OCH), Southern Expressway and ongoing Central Expressway to the CKE with different scenario analysis by minimizing the ridership guarantee.

Key words: BOT, Concession period, Financial viability, Traffic demand, Ridership Guarantee

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Criteria Based Funds Allocation System for Sabaragamuwa Provincial Road Network

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Abstract

Sabaragamuwa Provincial Road Network (PRN) consists of 2625 km length of class C and D roads. Majority of the roads are interconnected through Road Development Authority (RDA) road network. Sabaragamuwa Provincial Council (SPC) usually expends 750 million Sri Lankan rupees (SLR) for routine maintenance work and another 2250 million SLR in the form of capital investments. Provincial ministry of roads usually select roads for maintenance and improvement works are done on a random basis and as requested by politicians or the community.

On the other hand, well-constructed PRN is very important for the sustainable economic development of the country. PRN provides transport infrastructure facilities for agricultural products and agriculture based industries. Several Provincial roads provide access to tourist attractive places like as Adams peak, water falls etc. Population of the Sabaragamuwa province is approximately 2 million and nearly 800,000 people use PRN roads for transportation purposes. Some of the PR can be effectively used to reduce the traffic congestion in the main arterial roads.

As far as highways are concerned, at least there should be two lanes to accommodate the two way traffic. According to the National Highway Act, all C class roads are considered as highways. Recent survey carried out by SPRDA reveals that twenty five percent of the C class road segments have a traffic flow greater than 1000 PCU per day. However, all C class roads are still single lane roads with a carriage way width of 3.0 m to 5.0 m.

SPC has already invested nearly 50,000 million SLR for road works under the capital investment projects IRDP, JICA World bank and ADB etc. Present value of recurrent expenditure is also in the range of 20,000-25,000 million SLR. This gives a clear indication that after investment of 75,000 million SLR for the improvement and maintenance of provincial roads, desired targets could not be achieved.

Technical feasibility reports were prepared for individual capital investment projects and there was not any master plan to improve the entire road network cost effectively. According to the general definition, C class roads serve as collectors and connector roads and D class roads serve as collector roads and distributors.

This research paper deals with the fund allocation for the PRN under different conditions. Annual allocation starting from 100 million to 20000 million SLR will be considered for the analysis.

C class roads will be classified in to six groups depending on the vehicle flow rate, beneficiaries served by the road segment, interconnectivity, and present condition of the road. Similarly D class roads will be classified in to five groups. Cost benefit curves will be prepared for each group by considering capital investment as an independent variable. Dynamic programing method will be used to work out the optimum fund allocation at various stages.

Key Words: Provincial Roads, Network, C Class Roads, D Class Roads