Transport Research Forum 2019

Abstracts

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University of Moratuwa, Sri Lanka

Transportation Engineering Group

Department of Civil Engineering

University of Moratuwa

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Keynote Speakers' Profile

Associate Professor Russell G. Thompson

Department of Infrastructure Engineering

The University of Melbourne

Dr. Russell G. Thompson is an Associate Professor in Transport Engineering has a Bachelor's Degree in Mathematics (RMIT), Masters in Transport Engineering (Monash) and a PhD in Traffic Engineering (The University of Melbourne). For the last 15 years he has been involved in numerous local freight studies, including the Melbourne's Freight Movement Model and the Victorian Freight and Logistics Plan. Russell is a Team Leader of the Volvo Centre of Excellence in Sustainable Urban Freight Systems and Vice-President of the Institute for City Logistics based in Kyoto. Currently, Russell is actively involved in several urban freight projects in Melbourne including Freight Villages and Loading Dock Booking systems. He is currently supervising research projects involving modelling logistics sprawl, deliveries to towers, road pricing, collaborative freight systems and autonomous freight vehicles.

Russell is also active in a number of projects relating to the shared economy, including Integrating Mobility on Demand in Urban Transport Infrastructures (iMoD) and Urban Futures – Mobility Demand. Russell has contributed to a number of local and international studies relating to urban freight, including the European Union's Best Urban Freight Solutions (BESTUFS) project and the OECD report on urban distribution. He was a founding Director and has been the Vice President of the Institute for City Logistics based in Kyoto since 1999. Russell has co-authored over 10 books and 90 refereed publications. He recently co-edited a book, "City Logistics: Mapping the Future" (CRC Press, 2015) that presents a range of innovative solutions to increase the efficiency and reduce the impacts of freight in cities.

Russell heads the Transport and Logistics Unit in the Centre for Disaster Management and Public Safety (CDMPS) at the University of Melbourne and is currently supervising a number of projects including, traffic management points (road closures), driver warning and route guidance systems, distribution systems for relief supplies as well as strengthening and recovery schedules for transport networks.

Abstract (Keynote Presentation Brief)

There are many challenges that are threatening the sustainability and efficiency of urban freight systems. Rising levels of congestion in cities is leading to a growth in negative impacts such as emissions, noise and crashes.

The presentation will introduce city logistics and provide an overview of solutions that can be designed and implemented, including a description of how

(i) shared use of storage facilities and delivery vehicles in inner city areas can increase the consolidation levels of trucks
(ii) improved management of curb-side loading zones can reduce delays for carriers and other traffic
(iii) reservation systems at ports and loading docks can decrease queues at major activity hubs

Session 1A
Traffic Engineering and Safety

Traffic Conflict Analysis for Pedestrian Crossings at Un-Signalized Pedestrian Crossings in Kandy

M.C.C. Abeyrathne[1] and N. Amarasingha[2]

Abstract

Road traffic safety is normally measured in number of crashes and the consequences of the crashes in terms of severity. When the crash data are not available, the Traffic Conflict Technique (TCT) is used as an indirect method for determine the magnitude of the safety problem. TCT provides information on relative risks to diagnose the types of problems at a particular location, and it represents efficient tool to check location safety issues when there is limited or no crash data. The Lane Based Post Encroachment Time (LPET) will be the conflict analyzing method which used by many researches including Almodfer et al. (2016) followed to identify the pedestrian traffic safety in this study. LPET is the time difference between when the pedestrian leaves the conflict zone and at the same starting time when the vehicle approaches the conflict zone related to each lane. Pedestrian crossing area will be selected as the conflict zone in this method. For each pedestrian who uses the conflict zone, the time of he/she leaves the conflict zone and the time of the vehicle arrives the conflict zone is recorded.

This study was conducted at two marked un-signalized crossings in Kandy; Katugasthota - Kandy road and Peradeniya-Kandy road. The pedestrian crossings which were selected to conduct the research were on four-lane roadways having flexible pavements with good condition. Data were gathered monitoring the videos recorded during the peak hours at the pedestrian crossings. For each pedestrian crossing 100 pedestrians were observed covering the approaching from both side of the crossing. The pedestrian crossing in Katugasthota-Kandy road had 50.5% of slight conflicts, 24.5% of serious conflicts and 25% potential conflicts for one direction. The other direction had 50.5% slight conflicts 33% of serious conflicts and 16% of potential conflicts. The crossing at Peradeniya-Kandy road had 40% of slight conflicts, 34% of serious conflicts, and 26% of potential conflicts for one direction. The other direction had 36% of slight conflicts, 39% of serious conflicts, and 25% of potential conflicts. The percentage of serious conflicts in Katugasthota-Kandy road crossing was high that may be due to the placement of a Filling station in front of the pedestrian crossing. Also, the existence of a bus stop near the pedestrian crossing in Peradeniya-Kandy road may be the reason for high percentage of serious conflicts in that crossing.

Keywords: Pedestrian Safety, Non-signalized Crosswalk, Conflict Analysis

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The Physical Components of Noise and Vibration of Rail Transit and its Effects including Control Measures

Lakshmi Narayanan[1]

Abstract

Noise pollution generated by transport is acknowledged to be a major environmental problem. The use of environmental noise barriers, already widespread in Europe and the USA is now becoming increasingly important, changing the face of our road and railway networks and this in large urban areas is regarded as a growing problem of communities and there are various factors that contribute to increase of noise levels in urban areas.

One of the factors is the increase in urban population, which contributes to high traffic volume combined with increased intensity. In most urban areas, the corridors are developed in a proximity where people live and work, which led to limited space and thus increase the number of high-rise buildings. This type of settlement created a dense environment in urban areas, thus increasing the traffic volume. Numerous countries have implemented new technologies to control noise pollution in urban areas. For example, low noise generating engines, changes in quality of vehicle tires and changes in road material and these technologies have proven to reduce the noise on individual scale and as the overall noise pollution in urban areas is still increasing because of increasing traffic volume.

It is of great importance that noise modelling software on multiple noise scenarios and must be able quickly and reliably to turn these models into noise maps and these maps are used to assess and monitor the influence of the noise effects as well noise maps can be helpful in planning and decision-making processes for reducing the noise pollution.

With the speedy development of urban mass transit system, more and more environmental concerns are focused on the vibrations from underground trains. Vibrations can arise from the passage of trains inside the tunnel and spread through the tunnel and surrounding soil into nearby buildings. Ground-borne vibration can be a serious concern for nearby neighbors of a transit system route or maintenance facility, causing buildings to shake and rumbling sounds to be heard. In contrast to airborne noise, ground-borne vibration is not a common environmental problem. It is unusual for vibration from sources such as buses and trucks to be perceptible, even in locations close to major roads. Some common sources of ground-borne

vibration (other than train) are buses on rough roads and construction activities such as blasting, pile-driving and operating heavy earth-moving equipment.

Vibrations in buildings associated with rail network operations can cause disturbance and complaint in a similar manner to noise. It needs to be considered at the infrastructure planning stage as is difficult to mitigate retrospectively.

Keywords: Noise modelling, mapping, noise barrier

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A Quantitative Review on Travel-Time Reliability Measures

C. J. Vidanapathirana[1] and J. M. S. J. Bandara[2]

Abstract

The time spent on a trip which is termed the 'travel time' is a key parameter in effective journey planning. Having an understating about the travel time for a specific journey is crucial when deciding upon the departure time and route choice. With the advancement of technology, services and products have been introduced which provide travel time data and estimations to fulfil the journey planning needs. These are popularly being used by most of the travellers worldwide since the traffic conditions have become fairly unpredictable in the past few decades.

A common concern the travellers have today is the accuracy of the estimated travel times. Since the estimations are based on historical data and real-time data, an accuracy of 100% can't be achieved. Further, travel time depends on parameters which create uncertainty such as traffic composition, junction delays, pavement conditions, roadside accidents, special events (e.g.: a protest march) and weather. Some of these parameters can neither be quantified nor be predicted.

Studying the reliability of travel time became a major focus area in the field of transportation engineering with these recent developments. Various studies have been conducted in the interest of developing travel time reliability measures. Most commonly used travel time reliability measures are 95th percentile travel time, buffer index, planning time index and travel time budget. It is important to mention that such measures need to be simple and easily understood by people who aren't thorough with technical knowledge. If not, the public will not be able to incorporate travel time reliability for journey planning purposes.

This study is a review on the usability of travel time reliability measures. What is expressed by each measure, how they can be interpreted and how helpful they are for the users are discussed through this analysis. A large data set of travel times was used to develop reliability measures for a selected set of road links. Verification of the results was done afterwards. Mainly this can be described as a quantitative review with a qualitative analysis on the final outcomes.

Keywords: Reliability measures, Travel time

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Analysis of the Level of Safety of Public Transport in a 'Sustainable Development Goals' Perspective in the National Context

T. Thilakshan[1] and J.M.S.J. Bandara[2]

Abstract

In 2015, Sri Lanka along with 192 member countries of the United Nations identified the timeliness of the concept of 'Sustainable Development Goals' (hereforth referred to as SDGs) and mutually expressed their desire to work individually and collectively to achieve the SDGs by 2030 post the Millennium Development Goals tenure from 2000 to 2015. It can be observed that the diverse nature of the context of the goals and their targets is a cross cutting concern dissecting many sectors and concerns listed by the 17 goals and 169 targets.

Sustainable Transportation in the context of the United Nations has been classified into five dimensions: Accessibility, Affordability, Safety, Security and Environmental concerns. In this context, Public Transport plays a significant role in the sustainable transportation spectrum. Public Transport Safety is analyzed in this study in a global and national perspective in the context of the overall safety in transportation. The study narrows down to the concept of Public Transport safety which is identified as the one of the largest negative concerns in the current arena with a large number of commuters using the same mode at a given point of time involving high human intervention. Two targets listed in the SDGs give direct leverage to Road safety which also apply in the case of Public Transport: SDG target 3.6 - Halve the number of road traffic deaths and injuries by 2020 and SDG target 11.2 - Provide access to safe, affordable, accessible and sustainable transport systems for all by 2030.

The Global Sustainable Transport Conference which was held on the 27th and 28th of November 2016 in Ashgabat, Turkmenistan highlighted the importance of sustainable transport in promoting economic and social development while protecting the environment and the main concern was the large number of annual deaths from road traffic accidents along with the environmental impacts of transportation. In both regards, Public Transport plays an important role and the safety assurance of Public Transport is one of the main dominating factors in attracting people to Public Transport modes, which mainly constitutes buses and trains in the national context.

Thus, the study identifies the importance of Public Transport safety to achieve sustainable transportation and SDGs while analyzing the current status of Public Transport using available data and statistics in a national perspective. Apart from studying the pattern of Public Transport in terms of deaths, injuries and related parameters, more concern in the study

focusses on the post 2015 SDG timeframe to evaluate the impact of the SDG framework in the context of road safety and the practicality of achieving the SDGs: target 3.6 by 2020 and target 11.2 by 2030 in the perspective of Public Transport. 90 percent of road traffic deaths occur in low and middle-income countries even though the countries count to only 54 percent of the world's vehicles percentage. Sri Lanka is no different in terms of the crucial impact of road safety and analyzed data from the National road safety council of the Ministry of Transport and the Sri Lanka Police show no decrement in terms of road safety accidents and resulting deaths, injuries and damages. The analysis looks into the impact of Public Transport to the overall safety scenario and the steps that needs to be taken in dealing with Public Transport based safety issues with utmost importance due to the large number of lives involved in the scenario and the attraction factor of people towards using Public Transport as an alternative for their private vehicles.

The number of private passenger transport buses and Sri Lanka Transport Board (SLTB) involved in the accidents and their rate of involvement in an annual and monthly timeframe is analyzed along with the accident type. Thus, an analysis on public transport buses is carried out in an individual and overall (Private and SLTB buses) manner for better understanding. An analysis framework of the Railway sector and accidents in a periodic timeframe along with the category of railway accidents involving the railways is included in the study. Thus, the study analyzes the overall Public Transport in the national context with respect to safety and the reasons involved in the accidents along with evaluating the current position of the transport sector in terms of sustainable transportation in terms of public transport and achieving the SDGs in the national context.

Keywords: Sustainable Development Goals, Road Safety, Accidents, Public Transport

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Development of methodology to estimate trip attraction and parking demand for urban office developments: Case Study- Colombo

Madara Priyadarshani[1] and H.R. Pasindu[2]

Abstract

Urban commercial developments are an integral part of the urban land use and this affects the trip generation and attraction pattern in the city. More importantly these developments increase the demand for parking, which by law should be provided within the development. Lack of adequate parking facilities will impact the road network as it will lead to on-street parking and additional vehicular circulation to and from public car parking areas. Furthermore, provision of parking within the premises results in an increase in the cost to the developer which can escalate the prices of the property. Moreover, due to lack of local norms to indicate accurate traffic generation factors for different types of developments such as office complexes, business establishments etc., it is hard to forecast accurate future traffic figures that will generate due to the proposed new developments. Therefore, regulations need to ensure adequate number of parking are stipulated based on the type of facility.

Parking regulations for office building type developments used for the city of Colombo is based on gross floor area of the building, which may not necessarily represent the parking needs of the building depending on the type of operation which takes place. Therefore, the existing parking regulations for these types of development need to be revised in order to assess the optimal parking requirement for different types of office buildings. The study develops a methodology to estimate trip attraction patterns and parking demand for urban office developments. For that research aims to evaluate the trip attraction patterns for different types of office developments and it investigates the effectiveness of current parking regulations and calculation methods in Sri Lanka. Similarly, it identifies new criteria to evaluate parking provisions for the new office developments. Finally based on study results parking demand and trip attraction rate will be assessed.

Keywords: Parking demand, Trip attraction

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Session 1B
Pavement Materials

Effect of Styrene – Butadiene – Styrene (SBS) on Mixing Process and Laying of Asphalt Concrete

V. Varshihan[1] and W. K. Mampearachchi[2]

Abstract

Construction of flexible pavements involve the production and utilization of asphalt concrete (AC) for the wearing course and the binder course. The sustainable production of AC mixtures has become a major concern internationally. Recycling of waste polymer materials can be identified as an effective method which improves the aspects of sustainability and economy of highway construction projects. This research was conducted to investigate the modification of asphalt properties using Styrene-Butadiene-Styrene (SBS) as a modifier and to check the performance of the modified asphalt mixtures in the aspects of the quality and the cost at plant scale production.

At the initial phase, the selected bitumen binder was mixed with the SBS modifier to produce an AC mixture in which SBS acts as a binder modifier for bitumen, and as a filler modifier for aggregates. Mix design details for AC were obtained from the Marshall mix design. The first set of production was done for 6% of SBS to the total bitumen weight. SBS was added quickly to the pre-blending bitumen tank while stirring at 180 °C -190 °C temperature during the wet process. Then the mixture was allowed to flow through the high shear mixing and dissolving tank to produce a uniform mixture. Subsequently, the modified bitumen was mixed with the aggregates at a mixing temperature of 170 °C – 180 °C. Then the mixture was placed before it reaches the recommended laying temperature of 140 °C.

The optimum compacting temperature was obtained by changing the temperature of the mixture. The asphalt mixture was heated at the respective temperature and it was kept for 10 minutes at boiling water temperature to find the mixing temperature for a better coating of the modified bitumen.

At the final phase, the physical properties of asphalt mixtures were investigated using Marshall test parameters including the stability value, the flow value, the percentage of air voids, and the percentage of voids in mineral aggregates (VMA). Wheel tracking test was also conducted. Cost analysis of the above production process was investigated by varying the parameters of the plant operation such as the mixing time, the control temperature, and the set of plant modifications. Considering the outcomes of this research, it is recommended to improve the efficiency of the plant operation processes for the modification of AC. This will also enhance

the sustainability by minimizing the hazards to the environment due to the waste polymer materials causing environmental pollution.

Keywords: Asphalt concrete, SBS, Aggregates

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Sub Base Improvements by Stabilization Techniques using Waste Materials

T. Sathiyaparathan[1] and H.R. Pasindu[2]

Abstract

Improvements of rural roads are vital socio-economic pathways to a better quality of life for most of the Srilankan people living in rural areas. The fund allocated for low volume road project is limited, thus it is important to use existing resources for economic advantages. Also, adverse environmental impact can be reduced. Roads are designed for low-volume traffic and are constructed of local soils containing high percentages of fines and high indices of plasticity. These soils may not have characteristics appropriate for the sub base in the construction of flexible pavement in rural roads. Thus, it is necessary to modify or stabilize this kind of soil to make it suitable for construction. The soil modification process can be effectively used to meet the challenges of sustainability of the environment, to minimize the adverse effect of industrial wastes such as plastic, glass, paddy husks, etc. Wastes are increasing day by day leading to various environmental concerns. Therefore, the disposal of those wastes without causing any ecological hazards has become a real challenge. Thus using plastic waste, glass waste & paddy husks as stabilizing agents is an economical utilization since there are demand and shortage of good quality soil for sub-base. This research involves a detailed study on the possible use of the waste products for soil stabilization for the sub-base material in the North Central Province I-Road Project in Sri Lanka.

A series of field and laboratory tests were carried out for collected sub-base materials to identify the deficiency of sub-base material properties. ICTAD specification for the roads was referred and confirmed to the specification for the road projects in Sri Lanka. The specification says that Liquid Limit should be less than 40 (LL<40) and Plasticity Index should be lesser than 15 (PI<15). Sub-base materials from Polonnaruwa area were stabilized with different percentage of paddy husk ash, plastic waste and glass waste with weight-based mix proportions. But the experimental study demonstrated that with an 8 % mix of paddy husk ash as a reduction in Liquid Limit by 20 % and Plastic Index by 26 % was achieved. Also, California Bearing Ratio of the stabilized sample was improved by 10% as well. Finally, it was concluded that the stabilized composite soil can be used for the construction of flexible pavement in rural areas with low volume traffic.

Keywords: Sub base, Stabilization, Liquid Limit, Plastic Index, Waste Material, Paddy Husk Ash

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Thin Lift Asphalt Concrete Pavements for Low Volume Roads

P.M.A.K Udayakantha[1] and W.K Mampearachchi[2]

Abstract

Sri Lankan road construction sector is dealing with ever depleting construction material problem specially finding good quality aggregate has become more and more difficult for projects over the past few years. The accelerated development demands lot of natural resources and the extraction of resources like aggregate in mass scale also pose a great threat to the environment. Using the available resources sparingly and optimally is the way forward to brace the scarcity of construction material we are about to face.

There are many projects in progress to upgrade low volume roads. But the designs are done using 50mm asphalt wearing course which is a very conservative approach given the traffic movements of the roads are very much low. For the traffic levels in such roads by using a thin asphalt layer which is between 25mm-35mm the same design life could be achieved while cutting down costs significantly. The aim is to adopt a mix which can be laid in thin layers and perform well in Sri Lankan conditions.

To determine the characteristics and performances of thin layers first a suitable 10mm aggregate mix should be selected, for that mixes in section 404 of VicRoads August 2018 were selected and SMA10N mix was selected from the available mixes due to replicatability of the mix using available plant hot bins. Then Marshals were casted using the average line of the aggregate gradation and mixing with 60-70 penetration grade bitumen and tested for their properties. It was evident that though all other properties were satisfied except the VMA values, the specification requires addition of cellulose fibres to the mix but literature and availability prompt the use of glass fibers which exhibits superior properties. Addition of glass fibers 0.1%-0.2% can increase the air voids and VMA values while retaining the other parameters in specification range. The glass fibers can be used to manipulate mix properties in order to get desired properties and a satisfactory mix. The addition of fibers may also increase fatigue life and it should be checked using indirect tensile test.

Keywords: Thin Asphalt, Rural Roads

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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] and S.U. Adikary[3]

Abstract

The rheological behavior of bitumen is very complex and it can be varied 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 are failed due to the rutting and cracking of the bituminous layer which is due to the mostly poor performance of bituminous binders. So, the modification of the bitumen has been major approach in today and modified bitumen is effectively used in many countries during last three decades to construct the pavements. 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 are widely used montmorillonite (MMT) nano clay for wide range of applications. In Sri Lanka also, there had been few researches about the usability and characterization of MMT clay which is available at Mannar area near to the Giant tank. The clay powder prepared from the original samples taken from the above area was added to the original bitumen of 60/70 penetration grade binder to prepare the modified binder. The prepared clay powder was subjected to the X- ray diffraction to identify the MMT clay.

Modified bitumen samples were prepared by adding nano clay mixed at 160^0C with the mixing time of 25minutes. The properties of the modified binders with nano clay were evaluated in terms of their properties using penetration, softening temperature, ductility and dynamic viscosity tests. Finally, modified bitumen each sample were evaluated for the rutting and fatigue resistant 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 has decreased with increasing of clay percentage. Rutting resistance has not improved with compared to conventional bitumen and it was showed that modified bitumen and original sample were showed PG 70 grade with 2%, 4%, 6% and original bitumen sample. Finally, few samples of modified binder with nano clay was checked with Furrier Transform Infrared Spectrometer (FTIR) to identify any chemical changes with compared to conventional bitumen. As a conclusion from these findings that is

the montmorillonite clay modification helped to improve some characteristics of the bitumen binders. But at this level they are not at the stage to verify application at large scale.

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

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Feasibility Study of using Industrial Waste as an Internal Curing Aggregate for Rigid Pavements

K. I. Pradeep[1], T. Tharshigan[2] and W.K. Mampearachchi[3]

Abstract

The hydration process of cement in concrete affects the temperature conditions and moisture content which indirectly cause for strength, shrinkage and cracks. Curing starts immediately after setting of concrete. American Concrete Institute describes curing as "action taken to maintain moisture and temperature conditions in a freshly placed cementitious mixture to allow hydraulic-cement hydration and, if applicable, pozzolanic reactions to occur so that the potential properties of the mixture may develop". In external curing of rigid pavements, water inside the concrete consumed for hydration of cement, some part of water escapes to the atmosphere through concrete surface and some part absorbs to the ground. Thus. Internal drying occurs which reduces the relative humidity while increasing the internal stresses which results in shrinkage and thermal cracks. External supplied water will only affect for top part of the concrete layer.

Internal curing method has been introduced as a solution to the problems encountered in external curing. According to American Concrete Institute, they defined internal curing as "a process by which the hydration of cement continues because of the availability of internal water that is not part of the mixing water". It's a method which supply water internally through water reservoirs which need for hydration process. This research is to develop a fine aggregate for rigid pavements which performs the internal curing properties using industrial waste. Water treatment sludge (WTS) and Textile Effluent sludge (TES) used as industrial waste to prepare fine aggregates. After several steps in treatment process to remove inorganic, organic contaminants and suspended solid particles in surface water, produce large quantities of sludge by removing impurities from raw water. Sludge removed from above process called 'water treatment sludge'. Textile industry consume large amount water to convert raw materials and fabric to finished clothing materials. Specially for dyeing. So large quantity of sludge produces in the waste water treatment plants due to this case. The disposal of sludge from water treatment plants and textile dyeing industry is a huge issue for related authorities. Introduce a value-added product for waste sludge will be another solution for the waste. The water treatment sludge and textile effluent sludge was dried under sunlight and crushed in to powder form which passing through 0.6mm sieve. Thermogravimetric analysis and Differential scanning calorimetry are conducted to identify the thermal behaviour of sludges. Different

mixtures were prepared by changing two sludge contents (100% WTS, 90% WTS+10%TES, 80%WPS+20%TES). Atterberg limits was initially identified to select the optimum water content need to mix the samples. For laboratory tests, cylindrical samples (Height; 80mm, Diameter; 17mm) were prepared for heating process. Slow heating method used to sinter the samples for different temperature levels (800^0C, 900^0C, 1000^0C, 1100^0C, 1200^0C). Then samples were crushed to small particles which passes through 4.75mm sieve and retained on 0.6mm sieve. Water absorption test, Relative density test, bulk density test was conducted to observe the physical properties of developed fine aggregates. Scanning Electron Micrographs (SEM) analysis was followed to observe the microstructure of the fine aggregates. Compressive strength test was followed to identify which temperature shows the higher strength of fine aggregates. According to ASTM C1761M, internal curing aggregate shall have a 72-h absorption not less than 5%. Also, the fine aggregate shall release at least 85% of its absorbed water at 94% relative humidity. When Kelvin equation combined with Young's equation, a relationship between relative humidity and size of the pores being is established. According to the relationship, the pore size should be more than 200nm to release water from aggregate.

The fine aggregates which developed using sludge waste shows higher water absorption which need for internal curing property. According to the SEM analysis, it shows that the pore size increases with the temperature and textile effluent sludge content. According to thermogravimetric analysis, compressive strength test and microstructure, it concludes that 1150^oC is the optimum temperature to heat the sludge waste. The optimum textile effluent sludge and water treatment sludge were selected as 20% and 80% respectively, while 45% of water content should be added when preparing the mixture. As a conclusion to the above findings, the fine aggregates which developed using sludge waste feasible to use as an internal curing aggregate in rigid pavements.

Keywords: Water Treatment Sludge, Textile Effluent Sludge, Internal curing, Microstructure

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Session 2A
Transport Planning

Logit Choice Model for Boat Passenger Transportation in Colombo, Sri Lanka

S.M.D. Kaushalya [1] and G.L.D.I. De Silva [2]

Abstract

Public transportation service in Colombo canal network is a viable alternative or addition to road and rail road on Colombo Metropolitan Region (CMR) corridors. Though environmentally friendly and frequently, the most economical mode of canal boat service, it remains largely under exploited in Sri Lanka. The prevailing public transportation modes such as bus, train and private transportation modes such as cars, motor bikes and taxis play vital roles in passenger movements within the country. But with the increasing population and the land scarcity in CMC region vast traffic and congestion problems exists in prevailing conditions. Thus, introducing another transportation mode is essential for future. Lack of data availability in the transport mode choice modelling has create problems implementing passenger boat transportation in CMR that leads to do more researches in the field. This study intends to present an idea of developing suitable passenger choice model on the basis of discrete choice modelling technique. ALOGIT software has been used for model setup and data analysis process. A stated preference pilot survey has been carried out in CMR region by proposing a public boat service route from Wellawatta to Battaramulla. The model was done for single level logit model. ALOGIT model was estimated to develop utility function to get an idea about people's behavior patterns based on their socio-economic characteristics like age, gender, income level and based on travel characteristics like journey time, journey cost, waiting time, transit time. Further, separate travel characteristics, boat journey time and boat journey cost has been introduced to the model setup to identify public opinion of suitable fare terms for public boat transport service along the Colombo canal network. Results of this study provides an insight to incorporate boat transport service within the mainstream of CMR transportation planning.

Keywords: ALOGIT Model, Colombo Metropolitan Region, Boat Transport

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The Evaluation of Factors Influencing Cycle Trips in a Heritage City. A Case Study on Cycling Tourist in Anuradhapura Sacred City

S.S. Wanniarachchi[1] and G.L.D.I. De Silva[2]

Abstract

As the world endures an energy dilemma, most developing communities advance toward energy efficient modes and non-motorised transport modes such as walking, roller skate, skateboard and cycling. Cycling is an environmentally friendly mode that enables the commuter to experience the surroundings. Other than commuting, cycling-tourism is about a long to medium distance cycling trip for pleasure, experience, and liberty rather than exercise or sports. Being one of the major tourist attraction zones in Asian region, Sri Lanka experiences over two million tourists' arrivals every year to visit South and East Coast, Ancient Cities, Hill Country and Northern Region. Anuradhapura is one of the well-known ancient cities with many historical monuments connected with roadway links. This study identifies the design and influencing factors of local and foreign tourists to encourage cycling within the Anuradhapura ancient sacred city rather than using 3-wheeler taxi or other motorised travel methods.

As phase 1 of the research, an initial survey was carried out inside the Anuradhapura sacred city with a sample of twenty-one respondents out of the target population of local and foreign tourists. Data has collected through a questionnaire survey and discussions. The factorial extraction has been run to determine the factors influencing cycling tourism, and descriptive statistics have used to present the socio-demographical features of the study sample. The secondary aim of the research is to review the variations in soft mobility choices by local and foreign tourists based on the design and the extracted manipulating factors.

The analysis of data has generated factors with very strong loadings to represent the variables used in the survey. The descriptive analysis shows that the majority of the tourist visit Anuradhapura for pleasure, religious and business. Most of the tourist respondents had arrived from East Asia and Europe. The study explains that majority of them has used motorised transport to arrive at Anuradhapura and after arriving has used cycling within the sacred city. The analysis has highlighted that greater number of tourists prefer to use cycling for a short distance journey. The respondents have commented that safety and security issues have been a major tragedy in riding cycles inside the sacred city. It had mentioned that potholes in the road and the areas where the road has been damaged and unpaved had caused notable

accidents to the cycling tourists. The risk of theft and the awful surroundings in some areas of the sacred city has discouraged cyclists from riding through the area. The further discussions with cycling renters and cyclists have highlighted that the cycling tourist, both local and foreign have been relying on verbal instructions of landmarks and road, as the Anuradhapura tourist city map provided by the Ministry of Tourism - North Central Province and the google maps has not been providing the accurate information on the routes and pathways inside the sacred city.

The effort of the research is to help town planners prioritise services and improvements designated to the location to promote cycling tourism. Sri Lanka's tourism is one of the revenue generations industries through cycling tourism in the early stages of development. This study has taken a general view concerning the influencing factors of Anuradhapura scared city cycling tourism to develop the cycling within the sacred city and to develop the soft mobility within the Anuradhapura district ensuring more eco-friendly urban surrounding.

Keywords: Anuradhapura, Factorial analysis, Cycling tourism

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A Review on Demand Responsive Transportation System

R. D. S. S. Randeniya[1], W. U. L. D. P. Perera[2] and A. Anburuvel[3]

Abstract

Public transport services are generally of a reasonable standard on the main corridors of many countries, they tend to be inadequate; to meet users' needs in rural and other low population density areas, for servicing during off-peak times and to operate specialist community-based services for elderly population and differently-abled population. As the next level of transport services, the para-transits are not capable of managing high demands and not affordable for a considerable number of passengers because of the high cost. Providing regular transport services to all regions of sparse population is not economically feasible. These reasons have paved the way for the implementation of Demand Responsive Transport (DRT) all over the world.

DRT is a class of flexible transport services in which a fleet of vehicles dynamically changes routes and schedules, in order to fulfill the individual passengers' requests through door-to-door rides by specifying their desired start and end locations. Manifestations of Special Transport Services (STS) have provided dedicated solutions for special groups in parallel to the conventional public transport network. But to meet the growing demand more effectively and efficiently with low cost, DRT has evolved towards developing a niche for the general public. (Nelson, Wright, Masson, Ambrosino, & Naniopoulos, 2010). Further DRT evolved for feeding the conventional public transport network to provide wider access and opportunities. [e. g. Bus Rapid Transit (Lindau, Hidalgo, & Lobo, 2014)]. The Melbourne Telebus which has been operating in this concept for over 30 years is a hybrid falling somewhere between a full dial-a-ride service and fixed-route bus service. (Scott, 2010). With the support of advancements in vehicle tracking, communication and computing, automated demand responsive transport systems (Winter, Cats, Correia, & Arem, 2016) have been implemented recently.

Sri Lanka has a public transport system supported by para-transit services which are plenty in big cities and towns (e.g. Colombo, Galle, and Kandy). However, the sparsely populated areas (e.g. Kilinochchi, Moneragala) have insufficient, inaccessible public transport and a limited number of high-cost para-transit services. Approximately 80% of the population in Sri Lanka is in sparsely populated areas. (Lanka, 2012). And also with the rapid increase in elderly population, the portion of differently-abled population in Sri Lanka [87 per 1000 persons

(Disability in Sri Lanka - the United Nations, 2012)], as well as the increase in dispersed land-use patterns emphasize the necessity of door-to-door effective transport. A more effective and advanced DRT system is an immediate need for Sri Lanka covering a wide spectrum. By adopting the best practices of successful services DRT can have a role to play within the transport sector in sparsely populated areas in Sri Lanka.

Keywords: Demand Responsive Transportation, Public Transport, para-transit, sparse population

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Development of Bus Service Reliability Measures at the Stop Level

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

Abstract

Bus service reliability, one of the key performance measures, has become a major concern of both transit operators and users because it significantly affects user experience and service quality perceptions. Schedule adherence has been the most important existing reliability measure for infrequent services that operate with headways of more than 10 minutes. For routes characterized by high frequency service namely less than 10 minutes of headways, headway variability has been the most important existing reliability measure. But these measures do not differentiate between the cost of being early versus late. Different unreliability characteristics that cannot be captured by the existing measures calls for a supplementary measure. This research adopts two indices from (Saberi, et al., 2013) that overcome those issues such as Earliness Index (EI) and Width Index (WI). The Earliness Index is defined as the percentile rank of delay/headway deviation of zero. The percentile rank of a particular delay/headway deviation is the percentage of delay/headway deviations in its frequency distribution that are lower or equal to it. EI ranges between 0 and 1. For frequent services, an EI of 0 represents the "all behind schedule" condition and an EI of 1 represents the "all ahead of schedule" condition. For not frequent services, an EI of 0 represents the "all late" condition and an EI of 1 represents the "all early" condition. For infrequent services, the theoretical ideal distribution lays on the y-axis of the cumulative distribution function. Buses that are early can be treated as being one headway late, because passengers who are arriving near the scheduled departure time would have to wait for the next bus. Therefore, the "all late" condition is expected to be the achievable ideal distribution for non-frequent services to avoid early departures. Note that the above statement is true only when the theoretical ideal distribution (all "on-time" condition) is not achievable. The closer the EI is to 0, the more reliable is the service. For frequent services, one cannot argue similarly, since maintaining a fixed headway with a small deviation is more important than being ahead of or behind the schedule. Thus, another measure is required to capture the variation of headways.

To capture the width of the distribution of headway deviations in frequent services, the Width Index (WI) is defined as the 95th percentile of headway deviations minus the 5th percentile of headway deviations divided by the average scheduled headway.

Data needed for theses are as follows. Using the existing time keeper records at the bus stops, a number of measures can be simply calculated. The scheduled headway at a particular stop can be computed as the scheduled stop time for trip i at a stop minus the scheduled stop time for trip $_{i-1}$ at the same stop:

Note that the proposed reliability indices are not suggested as replacements for the existing measures; rather, they are complementary.

Keywords: Bus service, reliability, stop level

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A GIS based Methodology to redistribute Macro-Level Origin Destination Data based on the Landuse

Oshadhi Weerasinghe[1] and J. M. S. J. Bandara[2]

Abstract

The Origin-Destination (OD) data are often collected for the transport infrastructure planning projects to study the travel patterns. Conducting OD surveys are expensive and time consuming. Therefore, the practitioners tend to collect OD data according to a macro level zoning system. In Sri Lankan context; OD surveys are conducted based on Divisional Secretariat Division (DSD) boundaries. Further, OD surveys within major towns, such as Colombo, Kandy were conducted, considering the smallest administrative boundaries in Sri Lanka; the Grama Niladhari Division (GND).

Since the trip production and attraction is related to the landuse pattern of an area, the landuse can be considered as an independent variable in estimating the trip generation. Two models were developed to demonstrate the relationship between landuse (landuse floor area in m^2) and the trip generation as follows;

Trip production = 9117.980 + 1.425 (Private offices) + 0.792 (Educational) + 0.174 (Commercial) + 0.466 (Tourism) + 0.007 (Residential) ------(1)

Trip attraction = 6914.287 + 0.201 (Commercial) + 0.730 (Educational) + 0.189 (Health) + 0.010 (Residential) + 0.551 (Tourism) ------(2)

The research leads to redistribute the macro-level OD data into a modified zoning system based on its landuse character; specifically, DSD level OD data are redistributed among more than 100 zones. The research is based on both spatial and statistical analysis and spatial software, such as ArcMap, QGIS and statistical software, such as SPSS and MS Excel were utilized.

The Colombo DSD was considered as the study area and subdivided into 179 modified zones. The number of trips attracted to Colombo DSD from other 330 DSDs was divided proportionately to the trip attraction factor of the modified zones. Likewise, also the trip production was calculated. There were 59,070 OD pairs between 330 DSDs and 179 modified zones. The passenger trip assignment was done assuming that all the passengers travel via the shortest route between origin and destination.

Keywords: Trip Generation, Trip production and Trip attraction, Landuse floor area, Divisional Secretariat Divisions, Modified zones

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Barriers in Modal Integration: The Case of Rail and Bus Transportation in Sri Lanka

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Abstract

For the existence of competitive markets, transportation is an essential economic activity needed to fulfill the activities of daily needs by providing a mode for the mobility of people and freight. A selection of specific planning method of transportation, convincing the passenger to use public transportation over private transport modes is a vital element in the current transport policies. Efficient operation of transport services depends on how effectively transport planning is undertaken considering technical, economic, market, social and environmental requirements under which services are provided. Nowadays every country in the world is trying to establish its own national transport system, not in isolation but as a part of the international system of transportation. When a transport mode is incorporated into a model, it can be used to build a better transportation system by using split development, model share and model integration. However, the passenger flow would not take place as predicted by transport models due to the influence of personal transport modes. As a result, developed infrastructure and transport services are often underutilized or one attractive mode of transport services are highly demanded to lead to overcrowding. This leads to the development of modal share issue with public transport share tends to decline while private motorized transport share is on the rise. As a remedy, model integration is considered as one seamless entity which has made by the involving of the travel modes for the benefit of the fare paying customer. There are many integrated transportation systems can be seen in well-developed cities all around the world established to reduce car dependency (Buehler, Pucher, Gerike & Götschi, 2017). Transport modal integration (Intermodality) provide the advantages by keeping space through the traffic congestion and controlling and resultant time saving and vehicle operational costs savings to users, minimizing carbon footprint and other negative externalities and eventually reducing the country dependence on fuel. However, intermodality is not always successful due to certain barriers. This paper aims at identifying the barriers that affect to efficient model integration process between bus and railway service around selected bus and rail corridor.

The methodology followed in this research is a questionnaire-based data analysis using Principle Component Analysis (PCA). The relevant data were collected through a field study

conducted in a selected public transport corridor that is served by rail and bus transport. The data collection was carried out using an online survey form but carried out as face to face. At all location 100 randomly selected passengers were surveyed. Data from each location were collected to cover all the time frames as possible and covering different users of the transportation service.

Main factors acting as barriers to modal integration were derived as operational factors, comfortability, infrastructure design, competition, information flow and ethical behavior from the PCA analysis. Fourteen barriers identified, which includes security and safety concern of train, lack of information of bus and railway operating times, the capacity of current bus and train service and operating conditions of bus and railway stations, have been perceived as the main issues to be solved that make passengers participate in model integration between bus and railway services. Further, poor sanitary facilities, having uncomfortable fare collection methods and health and fitness issues of passengers have also been barriers. Further, considering the travel complexity of passengers in the sample, 28 travel patterns have been identified which includes traveling modes of the bus, foot, train, three-wheelers, taxi cabs and personal vehicles such as cars, bikes, and vans. Most of those 28 patterns have similar areas of destinations even they have different origins indicating hub and spoke transport behavioral pattern. Variable origins, less planned travel facilities, not having proper integration method, have been main reasons for the travel complexity.

Keywords: Public transportation, Modal share, Modal split development, Modal integration, Exploratory factor analysis

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Formulation of a National Framework for the Digital Transformation of Sri Lanka's Public Bus Transport System

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Abstract

Public transport is considered to be a country's primary transportation network that plays an increasingly important role in human navigation. Thus, many countries have digitally transformed their public transport services to ensure the delivery of a quality transportation experience to passengers whereas the use of digital practices in Sri Lanka's bus transportation industry is minimal. As a matter of fact, majority of the vehicles entering Colombo are private vehicles that carry an immaterial number of passengers compared to public transport. The availability of more private vehicles with less number of people gives rise to the problem of traffic congestion thus creating a requirement for an efficient public transport system. Hence, the authors aim to present how modern-day IT advancements could be used to deliver a quality bus transportation experience to Sri Lankan passengers.

First, the challenges experienced by passengers were investigated where, heavy traffic, long travel time, overcrowded buses, not receiving the correct amount of balance money and the inability to track the location of the bus beforehand were found to be the most common challenges experienced by passengers. Once, the issues and the corresponding needs were identified, the authors explored the different roles of IT in public bus transport and proposed four feasible solutions to overcome the prevalent issues.

The recommended solutions consisted of a bus tracking cum arrival time prediction system that uses GPS and GSM, a bus crowd monitoring system that uses IR sensors, a cashless ticketing mechanism that uses the Touch travel card introduced by Dialog and an inquiry cum complaint management system that would facilitate real time complaint handling and management. Furthermore, the research also introduced a digital transformation framework that could be used to digitalize the operations of public bus transport. The digital transformation of Sri Lanka's public bus transport system would result in the delivery of a quality transportation experience to passengers while minimizing traffic congestion in Colombo as the availability of a high-quality bus transport service would encourage citizens to use public transport more often instead of their own private vehicles.

The proposed research contrasts with other researches as it facilitates the development of a Digitized National framework that would be applicable to the entire bus transport system of the country. Furthermore, it would be beneficial if the passengers are provided with an integrated up-to-date solution where information such as the location of the bus, arrival time, bus fare, duration and journey distance is available in real-time. Besides, the study is also significant as this area has not been much focused academically in the Sri Lankan context. The Ministry of Transport and Civil Aviation, National Transport Commission (NTC), Sri Lanka Transport Board (SLTB) and Sri Lanka Private Bus Owners Association will be the main organizations benefitted by this research in addition to passengers travelling in and out of Colombo.

Keywords: Digital Transformation, Public Bus Transport System

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Session 2B
Highway Engineering

Optimization of Anti-Glare Block Spacing in Expressways

W.G.A.D. Dharmarathna[1] and H.R. Pasindu[2]

Abstract

Glare occurs when visual field brightness is greater than the luminance, to which eyes are adapted during driving. Glare can be occurred due to the approaching head lamps at night time / low light conditions. Visibility is required for a safe driving and any obstruction to the driver's vision can affect the driving, resulting a threat to the roadway safety. Glare is a significant factor causing vision obstructions. Hence, driving at night can be more hazardous and difficult compared to the day time as the headlight glare reduces the visibility of vehicles while causing fatigue to the driver.

Effective reduction of glare by utilizing anti-glare blocks will be helpful to address this issue. Considering the movement of high speed vehicles in the expressways (Design speed of Sri Lankan expressways =100kmph) and other design parameters, the provision of anti-glare blocks can be justified as a solution for the reduction of glare. However, anti-glare blocks do not work well in rolling alignments with vertical curvatures. Furthermore, anti-glare blocks can restrict the vision of opposing carriageways while affecting the surveillance and the safe utilization of emergency crossing points.

According to the recommended technical standards, the initial selection of the suitable type of anti-glare blocks are done considering the light screening/cut-off angle (α), the width of the blocks, the spacing of the blocks, and the height of the blocks. As per the British standards (BS EN12676-1:20000), the recommended range of the cut-off angle (α) for straight sections is $\tan \alpha \geq 0.33$. For curved sections, the degree of curvature at the center of the curve should be added to the above value. Recommended width of the blocks ranges from 200 mm – 300 mm. Cost of installation and aesthetically pleasing appearance should also be considered during the selection of the width of the blocks as they are installed on the top of NJBs, on the sides of half NJBs, on the guard rails, and on narrow center medians. British standards recommend (BS EN12676-1:20000) the non-glare height for straight sections to be 1.80 m above the finished surface of the road. Height of the anti-glare blocks depends on many factors like number of lanes, median width, head light distance for maximum glare, and height of driver's eyes. Apart from the design parameters, other factors contributing for the selection of anti-glare blocks are; cost of installation, method of installation, minimum cleaning

requirements, aesthetically pleasing appearance, and reduced weight (At an event of impact, the debris is light and non-metallic).

Since the country does not have a proper guideline for the selection of the optimum spacing for anti-glare blocks, it is complicated to conduct a selection process for the Sri Lankan context. Optimum spacing is not site specific and a general spacing value for expressways may not be economical as well. A model to determine the optimum spacing of anti-glare blocks was proposed by this study and it will ensure the safety and comfort of the roadway users.

Keywords: Anti-glare block spacing, Light screening/Cut – off angle (α), Optimization of block spacing, Cost optimization

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Development of Pavement Condition Prediction Model for National Highways

R.M.K. Sandamal[1] and H.R. Pasindu[2]

Abstract

National Highways are basic infrastructure which provide the connectively for the urban development in a country. An accurate pavement performance prediction model is essential for pavement asset management systems to optimize the life cycle cost of preventive and corrective maintenance strategies. In this study, pavement roughness and relevant distresses progression of national highways in the long-term pavement performance data was analyzed to develop such a pavement condition prediction model. International Roughness Index (IRI) is a global parameter to measure the ride comfort of road users and unevenness of pavement, therefore use as the basis for the pavement prediction model in this research. High intensity of repetitive axle loading, and aging effect caused for the failure of pavement and distresses related to traffic load and aging are developed, hence pavement roughness is increased while distresses are propagated. Structural failure, functional failure due to the non- smooth riding surface are the reasons for increasing of vehicle operating cost (VOC) and waste of resources. The relationship between roughness and relevant distresses progression with pavement age was developed and validated with comparing such models developed by previous studies. The pavement distresses progression with the pavement age is analyzed by using regression analysis. Three curves are plotted to express the pavement deterioration, in that roughness deterioration curve is developed by considering the initial construction quality. Those deterioration models can be used to calibrate HDM-4 software to adopt for the local condition as a decision-making tool for the maintenance and rehabilitation work. Increasing of roughness is a function of progression of distresses which is use for the model calibration process in HDM-4 software as shown in equation 1.

$$\Delta RI = Kgp + \Delta RIs + \Delta RIc + \Delta RIr + \Delta RIt + \Delta RIe \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where: Kgp - calibration factor of general surface roughness development, ΔRI - gradual increase of pavement surface roughness, ΔRIs - structural pavement deterioration, ΔRIc – deterioration due to cracking, ΔRIr – deterioration due to rutting, ΔRIt – deterioration due to potholes, ΔRIe – deterioration due to climate effects

From the results of the study, the components of roughness deterioration due to the pothole (ΔRIt) and cracking (ΔRIc) are established. Combination of deterioration due to the structural

condition, climate effect and rutting are representing as a constant. The findings from the research can be used to HDM-4 model calibration of roughness increasing of national road network in Sri Lanka instead of using default values which are currently use for the pavement performance modelling.

Keywords: deterioration models, pavement condition, International Roughness Index, calibration

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Development of Pavement Performance and Prediction Models for Flexible Road Pavements in Sri Lanka

E.P.N. Karunarathna[1] and H.R. Pasindu[2]

Abstract

International Roughness Index (IRI) is a pavement performance indicator which reflects not only the pavement condition but also the ride quality and comfort level of road users". "Many highway agencies around the world consider the initial IRI value (IRI just after construction) as a quality assurance criterion while the prevailing IRI of a pavement as an indicator of required pavement maintenance actions or reconstruction needs.

The aim of this paper is to develop an accurate IRI prediction model for Road pavements in Sri Lanka using linear regression analysis". This model was developed based on data obtained from Road Development Authority (RDA) of Sri Lanka collected mainly using the Road Survey Vehicle. Models were developed for National Highways (A and B Class Roads) only. Further, variation of IRI for different climatic regions and for different vehicle compositions will be analyzed.

The key parameters that the IRI value directly related on a particular pavement was decided based on the literature and the availability of data. The proposed regression model from this paper predict IRI as a function of pavement age, Average Annual Daily Traffic (AADT), initial IRI (IRI just after pavement construction) and transverse cracks or alligator cracks combined length per unit area of the pavement. A set of available data was used to calibrate the regression model and using other set of data, relationship between the measured and predicted IRI values for the proposed model was observed using the coefficient of determination (R^2 value) as a statistical measure to determine how close the data are to the fitted regression line, as the validation process. The proposed model yielded an R^2 value of 0.58. To identify critical parameters in above relationship statistical coefficient p-value was used.

Then the variation of IRI was analyzed for different traffic categories. For AADT is greater than 50000 veh/day model yielded an R^2 value of 0.36. For ADT in between 50000 to 10000 veh/day model yielded an R^2 value of 0.21 and for category AADT less than 10000 veh/day model yielded an R^2 value of 0.61. It was observed that due to some erroneous data the accuracy of the models became lower. So it was decided to remove pavement sections with age more than 25 years and some unacceptable values of IRI measurements using Engineering judgement and reanalyze.

To identify the variation of IRI for different climatic conditions Western, Central and Northern provinces were selected. Western province has an annual average temperature of 27.4°C and an annual average Rainfall of 2420mm while Central province has 24.5°C and 1840mm and Northern province has 28°C and 1230mm. Models yielded R^2 values of 0.18, 0.45 and 0.72 for Western, Central and Northern provinces respectively. Due to low R^2 values it was decided to remove some unacceptable values of IRI measurements using and reanalyze.

Keywords: IRI, regression analysis, age, AADT, cracks, R^2 value, traffic categories, climatic regions.

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Measurement of Road Surface Undulations using a Low-Cost Accelerometer Sensor

A.W.C. Chamikara[1] and H.R. Pasindu[2]

Abstract

International roughness index (IRI) is the main parameter that measures the comfortability of using a road. This index is also taken as a thumb rule when taking the road maintenance and rehabilitation decisions. Main problem of this method is the high cost of the equipment required. Low cost alternatives like travelling beam method is time and labor intense compared to the IRI measuring device. There are numerous researches done on the use of built-in smart phone accelerometer to determine the IRI value as a low-cost alternative.

Aim of this research is to improve the accuracy of the measurement of IRI by smart phone method using a low cost off the shelf accelerometer without compromising the cost aspect. In this method, accelerometer is fixed to the axle of a vehicle and collect the data via Bluetooth to a smartphone. Since the measurement is not damped by the shock absorbers of the vehicle, the readings are much more realistic. A machine learning algorithm is used to analyses the collected data and predict the road condition. This algorithm should be trained using a training data set prior to the use. This process involves to collect and label data according to the prior knowledge and available data. This was done by first collecting data using a smartphone application while manually labelling the data points. Then this data was separated as training and testing data as appropriate and training data was fed into the algorithm with the manually labelled data as a reference. After training the algorithm, testing dataset was fed to the model.

Second part of the research was carried out to train the algorithm on detecting potholes without human involvement. For this, the data collection application was slightly modified to label the pothole data points. Then the previous training and testing method was carried out.

Accurate results were observed during both instances with reference to the labelled data. It was observed that the more training data makes the prediction model more accurate.

Since this is a low-cost method to determine the road surface condition, local road authorities can implement this as a network to collect real time data and carryout the future road maintenance works effectively.

Keywords: IRI, Pavement, undulations

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A Study of the Performance of Passing Climbing Lanes Along Colombo – Rathnapura – Wellawaya – Batticaloa Road

D. M. Eknaligoda[1] and G. L. D. I. De Silva[2]

Abstract

With the increasing population and the development in the tourism sector, increasing volumes and a higher percentage of heavy vehicles and recreational vehicles in the traffic stream from Colombo Capital to central hills has created many traffic-related problems recently. Specially all the essential supplying services including fuel, food, export goods are transported using major highways. Traffic operations along steep upgrades grades on two-lane highways in mountainous terrains in central mountains are extremely important considering safety and level of service (LOS). Applying Climbing lane concept on two-lane highways is a good recommendation to reduced prevailing extreme conditions.

"A climbing lane is, in effect, a passing lane added on an upgrade to allow traffic to pass heavy vehicles whose speeds are reduced" (HCM,2010). However, applying Passing Climbing Lanes (PCL) are not a common practice in Sri Lanka, most of the steep upgrades on the major trans mountain highways do not have climbing lanes that cause traffic congestion at major highways. Due to the increasing vehicular traffic along the route, there exists an ongoing construction of Passing climbing lane on Colombo- Ratnapura-Wellawaya- Batticaloa (CRWB) road near to Ratnapura. This study evaluates the Impact of Passing –Climbing lane on traffic flow on the particular section at CRWB road considering both safety and LOS using the existing available data from RDA and Police Station at Ratnapura. The collected data at a particular location before the construction of PCL and after is expected to show the importance of having PCLs at essential places along CRWB. Further, the impact of selected PCL has been analyzed for various traffic volume by a simulation model which developed for this study. In this research, it also investigates the operational experience of traffic flow at the upper end of the climbing lane through a driver interview. PCL is a low cost improvement method rather than replacing extra lane or providing bypass lane, hence study discusses the economic advantages also in this concept.

Keywords: Climbing lane, highways, traffic congestion

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Effect of Heavy Vehicles on Performance of 'Colombo-Katunayake' Expressway

S.A.A.K.K Subasingha[1] and W.K Mampearachchi[2]

Abstract

Colombo-Katunayake Expressway (CKE) is linking the Sri Lankan capital Colombo with the Bandaranayake International Airport and it provides great service to expanded industrial areas in the region. It makes great importance that maintain quality of the expressway as to cater better service for the public.

One of the most important factors in the recent years is the pavement damage due to the overloaded heavy vehicles and the overloading effects caused by the increased heavy vehicles traffic volume. But heavy vehicles play an important role in the economy, and are expected to remain a common sight on our expressways in the foreseeable future. Accordingly, balance criteria should be used among these two factors as to minimize economical losses. Department of Motor Traffic Sri Lanka has implemented certain standards based on vehicle axle configuration. But the heavy vehicles drivers seldom follow these standards and regulations. This practice of overloading the vehicles will have a direct impact on the pavements getting more damaged. The research overview is analyzing the damage caused by overloaded vehicles and compare with the transport cost to optimize these two factors.

Heavy vehicle traffic data is collected throughout the operating period and the data illustrates that the heavy vehicle traffic is being increased every year so that average monthly traffic in 2013 is 12,300 and now it has increased to 26,500 by 115% over 5 years. Two intermediate CCTV locations were selected and videos were used to identify heavy vehicle drivers' lane behavior. It is understood that 94% of heavy vehicles drivers use outer lane as they enforced to do. In this study, two toll gate exits were determined where there are installed weight bridges as to measure gross weight and axle loads of randomly selected heavy vehicles and to identify distribution of heavy vehicles in CKE. Several other required data can be obtained through Planning Division, Road Development Authority.

HDM4 software will be used to develop a model using available data as to find out effect of heavy vehicles in CKE so that service life reduction, kind of maintenance required and incurred cost will be evaluated. Finally, the study will optimize the road damage due to heavy vehicles and transport cost, and overloading penalties will be implemented on extra weight that the heavy vehicle is carrying.

Keywords: Colombo-Katunayake Expressway, Heavy vehicles, Road Development Authority, HDM4 Software, Axle loads

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Analysis on Fundamental Factors affecting Fuel Economy of Light Duty Vehicles

S.P. Gajanayake[1], A.G.T. Sugathapala[2] and J.M.S.J. Bandara[3]

Abstract

Fuel economy is one of the two major performance indicators of a vehicle whereas the other key indicator is the emission of mass pollutants. Recent policy related initiatives that have taken in place in vehicle manufacturing countries/regions viz. EU, USA, and Japan depict that a strict attention has been paid to control the fuel economy of the newly manufactured vehicles, especially light duty vehicles (LDVs). In order that, obtaining a better level of understanding on the fundamental factors affecting the fuel economy of vehicles is significant. Goal 7 of the Sustainable Development Goals (SDGs) aims to ensure sustainability and accessibility of energy and as a part of it, target 7.3 aims to double the global rate of energy efficiency, which includes the improvements in vehicle fuel economy. Also Goal 13 of SDGs aims to take urgent action to combat climate change and its impacts. Since transport sector is accountable for almost a quarter of CO_2 emissions, the improved fuel economy can help reduce it.

Factors affecting the fuel economy of LDVs can initially be categorized into 2 main types i.e. vehicular factors and non-vehicular factors. Non-vehicular factors can secondarily be categorized into 5 main types i.e. weather-related factors, traffic related factors, Street environment related factors, Travel behavior related factors and Driver behavior related factors. Vehicular factors can secondarily be categorized into 2 types i.e. Static vehicular factors and Dynamic vehicular factors. Static vehicular factors can be defined as the vehicular characteristics that do not vary in the temporal domain whereas the Dynamic vehicular factors can be defined as vice-versa.

During the analysis, the Static vehicular factors affecting the fuel economy can again be listed into 4 sub-categories as mentioned below.

Static Vehicular Factors

- Power Generation related
- Power Transmission related
- Traction related
- Other Static Factors

The sub-factors that can be listed under power generation factors are engine configuration, type of energy/fuel used, number of cylinders, cylinder capacity, type of ignition, firing order,

engine valve configuration, camshaft configuration, method of fuel injection, compression ratio, power-boosting mechanisms and engine placement.

The sub-factors under the power transmission can be listed as type of transmission, speed ratio configuration, gear-changing mechanisms used and etc. The traction related sub-factors can be listed as type of driving-wheels (i.e. front-wheel drive/rear-wheel driver or all-wheel drive), wheel factors (i.e. size and weight of the wheel, without the tyre), tyre-related factors and brakes-related factors. The other static vehicular factors affecting the fuel economy can be mentioned as vehicular body dynamics and vehicular weight(no-load). The Dynamic vehicular factors can be listed as kinetics related factors (viz. torque, friction, drag, etc.), kinematics related factors (viz. velocity, acceleration etc.) and vehicular maintenance related factors (viz. vehicle-aging, vehicle-mileage, service routines, etc.).

Identifying and classifying the fundamental factors affecting fuel economy is primarily significant whereas developing functional relationships between fuel economy and fundamental factors will be performed secondarily. Governing equation(s) for fuel economy will be developed subsequently. Hence, the respective analysis is performed in order to explicitly identify the fundamental factors which affect the fuel economy of LDVs.

Keywords: Fuel Economy, Light Duty Vehicles, Fundamental Factors, Static Factors, Dynamic Factors, Sustainable Development Goals.

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Poster Presentation

A Study of Finding Choice Model for Class-Wise Railway Passenger Demand for Sri Lanka Railways

P.D.S.B. Chandrasena[1] and G.L.D.I. De Silva [2]

Abstract

Calculating passenger demand in the public transport is very important. In the railway service, passenger demand calculating is very important, because it is a mass transport mode. Passenger demand calculation is very useful when making decisions for existing railway lanes, changing number of train trips, opening new stations, changing capacity of stations and trains etc. Passenger demand calculation is much needed in finding requirements for introducing new railway lines, planning railway tracks and stations, planning train sets. Categorising service to different classes in public transport sector by facilities is crucial. In here same trip, especially same vehicle provides different facility. Different class passengers get same travel time, same distance same waiting time and only difference is the facility.

Mainly in train and airplane provide class facility in the transport sector. In airplane there are mainly two classes as business and economy. In railways 1st 2nd and 3rdclasses are available. In Sri Lankan Railway there are three classes, namely,1st 2nd and 3rd. Among them 1st class is always available for reservation. Both 2nd and 3rdclasses can be reserved on availability. When starting new train trips (in existing line or in a new line) identifying passenger choice is very important and useful. Then authority can arrange train with mixed classes according to the passenger demand. If a choice model is available, it can be applied for the area and can find community choice patterns. It is useful for designing train set or order train set. By this way, railway can provide a better passenger required service.

In this research, tried out to build a model for passenger choice when travelling by train on passengers' choice on what kind of travelling class they need according to their need of comfort. So many passenger choice models were built for calculating rail passenger demand and many researches were done for identifying many attributes affecting passenger demand. This research initially takes that attributes to the model. Then analyses geographical, socio - economic, human facts for discovering attributes which affects passenger choice model for choosing different classes. Then construct passenger choice model for different classes in train travel.

It can calculate which fraction of passengers like to travel in 2nd and 3rdclass in the railway station. While passenger demand can be calculated by using earlier passenger demand model,

this model can show how many passengers come to station for seeking 2nd class facility or 3rd class facility.

Keywords: Choice Model, Sri Lankan Railway, Passenger Demand

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Improving Pedestrian Movements at Congested Urban Areas: A Case Study of the Rathnapura Town

C.S. Punchihewa[1] and J.M.S.J. Bandara[2]

Abstract

Pedestrians are the main component of urban environment Traffic. Improved corridor for vehicle movements but lack of pedestrian facilities are indifferent identifications of conventional urban environment. Now transport planners considered about pedestrian friendly city environment to achieve sustainable development and encourage green patronage.

Unplanned and uncontrolled pedestrian movements result in delays and safety risk at town center. Individual facility development without proper traffic impact study may causes delays to pedestrians, motor vehicles and increase in safety risks. Often, there are lots of public requests for proper network for pedestrian pathways including amenity development. However, it is very difficult to plan and design an efficient pedestrian network without understanding pedestrian movement behavior at such vicinity. This study is focused on developing a methodology to identify pedestrian movement behavior, critical areas and make necessary adoptions to develop such facilities to encourage walkable city environment.

Rathnapura town is the capital city of Sabaragamuwa province, where having different terrain condition throughout the city area. One of Main arterial of country connecting South-Eastern side with the capital, induce a lot of vehicular movements into the city. Less development of pedestrian amenities is reflected heavy complexity in behavior of pedestrian movements, and it guided to a congested city environment.

Household or occupational purpose utility related trips are commonly identified in such urban environment and it directly relates with land use pattern of town area. This study is to identify specific land use and generated pedestrian trips within urban territory. Schools, educational institutes are specific components where it creates sudden demand for pedestrians. Privet medical centers, banks, commercial buildings, government office attract many pedestrians within town center. Collecting data using google maps, verified those data using field data collection and make GIS land use model is final output for land use identification.

Pedestrian movement has a high degree of freedom in origin - destination pair other than any mode of transportation. So, understanding of existing pedestrian route network and their conditions such as lighting, shading, security, other parameters are vital important factor.

Preparation of existing pathway condition index and priorities for the optimum pedestrian path is the main objective of this study.

After identification of optimum route possible improvements, changes and new adoptions can be introduced without arising further disputes. Major improvement changes from this study are; Improper pedestrian crossing locations shifting to optimum locations in urban proximity and One-way vehicle movement around bus stand for effective vehicle flow and safe pedestrian movements in urban setting.

Keywords: Pedestrian, Condition Index, Land use, Optimization

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Criteria to Identify Candidate Roads for Public Private Partnership Development

K. Tharmakulasingham[1] and H. R. Pasindu[2]

Abstract

In many cases, Public Private Partnership (PPP) projects are looked as skeptical phenomenon due to the risk factors involvement. However, in order to reduce the burden of government, it is essential to undertake PPP projects. Lack of project prioritization due to absence of supporting framework for selecting the projects in Sri Lanka was identified as one of the key findings by World Bank for accelerating PPP projects. Therefore, a study was conducted to identify the critical success and failure factors of PPP road projects in other countries, thus assist the public and private entities to identify the potential road projects in Sri Lanka. The aim of this research is to prioritize project from pipelines for PPP developments. Success of the projects are measured based on the risk allocation efficiency and productive efficiency. As a first step, criteria which are used by other nations for selection of PPP projects were collected. Further, Critical Successful Factors (CSF) of PPP projects were reviewed during the project preparation, procurement, development, construction, operation and maintenance stages. Top most factors were selected from various researches. Meanwhile, in this research we have considered not only the success case studies but also the failure road projects to critically analyze the factors influenced in the failure of those projects. In many cases, one of the prime reasons for failure was the absence of CSF. The importance of these factors in the selection criteria was analyzed. Having prepared the CSF, readiness of accepting the PPP model, constraints for the development and challenges for the implementation of PPP model in Sri Lanka can be evaluated. As an improvement of the research, questionnaire survey can be carried out and the stakeholder opinions can be taken. Major limitation in this study is that, there are no any PPP road projects in Sri Lanka, to compare our exploration and the real-world project scenario. In addition, another limitation was the lack of availability of detailed documentation in the projects.

Keywords: Public private partnership, Selection criteria, Critical success factors, Critical failure factors, Roads

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Evaluation of Traffic Forecasting Accuracy in Road Projects in Sri Lanka

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Abstract

Traffic demand forecasting is integral part in the highway planning and feasibility assessment. Forecasted traffic demand is used to determine the highway capacity, to estimate the design ESAL for pavement design and to evaluate road user benefits such as travel time, vehicle operating cost, emission and accident that are used in the economic feasibility assessments.

This research investigates the accuracy of demand forecasts using a sample of projects in Sri Lanka and identifies the factors influencing the demand forecast accuracy. The selected roads include, expressways, national roads in urban and rural areas. The forecast traffic demand values are derived from the demand analysis carried out in feasibility studies of highway projects. The corresponding observed traffic data for this study is drawn retrieved from traffic databases available at University of Moratuwa and the Road Development Authority. The forecasted traffic volumes at the corresponding location is adjusted based on the growth factors given in the demand model used to calculate the traffic volume for the year in which the observed data is available.

The study evaluates the variation of accuracy of demand variations with respect to the following factors, a) demand modelling tool used, b) differences in analysis scenario with respect to other transport infrastructure is the used in the model and condition at the time observed traffic volume was taken, c) variation in error with the forecasting period, and d) variation in error with type of highway. The results of this analysis would useful for highway planning and demand analysis studies to identify the demand variation risk and to incorporate it in improving the demand analysis processes.

Keywords: Traffic forecast

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Accident Analysis on A9 Road Section from Elephant Pass to Pallai

V. Sivagumar[1] and J.M.S.J. Bandara[2]

Abstract

Accidents considered as major hazard for any highway section. Highway safety can be improved with geometric features such as increasing lane width, improved horizontal and vertical curves, designated U-Turn and vehicle restriction, driver discipline, regulatory action and educational programs to public etc. The study intends to identify major accident causing factors in the particular sections, thus with better understanding of the factors improve safety of all stakeholders. The 20 km of Elephant Pass to Pallai section of A9 road considered as one of the two sections which connects north peninsula with other parts of the country. With the improvement of the sections from 2010 the vehicle entering rate of the section have increased and due to its good road condition vehicles are able to move at higher speeds. Motorcycles, buses, vans are the primary vehicles using this particular section.

The accident data were collected from 2010 to 2015 and its locations were identified. Accident which caused fatal impact, hospitalization of victims and property damage more than 0.1 million were selected for this research. Using GIS system, the accidents and its locations were processed. During the study, blackspots were identified by developing weightage by the impacts and number of accidents. The reasons for accidents were analyzed and categorized under human errors, traffic conditions, improper geometric designs, road conditions and environmental factors. Accident causes patterns were identified by analyzing the causes in five years period. Critical reason was identified as geometry design of the section. In order to verify this reason, another 20 km road section was selected in A9 road, where the geometric design is different from the study section. Hypotheses testing was carried out to validate the accident results of the two different sections. From the study, the accident growth rate per km was identified. Remedial measures to reduce the accidents are studied in this research. One of the major limitations was only police recorded accidents were analyzed in this research. Other limitation was reasons for the accident are ambiguous in many cases.

Keywords: Accident Analysis, Black spot, Geometric design

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Characteristics of School Trips in Colombo

M.J. Mishael[1] and Niranga Amarasingha[2]

Abstract

This study explores the characteristics of travel mode choice of school trips made by students whose age between 11 to 18 years. The objectives of this study were to investigate the factors affecting travel mode choice of school trips and to recommend mitigation strategies to reduce traffic congestion due to school trips in Colombo. Questionnaire surveys were conducted among school students in Colombo to gather information related to the mode of transport to and from schools. The factors that explain the reasons for the choice in the particular mode of transport were investigated. A model is developed to understand the relationship between each of the determinants and the choice of mode transport to analyze how this study can be utilized to benefit the overall modes of transport available for school children.

The pilot study was conducted among randomly selected 65 students from the Colombo district. The study went on to identify the mode of transport commonly used by students. It was identified that 53% of students used private mode of transport whereas just 34% of students used public transport when traveling to school. Moreover another 11% of the respondents went to school by walking. As per this study, it was identified that nearly 42% of the students were accompanied by parents or guardians when traveling to their respective schools. However, a similar 45% of the students who were taken into a pilot study, traveled to school alone. When considering the average distance to school from home, 79% of students traveled less than 10 km to school. Hence, this study clearly identified that the use of private transport methods has been a major factor contributing to the traffic congestions in the area, hence, improved public service transport, improved cycle paths and set-up of appropriate pedestrian paths are identified as major factors that can resolve this pertaining issue.

Key words: Travel Mode Choice, School Trips

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Decade of Action for Road Safety: Trends in Road Accidents, Sri Lanka

R.K.T.K. Ranawaka[1] and H.R. Pasindu[2]

Abstract

At present, nearly eight people die due to road accidents each day in Sri Lanka. This amounts to over 3000 fatalities per annum. This is an increase of 35.2% when compared to the fatalities in the year 2008. During the same period, the registered number of vehicles has increased by 113%. With the rapid motorization and decrease of public transport usage which has taken place over the last decade, new trends in road accidents have emerged in Sri Lanka. The study used accident data from 2008-2017, to identify how the accident types and patterns have changed over the period. In the year 2008, most of the accidents have happened in roads classified as urban, with a percentage of 53%. By 2017, 53% of the accidents have happened on roads classified as rural. Within the period from 2008 to 2012, most of the accidents have happened between 16:00-18:00. The trend has shifted to the time period of 18:00-20:00 from 2013 onwards. During the study period, the motorcycle was the highly exposed vehicle type to accidents. Motorcycles account for 23% of the total vehicles, engaged in accidents in the year 2008. It has increased up to 27% of the total vehicles engaged in accidents in the year 2017. Most numbers of motorcycles involved accidents are pedestrian-motorcycle accidents. The percentage of motorcycle-car accidents has increased from 10% to 14% from the year 2008 to 2017. Most numbers of three-wheelers involved accidents are three wheeler-motorcycle accidents. The percentage of three wheeler-car accidents has increased from 15% to 21%, when considering three-wheeler involved accidents. The age group with the highest number of casualties is 21-30 years when considering both motorcycle and three-wheelers involved accidents. Pedestrian accidents have increased by 10% when compared to the year 2008. Among pedestrian involved accidents, pedestrian-motorcycle accidents have the highest rate in each year. The highest exposed age group for pedestrian related accidents is 41-50 years each year. It is generally around 15% of the total pedestrian accidents each year. Among lorry involved accidents, lorry-motorcycle accidents have the highest rate in each year. Lorry-motorcycle accidents have increased by 6% when compared to the year 2008. In the year 2008, most of the lorry related accidents have happened by lorry drivers within the age group of 21-30 years, which is 30% of all lorry involved accidents. By the year 2017, the trend has shifted to the age group of 31-40 years, which is 36% of all lorry involved accidents.

The study could capture two weaknesses in the accident reporting system in Sri Lanka. 99% of the accidents have been recorded without identifying probable roadway and vehicle pre-

crash factors. Results of this study will be useful input for policymakers to develop effective long term and short-term strategies to reduce road accidents.

Keywords: Accident trends, Motorcycle accidents, Decade of Action, Road Safety

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Development of Stop Times File for General Transit Feed Specification (GTFS) Format in The Context of Western Province Bus Transits

B.H.A. Mendis[1] and G.L.D.I. De Silva[2]

Abstract

Public transport which is a vital aspect of transportation consists of a modal share 40.4% in Western Province of which 37.7% is of buses. However, regarding the convenience and ease of access to information, not so many measures are implemented in Sri Lanka. Recently in order to communicate better service information on public transportation to users, Google Transit service was enabled in Google Maps.

To provide the information via Google Maps, Google accepts the data feed in the format of General Transit Feed Specification (GTFS) which is an international data format. Currently a static feed is provided which includes the components of schedule, fare and geographic transit information. The schedule component contains the file stop_times.txt which provide the schedule of a bus journey. For a certain bus journey, it gives the stops that the riders board and alight, arrival and departure time at each stop and the stop sequence of a certain journey.

However, in Sri Lankan context, the transport agencies use the fare tables (figure 1) which depicts the stops that the bus makes and the fare at each stop and the bus frequency (figure 2) which gives the times that a bus of a certain route would leave the initiating bus station.

	පානදුර				
එළුවිල හංදිය	12.00	එළුවිල හංදිය			
කුරුඹ හංදිය	15.00	12.00	කුරුඹ හංදිය		
මහබෙල්ලන	19.00	15.00	12.00	මහබෙල්ලන	
බොල්ගොඩ පන්ස	24.00	19.00	15.00	12.00	බොල්ගොඩ පන්සල
බණ්ඩාරගම	28.00	24.00	19.00	15.00	12.00 බණ්ඩාරගම

Figure 1: Fare Table Example

430 මතුගම - කොළඹ (සාමාන්‍ය සේවා)									
පැය	විනාඩි								
HOURS	MINUTES								
3:00	07	30	45						
4:00	00	10	20	30	40	50			
5:00	00	07	14	20	28	35	42	49	56
6:00	03	10	17	24	30	37	44	50	57
7:00	04	11	18	25	33	42	52		

Figure 2: Frequency Table Example

In coding the arrival and departure times at each bus stop is required. However, in Sri Lanka no such time table exist for each and every bus stop. Therefore, an average speed was identified for each route and considering the distance travelled, arrival and departure times were recorded for each stop in a bus journey. In obtaining the average speeds, for the inter provincial buses, the average speed in the annual report of National Transport Commission was referred. In order to get the Western Province intra provincial bus average speeds the speed graphs of the CoMTrans Study were referred. An average speed for the whole day was taken approximately for all inter-Provincial buses.

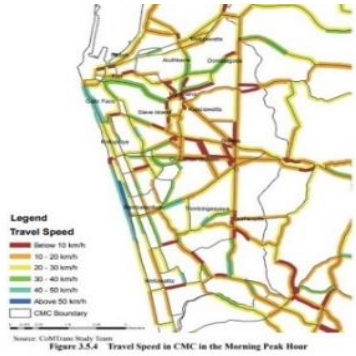

Figure 1: Average Speeds of Morning Peak (CoMTrans Study)

In practical scenario, inside Western Province most inter provincial buses do not allow the riders riding for a short distance to board the bus. Instead they are required to take the intra provincial bus. However, as the inter provincial buses travel faster than the intra provincial buses within the Western Province too, the google will indicate the inter provincial bus as the preferred best route. User is misguided.

Another error identified in inter-provincial bus routes is, bus routes in the same corridor having different average speeds. For an example the two buses Colombo-Kandy and Colombo-Katugasthota travels in the same corridor. But the Colombo-Katugasthota bus route's allocated average speed is higher than the Colombo-Kandy bus route's average speed which are defined by NTC. Therefore, higher speeded bus route is given priority which is misleading. For above errors mitigation methods were carried out by adjusting the speed of bus routes depending on the practical scenarios, traffic conditions, Western Province boundaries and the impacts of expressway network. Also, a major drawback of coding exact times for bus routes is that is not representing situations where the buses being delayed or cancelled. Also the waiting time at each bus stop varies and cannot be reasonably included in the coding. In order to represent the most accurate service information, the real time data feed is required.

Keywords: GTFS, Stop times, Western Province

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Development of General Transit Feed Specification Data for Sri Lanka

P.D.L. Fernando[1], B.H.A. Mendis[2], K.D.P. Damsara[3], S.P. Kumarage[4] and G.L.D.I. De Silva[5]

Abstract

General Transit Feed Specification (GTFS) refers to a common format that is used to represent transit data such as schedules and related geographical data (i.e. transit routes, stops). Provision of a specification for presenting transit data has expanded its applicability ranging from trip planning applications to operation analysis and research. At present transit data in Sri Lanka can be publicly accessed through each agency's website or through applications developed based on these data. The interconnectivity of transit data of different transit agencies is absent at present and the development of GTFS data will address the issue. A GTFS feed generally contains agency, routes, trips, calendar, stops, stop times, shapes, frequencies and transfer files. The Paper addresses aspects considered for the development of frequencies, stop times and transfers files in Sri Lankan context.

Frequencies can be represented in two ways based on the availability of a fixed schedule throughout the day by using the "exact_time" field. The paper highlights how the "exact_time" field was used for some bus routes of low frequencies. Development of stop times file is based on each transit mode's timetable. But for buses, the data relating to stop time at each bus stop is not available. The paper highlights how these values were derived for Western Province Transport Authority (WPTA) buses and the National Transport Commission (NTC) buses based on average travel speed while maintaining priority for trips within the Western Province to WPTA buses. The transfer file enables transfers from buses to trains or vice versa. Due to the dispersed locations of railway stations and bus stops in some parts of the country and the number of data to be found being high an efficient way is suggested in the paper using the network analyst tool in ArcGIS software.

Keywords: General Transit Feed Specification, Transit data, Network analyst

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A Methodology to Develop a Demand Model for School trips in Western Province

K.D.P. Damsara[1], G.L.D.I. De Silva[2] and R.M.N.T. Sirisoma[3]

Abstract

School trip is defined as a trip generated from a household or a hostel premises and ends at an educational institution (school) or vice versa. Origin-destination data is important to understand the travel patterns and also to estimate the future travel demand on transportation network over a particular catchment area. According to the administrative system of education, Sri Lanka consists of 25 districts which has 98 number of education zones having 312 education divisions. There are 10,194 total number of functioning government schools (National schools - 3.5%, Provincial schools – 96.5%) in Sri Lanka which have been categorized into 1AB – Schools having advanced level Science stream classes (1,029), 1C – Schools having advanced level Arts and/or Commerce stream but no Science stream (1,818), Type 2 - Schools having classes only up to grade 11 (3,288), Type 3 – Schools having classes up to grade 8 (4,059). Total school children population of the country is 4,165,964 and it has been divided among those 4 school categories as 1AB - 40%, 1C – 25%, Type 2 – 19%, Type 3 – 16%. Western province consists of 1,359 number of functioning government schools (965,113 students) in 3 districts which has 11 education zones and 38 education divisions.

This study is focused on school trips, where the destination schools are located in western province. List of schools located in western province (as destination) is available in data management portal maintained by the Data Management Branch of Ministry of Education. Currently there is an ongoing project named as NEMIS-SIS (Student Information System of the National Education Management System) which collects data related to students who are currently enrolled in Sri Lankan Government schools. From that, origin city/town of the students which is required anonymously for this study can be collected. Based on those data Origin-Destination matrix can be prepared and a strong sample which covers all four types of schools discussed above can be selected. When selecting the sample, it is important to consider about the number of students and the number of teachers available in the school as well as whether the school is a boy school/girls school or mixed school.

In Sri Lankan contest, travel patterns of school children depend on various variables such as school type, distance from home, access to transport, cost of travel etc. Therefore,

identification of origin-destination patterns and their relationship to those variables are used to develop a school trip demand model.

Keywords: O-D matrix, School trips, Demand model

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Open-Source Implementation of Environmental Monitoring System

Nilantha Premakumara[1]

Abstract

Air pollution receives one of the prime concern in Sri Lanka, primarily due to rapid economic growth, industrialization and urbanization with associated increase in energy demands. Lacks of implementation of environmental regulation are contributing to the bad air quality of most of the Sri Lanka cities. Air pollutants produced in any air shed are not completely confined, but at time trespassing all the geographical boundaries, hence do not remain only a problem of urban centers, but spread and affect remote rural areas supporting large productive agricultural land.

Whilst widely accepted as an important facet of Open Source technologies and their application, the scientific evaluation of such technologies and systems is often underexplored in research. This work presents an integrated approach of developing a prototype Environmental Monitoring System based on open source hardware and software, and the system's reliability in terms of data accuracy. The system is able to measure six environmental parameters: Air temperature, Air CO Percentage, Air NO_2 percent, Air O_3 percentage, Air PM Percentage, Air SO_2 percentage. This research has shown a promising way of establishing a dense coverage to monitor the environmental phenomena in a more cost effective manner.

Keywords: Open-source environmental monitoring information, Real time data, Sensors

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Identification of hydroplaning risk areas in Expressways: Case study on Southern Expressway, Sri Lanka

T.K. Nawaratne[1] and H.R. Pasindu[2]

Abstract

Safety is one of the main functional requirements of expressways which are designed to operate at 100km/h. One of the key considerations in providing safety is ensuring adequate frictional performance especially during wet weather. Hydroplaning is a phenomenon that occurs on wet pavements which poses a serious safety risk to vehicles especially on high speed roadways. Vehicles subjected to hydroplaning are likely to be involved in fatal or grievous accidents. There are several roadways, vehicular and environmental causal factors that contribute to the hydroplaning. A speed at which a vehicle hydroplaning is dependent on its tire pressure, wheel load, tire thread pattern, pavement micro texture and the water film depth generated during the rainfall among several other parameters. For expressways where vehicles generally travel at high speeds controlling development of Water Film Thickness is particularly important. The road alignment and longitudinal cross-sectional profile play an important role in affecting water film thickness generated during the rainfall event. Depending on the water film thickness generated on road segment, the hydroplaning risk for a given operational speed, vehicle characteristic will vary. This methodology is applied on the Southern Expressway-Sri Lanka to identify road segments that have higher hydroplaning risk.

Several locations were observed as water stagnating areas and one of them was used in the study. Gallaway formula and Road Research laboratory (RRL) method were used to find the estimated water film thickness and the contour maps of flow depths for different rainfall intensities were developed for the road segment. Based on the water film thickness, contour maps and the hydroplaning speed derived for the water film thickness and hydroplaning risk prone areas were identified. This will be useful for further study of these areas and to propose possible design or repair mechanisms. Further such a study will be helpful for the design of new expressways covering the whole island in the future.

Keywords: Hydroplaning, Expressways

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Study on Road Surface Noise of Asphalt Pavements

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Abstract

Traffic noise is an environmental and social problem in both urban and rual area transportation development. Meanwhile focussing on the sustainable development in transport sector, noise reduction measures play an major role. So far in the Sri Lankan context, noise reduction measures has not been considered rather than noise path control. In the near future in Sri Lanka, expansion of highways in urban area will cater for traffic conjestion reduction but may lead to social and environmental problems due to traffic noise. Since traffic noise lead to imbalance mind state of humans causing annoyance, difficulty to read and speach communication: there may be huge public objection for the incoming transport development projects.

Traffic noise consists of four parts such as engine noise, exhaust noise, aerodynamic noise and tire/pavement interaction noise. Comparatevely, tire pavement interaction noise play a major role in higher speeds greater than 50km/h. As in major highways vehicle operating speed and during night time vehicle speed is more than 50km/h. Therefore, it is more valuable to study tire pavement interaction noise which may help to adopt noise control measures. Traffic noise will be measured in cloxe proximity method (CPM) for various pavement conditions. ISO standards will be used as guidance for both test methods. CPM method will be used to measure traffic noise due to tyre pavemant interaction against pavement conditions. Pavement conditions will be evaluated by pavement texture, type of mixture and age of pavement. Ambient temperature and humudity will be also recorded during test period.

Traffic noise data collected will be analysed against pavement condition to derive best construction practices to control source traffic noise due to tyre pavement interaction and cost benefit of those construction methods against area land use pattern. The projected conclusion of this reasearch is to demarcate relationship between tyre pavement texture, type of mixture, pavement age and to recommend suitable measures for noise control by considering cost benefit.

Keywords: Traffic noise

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A Review on Alternative Pavement Construction Materials

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Abstract

In Sri Lanka, a significant amount of gravel is used for road and embankment construction as it is relatively cheap and have significantly high load bearing capacity. Gravel is of particle size between 2 mm and 64 mm according to the unified soil classified system, formed by weathering and erosion of rock, typically used in road constructions. With the urbanization and civil and infrastructure development, demand for gravel is escalating in a rapid pace. On the other hand, the available natural gravel deposits have depleted due to over exploitation and the pertaining laws by the forest department, department of archaeology and central environmental authority further prevent excavation of gravel. Gravel, therefore has become scarce. Studies have been undertaken to find alternative materials for pavement construction which are of high load bearing ability, economical and environmentally friendly. Researchers widely recommend Fly Ash (FA), Waste Recycled Products (WRP), Construction Demolition Waste (CDW), Recycled Asphalt Pavement (RAP), plastic fibers/strips, scrap tyres and geosynthetics as potential replacement for conventional pavement construction materials (Ossa, 2016 and Pérez, 2013). The selection of the above materials was determined in terms of strength, durability, cost and Eco friendliness. The strength parameters were determined from Los Angeles abrasion test, modified compaction test, California bearing ratio (CBR) test unconfined compression test, direct shear test and static tri-axial test.

Composition and compaction efforts are the main factors affecting the physical and mechanical behavior which should be seriously concern before and the after application in recycle aggregates to improve the quality of the recycle materials required to sorting, separation and processing (Dahlbo et al., 2015). Application of recycled CDW as an alternative is an environmentally friendly option and a sustainable approach for the CDW waste problem (Zezhou, Ann, Liyin & Guiwen, 2014). Geogrid reduces the gravel requirement in base and sub base construction (Moustafa Ahmed, Satish & Praveen, 2004). Geogrid provides frictional interaction and interlocking between soil particles by which the shear resistance of 1. Soil got enhanced is one of methods (Tang, Ghassan and Angelica, 2008). Choudhary et al. (2010) demonstrates that the inclusion of waste High Density Polyethylene (HDPE) strip with locally available granular soil improves the strength and deformation in highway sub base and also in embankments. Reusing waste materials for road construction is a viable solution in terms of

environmental conservation and economy. The quantity and quality of waste material can be collected from site visit method, waste generation rate method, life time analysis method, classification system accumulation method, variable method, empirical investigations, web-based estimation systems or waste estimation model (Zezhou et al., 2014) and laboratory or field tests. In Sri Lanka, the potential set of wastes could be considered for pavement construction are CDW, industrial polymer waste, rice husk, used vehicle tyres, wrapping material in industries.

Keywords: Gravel, Pavement

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Identify Possible Solutions and Develop Criteria to Review Geometric Designs to avoid Safety Issues created by Surface Water in Expressways

S.S. Kumara[1] and H.R. Pasindu[2]

Abstract

Proper drainage and smooth functioning can be considered as an important aspect in design of an expressway. Inadequate drainage facilities can lead to problems such as significant weakening of road pavement structure and adverse safety conditions due to aquaplaning. As Sri Lanka is a growing hub of economy in South Asia, construction of expressways has become prominent and safety of road users in adverse weather conditions need to be adequately taken into consideration in design stage of expressways. Objective of this research study is to identify current issues in existing expressways, propose solutions and define guidelines & recommendations that to be followed in geometric designs in related to the surface drainage by Sri Lankan highway/bridge designers.

Road segments where sag curve and super elevation developments are much likely to have problems regarding surface drainage. By observing newly constructed expressways in Sri Lanka such as STDP, it is evident that both sag curve and super elevation developments exists simultaneously are much vulnerable for aquaplaning.

Policy on Geometric Design of Highways-AASHTO and Geometric Design Standards of Roads-Road Development Authority of Sri Lanka emphasis cross fall, minimum gradient and rate of vertical curvature (K) values to be taken by proper consideration of surface drainage. But many researches have shown that despite of above factors, several parameters such as water film thickness, flow path length, flow path slope and rainfall intensity subjected to stipulated return period play a major role in preventing aquaplaning. In this research actual film thickness, rainfall intensity and flow path length will be measured through a field study in above mentioned critical locations in expressways.

Finally, a parametric study will be carried out considering above aspects as well as by reviewing geometric designs of existing expressway and guidelines will be provided to prevent aquaplaning of expressways in Sri Lanka.

Keywords: Surface Water, Water Film Thickness, Aquaplaning, Geometric Designs, Sri Lankan Expressways.

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