



*Research
Leads to
Advancement*



Transport Research Forum

2020



UNIVERSITY OF MORATUWA

DEPARTMENT OF CIVIL ENGINEERING
TRANSPORTATION ENGINEERING DIVISION

Transport Research Forum 2020



Abstracts

11th and 12th December 2020

University of Moratuwa, Sri Lanka

Transportation Engineering Group

Department of Civil Engineering

University of Moratuwa

Introduction

Transport Research Forum (TRF) is an annual conference organised by the Transportation Engineering Division of the Department of Civil Engineering, University of Moratuwa. The prime objective of this conference is to create a platform for researchers in the transportation field to build up their research career and to share their research findings with other colleagues and the industry. Practitioners, researchers and academics including a number of international experts in the areas of Highway Engineering, Transportation Engineering and Planning are the participants for this event. Representatives from the industry and the related government institutions are also invited every year.

Department of Civil Engineering conducted the first ever Sri Lanka Transportation Forum in 1983 and since late 90's the Transportation Engineering Group continued with Transport Research Forums and bi annual International Conferences. This is the 13th Transportation Research Forum conducted in consecutive years since 2010. Many of the research findings presented in Transport Research Forums have been put in to practice and the one of the main objectives of Transport Research Forum is to come up with solutions to address transport related problems in the country.

Table of Contents

Introduction

Message from the Conference Chair

TRF 2020 Organising Committee

Reviewers

Session 1:

1.1 Strategies into Practice Through the Pavement Management System

Prageeth Gunarathna and Amutha Thananjeyan [*on invitation*]

1.2 Effectiveness of Demolished Concrete Waste for Resurfacing of Low Volume Roads in Sri Lanka Using Roller Compacted Concrete (RCC) Technology

W.R.A.N. Jayantha and W.K. Mampearachchi

1.3 Statistical Approach to Develop High Mobility Road Network Plan for Sri Lanka

Sumudu Weththasinghe and Saman Bandara

1.4 Estimating the Follower Vehicle Platoon Delay due to “U” Turn Vehicles at Centre Median Openings

Chathuma Abeygunawardana and Vasantha Wickramasinghe

1.5 Development of Fine Aggregate Using Coal Fly Ash with Internal Curing Characteristics

Tharmarasa Tharshigan, Ishara Pradeep and Wasantha Mampearachchi

1.6 Enabling ITS Applications with Affordable Communication Technologies

Tilan Wickramarachchi, Nayan Dharmaraj, Danuka. Malinda, Gayan. Nettasinghe, Isuru Senevirathne, Sandalika Weerasuriya, Dileeka Dias, Tharaka Samarasinghe, Kasun Hemachandra

1.7 Review of Traffic Parameters Required in Performance Measuring Schemes in Traffic Signal Systems to Fulfil Multi-Stakeholder Objectives

S.C. Withana, J.M.S.J. Bandara and H.L.K. Perera

1.8 Experience in Calibrating the VISSIM Microscopic Simulation Model for a Signalized Intersection

Dinakara Gunathne, Niranga Amarasingha, Vasantha Wickramasinghe, and Asiri Kulathunga

1.9 Application of Intelligent Transport System (ITS) in Passenger Boarding and Alighting Surveys

Chathura Vidanapathirana, **Thisaiveerasingam Thilakshan**, Sabeen Sharic and Saman Bandara

1.10 A Data Acquisition Methodology for the Development of Local Driving Cycles

Surath Gajanayake, Saman Bandara and Thusitha Sugathapala

1.11 Assessing the Walk-Score of Walking Paths in Kandy City Area for Better Walking Experience for the Tourists

K.P. Wijeweera and **T.W.K.I.M. Dias**

1.12 Social Impact Assessment and Mitigation of the Negative Impacts in the Light Rail Transit Projects in Colombo Metropolitan Region of Sri Lanka

K. Karunathilake

1.13 Study of the Impact on Road Safety on Arterial Roads due to Close Distance Access Roads

W.T.G. Rathnasiri and T.W.K.I.M. Dias

1.14 GAP Acceptance of Crossing Pedestrians at Urban Unprotected Mid- Block Crosswalks in Divided Highways

Vishma Diddeniya, Lakmali Guruge and Vasantha Wikramasinghe

1.15 Effect of Crash Barriers on Driver Behaviour

Sachintha Rajapaksha and Vasantha Wickramasinghe

Session 2

2.1 Effect of Blending Temperature and Blending Duration on the Degree of Blending of Reclaimed Asphalt Binders

Chamod Hettiarachchi, Xiangdao Hou, Qian Xiang, Dara Yong and Feipeng Xiao [*on invitation*]

2.2 Axle Load Distribution Characterization for Mechanistic Pavement Design

Shanika Sumanasekara and Wasantha Mampearachchi

2.3 Feasibility Study of Using Calicut Tile Waste as an Internal Curing Fine Aggregate in Construction Industry

K. I. Pradeep, T. Tharshigan and W. K. Mampearachchi

2.4 Development of Performance Indicators to Evaluate Performance Based Road Maintenance Contracts

G.L. Mullevithana and J.M.S.J. Bandara

2.5 Development of a 3D Model of Open-Graded Friction Course to Evaluate the Inter-Connected Air Void with Aggregate Gradation

K.V. Dedigamuwa and W. K. Mampearachchi

2.6 Effect of Crowding Cost on Optimized Headway of an Urban Bus Route

Kaushan W. Devasurendra, Sumedha C. Wirasinghe and Lina Kattan [*on invitation*]

2.7 Evaluation of Aircraft Excursion Risk at Bandaranaike International Airport

Sameera Galagedera, H.R. Pasindu and Varuna Adikarivattage

2.8 Analysis on Transport Mode Choices of School Children in Colombo District, Sri Lanka

Pubudu Damsara, Dimantha De Silva and Namali Sirisoma

2.9 Evaluation of Criteria for Setting Speed Limits to Sri Lankan Highways (Built-up Areas)

Nadeesh Silva, Himaru Kumarage Malika Guruge and Vasantha Wickramasinghe

2.10 Evaluation of Criteria for Setting Speed Limits to Sri Lankan Highways (Non Built-up Areas)

Himaru Kumarage, Nadeesh Silva, Malika Lakmali Guruge and
Vasantha Wickramasinghe

2.11 Impact on Traffic Flow due to the New Apartments in Colombo Municipal Council Area

Yasantha Perera, Saman Bandara and Loshaka Perera

2.12 Use of Geographical Information System (GIS) in the Infrastructure Development

Projects: A Case of Coastal Railway Line Development Project in Sri Lanka

Auchithya Rathnayeke and K. Karunathilake

2.13 Applying Built – Operate - Transfer (BOT) Systems for Sri Lankan Expressways: A Case Study

Amila Prasadani Perera and Dimantha De Silva

2.14 Multi-Attribute Criterion to Identify Candidate Roads for Development Under Public-Private Partnership

Kopikah Tharmakulasingham and H.R. Pasindu

Message from the Conference Chair

Prof. W.K. Mampearachchi

University of Moratuwa



As the Chairperson of the research committee, I am delighted and honoured to bring this message to the Transportation Research Forum 2020.

This year has been significant, as we the Transportation Engineering Group, have decided to hold this prestigious conference as a virtual conference due to the COVID-19 pandemic situation.

I hope that this conference will allow the participants a productive discourse. Our technical program is rich and varied with several invited presentations from expertise in foreign countries and around 30 technical papers split between 2 parallel oral sessions. Some of the underlying issues in the transport sector in Sri Lanka will be covered in-depth in our conference, by our invited speakers and guest speakers. I extend my heartfelt appreciation to them.

As a conference chair, I know that the success of the conference depends ultimately on the many people who have worked with us, in planning and organizing the conference. I take this opportunity to acknowledge the support given by the Vice-Chancellor, Prof. Niranjan. Gunawardana and our Dean, Prof. Nalin Wickramarachchi, who have a very clear desire to upgrade research in the community in which we live in.

In particular, I thank the committee for their wise advice and brilliant suggestions for organizing the conference. All recognition should go to the committee members who have all worked extremely hard on the details of important aspects of the conference programs. A note of appreciation to the academia and industry partners for their thorough and timely reviewing of the papers.

Most of all, I thank you, the presenters, for enriching the conferences by your presence. As is a tradition with the conferences, I hope you will enjoy the content, new fellowships, get new ideas, and above all, have a great deliberation.

On behalf of the Conference Committee, we're looking forward to seeing you at the virtual conference.

TRF 2020 Organising Committee

Conference Chair

Prof W. K. Mampearachchi

Conference Secretary

Dr H L K Perera

Committee Members

Prof J M S J Bandara

Dr H R Pasindu

Dr G L D I De Silva

Supporting Staff

Mrs G.N. Wijekoon

Mrs G.A.N. Gurusingha

Mrs Melani Jayakody

Mr U.K. Padmaperuma

Reviewers

External

Dr Adeesha Wijayasiri (UoM-CSE)
Dr Amila Silva (HBA Specto Inc., Canada)
Dr Aruna Karunarathne (Swinburne University of Technology, Australia)
Dr Chamali Hewawasam (UoM-TCP)
Dr Chamod Hettiarachchi (Tongji University, China)
Dr Hansinee Sitinamaluwa (UoM-MSE)
Dr (Mrs) Ishani Dias (KDU)
Mr Isuru Gamalath (Canada)
Dr Kasun T. Hemachandra (UoM-ENTC)
Prof Kolitha Weersekera (OUSL)
Dr Mahinda Bandara (UoM-TLM)
Dr Nadika Jayasooriya (ACE Solutions)
Dr (Mrs) Niranga Amarasingha (SLIIT)
Dr Prageeth Gunarathna (DoT, Australia)
Mr R M Amarasekera (RDA-SL)
Dr Ravindra Wijesundera (Kimley-Horn and Associates, USA)
Mr Sajith Udayanga (Wayamba University)
Dr Shamain Saparamadu (ITUM)
Dr Shiran Jayakody (South Eastern University)
Dr Varuna Adikariwattage (UoM-TLM)

Internal

Prof J M S J Bandara (UoM-CE)
Prof W. K. Mampearachchi (UoM-CE)
Dr H R Pasindu (UoM-CE)
Dr G L D I De Silva (UoM-CE)
Dr H L K Perera (UoM-CE)

Strategies into Practice Through the Pavement Management System

Prageeth Gunarathna¹ and Amutha Thananjeyan²

Abstract

Pavement Management System (PMS) is a set of procedures/methods available for collecting, maintaining, analysing, and reporting pavement data to assist the decision-making process. When it comes to road maintenance planning, decision making is always challenging where road agencies have a limited budget to deliver their long-term strategies. This has put immense pressure on asset managers and asset Engineers to establish a process that priorities maintenance treatments for better network outcome.

Prioritising maintenance needs of a road network based simply on its current condition failed to satisfy the long-term impact of the maintenance (IDS 2019). It is recommended to combine project prioritization and the budget optimization process to achieve a balance between the maintenance needs and budget constraints. The optimised program will ensure the best value for money when analysing benefits of the desired maintenance options under a limited budget. The presentation will discuss the steps involved in developing the optimised road maintenance program for delivering long-term strategies and benefit of PMS for the long- term decision-making process.

Keywords: *PMS, Strategies, Optimization, Predictive modelling*

Reference

Infrastructure Decision Support (IDS) technical Brief, “Why do we need to optimize the maintenance investment of infrastructure? ”2019.

Author Details:

1. Senior Asset Modelling Engineer, Department of Transport, Victoria, Australia.
Prageeth.gunarathna@roads.vic.gov.au
2. Lead, Asset Modelling, Department of Transport, Victoria, Australia.
Amutha.thananjeyan@roads.vic.gov.au

Effectiveness of Demolished Concrete Waste for Resurfacing of Low Volume Roads in Sri Lanka Using Roller Compacted Concrete (RCC) Technology

W.R.A.N. Jayantha¹ and W.K. Mampearachchi²

Abstract

Roller Compacted Concrete Pavement (RCCP) is a type of zero slump concrete product, which has renewed the interests of sustainable pavement designers with its potential to reduce the total cementitious material content of the concrete mix. RCC is produced with the same ingredients as in conventional concrete paving, but with different proportions determined by a suitable mix design approach. RCCP construction procedure is similar to that of asphalt paving, where laying is performed using a modified asphalt paver and steel drum rollers follow the paver to ensure laid RCC mix to be compacted to its desired density. However, in low volume road construction, motor graders can be used in place of modified asphalt pavers for the laying process since the degree of precision required is low.

Even though concrete pavements are durable in the norm, owing to poor construction practices and improper maintenance, the concrete surfacing of low volume roads is at a stage in need of rehabilitation. The current rehabilitation practice of the damaged concrete roads in Sri Lanka is replacing the damaged pavement with a new surfacing, where the deteriorated concrete layer is removed as a landfill material or sometimes reused as a base for the new surfacing. However, full disposal of the damaged pavement and subsequent replacement with a new pavement is not an economically viable construction practice. The objective of this research is to evaluate the applicability of deteriorated concrete pavement for the reconstruction of new pavement in an economical and sustainable approach.

In this study, manually crushed concrete slabs were washed, sieved, and tested for aggregate strength to be used as a substitution of coarse aggregates (CA) in RCC. Control samples were cast with the use of virgin crushed aggregates (VCA) and test specimens were prepared with recycled concrete coarse aggregates (RCCA) in full replacement of CA. The mix proportions of the concrete mix were calculated using the soil compaction method, which focuses on the optimization of the dry density of the RCC mix. Vibratory hammer test – ASTM D7382 (VHT) was used in place of the modified proctor test – ASTM D1557 (MPT) in determining the optimum moisture content (OMC) of RCC concrete since an impact compaction test does not exactly simulate the actual site condition at the mix design stage.

The dry density of RCC test specimens was found to be very sensitive to moisture content when the compaction was coupled with vibration. VHT resulted in higher density and lower OMC while MPT produced almost the same density at a higher OMC. However, the actual site compaction practice involves a combined effect of vibration and impacts. A compressive strength over 20MPa can be easily achieved for RCC, even with full replacement of CA with RCCA. Therefore, the importance of incorporation of the VHT in the mix design process and the possibility of full replacement of CA of RCC by RCCA, are elaborated in this research.

***Keywords:** Roller Compacted Concrete, Optimum Moisture Content, Vibratory Hammer, Soil Compaction Method*

Author Details

1. Graduate Research Assistant, Department of Civil Engineering, University of Moratuwa, Sri Lanka. wranjyantha@gmail.com
2. Professor of Civil Engineering, Department of Civil Engineering, University of Moratuwa, Sri Lanka. wasnthak@uom.lk

Statistical Approach to Develop High Mobility Road Network Plan for Sri Lanka

Sumudu Weththasinghe¹ and Saman Bandara²

Abstract

Transportation among major commercial and socio-economic hubs will play a vital role in the economy during the next decade. Therefore, it is essential to look forward to developing a road network with high mobility among major hubs (can be considered as nodes) taking into account the existing and under construction expressway network.

Since administrative districts and its capitals have already defined, initially nodes to be served are defined as capitals of each district. Population, commercial activities, special tourist/pilgrims attractions are considered a major trip generating and attracting factors. Transport activity level and the population can be considered as directly proportional to above. Existing travel time and existing allowable speed or average speed between the nodes are the other essential initial data collected for identification of critical paths to access all nodes. In addition to 25 district capitals, other major road intersections (such as Dambulla) and expressway interchanges were also considered as nodes when defining the initial road network. During analyzing stage, development of minimum distance paths (which can be used to identify the level of service between two critical nodes) and minimum spanning tree (which is used to identify the most feasible network for the economy) to access all nodes was considered to identify bottlenecks and additional nodes required. Google data and data from other valid sources were used to develop origin-destination matrices with respect to travel time, distance, and vehicular average speed. With the effective use of tools such as SPSS as well as several online tools developed based on Dijkstra's algorithm, minimum distance path and the minimum spanning tree were developed to identify the feasible behaviour of the existing network. Adding new links to the expressway networks and improvements to other main roads are done using network analysis tools. To identify the optimum network, two criteria; minimizing overall link length and achieving desired average speed levels were considered. A logical criterion to be developed to identify the links to be added or improved such that overall mobility level of the country is improved.

Hambanthota, Rathnapura were identified as critical nodes due to influence from expressways (functioning & proposed). Dambulla was identified as a critical node which influences the mobility of northern and eastern nodes. Nodes and links located in the central region were

identified as bottlenecks of the entire network due to geographical barriers (terrain & landslide issues)

Keywords: *Mobility, Minimum distance path, Minimum spanning tree, Nodes*

Author Details

1. Civil Engineer, State Development & Construction Corporation,
Suranga19900211@gmail.com
2. Senior Professor, Department of Civil Engineering University of Moratuwa,
samanjbandara@gmail.com

Estimating the Follower Vehicle Platoon Delay due to “U” Turn Vehicles at Centre Median Openings

Chathuma Abeygunawardana¹ and Vasantha Wickramasinghe²

Abstract

U-turn vehicles at centre median openings create queues while waiting for acceptable gaps. This phenomenon creates delays for the follower vehicle platoon. The current study aims to estimate the delay for the follower vehicle platoon due to U-turn vehicles at centre median openings. This study considered the movement of the U-turn vehicles at the centre median opening at Dehiwala, Sri Lanka. The road stretch considered here is operated as a two-lane divided dual carriageway. Data were extracted from video footage done on a weekday for six hours in a heterogeneous traffic condition. Here more attention was paid to select the U-turn vehicles when the near lane is having continuous vehicle flow. This makes the follower vehicles to wait in a platoon until the U-turn vehicle takes the gap. When other vehicles passed awaiting U-turn vehicle, that U-turn vehicle was not considered for the calculations. The average waiting times (critical gaps) of different U-turn vehicle types were calculated. Those critical gap values are 14.5, 10.5, 9.2, and 8.2 seconds for heavy vehicles, cars/vans/jeep, bikes, and three-wheelers respectively.

Data were analyzed using ‘Queue Theory’. The M/M/1 queuing system that refers to ‘arrival rate (λ)’ and ‘discharge rate (μ)’ with a single lane queuing system was selected. Delay was calculated for the complete follower vehicle platoon due to U-turn vehicle. Using arrival rate (λ) and discharge rate (μ) to the equation of queue theory $\lambda / \mu (\mu - \lambda)$, ‘delay for the follower vehicle platoon’ was found. For a stable system, discharge rate (μ) should exceed arrival rate (λ) and here that requirement was fulfilled. U-turn three-wheelers created the highest platoon delay and the average time of delay created by three-wheelers is 70.6 seconds. Here λ and μ also depended on the traffic condition of both ‘opposite’ and ‘same direction’ of U-turn vehicle. Because of that reason, not only the ‘type’ of U-turn vehicle but also the traffic condition of both direction affects the delay caused by each U-turn vehicle. The vehicle type that more likely to make U-turn is ‘three-wheeler’.

Further, ‘delay cost’ for the follower vehicle platoon due to each type of U-turn vehicle was found by using the average value of time of a person. Calculating the delay cost for each follower vehicle platoon depended on the different vehicle types in that platoon during the waiting time of that U-turn vehicle. When the U-turn vehicle was a van, the delay cost for the

follower vehicle platoon was rupees 10.93. It is the maximum delay cost. The delay cost created by other different U-turn vehicles were rupees 9.05, 7.85, 7.75 and 7.55 from a car, light goods vehicle, three-wheeler and bike, respectively. The results from this study can be further extended to optimize the number of centre median opening for U-turns mainly in arterial roads.

Key Words: *U-turn vehicles, Delay cost, Queue theory*

Authors Details

1. Undergraduate, Department of Civil Engineering, Sri Lanka Institute of Information Technology (SLIIT), Malabe chathuabeygunawardana@gmail.com
2. Senior Lecturer- Higher Grade, Department of Civil Engineering, Sri Lanka Institute of Information Technology (SLIIT), Malabe, vasantha.w@sliit.lk

Development of Fine Aggregate Using Coal Fly Ash with Internal Curing Characteristics

Tharmarasa Tharshigan¹, Ishara Pradeep² and Wasantha Mampearachchi³

Abstract

Fly ash is produced as a byproduct from Lakvijaya coal power plant, Norochcholai, Sri Lanka. The daily production of fly ash at Lakvijaya power plant is 950 – 1000 tons. Some part (around 40%) of fly ash is consumed by cement manufacturers, the balance of fly ash is stored without any means of disposal inside the plant. This research study discusses the development of fine aggregate replacement material using sintered coal fly ash with internal curing characteristics. A series of samples were prepared with different composition of fly ash and reservoir sediment material and sintered from 800°C to 1300°C temperatures in the interval of 100°C for 30 minutes of sintering time then crushed to prepare fine aggregates. Here reservoir sediment material was used as a binder material and it improved green strength of solidified fly ash. TGA – DSC and XRF analysis was used to investigate the thermal and chemical properties of raw materials, respectively. The microstructure of produced fly ash aggregate was observed using SEM photographs. Water absorption, water desorption and relative density of fine aggregate were measured. Water absorption and relative density aggregates were the range of 21 – 40%, 1.2 – 1.55, respectively. The aggregate with 80% of fly ash and 20% of reservoir sediment material which heated at 1100°C had 21.4% water absorption and 74.12% water desorption was selected as suitable replacement material instead of natural river sand. concrete was prepared using wetted fly ash aggregate by replacing 23.5% of natural river sand and external curing has not been done for that concrete. Concrete with wetted fly ash aggregate achieved lower strength at an early stage then after 28 days, it achieved more strength than conventional concrete. Fly ash aggregate supplied internally stored water for hydration reaction of cement after finish the free water present inside the concrete and gave internal curing behavior to the concrete therefore concrete with fly ash aggregate gained more strength than conventional concrete without external curing.

Keywords: *Coal fly ash, Reservoir sediment material, Sintering, Fine aggregate, Water desorption, Water desorption, Internal curing concrete*

Acknowledgement

This research was supported by the Accelerating Higher Education Expansion and Development (AHEAD) Operation of the Ministry of Higher Education funded by the World Bank.

Author Details

1. Post Graduate Student, Transportation Engineering Division, Department of Civil Engineering, University of Moratuwa. tharshiganhc@gmail.com
2. Post Graduate Student, Transportation Engineering Division, Department of Civil Engineering, University of Moratuwa. ishara.kip@gmail.com
3. Professor, Department of Civil Engineering, University of Moratuwa. wk.mampearachchi@gmail.com

Enabling ITS Applications with Affordable Communication Technologies

Tilan Wickramarachchi¹, Nayan Dharmaraj¹, Danuka Malinda², Gayan. Nettasinghe², Isuru Senevirathne², Sandalika Weerasuriya², Dileeka Dias², Tharaka Samarasinghe², Kasun Hemachandra²

Abstract

Intelligent Transport System (ITS) aims to make travel and transportation safer, faster and more efficient. ITS includes but is not limited to emergency services, road safety, transportation infrastructure, traffic management as well as commercial and infotainment applications. This paper experimentally investigates the feasibility of using low-cost wireless technologies as an enabler for introducing ITS to Sri Lanka. We interpret our results with relevance to two ITS applications.

With the growing vehicular traffic in the country, the need for ITS applications has become imperative. For instance, while the current manual highway toll collection is ineffective during traffic peaks, the electronic version causes delays and congestion due to its stop-and-go process. Poor control of level crossings has become a major cause of fatal accidents. Road signs are often unnoticed or are deliberately ignored by drivers and dynamic road situations such as pedestrians, constructions, landslides, etc., will make the driver indecisive until alerted.

Dedicated Short-Range Communication (DSRC) is a standardized wireless technology for ITS, with its reliable operation in dense, high-speed vehicular environments. However, the high cost of the technology has restrained its penetration in the automobile industry and adoption by governments. DSRC is based on the IEEE802.11p standard. The IEEE802.11 family of standards also defines versions *b*, *g*, and *n*, better known as *WiFi*. The common root makes it possible to use WiFi which facilitates a subset of ITS applications with a significantly lower cost.

Several types of wireless links are fundamental to ITSs; between vehicles (mobile to mobile), between vehicles and roadside infrastructure (mobile to fixed), infrastructure to vehicles (fixed to mobile) and between infrastructure nodes (fixed to fixed). ITS applications rely on regular exchange of information (location, speed, bearing etc. or event-driven information such as the presence of a pedestrian) among vehicles in the neighbourhood via broadcast messages (data packets). Factors that influence the performance of the applications include packet loss, packet delay and communication range. This paper presents the experimental evaluation of fixed-to-fixed and fixed-to-mobile communications links established via WiFi. We study the packet

loss, delay and the communication range in each case. We then discuss the applicability of the results in relation to the following ITS applications:

- An Active Road Sign system which allows for messages to be relayed to drivers in the vicinity. Our results show that such messages can be received reliably over a range of 150m.
- A railway intersection warning system which allows warnings of approaching trains to be delivered to vehicles approaching the intersection. We demonstrate that vehicles within 200m distance of the intersection can be warned when the approaching train is 700m away.

Further, our design achieves an end-to-end delay less than 100ms, satisfying the criteria stipulated for safety-related ITS applications. Furthermore, our system allows the warning messages to be conveyed via audio-visual means, with the intensity proportional to the level of attention required by the driver.

Keywords: *ITS, IEEE 802.11p, DSRC, WiFi, Railway, Road signs*

Author Details

1. Research Assistant, Centre for Intelligent Transport Systems, University of Moratuwa, tilan.c.w@gmail.com,
2. Department of Electronics & Telecommunication Engineering, University of Moratuwa, dileeka@uom.lk

Identification of Traffic Parameters Required to Develop Performance Measuring Schemes for Traffic Signals Full-filling Multi-Stakeholder Objectives

S.C. Withana¹, J.M.S.J. Bandara² and H.L.K. Perera³

Abstract

Traffic signal systems are defined as a control measure or a traffic management strategy for road traffic to minimize traffic congestion and control the traffic flow. Today the traffic signal systems have evolved through semi and fully actuated signal systems and towards adaptive traffic signal systems where the traffic data are processed in real-time to predict future conditions using traffic models. Every intersection is a part of a roadway network and traffic signal operations are a special component in traffic management. The actual quality of operation in a signalized intersection is unknown without a proper performance measurement system. Therefore, it is important to develop an appropriate performance measurement scheme where adequate information is provided to the system operators in evaluating the performance of a signalized intersection.

The organizational processes and stakeholders of the intersection are vital components in developing a performance measurement system and their influence on traffic control measures are significant. Different stakeholders require different objectives to be achieved from the traffic signal systems. Different objectives require different parameters to be evaluated to measure the quality of an operation. Therefore, a multi-stakeholder analysis of performance measurement needs to be conducted to identify different objectives and relevant parameters to measure the quality of operation in a signalized intersection. This study is focused on identifying relevant parameters required to measure in determining the quality of operation at a signalized intersection based on multi-stakeholder objectives.

The existing literature has been used to develop the relevance and significance between the parameters and stakeholders. The influences between stakeholders and traffic parameters were developed to identify the most appropriate parameters to be measured to achieve a quality outcome in performance measurement. The outcomes are useful in developing performance measuring guidelines to evaluate traffic signal systems in general. The results show that there are seven main stakeholder groups with different perspectives. 29 parameters were studied considering different views of stakeholder in this study to identify most cost-beneficial and relevant parameters to be measured.

Keywords: *Signalized intersection, Performance measurement, Multi-Stakeholder analysis*

Author Details

1. Graduate Research Assistant, Department of Civil Engineering, University of Moratuwa. sudaracw47@gmail.com
2. Senior Professor, Department of Civil Engineering, University of Moratuwa. bandara@uom.lk
3. Senior Lecturer, Department of Civil Engineering, University of Moratuwa. loshakap@uom.lk

Experience in Calibrating the VISSIM Microscopic Simulation Model for a Signalized Intersection

Dinakara Gunathne¹, Niranga Amarasingha², Vasantha Wickramasinghe³, and Asiri

Kulathunga⁴

Abstract

Traffic microsimulation software is a traffic management tool which is currently being used in various countries to provide traffic management solutions. For developing countries like Sri Lanka, it is possible to observe a mixed heterogeneous traffic condition which includes lack of lane discipline, lack of lane marking, etc. The calibration process should be done before using the microsimulation software for local conditions in those countries to make the model results reliable and accurate and after the validation process, it is possible in simulating traffic management solutions. The main objective of this research study is to calibrate the VISSIM software for heterogeneous local traffic condition as the software is originally developed for homogeneous traffic conditions. VISSIM models which were calibrated previously for Sri Lankan traffic conditions are available and initially, the validity of some those models was tested. However, the simulated results of those models did not give the actual traffic characteristics in the study area. Also, in the VISSIM models calibrated previously in Sri Lanka, the driver behaviour parameter values were randomly selected and tested them on the VISSIM, but in this study, the calibration of driver behaviour parameters was done minimizing the simulation error percentage using a Genetic Algorithm (GA). The GA was used rather than randomly selecting the parameter values as it will provide with higher accuracy of the optimum values of the driver behaviour parameters and also it is fast compared to selecting the parameters randomly. The calibration was done in a signalized intersection focusing the driver behaviour parameters. Ten most sensitive driver behaviour parameters were identified through literature survey which is looking ahead distance, look back distance, average standstill distance, additive part of safety distance, multiplicative part of safety distance, distance driving, distance standing, minimum headway, waiting time before diffusion and safety distance reduction factor. The model was done for the Malabe three-legged signalized intersection and the average queue length was considered as the Measure of Effectiveness (MOE). Queue lengths were measured by using 5m marking tapes which were placed at 5m intervals in all the legs of the intersection. The data were input to the VISSIM software including the road geometry, and the signal timings related variables which measured at the intersection. The traffic volume and vehicle composition at each leg was recorded using video cameras and the videos were analyzed manually to gather the required data. The intersection was modelled in VISSIM software and the mean absolute percentage error (MAPE) for the

intersection was calculated by using the observed average queue length and the simulated queue length. For that GA optimization was done using the MATLAB GA Toolbox for the fitness function developed based on the percentage error, between the observed and simulated average queue length, under different driver behaviour parameters. The maximum value for MAPE was considered as 15% as recommended by literature. In future, the calibrated parameter set will be validated with similar intersections and it will be used for simulations of traffic in the area.

Keywords: *Heterogeneous traffic simulation, Signalized intersections*

Acknowledgement

Authors wish to thank the VISSIM Company for providing the Thesis version of the software for this research. This research was supported by the Accelerating Higher Education Expansion and Development (AHEAD) Operation of the Ministry of Higher Education, Sri Lanka, funded by the World Bank.

Author Details

1. Graduate Research Assistant, Department of Civil Engineering, Faculty of Engineering, Sri Lanka Institute of Information Technology, Malabe, Sri Lanka. dinakara.g@sliit.lk
2. Associate Professor, Faculty of Engineering, Sri Lanka Institute of Information Technology, Malabe, Sri Lanka. niranga.a@sliit.lk
3. Senior Lecturer, Faculty of Engineering, University of Peradeniya, Sri Lanka. vasantha.w@sliit.lk
4. Senior Lecturer, Faculty of Engineering, Sri Lanka Institute of Information Technology, Malabe, Sri Lanka. asiri.k@sliit.lk

Application of Intelligent Transport System (ITS) in Passenger Boarding and Alighting Surveys

Chathura Vidanapathirana¹, Thisaiveerasingam Thilakshan², Sabeen Sharic³ and Saman Bandara⁴

Abstract

Bus passenger transportation essentially requires continuous planning, evaluation and upgrading to maintain its level of service. Necessary traffic data including passenger counts, bus stop locations and corresponding demand, speed, relevant functional and infrastructure information have to collect regularly by the authorities to conduct such studies. Though there exist various conventional approaches for data collection, most of them are regarded as less effective in the present context. Global Positioning System (GPS) based applications in intelligent transport systems have proven to be efficient and cost-effective in identifying and tracking the geolocation of connected elements. Hence, with the intention of narrowing the technological gap, a holistic system that embodies both hardware components and software applications were developed for real-time data acquisition with remote access.

This multidisciplinary engineering solution collects data mainly from two sources. Firstly, a mobile application was developed to facilitate the collection of trip-specific data. For every journey, at the departure, the surveyor can create a new trip in the app and input the origin, destination, date, surveyor's position (front door, back door or middle door) and characteristics of the vehicle. Then a recurring sequence of features appears on the screen to record the GPS locations of bus stops, boarding and alighting counts at every bus stop, passenger demographics and the characteristics of each bus stop. All the data are transmitted to a server in real-time for storage and remote retrieval purposes. The surveyors are provided with unique login identities to improve the credibility of the survey. Every journey is labelled with a system-generated identifier which can be changed if necessary, to facilitate conducting surveys by placing two surveyors at the front and back doors of the same bus. On such occasions, retrieval of data can be carried out corresponding to the journey ID.

Secondly, a handheld portable electronic device which is capable of locating its position at regular intervals was developed with single-board computers (e.g.: Raspberry Pi), GPS receivers, data communication module and rechargeable power sources. An interactive display similar to a mobile phone is available in this device. The surveyor can input the details about each journey before the departure. When the journey begins, the automatically recognized real-time GPS coordinates and travelling speed are displayed to the user. A single-click feature to log waypoints with an accuracy of 2.5m was also provided. This serves as a facility to locate

bus stops, bottlenecks, intersections, or any other parameter as expected in the survey. These data are also sent to the same server and can be visualized through the front-end user interface. This approach can be directly utilized in assisting annual fare reviews incorporating both the cost component and income component eliminating past barriers. The data helps in developing driving cycles and thus fuel consumption and other cost parameters can be identified involved in bus services. The boarding and alighting surveys reflect the income components via the collected data. Thus, the calculation for fare review revisions become relevant and reliable with a good rationale and justifiable outcome helping three stakeholders (related authorities, passengers and bus owners/employees). This can be a fair play fare platform to all involved entities. The quality and level of service of public transit can be improved using this technological introduction including route requirements, increasing or decreasing supply as per the demand, improving and altering timetables (scheduling services) and restructuring bus stop locations and level of service of bus stops/terminals with available data based on demand and usage.

The results that can be tabulated in terms of data via the ITS incorporated approach can be utilized for analysis with effective outcomes. It is very important to attain the quality of data along with a considerable quantity. This approach helps in establishing healthy quality data over the conventional methodology in Passenger Boarding and Alighting Surveys. The outcomes from analysis of the available data can be utilized with a higher acceptance in inclusion for required transportation applications. The data security and storage phases provide high effectiveness in comparison to conventional technology redundant approaches. A digital platform can facilitate easy quick data retrieval without having to waste considerable time and effort. In a sustainable perspective, the inclusion of technology into the surveys and its process helps in the reduction of waste and usage of resources increasing environmentally prominent actions in terms of the survey process and outcomes. This technique is deemed the way forward of surveys in transportation engineering since it has a low margin for error unless it is a technical malfunction. With the use of highly reliable and state of the art technology, better levels of precision and accuracy can increase the validity of decision making in the industry. This approach which is initially implied to be applied in public bus transport services can be extended to other public transit forms such as railways with minor parametric changes and can be developed further into a passenger transport analytics platform.

Keywords: *Boarding and alighting surveys, Maximum load point, Passenger comfort, Passenger surveys, Public transport*

Acknowledgement

This research was supported by the Accelerating Higher Education Expansion and Development (AHEAD) Operation of the Ministry of Higher Education, Sri Lanka funded by the World Bank.

Author Details

1. Graduate Research Assistant, Department of Civil Engineering, University of Moratuwa, ra-chathura@uom.lk
2. Graduate Research Assistant, Department of Civil Engineering, University of Moratuwa, 198066d@uom.lk
3. PhD Candidate, Department of Civil Engineering, University of Moratuwa, sabeen@kdu.ac.lk
4. Senior Professor, Department of Civil Engineering, University of Moratuwa, bandara@uom.lk

A Data Acquisition Methodology for the Development of Local Driving Cycles

Surath Gajanayake¹, Saman Bandara² and Thusitha Sugathapala³

Abstract

Driving Cycles (DCs), the time speed profiles of a certain vehicle type for a given road segment can be considered as one of the main tools to quantify and to assess the performance in terms of fuel economy and emissions of a given vehicle category. There have been numerous approaches that have been adopted to develop DCs locally, representing various geographical regions of the world. Despite various approaches adopted, the researchers have defined a four-stepped common methodology for DC development viz. Route Selection, Data Acquisition, Cycle Construction and Cycle Assessment. During the study, approaches have opted under each step pertaining to the purpose of the DC development, i.e. for the characterization of fuel economy.

Acquisition of data for DC development is one of the most important steps of the procedure since the representativeness of the DC of local driving behaviour depends on the quality of the data collected. Regardless of the approach adopted, the acquired data should be reliable, representative, consistent and homogeneous. The three main approaches that are in practice throughout the world can be listed viz. chase-car method, instrumented-car method and hybrid method. During this study, more focus is concentrated on suggesting a methodology of data collection for DC development. Since local driving behaviour incorporates irregular kinematic patterns integrated with aggressive driving behaviour, the instrumented-car method has opted over the chase-car method. Moreover, the operational complexity and the cost associated with the latter approach is higher than that of the opted method. Furthermore, on par with the introduction of On-Board Diagnostics (OBD) protocol as a worldwide standard for automobiles in the later 1990s, the invention of many OBD data logging devices happened. Consequently, the data logging on an automobile has been made convenient than ever. When it's funnelled down to the instrumented-car method, the techniques in practice can be listed under two main categories viz. device-based methods and device and app-based methods. In device-based methods, the data are saved in internal storage and then it'll be transferred for analysis. On the other hand, the device and app-based method facilitate the real-time data to be transferred to the connected app-hosting device viz. a mobile device, tablet or a laptop. In the latter method, the data logging device is connected with the app-hosting device primarily via Bluetooth or WIFI.

Car manufacturers have introduced their own OBD data logging devices with internal storage viz. Chrysler DRBIII, Ford New Generation Star Tester, General Motors Tech II, Toyota Diagnostic Tester, Nissan Consult, VAG 551, etc. The said devices have mostly been introduced with the manufacturers' proprietary technology which has made them costlier. Due to the cost factor in the device-based method, most of the researchers have adopted device and app-based methods which have come up with low-cost alternatives. A dedicated data logging device, ELM-327 adapter has opted for the research study. Due to its lower cost and hence multiple devices can be used for parallel data collection in vehicles. Out of several third-party software applications for OBD data logging, Torque Pro™ has been opted for the study mainly due to its feature-rich interface, operational convenience and compatibility with a wider range of vehicle variants. The data is sampled at a frequency of 1 Hz. The logged data onto the app-hosting device is saved in two main types i.e. '.csv' file type and '.kml' file type. The mechanical parameters viz. engine speed and fuel flow rate, the spatial parameters viz. latitude, longitude and altitude have been logged using the said device-app arrangement.

During the study, data is planned to collect from two-wheelers (2W), three-wheelers (3W) and four-wheelers (4W). The initial phase of the study would be to analyze the data streams pertaining to 2W, 3W and 4W, then evaluate whether there are significant discrepancies among the driving behaviours and patterns. Then the second phase of data collection would be conducted to develop the local driving cycle. Unlikely in 4W, in 2W and 3W, an OBD port cannot be found in common. Thus, an app-based data acquisition method is recommended for 2W and 3W. With respect to this case, several readily available applications are tested. The major limitations of the applications are that they log data at lower frequencies such as less than 1 Hz and the operational difficulty of obtaining the logged data from the users' devices since the real-time data logging feature is unavailable in most. Therefore, a locally developed application at the University of Moratuwa which suits the data collection requirements has opted. The sample size has been selected as thirty vehicles from each category, accounting for ninety vehicles altogether in all three types. The geography of data collection has been selected as the urban areas of Colombo City.

Keywords: *Driving cycle, Data collection, Fuel economy, OBD*

Author Details

1. Graduate Research Assistant, University of Moratuwa, 198099f@uom.lk
2. Senior Professor, University of Moratuwa, bandara@uom.lk
3. Senior Lecturer, University of Moratuwa, thusitha@mech.mrt.ac.lk

Assessing the Walk-Score of Walking Paths in Kandy City Area for Better Walking Experience for the Tourists

K.P. Wijeweera¹ and TWKIM Dias²

Abstract

Walking has been always considered as a sustainable method of transportation which is more suitable for short-distance trips. The concept of “short distance trip” changes with the convenient maximum walking distance of a human being. However, it is observed that tourists would prefer to walk more than residents in cities with many tourist attractions located within close proximity. The City of Kandy, in Sri Lanka, can be recognized as one good example for such cities. Even though the tourists are willing to walk longer distances, this study has assessed the walking experience of a pedestrian in the city limits of Kandy, based on a walk score. Several walkability characteristics are taken into account to generate the walk score for segments of roads in the city and Pedestrian Level of Service (PLOS) was also considered. PLOS does not have considerations for tourists, it was used only to assess the basic requirements for pedestrians. A study done by Hall and Ram in 2018 comparing TripAdvisor ratings and Walk Score found that more specific assessments of walkability are required to evaluate the tourist requirements. Considering several works of literature as such, this study used an evaluation criterion developed by Dias in 2012 to obtain the walk-score and tourism specific features such as availability of shops and ATMs were taken into account. The objective of this study was to recognize the best walking paths between the tourist attractions using these qualities. The study area was based on the tourist attractions in Kandy and the importance of walking for the tourists within the city. Data were collected through field surveys in 2018 to identify walking facilities provided and to estimate PLOS in the selected street segments. Recommendations are proposed to improve the walking experience for the tourists. Twenty-six road segments were selected for the study and the Walk-score ranged from 24% to 60% with an average of 45% which cannot be considered as a satisfactory situation. As a walk score criteria were used, there was no requirement to do an opinion survey among tourists who walk these paths. Availability of amenities for pedestrians is one factor in estimating the walk-score in which the availability of bank facilities, restaurants, shopping malls, transportation terminals (bus stops and train stations), roadside benches etc. However, the results showed the lack of such amenities in many street segments which can be discouraging tourists to choose the street segment for their route. According to the results, it is important to remove obstructions which are located in the sides of the walkway which reduce the effective walkway width creating unnecessary queues. When selecting a walking path to reach a tourist destination it is expected that they will tend to select the best walking path.

Using the results of this study, a tourist can take an informed decision on choosing the best route and also the relevant authorities can prioritize the budget allocations on improving roadside facilities.

Keywords: *Walkability, Walk score, Pedestrian facilities, Pedestrian level of service (PLOS), Tourism*

Author Details

1. Undergraduate, Department of Civil Engineering, Kotelawala Defence University,
kasunjithpamitha@gmail.com
2. Senior Lecturer, Department of Civil Engineering, Kotelawala Defence University,
ishanidias@kdu.ac.lk

Social Impact Assessment and Mitigation of the Negative Impacts in the Light Rail Transit Projects in Colombo Metropolitan Region of Sri Lanka

K. Karunathilake¹

Abstract

Conducting a comprehensive Social Impact Assessment (SIA) is an essential and integral part during the planning stage of any infrastructural development project in today's world. Sri Lanka is planning its first Light Rail Transit (LRT) project in the Colombo Metropolitan Region (CMR) which covers 14 Divisional Secretariate Divisions (DSDs) in Colombo and Gampaha Districts. The core area of Colombo is mainly considered as the Central Business Development (CBD) area, while Sri Jayawardenapura is considered as the Administrative area of the country. Other suburban areas (Dehiwala, Rathmalana, Moratuwa, Piliyandala, Maharagama, Nugegoda, Kaduwela in Colombo Districts and Biyagama, Mahara, Kelaniya, and Wattala in Gampaha District) are considered as future segments of CMR as per the Urban Development Authority (UDA). Gampaha district is having the highest number of population in the country. The CBD, administrative capital and aforesaid segments in Colombo district are also having a high population density. The current transportation system prevailing in these areas of both districts are having very high traffic congestions in all trunk road networks towards Colombo. The LRT is a choice of UDA to reduce traffic congestions in the metropolitan area.

The LRT system is in its planning stage and there are four lines already been selected and prioritized by the UDA. There are three lines named Red, Blue, and Green are models identified as Public-Private-Partnership (PPP) implementation and the planning of this PPP model is focused on this research paper. The objective of the research is to identify the effectiveness of using the practical approach of SIA in terms of mitigating the negative impacts of the project toward the community in the project influenced area of LRT. The methodology of this research paper is constituted with the case study method and the ethnographic method. The techniques of data collection are interviews, discussions, and participant observation. The SIA is conducted in late 2018 to mid of 2019 and presented to the Western Region Transport Development Project under the UDA. The entire process of preparation of the SIA is considered as the platform of current research and the author was the team leader who conducted and prepared the SIA and Resettlement Action Plan for the project.

The findings of the research show that there is a significant avenue to reduce the overall project cost if there is a comprehensive SIA conducted. Especially, SIA helped to identify hotspots and sensitive issues in LRT. Further, it resulted in amendments in individual route designs and mitigate adverse social impacts. Also, it helped to reduce the length of the individual route. The public and stakeholder consultation process that needs to be conducted during the SIA data collection process is the key to the identification of the negative social impacts of the project. Also, it helps to minimize the impact on buildings and lands through finding less inhabited areas. Moreover, stakeholder consultation makes positive sense among the key trade and business community to invest in the LRT project. Finally, SIA inputs made sound awareness on all positive and negative impacts among the key officials and designers.

Key Words: *SIA, LRT, CMR, Mitigation of impacts*

Author Details

1. Senior Professor and Cadre Chair of Sociology, Department of Sociology, Faculty of Social Sciences, University of Kelaniya, Sri Lanka, kkaru@kln.ac.lk

Study of the Impact on Road Safety on Arterial Roads due to Close Distance Access Roads

W.T.G. Rathnasiri¹ and T.W.K.I.M. Dias²

Abstract

Arterial roads are high capacity urban roads, which get fed by the collectors and delivers that traffic to expressways. These are the main roads connecting city centres. Access roads connecting to the arterial road in close distances can cause road crashes as speeding traffic on arterials to get disturbed by the entering vehicles. Access Management Guidelines are available in other countries such as the USA and UK. According to the Access management manual of Texas DOT, the minimum gap allowed between two access roads ranges from 61m and 110 m when the posted speed limit is 48 km/h and 72 km/h respectively. Because there is no access management guideline for Sri Lanka, close distance access points may impose a road safety issue. Therefore, it is necessary to identify any effect on existing arterial roads and give optimum distance among two access roads to reduce intersection related crashes on arterials. This study evaluated how access point density affects the number of crashes per kilometre on arterial roads. Even though this issue can be significant for any road classification, only the arterial roads were selected to this study. Road crash data from 2014 to 2017 were obtained from Sri Lanka Traffic Police through the University of Moratuwa. Four segments of roads from (Galle road, Batticaloa Road, Kandy Road and Baudhaloka Mawatha) without centre medians were selected and the crashes that occurred on those stretches of road were plotted using Google My Maps. Only the intersection related crashes were plotted, and their significance was identified by converting them to EPDO values. A regression analysis, correlation analysis and generalized linear model were run as statistical analysis to identify any relationship between the number of access points per km and the number of intersection related crashes per km. From the gathered crash data in Sri Lanka from 2014 to 2017, nearly 4% from all recorded crashes are related to access roads. Out of that, 59% have happened on T junctions. When the crash rates were plotted in a histogram three groups of rates were identified: equal or less than 16 crashes/km, between 17 and 24 crashes/km and equal or greater than 26 crashes/km. The composition of gap categories was compared with these crash rate groups by graphical illustrations as well. On average, there have been 51 crashes per kilometre when the access road density is 6 per km or higher. A strong relationship between the access point density and the crash rates were not observed from the linear regression, but the gap₁ (50-100m), gap₂ (100-200m) and gap₇ (≥ 500 m) found to be significantly affecting the crash rate with 95% confidence interval in the generalized linear model. It could

also be recognized that the crash rate is limited to a maximum of 24 when the gap between access roads was greater than 400m. When there were high proportions of gap_1(50-100m) to gap_4 (200-300m) segments, the crash rate was increased to 26 or more crashes per km. So, it can be concluded that the cut off range should be gap_5 (300-400m) gap between roads and anything closer to that will increase the crash rate.

Keywords: *Access point density, Road safety on arterials, Intersection related crashes*

Author Details

1. Undergraduate, Kotelawala Defence University. terangayangana@gmail.com
2. Senior Lecturer, Kotelawala Defence University. ishanidias@kdu.ac.lk

GAP Acceptance of Crossing Pedestrians at Urban Unprotected Mid- Block Crosswalks in Divided Highways

Vishma Diddeniya¹, Lakmali Guruge² and Vasantha Wikramasinghe³

Abstract

Unprotected mid-block crosswalk is a hazardous location for pedestrians. In order to fulfil the crossing action at mid-block crosswalks in divided highways, the pedestrian must accept two gaps. The primary objective of this research is to find out whether there exists any significant difference between these two accepted gaps. Video footage was collected at an unprotected mid-block crosswalk located in a two-lane two-way divided dual carriageway. The data was extracted using an image processing software. Hypothesis testing was performed. The paired t-test results show that there is no significant difference between the two mean accepted gap values of the two crossing actions. The secondary objective was to develop a gap estimation model for an unprotected crosswalk in a divided highway. The effective gap was selected as the dependent variable to fit the model as there is no significant difference between the two gaps. Thus, multiple linear regression model was fitted in order to estimate the gap acceptance with pedestrian characteristics and vehicle stream characteristics. Gender, age, crossing point, waiting time, and crossing speed were selected as pedestrian characteristics while vehicle type and lane number were selected as vehicle stream characteristics. R statistical software was used for the model analysis. The regression model was developed with significant variables; gender and vehicle type. The results showed that females are accepting higher gap than males when crossing the crosswalks as an example, female pedestrian accepts 12.3sec gap when male pedestrian's acceptance gap is 9.46sec. When considering vehicle type, as an example pedestrian's acceptance gap is higher when the heavy vehicles were oncoming. The findings of this study can be useful for traffic planning work whilst assuring the safety of both pedestrians and drivers.

Keywords: *Unprotected mid-block crosswalks, Divided highways, Critical gap, Crossing pedestrians*

Author Details

1. Undergraduate student, Department of Civil Engineering, Sri Lanka Institute of Information Technology (SLIIT), Malabe, vishmacharuka@gmail.com
2. Lecturer, Mathematics Unit, Faculty of Humanities and Sciences, SLIIT, Malabe, malika.l@sliit.lk
3. Senior Lecturer- Higher Grade, Department of Civil Engineering, Sri Lanka Institute of Information Technology (SLIIT), Malabe, vasantha.w@sliit.lk

Effect of Crash Barriers on Driver Behaviour *Sachintha Rajapaksha¹ and Vasantha Wickramasinghe²*

Abstract

Crash barriers are widely used in mountainous roads with having open road sections. Crash barriers are often defined as safety barriers due to the positive safety impacts achieved. The current study is having the aim of checking whether there exists any relationship between the behaviour of the drivers with the presence of crash barriers. Here, the speed and lateral displacement of the vehicle are considered as driver behaviour. Class “A” road having consecutive similar radii bends with and without the presence of crash barriers was selected. The selected crash barrier was a Steel-type W-Guardrail crash barrier with having a height of 1.5m and a length of 50m in total. Data collection was done on a weekday from 4.00 pm to 6.00 pm using a drone and three cameras. Video footage data was extracted using tracking software. Speed and lateral position of each vehicle were collected at 5m apart along the curve. For the analysis, the average speed and lateral displacement values of each vehicle were used. The same data extraction procedure was adopted for both curves. Totally 180 number of vehicles were collected. As the primary objective, a hypothesis test was done to determine the effect of crash barriers towards the vehicle speed and the vehicle lateral position. According to the 2-tailed t-test results, obtained p-value <0.05 and hence, the null hypothesis is rejected. This implies that the existence of a crash barrier significantly effects for the vehicular speed and lateral displacement.

Keywords: *Crash barriers distance, Speed, Lateral position*

Author Details

1. Undergraduate, Department of Civil Engineering, Sri Lanka Institute of Information Technology (SLIIT), Malabe. sachintha2rajapaksha@gmail.com
2. Senior Lecturer- Higher Grade, Department of Civil Engineering, Sri Lanka Institute of Information Technology (SLIIT), Malabe. vasantha.w@sliit.lk

Effect of Blending Temperature and Blending Duration on the Degree of Blending of Reclaimed Asphalt Binders

Chamod Hettiarachchi¹, Xiangdao Hou², Qian Xiang³, Dara Yong⁴, Feipeng Xiao³

Abstract

Recycled asphalt mixtures are getting more popular due to many economic and environmental benefits such as a higher degree of recyclability, low material cost, less effect on the environment etc. Typically, reclaimed asphalt pavement (RAP) materials are combined with virgin aggregates and virgin asphalt binder to produce recycled asphalt mixtures. The amount of RAP binder mobilizes into the mixture is called the degree of blending. The degree of blending of reclaimed asphalt pavement (RAP) binder is strongly influencing the performance of recycled asphalt mixtures. If the degree of blending is known, the asphalt mix designers can make better decisions during the mix design process to produce more durable recycled asphalt mixtures. If the degree of blending is overestimated, the mixture could have less amount of binder. On the other hand, underestimating the degree of blending could produce mixtures with higher binder content. Hence, it is very important to properly determine the degree of blending of RAP binder. However, understanding the factors affecting the degree of blending and quantifying the degree of blending is still an open problem for researchers. This study investigates the effect of several factors such as blending method, blending temperature, blending duration, and RAP content on the degree of blending using Fourier Transform Infrared Spectroscopy (FTIR) analysis of the extracted binder from mixtures. It is revealed that the blending method, blending temperature, and blending duration have a significant influence on the degree of blending. The study revealed that prolonged blending durations and elevated mixing temperatures could improve the degree of blending. The amount of RAP in the mixture has little or no influence on the degree of blending. Further, based on the results, a blending chart is developed to determine the degree of blending with regard to blending duration and blending temperature.

Keywords: *Degree of blending, RAP, FTIR, Blending chart, Fluorescence microscopy, SBS modified asphalt*

Author Details

1. Postdoctoral Fellow, Key Laboratory of Road and Traffic Engineering of Ministry of Education, Tongji University, Shanghai 201804, China. chamod@tongji.edu.cn
2. Postgraduate Student, Key Laboratory of Road and Traffic Engineering of Ministry of Education, Tongji University, Shanghai 201804, China. 305308583@qq.com
3. Postgraduate Student, Key Laboratory of Road and Traffic Engineering of Ministry of Education, Tongji University, Shanghai 201804, China. xiangqian@tongji.edu.cn
4. Postgraduate Student, Key Laboratory of Road and Traffic Engineering of Ministry of Education, Tongji University, Shanghai 201804, China. yongdara45@gmail.com
5. Professor, Key Laboratory of Road and Traffic Engineering of Ministry of Education, Tongji University, Shanghai 201804, China. fpxiao@tongji.edu.cn

Axle Load Distribution Characterization for Mechanistic Pavement Design

Shanika Sumanasekara¹ and Wasantha Mampearachchi²

Abstract

As per the World Bank records of the year 2018, Sri Lanka had the highest road density among the South Asian countries with 173.9 km of roads per 100 square kilometres of land. Sri Lankan government reserves a considerable amount of finance in every year for developing and maintaining the existing road infrastructure, which is a well-recognized national priority. Currently, in local road designs, the Overseas Road Note 31 and AASHTO method are the most frequently used design references. However, in these methods, the consideration given for utilization of readily available in-situ materials and incorporating characteristics of substandard materials into the designs is not significant. Therefore, in most of the occasions, the economics of the construction processes are adversely affected due to overdesigns. The AASHTO Mechanistic-Empirical (M-E) method of pavement design combines the physical causes such as stresses, strains, and deflections within a pavement structure and the empirical mathematical models. It also allows the designer to utilize in-situ materials and allows to optimize the pavement design to suit the conditions at the site. Although attempts had been made to adopt M-E design method in Sri Lanka, since the M-E design process requires a lot of data input, the preference of local practitioners in using the M-E method is not satisfactory.

Out of the input parameters required for M-E design, traffic volume and axle load distribution data are crucial parameters. This study aimed at identifying trends in axle load group type distributions in different regions and to establish a classification for the pavement loading in regions throughout the island. It has been found that there are similar patterns in the distribution of axle group types throughout the island. Accordingly, on average the total axle counts in different regions constitutes of 57% single axles with single tires, 38% single axles with dual tires, 5% tandem axles with dual tires, and 0.1% tri axles with dual tires. Further, in this study, hierarchical clustering techniques have been utilized to identify geographical regions with similarities in pavement loading conditions. An attempt for zoning traffic load distributions for selected geographic areas has been presented in this study. Comparative for the resource utilization in obtaining axle load distributions, obtaining manual classified counts for a road is convenient. With the aid of the identified traffic load zones, this study will be useful for determining the traffic data input for M-E design, with a degree of accuracy level 2 as defined in the M-E design method.

Keywords: *Axle load distribution, Traffic load zoning, Mechanistic-Empirical pavement design*

Author Details

1. Civil Engineer, Road Development Authority, shanikasumanasekara347@gmail.com
2. Professor, Department of Civil Engineering, University of Moratuwa, Sri Lanka,
wasanthak@uom.lk

Feasibility Study of Using Calicut Tile Waste as an Internal Curing Fine Aggregate in Construction Industry

K. I. Pradeep¹, T. Tharshigan², W. K. Mampearachchi³

Abstract

Over recent decades, internal curing concept has become emerging technology and research in this area has increased tremendously. American Concrete Institute described 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”. Internal curing facilitates to minimize autogenous shrinkage as water in the pore structure will work to fill pores which lead to shrinkage. And also, effective cement hydration process will perform inside concrete by maintaining internal relative humidity which leads in to avoid self-desiccation.

Over the years, various methods and materials have tested to use as an internal curing aggregate. Calicut tile waste is generated as a wastage (damage tiles) in manufacturing factories and as construction and demolition waste in the construction industry. Waste Calicut tiles cannot be re-used to cast tiles as it is no longer shows clay properties with the phase changed of the material. The development of an internal curing fine aggregates using Calicut tile waste is described in the study.

The internal curing fine aggregates are prepared by crushing Calicut tile waste to the size less than 4.75mm. Then crushed calicut tile chips are soaked in water for 48hours to absorb and retain water inside the microstructure. Water absorption, Water desorption, the relative density of pre-wetted Calicut tile chips and microstructure were studied. According to ASTM C1761M, internal curing aggregate shall have a 72-h absorption not less than 5%., the release of at least 85% of its absorbed water at 94% relative humidity. Water absorption of 23%, water desorption of 91% and a relative density of 1.8 showed in the investigations. Scanning electron micrographs images of the aggregate show that tiny pores (> 100nm) are presented in the microstructure which can store water and release for hydration.

Initial investigations revealed that Calicut tile waste can be used as an internal curing fine aggregate since it has the required water absorption and desorption capacity.

Keywords: *Internal curing, Calicut tile waste, Self-desiccation, Calicut tile chips*

Acknowledgement

This research was supported by the Accelerating Higher Education Expansion and Development (AHEAD) Operation of the Ministry of Higher Education funded by the World Bank.

Author Details

1. Post Graduate Student, Transportation Engineering Division, Department of Civil Engineering, University of Moratuwa. ishara.kip@gmail.com
2. Post Graduate Student, Transportation Engineering Division, Department of Civil Engineering, University of Moratuwa. tharshiganhc@gmail.com
3. Professor, Department of Civil Engineering, University of Moratuwa. wk.mampearachchi@gmail.com

Development of Performance Indicators to Evaluate Performance-Based Road Maintenance Contracts

G.L. Mullevithana¹ and J.M.S.J. Bandara²

Abstract

Effective maintenance is essential to achieving sustainable development in Road sector. There are categories of maintenance activities as per the time of attendance, the period of attendance and frequency of attendance. Period for relevant activities is not specific. It is varying with the site condition and various parameters. Build-up the relationship between parameters helps to deliver the tangible results to programming, scheduling and budgeting for good governance, accountability and transparency in performance base maintenance.

Road maintenance activities can be classified as per nature of attending; Routine, Recurrent, Periodic and urgent. Indicators of Road Surfacing and Road Marking on the paved road under periodic maintenance were selected to monitor and evaluation in this study. These activities are required to attend at periods of several years, the frequency depending on the damage caused by traffic and other factors. International Roughness Index (IRI) of road surface data was collected by the existing RDA database and Roadroid Mobile App with comparing last improvement details on selected road segments. Data for thickness, skid resistance and reflectivity of road marking were collected by the field test with following the tools of monitoring and evaluation (M & E) which can be used to improve the way achieving better result.

Collected data were analyzed using panel regression, multiple regression and logistic regression tools. Initially stationary of data that represent variance and autocorrelation structure do not change over time was tested according to the Hadri Z statistic and results are significant providing selected stationary data. Out of random and fixed effect models, the most appropriate model is recommended by the Hausman test and that is the random effect model. According to this model, IRI gradually goes up due to Annual Average Daily Traffic (AADT) and within the periods, IRI will come to the critical level where the roads must be paid attention for the development. The range needs to be provided for periodically with achieving a critical range of IRI using selected stationary data models. Relationship between thickness, skid resistance & reflectivity of road marking with ageing is to be built up for future implementation and continue appropriate maintenance strategies.

Keywords: *IRI, AADT, Thickness, Skid Resistance, Reflectivity, Panel regression, Multiple Regression, Logistic regression*

Author Details

1. Postgraduate Student, Transportation Engineering Division, Department of Civil Engineering, gayaniapm@gmail.com
2. Senior Professor, Department of Civil Engineering, University of Moratuwa, samanjbandara@gmail.com

Development of a 3D Model of Open-Graded Friction Course to Evaluate the Inter-Connected Air Void with Aggregate Gradation

K.V. Dedigamuwa¹ and W. K. Mampearachchi²

Abstract

Open-Graded Friction Course (OGFC) is an asphalt material which has many advantages such as resistance to hydroplaning, low level of splash and spray, less headlight glare, improved visibility, a lesser number of accidents, reduced noise, and higher surface friction. OGFC is an advanced asphalt material which cannot thoroughly be understood by the results of traditional tests available. Though, OGFC consists of mastic, aggregate and air voids similar to hot mix asphalt, the porous structure of OGFC consists of a highly complicated interconnected void network. The number of voids and the void area of OGFC directly affects the durability and the permeability of the mixture. Therefore, it is necessary to increase the ratio of the area of interconnected voids to the area of total voids, in order to enhance the permeability of the OGFC mixture. A digital image analysis method has been introduced in this research in order to obtain different interconnected void structures for different gradations. This method consists of the identification of different properties such as number of void nodes, number of interconnected voids, areas of interconnected voids, reduction of interconnectivity with the depth, etc. An algorithm in “MATLAB” was developed to identify the properties of the cross-sectional images obtained by the captured surfaces of the cut specimens of OGFC. The obtained cross-sectional data of aggregates, voids and mastic was used to create the plotting data of the 3D model using the algorithm developed in excel. Finally, the python tool “plotly” was used on the “Anaconda” platform to create the 3D model based on the data model created in Excel. The data of three different gradations were analyzed by the use of this method and the results were obtained. According to the pre-evaluated test data of three gradations on durability and permeability, the validity of the 3D models was analyzed. The developed 3D model from this study can be used to determine the optimum gradations of OGFC considering the durability and permeability, based on the analysis of the internal structure arrangement.

Keywords: *3D model, Gradation, OGFC, Void arrangement*

Author Details

1. Research Assistant, Department of Civil Engineering, University of Moratuwa,
kasun.dv90@gmail.com
2. Professor, Department of Civil Engineering, University of Moratuwa,
wk.mampearachchi@gmail.com

Effect of Crowding Cost on Optimized Headway of an Urban Bus Route

Kaushan W. Devasurendra¹, Sumedha C. Wirasinghe² and Lina Kattan³

Abstract

Discomfort due to crowding in transit is a significant factor driving public transport mode choice. However, few studies account for passenger cost due to crowding in transit as an integral part of planning transit operations. This study explores the optimized headway operations of an urban bus line with attention to crowding costs. An analytical expression for the cost of crowding discomfort of passengers is developed. The cost of crowding discomfort is accounted for by penalizing the average value of riding time (VoRT) of passengers. Accordingly, VoRT is multiplied by a crowding penalty factor (CPF). CPF is formulated as a function of the load factor (L) that represents the crowding level inside the bus. This expression is integrated into an objective function that is the summation of operator and user costs, building on the square root dispatching policy developed by Newell (1971) and extended to 'many to many' demands by Wirasinghe (1990). The objective function is then optimized in terms of headway to obtain the value that minimizes the sum of passenger and operator costs. It is found that, in the presence of crowding costs, the optimum headway is smaller, and depends on bus size, the mean value of riding time, average trip time in the bus route, and the functional form of CPF. The scope of crowding cost on optimized headway is shown using an example.

Keywords: *Optimized headway, Crowding cost, Crowding discomfort, Transit scheduling*

Author Details

1. PhD. Candidate, Dept. of Civil Engineering, Univ. of Calgary, AB, Canada.
kaushan.wimalasiride@ucalgary.ca
2. Professor, Dept. of Civil Engineering, Univ. of Calgary, AB, Canada.
wirasing@ucalgary.ca
3. Professor, Dept. of Civil Engineering, Univ. of Calgary, AB, Canada.
lkattan@ucalgary.ca

Evaluation of Aircraft Excursion Risk at Bandaranaike International Airport

Sameera Galagedera¹, H.R. Pasindu² and Varuna Adikarivattage³

Abstract

Though Safety is one of the top priorities in the aviation industry, according to the IATA statistics (2020), all accident rate in 2019 was 1.13 per million flights. Among the aircraft accidents, the majority of aircraft accidents take place at airports and airport near vicinity areas. Considering the airport-related accidents, a high proportion of aircraft accidents have occurred during the landing and takeoff phases which are altogether only 1% of the whole flight time of 1.5-hours flight duration. Aircraft excursions and incursions are the two key types of accidents at runways. With regard to runway excursions, landing, and takeoff overruns, veer-offs and landing undershoots are common aircraft accident types. As IATA figures, there were 17 runway excursions (32% out of total aircraft accidents) in 2019 and it was identified as an area where further improvements need.

These excursion accidents can take place at any runway facility depends on the aircraft and airport operational and design factors. Thus, risk analysis which assesses potential event probabilities is a vital component in aviation risk management. Quantitative approaches such as risk models and qualitative approaches such as risk matrix, expert opinions, etc. are commonly used in risk assessments. Accordingly, under the Airport Cooperative Research Program (ACRP), Transport Research Board (TRB) developed models for overrun, veer-off, and undershoot probability estimation at landing and takeoff operations. Thus, excursion risk at distinct operational and weather conditions can be estimated along with these event probabilities and the corresponding severities.

Referring to Runway Protection Zones (RPZs) Risk Assessment Tool developed in ACRP 168 by Shirazi et al. (2016), this paper estimated landing overrun risk for 4E category B747-400 aircraft (critical aircraft for BIA) at various operational conditions at Bandaranaike International airport (BIA). The model developed by Ayres et al. (2014) was used to analyze landing veer-off risk. Those estimated landing overrun and veer-off risks were compared with regard to the risk at 30° C ambient temperature. Accordingly, the corresponding overrun risk increase by 27 times at tailwinds 12 knots or above. Similarly, when it rains, the above estimated overrun risk will increase about 5 times. Further, the corresponding veer-off risk increase approximately 10 times when crosswinds above 12 knots. Considering the sensitivity of various weather factors, the impact of fog, visibility, rain, and tailwinds gradually increase on landing overrun risk. In the BIA context, a condition at which tailwinds 12 knots with rain

and reduced visibility will be the worst weather conditions on landing overrun risk. Thus, excursion risks vary at different operational and weather conditions. Additionally, this research emphasizes the importance of runway design elements such as runway length, runway shoulders, airfield safety areas such as Runway End Safety Area, Object Free Area, and arresting systems such as Engineered Material Arresting System, etc. These elements can minimize potential excursion risk by minimizing corresponding event probabilities or respective severities. Accordingly, airfield design elements play a vital role in minimizing and maintaining aircraft excursion risks at a universally accepted target level of safety indeed 10^{-8} for a landing mission.

Keywords: *excursion, overrun, veer-off, undershoot*

Author Details

1. Student, University of Moratuwa, galagederasdb@yahoo.com
2. Senior Lecturer, University of Moratuwa, pasindu@uom.lk
3. Senior Lecturer, University of Moratuwa, varunaa@uom.lk

Analysis on Transport Mode Choices of School Children in Colombo District, Sri Lanka

Pubudu Damsara¹, Dimantha De Silva² and Namali Sirisoma³

Abstract

The increase in the usage of private transport modes for school trips has become a major reason for traffic congestion in Colombo District during peak hours. Colombo District consists of 402 functioning government schools, with a total student population of 374,995. Those schools have been categorized into four categories based on the availability of classrooms. According to the Ministry of Education, there is a limitation which is imposed on the distance from home to school, in the student enrollment process. However, it has been identified that the distances are exceeding the limitation, with respect to the school type and location. As a result, students choose different transport modes based on many factors such as accessibility, connectivity, safety, reliability and comfort. This study focuses on identifying the distances from home to school and the respective transport mode choice of the students in Colombo District. In addition, the factors which affect those school children to avoid public transport modes were analyzed. The quantitative research approach has been used in developing the research methodology in several phases such as factor identification, mode choices and demand distribution. Data collection has been conducted through a questionnaire survey which covers 28 selected schools under four categories, with a total sample size of 2875 in all Divisional Secretariat Divisions (DSDs) of Colombo District. Stratified sampling technique was used to collect data from the above school types. Schools which have classes in all streams up to advanced level (1AB schools) show the highest percentage of students (44%) who travel a distance of 2-10 km from home to school, while other school types show the highest percentage of students (49%) who travel a distance range of less than 2 km. Further, it has been identified that 1AB schools have some students who travel more than 25 km daily for their school trips. School van/bus services are the main mode of transport which is used by the students of schools located in Colombo Municipal Council (CMC) area, while public transport modes such as bus, train and “Sisu-Sariya school bus service” are the main modes of transport which are used by the students outside the CMC area. Active transport modes are the least popular mode of travel in both CMC and Non-CMC area (13% each), while private transport modes, which consists of car/van/jeep, motorbikes and three-wheelers contribute 25% in CMC area and 33% in Non-CMC area. Furthermore, it has been identified that longer travel times, longer waiting times, poor accessibility, less security and less comfort are the main reasons for the students in Colombo District, to not use public transport services. Even though there is a dedicated public transport service (“Sisu-Sariya”), which have been provided for school

children, it has been found that there is a considerable usage of private transport modes for school trips in the district. Therefore, this study recommends a procedure to develop an improved public transport system for school trips including a model for trip distribution patterns, network connectivity and system planning to attract more students into public transport services.

Keywords: *Travel mode choice, School trips, Public Transportation*

Author Details

1. Graduate Research Assistant, Department of Civil Engineering, University of Moratuwa, pubudu.damsara.93@gmail.com
2. Senior Lecturer, Department of Civil Engineering, University of Moratuwa, dds@hbaspecto.com
3. Senior Lecturer, Department of Management and Finance, General Sir John Kotelawala Defence University, ntsirisoma@kdu.ac.lk

Evaluation of Criteria for Setting Speed Limits to Sri Lankan Highways (Built-up Areas)

Nadeesh Silva¹, Himaru Kumarage², Malika Guruge³ and Vasantha Wickramasinghe⁴

Abstract

The speeds of vehicles are the most pivotal factor in most road traffic accidents. Enforcing a suitable speed limit is a tool for enhancing road safety. However, the currently available posted speed limits are placed without much scientific investigation. Those limits are merely decided by selecting a vehicle category. According to the Gazette of the Democratic Socialist Republic of Sri Lanka, No.1763/26, June 22, 2012, it was divided all vehicles into two vehicle categories and proposed only two-speed limits for the built-up areas. Such as 40 km/h for motor tricycles, special purpose vehicles, and 50km/h for all other vehicles. However, it is understood that road geometry, roadside environment, vehicle density, accident rates, average daily traffic values, etc, should be considered. The current study is having the aim of investigating the influence of such factors on speed limits. For that, ten site locations with different geometric characteristics, vehicle composition, and accident rates were selected in built-up areas. Using speed guns, the speeds of randomly selected vehicles were recorded. Totally, 3000 vehicle speeds were collected.

Initially, vehicles were divided into four categories as motor-bikes, three-wheelers, light vehicles, and heavy vehicles and performed ANOVA to find out whether there exists any difference in 85th percentile speed value between each vehicle category. The intention was to group the vehicles into similar speed clusters. It was identified that motor-bikes and light vehicles like Car/ Van/ Jeep are be selected as one cluster while three-wheeler and heavy vehicles like Buses/ Light good vehicles/ Heavy good vehicles as the other clusters. Next, in order to identify the influential factors towards the speed limit of each cluster, a correlation with each factor for the speed was observed. From the results, the speed limit of motor-bikes, three-wheelers, and light vehicles are heavily correlated with factors such as lane width, bicycle lane width, shoulder width, parking width, and the road markings, whereas the speed limit of heavy vehicle category is greatly correlated with the one-way or two-way operation and the roadside activity apart from the above factors.

Finally, a multiple linear regression model for each vehicle cluster was fitted and validated. The most influential factor in deciding the speed limit is the availability of bicycle lane irrespective of the vehicle cluster. Besides, not only for heavy vehicles but also three-wheelers and light vehicles, the roadside activities are also negatively contributed to deciding the speed

limit. These developed models are useful to review the existing posted speed limits in built-up areas.

Keywords: *Built-up areas, Speed limits, Traffic speed*

Author Details

1. Undergraduate, Department of Civil Engineering, Sri Lanka Institute of Information Technology (SLIIT), Malabe, nadeeshchameers@gmail.com
2. Undergraduate, Department of Civil Engineering, Sri Lanka Institute of Information Technology (SLIIT), Malabe, himarurk@yahoo.com
3. Lecturer, Mathematics Unit, Faculty of Humanities and Sciences, SLIIT, Malabe, malika.l@sliit.lk
4. Senior Lecturer- Higher Grade, Department of Civil Engineering, Sri Lanka Institute of Information Technology (SLIIT), Malabe, vasantha.w@sliit.lk

Evaluation of Criteria for Setting Speed Limits to Sri Lankan Highways (Non-Built-up Areas)

Himaru Kumarage¹, Nadeesh Silva², Malika Lakmali Guruge³ and Vasantha Wickramasinghe⁴

Abstract

Speed limits are posted on roads to enhance the safety of road users. However, no comprehensive norm is adhered in deciding the speed limits in many countries, and Sri Lanka is not an exception. In Sri Lanka, the speed limit is solely decided by the vehicle category and location (i.e., whether the road is located in a built-up area or non-built-up area). No geometric features of the roadway, roadside environment or safety concerns are been considered. Thus, this research is having the aim of investigating the factors to be considered in deciding the speed limits for roads in non-built-up areas. In that context, data were collected in ten locations located in non-built-up areas. At least 300 data samples were obtained from each selected location. Those ten locations were selected based on different geometrical characteristics, roadway environment, vehicle density, accident rates, and road classes. Initially, the ANOVA test was performed to find out whether there exists any difference in 85th percentile speed value between vehicle categories. The intention was to divide the vehicles into similar speed clusters. From that, it was identified that motor-bikes and light vehicles are selected as one cluster while three-wheelers and heavy vehicles as another cluster. Next, to identify the influential factors towards the speed limit of each cluster, correlation matrices were observed. From the results, the speed limit of motor-bikes is highly correlated with the roadside activities, roadway operation (one-way or two-way) and roadway marking. The speed limit for three-wheelers and light vehicles are mainly influenced by lane width, roadway operation (one-way or two-way), roadside activities and road markings. Roadside activities, lane width, roadway operation (one-way or two-way) and bicycle lane width are the factors affecting the speed limit of heavy vehicles. Multiple linear regression models were fitted for each vehicle cluster and validated. Mainly roadside activities, lane width, roadway operation, and road markings are collectively affected in deciding the speed limits. These developed models are useful in review the existing posted speed limits in non-built up areas.

Key Words: *Built-up areas, Speed limits, Traffic speed*

Author Details

1. Undergraduate, Department of Civil Engineering, Sri Lanka Institute of Information Technology (SLIIT), Malabe, himarurk@yahoo.com
2. Undergraduate, Department of Civil Engineering, Sri Lanka Institute of Information Technology (SLIIT), Malabe, nadeeshchameers@gmail.com
3. Lecturer, Mathematics Unit, Faculty of Humanities and Sciences, SLIIT, Malabe, malika.l@sliit.lk
4. Senior Lecturer- Higher Grade, Department of Civil Engineering, Sri Lanka Institute of Information Technology (SLIIT), Malabe, vasantha.w@sliit.lk

Impact on Traffic Flow due to the New Apartments in Colombo Municipal Council Area

Yasantha Perera,¹ Saman Bandara² and Loshaka Perera³

Abstract

The City of Colombo is the economic focal point in Sri Lanka and more and more people are attracted every day and the majority of them wanted to settle within Colombo city limits. Factors such as lack of proper public transportation system, traffic congestion, the concentration of reputed schools and easy access to other amenities have certainly added motivation towards this residing decision. From the supply point of view, the availability of limited land within Colombo City has skyrocketed the land prices and as a result, settling down in a high rise apartment has become a feasible solution for many people. Thus, many high rise apartment developments have been completed in the Colombo City and surrounding area recently and more projects are in the pipeline.

At present, an apartment building can be categorized as low income, middle income & high income depending on the unit size and facilities available. The impact on traffic generated from each category can be varied in terms of the number of vehicle trips, time and mode. Generally, the traffic pattern of an office building can be predicted as there are peaks in the morning as well as in the evening. However, when it comes to apartment buildings it is somewhat difficult to generalize the trip patterns since more distributed traffic flow can be observed throughout the day. Many land-use activities/developments may affect the traffic flow but this study is only confined to the residential apartments and its impact on the traffic flow during the operational stage.

Impact on traffic flow due to the traffic generated by apartments and trip generation rates from a different type of apartment buildings are important information and it is helpful to take planning decisions. However, there are no comprehensive studies available to quantify the impacts due to apartment buildings on traffic flow in the Sri Lankan Context. At present, parking requirement is assessed based on the floor area of an apartment unit and no standard or manual has been developed to estimate the trip generation. Therefore, this research aims to study the travel patterns of residents in apartment buildings and subsequently propose the trip generation rates as well as more appropriate and realistic parking requirements for different apartment types in and around Colombo city.

In this study, apartments are categorized into three major types; low, medium & high-income category based on the unit price. Fifteen apartments, five from each category, spread out within

Colombo Municipal Council limit were selected for this study. Trip pattern both in & out and traffic distribution by mode will be collected through traffic count survey while collecting the number of visitors, visitor's vehicle mode, vehicle ownership rate, number of occupied housing units and occupancy rate of parking lots will be collected through onsite observation survey. Level of satisfaction of residents with respect to the number of parking lots allocated for a unit, size of the parking, arrangement of the parking, width of the driveway, access for parking and number of parking lots allocated for visitors will be collected through a questionnaire survey.

Traffic generation rate per unit and vehicle compositions will be calculated separately and will compare with different apartment categories. Correlation analysis will be done to identify the relationship between trip generations with the number of occupied units, the total number of bedrooms and average unit price. Expected number of visitors per unit and mode of access will be estimated and will compare against the apartment category. Correlations between the number of visitors and number of occupied units, number of visitor parking lots, number of bedrooms and the average unit price will be checked to identify possible relationships. Category analysis using cross-tabulation will be carried out to identify any pattern between traffic generation and other independent variables.

Keywords: *Traffic impact, Traffic flow*

Author Details

1. Assistant Director (Planning), Urban Development Authority. pererayasa@gmail.com
2. Senior Professor, Department of Civil Engineering, University of Moratuwa. samanjbandara@gmail.com
3. Senior Lecturer, Department of Civil Engineering, University of Moratuwa. loshakap@uom.lk

Use of Geographical Information System (GIS) in the Infrastructure Development Projects: A Case of Coastal Railway Line Development Project in Sri Lanka.

Auchithya.Rathnayake¹ and K. Karunathilake²

Abstract

The theme "use of Geographic Information System in Infrastructure Development projects" is primarily based on the Coastal Line Development Project (CLDP) in Sri Lanka. An age-long practice of the Social Impact Assessment (SIA) and Resettlement Action Plan (RAP) was to address the community development in a top-bottom approach. With the westernization process, the international interference for the development projects has changed its approach to a bottom to top approach. And it uses newer technological systems to so-called development projects.

The Colombo Suburban Railway Project (CSR) is one of the projects which have been considered the bottom to top approach seriously, through SIA and RAP reports. However, this exercise is to investigate how the project has used GIS practically to meet the project objectives. Therefore, the research examines "How GIS assesses the social impact in CLDP?" The objective of this study is to identify advanced technological systems that can be implemented for the upcoming development projects to address the social impact, effectively.

The methodology of this exercise was ethnography. Therefore, the inductive analytic method has been used to generalise the whole population. The chosen sample of the study was Maradana to Kaluthara railway lines.

GIS is a database software which can be used for cartography as well as data analysis. The SIA is based upon the general public as well as the PAPs within the project influenced area. The structured questionnaire was planned to get the required information with the support of GPS coordinates. The PAPs identified within 50 meters (either side of the Right of Way) area. Google Earth map was generated to identify the locations and the GPS were taken from a mobile device with the use of Google Earth and Google Map applications. SIA sample was chosen proportionally from the Grama Niladhari Divisions with the use of the GIS database.

It was found that the use of GIS for data collection purpose and preparing the SIA report was an extraordinary benefit. Because it has given more accuracy to the data collection and the data analysis through spatially and quantitatively. When identifying the of issues towards the society and for introducing the CLDP to the ordinary people, drone images, 3D modelling with clip analysis, buffer and clip analysis would have been used for a comprehensive illustration. Finally, the CSR will be benefited with GIS application in project preparatory tasks.

Therefore, it was concluded that the use of GIS is not only essential and useful for the RAP but also the SIA, as GIS could help to investigate potential issues spatially and quantitatively.

Keywords: *Geographical Information System, Infrastructure development, Coastal Line Development Project, Social Impact Assessment*

Author Details

1. Postgraduate Student, Department of Sociology, University of Kelaniya, Sri Lanka, rathnayakermadb@gmail.com
2. Senior Professor and Cadre Chair of Sociology, Department of Sociology, University of Kelaniya, Sri Lanka, kkaru@kln.ac.lk

Applying Built – Operate - Transfer (BOT) Systems for Sri Lankan Expressways: A Case Study

Amila Prasadani Perera¹ and Dimantha De Silva²

Abstract

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

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

In this study, a model is developed to demonstrate the potentiality of applying BOT system for the expressway network of the country. The demand estimation, operation and maintenance cost and toll revenue used as the inputs for this model and financial viability is observed with different scenarios. The concession period, interest rates and optimality of selection of BOT are decided with different criteria based on financial viability.

As the Colombo-Katunayaka Expressway (CKE) meets the highest demand for traffic in the expressway network, inputs of CKE used to demonstrate the potentiality of applying BOT model and optimum subsidy level was determined with the application of variable concession periods.

This BOT model is further developed to validate any expressway network in urban or sub-urban basis by considering traffic demand with the considerations of unit length costs and revenues in operations with the performed analysis for existing and proposed expressways in Sri Lanka

The urban and sub-urban links were defined for expressways, by considering the actual traffic demands between each intersection of Outer Circular Highway (OCH), Southern Expressway and forecasted traffic on ongoing Central Expressway and proposed Ruwanpura Expressway

and costs and revenue per unit length were determined for each link in respectively by applying actual data.

Keywords: *BOT, Concession period, Financial viability, Traffic demand*

Author Details

1. Post Graduate Student, Transportation Engineering Division, Department of Civil Engineering, University of Moratuwa, prasadiefac@gmail.com
2. Senior Lecturer, Department of Civil Engineering, University of Moratuwa, dimanthads@uom.lk

Multi-Attribute Criterion to Identify Candidate Roads for Development Under Public-Private Partnership

Kopikah Tharmakulasingham and H.R. Pasindu

Abstract

In many cases, the Public-Private Partnership (PPP) projects are looked as a sceptical phenomenon due to the involvement of risk factors. However, in order to reduce the financial burden on the government, it is essential to undertake PPP projects. Lack of project prioritization due to the absence of a supporting framework for selecting the infrastructure projects in Sri Lanka was identified as one of the key issues by the World Bank for accelerating PPP projects. Therefore, a review was conducted to identify the criteria considered in the selection of road projects in other countries and to develop criteria that can assist the public and private entities to identify the potential road projects in Sri Lanka. The aim of this research is to develop criteria to prioritize highway project from pipelines for the developments under PPP.

As the first step, criteria which are used by USA (US Department of Transportation, Virginia Transportation, Commonwealth of Pennsylvania), Pakistan, Philippines, and World Bank for selection of PPP projects were collected. Further, Critical Successful Factors (CSF) and reasons for the failure of PPP highway projects were reviewed. The importance of these factors in the selection criteria was analyzed. A Multi-Attribute Analysis was used in the research. The criteria identified from other countries are subpackage under Demand, Financial, Risk and Scale categories.

A questionnaire survey was carried out with PPP and highway experts. The ranking of subpackage criteria, top six preferred criteria, and their score by nine respondents were collected. Using Garrett ranking technique, a single criterion was selected from each subpackages and used for the development of preliminary screening criteria. Based on the other countries' guidelines, the percentage responses, and scores for the top six preferred criteria, nine criteria were recommended for secondary screening. Financial viability of a project was identified as the topmost criterion to be considered in project screening.

The completed and ongoing 10 expressway projects were considered, and PPP candidate nature of these projects was analyzed based on the preliminary and secondary screening criteria. Five projects were eliminated from the preliminary screening. Due to less information availability: financial viability, economic development, traffic congestion reduced from the projects, roles of the road in-network and project cost were used for the comparison of projects. Port Access Elevated Highway has received the highest total score from the

secondary screening. The major limitation in this study is that there are not any successfully completed PPP road projects in Sri Lanka, to compare our study 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, Multi-attribute, Screening criteria, Garrett ranking technique*

Author Details

1. Engineer, Road Development Authority, kopikah@gmail.com
2. Senior Lecturer, Department of Civil Engineering, University of Moratuwa, pasindu@uom.lk



Transportation Engineering Division
Department of Civil Engineering
University of Moratuwa, Sri Lanka

Tel: +94 11 2640051 (Ext. 2219) | Fax: +94 11 26 51216
E-mail: trf.uom@gmail.com | Web site: <https://uom.lk/civil/transportation/trf>