

TRANSPORT RESEARCH FORUM 2011



Abstracts

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**Transportation Engineering Division
Department of Civil Engineering
University of Moratuwa**

Conference Program

Transport Research Forum 2011

Plenary Session		9.00 am – 10.30 am
Technical Session 1		11.00 am – 12.30 pm
H1: Highway Engineering	T1: Traffic Engineering & Planning	
<ul style="list-style-type: none"> ✦ A Review of Penetration Grading System and the Suitability of Alternate Grading System for Asphalt Binders in Sri Lanka Highways ✦ Evaluation of Feasibility of Polymer Modified Asphalt Binders for Sri Lankan Conditions ✦ Comparison of Density Specifications Used for Construction of Hot Mix Asphalt (HMA) ✦ Investigation on, Suitability of Cohesionless soil as a highway construction material 	<ul style="list-style-type: none"> ✦ Dynamic Travel Time Estimation Model for Real Time Travelers ✦ Evaluation of Flood Risk of Transport Infrastructure Using GIS Technology ✦ An Examination of the Appropriateness of Flyovers as a Traffic Management Measure to the Road Intersections of Sri Lanka ✦ Effectiveness of Vehicle-Actuated Signals for at Grade Four Legged Intersections in Sri Lanka: A Comparison Study Against Existing Fixed-Time Traffic Signals 	
Technical Session 2		1.30 pm – 3.00 pm
H2: Highway Planning	T2: Public Transportation & Road Safety	
<ul style="list-style-type: none"> ✦ Review of Axle Load Limits on Provincial Roads ✦ Finding Thresholds Based on Traffic, Sub-grade and Climate for Upgrading Surface Type of Roads Using HDM-4 Model ✦ An Approach to Evaluate Horizontal Alignment of Highways Using Curvature Index and Operating Vehicle Speed ✦ Selection Criteria for Minor Road Crossings for Expressways 	<ul style="list-style-type: none"> ✦ Study on Promotion of Bicycles for School Children in Eastern Province ✦ Development of Transport Infrastructure Master Plan for Long Distance Travel ✦ Franchising of Long Distance Bus Service in Sri Lanka in Order to Improve the Quality of the Service ✦ Compensation Systems for Road Accident Victims 	
Technical Session 3		3.30 pm – 5.00 pm
H3: Highway Construction & Maintenance	T3: Traffic & Transport Planning	
<ul style="list-style-type: none"> ✦ Evaluation of Cost Effectiveness of Performance Based Maintenance Contract ✦ Effectiveness of Rolling Straight Edge for Quality Control of Asphalt Concrete Surfacing ✦ The Cement Stabilized Soil as a Road Base Material for Sri Lankan Roads ✦ Cost Overruns of Foreign Funded Highway Projects in Sri Lanka 	<ul style="list-style-type: none"> ✦ Comparison of Transport-Land Use Models ✦ GIS Based Classification System for Low Volume Roads ✦ Improvements Need in Evaluation of Road Rehabilitation Projects ✦ Evaluation of Parameters Influencing Delays for Road Users at Railway Level Crossings in Sri Lanka 	

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A Review of Penetration Grading System and the Suitability of Alternate Grading System for Asphalt Binders in Sri Lankan Highways

J.N.Meegahage¹ and W.K.Mampearachchi²

Grading of asphalt cement is a very important factor in usage hot mix asphalt. It allows selecting the correct bitumen for road construction work. Bitumen or asphalt grading systems have changed from simple fundamental tests to more scientific methods in the past century. The development of grading of asphalt cement has lead to improve the performance of the road against the increasing traffic in last few decades. The fundamental test as chewing or penetration has been replaced by viscosity and aging properties of asphalt cement which gives more data about performance of roads.

However, number of countries in the world including Sri Lanka still using the traditional penetration grading system while developed countries have advanced to viscosity and superpave grading system. In Sri Lanka, 80/100 asphalt cement was used for road construction up to the year 2003. Due to high surface undulation problems, 60/70 binder asphalt cement was introduced. However, surface undulation problems still remain. Sri Lanka is a country with different temperature zones and penetration grade system is more susceptible for temperature.

This research attempts to review the use of penetration grading asphalt cement that is using Sri Lankan road construction and propose a possible alternative grading system. The important properties (viscosity, aging) of asphalt cement have not been tested in penetration grading system. There is no evidence for the performance of the properties of asphalt cement in mixing and laying temperatures. The research will penetrate through these facts and seek for better performance asphalt cement for Sri Lankan road construction.

Key words: *Asphalt Grading, Viscosity, Penetration*

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Evaluation of Feasibility of Polymer Modified Asphalt Binders for Sri Lankan Conditions

H.S.Sitinamaluwa¹ and W.K.Mampearachchi²

Polymer modification of asphalt binders has increasingly become the norm in designing optimally performing pavements. Pavements with polymer modification exhibits greater resistance to permanent deformation and thermal cracking, and decreased fatigue damage and temperature susceptibility. Polymer Modified binders (PMB) are effectively used in many countries, such as USA, Europe, Australia and India over last three decades to construct pavements with the superior performance and Extended service life.

In Sri Lanka 80/100 and 60/70 penetration grade bitumen has been used and it is observed that both binders cannot perform satisfactorily due to their temperature susceptibility. Modification of bitumen decreases the temperature susceptibility and therefore now it's time to Sri Lanka to move forward from conventional binders to modified binders.

Initial step of this research was to study about functionality of polymer modified bitumen and evaluating the need of polymer modified binders for Sri Lanka. After reviewing available data, it was identified that most suitable polymer modifiers for Sri Lanka are SBS, EVA, SBR, PE and Crumb rubber. Modification up to 4% - 8% of polymer is recommended and the modification level can vary with the desired properties of binder. That depends on the factors such as temperature, moisture level and other climatic conditions of the area and also traffic level.

PMB has to be characterized differently from penetration grade bitumen and the improved performance properties are difficult to demonstrate with conventional empirical rheological tests. This research is focused on reviewing the available PMB specifications and finally come up with a set of required properties for modified binders relevant to Sri Lankan roads, required testing methods and handling procedures for PMB. The final outcome of this research would become a good initiating point for local highway engineers to move from conventional binders to modified binders.

Key words: *Polymer Modified Binder*

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Comparison of Density Specifications Used for Construction of Hot Mix Asphalt (HMA)

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Measuring the density of asphalt concrete in the field is very important in quality controlling of the flexible pavements. Malpractices use in compaction of asphalt concrete in the field causes quality maintaining and durability problems in the Sri Lankan road system. In Sri Lanka Almost all the road projects use the Marshall Test Method to check the density of laid asphalt concrete. There are three methods for measuring degree of compaction of asphalt concrete in field; with respect to laboratory density, with respect to maximum density and with respect to a trial section. The objective of this research is to investigate the above three methods and select the most appropriate specification for quality control / quality assurance of HMA with further modifications to the prevailing systems.

In order to accomplish the objective following methods were undertaken. Air void percentage and degree of compaction of asphalt in binder/wearing course have been calculated w.r.t. Marshall Density and Theoretical Maximum Density. The results convince that core densities should be lie within the range of 97.5-100% of the Marshall Density of the same asphalt sample, and 92-98% of the Theoretical Maximum Density to satisfy the air voids within the acceptable region. Since it is difficult to have a control strip in the field, nuclear density gauge (CPN-MC-1DR-P PORTAPROBE) was used to check the density in the field. Observations imply that the number of roller passes need to be changed to maintain better quality in road construction.

Key words: Degree of Compaction, Theoretical Maximum Density, Marshall Density

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Investigation on, Suitability of Cohesionless Soil as a Highway Construction Material

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Major part of the Eastern and Northern provinces of Sri Lanka covered with Cohesionless soil which is available abundance in this region. It is important that utilization of locally available soil for the construction of the sub base of these roads to optimize the cost and reduce the environment impact. Recently it was noticed that failure in these roads which were constructed with this soil.

It is suspected that failure, such as developing cracks and settlements due to properties of used locally available sandy soil which was complied with specification requirement. Objective of this paper is to analyse and improve specification requirements. As well propose methods of utilization of cohesionless soil as a highway construction material. Initially, visited related road constructions and spoke to resource personalities. Further, observed the change of soil properties such as grading, maximum dry density, CBR value, Plasticity index, and liquid limit by mixing different type of clays with pure coarse sand. Laboratory test results and field visit experiences have helped us to propose the construction methods when cohesionless soil is used.

Key words: Cohesionless soil, Sieve Analysis, Proctor Compaction, Atterberg Limit, CBR

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Dynamic Travel Time Estimation Model for Real Time Travelers

U.S. Pilanavithana¹ and J. M. S. J. Bandara²

A broad range of diverse technologies, known collectively as intelligent transportation systems (ITS), holds the answer to many of our society's transportation problems. ITS are comprised of existing and new technologies, including information processing, sensors, communications, control, and electronics. Combining these technologies in innovative ways and integrating them into our multimodal transportation system will save lives, time, and resources. Transportation is the backbone of our society—the movement of people and goods provides the foundation of our quality of life and economic prosperity.

Various methodologies have been developed for dynamic travel time prediction. With the development of the Advanced Travelers Information Systems (ATIS), short-term travel time prediction is becoming increasingly important. As a key input for the dynamic route guidance system, travel time information enables the generation of the shortest path (or alternative paths) connecting the origins (or current locations) and destinations. **Traffic estimation and prediction system (TrEPS)** have the potential to improve traffic conditions and reduce travel delays by facilitating better utilization of available capacity. Moreover, a Short-term travel time prediction is incredibly significant to the real time travelers' information and route guidance system to hang on to the finest path during their route to the desired destination.

In this research, to fulfill the first objective a model for estimating path flows and modifying O-D flows simultaneously is proposed based on probabilistic information (Route selection behaviour of drivers) and traffic counts. The probabilistic information is accumulated to obtain prior information on path proportions. The link traffic counts are used as sectional volume information of links. The proposed model is constructed as a two stage model. The first stage model is estimation model of path flows and the second stage model is modification model of O-D flows. Moreover, it was clarified that the proposed two stage model had enough ability to estimate path flows and to modify O-D flows accurately even when prior O-D flows had inconsistency with the current traffic conditions.

By satisfying the Second objective, improved speed flow relationship employed which was focused on refining the speed estimates of network assignment models by using the modified Akçelik speed-flow model along with the literature findings. This Akçelik model produces significantly improved traffic assignment run times and provides more accurate speed estimates which lead accurate travel times to assure the last objective of identify the best path based on travel time using minimum real time information available.

In Conclusion, the estimation of link flows and modifying the O - D flows can be performed by two stages modal and travel time will be projected by the improved speed flow relationship. Projected travel time facilitates the selecting best path or the alternative for the user destination. Furthermore, integrate a method which will automatically update the system data base with the latest traffic data corresponding to road links and give the most up-to-date best travel time path to the road user is proposed as future development.

Key words: *Intelligent Transportation System, O–D Flow, Link Traffic Flow, Travel Time*

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Evaluation of Flood Risk of Transport Infrastructure Using GIS Technology

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Floods are not rare incidents in Sri Lanka. Historical record shows that Sri Lanka had experienced with many of catastrophic flood disasters. As a result of flooding, hundreds of thousands of lives, property, physical infrastructures are loss, damaged or destroyed. Especially, the transportation system & its infrastructure that includes roads & railways are frequently affected by floods. Neither a scheduled process nor any other resilience assessment plan or concepts to anticipate and reduce the impacts due to floods are available other than the traditional flood disaster management process of reconstruction. Hence, there is a need for an effective flood resilience assessment process to identify possible risks to the transportation system.

Information such as terrain, rain fall, drainage pattern that are relating to the factors affecting flood risk on transportation infrastructure is available in scattered manner. However, this information has not been analyzed in an integrated manner to identify the flood risk on transport infrastructure. Identification of flood risk of existing and proposed transport infrastructure will be very useful to mitigate impacts due to any type of flood disaster.

The paper presents a methodology developed to identify possible risk areas based on flood information available using Arc GIS platform. Data collection was done based on library & field surveys. Along with the literature survey relevant data such as flood records, physical infrastructures data, geographical & climatic data were collected and a GIS data base was prepared. A methodology was developed to identify possible disaster risk based on the information available using Spatial Analysis, 3D Analysis tools available in Arc GIS for the analysis and to produce results in map media.

A case study is presented to illustrate the application of the proposed methodology.

Key words: *Transport Infrastructure, Flood Mitigation, Risk Assessment, Spatial Analysis, Disaster Management*

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An Examination of the Appropriateness of Flyovers as a Traffic Management Measure to the Road Intersections of Sri Lanka

Osada.V. Peiris¹

Traffic congestion and related issues are mostly common phenomena in most of the developing countries. There are different, location specific measures have been taken as solutions for decongestion at the urban intersections. One of the recent traffic management methods for congestion alleviation in Colombo City is the introduction of flyovers to important intersections at main road corridors. The importance of a flyover is its use of the vertical space which assumed that cause fewer impacts to the adjacent properties and the existing infrastructure.

This study seeks to examine the level of success achieved through introducing flyover concept to the road intersections in terms of overall spatial development. It is argued by many people on the effectiveness of the flyovers, especially at road intersections such as Dehiwala, Nugegoda that their effects on the functional efficiency of the city through its mismatch between physical and design aspects.

The performance of the recently introduced flyovers road intersections can be tested by comparing before and after conditions in relation to the overall expected achievements by using spatial parameters. Basically, accident counts, speed and travel time surveys can be used as the main evaluation criteria to test this at a particular location. Moreover, the variation of the pedestrian movement pattern, impacts on the trading activities and vehicular flow pattern after the project implementation can be used to evaluate the level of impact to the users at the location.

Key words: *Traffic Congestion, Traffic Management, Flyovers, Effectiveness, Performance, Level of Impact*

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Effectiveness of Vehicle-Actuated Signals for at Grade Four Legged Intersections in Sri Lanka: A Comparison Study Against Existing Fixed-Time Traffic Signals

A. Kamalrajh¹ and J.M.S.J.Bandara²

The goal of traffic engineers in recent years is trying their best to get the most out of the systems that they develop. By designing most efficient systems, using the advancement of electronics the overall costs of transportation should be slightly easier to manage.

In Sri Lanka, it is anticipated that the prevailing fixed-time traffic signals would be replaced by modern actuated traffic signals in near future. This study has been carried out to evaluate the efficiency of vehicle-actuated signals against prevailing fixed-time traffic signals prior to their implementation.

Several existing signalised intersections in the capital city were carefully studied with their geometric and traffic turning movements. A traffic simulation was programmed in Microsoft Excel in such a way to generate traffic for a typical intersection in an urban area. In order to characterise real dynamic condition of traffic flow, various traffic volume combinations were selected among North-South and East-West through-traffic and other turning movements (Left-turns, Right-turns & Heavy vehicles) were randomised within their permissible limits. Numerous calculations for Cycle time, Vehicle-delay, Pedestrian-delay and Critical movements of different traffic combinations were computed by exploiting a renowned Australian Software called "*Signalised (and unsignalised) Intersection Design and Research Aid [SIDRA]*".

The outcomes of analysis were compared in graphical and tabular forms for the efficiency of *fully-Actuated Signals* against *fixed-time Signals*. It has been found that the replacement of fixed-time traffic signals with fully-actuated signals for stand-alone intersections shall not produce any major enhancement (reduction in delay) to the existing at grade four-legged intersections, which have three standard-approach lanes including right turn-bays with optimum length and two standard-exit lanes. Moreover, it is sensible that semi-actuated signals would be a better alternative for certain signalised intersections where major roads (continuous high demand) meet with minor roads (very stochastic or very low traffic demand).

Key words: *Fully-actuated Signal, Pre-Timed Signal, SIDRA*

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Review of Axle Load Limits on Provincial Roads

C. S. N. Liyanage¹ and W.K.Mampearachchi²

In 1989, According to the Provincial Council Act, the responsibility of managing of about 16,500 km Provincial roads which were classified as class C & D and Gazette noticed as maximum gross weight limit of 05 Tons were handed over to Provincial Road Development Authorities. Since these roads are the secondary links to the national road network, some of them are being used for transporting for heavy cargo. These roads had not been designed for such a heavy traffic. Currently, many roads experiences lot of deformations (rutting and settlement), cracking and shortening of the life time. As a result of poor operating conditions of these roads, users have to bear high vehicle operating cost and unsafe conditions leading to high risks and the road agencies request additional funding from the budget.

Primary objective of this study is to review of axle load limits in provincial roads and formulate a simple but reliable method to establish the axle load limits. To find out the optimum allowable Gross weight/ Axle weight limit, the life cycle cost with unique level of maintenance and services throughout the design period has been considered. A case study was conducted for Dodangoda-Thebuwana road in Kalutara district.

ESAL level of the roads were calculated based on the manual classified counts (MCC) survey and vehicle load survey. Load survey was conducted on road sides to survey the load factor and the commodity type of commercial vehicles. Distributions of gross weight among axles were estimated and converted axle load in to ESAL. Cumulative ESAL during the design life was estimated for axle load limit of no limit, 4 MT, 5 MT, 6 MT and 8 MT. and the gross weight limit of no limit, 6 MT, 8 MT, 10 MT and 15 MT. Pavement designs for the traffic level and selected subgrade conditions were estimated and the life cycle cost analyses were performed to estimate the axle load limits for provincial roads.

Key words: *Axle Loads, Provincial Roads*

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Finding Thresholds Based on Traffic, Sub-grade and Climate for Upgrading Surface Type of Roads Using HDM-4 Model

Y.P.S.R. Piyasena¹ and W.K.Mampearachchi²

Highway Development and Management Tool (HDM-4) is a powerful system for the analysis of road management and investment alternatives and it used to prepare road investment programmes and to analyze road network strategies.

In this study HDM-4 tool is used to find the thresholds based on traffic, subgrade and climate for upgrading minor roads in Sri Lanka.

Several road sections were defined based on different possible traffic, subgrade and Climatic conditions for Gravel, Penetration Macadam (PM), Surface Dressed (SD), Portland Cement Concrete (PCC) and Asphaltic Concrete (AC) pavement types. All together more than 300 sections were modeled in the HDM-4. Level-1 calibration was done in HDM-4 to harmonize with Sri Lankan condition. Using HDM-4 strategy analysis different rehabilitation and improvement alternatives were analyzed maintaining existing pavement as considering base case. Analysis were done for 20 years period and optimized to get maximum NPV.

The outcomes of the analysis, that is NPV and EIRR were compared in tabular and graphical forms in order to identify the thresholds of traffic, subgrade and climate for each pavement category for upgrading the surface type. This saws traffic volume is significantly affected and effect of subgrade condition and climate is less. It saws upgrading of Gravel road to PM is not feasible unless average daily traffic is greater than 150 vpd and it is not worthy to upgrade to PCC under considered conditions. Upgrade of PM road to SD is feasible if traffic is greater than 600 vpd and not worthy to upgrade to AC or PCC under the considered conditions. Upgrading of SD road to AC or PCC is not feasible under considered traffic and other conditioned. Furthermore it can conclude minor roads in Sri Lanka can used Gravel, PM or SD pavement type with proper maintenance under traffic volumes less than 1500 vpd and it is more economical than upgrading to AC or PCC. But AC or PCC roads can last long in good condition even without any maintenance.

Key words: HDM-4, NPV, EIRR

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An Approach to Evaluate Horizontal Alignment of Highways Using Curvature Index and Operating Vehicle Speed

R.P.G.K.S Rajapaksha¹ and J.M.S.J Bandara²

In recent years, Sri Lanka has experienced an urban traffic congestion that caused a waste of time and energy. It is known that road geometries partly contribute towards decrease in operating vehicle speed. According to conventional Highway Geometric design procedure there is no accurate method to predict operating vehicle speed with different combinations of horizontal alignment (variation of bends with respect to different curvatures). This study explores a methodology to evaluate the actual horizontal alignment of roads to increase the efficiency of highway management with respect to reducing travel time.

In this paper after classification of all the design elements, the new concept of “curvature Index” (the degree of angle variation per unit length) is introduced to represent actual horizontal alignment of a road segment including number of bends and nature of bends. The curvature index measures analyzed were : bend density (number of bends per km); cumulative angle (degrees per km); mean angle (degrees); and standard deviation of angles. The research confirmed that driver's speed choices are more strongly related to curvature Index than curve design speed, and to the approach speed environment.

The curvature index and operating vehicle speed is estimated using the database of GPS (Global Positioning System) receivers. GPS data is collected at selected road segments in Sri Lanka closely representing free flow condition. A methodology is developed to increase the reliability of GPS data obtained in order to investigate the relationship between curvature indexes and operating vehicle speed. Simple linear regression analysis is used to develop operating vehicle speed models, which related driver speed to the curvature Index of the highway. ArcGIS (Geographical Information System) provides a good platform to model relationship between curvature index and operating vehicle speed because the analysis tools in GIS can be directly used to analyze the GPS data.

Key words: *Horizontal Alignment, Curvature index, Global Positioning System (GPS), Geographical Information System (GIS), Highway Geometry*

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Selection Criteria for Minor Road Crossings for Expressways

N.Lodwick¹ and W.K.Mampearachchi²

Transportation network in a country plays a vital role in economic and social development. Government of Sri Lanka (GOSL) during past few decades has taken every effort to upgrade its transportation by strengthening the countries transportation infrastructure. In addition introduction of high speed links are one of the strategies used in this regard and few of them are now under construction under the jurisdiction of Road Development Authority.

Since the construction of expressways are newer to our country numerous types of problems have been encountered during preliminary and implementation stages causing impediments for the progress with additional project cost. Selection of crossing types for the minor roads for expressways is one of the problems under the above category which has caused severe problems in various stages.

Implementation of secondary crossings for expressway at present does not follow up a pertinent criterion. Most of crossings implemented were based on least cost criteria rather than considering social & environmental aspects have lead the views of public and the relevant authorities that the projects do not follow the guidelines given under Environmental Impact Assessments.

Contemporary outcomes of the above have generated negative impacts for the future projects in the pipeline. Therefore need of a systematic criterion for the selection of crossing types have become a timely requirement.

Objective of this research is primarily aimed at an attempt to identify the cause of impacts with their scale of magnitude at minor crossing locations on expressways and then to resolve the same by addressing them through a systematic approach in finding optimum solution.

No previous research has been found in this regard and was noted that there were no direct methods identified due to its complex nature. Since the area of study observed to be very vast the research has been converged and focused within the scope of Colombo – Katunayake Expressway Project.

Methodology adopted in this process contained a series of literature studies along with case studies carried out at field locations to identify the important factors dealt with the problems. Outcomes of the above have revealed that social, environmental and construction related issues would generate a compound effect in finding the optimum solution for the crossing types.

In this study Analytical Hierarchy Process has been used as a tool to find the optimum solution since it has been widely used for the problems associated with multiple causes of impacts with difficulties in determining the factor weightages.

A network has been established with related impacts along with proposed alternative crossing types. Main impacts were structured in to secondary impacts to make ease for the determination of weightages for the analysis. Introduction of comparison factors between issues were considered in

finding the scale of magnitude of each impact on final solution. Contemporary alternative evaluations were carried out under each impact issue concerned. Final solution was obtained by using the alternative with the highest weighted average for a particular location.

Findings from the above research have revealed that lack of a systematic criteria and negligence has caused severe impacts in selecting minor crossing types. Also it was observed that the final solutions obtained under proposed systematic criteria are equivalent to the final solutions resulted in the relevant case studies concerned.

Methodology proposed in this research will promote a way forward towards finding the optimum solution for secondary road crossings for expressways concerned for future projects. However necessary changes are to be incorporated in par with the issue related to the particular project locations in obtaining the best solution.

Key words: Expressways, Minor Road Crossings

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Study on Promotion of Bicycles for School Children in Eastern Province

W.P.D.V.M. Weerasinghe¹ and K.A.S. Kumarage²

Various organizations belonging to governmental as well as nongovernmental sectors are presently engaged in promoting the use of push bicycles. Every such organization involved in this endeavor is of the view that bicycle has the potential to face the challenges posed by the motorized modes of transport. In the Sri Lankan context, promotion of the use of bicycle is a long felt need and has reached the proportion of needing the priority basis for its handling.

This thesis is just a small step of a longer journey in that direction. It has collected and analyzed every fact and figure that counts to establish a solid factual basis to start a program of distributing bicycles among the needy school children in the Eastern Province as an initial step. The study also has the scope of extending it to other provinces, too.

The purpose of the thesis also carries an institutional requirement of the National Transport Commission (NTC) of facing the problem of providing transport for school children. The NTC which was setup for the sole purpose of handling transport by omnibus has now realized the usefulness of the bicycle in discharging its responsibilities.

The thesis, therefore, will provide the NTC with a factual basis to venture in to a program of donating bicycles to school children and at the same time to encourage the use of bicycles in the whole country.

The reasoning based on scientific analysis of data adopted here is applicable to other parts of the island, too, because, the sample area taken for the study is reflective of common conditions prevailing in the country.

Beyond the immediate need the study has well established the importance of the bicycle as a way of life in tomorrow's world. Things such as, special lanes for cyclist, wayside protective shelters and repair shops should not be in the area of wishful thinking in the future.

Key words: *Bicycle, School Children*

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Development of Transport Infrastructure Master Plan for Long Distance Travel

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Transportation is a facility which decides the level of achieving economic development in a country. Observing bird's eye view of the present condition in Sri Lanka it can be identified that transportation is currently suffering with many difficulties though the government is spending billions of Rupees on transport infrastructure development.

The current road network has a higher density comparing to the other developing countries, but it is lack with mobility and higher level of service though it provides wider accessibility. Therefore the long distance travelling consumes more time than it requires. The railway system in the country has not extended after the colonial period. The railway system is lack of both mobility and accessibility. There is no clear plan to optimize railway system as a public transport service by connecting major cities and integration it with the road network with higher mobility to reduce the travel time.

The present work describes a methodology which containing an integrated long distance transport network which reduces travel time while increasing mobility and accessibility. The research area covers the whole island by providing integrated rail and road system for the entire country. Data of the existing rail and road transport, land use data, traffic data, socio-economic data, future plans of infrastructure development, future plans of urban development and future plans of transport development were collected and analyzed to identify the existing and future demand centers of the country. Alternatives were evaluated with respect to travel time, environmental and social impacts and economic considerations with the help of GIS based analytical tool to generate optimum rail and road transport systems separately and integrated them to provide accessibility between transport modes to increase the efficiency of the system.

The final outcome of this research is a transport infrastructure master plan for long distance travel which will provide an efficient system while increasing both the mobility and the accessibility of the transport system in Sri Lanka.

Key words: *Mobility, Accessibility, Optimum Network*

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Franchising of Long Distance Bus Service in Sri Lanka in Order to Improve the Quality of the Service

P.G.C.Karunaratna¹ and K.A.S. Kumarage²

The topic consists with two main areas as franchising of long distance bus service and quality of the service. Long distance bus services are regulated by the National Transport Commission, and bus industry in Sri Lanka has passed mainly four periods, and it can be seen different services provisions in terms of management ownership and regulatory structure of the bus industry. But the problem is long distance bus services are not successfully providing a reliable ,safe and efficient service for passengers .The National Transport Commission is finding on possible ways of making balance with objectives of long distance the bus operator and the passenger in order to establish a reliable and sustainable long services .Sri Lanka has passed four periods of Omni bus services, and it can be seen different services provisions in terms of management ownership and regulatory structure of the bus industry. Although there is a period of 100 years old history of Omni bus transport in Sri Lanka, the country is not successful with providing a competitive service for passengers.

National Transport Commission has drawn its attention towards franchising of long distance bus services helps to create a better path for an acceptable bus services for the three parties (passenger, operator and the regulator).

The main objective of this study is to propose a suitable franchising system for long distance bus services and recognition of strengths and weakness of existing reform of management of omnibus industry that is being made by the National Transport commission.

Descriptive method is used for the study, and the conclusion is that the franchise system should be improved with new management system that is suitable to the country.

Key words: *Bus Service, Long Distance, Quality*

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Compensation Systems for Road Accident Victims

A.R.R. Piyasekara¹ and K.A.S. Kumarage²

Worldwide over 1.3 million Persons killed, 50 millions injured in 2007 due to road traffic accidents. In 2004, Road Traffic injuries was the ninth leading cause of death. By 2030 it is estimated the fifth leading cause of death, beating the rank of HIV/AIDS and Tuberculosis.

Sri Lanka is experiencing an increasing trend in road accidents during the last few decades. Ignoring safety hazards may lead to an increase in the number of serious accidents. Collected data on accidents from the police and literature reveals several important issues in road traffic accidents and the compensation process.

Traffic accident victims suffer a great amount of damages. They are not only susceptible to bodily injuries but they may also succumb to financial problems arising from the hospital bills, medical treatment or rehabilitation.

However, the trauma from such accidents seems to be immeasurable. As this trauma is often accompanied by pain, suffering and emotional distress, victims may not be expected to get on their feet as quickly as possible.

Often times, after a traffic accident, most victims are simply overwhelmed by the barrage of telephone calls, insurance paperwork, accident reports, treatment costs, medical bills, paperwork and other correspondence. These may be too hard to handle for a victim who may want to rest and take a time off from distractions. Due to the existing compensation system for road traffic accident victims in Sri Lanka, vulnerable road users are doubly vulnerable.

Hence it is very important that the compensation systems and legal procedures should be simple and accessible to the victims of road traffic accidents.

This thesis discusses the features of the post-accident process, its impact on the road traffic accident victims and systems which are practicing worldwide to compensate road traffic accident victims.

Key words: *Road Traffic Accidents, Victims, Compensation*

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Evaluation of Cost Effectiveness of Performance Based Maintenance Contract

R.M.N. Thennakoonwela¹ and W.K.Mampearachchi²

Road authorities around the world have been innovating and finding ways to cope with the high cost of road network maintenance, the growing demands of road users and the changing traffic type and volume. A well maintained road is needed to make the network sustainable for future generation.

Poorly maintained roads constrain mobility, increase vehicle operating cost, increase accident rates and their associated human and property cost. Poor maintenance of the imposes heavy burden on the economy. However maintenance allocation for road agencies has steadily increased. There is a need of providing better value for expenditure, through higher level of service and low total maintenance cost.

The objective of the study is evaluating the cost effectiveness of performance base maintenance contract especially provincial roads in Sri Lanka.

Four types of maintenance methods were analyzed. Maintenance cost and condition of the road in each category were analyzed. It was found that Performance Based maintenance contract method performed well low cost and good road condition. The road condition is maintained at good condition relative to the other method with low maintenance cost. And it was also founded that developed formula can be used for the road condition, when the overall damage percentages of the distress are given.

Road maintenance consist of several items such as maintaining of road carriageway (pavement), shoulders, draining stems, road signs & markings within the right of way. The research was focused on establishing a road condition rating index based on the road condition and analyzing the effectiveness of the maintenance standard, there are several types of Maintenance contracts, namely; Direct Labor, Contract, Performance based Contract and Performance based direct labour. Effectiveness of Maintenance standard in four contract method was analyzed using the road condition rating index and the maintenance cost.

It was found in the literature that most of the countries use International Roughness Index (IRI) to evaluate the pavement condition and the standards have been based on the IRI value. However, provincial road development authorities in Sri Lanka are still not using IRI to select road for maintenance or rehabilitation. The selection of roads for maintenance is done arbitrary. Survey was conducted to find the maintenance standard used in provincial road development authorities. Currently, Western Provincial Road Development Authority maintains the roads under different maintenance standard. Performance Based Maintenance (PBM) standards have been introduced recently for the Western Province Roads network especially for foreign funded projects to evaluate their performance. In this research, pavement distress data were collected of selected road sections and the pavement rating of the selected roads by a panel consists of Engineers, technical officers and Technicians. The Collected data was analyzed using SPSS software. It was found that the r-squared value of the selected independent variables for the relationship was about 0.36 with the shoulder damaged, Since the shoulder damage has minimal effect for the condition of the carriageway, it was removed from the

independent variables and R-Squared value of the relationship has been increased to 0.726 and the analyzed showed the significance of the selected parameters.

Cost of the conventional maintenance methods are higher cost than the performance based method. It was shown that the rating of the road condition in performance based contract system is higher than the conventional methods used in this analysis. It is clear that, cost saving can be achieved under the performance based contracts.

Key words: *Maintenance Contract, Performance Based*

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Effectiveness of Rolling Straight Edge for Quality Control of Asphalt Concrete Surfacing

M.S.K. De Silva¹ and W.K.Mampearachchi²

Today in each part of the country, road surfacing is done by Asphalt Concrete. With the increase usage of Asphalt Concrete, the necessity of Quality Management System was arisen. Hence the Quality Management System for Asphalt Pavement was developed and established in following areas;

1. Plant operation
2. Asphalt Concrete transportation
3. Paving and Compaction
4. On finished Asphalt pavement

To check the quality control on finished pavement, there are many parameters to be considered. One important parameter is Roughness value on the finished pavement. Different Technical Specifications provides various devices to quantify the Roughness value. One such method is to measure Roughness value using the Rolling Straight Edge.

Here the dominant parameter is ups and downs of the road surface. Rolling Straight Edge equipment was used to count total ups and downs (Bumps) with magnitude of a particular length. A correlation between International Roughness Index and Rolling Straight Edge measurement has been developed using statistical analysis software SPSS. Most significant parameters for the roughness were identified and modifications to the specification were made.

$IRI = 1.662 + 0.02X$; ($X =$ Summation of the magnitude of the total bumps ≥ 4 mm)

A case study on identifying the high roughness sections of a road was made and effects of remedial measures were analyzed using the developed correlation.

Key words: *Roughness, International Roughness Index, Rolling straight edge*

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The Cement Stabilized Soil as a Road Base Material for Sri Lankan Roads

W.W.Bandara¹ and W.K.Mampearachchi²

Dense Graded Aggregate Base has been used for road construction work in the Sri Lanka for many years. Rocks which are used to produce the aggregate are not available everywhere in the island. For example it is difficult to find suitable rocks in Northern part of Sri Lanka. Further, the available rocks are gradually decreasing due to the usage, land ownership and ecological issues. Therefore, cement stabilized soil can be used as an economically viable alternative material for the road base.

Soils that can be stabilized are coarse granular, Sandy, Salty and Clayey materials. Coarse granular materials are not widely available in Sri Lanka. Sandy materials are freely available and give higher elastic modulus than Salty and clayed materials. Cement stabilized base need at least 97% compaction of maximum dry density. According to the findings during the construction, it has been revealed that the most practical thickness of the cement stabilized base is 200mm for achieving the compaction. In order to control shrinkage cracks, unconfined compressive strength at seven days is not more than 4 MPa. This can be increased to 6 MPa by providing an Asphalt Crack Relief Layer.

For road pavements with stabilized base, critical tensile stress or strain is located at the bottom of the stabilized layer and the tensile stress should be limited to control the fatigue cracking for required number of axial load repetitions. Above mentioned limitations cannot be analyzed by the conventional Structure Number Based Pavement Design. Hence a Mechanistic – Empirical Method need to be used for the pavement design. This is difficult to carry out in general practice. Therefore, through our project Pavement design charts for the cement stabilized base with Sandy soil were developed by a Mechanistic – Empirical Method.

Key words: *Dense Graded Aggregate Base, Cement Stabilized Soil Base, Asphalt Crack Relief Layer, Structure Number, Mechanistic Empirical Method*

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Cost Overruns of Foreign Funded Highway Projects in Sri Lanka

H.H.N.A.Hettiarachchi¹ and W.K.Mampearachchi²

When an infrastructure development project is planned, an accurate estimation is critical. As a result of failing the fulfillment of expected accuracy, the cost overrun of the projects would result. The cost overrun is defined as a difference between the initial project estimate at the planning stage and the accounted project cost at the time of project completion. However, cost overrun is one of the major negative consequences that may influence to the economy of a developing country, like Sri Lanka. In order to fill the aforesaid financial gap, the necessity of pumping additional funds through the consolidated fund by the GOSL would be arisen.

Out of the significant impacts of which caused by cost overruns in foreign funded projects are delay in completion and curtailment of original scope of work. But both adverse impacts are restricted by the conditions and policies of funding agencies. It is the normal practice that influencing to complete the project up to the agreed scope under the specified standards by the funding agencies. Due to the fact that the highway projects would make greater impacts not only to the development of infrastructure but also to the higher cost overruns, it was decided to limit the analysis only for the highway projects.

The overlooked main factors that cause to turn the project into track of the cost overrun path are;

- Increase quantities
- Price Changes

However, there can have many factors that have supported above mentioned main factors. The objective of this research is to

- To study what is cost overrun?
- To identify factors behind cost overruns in Sri Lankan projects
- To identify main risk factors & risk management

The research would address the gap of knowledge of why highway projects overrun their cost. In addition to that, a method for minimizing cost overruns or identify cost overruns in advance will be proposed.

In this research, twenty numbers of cost overrun highway projects completed within recent years and funded by different agencies were collected and analyzed. What are the main causes for cost overrun, how is a BoQ item correlate to each other item and what is relationship of cost overruns with project period or delay will be studied.

This research highlights the significance of understanding proper risk allocation between contractual parties in Sri Lankan road projects by changing percentage of contingency component. It aims at assisting Sri Lankan road contractors and employers to

- a) Identify the risk sources inherent in road projects,
- b) Understand their risk responsibilities,
- c) Improve their risk handling strategies so that they would optimize the scarce resources
- d) Enhance the socio-economic value of Sri Lankan road projects.

Constructions are rich with many difficulties and had made less attempt for risk analysis allows us to at least make an attempt to identify these risky projects and attaching some financial contingent value to recover the same. The project budget then becomes a more realistic representation to the client to afford it.

Cost contingency is included within a budget to represent the total financial commitment for a project client and the quantum of such contingency is of critical importance to the projects. It is a normal practice that, maintaining 10% contingency for total cost overrun factors. But this thesis will prove that, it is incorrect and different allowances should be maintained. In this regards, the relationships are defined and they will be recommended to adopt.

Key words: Highway Construction, Project Budgeting, Inflation

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Comparison of Transport-Land Use Models

P.C.P. De Silva¹ and J.M.S.J. Bandara²

Over the last forty years, a variety of operational models has been developed and applied in the field of transportation and presently these models have become principal tools for strategic transportation planning. Once scholars started to point out that existing and future land use pattern exerts major impact on transportation and many of the issues prevailed in the cities at present occur due to the ignorance of the linkages of transportation and land uses, impact from the land uses and its changes is widely taken in to the transport modeling. Yet, lots of studies have shown there are shortcomings in the effectiveness of the transport models. Robert Cervero stated that *“Hampering coordination is the reality that the benefits of careful transport-land use integration are often not evident until ten or more years in the future”*.

This paper examines the current status of the development of transportation modeling which considers the impact of land uses and its changes, and identifies the future developments of such models which are either likely or desirable. This paper reviews ten such models which are used widely in transport planning in the means of data and data types used, surveying methods of such data, data modeling methods, traffic assignment and travel forecasting methods, outputs generated, spatial techniques involved and user interfaces in relation to accounting the impacts of land use. Further, this research is a comparison study between different models in above means that finds out prospects and constraints of each model. Finally the paper gives a summary for the future developers of transport models and paves way to employ the prospects and to overcome the constraints of existing models in future models.

Key words: *Transportation, Land Use, Modeling, Integration*

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GIS Based Classification System for Low Volume Roads

S.C.P. de Silva¹, Loshaka Perera² and W.K.Mampearachchi³

In Sri Lanka, vast amount of infrastructure facilities have been built, still building, but yet no proper classification system has implemented sometimes. The road network in Sri Lanka is a classic example for this. Based on the current classification systems, roads are categorized as “A” class, “B” class, “AB” class and so on. There are many miles of roads that have been built, yet not categorized under any of these classes and remained for years without a category. Most of these roads are low volume roads and total approximated length is 70,000 km according to statistics.

Planning is important for a country in many aspects. Specially for a developing country like Sri Lanka would definitely have a need for proper planning covering attributes such as financial, social, environmental and land use mix. Thus, classified road network comes into play where policy makers and planners can start thinking from transportation aspect because it is a well known fact that road network or the transportation system of a country is vital for its development.

This paper presents a model for classifying low volume road network system using multiple parameters. The Kesbewa DS Division was taken as the study area for this research and first main parameter considered was the shortest distance and adjusted shortest distance. The Map of the selected area is adopted and regenerated in to feature solution of ArcGIS 9.3 and network analysis component of ArcGIS 9.3 is used to obtain the routes of each goal nodes and other nodes by selecting different parameters. The Network Analysis component has been implemented by Digistra Algorithm. The customization capability with programming language like VB 6.0 is used to develop a customized software component to gather all the possible links between each of two goal nodes and other nodes. The proposed software model presents the capability of finding the minimum path of any two nodes for each of factors, and also it is to possibility to compare two routes for particular two nodes relevant to the factors. The final outcome is also implemented to list out the all list of nodes with number of link usage at each route.

This solution can also be extended to incorporate many other factors such as economical, road value, place of importance, land use mix, etc. depending upon the inherited values of considered area.

Key words: GIS, Road Classification, Low Volume Roads

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Improvements Need in Evaluation of Road Rehabilitation Projects

J.G.C. Sahantha¹, R.M.H.P.K. Rathnayaka², W.H.M.P. Weerakkody³, J.M.S.J. Bandara⁴

At the completion of this research, we hope to achieve several objectives; development of a methodology to identify possible impacts and their quantification (identify the benefits of the placing roads as direct and indirect impacts on social and physical infrastructure, geographical, community and Household characteristics), determination of appropriate parameters to use in HDM-4 for economic analysis (determine the most significance parameters and determine economically appropriate parameters to Sri Lanka) and preparation of a guideline for impact evaluation.

The Road Development Authority (RDA) in Sri Lanka uses the evaluation method "HDM -4" but parameters to Sri Lankan conditions are not determined correctly and no study to check its suitability to Sri Lanka has been done. Impact on environment, economy and society, road safety and quality are not properly taken into account when doing the analysis at present and it causes lots of problems in the respective areas of study. Huge wastage of money takes place as a result of wrong decisions taken in planning stage due to various reasons. A socio economic questionnaire survey is carried out and social data are collected in 10 roads in four provinces and data collected. Roughness data, traffic counts and other more required data are collected from the field to use in HDM- 4 analysis in these roads.

Different requirements and problems were discovered in different locations (socio parameters) and among them common issues were identified. Those common issues must be taken into account when rehabilitating a road. Further, the significant issues identified should be monitored during the data collection stage as well as in post construction stage. It would help the authorities to overcome the problems that they are facing now in constructing roads and monitoring them.

Social, economical data should be collected according to the requested guidelines and they should be analyzed properly.

Key words: *HDM4, Impact Evaluation, Socio Economic Questionnaire Survey*

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Evaluation of Parameters Influencing Delays for Road Users at Railway Level Crossings in Sri Lanka

J.Weerakoon¹ and J.M.S.J. Bandara²

Design, construction and maintenance of railway level crossings are responsibilities of Sri Lanka Railways. The funding agency in this regard is the Ministry of Finance where allocations are provided from the annual budget for above targets.

The additional time consumption born by the road users at level crossing is a current issue to be addressed at the earliest possible in order to minimize the delay and inconvenience. According to the SLR the reason behind in this issue is the poor geometry & lack of maintenance. Further more the officials of SLR highlighted the lack of equipped laboratories or skilled technical staff for doing research and also the application of advance high tech equipment such as sensors and replaceable surface materials. One of the main reasons behind the said issues is the high capital cost of implementation of said needful.

Under this research around 125 locations of level crossings were visited all over the country where the deficiencies and weaknesses influenced for delay was carefully observed. A random sample of 42 numbers of crossings (including good and bad sections) was selected for evaluation. The prominent causes detected were categorized for quantitative analysis. Few locations with high contribution on delay and safety such as Yangalmodara, Kolathenna, and Kapuwatta were taken as case studies and compared with some satisfactory level crossing such as Bentota. As the parameters such as number of rail tracks, traffic flows, type of crossings etc. differs from place to place it was decided to compare the delay per vehicle for 100m distance (50m distance from either sides of centre lines of the tracks) with the time taken by an average vehicle to travel the same distance in a particular location.

Correlations were checked among the parameters. The gravity of causes was assessed by giving a rating (1-3) at different locations. Furthermore a number of discussions were made with the responsible officers of Sri Lanka Railway and Road Development Authority.

With the help of the information gathered from the two organizations and also with the data collection and the evaluations carried out during the research it was able to forward some improvement proposals/ mitigation measures in order to minimize the delay at level crossings in Sri Lanka.

It was found that the main parameters causing for this delay are visibility, surface defects and poor vertical alignment in approaches and in between tracks due to settlement or in proper designs implemented at level crossings.

Key words: *Delays, Road Users, Railway Level Crossings*

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