INVESTIGATION INTO THE SUITABILITY OF WASTE MATERIALS IN ASPHALT CONCRETE

N. Jegatheesan, Terrance M. Rengarasu, and W.M.K.R.T. Bandara

ABSTRACT

Suitability of the waste as alternative materials for Hot Mix Asphalt Concrete (HMAC) was investigated through this study. Especially, the performance of modified HMAC (MHMAC) with Sawdust Ash (SDA) and PET, was studied with Marshall Method. MHMAC with SDA improved Bulk Properties (BP) however, decreased Marshall Properties (MP). 2.77% of SDA replacement satisfied the minimum stability requirement. But MHMAC with PET increase the MP and BP. Therefore, to improve the MP of HMAC with SDA, PET was added as additive at 5-15%. It resulted 30-103% increment in stability compared to HMA with SDA only. Maximum reduction in Bulk Density was 15% at 15% PET modification. Further, the absorption of the MHMAC also was controlled with addition of PET. The addition of the PET increased the absorption compared to MHMAC with SDA only. However beyond 10%, addition of the PET reduced the absorption.

1. INTRODUCTION

At present, around 80% of road is paved with HMAC as conventional one. Even though the traffic load is differed with type of road, the traditional method with similar materials are used in construction. This is not an economical way to follow in the case of medium and low traffic pavement. By using the recycled and secondary materials, pavement can be modified in a cost effective manner.

As an environmentally friendly construction, many researches have been conducted on MHMAC with different kind of waste materials. SDA as filler in MHMAC produced light weight concrete at low mixing and compaction energy, but the MP was reduced by lack of bonding ability and high absorption (Marteano 2002). Recycled PET ameliorated the MP and BP, due to the high bonding strength and recovering ability of the PET against stiffness (Moghadam et al. 2014). The effect of the MHMAC with SDA as filler and PET as binder additive was investigated through this study.

2. METHODOLOGY

2.1 Conventional materials

The mix proportion of aggregates at required nominal size (such as coarse, fine and filler) and binder was selected according to the specification. The 80/100 penetration grade binder with melting point at 43°C was selected.

2.2 Waste materials

SDA which was belonged to one type, Albesia (Albizia Julibrissin), with 1.18mm nominal size was taken as filler replacer at 1.77%, 2.73% and 3.75% of total weight of aggregate. PET with 0.5mm diameter, 4-6 mm length which was obtained from private company, was used as additive at 5%, 10% and 15% of total weight of binder.

2.3 Marshall procedure

The modified samples were cast in wet process. The modified binder with PET was commingled with SDA aggregate mix. 50 blows per each side were applied at 145°C to compact the samples. Marshall Properties (MP) which are Marshall Stability (MS) and Flow (MF) value, determined by using the Marshall Test apparatus.

2.4 Absorption test

The high MS samples were cast for each case of modification. Those were kept into the water to determine the absorption at two days interval.

3. RESULTS AND DISCUSSION

3.1 PET as additive of binder

PET improve the MP and BP of the HMAC as additive of binder. The addition of the PET, increased the MS compared to the control. The optimum binder content also was less compared to the HMAC but optimum binder content increases with addition of PET (Figure 1). When the binder was 4.85% (Optimum of control) the MS was increased by 14.1%, 25.1% and 67.4% with the addition of 5%, 10% and 15% PET respectively. Addition of the PET, increased the deflection compared to control but it was within the specifications. The Bulk Density (BD) was reduced by 1% at 5% PET but reduced with the addition. At the minimum percentage of the binder the air void was not between 3 and 5. However 4.8 - 6% of binder with PET with HMAC was stayed within the specification.

3.2 SDA as filler replacer

Due to the less specific gravity of the SDA, replacement was done at volume basis. It produced low BD sample with less air void compared to conventional mix. Around 5% to 10% of bulk density was reduced with 1.77% to 3.75% of SDA replacement. However, the MP was reduced with
the increment of SDA. Even though 1.77% of modification was stayed within the specification, compared to control sample, MS was less. At 2.73% of SDA, the range of 4.5% to 5.5% of binder content was satisfied the minimum specification of the medium traffic pavement. The addition of 3.77% of SDA, totally failed under the medium traffic load (Figure 1). Therefore 2.73% was considered as optimum one to satisfy the minimum specification. For further modification process 2.73% was selected to improve the MP with addition of the PET fiber as additive of binder.

**Figure 1: Variation of MS of MHMAC**

<table>
<thead>
<tr>
<th>BITUMEN PERCENTAGE</th>
<th>3.5</th>
<th>4.5</th>
<th>5.5</th>
<th>6.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>5% PET + 2.73% SDA</td>
<td>✔</td>
<td>✗</td>
<td>✔</td>
<td>✗</td>
</tr>
<tr>
<td>10% PET + 2.73% SDA</td>
<td>✗</td>
<td>✔</td>
<td>✗</td>
<td>✔</td>
</tr>
<tr>
<td>15% PET + 2.73% SDA</td>
<td>✗</td>
<td>✗</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Control</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
</tbody>
</table>

**Figure 2: Variation of MS of HMA with SDA and PET**

3.3 Modification with SDA and PET
Modification was done with 2.73% of SDA replacement and PET as additive at 5%, 10% and 15%. The addition of the PET with SDA, improved the MP. The MS was increased with increment of PET. At 4.2% to 5.8% with 5% PET, MS was stayed within the specification. Therefore to improve MP of the 2.73% SDA mix, 5% of PET was good enough to satisfy the minimum specification. Although the addition of the 10 and 15%

PET modified binder, increased the MS, compared to the traditional mix MS was reduced by 40% and 14%. MF also increased with addition of PET compared to control but it was within the allowable range (Figure 2). This modification was not only improved the MP but bulk properties also. The bulk density was reduced considerably compared to previous modification. The modification with 5 to 15% of PET reduced the BD by 15% to 10%. Further, SDA filled even small cracks in the aggregates. The air void also reduced due to the fineness of the SDA at the same time it satisfy the specification.

3.3 Absorption
The water absorption increased until 14 days for the MHMAC with SDA. But the water absorption rate of HMA with PET and SDA was high compared to HMA with SDA. The maximum absorption of the HMA with 2.73% SDA was 3.75% but HMA with PET and SDA reached 4.4%. Even though, addition of the PET increased the absorption until 10%, beyond that, the absorption was significantly reduced by modified binder which provide impermeable cover to the SDA particles. Therefore absorption can be controllable with the PET modified binder.

4. CONCLUSIONS
The PET modification HMA showed better performance against MP and the BP. The 15% PET improved the MS by 67.4%. However the SDA modification, even though improve the BP, MS was reduced by 60% at 2.73% SDA.

The modification with both PET and SDA improved the MP of the sample, compared to HMA with SDA only. When MS was compared with 2.73% of SDA only, MS increased by 30% to 103% due to the addition of 5-15% PET but compared control, MS was reduced by 13.3%. The bulk properties also showed better improvement because of the fine particles of SDA. Light weight HMAC was produced with maximum 18.4% of weight reduction. Further the absorption of HMA with SDA was controlled by the addition of PET modified binder. Therefore the HMA with SDA and PET can be used to produce light weight concrete for the medium traffic pavement as cost effective method.

REFERENCES

INVESTIGATION INTO THE SUITABILITY OF WASTE MATERIAL IN HOT MIX ASPHALT CONCRETE

M.H. Muhammed, Terrence M. Rengarasu, and W.M.K.R.T. W. Bandara

ABSTRACT

This investigation was carried out to study the suitability of waste material in Hot Mix Asphalt Concrete (HMA). Marshall Stability, Marshall Flow and Air Void Ratio were used as criteria to measure the suitability of modified HMA samples. The material tested were Fly ash, PET. Fly ash was used to replace the part of conventional type filler while PET was used to modify the asphalt binder. In this study, bitumen content was varied from 4% to 6% at 0.5 interval. PET was added in the percentage of 5%, 10% and 15%. Stone dust, widely used conventional filler, was replaced by fly-ash at 20%, 30% and 40%. It was concluded that PET used as additive increased the Marshall Stability and reduces Marshall Flow and the Air Voids. The addition of fly ash increased the Marshall Stability by 19.29% compared to unmodified HMA sample with the control sample. It was concluded that, addition of fly ash and PET in the same sample increases the Marshall Stability and reduces Marshall Flow and the Air Void. The addition of fly ash and PET in the same sample increases the Marshall Stability by 83.57% compared to unmodified HMA sample. This study infers that waste materials can be used as raw materials in HMA concrete.

1. INTRODUCTION

Production cost of Hot Mix Asphalt (HMA) is higher compared to other road making materials and this is due to the higher material cost. Owing to the rapid infrastructure development in Sri Lanka over last decade, there is a high demand for construction materials, which intern results in material shortages that affect HMA production. This could possibly be solved by utilization of waste materials generated in other industries in the production of HMA. Utilization of waste materials in HMA production would help to reduce the production cost of HMA while ensuring continuous material supply and reducing amount of solid waste dumping to landfills.

A study by Wright & Dixon (2004) revealed that, among the raw material used for asphalt concrete production, filler exerts a significant effect on the characteristics and performance of asphalt-concrete mixture. In a study by Warden et al. (1959) discovered that fly ash act as a good filler in terms of mixing, placing & compaction, stability, flexibility, and resistance to water damage. A study by Rosner et al. (1981) found that the retained strength of the specimens increased as additional fly ash was used. Shukla & Harad (2006) carried out a study, using non-biodegradable PET in stone mastic asphalt and the result obtained revealed that PET can be used as a bitumen modifier in asphalt concrete. This research aims to investigate the possibility of utilizing waste materials generated as byproducts or disposals in the other industries to modify the asphalt concrete.

2. METHODOLOGY

Marshall Mix design procedure was used to evaluate the asphalt concrete. Suitability of the waste materials was selected based on the Marshall and volumetric properties.

2.1 Materials

In this study, bitumen content was varied from 4% to 6% at 0.5 interval. The aggregates used in this study was obtained from a quarry which currently supply aggregates for road pavement construction in Sri Lanka. In terms of waste material, PET used was obtained from recycle waste plastic bottles. Fly ash was obtained from Norochcholai Coal Power Plant.

2.2 PET

Recycled PET with the diameter of 0.5mm was used in the study. It was selected to use as a binder modifier for our study. In this study, PET was added in the percentage of 5%, 10% and 15% of the bitumen weight. PET was added as an additive to the asphalt mix.

2.3 Fly ash

The Fly ash waste was first subjected to specific gravity test to find out apparent specific gravity of Fly ash which was 2.31. The allowable range for apparent specific gravity of Fly ash is 2.1 to 2.9. In this study, conventional filler, was replaced by fly-ash at 20%, 30% and 40%.

2.4 Marshall procedure

For each mix proportion used, three samples were cast in case of the control sample and one samples for the sample containing waste materials. The samples were casted according to the standard procedure of samples casting for Marshall Test. The mix was placed in a mould and compacted with 50 numbers of blows each on both the top and the bottom sides of the sample. The samples were tested for volumetric and Marshall properties. VMA and VIM values were obtained to check volumetric properties and Marshall Stability and Flow value were obtained to check Marshall properties. Before samples were taken to the testing with Marshall machine, they were kept into the water bath at 60 Celsius for a period of 30 minutes to provide the field condition according to the specification.
3. RESULTS AND DISCUSSION

3.1 Modified mix with PET as an additive
PET was added as an additive in the HMA mix with the percentage of 5%, 10% and 15% of total weight of bitumen. The result obtained for 5%, 10% and 15% of PET shows that Marshall stability satisfied the minimum requirement of 5.34 kN (CIDA specification). Marshall Stability of the PET modified concrete was increased with the binder content and reach the optimum value, followed by decreased with binder content. Marshall stability of the PET modified concrete was increased with the addition of the PET.

3.2 Modified mix with fly ash as filler
Fly ash was added as filler replacement with the replacement rate of 20%, 30% and 40% of total weight of filler. The VFB and VMA values for replacing 20%, 30%, 40% of mineral filler by fly ash satisfy the CIDA requirement, when the bitumen percentage is 4.2% to 6%, 4.3% to 6%, 4.65% to 6% respectively. Marshal Stability and flow values are satisfied for the medium and high Traffic road for 20%, 30% and 40% of Fly ash replacement with the conventional filler.

3.3 Modified mix with PET and Fly ash
In this case, 30% of conventional filler was replaced by fly ash. PET was added as additive in the asphalt mix in the percentage of 5%, 10% and 15% of total weight of bitumen. The PET was added as wet process. The VFB and VMA values for replacing 30% of mineral filler by fly ash and 5%, 10%, 15% of PET as additive ash satisfy the CIDA requirement. The optimum Marshall stability of 5%, 10% and 15% PET sample with 30% fly ash gives the higher values when compared with the control sample as shown in Figure 1. The optimum value of Marshall stability 26.2 kN was recorded, when 15% PET sample with 30% fly ash.

4. CONCLUSIONS

4.1 Suitability of PET as an additive
The physical properties such as VIM, VMA, VFB and specific gravity satisfied the CIDA specification. According to the result obtained, Marshall stability increased with the PET content from 5% to 15%. The highest stability obtained was 23.4 kN which is far more than the specific value (5.3 kN). The maximum stability is achieved when the Bitumen percentage is 4.75%. Finally, it can be concluding that PET can be use as additive.

4.2 Suitability of fly ash as filler
The result Obtained shows that, Marshall stability increased with the fly ash content from 0% to 30% and reduce from 30% to 100%. The highest stability obtained was 16.82 kN which is far more than the specific value (5.3 kN). Marshall stability is increased by 19.29% when compare with the control sample. The maximum stability is achieved when the Bitumen percentage is 5%. Finally, it can be concluding that Fly ash can be use as filler.

4.3 Suitability of fly ash as filler and PET as an additive
Marshall stability increased with the PET content from 5% to 15%. The highest stability obtained was 26.2 kN which is far more than the CIDA specification value (5.3 kN). The addition of fly ash with the PET increased the Marshall stability by 83.57% content for optimum binder when compare with the control sample. The maximum stability is achieved when the Bitumen percentage is 4.9%. Finally, it can be concluding that Fly ash with the PET can be use as in the hot mix asphalt. According to this research, PET as an additive and fly ash as a filler gives the highest among all methods used. So, this is the best way to prepare the asphalt concrete.

REFERENCES

Figure 1: variation of Marshal Stability with PET and fly ash
DEVELOPMENT OF QUALITY OF SERVICE INDEX FOR PUBLIC TRANSPORTATION BUSES WITH SPECIAL ATTENTION TO LOCAL CONDITION

S.D.M. Subair and Terrance M. Rengarasu

ABSTRACT

This study is basically depending on the point of view of passengers who use buses. The public transportation buses should have safety, comfort and convenience when using the buses. The factors under the above three situation should be identified. From this study the performance of those factors were discussed using the mathematical model. The results of this study will be useful to get a qualitative value about the infrastructure facilities of buses. Five factors and three levels have been selected for the questionnaire survey. The stated preferred was collected around southern area Sri Lanka for this study. This stated preferred was analysed in SPSS software by using conjoint technique. The linear regression model was prepared based on user perception. The results show that the bus travel time and bus fare are the most important factors for the users.

1. INTRODUCTION

Public transport is a shared passenger transport service which is available for use of general public for the purpose of travelling from an origin to destination. In Sri Lanka public transport system can be categories into two parts. Such as, private own public transport system and government own public transport system. The buses are the most widely used public transport system in Sri Lanka.

There are many advantages by using public transport system. Due to these advantages many country governments, transport operators, health organizations and environmental organizations are continually investing to develop the public transport system. However, some affecting factors, the usage of the public transport system is decreasing.

There are many factors affecting the public transportation. Those factors were identified in past studies. Most of the studies were conducted in other countries to identify these factors. In Sri Lankan context, the public transport system is in low level when compare with other countries due to these factors. This research has been conducted to identify those factors. The outcome of the research could be used to develop the public transportation system in Sri Lanka.

2. METHODOLOGY

This study was conducted in many steps. The Figure 1 shows the methodology of this study.

2.1 Identify attributes and levels

Five factors and three levels have been selected for this study by considering past studies and Sri Lankan local condition. The attributes and levels show in table 1.

<table>
<thead>
<tr>
<th>Level</th>
<th>Bus travel time (%)</th>
<th>Bus fare (%)</th>
<th>Audio sound in bus</th>
<th>Seat availability</th>
<th>Bus stop facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>20</td>
<td>Very comfortable</td>
<td>Good enough</td>
<td>Good enough</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
<td>50</td>
<td>Comfortable</td>
<td>Enough</td>
<td>Enough</td>
</tr>
<tr>
<td>3</td>
<td>80</td>
<td>70</td>
<td>Uncomfortable</td>
<td>Not enough</td>
<td>Not enough</td>
</tr>
</tbody>
</table>
2.2 Questionnaire survey design
There are $3^5$ combinations of factors and levels. All of them could not be considered in the question forming stage. Using the SPSS software and orthogonal array matrix, the most preferable set of comparison were identified and Questions were made as Profile Cards and Holdout Cards. Twenty number of profile cards were generated including three holdout cards and eighteen design cards for buses.

2.3 Data analysis
Data obtained from the questionnaire survey was analyzed using the conjoint analysis which is associated with the SPSS software. Average importance and influence each attributes and utility values for each level of attributes were determined. Utility values which are basically index numbers will be generated to measure how valuable or desirable a particular feature is passengers.

3. RESULTS AND DISCUSSION

3.1 Linear regression model
The part worth utility values have been calculated for each level. Figure 2 show the part worth utility value for each attributes. From this part worth utility values, the utility value for any kind of combination can be calculated by using linear regression model. The linear regression model is show in equation 3.2.

$$ Utility\ Value = \sum_{i=1}^{5} \sum_{j=1}^{3} u_{ij} - 0.123 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (3.2) $$

$$ \sum_{i=1}^{5} \sum_{j=1}^{3} u_{ij} = \text{Part worth utility values} $$

$$ i = \text{No of attributes.} $$

$$ j = \text{No of levels} $$

The model validation has been done by using holdout card results. From these results Average root mean square value has been calculated.

Average.RMS= ±0.098

3.2 Average important values
Averaged importance of each attribute of buses is shown in Figure 3.

<table>
<thead>
<tr>
<th>Importance (%)</th>
<th>Bus fare</th>
<th>Bus travel time</th>
<th>Audio sound</th>
<th>Seat availability</th>
<th>Bus stop facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.46</td>
<td>27.07</td>
<td>17.24</td>
<td>17.98</td>
<td>7.25</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3: Averaged importance of Buses

The most significant attributes is bus fare, while bus travel time has second highest average importance. However among these attributes the "Bus stop facility" has less important value. The seat availability and audio sounds inside of buses are having nearly same importance values.

3.3 Service quality index for buses
Service quality index for the public transportation buses can be calculate by comparing with presence bus condition.

$$ SQI = \frac{\text{utility for design bus}}{\text{utility for presence bus}} $$

4. CONCLUSIONS
There are many factors affecting the public transportation, those factors need to be identified to develop the public transportation. This research main focused was to identify those factors in Sri Lanka. The research was conducted based on questionnaire survey. Five factors and three levels were selected for the questionnaire design. The collected stated preferred was analysed by using conjoint technique in SPSS software. The linear regression model has been prepared from the stated preferred. The bus fare and bus travel times are the most important factors for the public. Public are like to travel with short time and with low cost.

REFERENCES
DEVELOPMENT OF A GIS BASED TRAFFIC ACCIDENT ANALYSIS SYSTEM

B.N.D.A. Pamod, Terrance M. Rengarasu, and W.M.K.R.T.W. Bandara

ABSTRACT

The number of traffic accidents are increasing day by day as a result of increasing vehicle ownership, highway development and poor traffic control systems/methods. Previous researchers suggest two approaches which are prevention and reduction to mitigate this problem. This research has developed a Traffic Accident Analysis System (TAAS) which could be useful for the stakeholders in Sri Lanka who responsible to introduce mitigation measures. TAAS is developed as a set of tools which contain in a toolbox of ArcGIS 10.X as first objective. At present TAAS toolbox has five tools. When tools are executed, relevant results appear in ArcGIS. As for the second objective of this study a spatial regression model was developed to predict traffic accidents. There were 10 no. of variables considered and two of them significantly affected; population and road solidity. This analysis can be further improve and that can be used for future road safety.

1. INTRODUCTION

The Global status report on road safety 2015, reflecting information from 180 countries, indicates that worldwide the total number of road traffic deaths has plateaued at 1.25 million per year, with the highest road traffic fatality rates in low-income countries (Toroyan 2013). Sri Lanka, as one of the developing countries, has high level of traffic accidents. Government has to spend large amount of money for managing resources and disabled people. 2,700 people were killed in road traffic accidents in year 2015 and it is an increase of more than 300 compared to 2014 in Sri Lanka (The Sunday Times 3 January 2016). There were all together more than 294,969 of traffic accidents (from 2008-2015) were reported in Sri Lanka according to Traffic Police Headquarters. Figure 1 shows the variation of road traffic accidents happened from year 2008 to year 2015. According that, accidents are gradually increased upto 2012, although it decreased 2013 and 2014 and again increased in 2015. But the reduction is not much less than year 2008.

2. METHODOLOGY

2.1 Traffic accident data collection

Data for traffic accidents occurred during eight years were collected from the Traffic Police Headquarters in Colombo for Traffic Accident Analysis System (TAAS). Macroscopic data was collected for the spatial regression analysis from survey department, transport ministry and weather and climate web sites.

2.2 Graphical User Interface (GUI) with GIS

GUI will be the final outcome of TAAS, which shows the entire system in a desktop. The developed GUI has been done using Model Builder in ArcMap and there were all together five tools developed specially for Sri Lanka.

2.3 Spatial Regression Analysis

Spatial regression analyzes is done to develop an accident prediction model. Collected data input spatially to the ArcMap shape file which contained Sri Lankan administrative areas. Then “Ordinary Least Squares” tool is used to develop the model.

3. RESULTS AND DISCUSSION

3.1 Traffic Accident Analysis System (TAAS)

In this research, each tool developed for the TAAS can identified as the main result for the first objective. By running each tool on ArcMap according to the required output for data analysis, user can obtain various combinations under traffic accidents happened in between 2008-2015 Sri Lanka. For the final outcome of the research, there are all together five graphical user...
interfaces (GUI). They named as “Analysis by Graph, Export to Excel Tool, Filter Accident Data by District Tool, Filter Accident Data Tool and Select by District Tool”. Each tool developed, can be used by the user in performing accident analysis. The user is given the facility to select the inputs from the drop down list. TAAS is develop for Sri Lankan Accident Analysis and all the related data, shape files and maps are provided along with the system. Therefore user can work stand alone. Also the descriptions of the input and other conditional selections are mention in the tool and it will display at right side when the tool is opened.

Rather than go to Office based software analysis, these tools included in TAAS provide many user friendly facilities to analysis the traffic accidents properly; simply choose the input, output automatically display, No. of available combinations, easily update offline, spatially visualized results, etc. Also TAAS is capable to handle huge no. of data set easily.

3.2 Spatial Regression Analysis
In order to develop the model which capable of accidents prediction using macroscopic data available, spatial regression analysis is done as the second objective of this research. In this objective, result is given as an equation which can predict the no. of accidents happened in an admistration area of Sri Lanka.

Spatial regression analysis is done for the part of Sri Lanka which is including all the district in Western province, Sabaragamuwa province, Southern province and Nuwara-Eliya district. Only this districts were considered for the spatial regression analysis due to lack of data in other districts. Standard deciation values of the analysis showed that Western province district data is clustering with less than and more than 2.5 value. Therefore, the developed model is not valid for Western province, but for other area considered.

According to the analysis, there are two variables caused for the no. of accidents happened; population and road solidity. As the result of accident prediction model, below shown equation is obtained.

**Number of Accidents = 1083.5 + (0.0046 x A) + (261789.6 x B) - (0.35xC) - (52.33xD) + (37.40xE) - (19.06xF) - (0.036xG) + (44.41xH) + (12.63xI) - (34.25xJ) + (28.21xK)********** Equation 1


(Multiple R Squared value = 0.561277 & Adjusted R Squared value = 0.519674)

Spatial regression analysis is very much important to a low income country, because using this kind of model authority can predict the accident happene in future and get relevant precautions to mitigate the no. of accidents. This accident prediction model is done for selected area in Sri Lanka (Souther, Sabaragamuwa provinces and Nuwra-Eliya district), but it can develop for entire country to have a better accident prediction model. Increasing the no. of explanatory variables increase the accuracy of the model.

4. CONCLUSIONS

4.1 Traffic Accident Analysis System (TAAS)
This research study is done to develop a user friendly traffic accident analysis system which has ability to display results visually compare to present method using papers. Model Builder in ArcMap, used to develop the analysis tool. This traffic accident analysis system is including 8 years traffic accident data from 2008 to 2015 and tools are specially develop to analysis accidents happened in Sri Lanka.

The main purpose of this analysis system is to identify the actual reasons for accidents behind in prone areas and reasons. The application directly gives ability to identify the accident prone areas on the digital map. Therefore, by categorizing those data by this analysis system, we can identify the causes for those accidents. It is very important to identify the solutions for those problems in specific areas. Therefore better actions can be proposed or applied for them. Even the suitable legislations can be implemented by these results.

4.2 Spatial Regression Analysis
In spatial regression analysis, tried to find out the most affected factors for accident happening and that factors are selected by probability values, which are less than 5%. In this case there were 2 factors which were having less than 5% of probability value; Population and Road Solidity. That means, for selected area, accidents happen due to roads spreading and population. In the analysis, if results are randomly spreading it consider as good compared to clustering data. Clustering area is not valid from the results, because there is an error with the data which cannot describe by the model. To overcome this error, this analysis can be redone by increasing the data.

REFERENCES

MODELING WILLINGNESS OF THREE WHEELER OWNERS TO CONVERT THREE WHEELERS TO USE ELECTRICITY

K.M. Mohamed Ilham and Terrence M. Rengarasu

ABSTRACT

This study is aims to CO2 control and noise pollution control by introducing Electric Three-Wheeler (ETW). It is commonly accepted that the supply and demand relationships for taxi services are much more complicated and the cost of travel significantly higher than taxi, with compared to Three-Wheeler. Three Wheelers (TWs) are an ideal candidate for electrification because of the low speeds of the vehicle, relatively low distance covered in a day and emit the high emission. To provide the willingness to convert ETW, five most suitable attributes and three levels were developed. Questionnaire was developed with partial factorial method having 21 cards (three Holdout cards). Data collection was done in Galle and Colombo district for TW owners and passengers separately. User rating for each card was modeled as a linear function in SPSS. Averaged importance and utility values of each attribute of convert to electric three-wheeler was obtained.

1. INTRODUCTION

Three-Wheeler (TW) is a vehicle for hire that is one of the chief modes of transportation in Asian countries. The most common and visible mode of transportation in Sri Lanka is the TW. The introduction of TW in Sri Lanka in the earlier 1980s. In Sri Lanka, some families are buying TWs for private use, attracted by the lower price of the vehicles relative to passenger cars.

Three-wheeler electrification is a promising approach towards attaining green transportation according to rate of pollution. In this study, Environmental burden and customer (three wheel owners, users) satisfaction are the main consideration. A considerable number of researches have been conducted in the recent past about electrification of three-wheeler but the obtained results from each study are not much related to Sri Lanka. So there is a need to conduct the research in a local context with identifying the most suitable factors. The final outcome of this research is enhanced to convert to electric fuel three-wheeler.

2. METHODOLOGY

The required data were collected only using Questionnaire Survey. Identify the factors, Questionnaire survey design and Data analyzing were the major process of this study.

2.1 Identify the factors

Questionnaire survey is designed therefore that the users and passengers will rate the several attributes. Five attributes were identified for convert to electric fuel three-wheeler with three levels.

<table>
<thead>
<tr>
<th>Level</th>
<th>Fuel type</th>
<th>Noise control</th>
<th>Usage comfortable</th>
<th>Travelling comfortable</th>
<th>Travelling cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Petrol</td>
<td>Can’t control</td>
<td>Uncomfortable</td>
<td>Uncomfortable</td>
<td>Same</td>
</tr>
<tr>
<td>2</td>
<td>Hybrid</td>
<td>50% can control</td>
<td>Comfortable</td>
<td>Comfortable</td>
<td>Increase</td>
</tr>
<tr>
<td>3</td>
<td>Electric</td>
<td>100% can control</td>
<td>High comfortable</td>
<td>High comfortable</td>
<td>Reduce</td>
</tr>
</tbody>
</table>

2.2 Questionnaire survey design

There are 3^5 combinations of factors and levels. All of them could not be considered in the question forming stage. Using the SPSS software and conjoint technique, the most preferable set of comparison were identified and Questions were made as Profile Cards and Holdout Cards. Holdout cards were used to check the validity of the estimated utilities. Twenty-one number of profile cards were generated including three holdout cards and eighteen design cards for electric three-wheeler. Then those questions were performed with the scale (for linear analysis).

2.3 Data Analysis

Data obtained from the questionnaire survey was analyzed using the conjoint analysis which is associated with the SPSS software. Average importance and
influence each attributes and utility values for each level of attributes were determined. Utility values which are basically index numbers will be generated to measure how valuable or desirable a particular feature is to both passengers and owners.

3. RESULTS AND DISCUSSION

3.1 Linear Regression model for passengers

Averaged importance of each attribute is shown in Figure 1

![Figure 1: Average importance value.](image1.png)

Correlation between observed and estimated preference from passenger’s data.

<table>
<thead>
<tr>
<th>Table 2: Correlation of passenger data.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson's R</td>
</tr>
<tr>
<td>Kendall's T</td>
</tr>
</tbody>
</table>

3.2 Linear Regression model for owners

Averaged importance of each attribute is shown in Figure 2

![Figure 2: Average importance value.](image2.png)

Correlation between observed and estimated preference from owners.

<table>
<thead>
<tr>
<th>Table 3: Correlation of owners’ data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson's R</td>
</tr>
<tr>
<td>Kendall's T</td>
</tr>
</tbody>
</table>

3.3 Generate the models

3.3.1 Passenger utility value

Utility Value = Utility value of fuel type + Utility Value of noise control + Utility Value of usage comfortable + Utility value of traveling comfortable + Utility value of travelling cost – 0.228

3.3.2 Owners utility value

Utility Value = Utility value of fuel type + Utility Value of noise control + Utility Value of usage comfortable + Utility value of traveling comfortable + Utility value of travelling cost – 0.220

Then the accuracy of the model was checked using holdout cards data.

![Figure 3: Observed value Vs. model value](image3.png)

4. CONCLUSIONS

In this study the two models were generated regarding the Electric fuel Three wheeler(ETW) according to passengers and Three Wheeler owners. Linear regression model for convert to ETW, obtained results were indicates that the “Travelling cost, Usage comfortable” are the most important factors for the ETW according to the passenger’s and TW owner’s view. Travelling comfortable takes second highest importance. But in both cases, noise control shows the significant importance and both cases fuel type shows the less importance. Passengers point of view they always prefer the low traveling charge for each travelling.

People can get idea about how much desirable of electric three-wheeler services benefits rather than the current Three-Wheeler services with prepared tool.

REFERENCES


MODELING NOISE POLLUTION LEVELS ALONG EXPRESSWAY IN RURAL SOUTHERN SRI LANKA
K. Thampirasa, Terrance M. Rengarasu and W.M.K.R.T.W. Bandra

ABSTRACT

Traffic noise is an undesirable byproduct of urbanization. The major contributor to the transportation noise is expressway traffic noise which depends largely on the speed and the type of vehicle. Recognition of the adverse health impacts due to traffic noise has led to many studies. This study aims to measure the existing traffic noise levels along a stretch near of Southern expressway in Galle district and to develop a GIS-based traffic noise prediction model under an uncontrolled heterogeneous traffic flow condition. Measured traffic noise levels were checked for the conformity with Sri Lankan standards and traffic noise map for the area was created.

1. INTRODUCTION

Unwanted sound is defined as noise (Birgitta et al. 1995). Noise pollution due to traffic is in the rise in Sri Lanka, because of the less attention has been paid to traffic noise pollution. Southern expressway runs through rural areas, where may be experiencing higher traffic noise levels nowadays. Aims of this study are to measure and map the traffic noise levels along the southern expressway; and to develop a GIS-based model for predicting traffic noise. Also, to measure ambient and absorption sound level in different land uses in Sri Lanka.

Sri Lanka is developing country therefore, not much attention has been paid to health hazards due to environment noise. The standards for the environment noise is well established, with the increasing traffic volume and frequent traffic congestion on urban roads, attention has often been paid to improve the traffic congestion rather than to arrest the noise pollution (Sooriyaarachchi & Sonnadara et al. 2008). Also a huge expenditure is being spend by Sri Lanka government to develop infrastructure facilities now a day mainly in development of transportation facilities such as highways, express ways etc. In addition, spread GIS software was adapted for Sri Lanka land uses. It gives output as how sound spread in different situations such as climate change, elevation change, wind change, lands use, temperature and etc. It is used for single point or multi points sound sources. It has 5 tools and tool1 and tool 2 are used for single point. In tool1 ambient sound level is one of the input and in tool2 absorption sound level is one of the input.

2. METHODOLOGY

Traffic noise levels were measured along the southern expressway in Galle district. The total study area was about two kilometers. For absorption rate and ambient sound level, measured suitable area was selected.

2.1 Data collection

In this study uncontrolled traffic approach was used to collect data (Paoparayooyon et al. 2004). Expressway was roughly divided into 100 m section, three on a side. Traffic noise level prevailed for 5 minutes was recorded as the traffic noise level. The distance was increased up to the location which has permissible sound level for the human (55dBA) (National Environmental Regulation No.1, 1196). In addition to the noise level GPS location and vegetation type was also recorded. For ambient sound level, in selected land use took continuous readings in an hour in 5 minutes interval when the wind speed is equal zero and there was no other sounds than natural sounds (bird sound). For absorption sound level in selected area took reading while making noise with three-wheeler, where there is no wind speed and no natural sounds. In same time, readings were taken distance in 20m and 25m inside the different land uses.

2.2 GIS based model for traffic noise prediction and mapping

GIS-based model was used to model the traffic noise pollution along the expressway. GIS provides the central database management environment and noise data can be imported into an ArcGIS. It can be predicted the noise levels relevant to the measured noise levels in the study area. Noise maps build in GIS can be used for analysis and management process. It was developed for different vegetation types and it can be clearly identified the variation of noise propagation in different vegetation areas. It can be identified the safe boundary for the human lives without disturbance from noise induced by the traffic in southern expressway.

2.3 Materials and equipment

The SL-1350 sound level meter was used which is manufactured by Custom corporation and Garmin GPS was used to locations. Digital anemometer was used wind speed measuring.
3. RESULTS AND DISCUSSION

3.1 Comparison of measured against predicted in different land uses based ArcGIS model

Figure 1: The graph of measured against predicted in different land uses based on ArcGIS model

Figure 1 shows the different land uses based on ArcGIS spatial analysis model. It is clearly shown that there is a significant difference between measured dB (A) and predicted dB (A).

3.2 Noise difference distribution with the distance in different land uses.

Figure 2: The graph of distance against noise difference in different land uses

Figure 2 is shown the distance against noise difference in different land uses in study area. Noise difference can be obtained by using difference between calculated noise level and measured noise level.

\[ L_w = L_m - 10 \log (R_w/R_m)^2 \]

Where \( L_w, L_m, R_w \) and \( R_m \) are calculated noise level, measured noise level, distance to the calculated noise level and distance to the measured noise level respectively. Regression functions of noise reduction (\( Y \)) of different areas with the distance from the Southern expressway (X) are shown in Table 1.

Table 1: Noise difference distribution with the distance in different land uses

<table>
<thead>
<tr>
<th>Land uses</th>
<th>Regression function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin tree cover</td>
<td>( Y = -0.0053x^2 + 0.681xR )</td>
</tr>
<tr>
<td>Open area</td>
<td>( Y = -0.013x^2 + 1.2165x - 5.3944 )</td>
</tr>
<tr>
<td>Mountain</td>
<td>( Y = -0.0177x^2 + 0.1766xR )</td>
</tr>
</tbody>
</table>

3.3. Ambient sound level in different land uses in Sri Lanka.

Table 2: Ambient sound level in different land uses

<table>
<thead>
<tr>
<th>Land uses</th>
<th>A.S. level (dB(A))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>52.79</td>
</tr>
<tr>
<td>River</td>
<td>46.85</td>
</tr>
<tr>
<td>Pond</td>
<td>46.75</td>
</tr>
<tr>
<td>Paddy field</td>
<td>46.35</td>
</tr>
<tr>
<td>Grass land</td>
<td>42.68</td>
</tr>
<tr>
<td>Rubber estate</td>
<td>41.14</td>
</tr>
<tr>
<td>Tea estate</td>
<td>40.78</td>
</tr>
<tr>
<td>Home garden</td>
<td>39.71</td>
</tr>
<tr>
<td>Open area</td>
<td>39.62</td>
</tr>
<tr>
<td>Coconut estate</td>
<td>39.44</td>
</tr>
</tbody>
</table>

3.4. Ambient sound level in different land uses in Sri Lanka.

Table 3: Absorption rate in different land uses

<table>
<thead>
<tr>
<th>Land uses</th>
<th>Ab. rate (dB(A)/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>0.2771</td>
</tr>
<tr>
<td>River</td>
<td>0.2175</td>
</tr>
<tr>
<td>Tea estate</td>
<td>0.2061</td>
</tr>
<tr>
<td>Home garden</td>
<td>0.1543</td>
</tr>
<tr>
<td>Rubber land</td>
<td>0.1239</td>
</tr>
<tr>
<td>Pond</td>
<td>0.1091</td>
</tr>
<tr>
<td>Coconut estate</td>
<td>0.1032</td>
</tr>
<tr>
<td>Grass land</td>
<td>0.0709</td>
</tr>
<tr>
<td>Open area</td>
<td>0.0469</td>
</tr>
</tbody>
</table>

4. CONCLUSIONS

Spatial analysis extension of Arc GIS. Near the southern express-way traffic noise levels exceed the noise limits prescribed in Sri Lankan standards limit. According to the noise level difference Vs distance mountain areas have higher noise reduction. Therefore, mountain areas can be used as a noise abatement measure. Also it is a minimum negative impacts solution because it is cost effective and environmental friendly method. In different land uses have different ambient sound level and in forest has high and coconut estate has less ambient sound level. And in forest has high and open area has less absorption rate. Therefore, forest land is good reduction for noise pollution.

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National Environmental (Noise Control) Regulations No.1 (1996), 924/12 PART I: SECTION (1) GENERAL Government Notifications.


MODELING THE EFFECT OF ROAD GEOMETRY ON RURAL TRAFFIC ACCIDENTS

H.A.Sanath and Terrance M. Rengarasu

ABSTRACT

This study aims to investigate the effect of road geometric factors on rural traffic accident rates. Data were collected from a national road in Sri Lanka which connects Galle with the capital city of Colombo. Two statistical models were estimated for all accident rate and fatal accident rate. For the all accidents previous traffic accident from 2014-2015 was considered to developed model and for the fatal accidents from 2011-2015 accidents rated were considered. The results shows that for the traffic accidents bendiness, pedestrian crossings and traffic flow are the significance factors and for the fatal accidents junctions has been identified as significant factor.

1. INTRODUCTION

The problem of road traffic accidents on a large scale has arisen for the first time in the 20th century (Norman et al. 1962). According to the World Health Organization traffic accidents will become the fifth major cause of death worldwide in 2030 (Organization 2000). However, the occurrence of such accidents are not easy to mitigate. Global road fatalities are forecast to reach 1.9 million by 2020 (CGRS 2009). A study by Transport Research Laboratory (Jacobs et al. 2000) has estimated that in 1999, about 750,000 people were killed in road accidents globally.

Developed countries utilize many methods to reduce traffic accidents. However, developing countries it’s differ. DES (2013) revels that there is a great need to give focus efforts in the developing countries. Further, the above study states that about 640,000 of the accidents, which 85% as a percentage is occurred in developing countries or arising nations.

Sri Lanka is also considered as a developing country. Therefore, it is also required to take an immediate counter measurement to reduce the severity of the road accidents. Sri Lanka still lacks a strategic and comprehensive design plan to provide safe roads for the citizens. Therefore, this study aim to create statistical model to identify the geometric factors on traffic accident and for fatal accident separately.

2. METHODOLOGY

This study has utilized the accident data in the Galle Police Division area in Sri Lanka. Only the A class roads were subjected to this work and the research area was selected from the past traffic accident data along the Wellawaya - Colombo main road from Hikkaduwa to Koggala. Past five year fatal accident data were considered from 2011 to 2015. Then 10 km length road section was identified as accident prone area. From this study our aim is to analyze road geometric factors. From the collected raw data within that rural road section, we created models to analyze the reasons for those fatal accident as well as for all accident

by dividing that 10 km part in to separate 0.1 km interval. Separate models were developed for all accidents and fatal accidents using Poisson Regression and Negative Binomial regression. The best fit model was selected by considering the log likelihood ratio and subsequently, used them to explain the relationship of road geometry on traffic accidents.

3. RESULTS AND DISCUSSION

3.1 For all Accidents

Table 1: Numerical values for Poisson regression model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-3.777</td>
<td>0.000</td>
</tr>
<tr>
<td>Traffic Flow</td>
<td>0.002</td>
<td>0.000</td>
</tr>
<tr>
<td>Bendiness</td>
<td>0.027</td>
<td>0.000</td>
</tr>
<tr>
<td>Ped. Crossing</td>
<td>0.611</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Table 2: Numerical values for negative binomial model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-3.345</td>
<td>0.000</td>
</tr>
<tr>
<td>Traffic Flow</td>
<td>0.002</td>
<td>0.000</td>
</tr>
<tr>
<td>Bendiness</td>
<td>0.022</td>
<td>0.033</td>
</tr>
</tbody>
</table>

Table 3: Summary table for all accident data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Poisson Regression</th>
<th>Negative Binomial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log likelihood in null model</td>
<td>-216.597</td>
<td>-168.253</td>
</tr>
<tr>
<td>Log likelihood in alternative model</td>
<td>-179.750</td>
<td>-156.490</td>
</tr>
<tr>
<td>Log likelihood ratio</td>
<td>73.694</td>
<td>23.526</td>
</tr>
<tr>
<td>P Value</td>
<td>&lt; 0.01</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

Among the created models Poisson regression model is the best because the log likelihood ratio in that model is considerably higher than the other model. It can said that bendiness, pedestrian crossings and traffic flow are the
main key factors which affect for the traffic accident. In Table 1, you can see that their significance values are less than 0.05 so this model is valid within 95% confident interval. With the increment of those factor the possibility to occur traffic accident also increasing. If the bendiness of the road is higher, the sight distance is reduced than of a straight road sections owing to the road curves. As a result, it affects the view of the drivers and hence, increase the accident rates. We know that vehicle speed in the rural area is considerably higher than the urban area due to that if the bendiness of the road is higher, the high speed drivers cannot control their vehicle in those locations that also may be a reason to increase the accident with the bendiness. According to the model developed it reveals that when the number of pedestrian crossing increases the possibility to occur traffic accident also increasing. Due to the high speed of the vehicle in rural areas it’s difficult to stop suddenly. When observing the data we identified that most of the pedestrian locations are located near to the bend. When selecting a pedestrian location it should select a straighten road section because it can easily see the both side of the road. Though traffic flow is not a geometric factors according to our analyze it certify that it also have significance effect to the traffic accidents.

\[
\text{Exp (Number of Accident) = -3.777 + (0.002 x Traffic Flow) + (0.022 x Bendiness) + (0.611 x Ped.crossing)}
\]  

--- Equation 1

3.2. For fatal accidents

Table 4: Numerical values for Poisson regression model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-6.605</td>
<td>0.000</td>
</tr>
<tr>
<td>Traffic Flow</td>
<td>0.003</td>
<td>0.000</td>
</tr>
<tr>
<td>Junctions</td>
<td>1.259</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Table 5: Numerical values for negative binomial model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-6.294</td>
<td>0.000</td>
</tr>
<tr>
<td>Traffic Flow</td>
<td>0.003</td>
<td>0.001</td>
</tr>
<tr>
<td>Junctions</td>
<td>1.216</td>
<td>0.022</td>
</tr>
</tbody>
</table>

Table 6: Summary table for fatal accident data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Poisson Regression</th>
<th>Negative Binomial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log likelihood in null model</td>
<td>-82.259</td>
<td>-77.258</td>
</tr>
<tr>
<td>Log likelihood in alternative model</td>
<td>-67.164</td>
<td>-67.568</td>
</tr>
<tr>
<td>Log likelihood ratio</td>
<td>30.19</td>
<td>19.38</td>
</tr>
<tr>
<td>P Value</td>
<td>&lt; 0.01</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

Estimated model for fatal accident shows that junctions and the traffic flow are the main significance factors for the fatal accidents. The significance value of those two factors is well below the 0.05 so within 95% confident interval we can prove that those factors have a significant contribution on accidents. If the number of junctions in a road section is increasing there is a possibility to occur traffic congestion within those location. As a suggestion safety policies of the main junction can be increase. Such as by introducing traffic color light system for those junctions or by making roundabout.

\[
\text{Exp(Number of Accident) = -6.605 + (0.003 x Traffic Flow) + (1.259 x Junctions)}
\]  

--- Equation 2

4. CONCLUSIONS

From the above developed Poisson regression models it can say that Traffic flow, Bendiness and pedestrian crossings are significantly effect for the all traffic accidents. Further it can explain that if the bendiness of the road increased by 1 unit number of accident increased by 3%. For the pedestrian crossings if it is increase by 1 unit accident will rise by 84%. Also due to the traffic flow, value of accident increment is 0.2%.

When we consider Poisson regression which developed for the fatal accident the junctions and traffic flow are the main significance factors. When the junctions increase the amount of fatal traffic accident increase by xx%. If the traffic flow increase the number of fatal accidents will increased by 0.3%. Using these values it can get a clear idea about the variation of the traffic accidents with the geometric factors.

Although the selected area is small, these analytical models can be developed and applied large study areas to improve the traffic safety. Besides of that, it is recommended to widen the study area to include more variable in the regression models. Which results in enhancing the traffic safety. Such as Cross section, line of sight etc. Also in here we considered the traffic flow for a 1 hour time period. If we can calculated the Average annual daily traffic flow it may give better result than this. All the traffic personnel can be trained to deal with the statistics such as SPSS software and keep them updated with the recent studies and researches regarding traffic safety issues to ensure the potential objectives of these types of researches.

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INVESTIGATION OF SUITABILITY OF USING UNIQUE PRICE INDICES (ICTAD) FOR PRICE ADJUSTMENTS IN CONSTRUCTION PROJECTS

C. K. Ganegoda and S.N. Malkanthi

ABSTRACT

The nature of construction industry is it consumes huge cost and it needs considerably long duration. This time and cost are interrelated. If the project duration is too long, the initial estimation may not sufficient to recover the actual cost of contract. To address this problem ICTAD has introduced a price adjustment method called “ICTAD formula method for adjustments to contract price due to fluctuation in prices”. To use this procedure, price variation compared to a base month also are published by ICTAD as “indices”. These indices are identical to use in anywhere in the country. But it is obvious that the price of one material is not same in different districts. Therefore aim of this study is to evaluate the suitability of using unique indices of the ICTAD price fluctuation formula for the successful construction projects.

1. INTRODUCTION

Due to the price fluctuations of material and services many problems and challenges can be arisen. Also repercussions for the construction industry such as high contractor bids that includes a cushion may lead to uncompetitive bids. Repercussions also consist of dramatic contract losses and defaults, sternly impacted and delayed projects and litigation resulting from efforts to reduce, remove or get back unexpected losses.

Adding price fluctuations to the contract sum to recover the cost mainly depends on the category of contract that the construction project. Therefore, that is important using simple way to calculate the price fluctuation and it should be nearly as much as to the real variation. That means the client and the contractor, both should be satisfied. When considering about the construction works related activities in Sri Lanka, the Institute for Construction Training and Development (ICTAD) is the governing authority and it has introduced a general formula to adjust the contract price due to variation in prices. The equation which introduced by ICTAD is used by construction companies to recover the fluctuations and ICTAD formula is the major technique that most of the constructors are utilized. ICTAD price fluctuation formula was introduced to aimed at this goal which has been used for some time but there are only few studies have been done to revision the sensitivity of this formula indices to actual price fluctuations.

ICTAD publishes price indices monthly with their monthly bulletin and it is unique to use all over the country. But at one particular time the material cost for a particular material will differ from one place to another. So the usage of same price indices may have a significant effect either to the contractor or to the client. So it is vital to identify the applicability of variation of price indices in island wide.

2. METHODOLOGY

Followed procedure of this research can be divided into different stages such as literature review, preliminary survey, Data collecting and analysis and Result and discussion.

After a preliminary survey, the data collection was initiated. Data collection is done by aiming the monthly price variation of four main materials; sand, rubble, aggregate and bricks in the main cities of the district.

Several locations of one district was also considered covering the time period January 2015 to August 2016.

Data collection for material prices were carried out for twenty districts and the collected data were analyzed and interpreted. Data analysis is carried out to find the relationship between variation of price indices of ICTAD price adjustments formula & true price variation of sand, aggregate, rubble and bricks.

3. RESULTS AND DISCUSSION

Objective of preliminary questionnaire survey was to get the idea and feedback about the currently available ICTAD price fluctuation formula procedure from construction organizations. Survey was conducted through questionnaire among the selected construction organization. There were lot of comments about this formula and final inference was that there are some problems about sensitivity of this formula and indices when consider the all island as one region.

When there is rise and fall of the prices throughout the project duration, there is a tendency to become ICTAD price adjustment smaller than the true price adjustment due to the lack of sensitivity of the formula to the true fluctuation.
Figure 3.1: Graph of price variation of sand in Colombo district

Figure 3.1 represents the percentage variation of actual price of sand in Colombo and variation of ICTAD indices for sand. Correlation coefficient of these two types of variations was 0.95. When considering that there is similar behavior of the variations, graphically and statically for both indices and actual price of sand.

Figure 3.2: Graph of actual and ICTAD price variation of sand

Figure 3.2 and Figure 3.3 show price variations of sand and aggregate in some district with respect to Colombo taking the base month as January, 2015. This shows there is no similarity of price variation in different district. Also when considering the Kolmogorov-Smirnov test (KS-test) result (this test was done for further explanation by statically) was clearly shown that the null hypothesis is fail at 95% confidence interval which means that the price distributions are significantly different from Colombo. Same procedure was adopted to see the price variation for aggregates, clay bricks and rubble. For all the materials price variation is having different patterns compared to price variation in Colombo.

4. CONCLUSIONS

Variation of prices of construction inputs during a contract period is not avoidable. To address this problem ICTAD has introduced a price adjustment formula procedure. But for this formula price adjustment is based on unique set of price adjustment factors for a particular construction input for the whole country. But material price differ from place to place. This research aimed to clarify that un-similar behavior of price fluctuation.

During this research it was identified the behavior of price fluctuation for selected materials in Colombo district and variation of price indices published by ICTAD. Based on analyzed data, it can be clearly see that the price indices calculation procedure may be based on the available prices for construction inputs in Colombo region. Then for the other district, Colombo was taken as the base and price variations were calculated. The price indices variation pattern and actual price variation patterns in other district except Colombo are not similar and it was proven by graphically and statically. Therefore use of same indices for projects in anywhere in the country may cause to loss to the contractor or to the client.

So through this research it was identified the use of unique indices are not suitable. To overcome this problem, ICTAD may publish separate set of indices for different district. It may cause to make the project management complex but fare payment to the contractor can be achieved. Or else price adjustment formula can be modified by incorporating some additional factors depending on the applicable district.

REFERENCES


INVESTIGATION OF EFFECT OF ICTAD PRICE FLUCTUATION FORMULA PROCEDURE TO RECOVER THE ACTUAL MATERIALS COST OF CONTRACT

W.M.P.M. Wijesinghe and S.N. Malkanthi

ABSTRACT

The cost estimation prepared during the bidding stage may not same as the cost calculated for the time of actual work done. This is because open market escalation of construction inputs such as price variation of materials, equipment, and labour hours. ICTAD has introduced a country specific document: “ICTAD formula method for adjustments to contract price due to fluctuation in prices”. This research mainly focused on effect of ICTAD price adjustment formula procedure to recover the actual construction cost. Analysis was carried out under four sections for the data gathered from 11 actual projects which are already completed. Base on the results it was identified that excluding non-adjustable elements in the formula is not affect to the actual cost recovery. But careful identification is very essential. Also use of same input percentages throughout the project may leads to get higher price adjustment. Dividing the input percentages based on the interim bills and not for the entire project may have fair decision to both contractor and the client, but further research is suggested on this.

1. INTRODUCTION

It is obvious that, many construction projects last for a long duration. Also the time of preparation of the tender, time of awarding the tender and the time of completion of the project has significant difference. So, to satisfy both client and contractor, it is necessary to use some simple mechanism to compute the price adjustment to fair fluctuation formula (Jayasinghe et al. 2015). The purpose of the Price fluctuation formula system is for equitable risk sharing between the client and the contractor in terms of materials, labour and plant & equipment cost fluctuation. By using Formula method, the price fluctuation adjustments are based on price indices at tender month and date of measurement. Price adjustments are calculated according to the change in the Price Index of relevant resources within the contract period published by the ICTAD. The Price Fluctuation Formula will be determined by comparing the difference between the price indices in effect for the base month and current month (Jayasinghe et al. 2015).

With this background, research is aiming to study whether the available ICTAD price adjustment procedure is exactly suitable to use with the present format. This was achieved through finding the relationship between ICTAD price adjustment and price indices, estimating the accuracy and effect of the ICTAD price fluctuation formula procedure and suggesting modifications to increase of accuracy of ICTAD price fluctuation formula.

2. METHODOLOGY

The research was started with comprehensive literature survey to get familiar with related studies followed by preliminary survey, data collection, analyzing of data and proposed out comes. Analyzing of the data was done by comparison with indices variation and cost recovery calculated based on the ICTAD formula method for selected projects. Following equations were used for data analyzing.

Percentage variation of current indices = (Current Indices - Base Indices) / (Base Indices) *100%

All the indices are published by the ICTAD in their monthly bulletins. With this calculation it is expected to see the indices variation theoretically.

Percentage of price adjustment (Including non-adjustable elements) = (Price adjustment) / (Work done in period (v))*100%

With this, it is expected to see the variation of price adjustments that the contractor received based on the work done during the concerned period.

Percentage of price adjustment (without non-adjustable elements) = (Price A adjustment) / (Computation of V-Vna)*100%

Usually price adjustments are done by eliminating value for non-adjustable work. So it is expected to see the relationship of price adjustments without the value for non-adjustable works.

3. RESULTS AND DISCUSSION

Collected data were analyzed considering following points which were identified as some of the effects to recover the actual construction cost during the preliminary surveying and through the literature review. Those are Effect of Non-adjustable elements, Effect of current indices related to the materials which are not used during a particular valuation period, Effect of selecting Input percentage and Effect of Cost of Materials at the site. The graphs which are shown below were used to identify the above mentioned effects.
By considering the plotted graphs for projects, current indices variation and price adjustment variation to the value of work done without non-adjustable are same pattern. But price adjustment variation to value of work done and variation of current indices are not same pattern. Work done without considering the non-adjustable element is used to calculate price adjustment in ICTAD formula. By considering the all graphs for projects, using \((V - V_{\text{na}})\) to the formula is correct.

According to the figure 2, some current indices are not used at the valuation period but those current indices are used for the price adjustment calculation. Because of that Factor sum \([P_x (I_{xc} - I_{xb})/I_{xb}]\) increases for low work done value for the valuation period. This can be proved using figure 3 also. Table 1 shows information relevant to Bill number 2 under Figure 3.

<table>
<thead>
<tr>
<th>Input name</th>
<th>Input %</th>
<th>Current index variation</th>
<th>Factor of sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>3%</td>
<td>50.32%</td>
<td>1.51</td>
</tr>
<tr>
<td>Machinery</td>
<td>41%</td>
<td>10.41%</td>
<td>4.57</td>
</tr>
</tbody>
</table>

According to the Table 1, input percentage is more significant to the factor of sum than the index variation. If that material having the highest input is not used during the valuation period, the calculated price adjustments may not be accurate. So, input percentage is more effective than the current indices variation.

According to the Figure 4, for bill no 8 and 17, price adjustment is relatively high. This is because the cost of materials at site. Those information are shown in Table 2.

<table>
<thead>
<tr>
<th>Bill No</th>
<th>Cost of Materials (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>8,128,740</td>
</tr>
<tr>
<td>8</td>
<td>21,912,262</td>
</tr>
<tr>
<td>17</td>
<td>24,265,415</td>
</tr>
<tr>
<td>18</td>
<td>8,423,358</td>
</tr>
</tbody>
</table>

This shows the cost of materials at the site is effect to price adjustments.

4. CONCLUSIONS

Based on the above explained results, price adjustment calculation without non-adjustable elements is fair. Use of current indices & their input percentages defined at the beginning, for all the valuation period is not fair. Suggestion for that effect is check the price adjustment using indices which are related to the materials used during the valuation period. Similarly, use of same input percentage values is not fair. Suggestion for that effect is Input percentages can be calculated considering the materials used during the valuation period and not the entire project. Also adding the cost of materials at site to work done leads to higher price adjustment. So eliminating that part that effect can be minimized.

REFERENCES


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6th January 2017
EFFECT OF COST, DISTANCE AND TRAVEL TIME ON THE COMMUTERS’ SELECTION OF THE MODE OF TRANSPORT

G.G.A.S Ganegoda, K.C. Ellawala and Terrence M. Rengarasu

ABSTRACT

The objective of this study is to investigate the influence of cost, distance and time on selection of the transport mode and develop a model explaining the level of influence of these parameters. A preliminary questionnaire survey was conducted to identify the most desirable values for each threshold of cost, distance and time in selecting transportation mode. After assigning the threshold values for each attribute, best combination of attributes was generated by using uniform design method and twenty number of profile cards were presented individually to each person. Questionnaire survey was conducted and data were analyzed by using multinomial logit model with the aid of SPSS software. Each scenario was entered into SPSS using effect-coding method. The indicate that the time is the most important factor in selecting bus, train and motor bike as transport mode and cost is the most important factor in selecting motor car as the transport mode by the commuters.

1. INTRODUCTION

An increasing trend of using private transport modes in commuting is observable at present. This trend results increased traffic congestion and air pollution. When consider Sri Lankan condition, there are no enough road capacity to solve increasing traffic congestion and when consider the public and private transport modes, public transport is less effect to increase the air pollution and traffic congestion also. However, commuters tend to consider travel cost distance travel time and etc., when select transport mode for their travelling Therefore, the aim of this study is how to effect cost distance and convenience of commuters to select transport mode by considering Sri Lankan condition and referring past researches.

There are more factors are considered to select transport mode in addition to cost, distance and time. Comfort and socioeconomic factors may influence the selection of transport mode. European countries had carried out some researches on this aiming to reduce the traffic congestion and air pollution. But related to Sri Lanka situation may change.

There is a direct link between the actual service and the customer’s satisfaction. To increase public transport use, the service should be designed and performed in a way that it accommodates the levels of service required by customers (Ellaway, 2003). To calibrate the model, SPSS software to analyze data obtained from study on how social economic and service attribute factors effect when the mode of transport is selected (Dewi, A., U.,2010).

2. METHODOLOGY

2.1 Defining Thresholds for Each factors and Level

Thresholds of travelling cost travel time and travel distance had to be determined according to the Sri Lankan situation and there was any reference to make it. Therefore, preliminary open-ended questionnaire survey was conducted among 100 commuters to decide limitation values for each attributes that were considered.

2.2 Questionnaire survey Design and Data Collection

After collect the preliminary questionnaire survey, limit values were generated for each attributes using SPSS software referring orthogonal design methods. But it cannot be used because get large number of profile cards. Therefore, uniform design method was used to design profile cards. Using uniform design method, twenty number of profile cards were generated. Example of a profile card is shown in Table 2.1.

<table>
<thead>
<tr>
<th>Table 1: Example of a profile card used in the questionnaire survey</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distance (km)</strong></td>
</tr>
<tr>
<td><strong>Time</strong></td>
</tr>
<tr>
<td><strong>Cost (LKR)</strong></td>
</tr>
<tr>
<td><strong>Transport mode</strong></td>
</tr>
</tbody>
</table>

After generation of profile cards survey was completed. 500 respondents were asked to give their choices for scenarios explained in each and every profile. If they assume that none of the given scenarios were acceptable “no option” alternative was available. Collected data were entered excel sheet using effect coding method before analyzing and logit values were calculated for all transport modes under each scenario.
2.3 Data Analyzing
Influences of cost, distance and travel time of commuters on the selection of mode of transport were determined by using the utility values. The minimum total utility value of some transport mode indicates the worst case, while maximum indicates the best case.

3. RESULTS AND DISCUSSION
3.1 Average importance and Utility Values
The output of SPSS software provides values for the average importance for each factor. Average importance of each attribute for bus as the example for selection of transport mode is shown in Figure 1. The most significant attribute is time, while cost has the least influence when compared with the other attributes. The utility values of each level of selection of transport mode for the bus and motorcar are shown in Figure 3.1 and Figure 3.2 respectively. It can be noted that every level of the cost distance and time. According to the results of utility values, level 5 condition (Lowest time) of the time is most preferable for the commuters. But level 2 condition of time is not preferable for the commuters.

![Figure 1: Utility values of each Attributes for bus](image1)

![Figure 2: Utility values of each Attributes for motor car](image2)

Likewise, variation of factors were observed to selection of transport mode for the each and every transport mode that are considered, using the average importance values, most effective factor can be observed.

![Figure 3: Average Importance Values of Attributes for bus](image3)

![Figure 4: Average Importance Values of Attributes for motor car](image4)

4. CONCLUSIONS
The results obtained from the multi nominal logit model indicate that the time is the most important factor to select the bus train and motor bike as transport mode and cost is most important factor to select motor car as transport mode. Then distance is lower effect to select transport mode. Therefore, reducing the influence of time for the public transport system, people can be attracted to the public bus transport service.

REFERENCES


Wang, D. & Li, J., Handling Large Numbers of Attributes and/or Levels in Conjoint Experiments, Baptist University, Hong Kong.
EFFECT OF SOCIOECONOMIC FACTORS ON THE COMMUTERS DECISION ON THE MODE OF TRANSPORT

A.H.M.P. Wijesinghe, K.C. Ellawala and Terrence M. Rengarasu

ABSTRACT

The objective of this study is to analyze the effect of socioeconomic factors on the selection of mode of transport by commuters. By considering the Sri-Lankan situation and past research, it has been selected gender, age and income levels are the influential socioeconomic factors. The variations in different groups on the selection of mode of transport in terms of time, cost and distance (attributes) were evaluated. Preliminary questionnaire survey was conducted to identify the most desirable ranges for above attributes. After that, best combinations of attributes were generated using uniform design method. Profile cards were presented individually to each person. There were another three questions also included in the questionnaire survey paper to identify the socioeconomic conditions. After the questionnaire survey, data were analyzed by using a multinomial logit model associated with the SPSS software. Finally average importance values were developed to evaluate the effect of socioeconomic factors on the selection of mode of transport by commuters.

1. INTRODUCTION

The commuters in Sri Lanka use several means of transport. They can be categorized as public transport and private transport. Selection of private transport methods more and more results in lack of spacing on the roads. It is the main problem in the transportation, called as traffic congestion.

When it considers income categories, rich people and low-income people have different affordability with their financial condition. Use of private transportation modes is not only causing the traffic congestion but also increase the road accident for vulnerable road users and for longer travel times for many people. Age, gender and income directly effect on the selection if a mode of transport (Bajwa et al., 2013). With improper selection, transport problems can be induce. But sometimes peoples don’t have any solution other than select that model selection with their socioeconomic condition. Therefore the objective of this study is to analyze the effect of socioeconomic factors on the selection of mode of transport by commuters.

Considering the significance of the study, it is directly deal with the congestion. If it can be turned private transport mode into public transport mode, it can be reduced number of vehicles on the road. As well as with the proper management of transport system it can be reduced the traffic congestion. For divert people from private transport mode into public transport mode, need to have an idea about requirement of the people. For that this study can be very useful.

2. METHODOLOGY

This research is started from problem identification and formulation. In this step the problem is identified and formulated through literature review and observation of the variables affecting the objective of research is composed. Then determining the research location of study and also how to do the research continued, then the initial survey is conducted to check levels of the factors. The next step is the survey itself to collect data and continue with further analysis and discussion which result in conclusion and recommendation.

2.1 Preliminary questionnaire survey

The variations in different groups on the selection of mode of transport in terms of time, cost and distance (attributes) were evaluated. Threshold limits were determined for travel time, travel cost and travel distance according to the Sri Lankan situation. Therefore preliminary open end questionnaire survey was conducted in the Galle area to identify the most desirable values for thresholds of travel times, travel cost and travel distance with 100 people.

2.2 Questionnaire survey design and data collection

Uniform design method was used to design the set of profile cards. There were twenty numbers of profile cards were generated and another three questions for segmentation analyze in final questionnaire survey paper.

When data was collected, it had been to cover the different age levels, different gender and different income level of people. While data collection is going on it was ensured that approximately same number of respondents in each category was included. Finally data was collected from 500 respondents.

2.3 Data analyzing

All the profile cards were coded using effect-coding method before doing model development. All the responses received from the respondents were transformed into logit values, compared with the ‘no option’ alternative. Multinomial logit model was developed with the aid of SPSS software (version 16.0).
The output of the software was given as the utility values and they were used to evaluate the effect of different attribute for each level of socioeconomic condition. Using the utility values, average importance values were calculated. Average importance values were used for the comparison of the influence of different attributes for different socioeconomic groups in selection of mode of transport for their commuting.

3. RESULTS AND DISCUSSION

3.1 Utility values

The maximum total utility value indicates the best case, while minimum indicates the worst case. For the example in here it is given the utility values for motorcar change with the cost with gender category from the Figure 1. It shows that female people more likely to travel by motorcar when cost is very low, as well as they are the people who easily reject motorcar option when cost is very high.

![Figure 1: Utility values for motor car change with the cost in gender category](image)

3.2 Average importance values

Figure 2 and Figure 3 shows the average importance values for the motorbike for female and male respectively. For males, travel time is the most important selection factor when they select motorbike as their commuting mode. However when females are considered cost and travels time both have almost similar importance values.

![Figure 2: Average importance values vs each factor of motorcar for Female](image)

4. CONCLUSIONS

Finally as the conclusion results can be summarized as,

- For the motorbike, female people are more influenced by the travel time and cost and male people are more influenced by the travel time.
- For the motorbike age above 55 people are more consider the cost but others are more consider time for travel.
- For the train, below 25 year age people are more consider the time but others are more consider the cost for travel.
- For the other selection, there are no any variations inside the socioeconomic categories.

From the future research it can be selected more socioeconomic factors for the study as well as it is better to update these results minimum every 5 years.

REFERENCES


Wang, D. & Li, J., 2008, Handling Large Numbers of Attributes and/or Levels in Conjoint Experiments, Baptist University, Hong Kong.