TAXONOMY FORMULATION FOR FACTORS AFFECTING COST OVERRUN IN SRI LANKAN CONSTRUCTION INDUSTRY

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ABSTRACT

Cost overrun which is meant as exceeding the final cost of the project than the original estimate of the construction project leads to profit reduction or losses. Hence, this study is aiming to distinguish the factors affecting cost overruns in Sri Lankan construction industry. Mitigating measures for cost overrun have been proposed with the severity of the cost overrun factors. Qualitative analyzing was done through questionnaire surveying choosing 76 respondents as 38 from each of contractor and consultant. Relative importance index method was used to develop two taxonomies considering opinions towards cost overrun phenomena by contractor and consultant. In both taxonomies, the most critical category was contractor related cost overrun factors and least critical category was external cost overrun factors. Among all 42 cost overrun factors, Poor site management, Poor allocation of labours and lack of coordination between constructions parties have ranked as the most critical cost overrun factors.

Keywords: Cost overrun, Taxonomy, Construction industry, Relative importance index

1. INTRODUCTION

Every construction project aims to complete the project successfully within the imposed cost, time and quality limitation. But, it is very rare to complete a project within these limitations.

Cost overrun is a common phenomenon that can be seen in the construction industry nowadays. If the final cost of the project exceeds the original estimate, it is called cost overrun. For the developing countries, cost overrun is a prominent issue among cost-related issues. Project withdrawal due to delayed payments to project participants, Projects leads to losses or reduction in project profit, Increase in capital-output – ratio for the entire economy and conflicts between involved parties in a project like consultant, client and contractor are drawbacks of project cost overrun. Although the personnel in a project know what factors are affecting cost overrun, they are having a minor idea about the importance level of the factors affecting cost overrun. So, this research produces a guideline for construction projects which can be used to minimize the influence of cost overrun factors.

2. METHODOLOGY

2.1 Major Categories of Cost Overrun

Referring to previous researchers, cost overruns factors were categorized as Design related, Material related, Client related, Site related, Contractor related, Finance related and External cost overrun factors. Each major category consisted of 6 sub cost overrun factors. Hence, there are total 42 cost overrun factors.

2.2 Questionnaire Design

The questionnaire was designed to evaluate the severity of the finalized 42 cost overrun factors. This consists of two sections.

1. Background of respondent
Under this section, type of the respondent (consultant / Contractor), work experience in the construction industry (In years) and grade of the company were evaluated.

2. Importance level of factors
Under this section, the importance level of factors was identified using the 5 point scale.
The sample size was selected as 38. So, there were total 76 respondents representing 38 from contractor and consultant separately. ICTAD registered list of contractors was the sample population for the questionnaire covering C1 to C5 grades contractor as per the research scope.

2.3 Data Collection

Through direct interviews and Google forms, total responses of 76 were collected.

2.4 Data Analyzing Method

The relative important index is a commonly used formula for data analysis. When considering the importance level of the cost overrun factor according to the respondents’ view, 5 point scale was used and RII was calculated.

\[ RII = \sum \alpha \cdot \frac{n}{N} \]

Where,
RII = Relative importance index
\( \alpha \) = Constant expression weight
n = Frequency of response
N = Total number of response
Here, ‘N’ = 38, ‘a’ and ‘n’ are variables.
In 5 point scale, the importance level of the relevant factor as follows.
1 = not significant
2 = slightly significant
3 = moderately significant
4 = very significant
5 = extremely significant

3. RESULTS AND DISCUSSION
3.1 Assessing Major Categories of Cost Overrun
Based on the relative index for individual factors, average RII value for each major cost overrun category was calculated to evaluate the most influencing cost overrun category. Graphs were plotted considering both views of consultant and contractor.

Figure 1: Major cost overrun categories – consultant’s view

Figure 2: Major cost overrun categories – contractor’s view

According to the Figure 1 and Figure 2, category of contractor related cost overrun factors was selected as most influencing category for cost overrun while the category of external cost overrun factors selected as the least influencing one.

3.2 Usage of Taxonomies in Construction Industry
The proposed taxonomies can be used to make guidelines to mitigate cost overruns in construction projects.
Followings are proposed as important guidelines.
1. Effective site management and supervision with frequent progress meeting
2. Giving focus on capabilities and past performance of contractors
3. Enhancing the relationship among client, contractor and consultant throughout the project period.
4. Performing a preconstruction planning of project tasks and resources needs
5. Enhancing coordination between administration and workers through frequent progress meetings - Comprehensive contract administration
6. Using actual value and earned value concept for cost monitoring in the project

4. CONCLUSIONS
Cost overrun is an essential topic to be researched as it directly influences the success of the project. In this research, 7 main categories of cost overrun factors were evaluated. As the final objective, all the seven factors were ordered according to the severity of them. Hence, two taxonomies were developed considering contractor and consultant. Most influencing category for cost overrun was selected as contractor related factors. Among all 42 cost overrun factors, poor site management, poor allocation of labours, lack of coordination between construction parties, problems with availability of labour, material and equipment and unrealistic schedules were selected as most influencing factors for cost overrun.
This research will be a guideline for construction projects. At the preliminary stage of the project, most influencing circumstances for cost overrun can be identified and they can be avoided or minimized referring mitigation methods. As the final result depicts both views of contractor and consultant, impartial solution can be obtained.

REFERENCES
TAXONOMY FORMULATION FOR FACTORS AFFECTING TIME OVERRUN IN SRI LANKAN BUILDING CONSTRUCTION INDUSTRY

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ABSTRACT

The construction industry is a challenging industry by its nature. Cost, time and the quality are triple constraints to put more attention throughout the project to its successful completion. So, it is vital to prevent the factors affecting for constructions negatively. This study is carried out to evaluate the influencing factors for time overrun by its severity and to make a set of guidelines to minimize construction delay. Questionnaires were distributed among C1 to C5 graded companies registered under CIDA classifications and evaluated by ‘Relative Importance Index’ method. Both consultants’ and contractors’ were considered in this study to make the reliability of results high. According to the formed two taxonomies, a set of guidelines were made which can be used to minimize construction delay. The most significant research finding is that according to the contractor’s view, Consultant related factors are more dominant for construction delays and vice-versa.

Keywords: Construction delay, Significant factors, Ranking, Delay factors, Time overrun, Effect of delay

1. INTRODUCTION

Construction is the process of constructing a building or infrastructure. Construction industry is a multi-party industry hence many people, materials, equipment, etc. are involved. Those parties should be managed effectively to achieve company objectives successfully not letting to delay the whole project. Construction delay, or in other words time overrun, is the non-completion of the project within the specified duration as previously agreed. Time overrun is currently a common problem in many of construction projects which causes considerable losses to project parties. Since time overrun is a major problem in a country, many countries had investigated about time overrun in construction industry. Therefore, it is essential to identify the actual causes of delay in order to minimize and avoid the delays and their corresponding expenses; however, a deeper understanding is still needed.

This research is only for building projects since the factors affecting to time overrun in building projects and other infrastructure projects may have completely different nature. Client and contractor see the causes for construction delay in different manners. Therefore this research will carry out two questionnaires surveys separately for consultants’ side and contractors’ side. For the reliability concerns, only grade C1 to C5 companies were selected under CIDA registered companies.

2. METHODOLOGY

Methodology is the process of achieving the expected objectives of the research. Most influencing sub-factors (49 Nos) were identified under different categories (8 Nos) with the help of previous literature and prepared the preliminary questionnaire as an approach to the research. Prepared preliminary questionnaire was distributed among field expertise to get valuable comments prior to making of final questionnaire. After making of final questionnaire with the help of field expertise as well as previous literature, the representative sample size was calculated as 38. Therefore total of 76 responses was achieved as 38 for each perspective. Responses were analyzed by ‘Relative Importance Index’ method. Every sub-factor was ranked by RII method and main factors were ranked by using the average value of RII values of sub-factors included in the particular category. By looking at the finalized results, a set of guidelines were prepared.

3. RESULTS AND DISCUSSION

Finalized results show the significance of each factor on time overrun. Table 1 shows the summarization of the results with main categories and highest ranked sub-factor in the particular main category.

According to Table 1, some sub-factors got highest RII for contractors’ perspective as well as consultants’ perspective. It realizes that such kind of sub-factors should be prevented from occurring giving high concentration on them.

Table 2 shows the highest ranked sub-factors according to both perspectives irrespective of the categories. Necessary arrangements should be made to prevent occurring those factors. According to contractors’ idea, daily works should be carried out controlling weather effects effectively. According to consultants’ idea, qualified technical staff should be used by the contractor in order to have better outputs.
Table 1: Highest ranked sub-factor in each main factor

<table>
<thead>
<tr>
<th>Main Factor</th>
<th>Contractor Related</th>
<th>Consultant Related</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client Related</td>
<td>Delay in decision making</td>
<td>Delay in decision making</td>
</tr>
<tr>
<td>Consultant Related</td>
<td>Slowness of decision making</td>
<td>Delay in approving major changes</td>
</tr>
<tr>
<td>Contractor Related</td>
<td>Rework due to mistakes and defects in construction</td>
<td>Improper qualification of the contractor’s technical staff</td>
</tr>
<tr>
<td>Professional Management Related</td>
<td>Ineffective planning and scheduling</td>
<td>Poor Site management</td>
</tr>
<tr>
<td>Material Related</td>
<td>Delay in delivering material to construction sites</td>
<td>Delay in delivering material to construction sites</td>
</tr>
<tr>
<td>Labour &amp; Equipment Related</td>
<td>Insufficient number of equipment</td>
<td>Low productivity level of labourers</td>
</tr>
<tr>
<td>Contractual Relationship</td>
<td>Mistakes and discrepancies in contract documents</td>
<td>Inappropriate contractor selection methods or type of contract used</td>
</tr>
<tr>
<td>External Factors</td>
<td>Effects of weather</td>
<td>Effects of weather</td>
</tr>
</tbody>
</table>

Table 2: Individual ranking of sub-factors

<table>
<thead>
<tr>
<th>Rank</th>
<th>Contractor’s Perspective</th>
<th>Consultant’s Perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Effects of weather</td>
<td>Improper qualification of the contractor’s technical staff</td>
</tr>
<tr>
<td>2</td>
<td>Rework due to mistakes &amp; defects in construction</td>
<td>Delay in delivering material to construction sites</td>
</tr>
<tr>
<td>3</td>
<td>Poor coordination &amp; communication</td>
<td>Low productivity level of labourers</td>
</tr>
<tr>
<td>3</td>
<td>Shortage of sub-contractors &amp; specialist firms</td>
<td>Delay in decision making of client</td>
</tr>
<tr>
<td>3</td>
<td>Ineffective planning &amp; scheduling</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Delay in decision making of client</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Taxonomies of time overrun

Figure 1 shows the taxonomies formed considering main categories.

According to the contractors’ view, consultant related factors should be prevented and according to the consultant, contractor related factors should be prevented. They both rated professional management related factors at a higher place highlighting the importance of maintaining good management practices.

4. CONCLUSIONS

According to the results, although almost all the factors had a great importance, some significant factors and significant categories were identified. So, necessary implementations could be given to mitigating those problems focusing mainly on highest severity factors. As a general overview, both parties arguing directing the responsibility of construction delay to the other party. Individual ranking of subfactors also gave an idea of facing weather effects effectively and using a qualified technical staff.

Individual ranking of subfactors and two taxonomies help to get an idea about the most impressive causes of construction delay and people can use those as guidelines. That will lead to take decisions in construction sites minimizing construction delay.

REFERENCES


EFFECT OF CONTRACTOR-CLIENT RELATIONSHIP TO MINIMIZE CONSTRUCTION DELAY

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ABSTRACT

Construction delay is a major problem encountered by most of the construction projects all around the world. There is a strong requirement to identify causes, influencing factors and find applicable measures to minimize the delay up to the most possible extent. This work is directed to investigate on to the contractor-client relationship, the effect of this relationship on construction delay and whether it can be positively used to minimize delay. A questionnaire survey was conducted in the form of 24 direct interviews, 33 printed questionnaires and 9 Google forms involving 36 contractors and 30 clients/consultants to evaluate the severity of influencing factors. Gathered data was analyzed through severity index and Principal Component Analysis through SPSS software; hence a ranking is put forward. Recommendations to improve relationship, to address delay are emphasized in view of the results of this study.

Keywords: Contractor-client relationship, Construction delay, Severity index

1. INTRODUCTION

Success of any construction project is determined considering the project utilized cost, time and the output quality; whereas time is a major concern. In construction, delay can be defined as the time overrun beyond the completion date specified in the contract, or beyond the date that the parties have agreed upon for delivery of a project (Assaf & Al-Hejji 2005). Construction delay costs and burdens both client and contractor.

As many researchers have pointed out, construction delays happen due to both parties: contractor and client. So the mutual understanding between the two parties is very important. Conditions of contract by FIDIC and CIDA helps to maintain the contractual relationship. With the intensions of positively improving contractor-client relationship, this work was narrated along the objectives of;

1. Identifying the hypothetical relationship that should prevail between contractor and client to minimize construction delay.
2. Identifying problems affecting the relationship between contractors and clients who are in practice.
3. Proposing solutions to minimize problems which affect the contractor-client relationship.

2. METHODOLOGY

Data collection was mainly done through a questionnaire which is formulated through a comprehensive literature survey. Questionnaire consisted with factors under different categories namely legal aspects, general causes, causes with regard to the contractor, consultant and client. The collected data was mainly analyzed through Severity Index: A formula used to rank problems which affect contractor - client relations based on severity as indicated by the participants.

Severity Index (S.I.) (%) = Σ a(n/N)×100/5

Where a is the constant expressing weighting given to each response (ranging from 1 for ‘does not affect’ up to 5 for ‘extremely affect’), n is the number of responses for each factor, and N is the total number of responses (Assaf & Al-Hejji 2005). The questionnaire was formulated with a 5-point scale to identify each of affecting factor’s severity on the contractor-client relationship: Extremely Affect - 5, Highly Affect - 4, Moderately Affect - 3, Slightly Affect - 2, Does Not Affect - 1.

Furthermore, a factor analysis with SPSS software was done to identify the principle components from the list of factors given as variables with the aid of responses given by contractors.

3. RESULTS AND DISCUSSION

Data collection was questionnaire survey oriented which included 24 direct interviews, 33 printed questionnaires and 9 Google forms. The questionnaire had 34 factors listed under 5 categories such as legal aspects, general causes, causes with regard to the contractor, consultant and client each. The respondents’ experience varied from below 5 years up to more than 15 years. The survey captured views from 36 contractors and 30 clients/consultants.

Figures 1 and 2 show the variation of averaged severity indices for different categories from the client’s perspective and contractor’s perspective.
Table 1 and 2 give the results when the individual factors were ranked with the severity index irrespective of the categories.

### 3.1 SPSS Analysis

A Principal Component Analysis was done with SPSS software and 3 main principal components were identified having much effect on the relationship. A correlation value of 0.750 was used in the extraction of variables; hence 6 factors in PC1, 5 factors in PC2 and 1 factor in PC3 was obtained. PC1 was determined to be a measure of causes with regard to the contractor whereas PC2 was determined to be a measure of causes with regard to the consultant and client.

### 4. CONCLUSIONS

This research was focused to identify the effect of contractor-client relationship to minimize the construction delay through a field survey. 34 factors were evaluated under five different categories through responses of the respondents. The field survey included 36 contractors and 30 clients/consultants. Contractors have specified ‘causes with regard to the consultant’ whereas clients/consultants have pointed out ‘causes with regard to the contractor’ to mainly cause troubles in the contractor-client relationship. All these project participants have agreed on: ‘poor site management and supervision’ of contractor and ‘slowness in decision making’ of client to have severe negative effects on the relationship, where the category of ‘legal aspects’ has been identified to have very less effect on the relationship.

### REFERENCES


INVESTIGATION OF BARRIERS TO IMPLEMENT ERP SYSTEM IN CONSTRUCTION COMPANIES

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ABSTRACT

Enterprise Resource Planning (ERP) is a central system which integrates many sectors such as financial, inventory, planning, etc. and it can be considered as an important management tool. In Sri Lanka, construction industry is lacking the knowledge of modern IT and this study aims to investigate such a system. The research was based on a questionnaire and targeted construction firms which are registered in CIDA. The Relative Importance Index (RII) was used to perform the analysis part and it was found that the majority in Sri Lankan construction industry are well aware of the system but very few are practicing. Furthermore, the study elaborates different stages of ERP system, challenges and how to overcome those, Benefit and method of implementing, Failure and Success factor. Finally, the results of this study have provided vital information to the construction firms which are practicing and seeking to implement ERP system.

Keywords: Enterprise resource planning, Awareness, Implementation, Challenges, Benefits

1. INTRODUCTION

Construction project management is a professional service that uses specialized, project management techniques to oversee the planning, design and construction of a project from its beginning to the end. The main focus is to control the time, quality and cost of a project. One such system which controls those factors is Enterprise Resource Planning (ERP) system.

In the construction industry, the organization focus is to maintain a proper information system. As a result, many organizations preferred to have one common database and one such integrated management system is ERP system. ERP is an enterprise-wide application software package which integrates all the functional process into one single common database (Khaparde, 2012). In recent time ERP system has significantly contributed towards the effectiveness of the organizational performance. This is a system which includes purchasing, inventory management, finance, human resource management, budgeting and tendering, etc. In Sri Lanka, very few major organizations have implemented ERP system the awareness among other construction firms is questionable. For this, a questionnaire survey was performed between the construction firms in Sri Lanka which are registered under CIDA. This research will provide sufficient information about the awareness, challengers during implementing and furthermore.

2. METHODOLOGY

The methodology is the course of achieving the research objectives. At the beginning of the research stage, literature review was carried out. From the literature review and by getting the opinion of field expertise factors needed for the questionnaire was obtained. Later, a final questionnaire was prepared and factors were evaluated using five-point scale method. Then from the population of 4458 construction firms, a sample size of 41 was identified. Data collection based on the final questionnaire was undertaken using two methods such as direct interviewing and via google forum. After receiving the responses, all the data were analyzed using the method of Relative Importance Index (RII) and simple percentage theorem. Under each category, main factors were evaluated using RII and ranked base on their significance. In order to identify the reliability of the data both data collected from the forum and direct interview was analyzed separately and assessed for any deviation. Finally, the complete set of data was analyzed and results were acquired.

3. RESULTS AND DISCUSSION

The final outcome of the research based on the awareness is obtained as in Figure 1 which expose in Sri Lankan construction industry almost 61% are well aware of the ERP and out of them almost 69.5% are practicing.

![Figure 1: Awareness and practicing of ERP system](image1.png)

Figure 1: Awareness and practicing of ERP system
The organizations which are not aware of the ERP system are mainly related to an organization which is falling under C5 graded and organization which are aware of the ERP system and practicing are above C5 graded.

The main factors which significantly influence the ERP system under each subsection are represented in Table 1. All the factors were ranked based on their significance towards each subsection.

Table 1: Ranked factors on implementing ERP system

<table>
<thead>
<tr>
<th>Opinion</th>
<th>1</th>
<th>Organization can succeed without ERP system</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>Mainly related to top management</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Complexity in procedure of work</td>
</tr>
<tr>
<td>Barriers</td>
<td>1</td>
<td>Lack of Knowledge on ERP</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>High cost of implementation</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Lack of support given by the staff members and labourers</td>
</tr>
<tr>
<td>Benefits</td>
<td>1</td>
<td>Increase in organizational performance</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Easiness in accessing data</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Better strategic decision making</td>
</tr>
</tbody>
</table>

All the above results are obtained from the point of view of the organization representative and they have pointed out that the opinion they got regarding the ERP system does not positively influence towards the ERP system promotion. In order to overcome barriers, the main solution can be taken as conducting training sessions and getting the guidance of experts.

Table 2: Factors Ranked based on success and failure

| Failure factor | 1 | Lack of Experience                        |
|               | 2 | Insufficient training on end users        |
|               | 3 | Failure to get user support               |
| Success Factors | 1 | Commitment and support given by the top management |
|                 | 2 | Method of implementation                   |
|                 | 3 | Proper Training given to staff            |

Table 2 is the final outcome based on failure and success factor on ERP system and it shows that in both subsections, training on end users has become a common significant factor towards the success of ERP. Many organizations have pointed out that the “Uses of a common ERP system” or customization does not create any significant impacts towards the success of ERP system.

Figure 2 represents the method which many organizations preferred to go with during the stage of implementation. And it was clear that almost 55% of the firms are preferred partial implementation and very few are agreed on implementation of a component. The main drawback of full implementation is once the system got collapse every operational activity will be ceased.

4. CONCLUSIONS

It was identified that in the Sri Lankan construction industry the awareness of ERP system is more than 50% and the organizations which are well aware of the ERP system they prefer to practice. Out of them, it was found that almost 70% are practicing ERP system. This makes sure that the ERP is a well reliable management tool in construction firms. But research shows that majority of them are above C5 graded companies and below C5 graded are lacking knowledge.

These findings point out that this system also enhances the organizational performance in a vast manner and the main barrier to implement ERP is the lack of knowledge of ERP system. Even though there are pros and cons still practicing ERP system gives relatively more benefit to the construction firms.

REFERENCES


COMBINED EFFECT OF WASTE MATERIALS ON HOT MIX ASPHALT

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ABSTRACT

Most of the developing countries are preferable to use Flexible pavements considering cost, strength as well as durability. In most of the cases, asphaltling of minor roads exceed the bearing capacity requirement over applied load consuming extra construction cost. By the same time accumulation of unmanaged wastes causing environmental issues impacting all living beings and atmosphere. So there prevails a requirement of proper management of Solid wastes rather than open dumping. Many studies had been carried out over combined effect of waste materials in hot mix asphalt by touching all above mentioned issues. So it contrasts the requirement of innovative asphalt mixture over typical mixtures in case of critical situations which will be economically as well as environmentally significant. This study is based on combined effect of polyethylene terephthalate and saw dust ash with hot mix asphalt which will concern on environmental and cost issues. So improved asphalt mixture will be most appropriate for low loaded minor roads which will be economically and environmentally profitable.

Keywords: Combined effect, Waste materials, Hot mix asphalt, Sawdust ash, Polyethylene terephthalate

1. INTRODUCTION

Recently flexible pavements are used more over rigid pavements for road construction. So it required huge amount of raw materials for maintenance as well as reconstruction. Especially the amount of cost for aggregate is significant when compared to other materials of asphalt concrete. Majority of the aggregates of asphalt concrete is consumed by the filler content. Therefore, it is required to find economical filler materials through innovations and researches (Marteano 2002).

It has been estimated that over 6400tons/day of solid waste are generated in Sri Lanka. About 85% of collected waste in Sri Lanka is subjected to open dumping (Visvanathan 2006). Wijetunga (2013) stated that the average percentage of plastics and polythene in municipal solid waste in Sri Lanka is about 5.91. So reuse of plastic waste may lead towards proper solid waste management rather than land filling. It has been recognized that amount of sawdust ash waste generated during last two decades is increasing year by year in the household, mills and factories. Mageswari and Vidivelli (2009) revealed that use of Saw dust ash as fine aggregate can considerably reduce the problem of dumping and waste storage simultaneously while preserving the natural fine aggregate resources. So the amount of cost for aggregate will reduce due to replacement of filler with freely available waste material combined with polyethylene terephthalate as additive to enhance the performance of asphalt concrete. By the same time it will contribute towards the sustainable solid waste management. Ultimately overall process may lead towards environmentally friendly productive construction. So Study to investigate optimum composition of polyethylene terephthalate as additive and saw dust ash as fillers in modified asphalt concrete will make this study significant.

2. METHODOLOGY

2.1 Required Materials

The binder used in the experiments is bitumen of penetration grade 60/70, which is a petroleum based bitumen. The selection of binder was based on the wide application of open grade bitumen in Sri Lanka. The aggregates were collected from a quarry near Galle which currently supply aggregates for road construction in local roads. Therefore carried out sieve analysis for aggregates and selected 20% of coarse aggregate, 20% of fine aggregate and 60% of filler aggregate which satisfy the requirements of wearing coarse type 3 of asphalt concrete according to CIDA specifications.

2.2 Casting of Specimens and Testing

In the mixing process 110 to 150 Celsius oven dried aggregate sample was taken. Initially aggregates were mixed according to proportions. Finally bitumen was mixed with heated aggregate and thoroughly mixed at required temperature. For modified samples, burnt Saw dust ash is used after sieved through 1.18 mm sieve. PET is used in form of fiber which is cut in to small pieces. It was used as bitumen modifier. After prepaid the mix, it was placed in the mold and compacted with 50 numbers of blows at both sides of the sample. In the modification of filler initially SDA will be mixed with aggregate as replacing part of aggregate. After that Modified bitumen with PET will be added to get modified asphalt sample. Modified samples were casted for every combinations of PET up to15% at 5% interval and SDA up to 30g at 10g interval. Once samples were casted, kept it for 24 hours.
and bulk properties were checked. Then samples were kept in 60 Celsius water bath around 30 minutes and Marshall Properties were checked.

3. RESULTS AND DISCUSSION

Total aggregate weight of 1200g were selected from each aggregate type for a Marshall sample and 15 control samples casted where three samples for each bitumen percentage with interval of 0.5 range from 4 to 6%. According to the results, it was clear that bulk properties of control samples are over the requirements where air void percentage is in between 3-5% and voids in mineral aggregate is over 13%. In case of Marshall Properties, stability is over 5.33kN and flow is in between 8-18 mm. These results were used to compare with modified samples. According to test results and information from the literature review, PET up to 15% and SDA up to 30g were used for further experiments. Samples were casted as combinations of PET in 5% interval up to 15% and SDA up to 30g in 10g intervals. Marshall Stability is the dominant parameter that can be used to determine optimum combination where other parameters are required to satisfy certain limits. So results of Marshall Stability are shown in figure 3.1.

![Figure 3.1: Marshall properties of modified samples](image)

According to figure 3.1 it is clear that 5% bitumen has average optimum results for every combinations. In case of combinations, 15% PET and 0.85% SDA show consistent results throughout each bitumen percentages and it was the optimum combination that satisfy all the Marshall and bulk requirements. According to figure 3.1, 15%PET of 6% bitumen has optimum stability. In order to be optimum combination, it should satisfy all the requirements of CIDA specification for field application. According to results, all the combinations of 5% and 6% bitumen satisfied the flow requirement. Majority of the results satisfied the Marshall Flow requirement and it does not show a significant relationship with the variation of combinations. In case of bulk properties, Air void percentage of samples, show significant variation with modified combinations and results are shown in figure 3.2.

![Figure 3.2: Air void percentage of modified samples](image)

4. CONCLUSIONS

According to all the results, it is clear that stability of the modified samples improve with the increment of PET and decrease when SDA percentage is high. It is clear that all the results of 5% bitumen satisfy CIDA specifications for selected combination of waste materials. In case of optimum combination, 15% PET and 0.85% SDA has average optimum results in Marshall Stability when compared to other combinations. When it compare with other properties 5% bitumen of above combination satisfy all the requirements as shown table 3.1. So 15% PET and 0.85% SDA of 5% bitumen has the optimum stability that satisfy all the requirements of CIDA specification. Results of 15% PET and 0.85% SDA are shown in Table 3.1.

<table>
<thead>
<tr>
<th>Bitumen(%)</th>
<th>Stability(kN)</th>
<th>Flow(mm)</th>
<th>Air void(%)</th>
<th>VMA(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>16.05</td>
<td>16.2</td>
<td>4.15</td>
<td>13.85</td>
</tr>
<tr>
<td>4.5</td>
<td>17.06</td>
<td>15.6</td>
<td>3.16</td>
<td>14.08</td>
</tr>
<tr>
<td>5</td>
<td>20.60</td>
<td>17.8</td>
<td>3.05</td>
<td>15.08</td>
</tr>
<tr>
<td>5.5</td>
<td>17.06</td>
<td>19.2</td>
<td>2.04</td>
<td>15.29</td>
</tr>
<tr>
<td>6</td>
<td>21.20</td>
<td>16</td>
<td>0.14</td>
<td>14.20</td>
</tr>
</tbody>
</table>

Table 3.1: Results of modified samples with 15% PET and 0.85% SDA

REFERENCES

DETERMINATION OF MARSHALL PROPERTIES AND CHEMICAL LEACHING FROM FLY ASH MODIFIED HOT MIX ASPHALT

W.Y.S. Fernando and Terrance M. Rengarasu

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ABSTRACT

Asphalt concrete is commonly known as asphalt and it is used in the construction of highways and roads. Asphalt is a mixture of aggregates, binder and filler that is used for constructing and maintaining all kind of roads, parking areas and also sports areas. Aggregates for asphalt mixtures can be crushed rock, sand, gravel or slags. In order to bind the aggregates into a cohesive mixture a binder is used. In present day, the cost of asphalt concrete production is high due to the high material cost that involve in the production processes. Also waste disposal process does not well execute on these days in Sri Lanka. Fly Ash, is a by-product of Lakvijaya coal power plant in Norochcholai, Sri Lanka. In this research, it is proposed to examine the effects of Fly Ash from Lakvijaya coal power plant on the cost of Asphalt concrete, the effect on environment and the performance of the asphalt concrete. This research will also be test the samples by using the Marshal Mix design procedure and it will be a great discovery for future mankind.

1. INTRODUCTION

Basically a highway pavement can be defined as a structure that consist of superimposed layers of processed materials above the natural soil subgrade. The pavement structure should be able to provide an adequate skid resistance, favourable light reflecting characteristics, surface of acceptable riding quality and low noise pollution. Three types of pavements are generally recognized as serving this purpose, namely flexible pavements, rigid pavements and composite pavements.

The flexible pavements have less flexural strength and acts like a flexible sheet and the design is based on overall performance of flexible pavement, and the stresses produced should be kept well below the allowable stresses of each pavement layer. (Adam 2015)

For saving natural rock and reusing solid waste, fly ash can be used as part of coarse aggregate. Then fly ash can be used as a replacement for asphalt aggregates and reduce environmental pollution. (Xue et al. 2009)

2. METHODOLOGY

2.1 Required Materials

Bitumen is a mixture of different organic materials, mostly of carbon and hydrogen. It is produced through vacuum distillation of petroleum and penetration grade is 60/70. The aggregates were collected from a quarry near Galle which currently supply aggregates for road construction in local roads. Then carried out a sieve analysis for aggregates and selected 20% of coarse aggregate, 20% of Chip aggregate and 60% of fine aggregate which satisfy the requirements of wearing coarse type 3 of asphalt concrete according to ICTAAD specifications.

2.2 Waste Material

Fly ash was obtained from "Lakwijaya Coal Power Plant, Norochcholai". The particular class fly ash was used in the experiment. Fly ash is produced in small dark flecks by the burning of coal in this power plant.

2.3 Casting of Specimens and Testing

The required quantity of the mix was taken so as to produce compacted bituminous mix specimens of thickness 63.5mm approximately. 1200g of aggregates were collected and the percentage of binder content is varied from 4 to 6.0 in 0.5 percent intervals and it was calculated with respect to the total weight of mix. Fly ash content is varied from 0 to 20 in 4 percent intervals and also fly ash was used as filler to replace the conventional filler used.

For each mix proportion used, five samples will be cast in case of the control sample without any intervention of waste materials, three for samples containing the waste materials and other one to test the chemical leaching. Also, three samples will be casted with the fly ash as a filler. The results obtained for each mix proportion will be averaged and concluded as one value. Then the required amount of bitumen was added to the heated aggregate and thoroughly mixed. The mix will be placed in a mould and compacted with 50 numbers of blows each on both the top and the bottom sides of the sample.

2.4 Chemical Leaching Test for Casted Samples

First a distilled water sample will be selected and then Fly ash replaced cylinders will be soaked in one liter of distilled water for 24 hours. After that the soaked water will be collected and checked the chemical leaching...
concentration by using Atomic absorption spectrophotometer apparatus.

3. RESULTS AND DISCUSSION

15 number of control samples casted where three samples for each bitumen percentage with interval of 0.5 range from 4 to 6%. And total aggregate weight of 1200g were selected from each aggregate type for a Marshall sample. When considering Marshall Properties, according to the Standard Specification for Construction and Maintenance of Roads and Bridges (SCA/5), Stability is not less than 5.34 kN and Flow is varying between 8-18mm for Medium Traffic.

According to test results of Fly Ash replaced samples Marshall Stability is obtained as a higher value when of Fly Ash% equals to 12%. But the increment of Fly ash %, Marshall Flow is also increasing. Air voids ratio is increasing and bulk specific gravity is decreasing when increment of Fly Ash respectively. Marshall Stability is the main parameter that can be used to determine optimum combination where other parameters are required to satisfy certain limits. So results of Marshall Stability are shown in figure 3.1

Figure 1: Graph of stability for control sample

Figure 2: The graph of flow value for control sample

According to above table, checked the As,Pb,Zn and Cd output from selected samples. Table 3.2 is shown the chemical leaching data.

Table 3.2: Summery of chemical leaching data

<table>
<thead>
<tr>
<th>Element</th>
<th>Highest</th>
<th>Lowest</th>
</tr>
</thead>
<tbody>
<tr>
<td>As</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Pb</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Zn</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Cd</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

4. CONCLUSIONS

From above results sample no 1 cannot be accepted, because it have highest leaching ability of Zn, Pb and Cd. Also sample 5 cannot be accepted, because it have highest leaching ability of As. So sample 2 and 3 can be acceptable, because it have lowest leaching ability of Zn, Pb. Also sample 3 has the low leaching ability of As and Cd rather than sample 2. Also sample 3 has Intermediate Stability, high value of Specific gravity, high value of VFB and Low value of Void ratio. Then most suitable sample for road construction is sample 3 that contains 5% of bitumen and 16% of Fly Ash. (All the samples are define in table 3.1 with their sample numbers)

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MODELLING THE REASONS FOR PEDESTRIAN ILLEGAL CROSSING USING CONJOINT ANALYSIS

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ABSTRACT

This paper presents the results of a conjoint analysis study carried out in 2017 to model the factors affecting the illegal pedestrian crossings in Sri Lankan cities and suburbs. Pedestrian illegal crossing behaviour has been a huge concern in Sri Lankan cities and suburbs from the past few years in Sri Lanka. In addition to frequent delays to the vehicle stream illegal pedestrian crossings increases frequency of accidents. This study focused on pedestrian illegal crossings in Colombo, Pelmadulla and Openayaka so that the variations in the illegal pedestrian crossings between urban and semi urban area can be modelled. Five factors and levels for each factor were identified by doing two surveys for the questionnaire. Collected data were analysed using preliminary, conjoint and sensitivity analysis. Three different liner regression models were developed. Models were calibrated and validated by Pearson’s correlations and four profile holdout data. Identified that importance of the factors deviating from urban area to semi urban area. And also common model can’t use for three cities, due to significance changes of the models of each cities.

Keywords: Pedestrian, Illegal crossing, Accidents, Conjoint

1. INTRODUCTION

Traffic accidents involving pedestrians have become a major safety problem all over the world, particularly in developing countries, due to high population density, rapid urbanization, and lack of adherence to traffic regulations by both drivers and pedestrians Jain et al. (2014). Wickramasinghe and Priyankara (2011) identified that pedestrians follow illegal road crossing patterns creating life threats and disturbing the smooth traffic flow. Reviewed that physical and psychological characteristics affect for the illegally crossing the road.

Aim is to decrease the pedestrian traffic accidents and interruption to moving vehicles due to pedestrian illegal crossing behaviour. Identify the factors, levels for each factor are the first two objectives and finally identify the effects of factors in illegal pedestrians’ crossings.

2. METHODOLOGY

Proposed methodology consists of mainly six major part to achieve the three objective of this research figure 1 shows the step-by-step process. To identify the attributes and the levels two surveys were done. Conjoint questionnaires were prepared by using SPSS software. Data was collected and preliminary, sensitivity and conjoint analysis were performed. Then fit the model and Finally Linear Regression models were developed for each cities and common model also created.

2.1 Questionnaire and Data Collection

Attributes and levels were selected from the conducted survey and the literature. The factors and the levels are shown in the table 1. Orthogonal matrix reduction was performed to create twenty-two conjoint questionnaire profiles by considering these different levels and attributes show in table 1. A questionnaire consists eighteen design profiles and four holdout profiles. Colombo-215, Pelmadulla-105, Openayaka-65 altogether 385 sample were collected.

Table 1: Attributes and levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Road type</th>
<th>Traffic condit</th>
<th>Pedestrian walk c</th>
<th>Pedestrian availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>One lane</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;12</td>
</tr>
<tr>
<td>Level 2</td>
<td>Two lanes</td>
<td>10-20</td>
<td>10-20</td>
<td>12-40</td>
</tr>
<tr>
<td>Level 3</td>
<td>Four lanes with</td>
<td>&gt;20</td>
<td>&gt;20</td>
<td>&gt;40</td>
</tr>
</tbody>
</table>

Figure 1: Chevron list of methodology

3. RESULTS AND DISCUSSION

3.1 Average Importance

Figure 2 clearly shows importance of each factor for particular data set. From the graph can be conclude that
the road type, policeman availability and traffic condition
importance values are approximately equal for three
cities. That mean these three factors affect to illegally
cross the road from urban area to semi urban area are
merely same. Other two factors have significant
deviation from urban area to semi urban area.

![Figure 2: Attributes’ average importance](image)

3.2 Models
Multiple liner regression models were developed for three
cities as well as for the common data. Utility values and
model constants were shown in table 2.

<table>
<thead>
<tr>
<th>Table 2: Utility values for regression model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Road type</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Far to crossing</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Pedestrian walk crowd</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Common data model can be given as given in equation 1.

\[
U_{\text{estimation}} = \sum_{i=1}^{n} \sum_{j=1}^{n} U_{ij} - 0.395 \quad \ldots (1)
\]

But when comparing with the utility values given in the
table 2 and the value of the constant significantly
deviating from each city. So finally came across that one
model can’t be provided for the three cities. Hence the
model for Colombo, Pelmadulla and Openayaka cities are
given in equation 2, 3 and 4.

\[
U_{\text{estimation}} = \sum_{i=1}^{n} \sum_{j=1}^{n} U_{ij} - 0.467 \quad \ldots (2)
\]

\[
U_{\text{estimation}} = \sum_{i=1}^{n} \sum_{j=1}^{n} U_{ij} - 0.178 \quad \ldots (3)
\]

Therefore these three utility estimations models can be
used for the particular city. That mean model is changing
form urban area to semi urban area.

4. CONCLUSIONS
Lot of accidents and interruptions of the moving vehicles
on the road occur due to pedestrian illegal crossing
behaviour. There are many factors affecting for the
pedestrian illegal crossing behaviour, those factors need
to be identified to decrease the illegally crossing
behaviour of the pedestrians. Identified the five factors
and the levels for each factor. Then develop the
questionnaire and analyse the data using SPSS software.
Model is validated and calibrated using holdout cars and the
correlation values.

From the result can be identified that, according to the
areas there is a variance of the affecting of factors. Due to
that can’t have a common model for the three cities due
to variation of the utility values and the constant. Hence
each city has the particular model. When compare the
importance values of the results, finally conclude that the
factors which are road type, policeman availability and
traffic condition are affecting for these three cities are
approximately same. But far to zebra crossing and the
pedestrian walk crowd importance are significantly
varying with urban area to semi urban area.

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DEVELOPMENT OF DRIVING CYCLES FOR GALLE ROADS

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ABSTRACT

This presents the traffic related performance of B128 and B130 route in Galle, Sri Lanka using basic traffic engineering parameters. The driving pattern data was collected using on board measurement method by a constructed GPS tracking device. The cycle construction was done according to the segment based cycle construction method and roads were segmented considering the major intersections. Driving cycles were constructed in morning peak, noon peak, evening peak and off peak hours in B130 route and off peak hours in B128 route and the travel time, average speed, maximum speed, average acceleration and average deceleration were 840 s, 26.088 km/h, 44.85 km/h, 1.39 km/h², 1.22 km/h², 892 s, 22 km/h, 46.15 km/h, 0.88 km/h², 1.018 km/h², 830 s, 23.53 km/h, 40.47 km/h, 1.65 km/h², 0.69 km/h², 1072 s, 19.67 km/h, 44.25 km/h, 0.87 km/h² and 0.87 km/h² respectively.

Keywords: Driving cycle, Galle road, Cycle length, GPS tracking

1. INTRODUCTION

Driving cycle is a speed Vs time profile which represents the driving characteristics of a particular area. It developed to assess the vehicular performance through fuel consumption and pollutant emission and for traffic based analysis in different road ways (Lyons et al. 1986). So that the driving cycle development was rapidly increased recently (Galagamuwa et al, 2015)

2. METHODOLOGY

2.1 GPS Tracking Device

GPS tracking device consist of an Arduino UNO board, Neo 6M GPS sensor, External storage device, Chip writer and LED indicators to indicate data writing and satellite detection. It was powered using the lighter of the vehicles.

2.2 Cycle Stratification Factors

According to the availability of the resources, cycle stratification factors was selected as shown in Table 1.

Table 1: Cycle stratification factors

<table>
<thead>
<tr>
<th>Stratification Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route type</td>
<td>Urban, Sub urban</td>
</tr>
<tr>
<td>Vehicle type</td>
<td>Light duty</td>
</tr>
<tr>
<td>Time period</td>
<td>Morning peak (MP), noon peak (NP), evening peak (EP) and off peak (OP) hours</td>
</tr>
</tbody>
</table>

2.3 Data Collection

Data collection was done by on board measurement method by installing the GPS device inside the vehicle and allowed it to travel along the usual traffic conditions.

2.4 Route Selection

B130 route, from Hapugala junction to Galle and Galle to Karapitiya route Via B128 route was selected as the routes for cycle construction.

2.5 Cycle Construction

Segment based cycle construction method was used to constructed the driving cycle as the driving cycle was constructed to analyse the traffic related parameters. Segmentation of the routes were done according to the intersections using fusion tables and segments of Hapugala to Galle road are Hapugala junction to Kahaduwaththa junction (HK), Kahaduwaththa junction to Julgaha junction (KJ), Julgaha junction to Minuwangoda junction (JM) and Minuwangoda junction to Galle (MG). Segments of Galle to Karapitiya via B12 route are Galle to end of Main Street (GEMS), end of Main Street to Sarenthukade junction (EMSS), Sarenthukade junction to Beligaha junction (SB), Beligaha junction to Kahaduwaththa junction (BK) and Kahaduwaththa junction to Karapitiya (KK).

Then the time period base data separation was done. Actual trips made in each segment for each time period is presented in Table 2.

Table 2: Actual number of trip segments made in B130 road

<table>
<thead>
<tr>
<th>Segment and time</th>
<th>HK</th>
<th>KJ</th>
<th>JM</th>
<th>MG</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP</td>
<td>9</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>NP</td>
<td>7</td>
<td>7</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>EP</td>
<td>5</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>OP</td>
<td>18</td>
<td>22</td>
<td>16</td>
<td>11</td>
</tr>
</tbody>
</table>

Table 3: Number of trip segments made in B128 route

<table>
<thead>
<tr>
<th>Segment and time</th>
<th>GEMS</th>
<th>EMSS</th>
<th>SB</th>
<th>BK</th>
<th>KK</th>
</tr>
</thead>
<tbody>
<tr>
<td>OP</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td>9</td>
<td>5</td>
</tr>
</tbody>
</table>

2.5.1 Outlier Analysis

The total time taken to travel through each segment was taken to determine outliers. Upper bound was taken by adding 1.5 times inter quantile range to third quantile and the lower bound was taken by subtracting 1.5 times inter quantile range from first quantile. Values which do not
fall between upper and lower bound were considered as outliers.

2.6 Limitations
Data collection was limited only to four instruments as the construction cost of GPS tracking device is a higher. So that it was impossible to cover all the Galle routes. Manual data separation with the use of fusion table also limited the number of segments in constructing driving cycle.

3. RESULTS AND DISCUSSION
Driving cycles obtained at each peak hours in Hapugala to Galle and Galle to Karapitiya roads are shown in Figure 1, Figure 2, Figure 3, Figure 4 and Figure 5.

![Figure 1: Driving cycle for morning peak in B130 road](image)

![Figure 2: Driving cycle for evening peak in B130 road](image)

![Figure 3: Driving cycle for noon peak in B130 road](image)

![Figure 4: Driving cycle for off peak in B130 road](image)

According to Figure 1, total time taken to travel was 14 minutes. The average speed, maximum speed, average acceleration and average deceleration be 26.09 km/h, 44.85 km/h, 1.39 km/h² and 1.22 km/h² respectively. According to Figure 2, total time taken to travel was 15 minutes. The average speed, maximum speed, average acceleration and average deceleration be 22.00 km/h, 46.15 km/h, 0.88 km/h² and 1.08 km/h² respectively. According to Figure 3, total time taken to travel was 13.33 minutes. The average speed, maximum speed, average acceleration and average deceleration be 23.53 km/h, 40.47 km/h, 1.65 km/h² and 1.91 km/h² respectively. According to Figure 4, total time taken to travel was 18 minutes. The average speed, maximum speed, average acceleration and average deceleration be 27.53 km/h, 42.4 km/h, 0.69 km/h² and 0.69 km/h² respectively. According to Figure 5, total time taken to travel was 13.33 minutes. The average speed, maximum speed, average acceleration and average deceleration be 19.67 km/h, 44.25 km/h, 0.87 km/h² and 0.87 km/h² respectively.

Average speed implies the overall route condition while the maximum speed implies the optimum road conditions. These cycles represent the actual driving behavior of B128 and B130 routes and it can use to predict driving behaviors of similar or identical “B class” routes.

4. CONCLUSION
According to the results obtained for B130 road, maximum cycle length of 892 s was achieved in noon peak hours and minimum cycle length of 800 s was achieved in off peak hours. Maximum average speed of 27.53 km/h was recorded in off peak hours and maximum speed was 46.15 km/h. In B128 road cycle length, average speed, maximum speed, average acceleration and deceleration are 1072 s, 19.67 km/h, 44.25 km/h, 0.87 km/h² and 0.87 km/h².

REFERENCES
DRIVING CYCLE PATTERNS OF THREE WHEELERS IN GALLE

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ABSTRACT

Driving Cycles are extremely important in establishing compliance of emission control norms for vehicles. Internationally, it has been observed that there are considerable differences between the driving conditions of type approval cycles and those real world vehicle use. This lead to real world emission being higher than expected, and hence, failure of employed policies. The current study assesses the real world driving conditions in different cities and countries for different categories of vehicles. The driving cycles for different categories of vehicles such as cars, two wheeler, buses etc. are distinctly, different and not representative of the actual driving conditions. World harmonized cycles cover a wide range of speed and acceleration profile, and hence, they provide fewer opportunities to meet the standards only on the cycle while emitting much more in the real world.

Keywords: Driving cycle, GPS tracker devices, Chase car method, On board method, Cycle length

1. INTRODUCTION

There are two major ways of estimating emission inventories fuel consumption, namely, travel based models and fuel based models. There are many fuel based models around the world which are used to estimate fuel consumption and emission inventories such as traffic flow models and traffic emission models, instantaneous emission models, average speed emission models and using independent driving pattern factors. In general, these models use top to bottom approach, where, the results were measured first and then try to identify the causes for the results. The methodology, driving cycle, falls under travel based models and it’s been used to estimate fuel consumption and to develop emission inventories. The bottom-up approach is used to develop driving cycles, where prior to data collection, spatial and temporal characteristics of a region is identified. A driving pattern which influences exhaust emission and fuel consumption can be illustrated based on such data and the prime advantage of this travel based method of driving cycle development is the less capital requirement compared to many other available methods.

2. METHODOLOGY

Methodology for this research is used as below:

- Developing the GPS tracker device
- Collecting data
- Analyzing data
- Route selections
- Derive the driving cycle for the particular selected routes

2.1 Developing the GPS Tracker Device

GPS tracker device is made to determine the following parameters:

- Travel starting time
- GPS Co-ordinates at each and every 5 seconds
- Spot speed for each and every 5 seconds
- Average speed of the travel
- Maximum speed of travel

2.2 Collecting Data

Collecting data is done by using 5 Nos. of three wheelers those are parked at Galle city for two weeks’ time periods for each and every three wheel.

2.3 Analyzing of the Data and Route Selection

Data will be analyzed by using observed co-ordinates and the spot speeds at each and every 5sec periods of the time.

2.3.1 Rout Selection

In this research route selection is done by using the popularity of the road and the Main roads which is used by three wheel drivers in the Galle city area. Above selected road is divided to the road segments by using the travel time, Basic junctions in the road and the speed variations in the road of the three wheelers. After the selection of the route data set will be isolated base on the observed co-ordinates. Author is used manual method to select location’s co-ordinate by using the Google Maps. After that spot speed verses time will be draft for each and every single trip for the particular road segment.

Author is used time portion instead of the time. This time portion is consist 5s time period.
2.4 Derivation of the Driving Cycle for the Selected Routes
After observing of the single trip driving cycle average speed will be calculated based on the co-ordinates then average speed versus time is plotted for the whole road portion by considering the road segment average speed. Derived driving cycle for the Wakwella road from Galle city to Hapugala Engineering Faculty Junction is shown below.

3. RESULTS AND DISCUSSION
Under this research following driving cycles were derived for the three wheelers.

3.1 Driving Cycle for the Colombo Matara Road (A2) from Mahamodara Teaching Hospital to Dewata Junction
Derived Driving cycle for the A2 road segment is as follow.

3.2 Driving Cycle for the Wakwella-Galle Road from Galle city to Hapugala Engineering Faculty Junction
Derived driving cycle for the Wakwella road is as follow.

3.3 Driving cycle for the Julgaha Junction to Karapitiya Town

3.4 Driving Cycle for the Richmond Hill Road

4. CONCLUSIONS
Author is conduct this research to derive Driving cycle patterns of three wheelers in Galle area. Rather than that author like to obtain average speeds and cycle lengths for each and every roads explained in this research is as follow.

Table 1: Average speeds and cycle lengths

<table>
<thead>
<tr>
<th>Road</th>
<th>Average Speed (km/h)</th>
<th>Cycle Length (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colombo Matara Road (A2) from Mahamodara Teaching Hospital to Dewata Junction</td>
<td>12.2</td>
<td>985</td>
</tr>
<tr>
<td>Wakwella-Galle road from Galle city to Hapugala Engineering Faculty junction</td>
<td>11.8</td>
<td>2085</td>
</tr>
<tr>
<td>Julgaha junction to karapitiya town</td>
<td>13.9</td>
<td>525</td>
</tr>
<tr>
<td>Richmond Hill road</td>
<td>11.8</td>
<td>575</td>
</tr>
</tbody>
</table>

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ANALYZE THE INFLUENCING FACTORS FOR THE SELECTION OF TRANSPORTATION MODE FOR SCHOOL COMMUTING

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ABSTRACT
The traffic congestion during the starting and ending times of schools has become a regular experience mainly in most of urban areas in Sri Lanka. Prior to the implementation of mitigation measures, it is necessary to identify the governing factors and their influence to the mode selection decision. Accordingly, this study aims to address the factors affecting the decision of mode choice. The results of the descriptive analysis concludes that private own vehicles and privet school transportation are the popular mode choices of students for their school commuting. In addition, this study develops mode choice models for school commuting that can explain the relationship between travellers’ choices of transportation mode and factors effect to select mode choice for school commuting. The model output concludes that travelling distance is the most critical factor for select mode choice for school commuting. The finding of this study could be utilized to make policy decisions in order to mitigate the ad-hoc traffic congestion during school hours.

Key words: Mode choice, School commuting, Choice model

1. INTRODUCTION
In recent years, interest in the mode choice of students for school commuting has grown. Students have complex and unique travel behavior and they are not represented in most travel studies in Sri Lanka although they comprise important proportion of the traveling public. Understanding the travel behavior of students and particularly their reliance on the private vehicles for commuting, can help schools and other stakeholders work towards improvements to policies, programs, and infrastructure that encourage students’ use of public transport or non-motorized modes of travel (Shannon T., et al., 2006). This is critical especially in the context of urban areas since student travel directly affects the levels of congestion in adjacent streets with impacts on the well-being of students and employees, as well as that of residents and businesses in the school neighborhood.

Objectives of this study are to find popular mode choices for school commuting and to find the critical factors directly affect the decision of selecting particular mode. Revealing the factors affecting the mode choice decision would help to improve the areas which are currently demote the selection of public transportation modes.

2. METHODOLOGY
2.1 Survey
The survey conducted by distributing a printed questionnaire among school students in three leading public schools in galle namely Sangamiththa Collage (Girl), Mahinda Collage (Boys) & Hapugala Collage (mix).

2.2 Analysis
The preliminary analyses was conducted to summarize the key features and trends of the collected dataset. Descriptive analysis of the data identified the most popular modes based on different angles such as based on the gender, age groups and income levels.

This study developed a MNL models that are based on the probabilistic choice theory in which the individual is assumed to choose an alternative if it utility is greater than that of any other alternative (Algers S., 1993). In probabilistic choice theory, the utility function for the individual n to choose mode t includes two components: the deterministic or observable portions that represent the portion of utility observed by the analyst (Vn,t), and the error or the portion of the unobserved utility to the analyst (En,t).

Un,t = Vn,t + En,t (t = i, j, ..)

3. RESULTS AND DISCUSSION
3.1 Basic Analysis
According to the figure 1 more than 85% of students who used foot as their mode are in travelling distance below 1km to school. More than 70% of students who used hired vehicles or privet own transportation as their mode are in travelling distance below 5km.

According to figure 2 more than 90% of students who have travelling distance more than 40km are used public transportation or privet school transportation as their mode for school commuting and also more than 70% of students travelling distance category more than 20km are used privet school transportation and public transportation as their mode choice. From that we can...
and also from the data modelling it is conclude that travelling distance is the critical factor effect to select mode choice for school commuting in Sri Lanka. From that it may help to plan school transportation system in Sri Lanka as well as it may help to find a method to reduce traffic congestion in school time in urban areas of Sri Lanka as a future direction of this study.

REFERENCES


Table 1: Results of data modelling

<table>
<thead>
<tr>
<th>Mode Choice</th>
<th>Value of Maximum Coefficient for factor</th>
<th>Factor Which Have Maximum Coefficient</th>
<th>Significant Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hired Vehicles</td>
<td>0.432</td>
<td>Travelling distance</td>
<td>0.002</td>
</tr>
<tr>
<td>Privet own vehicles</td>
<td>0.439</td>
<td>Travelling distance</td>
<td>0.001</td>
</tr>
<tr>
<td>Privet school transportation</td>
<td>0.547</td>
<td>Travelling distance</td>
<td>0.000</td>
</tr>
<tr>
<td>Public school transportation</td>
<td>0.517</td>
<td>Travelling distance</td>
<td>0.000</td>
</tr>
<tr>
<td>Public transportation</td>
<td>0.512</td>
<td>Travelling distance</td>
<td>0.000</td>
</tr>
</tbody>
</table>

3.2 Data Modelling

This research utilized multinomial logistic regression, a specific type of discrete choice model, to determine factors that influence travel mode choice for school commuting. The results shows that for almost all models, distant from home to school has a greater influence on the decision of mode choice.

4. CONCLUSIONS

From the result obtained from descriptive analysis and discrete choice model we can conclude that privet own vehicles and privet school transportation are the most popular modes used for school commuting in Sri Lanka.
INVESTIGATE THE WAITING TIME OF PEDESTRIANS IN DIFFERENT CROSSES OF SRI LANKA

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ABSTRACT

Pedestrian safety still remains as an unsolved issue all over the world. They have unique need to ensure their safety. Pedestrians become holders of most fatalities and casualties occur in Sri Lanka. Pedestrian waiting time is an important in ensuring safety especially in signalized crossings. Accordingly, this study was taken part to investigate whether differences of waiting time exists in different crosswalks in Sri Lanka. Moreover, the study furthered to identify the factors that directly affects the waiting time of pedestrians. The data were collected through video observations and analyzed by using statistical methods such as t-test, regression model, mean and analysis of variance (ANOVA) and non-parametric tests. Waiting time shows increasing trend with the age. It is also observed that waiting time changes according to the gender and type of crosswalks. Traffic flow shows different patterns to the different crosswalks and requires more structured further studies in depth. Hence, these strong patterns will hopefully aid in the understanding of pedestrian behavior in Sri Lanka in order to plan and design the crossing facilities.

Keywords: Pedestrian behavior, Different crosswalks, Pedestrian characteristics, Waiting time, T-Test, Sri Lanka

1. INTRODUCTION

Pedestrians are the most vulnerable road users as they are more exposed to risk than other road users. Pedestrian safety at road intersections still remains as unresolved and important issue. Traffic accidents involving pedestrians have become a major issue all over the world, especially in developing countries, due to lack of adherence to traffic regulations by both drivers and pedestrians.

Many researches have tried to detect factors influencing pedestrian behavior. Author Hamed (2001) considered some factors which are influence the pedestrian’s decision to cross the roadway, here author considered factors relating to physical environment (road width and existence of a central refuge at the crossing), road user variables (gender, age and marital status) and the number of pedestrians in the group. Pedestrian delay (waiting time) is an important variable to study through all above-mentioned factors because pedestrians habitually become impatient while waiting to cross the street (Guo et al.,2012). Waiting time of pedestrian’s plays an important role in safety.

2. METHODOLOGY

In order to collect the data to the study Galle, Kalutara, Colombo districts which have reasonable road users were selected. Main reason to choose different places to represent Sri Lanka through the study and to get different crosswalks. Such as crosswalk with median and without median (two lanes and four lanes). Two locations were selected for each type of crosswalk to present most reliable value to the study. Approximately same geometry and traffic related characteristics were considered to select locations in order to get high accuracy results.

Videos were recorded from the selected six locations to capture the pedestrian behaviours. They were extracted in to frames by using “KMP Player” frame extraction tool. Here waiting time was concerned by the time between the arrival and to departure in the waiting area of pedestrian. Gender recordings were clear with few examples of physical characteristics. But age recordings were strongly based on physical appearance of pedestrians because no any possible way to collect those data from questionnaire. According to Rhodes (2009) studies, facial characteristics has been shown to be an accurate measure. Other than both spatial and surface cues were used to estimate the age group.

Initially all waiting time related to their crosswalk were compared together and analysed using Descriptive statistics by using the analytical IBM SPSS statistics. T-Test, ANOVA, Regression models and Non-parametric tests were used to analyse further.

3. RESULTS AND DISCUSSION

3.1 Descriptive Statistics

There were 589 pedestrians observed and recorded from all six locations. There were 328 male pedestrians (55.69%) and 261 female pedestrians (44.31%) were observed when crossing the road. The average waiting time was 5.6 s, age group estimation was middle age and average traffic flow was 887 vehicles per hour per lane. Waiting time follows an exponential decay curve as expected (Fig:1).
In order to perform the desired analysis, pedestrian sample was separated and arranged by characteristics of crosswalks, gender, age group and traffic flow. Initially it was done to compare the waiting time of pedestrians with respect to the type of crosswalks. Three types of crosswalks were used for the study such as two lanes crosswalk, four lanes crosswalks without median and four lanes cross walk with median. To compare the waiting time of three types of crosswalks, ANOVA was conducted (n=0.05). The results reveal that the waiting time of three types of crosswalks were significantly different between the types.

### 3.2 Gender
Waiting time was analyzed respect to gender. Male pedestrians and female pedestrians waiting time were compared through Boxplot method and the average waiting time was found as 3.35 s and 4.9 s respectively to male and female, which is 46.3% greater than the male pedestrian. Based on 0.154 significance of the Levene’s Test, two waiting time sample was assumed to be statically equal variances and using independent sample t-tests (Table 1), it shows that two waiting time samples were statistically different to one another in terms of waiting time.

Females always look certain amount of safeness before crossing the road compare with males (Hameed, 2001). So, it takes the reason to the higher waiting time and less number in to break traffics to cross the road.

### 3.3 Age Group
Statistically significant relationship was observed between waiting time and age group through Kruskal-Wallis non-parametric test (p<0.05). Test consisted 88 pedestrians of young group, 322 pedestrians of middle age group and 179 of old pedestrian group. Boxplot was used to illustrate the result, Result shows that waiting time was increased with age. Old age group were more conservative in their crossing behaviors than their youngsters by waiting longer to cross road. However, there were some higher values also obtained in middle age group. Because, sometime middle age group dominated in their children’s or elders’ behaviour when the pairs crossing the road. Middle age group pedestrians have different psychological activities. Firstly, they needed to take care of their pairs. So, they were looking carefully the traffic condition prior to crossing the road. Until they find safe, they didn’t cross the road (Li et al, 2013).

### 3.3 Traffic Flow
Traffic flow was checked in relation to the waiting time respect to type of crosswalk. Quadratic regression was used to carried out the test. All three type crosswalks weren’t shown significant relation with waiting time (p>0.05). each crosswalk showed different characteristics on waiting time in relation to the traffic flow. Therefore, it need to be investigate further.

### 4. CONCLUSIONS
Pedestrians are most vulnerable road users of the transport system. Special care should be taken to understand their behaviors and specific needs. Waiting time in relation to the gender, age group and type of cross walk showed significant relations. Pedestrians showed various behavior on waiting time in related to traffic flow. So, it is need to be analyse further for better understanding. Among the factors that were considered in the study, different type of crosswalk influenced more than other factors to contribute the pedestrian behaviour on waiting time.

### REFERENCES


INVESTIGATE THE CROSSING SPEED OF PEDESTRIANS IN DIFFERENT CROSWALKS OF SRILANKA

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ABSTRACT

Pedestrians are vulnerable to traffic accidents in an unsafe traffic environment and therefore, it is important to study on the areas that could improve pedestrian safety. Identifying the behaviour of crossing speed would be important for future safety measures as well as for the design considerations such as signal timing. The 15th percentile crossing speed is the standard design parameter, which used to determine the pedestrian crossing time. However, present signal design concepts use standard speed for all types of crosswalks. Accordingly, this study aims to investigate whether significant differences could be observed in different types of crosswalks. The data were collected using video recordings and the analysis revealed that the age, gender and five-minute traffic flow consist significant effect on crossing speed. The speed distributions, compared by Mann-Whitney U test, did not indicate an interrelation with each other. Mean crossing speed of pedestrian varied from 1.1363 m/s to 1.4469 m/s. The 15th percentile crossing speed was between 0.9700 m/s and 1.22 m/s in five crosswalks. It is also noticed in the data that males demonstrate higher crossing speed compared to females while the crossing speed shows increasing trend with traffic flow.

Keywords: Pedestrian, Crossing speed, Crosswalk type, 15th percentile crossing speed, Traffic signal design

1. INTRODUCTION

The safety and the convenience of pedestrian has become the most critical parameters in designing. Therefore, pedestrian studies are frequently carried out to ensure pedestrian safety by updating existing design values. Pedestrian Crossing Speed is an important design parameter in traffic signal design and use 15th percentile speed as standard value for design (Rengarasu, et al., 2013). Crossing speed is affected by several factors that can be categorized as pedestrian related, traffic condition, site condition and environmental related factors (Knoblaugh, et al., 1996).

The Manual on Uniform Traffic Control Devices for Streets and Highways, propose a crossing speed of 1.2 m/s as a common designing crossing speed (Highway, 2009). However that might be varied with the type of crosswalk and hence, this research focus on investigating the crossing speed of geometrically different crosswalks in view of identifying differences.

2. METHODOLOGY

The proposed methodology of the research is shown in figure 1. Crosswalk types available in road network was identified from the literature review and practical observation. Five crosswalk types located at Galle, Mathara and Kaluthara districts were selected for the study. The Pilot survey was conducted to identify the problem and difficulties that have to be faced during the data collection and analysis.

3. RESULTS AND DISCUSSION

The descriptive analysis of the results were determined the mean and 15th percentile crossing speed in five crosswalks.

Figure 1 : Proposed methodology

In the data collection pedestrian crossing, events were recorded by an invisibly placed HD camera near by the crosswalk. Crosswalk width, time of data collection, crosswalk type and other details was noted down as the manual data collection.

The data extraction process was done by using adobe premiere video editing software. The Accuracy of the time measurement was 0.04s in this process. The analysis process for the extracted data were done by using IBM SPSS Statistic software. Outliers of the data were eliminate by using box plots. The data set was subjected to normality tests and Mann-Whitney U test to compare distribution. Descriptive analysis was conducted based on age, gender and traffic flow on five crosswalks.
Table 1: Mean and 15th percentile crossing speed in five crosswalks

<table>
<thead>
<tr>
<th>Crosswalk Type</th>
<th>Mean crossing speed</th>
<th>Standard deviation</th>
<th>15th percentile speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>1.1363</td>
<td>0.1713</td>
<td>0.97</td>
</tr>
<tr>
<td>02</td>
<td>1.2818</td>
<td>0.1153</td>
<td>1.17</td>
</tr>
<tr>
<td>03</td>
<td>1.2935</td>
<td>0.1706</td>
<td>1.13</td>
</tr>
<tr>
<td>04</td>
<td>1.4085</td>
<td>0.1975</td>
<td>1.22</td>
</tr>
<tr>
<td>05</td>
<td>1.4469</td>
<td>0.2256</td>
<td>1.21</td>
</tr>
</tbody>
</table>

Figure 2: Variation of mean crossing speed

3.1 Distribution Comparison

The normality was evaluated by using K-S test and Shapiro-Wilk test. The non-parametric approach was selected to compare distribution. According to Mann-Whitney U test results speed distributions were not performed relationship between each in five crosswalks. Hence, it is unfairness to use same design value for every crosswalk types

3.1 Effect of Age, Gender and Traffic Flow

Effect of these factors were determined by descriptive analysis. Mean crossing speed under age influence is increased gradually from crosswalk type 01 to crosswalk type 05. The lowest mean speed is performed by older pedestrian. As a whole, the old pedestrian mean crossing speed was 1.1394 m/s, Middle age pedestrian was 1.2695 m/s and younger pedestrian mean crossing speed was 1.3394 m/s.

According to the gender analysis results, female pedestrian shows the slower crossing speed than male pedestrian in every crosswalks does. Therefore, it seems that female pedestrian are waiting more time than males until clear and safe gap is occurred. Mean crossing speed in all age categories are lower in female pedestrian.

The mean crossing speed does not reasonable output with the traffic flow. According to analysis traffic speed are greater in multi-lane crosswalk. The mean crossing speed is also higher in in multi-lane crosswalk. According to that point, we can say that the crossing speed of the pedestrian is trend to higher when the traffic flow is greater.

Figure 3: Mean crossing speed variation with age

Figure 4: Mean crossing speed variation with gender

4. CONCLUSIONS

The speed distributions, which are compared by Mann-Whitney U test, did not indicate an interrelation with each other. Mean crossing speed of pedestrian varied from 1.1363 m/s to 1.4469 m/s. The 15th percentile crossing speed was between 0.9700 m/s and 1.22 m/s in five crosswalks. The males cross the road faster than the females. The Crossing speed is trend to greater in higher traffic flow.

REFERENCES


THE EFFECT OF DIFFERENT ATTRIBUTES IN PUBLIC BUS TRANSPORT FOR USERS IN DIFFERENT AGE GROUPS

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ABSTRACT

Traffic congestion, as a result of urbanization, is becoming a tempting issue in Sri Lanka triggering many other economic, environmental and social issues. Reducing the extensive use of private modes and improve public transportation as a mass and shared transportation mode would be a feasible solution in this regard. However, prior to the investments on developing public transportation, it is important to understand the attributes and their effect on users on the decision of selecting public transportation modes. Accordingly, this study focus on understanding the levels of satisfaction of commuters in different age groups on existing Private Bus Transport (PBT) system. Data were collected in the form of a questionnaire survey distributed in Galle municipal area. Collected data were analyzed using preliminary, conjoint and sensitivity analysis. Five different linear regression models were developed for commuters’ satisfaction by considering waiting time, late time, staff behavior and crowdedness as attributes with different levels. The created models were calibrated and validated by Pearson’s correlations and three profile holdout data. Attributes importance were deviated according to the age classification. It is concluded that crowdedness of the bus has high level of importance value in overall preferences while waiting time and expected delay are among the prior concerns of nineteen to thirty years age group in selecting private buses to fulfill their commuting requirements.

Keywords: Bus, Transportation, Age, Comfort

1. INTRODUCTION

With the recent developments, traffic congestion has become a prior concern in almost all urbanized city centers in Sri Lanka. Extensive use of private transportation modes such as motor cars is generally identified as one main reason for the urban gridlocks especially in morning and evening commuting hours. Implementing policy decisions and investment on the development of a public bus network would assist in solving the above issue to a greater extent. However, at the same time, it is necessary to identify the drawbacks and levels of user attractions on existing public bus system which is currently operated by a state owned transportation body and private service providers.

Accordingly, this research aims to identify the effects of commuter’s age in selecting public bus transportation as a mode of travelling and how it could be vary when considering with other attributes as a whole.

2. METHODOLOGY

This research used the conjoint analysis method to investigate the effect of commuter’s age. The proposed methodology consist of mainly five major parts as show in figure 1. At the beginning, attributes and its levels as well as the age classifications was selected. Conjoint questionnaires were prepared by using SPSS software. Data was collected about the customers’ satisfaction on using public bus transportation. Preliminary, sensitivity and conjoint analysis were performed. Finally Linear Regression models were developed for four different age groups and overall commuters.

Figure 1: Chevron list of methodology

2.1 Questionnaire and Data Collection

Attributes and levels were selected according to the previous conducted research. Orthogonal matrix reduction was performed to create twelve conjoint questionnaire profiles by considering these different levels and attributes show in table 1. A questionnaire consists nine design profile and three holdout profile 281 sample were collected among different age groups of commuters under the Galle municipal council region.
Table 1: Attributes and levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Waiting time</td>
</tr>
<tr>
<td>Level 1</td>
<td>10 min</td>
</tr>
<tr>
<td>Level 2</td>
<td>20 min</td>
</tr>
<tr>
<td>Level 3</td>
<td>30 min</td>
</tr>
</tbody>
</table>

3. RESULTS AND DISCUSSION

3.1 Average Importance

Figure 2 clearly shows importance variation according to the age classification of commuters. When consider the less than eighteen years old commuters’ travelling preference is mainly depended on crowdedness at the same time they do not worry about the staff behavior. Time delay and the waiting time for a bus have significant impact on 19-30 age group of commuters. Approximately all the attributes have equal significant importance in 31-50 age group of commuters. The most elderly commuters consider the crowdedness of buses more significantly.

3.2 Model

Multiple liner regression models were developed for four age commuters’ age groups and overall commuters. Liner constants, utility values and model constants were shown in table 2. Crowdedness and staff behavior are considers as discrete variable therefore utility values were used as model constants at the same time waiting and time delay were considered as liner variables therefore liner constants were used as model constant for particular selected as dependent variable. Here commuters’ satisfaction is selected as dependent variable.

Table 3: Sensitive slope per level

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Sensitive pre level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crowded</td>
<td>-0.781 per level</td>
</tr>
<tr>
<td>Staff behavior</td>
<td>-0.706 per level</td>
</tr>
<tr>
<td>Waiting time</td>
<td>-0.54 per 10 min</td>
</tr>
<tr>
<td>Late time</td>
<td>-0.52 per 10 min</td>
</tr>
</tbody>
</table>

3.3 Sensitive Values

Crowdedness of the bus is highly sensitive to judge the satisfaction according to the sensitivity analysis. Waiting time and late time have lower level sensitive compare with crowdedness and staff behavior. The relevant sensitive values for attributes are shown in table 3.

Table 4: Sensitive slope per level

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Sensitive slope per level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crowded</td>
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<td>-0.54 per 10 min</td>
</tr>
<tr>
<td>Late time</td>
<td>-0.52 per 10 min</td>
</tr>
</tbody>
</table>

4. CONCLUSIONS

The main purpose of the research is to identify the effects of age in selecting PBT as a mode of travelling by considering different attributes. The created liner regression modals for each age groups of commuters, show the commuter’s age is a significant factor in selecting PBT for their travel needs.

This study found that importance of attributes vary according to the age classification.19 to 30 age group of commuters give maximum priority for time because generally working people and advance level students are fallen into this category. Crowdedness of the bus has leading importance and overall high sensitive values in overall commuters’ preferences. According to surveyed data half of the participants are women and usually women don’t like to step into a crowded bus it may be a valid reason for higher importance of crowdedness. 52.3 percentage of importance has been given by very older commuters for crowdedness because they don’t have enough medical fitness and strength to stand therefore most of them expect enough sets and crowded free buses.

According to this study by providing non crowded bus with proper seating arrangements will significantly increase the overall commuter’s satisfaction it may be a key to improve the quality of existing PBT.

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