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Pedestrian Safety Analysis at School Zones

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Abstract - *Walking is one of the active transport modes with many public health benefits and precedes all other transportation modes. It helps with reducing greenhouse gas emissions, which is responsible for global warming, climate change, and poor air quality. Walking can also help relieve traffic related congestion problems. With a rise of motor vehicles, separation of pedestrian path from vehicle seemed to be inevitable in order to provide pedestrians safety. The goal of organising transportation is to ensure the safety of road users. Safety can be measured by comparing the accident rates. Road traffic accidents are sometimes associated with the pedestrians. Therefore, the research in the safety of educational spaces for children aims to analyse the potential dangers during pedestrian activities and to promote safety standards so as to create a safe and healthy outdoor environment for our children. The safety of vulnerable road users such as pedestrians is a critical issue. School zones are typically high pedestrian areas, particularly with children and young people walking in groups or individually without adult supervision. These groups of pedestrians might exhibit unpredictable behaviour and take more risks when walking or crossing the road. The relationship between the school infrastructure, the sidewalks and the pedestrian crossings determine the comfort and safety level of pedestrian in school zones. The safety evaluation of school zones will be done by assessing the condition of the pedestrian infrastructure and analyzing pedestrian behaviour. Also the percentage of pedestrian crashes that occurs at school zone will be calculated. A model related to pedestrian safety will be developed.*

Key Words: Pedestiran, Vulnerable road user, School zone, Safety, Pedestrian behaviour

1. INTRODUCTION

Walking is an important mode of transportation. The safety of vulnerable road users such as pedestrians is a critical issue. Understanding pedestrians road-crossing decisions is an important traffic safety issue, especially for those countries, where populations are rapidly aging. Safety of pedestrians becomes more questionable in uncontrolled midblock sections. The risk to pedestrians becomes high because of the least priority given by the vehicle drivers to yield for the pedestrians. As per the data of Ministry of Road Transport and Highways in India, there were pedestrians killed in 8.7% of total traffic accidents. Globally, pedestrians constitute 22% of all road deaths, and in some countries this proportion could be as high as two third. Past studies analysed pedestrian movements in walkways, sidewalks, movements under unidirectional or bidirectional pedestrian flows or under mixed traffic conditions. In India, little attention has been devoted to study pedestrian behaviour and the risks involved, or model them for their use in integrated design of urban areas with consideration to walking as a mode of movement. In research studies on pedestrian safety, pedestrian behaviour is very often considered in terms of the degree to which pedestrians obey rules, that is, whether the pedestrian cross the road in accordance with road safety regulations or not. Among pedestrians students causes more unsafe behaviour and this will leads to crashes. Due to this a project based on pedestrian safety analysis at school zones is necessary to ensure safety of school students. School zones are typically high pedestrian areas, particularly with children and young people walking in groups or individually without adult supervision.

1.1 Objectives

i. Before To evaluate the safety of pedestrian in school zone by comparing the pedestrian crossing behaviour and safety of LP, UP, HS and HSS
ii. To develop a model based on pedestrian safety index

1.2 Scope of the Work

Analyzing pedestrian crossing behaviour and safety at school zones and to provide valuable insights for improving pedestrian safety at school zones.

2. METHODOLOGY

Several researches were carried out on the basis of pedestrian safety analysis. Many researchers have verified that one of the parameters that most influence the pedestrian safety is pedestrian crossing behaviour. By referring different journals information required for the successful execution of the project was gathered. About eighteen journals were referred in order to get a general concept of our study. It mainly helps to know what all data that needs to collect to reach at the ultimate aim. It also helps to know about various analysis procedures that can be used. The general behaviour of students were

identified and it helps to know how a parameter can be selected for modeling.

After the successful completion of the literature review, the next step was to moved on to the details of the different methods adopted for the completion of the project.

2.1 Identification of Schools

Schools were selected according to type of adjacent road. Seven schools were selected for the study out of which three schools were from Alappuzha district and four schools were from Pathanamthitta district. The selected schools were highly populated and having lower primary, upper primary, high school and higher secondary sections. The adjacent road of the selected school were State Highway (SH-6). The selected study area is Thiruvalla to Kayamkulam route which is under SH-6 and is about 28 km.

2.2 Pilot Study

A pilot study was conducted for identifying study stretch and school zones which required pedestrian safety analysis. School timings for each schools also find out by conducting pilot study.

2.3 Videographic Survey

Videographic survey were mainly done for evaluating pedestrian crossing behaviour at the school zones. From the videographic survey we can find the crossing speed, waiting time before crossing, walking time, unsafe behaviour across the road etc of the students. Videographic survey were done for lower primary, upper primary, high school and higher secondary sections.

2.4 Questionnaire Survey

Questionnaire survey is to understand the crossing behaviour of pedestrians and their safety in various traffic conditions. Questionnaire survey were done for lower primary, upper primary, high school and higher secondary sections. We can not do questionnaire survey directly to lower primary sections. So that, for lower primary sections questionnaire survey were done to their parents.

2.5 Accident Data Collection

Accident data was collected from four police stations that are Mannar, Mavelikkara, Pulikeezhu and Thiruvalla police station. Accident data collection was mainly focused on pedestrian crash data.

2.6 Data Analysis

Data analysis were done by evaluating the safety of pedestrian in school zone by comparing the pedestrian crossing behaviour and safety of LP, UP, HS and HSS. Analytical software IBM SPSS statistics will be used in the analysis.

2.7 Model Development

A model were developed based on pedestrian safety index. A multiple linear regression model were developed to find pedestrian safety index. The developed PSSI model can enable engineers and planners to evaluate safety at existing crossings at unprotected mid-blocks.

3. ACCIDENT DATA ANALYSIS

Bar chart diagrams are prepared using the accident data collected form police stations.

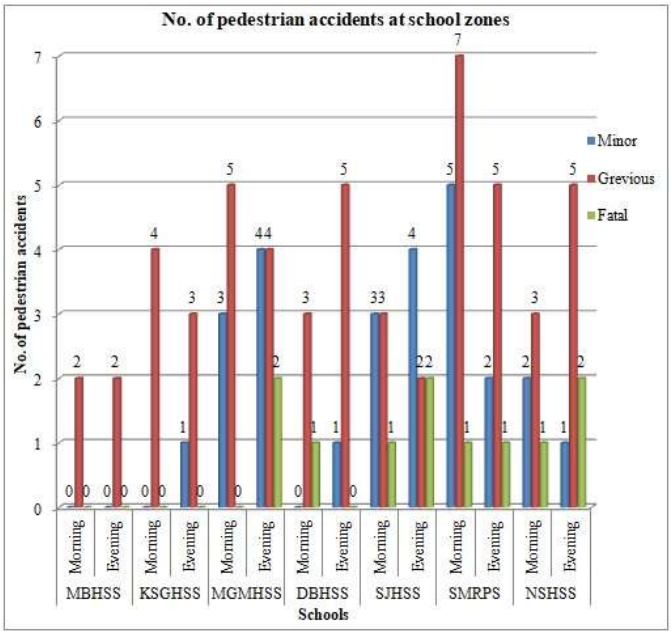

Chart -1: Relationship between no. of pedestrian accidents at school zones

It was found that number of pedestrian accidents at school zones are more especially in evening period. So it is very necessary to analyse pedestrian safety at school zones.

4. ANALYSIS OF QUESTIONNAIRE

A total of 880 individuals responded to the questionnaire survey. Male constituted a portion of 51.02% and female constituted a portion of 48.98% of the total gender. The average age of the respondents is 13 years. In the questionnaire survey, 8 multiple choice questions were asked.

From the questionnaire analysis, the attitude of people in terms of unauthorized crossing on midblocks where proper facilities are not provided for crossing are analysed. From the responses, it was observed that the accidents occurred for pedestrians were found out to be non-severe condition. The responses indicating the alertness behaviour when crossing alone and as a group respectively. This shows that most of the students were less alert condition while crossing as a group than individually. When it was asked about the factor which decided the pedestrians to cross the road, 41.25% for distance of approaching vehicle, 24.77% respondents opted for speed of the approaching vehicle, 18.18% for vehicle type, and 12.95% for presence of other pedestrians. Sometimes 48.18% of students have confusion while judging the gap. 35.68% of students have major accidental situation, 36.93% of students never faced any accidental situation 17.27% of students have once or twice some minor accidents and 10.12% of students was about to collide but saved while crossing. For the factors creating unsafe crossing and 43.06% of students opted no signal and markings, 47.61% opted less priority given by drivers for pedestrians and 9.33% of students opted blocking vision during crossing due to improper location of bus stop as the factor creating unsafe crossing. For the preference of crossing location and 39.54% of students prefer where traffic signals or policemen are present, 31.81% of students prefer zebra crossings, 26.25% of students will cross anywhere randomly and 2.4% of students prefer to use foot over bridge or subways.

To understand the perceptions of pedestrians on safety and crossing behaviour, questionnaire survey was conducted on lower primary, upper primary, high school and higher secondary section of all seven schools. The factors affecting pedestrians to make decisions to accept the gap, perceptions of safety, preference of crossing etc. are included in the questionnaire. A comparative study were done among lower primary, upper primary, high school and higher secondary section for all questions. A total of 880 pedestrians participated in the questionnaire survey. Pedestrians were asked about the safety level while crossing the crosswalk. Most of the pedestrians reported that they are very alert when they cross the crosswalk alone. That means pedestrians claimed that they felt risky and it shows that the high-level improvement is required to improve pedestrian safety.

5. ANALYSIS OF VIDEOGRAPHIC SURVEY

The required data for statistics and model development were extracted from collected video by manually. One camera were used and a total of 3477 pedestrian details were extracted. The required data were extracted from seven schools and all the required parameters were extracted.

Based on earlier studies and field observations, several possible factors influencing pedestrian safety at midblock were identified for Indian conditions. The recorded video provided information about pedestrian crossing volumes, crossing time, crosswalk length, crossing behaviours (such as walking or running, alone or in groups and walking speed), pedestrian characteristics (like gender and age group) and pedestrian-vehicle interaction.

A total of 3477 pedestrians were clearly observed from recorded video and detailed information on pedestrian crossing behaviour was obtained. The statistics from the observed data shows that the proportion of male pedestrian is higher than female pedestrian during peak hours among children. The data indicate that pedestrians are interested to walk while using the crosswalk rather than running, with 89% of pedestrians crossing the crosswalks at various crossing speeds ranging from 1.2 to 1.4 m/s. The average pedestrian crossing speed is found to be 1.36 m/s. Only 61.28% of pedestrians have been found to utilize the crosswalk during peak hours. The survey findings from the data collected for different pedestrians were analyzed.

6. MODEL DEVELOPMENT

The model were developed using multiple linear regression method. For that the assistance of SPSS software and Microsoft excel was taken. Multiple linear regression analysis helps to predict the value of a variable based on the value of two or more other variables. The variable to be predicted is called dependent variable. In this study WSI rating was considered as dependent variable and data obtained from videographic data as independent variables. Some of the key features of regression analysis is that it can use unlimited number of independent variables for a single dependent variable. It is the best analysis for predicting the future demand and optimization of the obtained sample. Data of about 3477 students was collected. Several trails were performed and the most significant one is only presented. For the better models several conditions were adopted in the analysis:

a) There should not be multi collinearity between the independent variables
b) The coefficient of determination (R^2) must be significant
c) The t statistic value should be significant. It must have a value of at least '2' for significance to be established.
The linear regression model can determine the relative influence of one or more predictor variables to the criterion value and able to identify outliers based on correlation statistic value. Therefore, multiple linear regression techniques were adopted to decide if a multiple linear relationship might occur that can calculate the mean rating obtained from accident data. Five years accident data (secondary data) were analyzed to obtain the

accidents in the selected school zones using WSI method by assigning scores based on the number and severity of accidents at that particular location in the last 5 years. WSI for each school zones are represented in Chart-2. Weighted Severity Index (WSI),

$$WSI = 41 \times K + 4 \times GI + 1 \times MI \quad \text{..... (1)}$$

Where, K is the number of persons killed; GI is the number of grievous injuries; and MI is the number of minor injuries.

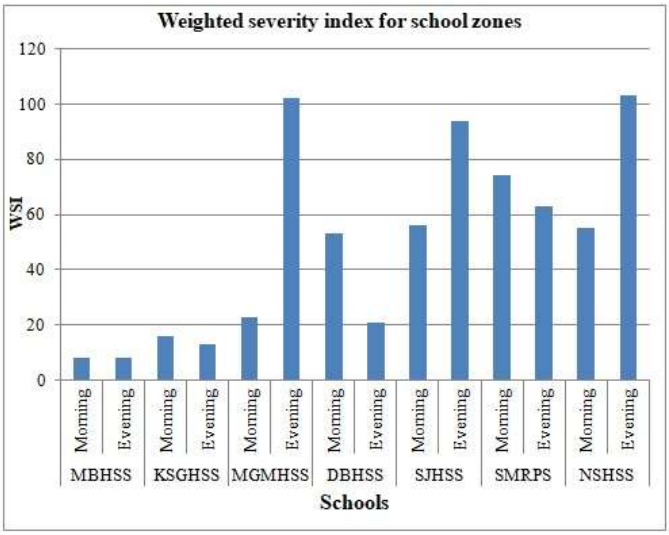

Chart -2: Weighted severity index for school zones

Table -1: Rating for WSI

Classification on WSI	Description	Rating
0-4	Highly Safe	1
4-10	Safe	2
10-41	Average	3
41-100	Risk	4
Greater than 100	High Risk	5

The WSI rating was considered as dependent variable and the variables obtained from the Pearson correlation test was selected as independent variables for model development. The primary structure of the safety index model is expressed in the following mathematical expression,

$$PSSI = 0.501 + 0.243T + 0.061CL + 0.002WT + 0.01UB - 0.028R - 0.073I + 0.125PC + 0.004PV + 0.001TV \quad \text{.....(3)}$$

where PSSI = pedestrian safety index score through WSI of accidents (rating 1–5)

T = timing (morning/evening)
CL = crossing length in m
WT = waiting time in sec
UB= unsafe behaviour
R= rolling pattern of movement
I= Interruption with vehicle
PC= presence of crossing marking
PV= pedestrian volume
TV= traffic volume

The stepwise regression technique was performed in SPSS 25.0 software at 95% confidence interval. The adjusted R^2 value for the proposed model is 0.951 which specifies that 95.1% of the variation in the predicted dependent variable has been explained by the explanatory variables and this denotes the moderate accuracy level of the proposed model prediction. The calculated t values are greater than the critical value (± 2.326) and the p values are less than the p critical value (0.05). This represents that the model variables are significant at 95% confidence interval.

6.1 Model Validation

The pedestrian safety model was validated using total 1059 data points from unprotected mid-block crosswalk location which were pooled out due to significant difference in PSSI values. Based on the model results, significant variables were collected from the selected location for the model validation, the predicted values were calculated by substituting the values of variables in the obtained model and comparing with the observed values. From the developed model, the root mean square error is 0.076 and this indicates that the difference between the observed mean value (3.987) and predicated mean value (4.195) is less. Further, the graph was plotted between observed and predicted PSSI values a valid R^2 value has been found as 0.951 and is shown in Chart-3.

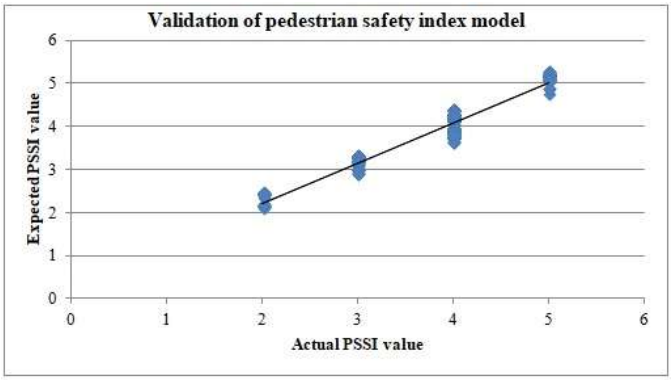

Chart -3: Validation of pedestrian safety index model

The results proved that the developed MLR model has better prediction capabilities for estimating the pedestrian safety score index for the pedestrian road crossing behaviour at uncontrolled midblock crosswalk section in school zones. By using pedestrian safety score index & safety index model, the safety level rating is coded as given in the below Table-2.

Table -2: Details of safety level rating

PSSI Rating	Descriptions (Midblock)
1	Highly safe
2	Safe
3	Average
4	Risk
5	High risk/Less safe

6.2 Application of Model

We can find PSSI value of each school and from that we can identify the factors which influence the pedestrian safety. According to that we can suggest remedial measures to improve safety. Each schools and its corresponding PSSI value is shown in Table 8.7. From the Table 8.7 shown below, five schools are in risk and one school is in highly risk condition. Therefore we can say that most of the schools are in risk ie., they are not safe. So we have to provide some methods to improve pedestrian safety.

Table -3: Schools and its PSSI

School Name	PSSI	Descriptions
DBHSS	3.5	Risk
KSGHSS	3.7	Risk
SJHSS	4.2	Risk
MHSS	2.5	Average
SMRPS	4.1	Risk
MGMHSS	4.3	Risk
NSHSS	4.7	Highly risk

The main reasons for risk condition in this study area are:

- High traffic volume
- High pedestrian volume
- Pedestrian interruptions with vehicle

So we have to adopt some surrogative measures to improve the pedestrian safety of these school zones.

7. MEASURES FOR THE PEDESTRIAN SAFETY

The main reasons for risk condition in this study area are high traffic volume, high pedestrian volume and pedestrian interruptions with vehicle. So in this area safe segregation of pedestrian and vehicle is required for improving safety. Some measures to improve the pedestrian safety of these school zones are given below.

7.1 Pedestrian Traffic Signal

Presence of pedestrian traffic signal ensure safe way for pedestrian crossing where high traffic volume is presented. A midblock crossing creates a safer, more visible and more direct route without requiring the pedestrian to walk to the nearest intersection or cross at a random and sometimes dangerous location. Midblock crossings are also often placed where there is heavy pedestrian traffic near major destinations, such as schools, shopping centers, or transit stops. Crossing in mid-block creates a dangerous situation for both pedestrians and drivers. Pedestrians may put themselves in danger if they misjudge the speed of approaching vehicles and the time it takes to safely cross the street; drivers may be startled and confused by the pedestrian crossing the street, causing a driver to slam on the brakes.

According to the Federal Highway Administration (FHWA), traffic signals at midblock crossings are helpful or essential under the following conditions:

- In school zones
- On higher volume roadways
- Where gaps are infrequent
- Where elderly or disabled pedestrians cross
- Where speeds are high

My study area is school zones near midblock sections. So we can adopt pedestrian traffic signal as an efficient method to improve the pedestrian safety at school zones near midblock sections.

7.2 Footover Bridge

Usually the footbridge is constructed across the road with higher volume of traffic and pedestrians crossing the road. Presence of Footover Bridge can segregate pedestrians from vehicles. So their is no chance for colliding vehicles with pedestrians. It will ensure high level of pedestrian safety. Pedestrian bridge is a facility for pedestrian crossing the road. They provide security during the crossing to pedestrian. Besides that, it is high cost and requires extensive time to implement. If steel footover bridges are provided. It will be economical. Pedestrians tend to choose the quickest way to reach the destination. As factors to be fast, then their personal safety is often ignored. We often hear is complaints about the behavior of the driver of this pedestrian. This is because many pedestrians ignore traffic conditions when they want to pass that will interfere with other road users. Therefore, facilities for pedestrians are very important. The best method is to provide a pedestrian bridge.

7.3 Zebra Crossing

First of all we have to maintain the existing facilities for pedestrian safety like zebra crossing. In some of the school zones zebra crossing were not provided and some areas zebra crossings are faded in nature. So provide proper zebra crossing in every school zones. Most of the students will prefer zebra crossing so that we can adopt this as an efficient method for improving pedestrian safety.

Several methods are suggested to improve pedestrian safety at these school zones. If we properly implement these method it will reduce the pedestrian risk and improve pedestrian safety while crossing at school zones.

8. CONCLUSION

School zones are typically high pedestrian areas, particularly with children and young people walking in groups or individually without adult supervision. About eighteen journals were referred in order to get a general concept of our study. It mainly helps to know what all data that needs to collect to reach at the ultimate aim. It also helps to know about various analysis procedures that can be used. The general behaviour of students were identified and it helps to know how a parameter can be selected for modeling. Mainly questionnaire survey, videographic survey and accident data collection were done. Preliminary analysis were done for accident data and questionnaire survey. A detailed analysis were done based on videographic survey. A multiple linear regression model is developed to find pedestrian safety index. According to the PSSI rating and Ped ISI calculation, the school zones comes under 3 equal to Average and 4 equal to Risk, as per above calculations. In Future there is a scope to Improve pedestrian safety at various locations in the city. 1 is safest, lowest priority for further evaluation and 5 is least safe, highest priority for further evaluation. The developed PSSI model can enable engineers and planners to evaluate safety at existing crossings at unprotected mid-blocks. The results of the PSSI model may be useful to design pedestrian facility and suggest appropriate remedial measures to enhance pedestrian safety. The findings of the current study are limited to only two-lane two-way (undivided) carriageway.

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