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COMPREHENSIVE ANALYSIS OF PEDESTRIAN BEHAVIOUR UNDER MIXED FLOW CONDITIONS AT GRADIENTS

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Abstract:- *The present study deals with the analysis of behaviour of pedestrians at different gradients for Visakhapatnam city. The pedestrians behaviour is observed by conducting a videographic survey during the peak hours. Based on the survey the pedestrian flow characteristics were extracted such as gender, age, baggage, movement and usage of phone. The analysis of data extracted is done by considering various combinations, the relation between walking speed and gradient models are developed by using regression analysis*

Keywords*:* pedestrian, gradient, behavior, walking speed, Regression

1. INTRODUCTION

Walking is important mode of transportation system. Most of the earlier studies have focused on plain topography. (Al-Azzawi et al., 2007) pedestrian movement on sidewalks have been analyzed to yield data on pedestrian flows and speeds and a variety of other variables. From this data regression models have been constructed and the predictive performance of these models are assessed. Studies shows that females walking speed is 41% decreases as compared with males (Gupta et al., 2017). The work formulates the problem of pedestrian-driver interaction and sheds light on its complexity in traffic (Rasouli et al., 2018) the way they communicate with drivers prior to crossing and the factors that influence their behavior were analyzed. (Rastogi et al.,2011) pedestrian walking behavior with the help of walking speed of pedestrian. (Marisamynathan et al., 2014) pedestrian crossing speed, design crossing speed had been determined for old and adults at 0.95m/sand 1.12m/s. (Tabish et al., 2017) to establish a methodology to reduce the pedestrian problems at intersections in Haryana, India. (Wang et al.2013) developed the speed-density model it is found that stochastic model more suitable than deterministic model. (Rasouli et al., 2018) study shows that changes in head orientation in the form of looking at the traffic is a strong indicator of crossing intentions. (Zaki et al., 2018) to identify commonality on pedestrian walking behavior and to introduced movement similarity measure.

2. METHODOLOGY

Methodology involves the problem identification, Reconnaissance survey, Selection of study locations, Data collection using videographic survey, data extraction, data analysis, develop a model shown in fig 1.

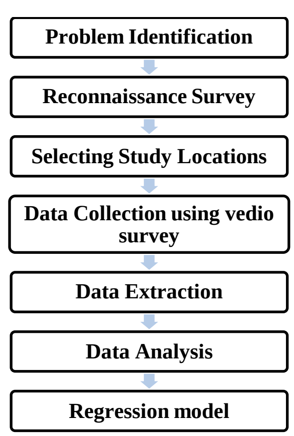

Fig 1: showing the work flow

2.1 Study area and Data collection

Visakhapatnam has been chosen as the study area which lies to the North East of Andhra Pradesh, India. In this city nine locations are selected for data collection. The study location shown in fig 2.

Data were collected, videographic survey was employed at each location during peak hours to record the movement of pedestrians using camera and these videos were analysed manually. The features of the road like carriageway width, footpath width were measured using measuring tape. The gradient of the carriageway was calculated with help of Auto level shown in Table 1

Fig 2: locations of study area

Table 1: Details of survey locations

Name of the location	Gradient (%)	Survey date	Time	Number of samples
Aasilmetta	7	05-12-2018	8.30 am-9.30 am	276
Shivajipalem	1	07-12-2018	8.30 am-9.30 am	291
Venkojipalem	8	10-12-2018	4.30pm-5.30 pm	449
Seetammadara	5	13-12-2018	8.30 am-9.30 am	137
Maharanipeta	13	16-12-2018	4.30 pm-5.30 pm	556
Hanumanthawaka	9	21-12-2018	8.30 am-9.30 am	101
King George Hospital	4	24-12-2018	4.30 pm-5.30 pm	346
Akkayapalem	3	27-12-2018	8.30 am-9.30 am	157
Kommadi	5	03-01-2019	4.30 pm-5.30 pm	470

2.2 Observations and Data Analysis

The total 2785 pedestrians were observed and recorded at gradient at nine locations. After extraction of the data were analysed using analytical software. Some combinations are used in data analysis they are gender-are, gender-baggage, gender-movement, gender-using phone, Age-baggage, Age-movement, Age-Using phone, Baggage-Movement, Baggage-Using phone, Movement-using phone. The analysis is done for average walking speed, maximum walking speed and minimum walking speed of pedestrians at gradients using various combinations i.e.

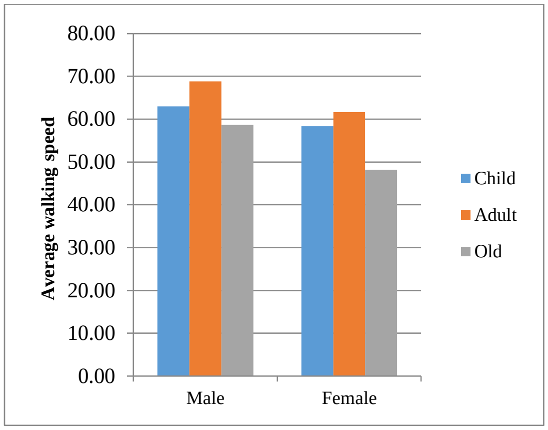

Fig 3: Average Walking Speed (Gender-Age)-upward gradient

From the fig.3 the gender-age combination for upward gradient, the average walking speed of old male is 14.8% less compared to child and adult and for female, the average walking speed of old male is 21.2% less compared to child and adult.

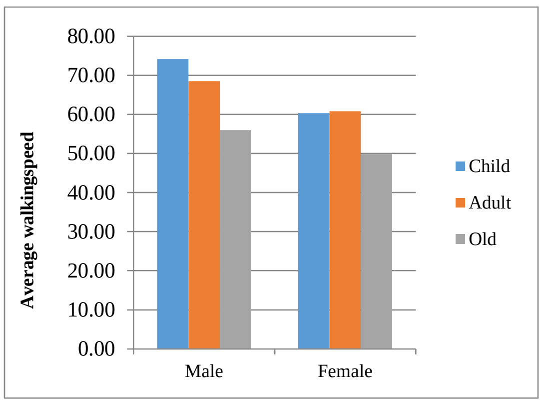

Fig 4: Average Walking Speed (Gender-Age)-downward gradient

From the fig.4 the gender-age combination for downward gradient, the average walking speed of old male is 19% less compared to child and adult and for female, the average walking speed of old is 16% less compared to child and adult. The average walking speed of old is 22% less compared to child and adult.

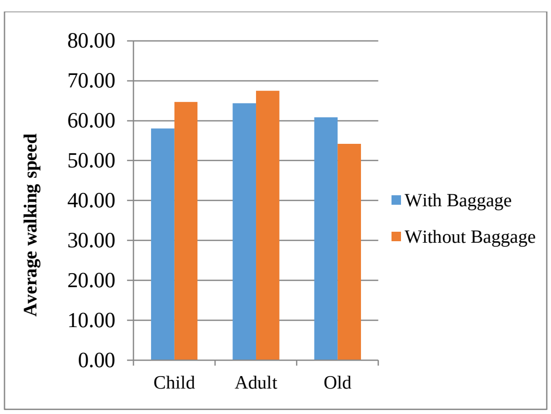

Fig 5: Average Walking Speed (Age-Baggage)-upward gradient

From the fig.5 the age-baggage combination for upward gradient, the average walking speed of old pedestrians either with or without baggage condition is less 16% compared to child and adults.

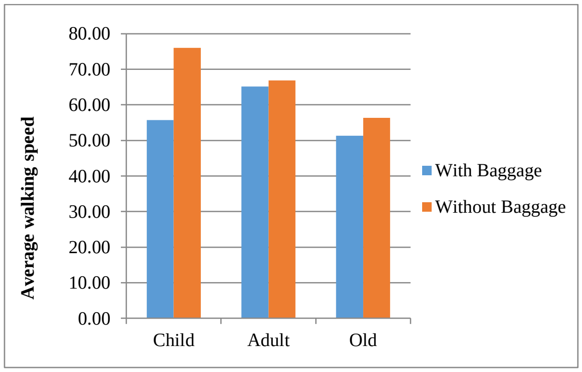

Fig 6: Average Walking Speed (Age-Baggage) - downward gradient

From the fig.6 the average walking speed of old pedestrian is 21.23% is less compared to child, adults in both with or without baggage conditions.

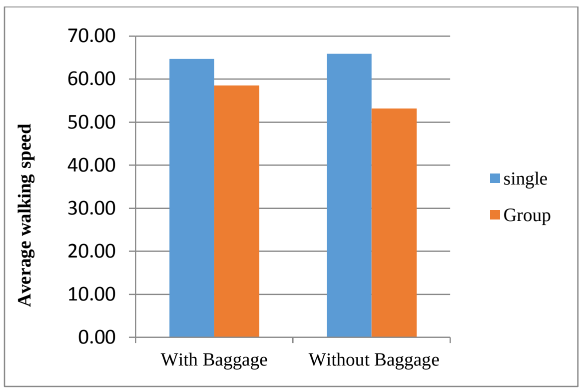

Fig 7: Average Walking Speed (Baggage-Moving)-upward gradient

from the fig.7 is the baggage-moving combination for upward gradient, the average walking speed of single moving pedestrians is 7% less compared to moving in group in the case of with baggage, the average walking speed of single moving pedestrians is 5% less compared to moving in group in the case of without baggage

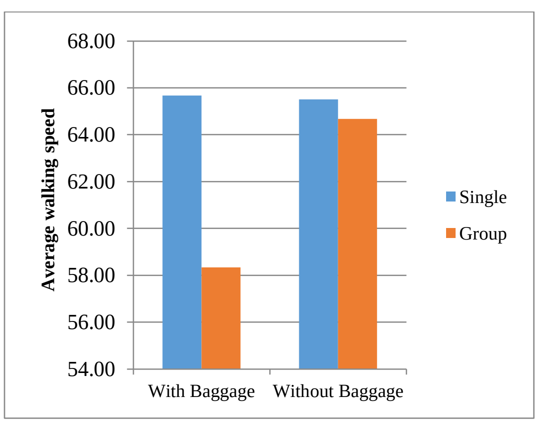

Fig 8: Average Walking Speed (Baggage-Moving) - downward gradient

from the fig.8 the baggage-moving combination for downward gradient, the average walking speed of single moving pedestrians is 12% less compared to moving in group in the case of with baggage, the average walking speed of single moving pedestrians is 1% less compared to moving in group in the case of without baggage.

3. Descriptive statistics and Results

This study is focused on relation between walking speed and gradient. For this study speed and gradient, lane width are chosen as dependent variable and independent variables respectively. The data given in Table 2.

3.1 Linear regression analysis

This predictive analysis measures the relation between one dependent variable and one or more independent variables. The relation expressed as:

$$Y=ax_1+bx_2+c \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The pedestrian walking speed is analysed using linear regression analysis. The 80% of data was used in regression and the 20% of data was used for validation. This test has been performed at 95% confidence interval and statistical results are given in Table 2.

Table 2: Data for regression analysis

S.no	Area	Lanewidth (m)	Gradient (%)	Average walking speed (m/min)	
				upward	Downward
1	Shivajipalem	7	1	86.2	96.68
2	Akkayapalem	7.5	3	79.9	80.18
3	KGH	7	4	75.23	78.13
4	Asilmetta	7.5	7	69.37	67.01
5	Kommadi	7	5	71.24	70.35
6	Hanumantawaka	7	8	60.85	62.14
7	Seetammadara	7	5	75.15	65.64
8	Maharanipeta	7.5	13	49.96	51.01
9	Venkojipalem	7	8	59.2	60.38

3.1.1 Upward Direction

Table 3: Linear regression results for upward direction

R^2	F	a	b	Sig.F
0.98	53.53	6.90	-3.12	0.02

3.1.1.1 Descriptive statistics ANOVA results

variables	Coefficient	t stat.	p-value
Intercept	38.47	2.07	0.17
a	6.90	2.73	0.11
b	-3.12	-9.34	0.01

Note: p-values are significance at 95% confidence interval

Where y is the walking speed, x_1 is gradient, x_2 is lane width, c is constant. From the regression analysis developed a model for upward gradient i.e.

$Y= 6.90x_1-3.12x_2+38.47$…………………… (2)

3.1.1.2 Measures of Forecasting errors Accuracy

In transportation modeling commonly used these measures for evaluating the accuracy of the forecasting, in order to eliminate the effect of the variability observed in most transportation data sets (Makridakis et al,1983), how well the model is good to fit for the known data. The errors given Table

Table 4: Measures of Forecasting errors Accuracy

Error	Value
Mean error(ME)	-0.53
Mean absolute deviation(MAD)	1.47
Sum of square error (SSE)	10.27
Mean square error (MSE)	3.42
Root mean square error (RMSE)	1.85
Standard deviation of errors (SDE)	2.27
Mean percentage error (MPE)	-18.53%
Mean absolute percentage error (MAPE)	44.47%
theil's forecast accuracy coefficient	0.53

3.1.2 Downward Direction

Table 5: Linear regression results for downward direction

R^2	F	a	b	Sig. F
0.96	22.99	2.1	-3.5	0.04

3.1.2.1 Descriptive statistics ANOVA results

variables	Coefficient	t stat.	p-value
Intercept	75.4	2.5	0.1
a	2.1	0.5	0.7
b	-3.5	-6.6	0.0

Note: p-values are significance at 95% confidence interval

3.1.2.2 Regression model for downward gradient

Where y is the walking speed, x_1 is gradient, x_2 is lane width, c is constant. From the regression analysis developed a model for downward gradient i.e.

$Y=2.1x_1-3.5x_2+75.4$ ………. ……. (3)

Table 6: Measures of Forecasting errors Accuracy

Error	Value
Mean error(ME)	-3.58
Mean absolute deviation(MAD)	2.63
Sum of square error (SSE)	32.8

Mean square error (MSE)	10.93
Root mean square error (RMSE)	3.31
Standard deviation of errors (SDE)	4.05
Mean percentage error (MPE)	-42.80%
Mean absolute percentage error (MAPE)	80.31%
theil's forecast accuracy coefficient	0.93

4. Conclusions

In this study, pedestrians walking speeds were studied at different gradients in Visakhapatnam, Andhra Pradesh, India. These behaviours were analysed in relation to the pedestrian characteristics of Gender, age, baggage, moving pattern for individual pedestrians. The age-baggage conditions the average walking speed of old pedestrians is less 16% compared to child, adults at upward gradients, 21.25% less compered to child, adult at downward gradient. This study indicates that the walking speed of pedestrians is also affected by human intentions.

Linear regression models were developed and satisfied the Model speed is changing with slope of “a” with respect to gradient, changing with slope of “b” respect to lane width. This study shows that forecasting accuracy errors are good to fit the data. Future work can be extended by taking larger sample and to consider more factors like footpaths, obstructions and street lights giving better statistics results in other regression models.

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