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Impact of Side Friction on Urban Roads

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ABSTRACT

Urban roads in India operate under mixed traffic conditions. They are subjected to side friction factors such as slow-moving vehicles, interference of buses, pedestrian traffic, trading activities, frequent side roads, vehicles parked along the carriage way, entry and exit through approach road. But the side friction factors are not considered while designing roads as per IRC guidelines. Hence, the present work aims to determine the effect of side friction parameters on speed reduction. A road side friction index (RSFI) has been developed to quantify side frictions. Percentage speed reduction (PSR) from free flow speed was analysed to study impact of road side friction on speed. Level of service (LOS) is determined from the data collected.

Keywords:*-Side friction, percentage speed reduction, roadside friction index*

INTRODUCTION

In a country, transportation is an important factor for its development economically. In India, which is a developing country, there arises a problem of side friction. Side friction include slow moving vehicles, interference of buses, pedestrian traffic, trading activities, frequent side roads, vehicles parked along the carriage way, entry and exit approach road. Rapid urbanization has resulted in increase in vehicular growth. The interaction of these activities with the traffic stream tends to slow down the vehicles which also reduce the capacity of roads and are detrimental to the safety of commuters and other road users. In the present study, efforts have been made to quantify impact of side friction on travel speed and LOS of urban roads. The capacity of roadway is used as an important parameter to measure congestion and level of service (LOS). In India, the side friction factors are not considered while designing roads as per IRC guidelines. Hence, the present work aims to develop a methodology for estimating the effect of road side frictions on urban traffic flow characteristics, and an index, namely the roadside friction index (RSFI) has been developed. In this study effort has been made to quantify impact of side friction on travel speed of Indian urban highways. Mid-block sections in Thiruvananthapuram were selected as study sections. The percentage speed reduction (PSR) from free flow speed is taken as a performance measure as it is transferable to any other urban road segment. LOS criterions were suggested and impact of side friction was investigated.

LITERATURE REVIEW

The influence of the side friction parameter on speed has been analysed in the present study. Pedestrian movements, parked vehicles and entry-exit of vehicles from side roads and the effect of bus stops are observed from videos and analysed using AVS video editor and percentage speed reduction is calculated to examine the combined effects of all the side friction on the road.

Munawar[1] carried out surveys at congested urban roads (with high side friction) during peak hours, to analyse the effects of the characteristics of urban roads, specially the side friction, in reducing the capacity and speed. The results were then compared to the capacity and speed predicted by Indonesian HCM and the actual speed-flow relationship and that predicted by Indonesian HCM.

Biswas et al. [5] identified percentage Speed Reduction (PSR) from Free Flow Speed (FFS) as the performance measurement of LOS assessment. Kolmogorov-Smirnov (K-S) test were performed to check the accuracy of modelled curves K-mean clustering has been adopted to classify the observed PSR data into sub groups and he proposed six LOS classes bounded by threshold values of PSR.

Roy et al. [6] conducted a study to quantify the impact of road side friction on travel speed and LOS of Indian rural highways. Authors proposed road side friction index (RSFI), which quantifies the impact of various side friction parameters on urban roads. Salini et al. (2016) analysed in detail the impact of side friction factors on speed of four lane divided urban roads in developing countries. Analysis was conducted on speed variability observed on stretches with side friction factors. Speed prediction models were developed with side friction parameters and traffic composition which can be used for predicting speeds and there by speed reduction caused by each of the side fiction parameters. Speed prediction models were employed to assess the impact of variations in side friction parameters and it was observed that the most significant parameter was the dwell time of buses. Speed prediction models developed in the study can be used to determine the speed of traffic flow which is affected by various side friction parameters. The model developed on the basis of the weighted index can be used to predict the combined effect of these frictional parameters are determined.

Rao et al.[2] reviews the impact of different types of frictional activities on urban roadway capacity and speed. In this study side friction elements such as kerb side bus stop, bus bay and on street parking are considered for study and an attempt has been made to find the effect of these friction types on travel speed and capacity of urban arterials of Delhi. The authors determined that with the increase in duration of dwelling time of buses capacity is reduced, as more the time buses stops on road more the disturbance it causes to traffic on the section.

Gulivindalal et al.[3] examined the combined effects of all the activities by considering the weighing factors to determine total value of side friction on the road. Capacity value was obtained for the combined data based on Greenshield’s theory. The author also developed a speed prediction model with flow and side friction as independent parameters.

Pal et al.[6] quantified the impact of roadside friction generated by roadside markets on travel speed, capacity, and level of service (LOS) of rural highways in India. A roadside friction index (RSFI) had been developed to quantify side friction. Using data collected from study sections, speed flow curves were developed for various side friction levels. The k-mean cluster analysis algorithm was applied for determining threshold values for LOS. Five threshold limits for LOS are recommended for a stable flow zone considering percentage speed reduction (PSR) and volume: capacity ratio as measure of effectiveness. Impacts of side friction on the capacity of rural highway were also investigated.

Bhat et al. (2019) made an attempt to quantify the impact of roadside friction on average travel speed and LOS of Indian rural highways. Based on data collected a detailed procedure has been followed to calculate the Average Travel Speeds, Flow, Level of Service and Roadside Friction Index (RSFI). Speed-flow curves and speed-density curves for different friction levels have been generated and the impact of the roadside friction has been analysed by the authors. Regression modelling had been done in SPSS statistical software to derive the relationships between the average travel speed as dependent variable and flow and roadside friction as independent variables. He made a comparison between the impact of friction on average travel speed at low friction affected segments and higher friction affected segments. The authors performed T tests to check the significance in the difference in average speeds at lower friction levels and higher friction levels. Regression Models with both Flow and RSFI as independent variables and only Flow as an independent variable have been compared based upon the R square values obtained.

METHODOLOGY

The initial step involves collection of traffic data from the study section and the ideal section which is followed by the extraction of data collected. The various friction factors contributing to road side friction is determined and speed data is computed from the traffic data. Road Side Friction Index and Percentage Speed Reduction are also determined.

Site Selection

In this study traffic data was collected from Sasthamangalam- Vellayambalam and Vellayambalam- Kowdiar road stretches in Thiruvananthapuram, Kerala. The traffic in Sasthamangalam-Vellayambalam road stretch is heterogeneous which includes two wheelers, cars, buses, three wheelers etc. Vellayambalam- Kowdiar road stretch is considered as an ideal section in Thiruvananthapuram. In this road section, the various side friction elements such as road side parking, bus stops, side road etc. are absent.

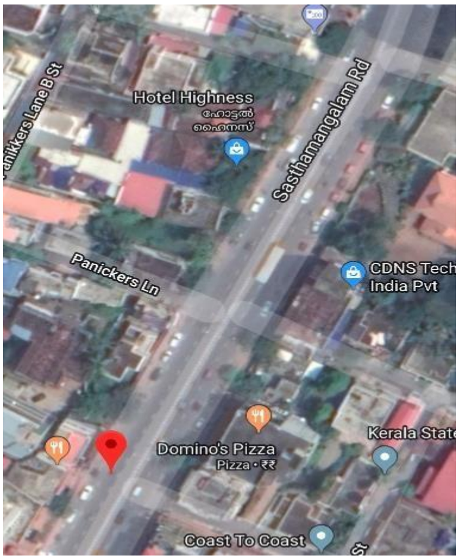

***Fig.1:**-Satellite image*
Source: Google earth image

Fig.2:-*Screenshot from AVS video player)*

DATA COLLECTION

Traffic data was collected using videography technique. Peak hour and free flow data were collected from the road stretches. Urban two-lane divided roads were selected for study. Straight road segment was selected for video data collection. To capture the movement of vehicles at a wide range, camera was kept on a tripod stand, placing it on terrace of a building which is near to the edge of the carriageway. Camera had been adjusted in such a way that entire segment of road could be captured without trouble. The video was collected at peak hour from Vellayambalam-Sasthamangalam section. Free flow data, was collected from Vellayambalam- Kowdiar section.

DATA EXTRACTION

The traffic data extraction was carried out using AVS video editor. The collected video data was imported into the editor and lines were marked on the road stretch to divide it into the required length of stretch. The entry and exit time of vehicles were noted. Other data extracted includes classified volume count per minute, pedestrian flow along carriageway, number of parked vehicles, vehicles entering and leaving from the side road inside the considered stretch. From the ideal section, data was collected under free flow condition. Free flow speed of various vehicles in the ideal section and peak hour speed in the section with road side friction was determined.

FRICTION DATA

Road side friction is expressed in terms of number of elements on carriageway or crossing the carriage way. The carriageway was divided into three strips in longitudinal direction, depending on the number of friction elements across the cross-section of the road. It was observed that number is more near carriageway edge and it gradually decreases towards the centre of carriageway. One-meter strip on either side of the carriageway was considered as edge strip and middle strip consist of remaining part of the carriageway. One set of friction data was collected for each one-minute interval.

SPEED DATA

The time difference between the entry and exit time of vehicles was recorded from the video. The speed data of different vehicles categories was computed. Free flow speed and peak hour traffic speed was obtained. From this percentage speed reduction from free flow speed is estimated.

ROAD SIDE FRICTION INDEX (RSFI)

Various friction elements have different impacts on travel speed based on their

static and dynamic characteristics and their position on the carriageway. An index namely "road side friction index" has been proposed by Pal et al. (2019) to quantify the side friction. Number of friction elements in the form of pedestrians, parked vehicles standing or crossing the carriageway present within 35meter stretch have been multiplied with a weight factor to estimate RSFI value. Impact of the side friction was considered as combined effect of physical dimension of friction element and their position on carriageway. In the present study pedestrian standing on the carriageway edge strip is considered as unit of side friction. Area effect was estimated as ratio of projected area of a particular type of friction element and pedestrian which is referred as area ratio (AR). The disturbance to thorough traffic also depends on the position of friction element on carriageway. This effect was estimated as ratio of distance of particular midpoint of strip from carriageway edge on which friction element currently standing to midpoint of edge strip presented as distance ratio. For example,
Distance ratio (DR) of a friction element standing on middle strip of a two-lane carriageway
= (Distance of midpoint of middle strip from carriageway edge) / (Distance of midpoint of edge strip from carriageway edge) [pal. et al]
Weight factor (Wi) for each case is determined by considering the sum of area ratio (AR) and distance ratio (DR). Weight factor is multiplied by number of friction element to determine RSFI.

The RSFI value based on parking effect is determined by considering the weight factor of vehicles on the edge strip. The slow-moving vehicles also have an effect and it is quantified by considering weight factors on the middle strip. The buses occupy both the edge and the middle strip hence these two weight factors are considered while in the case of pedestrians. Occupancy of edge strip and crossing are considered.

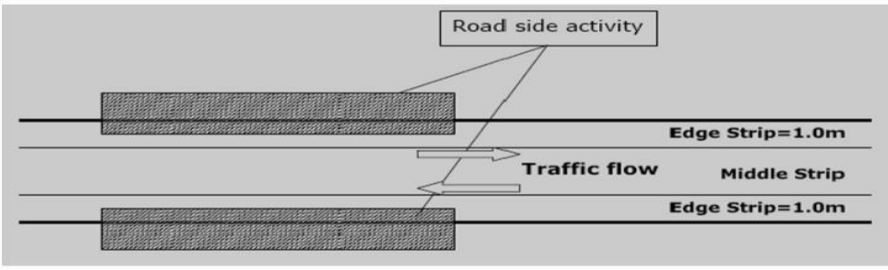

Fig.3:-*Details of edge and middle strip marked on carriageway*
Source: Pal, S. et al. (2016)

PERCENTAGE SPEED REDUCTION (PSR)

Percentage speed reduction from free flow speed (FFS) may be taken as a performance measure as it is transferrable to any other urban road segment. FFS is the prevailing travel speed in very low flow conditions where there is very little interaction among vehicles, and vehicles are almost always able to travel at driver's desired speed.

RESULTS AND ANALYSIS

Road side friction has been developed to quantify side friction. The RSFI for a particular instance is defined as a number of each type of friction element standing or crossing the carriageway within the selected stretch multiplied by the respective weight factor.

Table 1:-RSFI calculation (Edge strip)

Details of friction element	Projected area (m^2)	Distance of edge from strip midpoint (m)	Area ratio AR= Ai/Ap	Distance ratio DR= di/0.5	Weight factor (Wi)=AR+DR
1.Pedestrian	0.50	0.5	1	1	2
2.Two-Wheeler	0.86	0.5	1.72	1	2.72
3.Three-Wheeler	2.56	0.5	5.12	1	6.12
4.Small Car	6.50	0.5	13	1	14
5. Bus	29.8	0.5	59.6	1	60.6

From the Table 1, it can be observed that the weight factor of bus is more. As the size or projected area of a vehicle increases its area ratio increases correspondingly. At the edge strip, parked vehicles and buses have more impact.

Table 2:-RSFI calculation (Middle strip)

Details of friction element	Projected area(m^2)	Distance of edge from strip midpoint (m)	Area ratio AR= Ai/Ap	Distance ratio DR= di/0.5	Weight factor (Wi)=AR+DR
1.Pedestrian	0.50	4.50	1.00	9.00	10.00
2.Two-Wheeler	0.86	4.50	1.72	9.00	10.72
3.Three-Wheeler	2.56	4.50	5.12	9.00	14.12
4.Small Car	6.50	4.50	13.00	9.00	22.00
5. Bus	29.8	4.50	59.60	9.00	68.60

At the mid strip the impact mainly occurs due to the vehicles travelling through carriageway. Some of the vehicles may slow down which results in overall reduction in the traffic speed. As the distance of edge strip from midpoint of the section increases, there is considerable increase in each weight factor in the middle strip, it is shown in Table 2.

Table 3:-RSFI calculation (Crossing)

Details of friction element	Projected area (m^2)	Distance of edge from strip midpoint (m)	Area ratio AR = Ai/Ap	Distance ratio DR = di/0.5	Weight factor (Wi) =AR+DR
1.Pedestrian	0.50	9.00	1.00	18.00	19.00
2.Two-Wheeler	0.86	9.00	1.72	18.00	19.72
3.Three-Wheeler	2.56	9.00	5.12	18.00	23.12
4.Small Car	6.50	9.00	13.00	18.00	31.00

From the Table 3, it can be identified that car have more impact than two wheelers, three wheelers or pedestrian crossing, in the case of friction elements crossing the carriageway. Here there is no need to find the weight factor of bus because a condition of bus crossing the carriage way will not arise in normal condition.

Table 4:-RSFI values

Factors affecting RSFI	Type of vehicle	Weight Factor	Average No:	RSFI
Parking effect	Two-wheeler	2.72	1.10	58.82
	Three-wheeler	6.12	1.46	
	Small car	14	3.35	
Slow moving vehicle	Two-wheeler	10.72	0.18	4.53
	Three-wheeler	14.12	0.06	
	Small car	22.00	0.08	
Pedestrian traffic		19	1.03	19.57
Bus		129.2	0.51	65.89
Side road	Two-wheeler	10.72	1.55	24.13
	Three-wheeler	14.12	0.70	
	Small car	22.00	1.11	

Table 4 shows RSFI values of each friction elements which are calculated based on their weight factor corresponding to the respective strip in which the friction elements have impact. In the case of parking effect, the vehicles occupy the edge strip therefore the weight factors corresponding to the edge strip for the respective vehicle is taken and multiplied with the average number of respective vehicles. (i.e.,(2.72 X 1.10)+(6.12 X 1.46)+(14 X 3.35) =58.82)The slow-moving vehicles which occupy the middle strip contribute to the side friction effect. Hence the weight factor corresponding to middle strip is taken for each type of vehicle which is multiplied in the similar way with the average number of each vehicle.

Whereas, the weight factors from the crossing condition of pedestrian traffic is taken in order to determine the RSFI for pedestrian as the major influence is from the pedestrians crossing the carriage way.

When we consider buses, it occupies both the edge and middle strip, hence the sum of the weight factors corresponding to these two strips are taken to determine the weight factor.

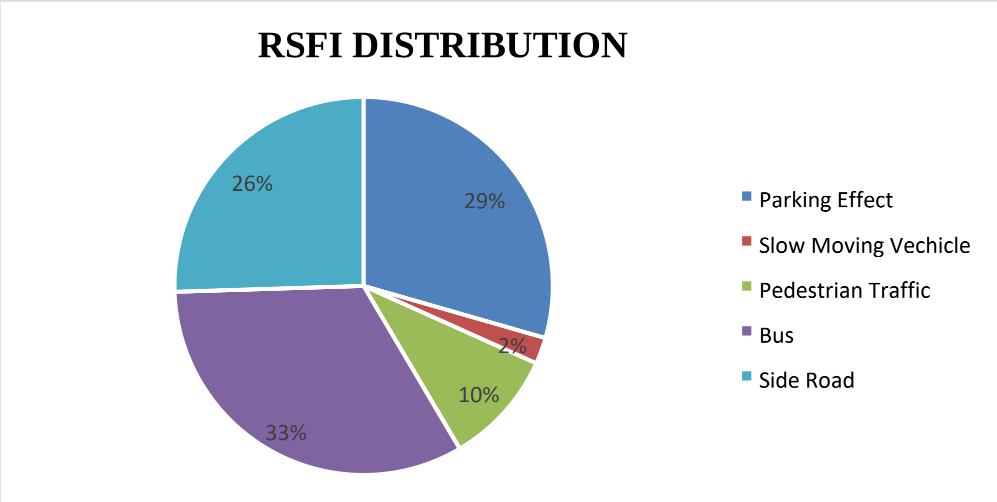

Fig.4:-*Proportional distribution of factors affecting RSFI*

The effect of each side friction factor and their proportional impact on the carriageway is different, which is shown in the Figure 4. From this figure, it can be concluded that the effect of bus is more pronounced than other side friction factors.

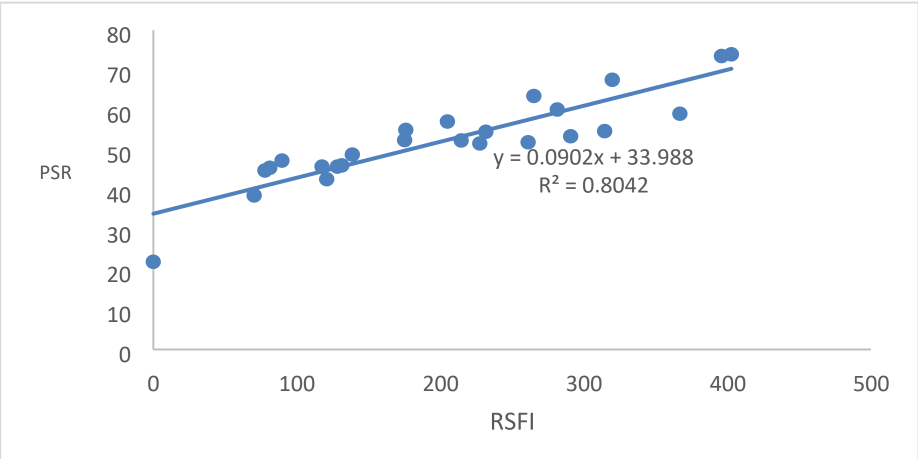

Fig.5:-*Relationship between PSR and RSFI*

Figure 5 shows the relation between PSR and RSFI. PSR is taken along the Y axis and RSFI is plotted along the X axis. From the graph we can conclude that as the value of RSFI increases PSR also increases. A model is developed relating RSFI and PSR. An R^2 value of 0.8042 is obtained.

PSR = 0.0902xRSFI + 33.9879

Total RSFI value is found to be directly proportional to the PSR. So, as the road side friction increases, the percentage speed reduction of vehicle also increases.

CONCLUSION

In the present study a methodology has been demonstrated to quantify roadside friction considering projected area and position of friction elements on carriageway. Road side friction index was estimated for urban road. The effect of road side friction on percentage speed reduction from free flow speed was analysed.

With the increase in road side friction index value, there is a corresponding increase in the percentage speed reduction, therefore there is significant impact of road side friction on travel speed.

Total RSFI value is found to be directly proportional to the PSR and a model was developed by comparing the RSFI and PSR values.

The effect of bus stops is more pronounced than the other side friction factors.

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