IMPACT OF ROADSIDE FRICTION ELEMENTS ON AVERAGE TRAVEL SPEED AND LOS OF URBAN TWO LANE STREETS

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Abstract
Roadside Friction Elements including street parked and stopping vehicles, haphazard movement of pedestrians along the sides and mid sections of the roads, slow moving vehicles (SMV), on road parked vehicles, roadside vendors on a roadway not only restricts the continuous or smooth vehicular flow movement but also affects maximum flow and level of service. This study was carried out with the intention to quantify the effect of roadside friction on average travel speed and Level of Service (LOS) of roads and the road selected for the study is Nagbal-Manigam Ganderbal road of J&K state. Based on data collected at different periods of the day and at different friction levels, a detailed procedure has been followed to calculate the Average Travel Speeds, Flow, Level of Service and Roadside Friction Index (RSFI) for each run made. Speed-flow curves and speed-density curves for different friction levels have been generated and the impact of the roadside friction has been analyzed. In the later stages of the work, Regression modelling has been used to derive the relationships between the average travel speed as dependent variable and flow and roadside friction as independent variables.

***Keywords*:** Roadside Friction, average travel speed, Regression Models, RSFI, FRIC.

1. Introduction

As per the Indian scenario, roadside markets attract people to stop by, which reduce the effective road width due to roadside parking of vehicles and other parking and un-parking manoeuvre. On urban roads, pedestrian movement on or along the road side also affects the smooth traffic flow. Due to roadside markets, vendors, food stalls or lack of pedestrian facilities people use to walk on or along the road which disturbs the traffic flow. Another problem of Slow Moving Vehicles and non-motorized vehicles on urban roads also contributes to side frictional events. Many of the above-stated problems are arise due to lack of parking, pedestrian and terminal facilities on urban road links. Also, the roadside commercial development including the market areas contribute to these factors. Of all the studies performed related to roadside friction impacts on Travel Speed and hence the quality of travel most of these have been performed in Asian countries especially India and Indonesia. **The Indonesian HCM (1993)** classifies side friction to high and low levels and considers side friction correction factors to be incorporated in the calculation of free flow, saturation flow and capacity. **Sherin George** had proposed an analysis of roadside friction on a major arterial in thickly populated urban cities viz. Mumbai, Bangalore, and Thiruvananthpuram. Side frictional factor was limited to pedestrian movement along the roadside, the bus stopped at bus stops and on street road parking. They have concluded that side friction has a significant effect on speed and need to include side friction in all traffic related study for proper result.

2. Methodology

The methodology opted for this study involves identification of sites for the study, collection of required study data from these study sections, calculation of Average Travel Speed for each run at each study site, determination of Flow, Density and Level of Service of the respective road sections, calculation of RSFI with a comprehensive method.

2.1 Site Selection and Data Collection

Study sections were selected in such a way that there was no major intersection within the stretch. There were a numerous variations of road side activities within the study stretch. Traffic Flow was heterogeneous in nature.

S.NO	STUDY STRETCH	TYPE OF ROAD	LENGTH OF STUDY SECTION
1	BEEHUMA TO NAGBAL	2 Way-2 Lane	3.1 km
2	BEEHUMA TO SEERCH	3 Way-2 Lane	2.6 km

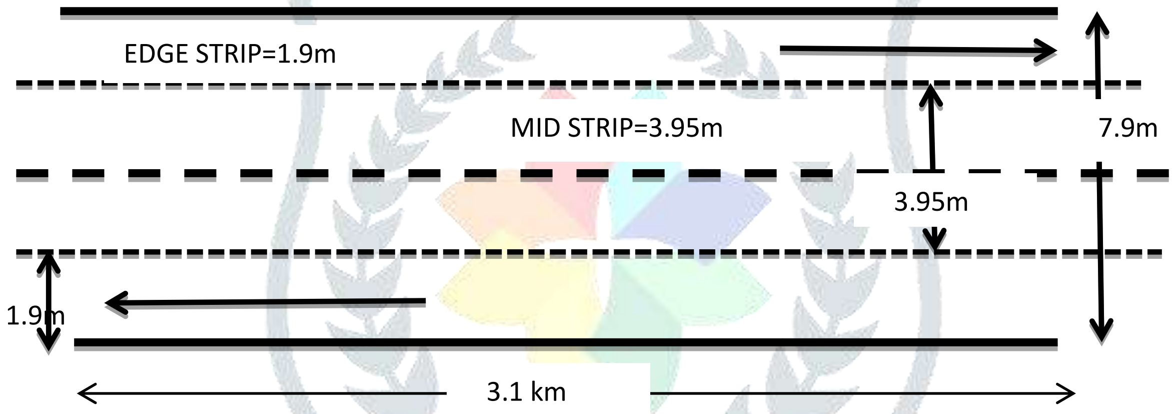


Fig 1 Details of Study Section 1 (B-N)

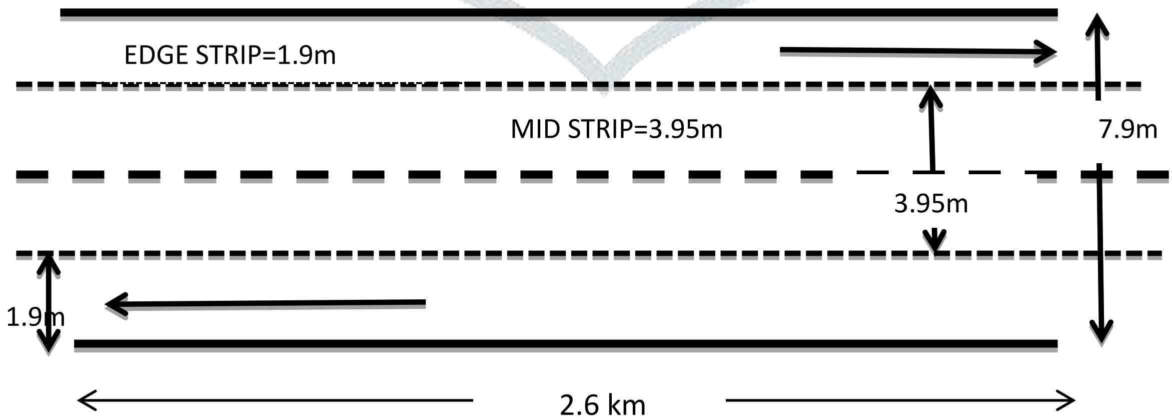


Fig 2 Details of Study Section 1 (B-S)

2.1.1 Data Collection

Traffic data was collected from the study sites at five different time periods of the day viz. Early Morning (EM) , Peak Morning(PM), Mid-Day(MD), Peak Evening(PE) and Late Evening(LE), Video graphic Method was used to count the traffic data after making numerous runs on the study sections at different time periods of the day. During market hours and non market hours number of pedestrians, slow moving vehicles (SMV), on road parked vehicles, roadside vendors, on road stopping vehicles were counted at five different time periods of the day .To study the impact of Friction on Travel Speeds at different Friction Levels, the speed for each individual run was calculated by floating car technique, for the segments that were continuous segments twenty runs were made for each segment and calculation for speed, flow and FRIC were made for each run.

2.2 Data Analysis

The graphical representation was the method opted for data analysis and representation as it is quite easy to understand the changing trends in the flow and speed by means of graphs.

3.1 Road Side Friction Index (RSFI)

An index namely ‘‘road side friction index’’ has been proposed to quantify the side friction. Number of friction elements in the form of like pedestrian, slow moving vehicles (SMV), on road parked vehicles, roadside vendors, on road stopping vehicles standing on the carriageway or crossing the carriageway present per kilo meter stretch have been multiplied by respective weight factor to estimate a ‘road side friction index’ (RSFI) for that particular instance and FRIC values were calculated.

Various friction elements will have different impact on through traffic based on their physical dimension and their position within the carriageway. For example a passenger car on the middle of carriageway will certainly have larger impact to travel speed in comparison with a pedestrian standing on inside of carriageway edge. The concept of weight factor was developed to assign different weight to each friction element based on their contribution towards disturbance to through traffic. In the present study, a passenger car standing on carriageway edge strip considered as unit of side friction.

As we know that 2.5m is the standard Roadside parking Stall width so above section has been considered as a standard section for finding the weight factors and hence RSFI. Any section greater or lower in width than the above mentioned section has been given weights as per the width of the section. For example a section wit 8 m width will be having a strip width of 2 m which is narrower than the standard parking stall width, so the friction will be having some extra impact on the through movement of the traffic and hence an extra weight of 2.5/2 i.e. 1.25 will be given to the RSFI by multiplying the RSFI by a factor of 1.25.

The RSFI is calculated per 1 k.m. length of the stretch per 5m standard mid strip.

- Area Ratio = $\dfrac{\text{Projected Area of a particular Roadside Friction element}}{\text{Projected Area of a car}}$

- Distance Ratio = Distance of midpoint of a particular strip (on which the element is

Standing) from the carriageway edge

Distance of midpoint of side strip from the carriageway edge

4.0 Data results and analysis.

4.1 Weight factors estimation

A comprehensive procedure for the estimation of weight factors for the study sections has been illustrated in by the help of following example

Considering the width of the road to be 7.9m and hence width of the strip to be 1.975m.

Details of Weight factor estimation for edge strip

S.No.	Details of Friction Element	Edge Strip				
		A_i	D_i	A.R	D.R	W_i
1	Pedestrians	0.5	0.987	0.087	1	1.087
2	Cars	5.72	0.987	1	1	2
3	Two wheeler	1.48	0.987	0.26	1	1.26
4	Truck	17.63	0.985	3.08	1	4.08
5	Mini Bus	15.18	0.985	2.65	1	3.65
6	Full Bus	25.73	0.985	4.49	1	5.49
7	Cycle	0.86	0.985	0.15	1	1.15
8	Auto Rickshaw	3.28	0.985	0.57	1	1.57
9	Carts	2.56	0.985	0.45	1	1.45

Details of Weight factor estimation for Mid strip

S.No	Details of Friction Element	Mid Strip				
		A_i	D_i	A.R	D.R	Wi
1	Pedestrians	0.5	3.95	0.087	4	4.09
2	Cars	5.72	3.95	1	4	5
3	Two wheeler	1.48	3.95	0.26	4	4.26
4	Truck	17.63	3.95	3.08	4	7.08
5	Mini Bus	15.18	3.95	2.65	4	6.65
6	Full Bus	25.73	3.95	4.49	4	8.49
7	Cycle	0.86	3.95	0.15	4	4.15
8	Auto Rickshaw	3.28	3.95	0.57	4	4.57
9	Carts	2.56	3.95	0.45	4	4.45

S. No.	Friction Element	Edge Strip	Mid Strip	Crossing
1	Pedestrians	0.544	2.044	4.044

Details of Weight factor estimation for Crossing

S.No	Details of Friction Element	Crossing				
		A_i	D_i	A.R	D.R	Wi
1	Pedestrians	0.5	7.9	0.087	8	4.087
2	Cars	5.72	7.9	1	8	9
3	Two wheeler	1.48	7.9	0.26	8	8.26
4	Truck	17.63	7.9	3.08	8	11.08
5	Mini Bus	15.18	7.9	2.65	8	10.65
6	Full Bus	25.73	7.9	4.49	8	12.49
7	Cycle	0.86	7.9	0.15	8	8.15
8	Auto Rickshaw	3.28	7.9	0.57	8	8.57
9	Carts	2.56	7.9	0.45	8	8.45

Where;

Ai = Projected area of friction element in sqm

Di = Distance of c/w edge from strip mid point

A.R = Ai/Ac [Ac = Projected area of car]

D.R = Di/De [De = distance of c/w edge from edge strip midpoint]

Wi = A.R + D.R

Scaled Weight factors considering Cars at edge strip as unit

2	Cars	1	2.5	4.5
3	Two wheeler	0.63	2.13	4.13
4	Truck	2.04	3.54	5.54
5	Mini Bus	1.825	3.325	5.325
6	Full Bus	2.745	4.24	6.245
7	Cycle	0.575	2.07	4.075
8	Auto Rickshaw	0.785	2.28	4.285
9	Carts	0.725	2.225	4.225

Road side friction index (RSFI) = ∑niWi where, ni is the number of ith type friction elements in stretch and Wi is the Scaled Weight factor for a particular type of element.

Typical Calculation of RSFI

Edge Strip									
	Pedestrians	cars	Two Wheelers	Truck	Mini Bus	Full Bus	Cycle	Auto Rickshaw	Carts
W.F	0.544	1	0.63	2.04	1.825	2.745	0.575	0.785	0.725
No.	79	39	24	2	9	2	0	5	3
RSFI	42.976	39	15.12	4.08	16.425	5.49	0	3.925	2.175
								Total	129.19
Mid Strip									
W.F	2.044	2.5	2.13	3.54	3.325	4.245	2.075	2.285	2.225
N.o	20	1	0	0	0	0	0	0	0
RSFI	40.88	2.5	0	0	0	0	0	0	0
								Total	43.38
Crossing									
W.F	4.044	4.5	4.13	5.54	5.325	6.245	4.075	4.285	4.225
N.o	0	1	1	0	1	0	0	0	0
RSFI	0	4.5	4.13	0	5.325	0	0	0	0
								Total	13.955

Total FRIC for Section B-N Road.

129.19 + 43.38 + 13.96 = **186.53** per 3.1 k.m and 3.95 m mid Section.

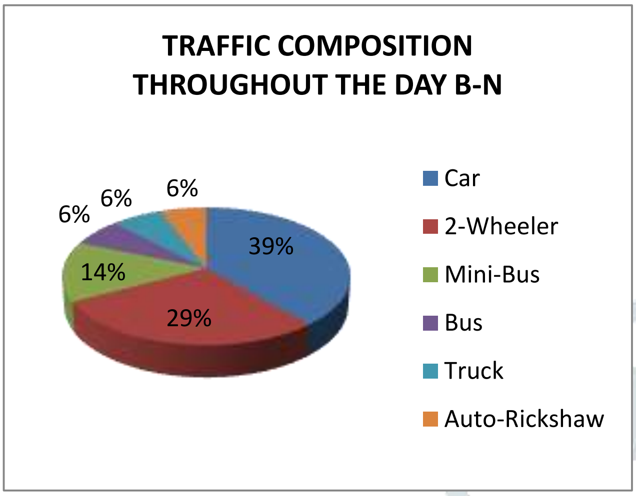
So, for 1 k.m and 5m standard mid-section:- FRIC = [(186.53/3.1) x (5/3.95)] = **76.166**

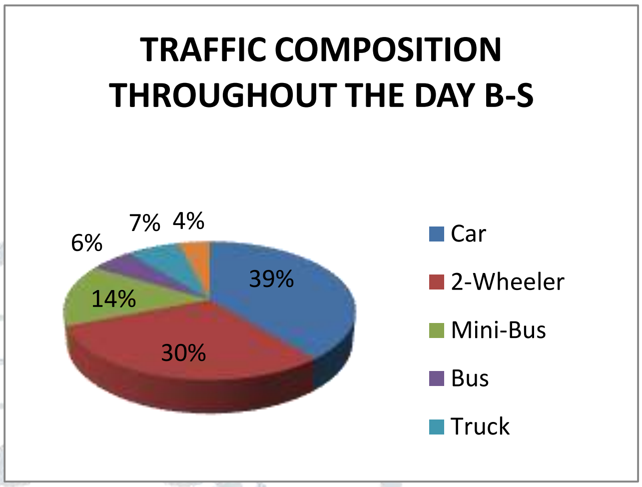
5.1. Development of Speed Flow Curves

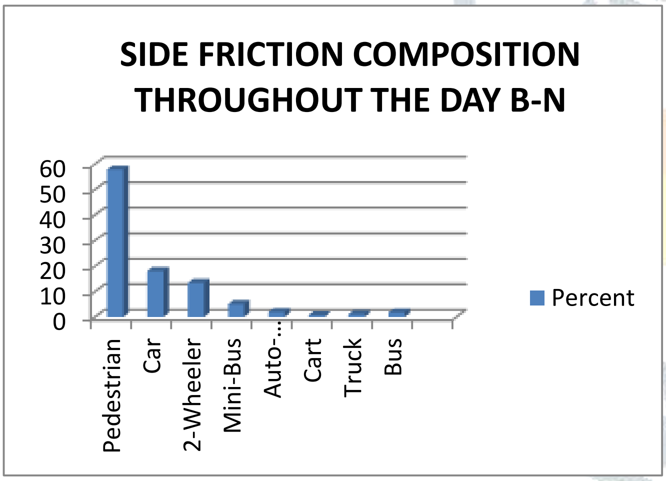
Speed – Density and Speed-Flow curves were plotted for Section B-N that had been highly affected by the side friction activities. The graph were plotted by using Excel software and trend lines along with equations and r square values were also developed to make it easier to understand how the speed is being affected by the side friction activities. Best fit lines following straight line and logarithm relations were tried to model the relation. It is observed that Greenberg model i.e., logarithmic relationship have higher R^2 value.

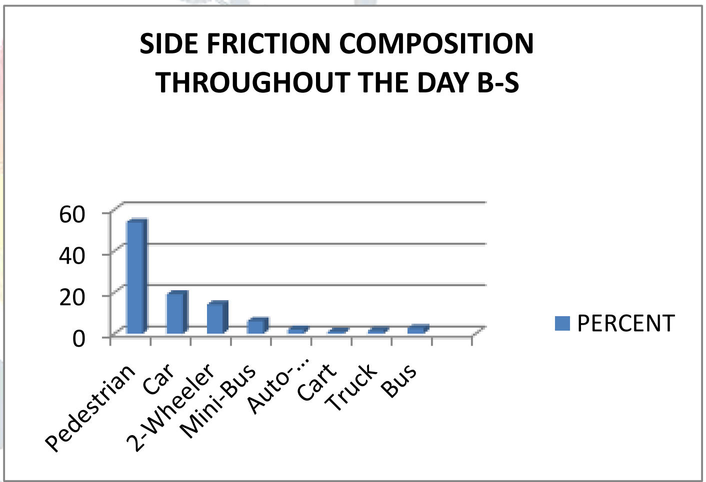
Using the Speed-Density equation obtained from representative flow were estimated using fundamental relationship i.e., flow = speed x density. Speed-flow curves were thus developed for Section under consideration.

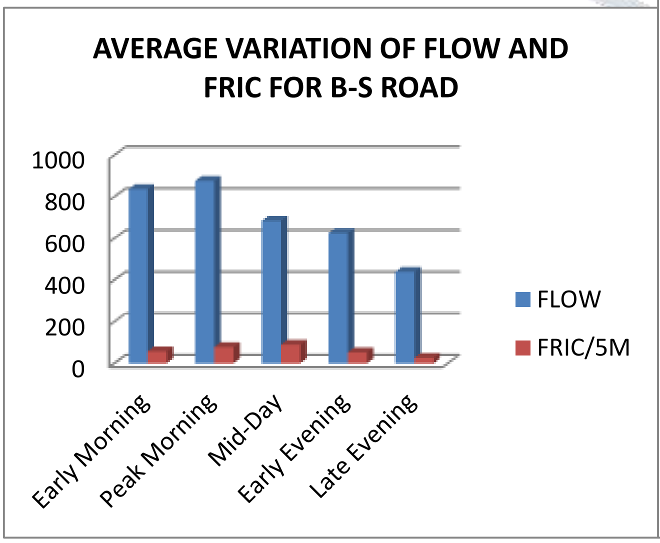
Equation for the curve was also generated in order to predict the speeds at different density levels.

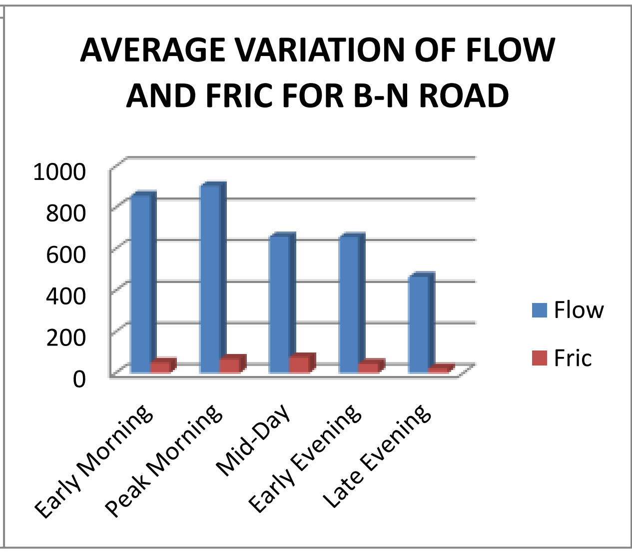


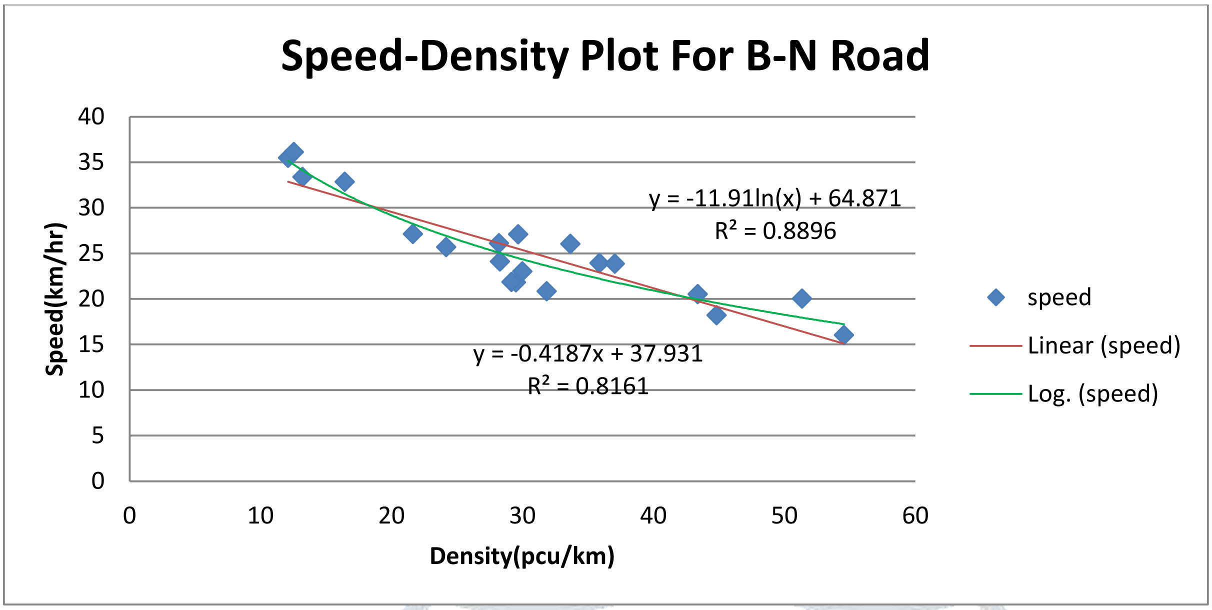


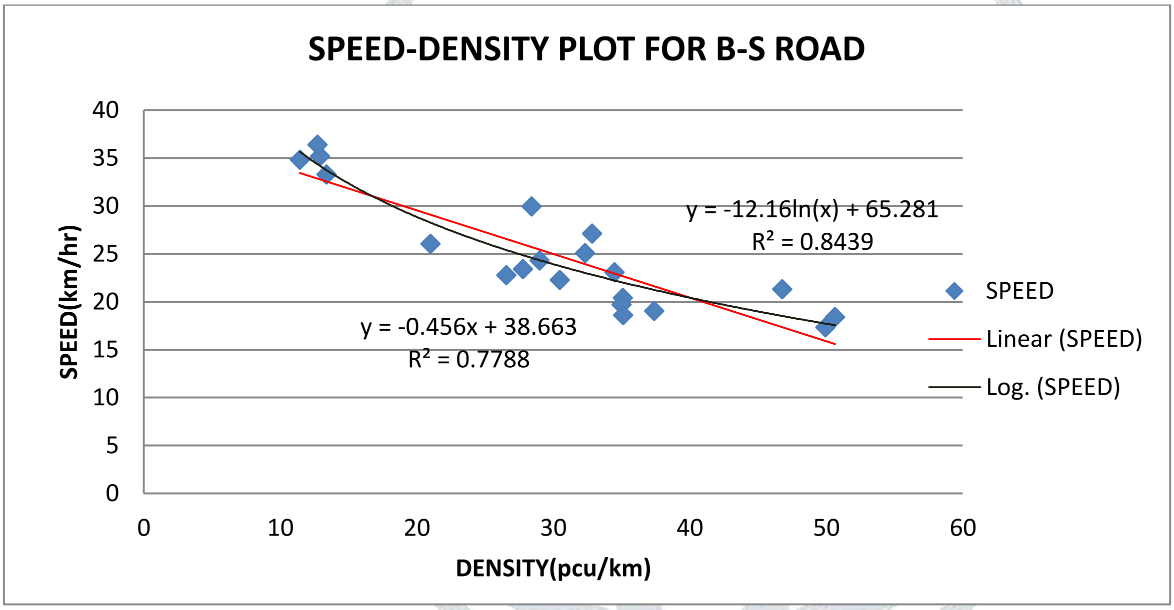


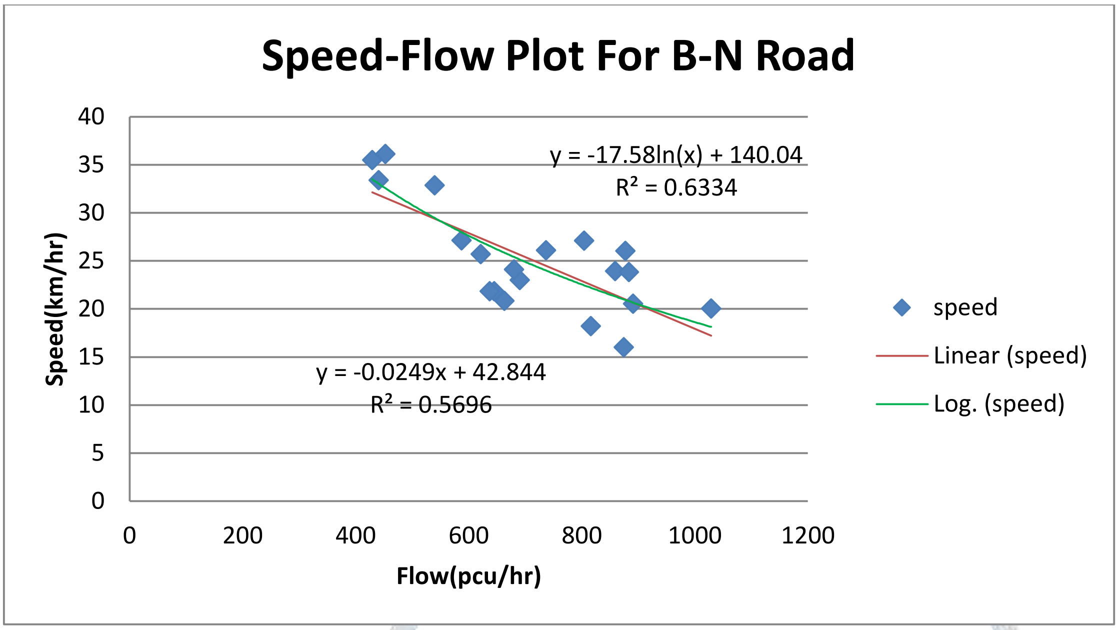


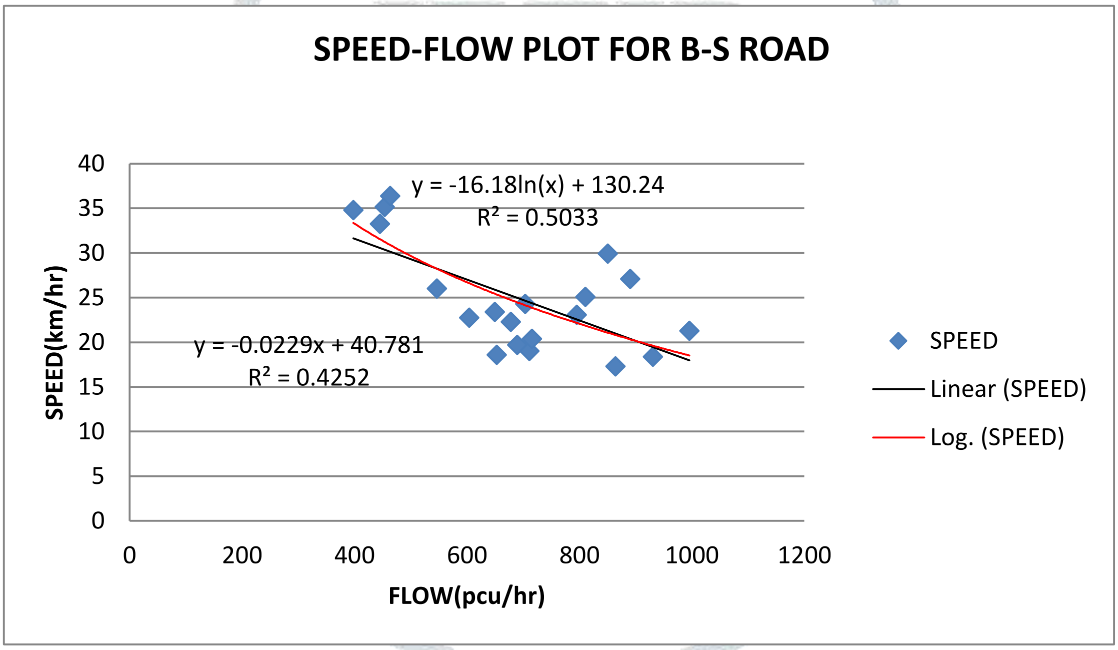





Speed-Density Plot For B-N Road
Speed(km/hr)
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
Density(pcu/km)
y = -11.91ln(x) + 64.871
R² = 0.8896
y = -0.4187x + 37.931
R² = 0.8161
speed
Linear (speed)
Log. (speed)


SPEED-DENSITY PLOT FOR B-S ROAD
SPEED(km/hr)
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
DENSITY(pcu/km)
y = -12.16ln(x) + 65.281
R² = 0.8439
y = -0.456x + 38.663
R² = 0.7788
SPEED
Linear (SPEED)
Log. (SPEED)

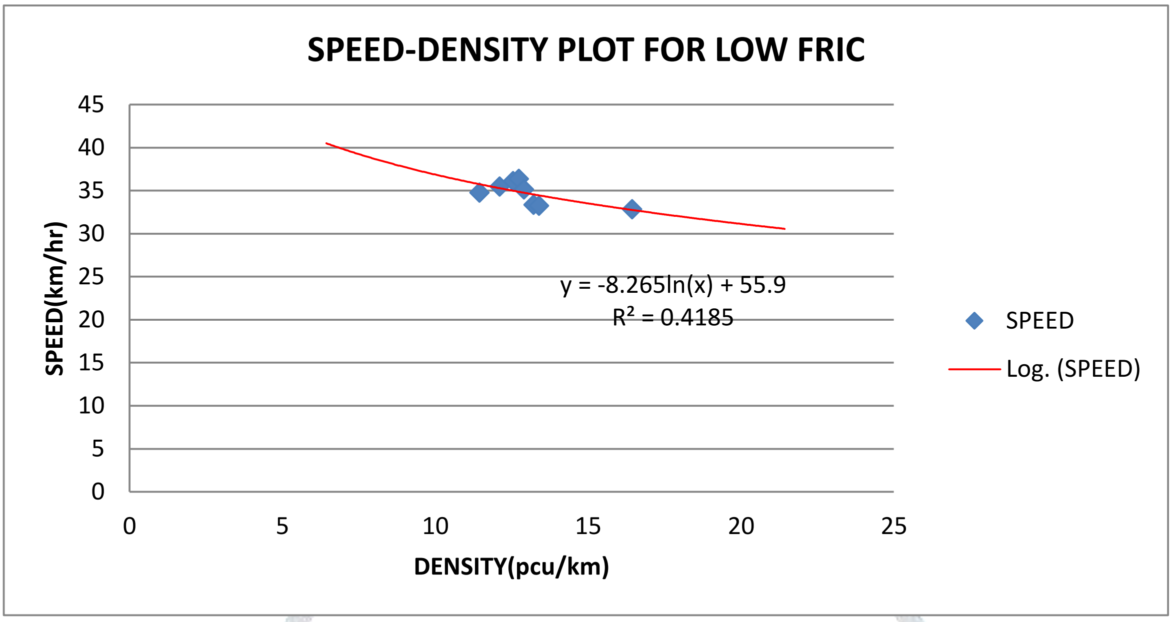


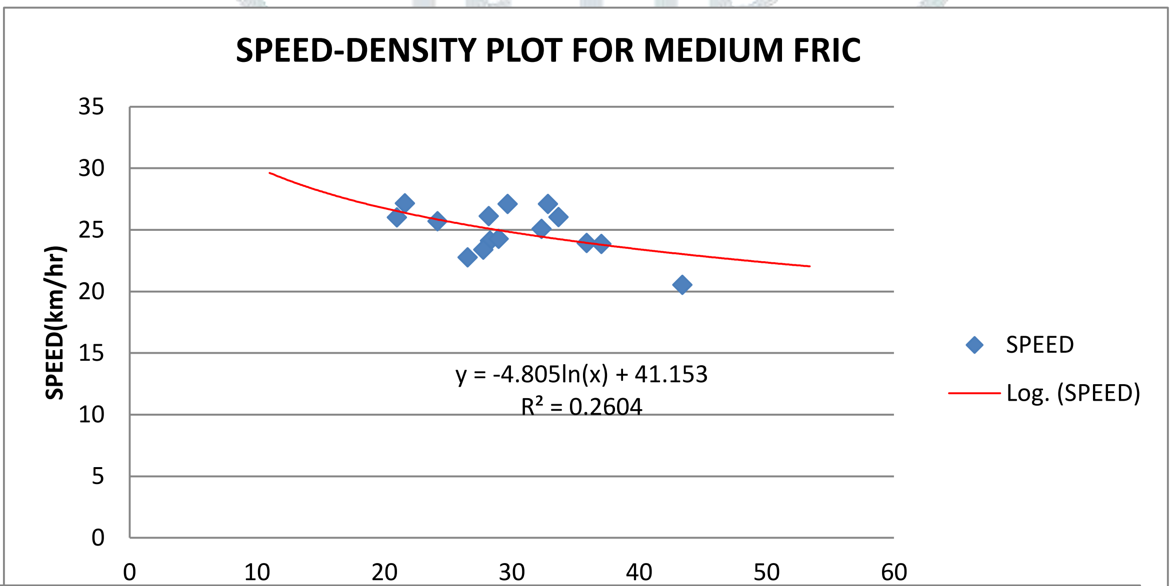


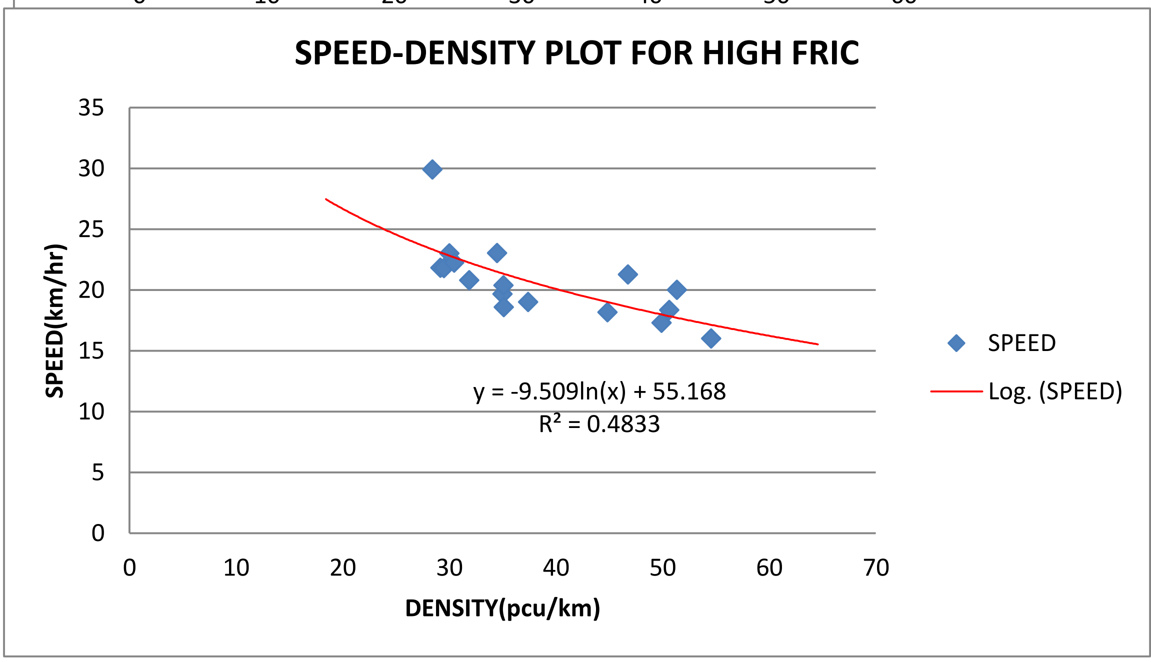
6.1 Classifying the friction levels

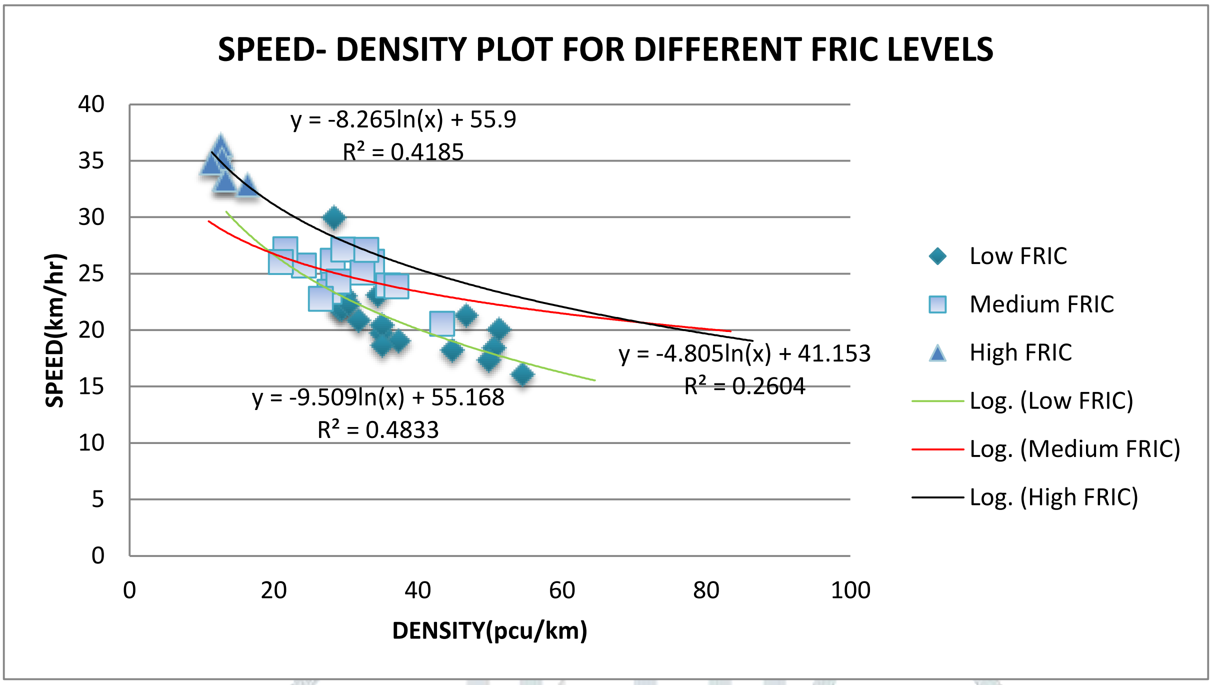
In this approach, speed-flow relationships were compared during different intensities of 'RSFI' on each site. 'RSFI' was categorized into three classes of intensity representing low, medium and high levels of intensity.

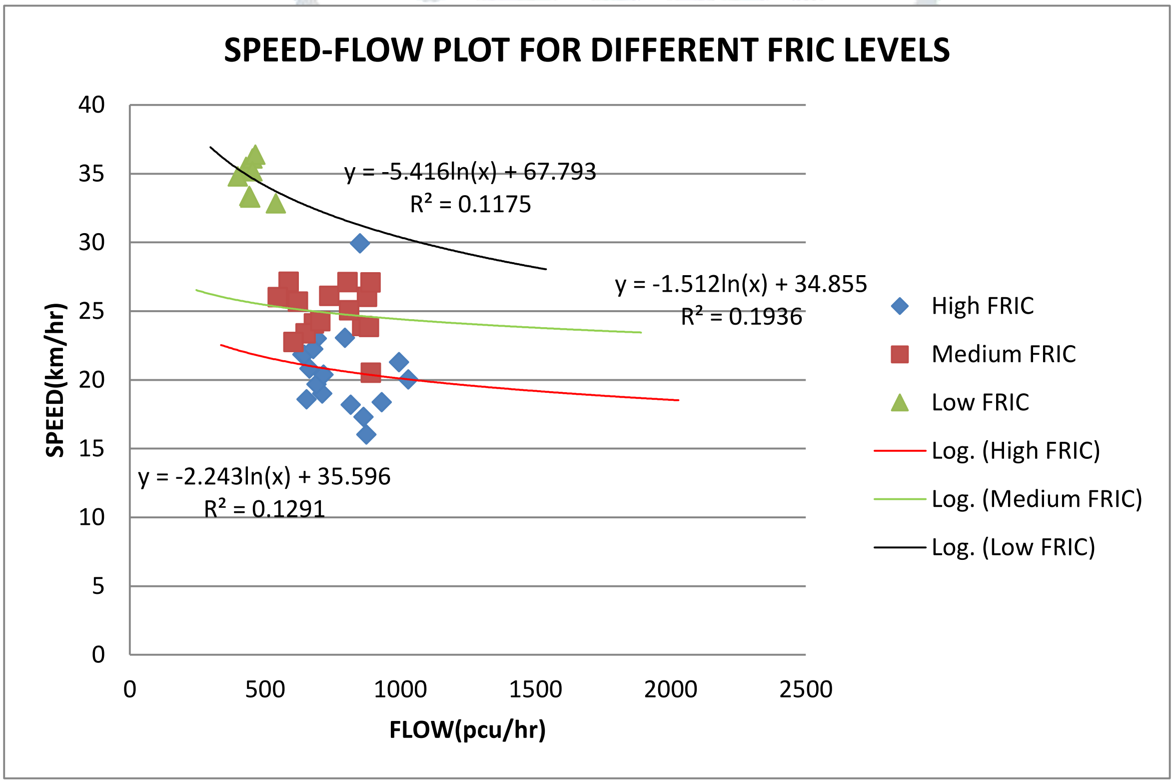
Speed - Flow and Speed – Density Curves for Different Friction Levels


SPEED-DENSITY PLOT FOR LOW FRIC
SPEED(km/hr)
DENSITY(pcu/km)
y = -8.265ln(x) + 55.9
R² = 0.4185
SPEED
Log. (SPEED)


SPEED-DENSITY PLOT FOR MEDIUM FRIC
SPEED(km/hr)
y = -4.805ln(x) + 41.153
R² = 0.2604
SPEED
Log. (SPEED)


SPEED-DENSITY PLOT FOR HIGH FRIC
SPEED(km/hr)
DENSITY(pcu/km)
y = -9.509ln(x) + 55.168
R² = 0.4833
SPEED
Log. (SPEED)





From the above five graphs of speed – density and speed – flow at different RSFI Levels, following points can be concluded :

- Speed Values have considerably dropped for higher RSFI Levels in both the cases
- For the same density levels the speeds are varying for all three different RSFI Levels
- For Example taking the density range between 10 - 40 pcu/km following different values for Speeds are obtained for different RSFI Levels

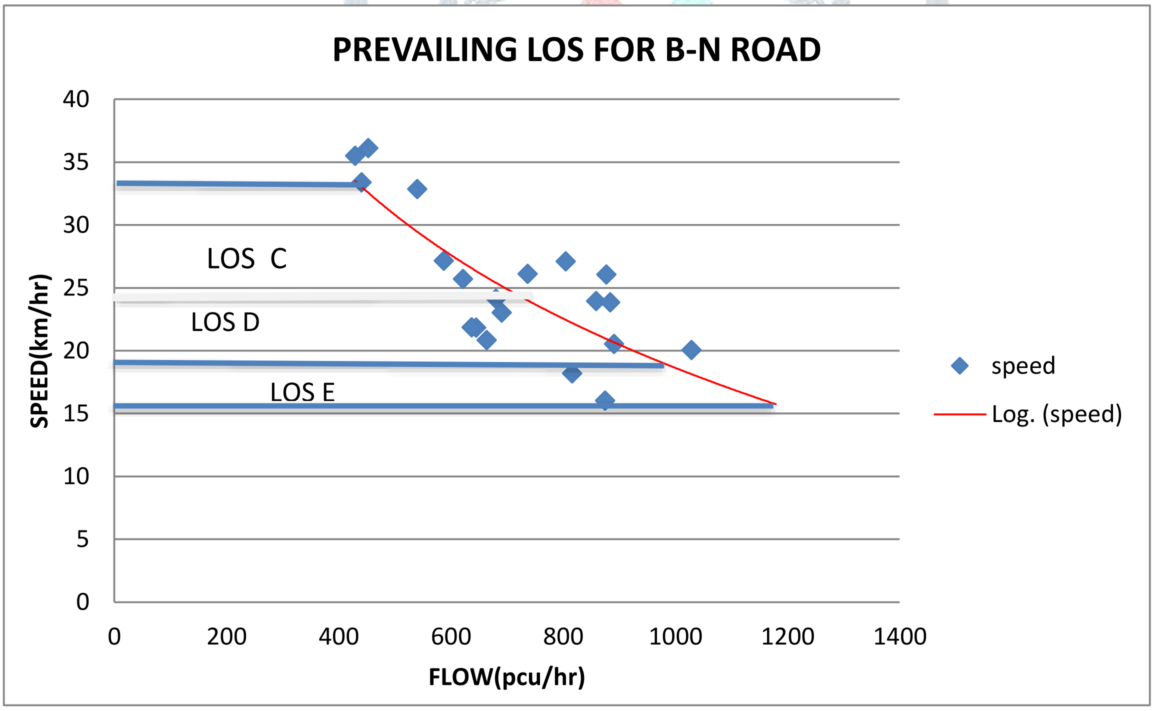
Speed Range	RSFI Level
32 km/h to 36 km/h	Low
23 km/h to 27 km/h	Medium
19 km/h to 23 km/h	High

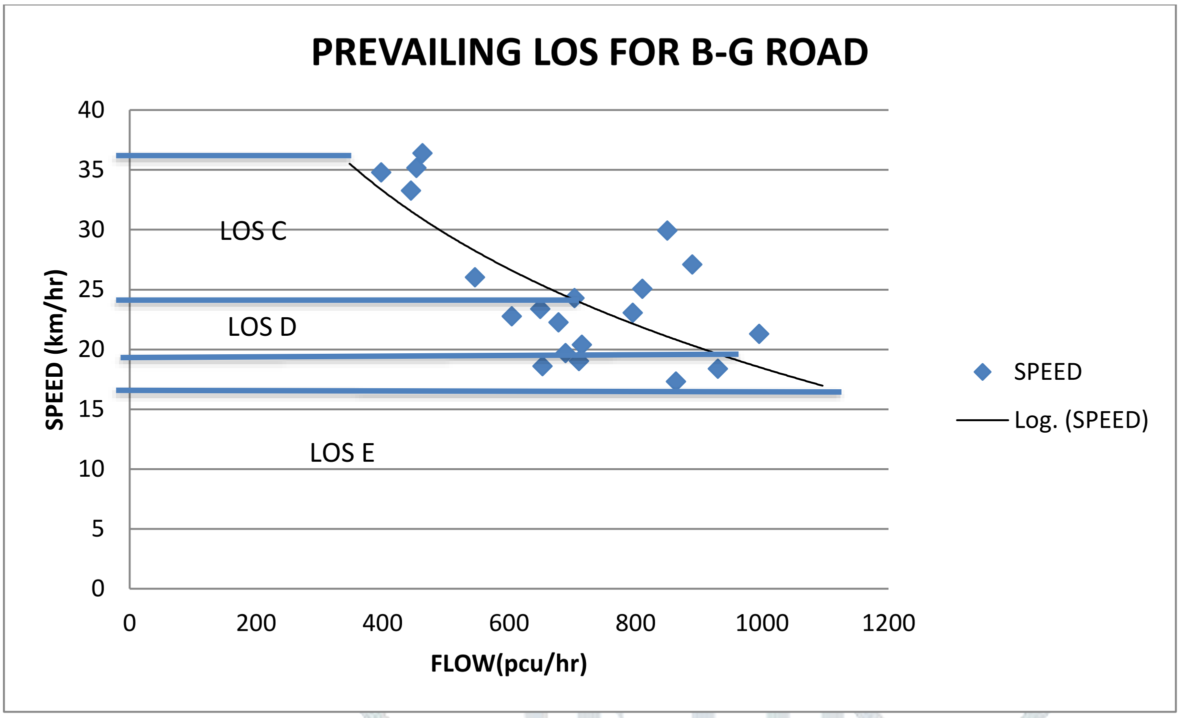
- Same is the scenario when Speeds corresponding to same flow levels for different RSFI Levels is compared taking flow range between 350 – 800 pcu/hr

Speed Range	RSFI Level
32 km/h to 36 km/h	Low
22 km/h to 28 km/h	Medium
18 km/h to 24 km/h	High

7.1 Impact of RSFI on Level of Service

The free flow Speed and the average Travel Speed were considered as measure of effectiveness for defining LOS.





Two speed flow curves representing operating condition each for section B-N and section B-S are shown above in which LOS regions have been marked.

Most of the region in case of section B-N lies under LOS C and some other in LOS D while a little lesser cover LOS and section B-S has same LOS as in B-N section. This clearly indicates the severe impact of Road Side Friction on ease to travel i.e. the Level of Service of the Road.

Conclusions

It can be concluded that the lesser concerned factors in the traffic which are the side friction causing elements have greatest impacts on the quality of travel. However, in many developing Asian countries including India, the range and intensity of such side friction is so great that these activities need to be incorporated explicitly into procedures for calculation of speed and capacity of road links. It is therefore evident that the impacts of side friction need to be taken into account in geometric design analysis as well as in pavement management analysis for many countries in Asia and especially in India. It has been shown that side friction can have effects on travel speeds in India especially in Ganderbal city, which indicated considerable effects like other commonly used factors in capacity analysis. This leads to the recommendation that highway capacity studies, particularly in the developing world, should include this variable, though in a form suited to their own particular circumstances.

Proper parking spaces and more importantly the proper enforcement of parking laws should be imparted. Areas with parking problems should be paid more emphasis at periods when the effect of side friction is the greatest.

It is recommended to further analyse the impact of individual friction causing element on the travel speeds using the prescribed procedures. It is thus recommended to conduct this study on a much larger scale including a wider range of all frictional components in order to account for much of the variation in the criterion variable. Similarly, larger scale-study would imply to include wider spectrum of facilities such as intersections, roundabouts, ramps and different terrains. It is likely that the effect of different friction factors would vary for different facilities and different terrains.

References

[1] Birva Shah, “Estimation of capacity for the arterial road of urban area”,VISSIM, IJIRT (May 2016).

[2] IinIrawati “Delay evaluation of impact of side friction on heterogeneous traffic towards road performance with VISSIM micro simulation”, VISSIM, IJERT (Feb 2015).

[3] Sherin George, “Effect of side friction on traffic characteristics of urban arterial”, www.civil.iitb.ac.in (2014)

[4] Karl L. Bang, “Impact of side friction on speed-flow relationship for rural & urban highway”, Regression model, HDM4 report (July 1995).

[5] Sudipta Pal & Sudip Roy “Impact of roadside friction on travel speed and LOS of rural highways in India, “Regression model, Springer (Nov 2015).

[6] Chinua M L. Sweden “Analysis of side friction impacts on urban road links. Case study, Dares-salaam”, Swedish National Road and Transport Research Institute (VTI), 2007, pp. 176.

[7] Highway capacity manual (2000), Transportation Research Board, National Research Council, Washington, DC.

[8] Indonesian Highway Capacity Manual (1997), Directorate General of Highways, Republic Indonesia, Jakarta