Journal of Transportation Systems

Volume-5, Issue-3 (September-December, 2020)

www.matjournals.com

Performance Measure Appraisal for Two-Lane Roads under Indian Traffic Condition

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ABSTRACT

The highway traffic condition in India mixed in nature with various types of vehicles. The plan area of vehicles, engine power of vehicles, and the percentage of various categories of vehicles also variation in two-lane rural roads. The study aims to estimate various performance measures of a two-lane road, and the relationship between performance measure with a total flow of two-lane undivided rural road and find the appropriate performance measure of a two-lane road. Study conducted at different places in India including NH and SH. Followers on rural highways identify based on the procedure of INDO HCM-2017. Critical gap values for site-I and site-II 4.9 sec and 2 sec respectively. The number of followers as a proportion capacity (NFPC) has the R^2 value 0.80 with flow. NFPC and FD are 1st best and 2nd best parameter for Indian two-lane rural roads.

Keywords-- Two-Lane Road, Speed Differences, Performance Measure, Heterogeneous Traffic, Gap

INTRODUCTION

Two-lane roads play a main role in the transportation arrangement of developing countries like India. Two-lane unlived roads are considered two-way traffic. Two-lane roads are considered traffic of up direction and down direction with no barrier in the carriageway and different types of vehicles on a two-lane road. Two-lane roads in India have carriageway dimension more or less approximately 7m. So, each lane of the two-lane road dimensions generally more or less approximately 3.5m. Various vehicle operations in two-lane roads are low due to less traffic volume. Due to less traffic flow speed achievement of various categories of vehicles on the two-lane road good compare to other categories of roads [1]. The whole categories of vehicles of two-lane road convert into standard unit small cars. IRC [2], provide information of capacity estimation of rural road in India. Capacity estimation based on speed and volume relationship of rural highway. Al-Kaisy A et al. [3], have been conducted a study based on an indicator of the performance of the two-lane rural road. Penmetsa P et al. [4], have been conducted a study developed LOS criteria based on NFPC and flow of rural road. Three study locations are selected including national highway and state highway of India including the relationship of six performance measures with two-way traffic. Study of two-lane road based on follower of dual-lane road and not following vehicles. Critical gap value found for two-lane road 2.4 sec based on study. And NF father modify with capacity and introducing new parameter NFPC. NFPC have strong relation with the flow of two-lane road under heterogeneous traffic condition. LOS criteria propose based on the relationship between NFPC and PF. Boora A et al. [5], have been examined good measures for define LOS of the 2-lane road under varied traffic situation of India. A study conducted at five different locations and free-flow speed of vehicle determine on roads based on gap values 8 to 10 sec. Critical gap values for NH 47, NH 58, SH 31, SH 59 are 1.9 sec, 3sec, 3.7 sec, 3.4 sec, 4.3 sec respectively. Among all this speed-related performance measure a less sensitive relationship with two-way flow compare to other factors, Follower related performance measures are best. Boora A. et al. [6], Study carried out for estimation of free moving gap of vehicle, define LOS, and developed a relation between FD and NFPC. Equation between FD and NFPC has a correlation value of 0.9889. In this study also comparison of LOS range based on PTSF and NFPC. To identify follower new methodology based on new concepts with the help of speed differences and gap. SD range between -5 km/h to +11 km/h with gap 10sec. In this study four variables used like FD, PF, NF and NFPC. FD and NFPC are the good variable compare to other measures. CSIR-CRRI [7], developed based on various past research of Indian rural highways like (P. Penmesta et.al 2015, A. Boora et al. 2016) [4-6].

RESEARCH OBJECTIVES

Any field of research need is an important part of research. Developed country have own procedure for a range of level of service of a two-

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lane road, but developing countries like India depends on the manual of a developed country. IRC-64 considers methodology for capacity estimation of two-lane road but not consider methodology for a level of service (LOS) estimation of a rural road. INDO-HCM 2017 considers methodology for LOS estimation based on few researches of India like (P. Penmesta et.al 2015, A. Boora et al. 2016, 2017) [4-6]. Objectives of the study for performance measure of two-lane road under mixed traffic condition are represented below:

1. To estimate various traffic features of two-lane road under varied traffic situation.
2. To estimate the capacity values and Passenger car equivalent (PCU) values under dissimilar categories of vehicle on the dual-lane highways.
3. To determine various performance measures of two-lane roads with various categories of vehicle and base condition of the road.
4. To determine R^2 between performance measure and flow of two-lane road under base condition.

METHODOLOGY

For identification of good variable of two-lane rural highway, first to identify what is the problem in rural highways. Then the next step is to improve knowledge of the condition of rural highways with the help of various literatures. Then select sites for data collection. After data collection extraction of data in AVIDE-MUX 2.6 software and estimate PCU, capacity. Then approximation of various performance indicators then analysis of various variables of rural highway detailed methodology for the study shown in Fig. 1 below flow chart.

FIELD DATA COLLECTION

The study is carried out on the two-lane highways of mid-block section with more than 500m no influence of any activity. Two study sites considered for the study of performance measure. One is Atladra to Anand (NH228) and another is Kothariya to Gondal (SH122) Study site consider 7.5 m carriageway width, and 1.5m paved shoulder both sites with total width of road 10m.

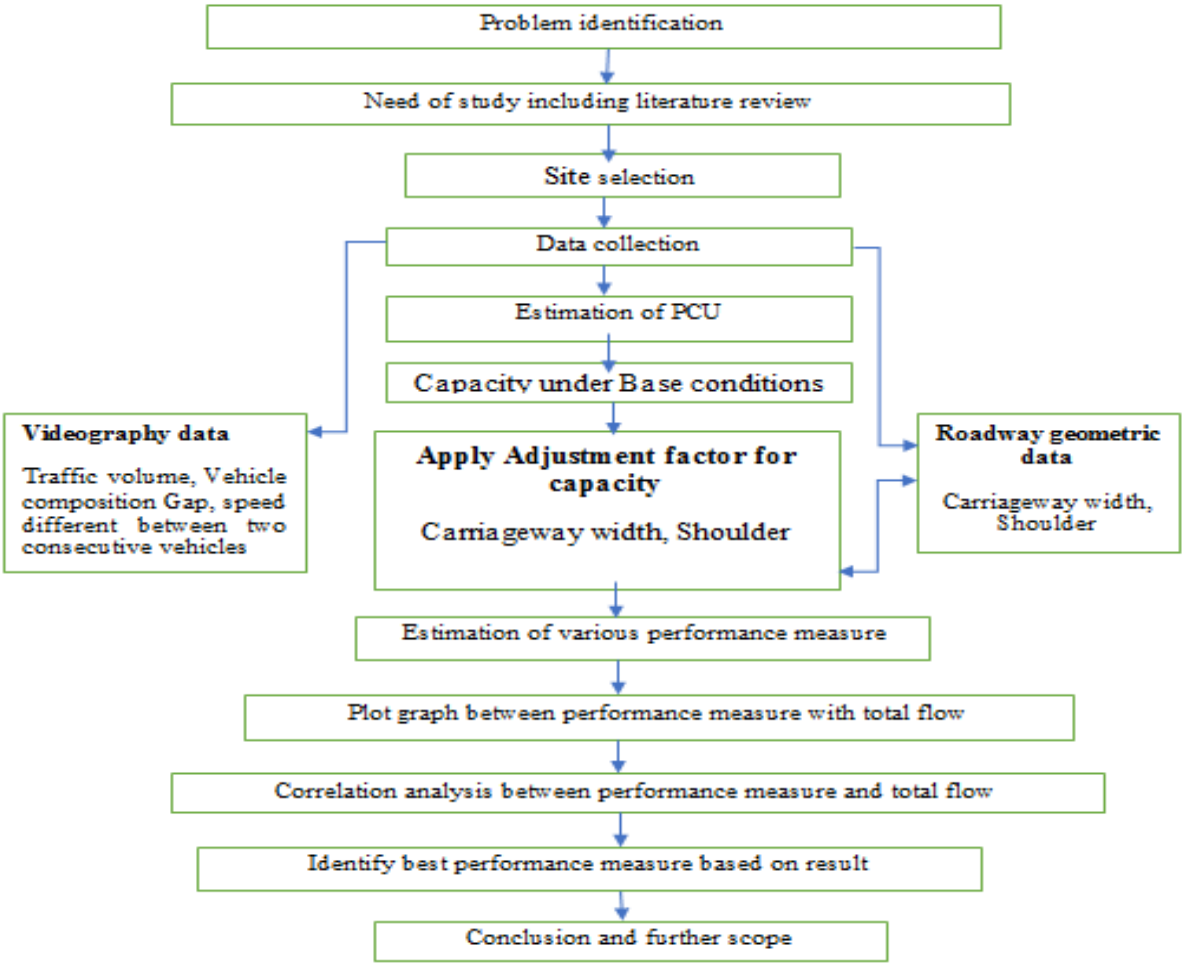
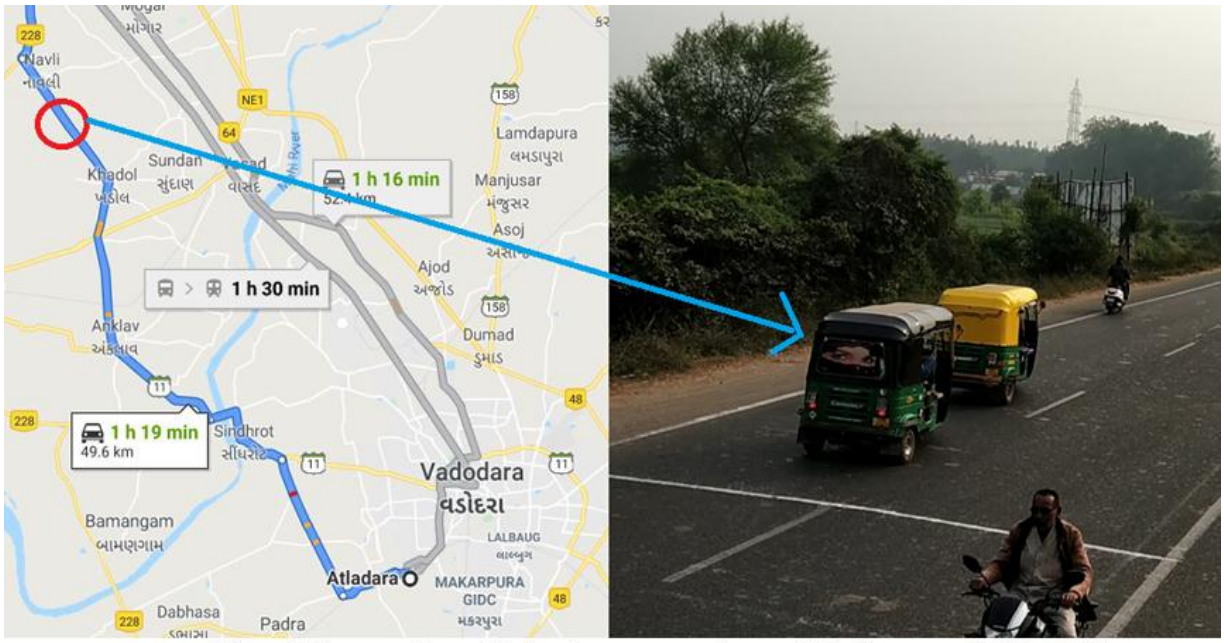
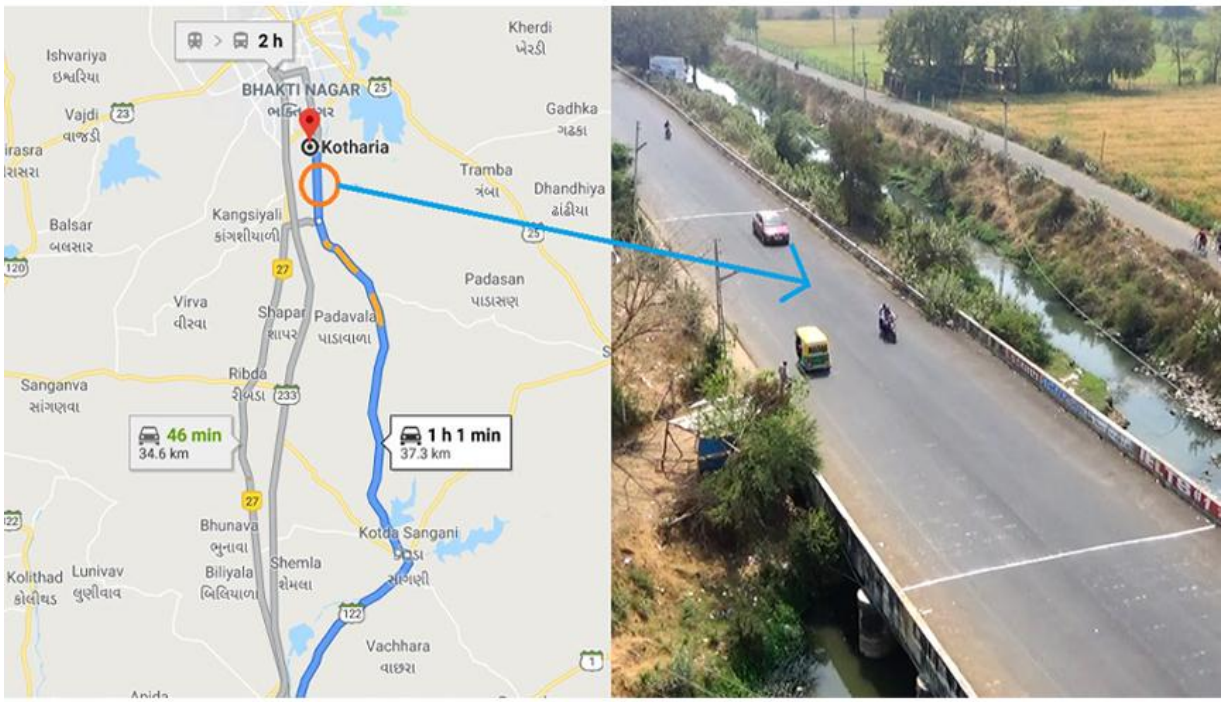


Figure 1: *Methodology Flow Chart.*

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Site-I Anand to Vdodara two lane highway (NH-228)



Site-II Rajkot to Gondal two lane road (SH-122)

Figure 2: *Site location.*

For estimation of various performance measure of two-lane intercity highway require data of traffic volume and composition of various categories of vehicle and speed data of individual category of vehicle, and speed differences between two successive vehicles and gap value between two successive vehicle travel in the same lane. Various preliminary surveys conducted at the site location for the study. Preliminary survey for primary information of geometric data, number of lanes, pavement condition, no horizontal curve, no vertical curve, and no influence of intersection. Data of video-grapy collected at smooth moving vehicles section of dual-lane undivided road under varied traffic conditions. Speed and traffic volume conducted at throughout 500m, but 500m data not cover in camera, so mark line 60m at mid-block section of the two-lane road and conducted data. Traffic volume study is carried out for 4 to 6 hours on two-lane roads. The traffic volume survey

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conducted in normal working days in light hours. Site condition-1 located at Anand to Atladra near Vadodara city upward direction consider from Anand city to Atladra and downward direction from Atladra to Anand city. Site condition-2 select from Kothariya near Rajkot city to gonadal. In site-2 upward direction considers from Katharina to Gondal and downward direction from Gondal to Kothariya.

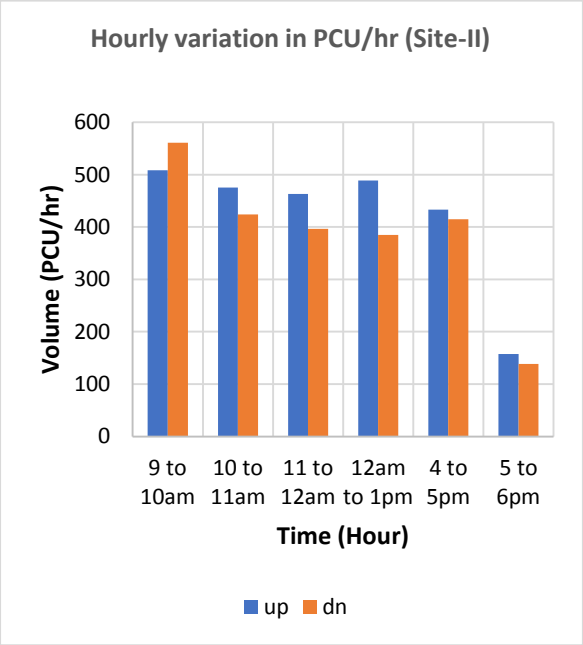


Figure 2(a): *Hourly variation in PCU/hr (Site-I).*

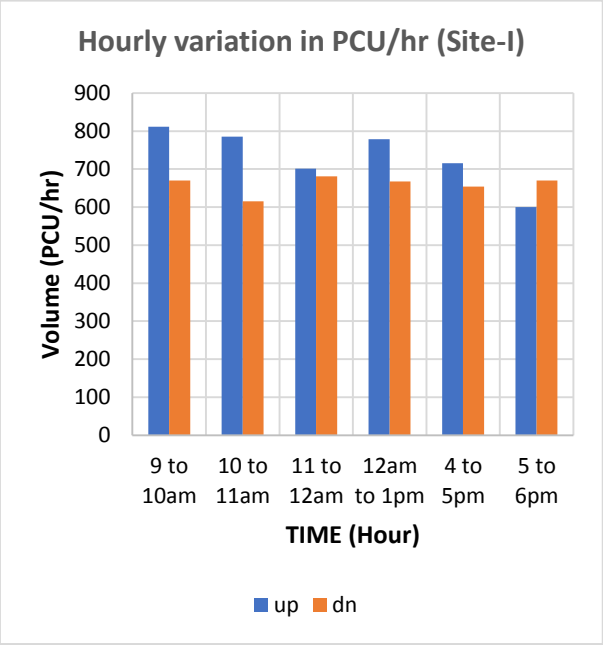


Figure 2(b): *Hourly variation in PCU/hr (Site-II).*

Table 1: *Composition of various categories of vehicle.*

Site	%2W	%AR	%BC	%BUS	%LCV	%SC	%TRUCK	%TRAC
NH-228	55.41	14.48	4.85	1	3	18.29	2.14	0.77
SH-122	68.57	10.65	2.39	1.18	3.38	12.04	1.1	0.66

Spot speed of individual category of vehicle measure for the study with the line laying 60m and time interval. Data of spot speed divided in 5 minutes interval from video grapy technique. The free-flow speed of small car considers 85th percentile speed. Table 2 and 3 shows the variation in speed on site-1 and site-2.

Table 2: *Speed of different categories of vehicle (Site-1).*

Time	2W Speed (Km/hr)			AR Speed (Km/hr)			4W car Speed (Km/hr)		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
9:00am to 10:00am	49	37	40	41	32	37	70	42	50
10:00am to 11:00am	47	38	41	40	35	38	55	34	47
11:00am to 12:00am	48	30	40	41	35	39	65	32	45
12:00am to 1:00pm	46	31	39	43	33	38	55	36	45
4:00pm to 5:00pm	46	31	39	43	34	38	55	36	45
5:00pm to 6:00pm	51	31	41	51	35	43	52	36	43

Table 3: *Speed of different categories of vehicle (Site-II).*

Time	2W Speed (Km/hr)			AR Speed (Km/hr)			4W Speed (Km/hr)		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
9:00am to 10:00am	45	39	42	41	36	39	55	38	47
10:00am to 11:00am	48	39	44	45	38	40	52	45	49
11:00am to 12:00am	51	40	42	45	37	40	64	42	50
12:00am to 1:00pm	48	40	44	48	37	41	60	43	52
4:00pm to 5:00pm	50	31	42	47	35	42	71	42	52
5:00pm to 6:00pm	50	38	44	46	38	42	61	42	54

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ESTIMATION OF CAPACITY

To convert varied traffic of vehicles to similar traffic of vehicles by Chandra et al. [1]. For individual categories of vehicle covert into standard small car by speed and area value. PCU value estimated by;

$$PCU = \frac{Vc/Vy}{Ac/Ay}$$

Vc = Speed of small car (km/hr);
Vy = Speed of vehicle type 'y' (km/h);
Ac = Projected rectangular area of a small car (m^2);
Ay= Projected rectangular area of vehicle type 'y' (m^2);

Table 4: *PCU values of different classes of vehicle.*

Type of Vehicle	Average (PCU)	Variance	Std. deviation
2W	0.265127	0.001192	0.034524525
AR	1.034169	0.010935	0.104570657
BC	1.551439	0.039508	0.198767414
BUS	3.913826	0.613609	0.783331771
LCV	2.963782	4.785388	2.187552927
TRUCK	4.385041	1.230394	1.109231395
TRAC	2.962862	0.988964	0.99446669

Capacity of two-lane road under mixed traffic condition measure with the help of speed-flow relationship. Data of traffic volume and speed of 5 min interval use to plot speed flow relationship. Green shield model fitted for curve plotting for capacity estimation. Base capacity of two-lane road identifies and capacity of road changes with changes carriageway width and shoulder width of road. So, the base capacities of road multiply by a correction factor of carriageway width, shoulder, and traffic movement up and down direction. Show speed flow curve for site-1, 2 in Fig. 4(a) and (b).

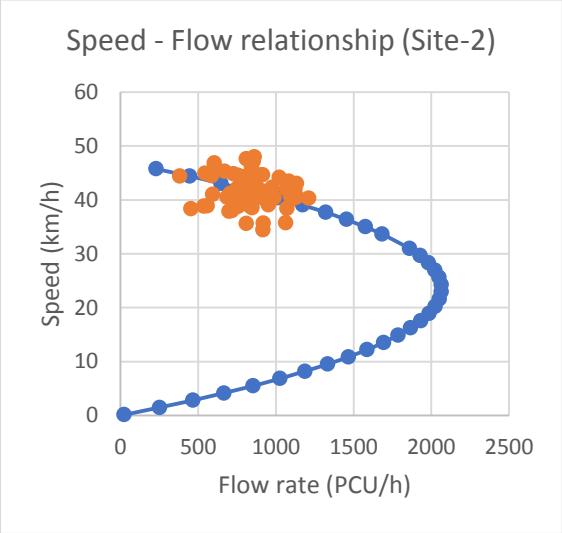


Figure 4(a): *Speed – Flow curve (Site-1).*

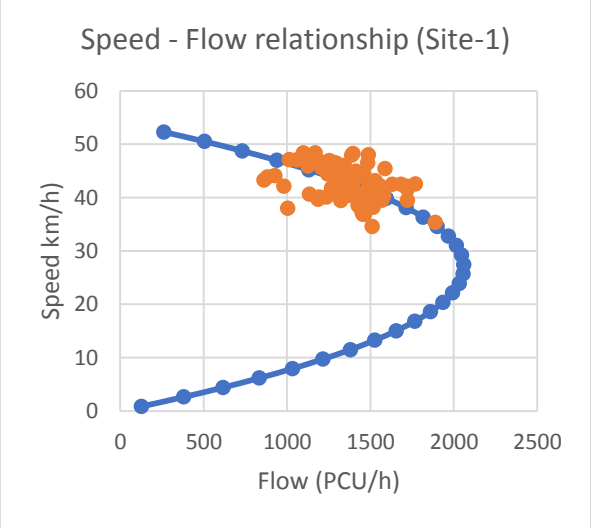


Figure 4(b): *Speed – Flow curve (Site-I1).*

Table 5: *Capacity and FFS of PC.*

Site	Base capacity	Adjustment CW	Adjustment SW	Adjustment Dire.	Adjustment Capacity	FFS PC
1	2060 PCU/h	1	1.33	1	2740 PCU/h	55 km/h
2	2064 PCU/h	1	1.33	1	2745 PCU/h	59.9 km/h

PERFORMANCE MEASURES FOR TWO-LANE HIGHWAY

Various types of data used to determine the performance measure of rural roads like video-grapy extraction data, roadway geometric data. The performance assessment procedure is very complex under the varied traffic conditions of Indian roads.

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Speed Related Performance Measures

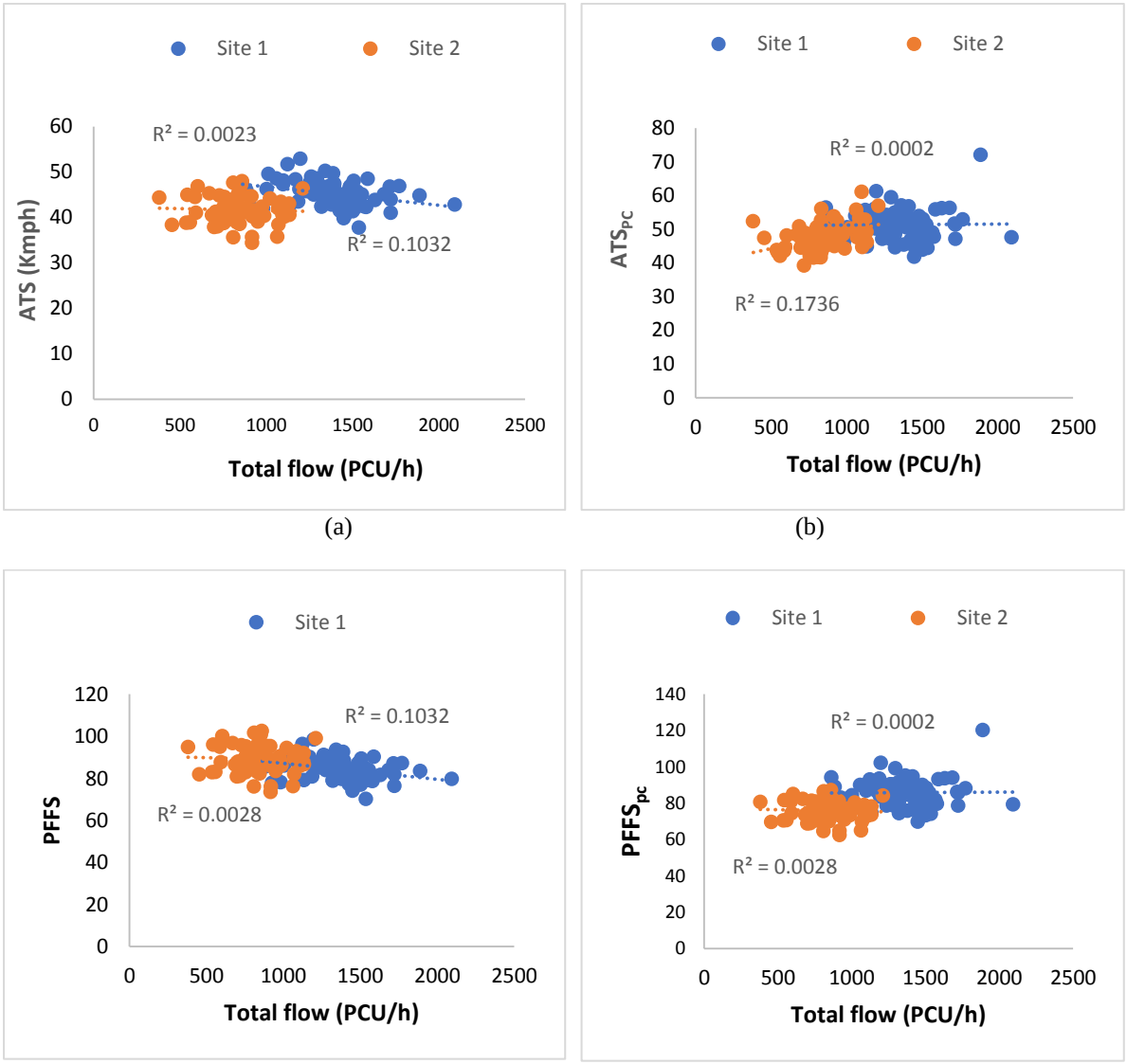


Figure 5: *Speed related performance measures relation with traffic volume.*

Speed related performance measure estimate with the help of 5 min interval speed. 5min interval speed estimate by video data extraction. Average travel speed (ATS), Average travel speed of passenger car (ATS_{PC}), Percent free-flow speed (PFFS), Percent free-flow speed of small car ($PFFS_{PC}$) relation with total flow shown in Fig. 5.

Follower Related Performance Measures

Follower related performance measure estimate with the help of gap and speed different data consecutive vehicle. Percent follower (PF), Number of followers (NF), Follower density (FD), Number of follower proportion capacity (NFPC) are measure with the help of speed differences and gap values on a two-lane road. Speed differences for site-1 -7.5 km/h to +7.5 km/h and for site-2 -5 km/h to +5 km/h to +5 km/h and critical gap estimation at %50 not following vehicle. Not following vehicle estimate with the help of gap more than 8sec to 10-sec gap values. Followers in two-lane road identify for individual lane. Follower vehicle affects the whole traffic stream if a follower of the two-lane road is more then level of service of the two-lane road is low and follower of two-lane road low then the level of service of the two-lane road is high. Follower of two-lane road inversely proportional to the level of service of a two-lane road. The critical gap value for site-1 is 4.9 sec and for site-2 2 sec. Follower related factor of two-lane road under mixed traffic and total flow plot shown in Fig. 6.

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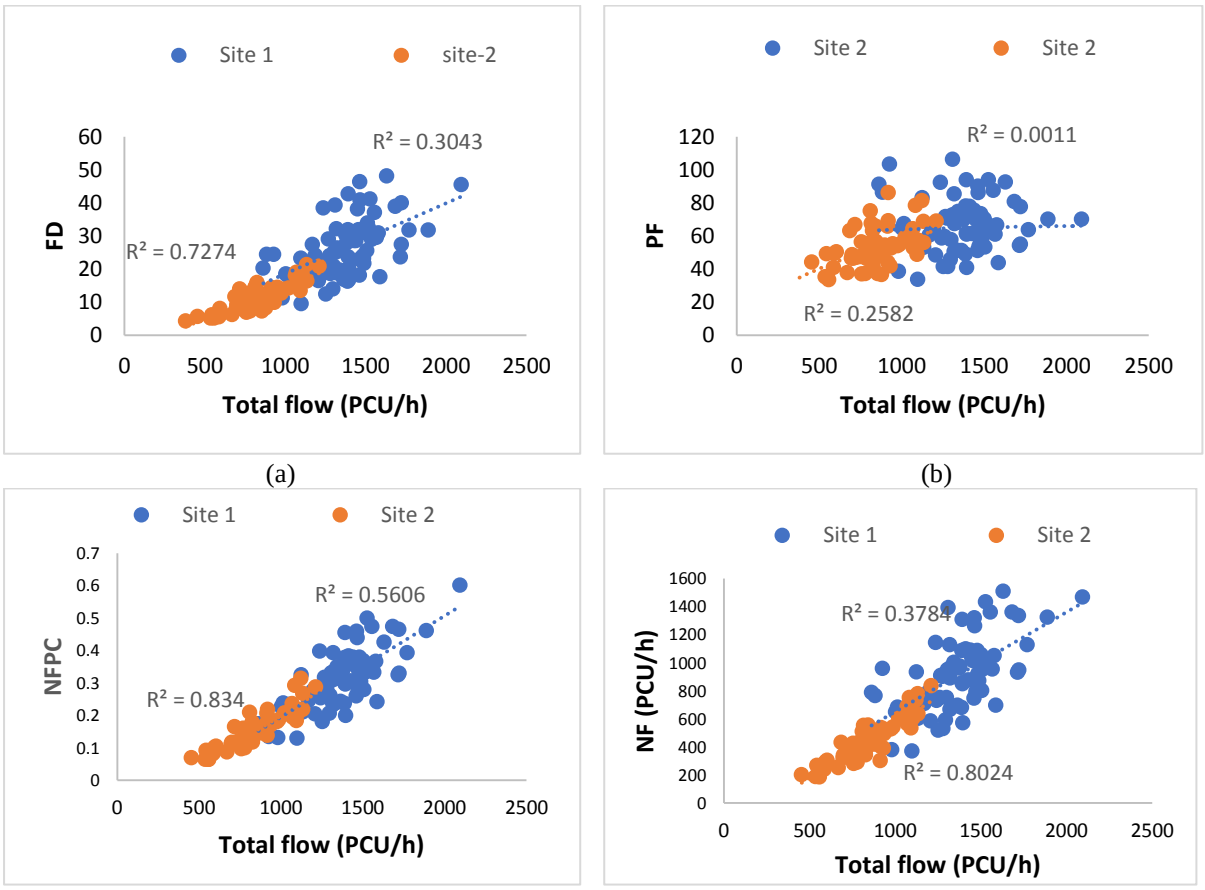


Figure 6: *Follower related performance measures relation with traffic volume.*

Shown in Fig. 6(d) NFPC has a better relationship with two-way flow compare to other variables based on R- square values. NFPC value on two-lane road for site-1 and site-2 R^2 value 0.56 and 0.83 respectively.

Table 6: *Regression analysis result of performance measure.*

P.M.	Best fit	R^2	t-stat intercept	t-stat flow
ATS	ATS = 0.00032*volume+39.87	0.1	41.47	4.011
ATSpc	ATSpc = 0.0058*volume+43.10	0.16	33.02	5.25
PFFS	PFFS =-0.0078*volume+95.38	0.17	55.97	-5.43
ATS_{PC}/FFSpc	ATSPC/FFSpc = 0.0120*volume+67.55	0.229	30.62	6.43
NF	NF = 0.7920*volume-181.34	0.68	-3.37	17.35
PF	PF = 0.01956*volume+38.54	0.18	9.4	5.625
FD	FD = 0.02572*volume-9.40	0.709	-5.63	18.16
NFPC	NFPC = 0.00029*volume-0.0941	**0.80***	-6.5	24.1

Table 7: *R-Square value between performance measures and platooning variables for each site.*

Performance Measure	Two-way Volume	
	NH 228	SH 122
ATS	0.0023	0.1032
ATS_{PC}	0.0002	0.1738
PFFS	0.1032	0.0028
$PFFS_{PC}$	0.0002	0.0028
PF	0.0011	0.2582
NF	**0.3043**	**0.7274***
FD	**0.3784**	**0.8024***
NFPC	**0.5606**	**0.834***

CONCLUSION

This study is based on the approximation of the good performance variable of two-lane roads. The outcomes of the study are shown below:

1. The parameter prompting the speed of various categories of vehicles found out like traffic volume data for two-lane and single lane the composition of various categories of vehicles on a two-lane road, the density of various categories of vehicles.
2. Site-1 two-wheeler and small car composition are 55.41% and 18.29% respectively and for

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site-2 two-wheeler and small car composition are 68.57% and 12.04% respectively.

3. The base capacity of the two-lane road identifies with the help of a speed flow curve. For site-1 and site-2 2060 pcu/h and 2740 pcu/h and adjustment capacity of two-lane roads are 2064 pcu/h and 2745 pcu/h respectively.
4. Various performance measures of two-lane road found out and the relationship of performance measure with total flow found out and best suitable performance measure NFPC with R^2 value for site-1 and site-2 0.56 and 0.83 respectively.
5. ATS, $ATS_{pc,}$ PFFS, $PFFS_{pc,}$ have a poor relationship with the total flow. NFPC, FD have 1st best and 2nd best parameter because NFPC and FD have R^2 value for Site-1 0.56 and 0.37 respectively and for Site-2 0.83 and 0.80 respectively.

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