Study on the Relationship Between Speed and Flow for Highway Traffic Management

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Abstract - The problems associated with mixed traffic conditions on urban streets in developing countries are distinct and complex. Pedestrians, bicycles, buses, cars, motorcycles, auto-rickshaws, and various other modes share the same roadway space, creating operational inefficiencies that negatively impact mobility and reduce the economic productivity of urban areas. Rapid growth in motor vehicle ownership has further intensified congestion, making traffic flow management more challenging than ever. Understanding fundamental traffic flow characteristics—particularly the relationships between speed, flow, and density—is essential for effective planning, design, and operation of urban transportation systems. Traffic flow theory provides the analytical framework for quantifying these relationships under varying roadway and traffic conditions. Although numerous models have been proposed by researchers worldwide, many exhibit limitations when applied to heterogeneous traffic environments dominated by non-lane-based movement. In this study, mathematical models describing the speed–flow relationship under mixed traffic conditions were developed for selected urban corridors in Vijayawada city. Using detailed field observations, speed–flow equations were formulated, and the capacity of each road section was subsequently estimated. The findings offer valuable insights for urban traffic management, roadway capacity evaluation, and strategic planning in cities experiencing heterogeneous traffic patterns.

Key Words: Mixed traffic, Heterogeneous conditions, Speed–flow relationship, Roadway capacity, Urban traffic management, and non-lane-based movement.

1. INTRODUCTION

1.1 General

Mixed traffic conditions on urban streets in developing countries present unique and persistent challenges. A wide range of users, including pedestrians, bicycles, buses, cars, motorcycles, auto-rickshaws, and other intermediate transport modes, share limited roadway space, resulting in inefficient mobility and reduced economic productivity. Rising motor vehicle ownership has aggravated congestion levels, making traffic management increasingly complex. Therefore, a thorough understanding of fundamental traffic flow characteristics, supported by analytical techniques, is essential for effective planning, design, and operation of transportation systems.

1.2 Urban Transport Scenario in India

Urban transport forms a critical component of urban infrastructure, significantly influencing the operational efficiency of large cities. Inadequate transport systems hinder economic growth and contribute to urban deterioration. Current traffic and transportation inefficiencies in Indian cities result in annual losses exceeding ₹20,000 crores, primarily due to increased travel time and higher vehicle operating costs. Rapid population growth has intensified pressure on urban transport networks, creating a widening gap between travel demand and available capacity.

Peak-hour crowding, such as Mumbai's suburban trains carrying over 4,000 passengers against a desirable capacity of 2,600, reflects severe congestion issues. While metropolitan cities require nearly 80 million daily trips, existing systems cater to only about 37 million. With increasing per capita mobility, trip lengths, and vehicle ownership—projected two-wheeler and car ownership of 393 and 48 per 1,000 population by 2021—the demand on transport infrastructure will rise substantially without adequate expansion of mass transit.

1.3 Mixed Traffic Situation – Problems

Urban traffic in India is highly heterogeneous, consisting of vehicles with wide variations in speed, size, and maneuverability. Slow-moving units, such as hand carts and animal-drawn vehicles, reduce roadway capacity, cause delays, and increase operational costs. The absence of lane discipline, frequent interruptions, and high pedestrian activity further increase conflict points, leading to congestion and accidents. Studying mixed traffic flow in the field is challenging; hence, appropriate modeling is required to replicate real-world interactions and analyze speed, flow, and headway behavior under heterogeneous conditions.

1.4 Need for the Study

Understanding heterogeneous traffic behavior is essential for planning and optimizing urban road networks. Speed–flow relationships are vital tools used in capacity estimation, level-of-service analysis, and travel-cost evaluation. Developing models tailored to mixed traffic conditions provides a better understanding of roadway performance.

1.5 Objectives of the Study

1. Develop mathematical models for speed, flow, and headway under mixed traffic conditions.
2. Determine traffic flow characteristics using volume, speed, and flow data from selected roads in Vijayawada city.
3. Establish speed–flow relationships and estimate roadway capacity for heterogeneous traffic.

2. LITERATURE REVIEW

2.1 General

Speed is a fundamental indicator of traffic performance on highway systems and serves as a key output variable in analytical and simulation-based traffic models. Because vehicle interactions—such as overtaking, following behavior, and lateral movements—are highly sensitive to speed, accurate representation of speed characteristics is essential for developing realistic simulation programs. Under homogeneous traffic conditions, vehicle speed data generally follow a normal distribution. However, in heterogeneous traffic systems, as seen in India and other developing countries, the presence of both fast-moving (cars, buses, motorized two-wheelers, auto-rickshaws) and slow-moving modes (cycles, rickshaws, animal-drawn carts) introduces wide variations in operating speeds. This causes the speed distribution to deviate from a standard unimodal normal pattern, often resulting in bimodal or multimodal distributions. Understanding these variations is crucial for analyzing traffic performance and developing robust models of traffic flow.

2.2 Speed–Flow Modeling

Several researchers have investigated the speed–flow relationship under various traffic conditions. Raichur (1996) analyzed speed–flow characteristics on NH-8 using the moving-car observer method and concluded that rapid industrial development along the corridor reduced stream speeds with increasing traffic flow. Hurdle (1997) demonstrated that for individual lanes, mean speeds can be modeled effectively using linear functions, while cubic functions offer improved accuracy over a wider range of flows. Dowling (2004) refined the Bureau of Public Roads (BPR) speed–flow curves, recommending higher power functions to capture speed sensitivity near capacity. Although accurate, the updated BPR curves significantly increased computation time. Akçelik (2004) proposed an alternative speed–flow model based on queueing theory, which offers better predictions of congestion effects and more efficient model performance. Studies focused on mixed traffic further highlighted the complexity of heterogeneous flow. Minh (2005) developed motorcycle equivalency factors (MCU) considering vehicle dynamics, while weighted stream speed models were used to capture variations across vehicle classes. Findings emphasized that traffic composition, lane discipline, and roadway configuration have a substantial influence on stream speed and capacity. Research by Dey (2006) introduced the "spread ratio" to distinguish between unimodal and bimodal speed distributions under mixed traffic. Porter (2007), Hao Wang (2007), and Zhao Yi Huang (2008) examined factors such as work-zone geometry, speed dispersion, and bottleneck location, demonstrating their influence on speed–flow behavior.

2.3 Headway Modeling

Time headway—the time gap between consecutive vehicle arrivals—is a key microscopic traffic characteristic influencing safety, driver behavior, level of service, and roadway capacity. Under low-flow conditions, vehicle arrivals are random and well represented by the Poisson process, as demonstrated by early studies of Kinzer (1933) and Adams (1933). With increasing flow, interactions intensify and headway become more uniform, leading researchers to apply shifted exponential, composite, gamma, binomial, and negative binomial models for medium to high volumes. Several studies (Katti et al., Ramanayya, Pathak) have identified suitable distributions for different traffic ranges, especially under mixed traffic conditions. The M3 distribution proposed by Cowan and later refined by Hagring and Luttinen gained prominence due to its simplicity and suitability, where accurate modeling of short headways is unnecessary. Indian studies (Thamizh Arasan, Chu Cong Minh) highlighted the effect of heterogeneous traffic and two-wheeler dominance, supporting the use of a negative exponential distribution across a wide range of flows.

2.4 Modeling Heterogeneous Traffic

Sarosh I. Khan (1999) emphasized that heterogeneous traffic flow is governed by roadway geometry, prevailing operational conditions, and the diverse static and dynamic characteristics of vehicles. In mixed traffic, faster vehicles often follow slower and wider vehicles, creating unique decision-making situations for overtaking, lane changing, and passing, which in turn influence macroscopic relationships such as speed, flow, and density. To address limitations in data collection under such conditions, Mallikarjuna (2009) developed TRAZER, an offline video-based image processing system capable of detecting, tracking, and classifying vehicles without assuming lane discipline. It performs reliably even under dense conditions with up to 30% occlusion, providing both macroscopic parameters (flow, speed, occupancy) and microscopic data (trajectories, spacing). Partha Pratim Dey (2008) estimated the roadway capacity for individual vehicle categories—such as two-wheelers, three-wheelers, heavy vehicles, and tractors—and proposed a composition-based capacity equation to evaluate total mixed-traffic capacity, enabling more realistic assessment of heterogeneous traffic performance.

2.5 Summary

Mixed or heterogeneous traffic consists of fast- and slow-moving, motorized and non-motorized vehicles with significant variations in size, maneuverability, and dynamic characteristics. Urban conditions further complicate traffic flow due to the presence of pedestrians, roadside activities, parking, and narrow roadways. Several researchers have developed models to describe speed–flow relationships, with cubic equations often performing better than linear forms. Speed data frequently exhibits normal distribution, while bimodality can be identified using parameters such as the spread ratio. Headway studies depend strongly on the degree of heterogeneity, and video-based data collection is preferred for accuracy. Literature indicates three flow regimes—low, high, and intermediate—each suited to different headway distributions. Methods developed for homogeneous traffic cannot be directly applied to heterogeneous traffic due to its diverse composition and behavior.

3. METHODOLOGY

3.1 General

This chapter explains the overall methodology adopted in the study. The step-by-step procedure followed is illustrated in the flow chart shown in Figure 1. Seven major stages were identified, beginning with the selection of study sections and progressing through data collection, extraction, analysis, model development, and final summarization. Each step is described in the following subsections.

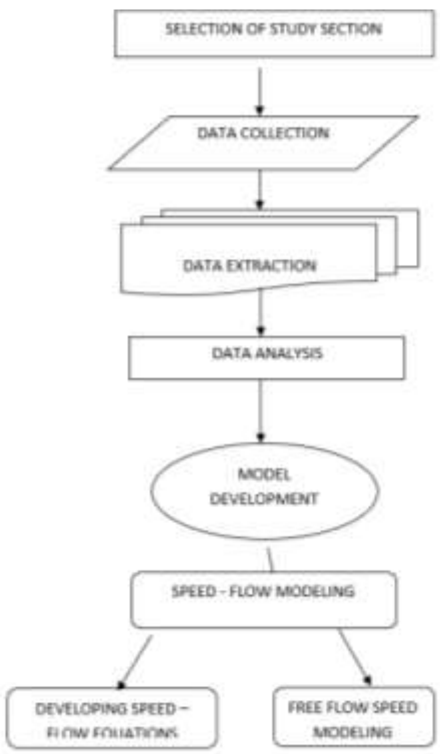

Figure 1. Flow chart showing study methodology

3.2 Selection of Study Sections

Study stretches were selected to represent realistic mixed-traffic conditions. Road sections were required to be straight, level, free from intersection influence, and have smooth pavements with uniform width. Locations with parking, pedestrian activity, or nearby bus stops were avoided. Based on these criteria, three four-lane divided road stretches in Vijayawada were chosen: Benz Circle Area, the IGMC Stadium stretch, and the Chuttugunta Junction corridor.

3.3 Data Collection

Traffic volume, spot speed, mean speed, and time headway data were collected through manual counts, radar gun measurements, and registration methods over six hours daily from June 18 to 30, 2025.

3.4 Data Extraction

The data collected were compiled and processed using Microsoft Excel.

3.5 Data Analysis

Traffic volumes were converted to PCUs, speed–flow graphs were developed, and normality tests were applied to speed data using chi-square methods.

3.6 Model Development

Speed–flow relationships, capacity estimates, free-flow speeds, percentile speeds, and headway-based flow levels were developed.

3.7 Summary

The methodology and subsequent steps form the basis for the results presented in later chapters.

4. DATA ANALYSIS

4.1 General

The field studies, their locations, and data collection methods have been outlined in the previous chapter. The traffic data obtained from each site were processed to classify vehicle types, extract relevant variables, and establish speed–flow relationships for different categories. The analysis also involved determining free-speed distributions and headway characteristics. All selected sites were urban mid-block road sections with good geometric standards and level terrain, ensuring uniformity in traffic behavior and data reliability.

4.2 Traffic Volume

Traffic volume is the most fundamental traffic parameter and is extensively used in planning, design, control, and operational assessments. Urban traffic in India typically represents a heterogeneous mix of motorized and non-motorized modes. Literature indicates that at low traffic volumes, movements tend to be random, speeds remain high, and headways follow a negative exponential distribution. As traffic flow increases, vehicle interactions intensify, resulting in reduced speeds. At all four study locations, traffic volume was recorded for six hours (9:00 AM–12:00 PM and 2:00 PM–5:00 PM), with each hour subdivided into 15-minute intervals.

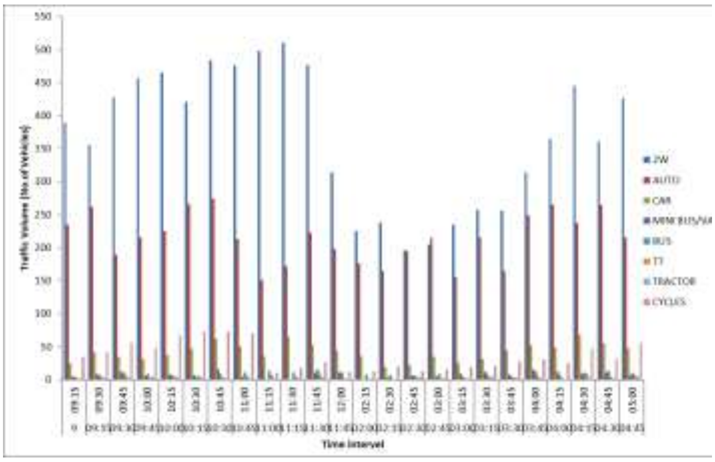

Figure 2. Traffic volume of different types of vehicles in 15-minute intervals at the Benz Circle Area

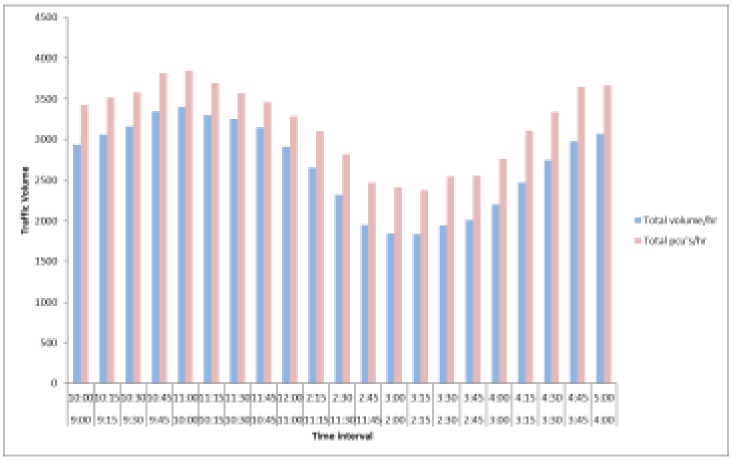

Figure 3. Hourly traffic volume at Benz Circle Area

Table - 1: Traffic volume and composition at Benz Circle Area

FROM	TO	2W	AUTO	CAR	MINI BUS/VAN	BUS	TT	TRACTOR	CYCLES	Total volume/15min	Total volume/hr	Total pcu's/15 min	Total pcu's/hr	(pcu's/15min)*4
PCU Values		0.75	2	1	1.4	2.2	2.2	4	0.4					
9	09:15	389	235	25	5	4	2	1	35	696		825		3300
09:15	09:30	356	262	42	8	8	4	3	42	725		899		3598
09:30	09:45	428	189	35	12	11	7	2	56	740		821		3283
09:45	10:00	456	215	32	6	9	3	5	49	775	2936	878	3424	3514
10:00	10:15	465	225	37	8	7	5	4	67	818	3058	916	3515	3665
10:15	10:30	420	266	47	7	5	6	3	73	827	3160	969	3585	3877
10:30	10:45	484	274	62	16	9	3	1	73	922	3342	1055	3819	4220
10:45	11:00	476	213	50	5	11	5	1	70	831	3398	907	3848	3629
11:00	11:15	498	151	36	0	14	7	1	10	717	3297	766	3697	3063
11:15	11:30	510	172	65	0	11	5	2	18	783	3253	842	3570	3368
11:30	11:45	477	223	53	11	16	8	3	27	818	3149	948	3463	3791
11:45	12:00	314	198	44	11	11	2	1	12	593	2911	728	3284	2913
02:00	02:15	225	176	36	0	8	1	0	13	459	2653	582	3100	2327
02:15	02:30	238	165	19	3	7	0	0	20	452	2322	555	2813	2220
02:30	02:45	196	195	23	6	6	3	4	13	446	1950	609	2475	2438

02:45	03:00	205	215	35	5	9	2	2	16	489	1846	664	2411	2657
03:00	03:15	235	156	26	9	4	1	1	19	451	1838	549	2378	2198
03:15	03:30	257	215	32	12	8	4	5	21	554	1940	726	2550	2905
03:30	03:45	256	165	45	8	5	3	3	28	513	2007	619	2559	2476
03:45	04:00	314	249	52	15	12	5	2	31	680	2198	864	2759	3457
04:00	04:15	365	265	49	12	6	2	0	25	724	2471	897	3107	3589
04:15	04:30	445	237	68	9	11	9	2	47	828	2745	959	3340	3837
04:30	04:45	361	264	55	11	14	5	1	32	743	2975	928	3648	3711
04:45	05:00	426	215	48	7	10	7	4	56	773	3068	883	3667	3532

Table - 2: Traffic volume and composition at Near IGMC Stadium

FROM	TO	2W	AUTO	CAR	MINI BUS/ VAN	BUS	TT	TRACTOR	CYCLES	Total volume/15min	Total volume /hr	pcu's/ 15min	pcu's/ hr	(pcu's /15min)*4
PCU Values		0.75	2	1	1.4	2.2	2.2	4	0.4					
9	09:15	45	35	8	5	9	12	4	15	133		187		748
09:15	09:30	52	48	10	9	8	14	1	18	160		217		869
09:30	09:45	49	53	8	13	11	15	3	21	173		247		986
09:45	10:00	62	49	11	7	5	11	5	16	166	632	227	878	908
10:00	10:15	58	65	15	6	5	13	0	18	180	679	244	934	975
10:15	10:30	72	78	12	2	7	10	1	13	195	714	271	989	1086
10:30	10:45	65	76	16	4	9	9	3	11	193	734	278	1020	1113
10:45	11:00	51	68	18	3	4	11	2	23	180	748	247	1040	987
11:00	11:15	53	75	14	2	5	10	2	20	181	749	256	1052	1022
11:15	11:30	48	79	12	6	4	9	4	15	177	731	265	1046	1060
11:30	11:45	36	65	8	4	6	7	2	11	139	677	212	979	846
11:45	12:00	42	54	11	5	7	5	1	12	137	634	193	925	771
02:00	02:15	29	42	10	3	3	3	0	9	99	552	137	806	547
02:15	02:30	32	35	8	2	4	6	0	8	95	470	130	671	520
02:30	02:45	36	41	12	2	8	9	1	10	119	450	169	629	677
02:45	03:00	41	36	10	5	7	6	4	13	122	435	170	606	678
03:00	03:15	39	29	9	6	4	12	5	9	113	449	163	632	654
03:15	03:30	49	31	15	7	8	10	2	7	129	483	174	676	696
03:30	03:45	58	42	16	10	11	14	1	12	164	528	221	728	885
03:45	04:00	42	44	20	12	14	11	1	15	159	565	221	780	885
04:00	04:15	65	38	14	9	10	13	3	19	171	623	222	838	886
04:15	04:30	69	43	16	14	8	9	5	23	187	681	240	904	960
04:30	04:45	76	51	19	12	15	15	4	24	216	733	286	969	1146

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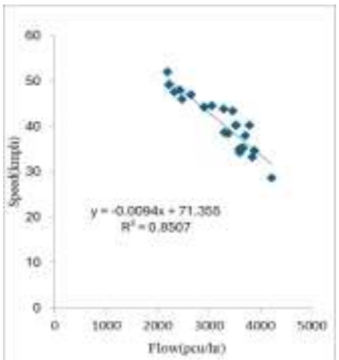
04:45	05:00	58	57	22	9	14	10	6	17	193	767	276	1024	1103

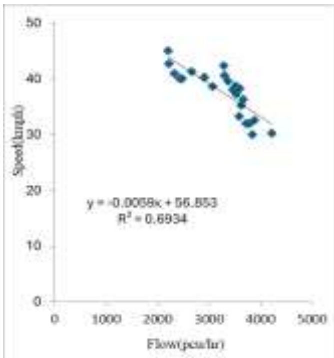
Table - 3. Traffic volume and composition at Near Chuttugunta Junction

FROM	TO	2W	AUTO	CAR	MINI BUS/ VAN	BUS	TT	TRACTOR	CYCLES	Total volume/15min	Total volume/hr	pcu's/ 15min	pcu's/ hr	(pcu's /15min)*4
PCU Values		0.75	2	1	1.4	2.2	2.2	4	0.4					
9	09:15	85	82	36	15	10	8	3	13	252		342		1366
09:15	09:30	72	79	42	10	16	12	2	16	249		344		1376
09:30	09:45	79	82	59	9	18	15	5	10	277		391		1566
09:45	10:00	110	99	41	7	15	17	4	14	307	1085	423	1500	1693
10:00	10:15	132	102	50	3	12	10	0	8	317	1150	409	1568	1635
10:15	10:30	121	110	44	5	11	15	1	9	316	1217	427	1650	1706
10:30	10:45	117	106	47	4	10	11	1	10	306	1246	407	1665	1626
10:45	11:00	125	95	39	0	13	10	2	15	299	1238	387	1629	1549
11:00	11:15	131	89	41	3	10	9	3	9	295	1216	379	1599	1515
11:15	11:30	109	113	52	4	11	8	0	8	305	1205	410	1583	1641
11:30	11:45	125	124	40	1	9	6	6	6	317	1216	443	1619	1770
11:45	12:00	116	95	36	2	8	9	4	7	277	1194	372	1604	1488
02:00	02:15	95	89	40	3	6	7	1	6	247	1146	328	1553	1314
02:15	02:30	79	96	39	8	6	11	2	4	245	1086	348	1491	1394
02:30	02:45	69	76	32	10	9	9	4	3	212	981	307	1355	1226
02:45	03:00	76	89	43	13	7	6	5	4	243	947	346	1330	1386
03:00	03:15	111	110	30	9	5	7	4	6	282	982	391	1392	1563
03:15	03:30	121	104	31	7	8	7	0	3	281	1018	374	1417	1495
03:30	03:45	95	95	39	5	11	9	3	8	265	1071	366	1477	1466
03:45	04:00	89	112	49	5	12	11	5	6	289	1117	420	1551	1679
04:00	04:15	101	125	45	10	15	10	4	7	317	1152	459	1619	1834
04:15	04:30	113	136	47	8	17	9	1	12	343	1214	481	1726	1924
04:30	04:45	126	142	51	10	13	6	3	11	362	1311	502	1861	2007
04:45	05:00	158	159	55	12	12	11	4	15	426	1448	581	2022	2324

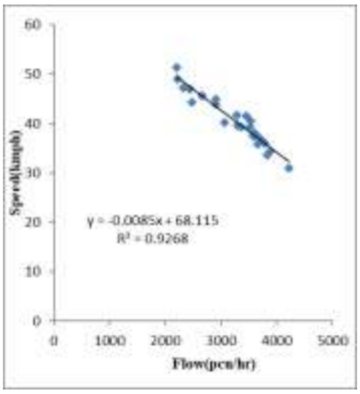
4.3 Speed – Flow Modeling

Speed-flow relationships form the basis for determining a road's capacity. The theoretical speed-flow curve is a parabola, and maximum flow (capacity) occurs at half the free flow speed. Linear regression analysis was conducted





to investigate the relationship between flow and speed.



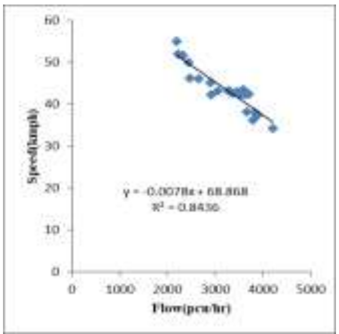
The scatter diagrams of space mean speeds of different classes of vehicles and corresponding flows were plotted. The speed was taken as the dependent variable, whereas the corresponding flow (in PCUs/hour) was taken as the independent variable. A straight-line regression fit was attempted, and speed-flow equations were developed for various vehicle classes and mixed traffic conditions.

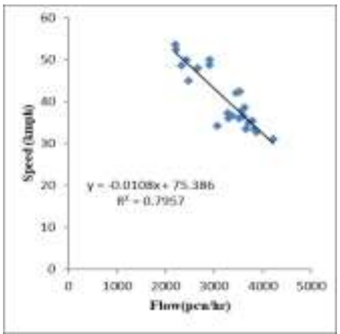
Figure 4. Speed-flow curve for a car and a bus

Figure 5. Speed-flow curve for a 2w and for auto

Figure 6. Speed-flow curve for all vehicles

Table - 4: Speed – Flow Equations of All Vehicles at Various Stretches





Location	Speed – Flow equation	R^2 value	Capacity
Benz Circle	Y = -0.0085x + 68.11	0.9268	4007
Near IG MC stadium	Y = -0.0273x + 67.09	0.8581	1416
Near Chuttungunta junction	Y = -0.014x – 66.47	0.8445	2374

4.4 Discussion on Speed–Flow Curves

Speed–flow relationships for all study locations were developed using linear regression by pairing average 15-minute speeds with corresponding flow rates (PCU/h). Flow was computed by converting 15-minute volumes to hourly values. The regression models exhibited strong correlations, with R^2 values ranging from 0.84 to 0.93. Using these equations, roadway capacities were estimated. At Benz Circle, the model $Y = -0.0085X + 68.11$indicated a capacity of 4007 PCU/h. At IGMC Stadium, $Y = -0.0273X + 67.09$gave 1416 PCU/h, while Chuttugunta Junction showed 2374 PCU/h from $Y = -0.014X + 66.47$. These models effectively represent the traffic behaviour at all sites.

4.5 Speed Data Distributions

Spot speed refers to the instantaneous speed of a vehicle at a specific location and is essential for geometric design, traffic regulation, accident analysis, and congestion studies. The speed data collected using the described methodology was analyzed separately for each vehicle category and for mixed traffic. Graphs (4.32–4.52) were used to determine percentile speeds, which indicate the speed below which a certain percentage of vehicles travel.

4.5.1 15th Percentile Speed

Speed below which 15% of vehicles travel; used to identify lower speed limits.

4.5.2 50th Percentile Speed

Median speed at which equal numbers of vehicles travel faster and slower.

4.5.3 85th Percentile Speed

The speed below which 85% of vehicles travel; commonly used for setting speed limits.

4.5.4 98th Percentile Speed

Speed below which 98% of vehicles travel; typically used as design speed in geometric design.

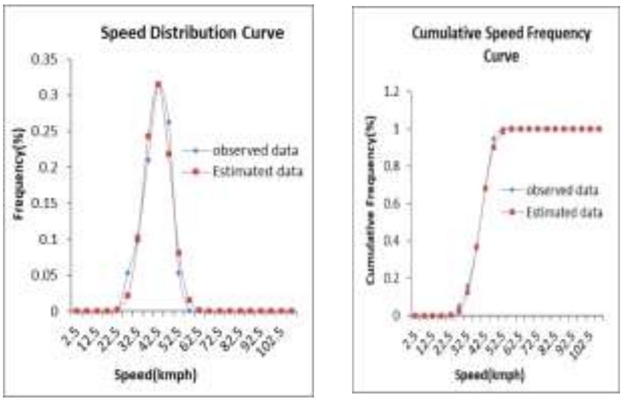


Figure 7. Distribution of spot speeds at Benz Circle Area : Auto's

The spot speeds of all vehicles and different types of vehicles on various sections of the present study are given in Tables 5.3 and 5.4 respectively. The table also gives the various percentile speeds of different types of vehicles in each section. A comparative assessment of the mean and standard deviation of the free speeds for various vehicle classes was also given. The results showed that the normal distribution curve described the speed distributions satisfactorily in most of the vehicle classes.

Table - 5: Spot Speeds of all vehicles at Different Stretches

Location	Average Speed	Max Speed	Std Deviation	Percentile Speeds			
				15th	50th	85th	98th
Benz Circle Area	48.44	70	8.5	40.8	48.5	57.5	65.8
Near IGMC Stadium	45.19	66	7.99	36.25	45.41	53.57	60
Near Chuttugunta Junction	49.38	78	9.3	39.37	48.81	59.72	70.83

Table - 6: Spot Speeds of Different Type of Vehicles at Different Stretches

Location	Vehicle type	Average Speed	Max Speed	Std Deviation	Percentile Speeds			
					15th	50th	85th	98th
Benz Circle Area	Auto	41.9	53	6.307	32.13	39.58	45.65	50.5
	Car	46.5	65	6.63	38.86	47.1	53.75	60
	2W	51	70	8.72	38.55	48.1	57.15	65.5
Near IGMC Stadium	Auto	42.09	58	8.54	29.5	39.04	47.8	55
	Car	48.09	66	5.87	40.57	46.98	54.58	61.5
	2W	41.4	57	8.56	29	38.21	47.3	54.16
	Bus	43.5	61	9.33	30.37	40.55	50.56	57.5
Near Chuttugunta Junction	Auto	41.26	52	5.28	32.77	38.33	43.13	49.16
	Car	47.16	65	7.14	39.3	47.4	55.15	62.5
	2W	56.6	78	9.78	43.3	59.5	63.2	72.5
	Bus	47.3	69	8.32	35.83	44.5	51.2	62.5
	Truck	46.02	61	7.34	34.34	43.13	51.19	57.5

4.6 Discussion on Spot Speed Distributions

The spot speeds measured at any particular location will depend upon a number of factors such as the geometric layout of a road, the volume of traffic, the composition of traffic, the condition of the road, environmental influences, the human element associated with individual drivers and the characteristics of vehicles. As a result, the speeds measured show a considerable amount of scatter. The analysis is done by grouping the speed data with a speed - class interval of 5 kmph and a frequency distribution table is constructed. In the graphs the horizontal axis represents the speed class limits, and the vertical axis represents the percentage frequency and cumulative percentage frequency. At Benz Circle Area it is observed that the speeds of the vehicles are less because of high traffic volume (approximately 1300 vphpl) and more proportion of two wheelers and three wheelers. It is observed that Spot speed data concerning a particular type of category of vehicle follows approximately normal distribution with a specific means and standard distribution.

5. CONCLUSIONS

i. Capacity of a two-lane road at Benz Circle Area is found to be 4007 PCUs/Hr, at Near IGMC Stadium 1416 PCUs/Hr and Near Chuttugunta Junction 2374 PCUs/Hr.

ii. The analysis has shown that the spot speed data for any particular vehicle follows a normal distribution with a specific mean and standard distribution.

iii. From the free speeds study at various stretches the standard deviation values for different type of vehicles are less which means that most of the vehicles are travelling almost around mean speed of that particular group of vehicles.

iv. The free speeds of vehicles on highways are lower than the expected for both individual type of vehicles and mixed traffic. Some of reasons are generally lower standards of driving discipline (lane Discipline) prompt the drivers to adopt safe speeds.

v. From the analysis at Benz Circle Area, it is observed that the capacity values are exceeding the standard values specified in IRC. It shows that existing capacity may not be sufficient for accommodating exiting traffic. If proper measures are not taken then it will be problem to accommodate the future traffic.

vi. The equations developed for determining the influence of percentage of various vehicles lead to mixed results. The extensive study is needed to achieve accurate results. At various stretches the influence of percentage of different types of vehicles on average speeds of various vehicles are different.

6. SCOPE FOR FUTURE STUDY

The current Speed–Flow study on four-lane carriageways did not capture traffic conditions close to capacity. Further research is required in this area, potentially by creating controlled congestion through systematically planned experiments.

Future studies should use continuous (24-hour) traffic data to better represent flow variations. Additional efforts may include modelling flow parameters on arterials with different geometric features and on sub-arterial roads. Selecting roads with varied configurations will also help improve the reliability of capacity analysis.

REFERENCES

1. M G Raichur. (1996) “Speed – Delay characteristics on NH – 8 between Baroda – Surat section”, *Indian Highways, 1996.*
2. Dr Thamizh arasam , R Z Koshy , (2002), “Headway distribution of Heterogeneous Traffic on Urban arterials”, *IE (I) Journal - CV volume 84,November 2003.*
3. Partha Pratim Dey, Satish Chandra , S.Gangopadhyaya , “Speed distribution Curves under Mixed traffic conditions”, *Journal Of Transportation Engineering © ASCE/ june 2006.*
4. Ola Hagring , “calibration of headway distributions” *Dept. of Technology and Society - University of Lund*
5. V.F.Hurdle, Mark.I.Merlo, Anddoug Robertson, “Study of Speed-Flow Relationships on Individual Freeway Lanes”. *Transportation Research Record 1591* **,**Paper No. 970224
6. C. Mallikarjuna , A.Phanindra , K.Rama Chandra Rao , “Traffic data collection unde mixed traffic conditions using video image processing” , *Journal Of Transportation Engineering © ASCE/ April 2009.*
7. Richard J. Porter, Kevin M. Mahoney, John M. Mason, “Estimation of Relationships between 85th Percentile Speed, Standard Deviation of Speed, Roadway and Roadside Geometry and Traffic Control in Freeway Work Zones”, *TRB 2007 Annual Meeting.*
8. Hao Wang, Wei Wang, Xuewu Chen, Jun Chen, Jie Li, “Experimental Features and Characteristics of Speed Dispersion in Urban Freeway Traffic”, *TRB 2007 Annual Meeting.*
9. V. F. Hurdle, Mark I. Merlo, And Doug Robertson “Study of Speed-Flow Relationships on Individual Freeway Lanes”, *Transportation Research Record 1591 Paper No. 970224.*
10. Richard G. Dowling, Rupinder Singh, Andwilliswei-Kuo Cheng ,” Accuracy And Performance Of Improved Speed-Flow Curves”, *Transportation Research Record 1646 Paper No. 98-0146.*
11. R. Tapio Luttinen, “Properties of Cowan’s M3 Headway Distribution *Transportation Research Record 1678 Paper No. 99-0578.*
12. Sarosh I. Khan And Pawan Maini,” Modeling Heterogeneous Traffic Flow”, *Transportation Research Record 1678,* Paper No. 98-0906.
13. C. F. Tang, Q. S. Wu, R. Jiang, B.Wiwatanapataphee, Y. H. Wu ,” Study of Mixed Traffic Flow in Anisotropic Continuum Model”, *TRB 2007 Annual Meeting.*
14. Zhao Yi Huang, Xiao Hong Chen, Hang Fei Lin, Zhong Liang Yang and Le Yuan Li. “Movement Nature of Speed-Flow Relationship on Congested Expressway”, *Journal Of Transportation Engineering © Asce / March 2008.*
15. Serge P. Hoogendoorn And Hein Botma ,”Modeling and Estimation of Headway Distributions”, *Transportation Research Record 1591, Paper No. 970476.*
16. Pathak .R.H , (1983), “A study of Headway distributions under mixed traffic

conditions", *a dissertation submitted to south Gujarat University,Surat*.

17. Prasanna Dutta, "Urbanization in India", Regional and Sub-Regional Population Dynamic Population Process in Urban Areas European Population Conference 21-24 June, 2006.

18. Bhagat. R. B., "Urbanization in India: A Demographic Reappraisal", Department of Geography,Maharshi Dayanand University,Rohtak-124001, India

19. May. A.D (1990) ,"Traffic flow fundamentals", *Prentice hall, Englewood cliffs, New Jersey 07632.pp.376-383.*

20. Kadiyali.L.R, (2000), "Traffic engineering and Transport planning", *Khanna publishers.*

21. Cowan.R.J, " Useful Headway models", *Transportation Research 9(6) , pp.371-375.*

22. Pak – Poy .P.G (1964), "The use and limitations of poisson distribution in Road traffic", proceedings of Australian Road Research Board, vol.2,1964, pp.223-246.

23. Road transport year book (2006-07) Transport research wing, Ministry of shipping, road transport & highways Government of India, New delhi March 2009.

24. Guidelines For Capacity Of Urban Roads In Plain Roads, IRC: 106 – 1990.

25. Qiang Meng and Hooi Ling Khoo "Self-Similar Characteristics of Vehicle Arrival
    a. Pattern on Highways" *Journal Of Transportation Engineering © Asce / November*
    b. *2009.*

26. Partha Pratim Dey, Satish Chandra and S. Gangopadhyay "Simulation of Mixed Traffic Flow on Two-Lane Roads" *Journal Of Transportation Engineering © Asce / September 2008*