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Study and Determination of Pedestrian Level of Service & Pedestrian Flow Parameters for a Busy Street in Anand City

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Abstract: ***There are many modes of transport Starting from Walking to the Multi Axle Vehicles. But, From the Modal Split study carried out by various authors says that, amongst all the various modes the traffic load shares by the Pedestrian is varies from 22% to 34% in the urban areas. While the Pedestrians are faced with the poor linkages with footpaths, congestion, and difficulty in free movement of the persons at the various parts of the Anand City. For Ensuring the mobility and transportation as the key component, it warrants for critical study in the Anand Commercial Centre. The study involves defining the pedestrian flow parameters for a selected stretch area of the Anand City's one of the busiest street, and determining the Pedestrian level of service according to that. For this purpose a marked area was taken into consideration for the videography survey on two different points, and the analysis is done on the videography.***

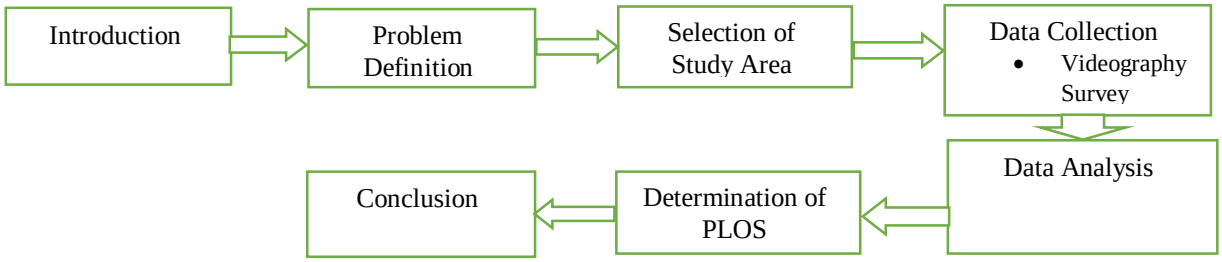
Keywords: Pedestrian, Flow parameters, PLOS, Level of service, Pedestrian Space, Pedestrian Walking Speed, Pedestrian Density.

I. INTRODUCTION

The demand of transportation rises when there's a need of people to move from one location to another location and their urge of belongings. Out of all the different modes available, the mode which is more convenient, comfortable, economical feasible, and beneficial in saving of time and money is selected by the users. And the walking is the mostly used mode of transport around the world. And for the effective implementation of the walkable environment, Planners, designers and decision makers has to define and evaluate the elements which supports the built environment in order to strengthen the walking facilities. One of the effective measuring quality of the pedestrian's environment is the approach to the Level of service (LOS). There are several factors which affects the pedestrian LOS and the Pedestrian LOS do vary from person to person. For defining the PLOS the pedestrian flow parameters are required. The design features like Road type, width of carriageway, intersection and weaving section is required to define the capacity. Suitability of the roadway network can be evaluated by comparing the present traffic volume with the capacity of the road. The service provided by the rod network in terms of space, speed, density and flow is the Level of Service of the road network.

II. METHODOLOGY

The study methodology consists of two basic steps, first is to collecting the data and, second is to analyse the data. The data collection has been done on the two spots on a selected street of the Anand city. The data collection has been done by adopting the method of videography survey. By analysing the collected data, the Pedestrian flow parameters, Pedestrian Space, Density, and Speed were then found out. After deriving the parameters the PLOS is then defined by comparing the frequency distribution with the available standard code provisions which are, HCM 2000, IRC:103-2010, And M.Parida at el. (2015).



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III. STUDY AREA PROFILE

Anand City is a city located in the State of Gujarat in India. Anand is also known as the Milk Capital of India. It is very well known for the Amul Dairy and its milk revolution. the city hosts the National Dairy Development Board (NDDB), Anand Agricultural University (AAU) and Sardar Patel University (SPU). Vallabh Vidyanagar and Karmsad , an Educational suburb of Anand is located within the Anand Urban agglomeration. Anand is located between the Ahmedabad and Vadodara, The Western Railway, The National Highway and National Express Highway passes through Anand.

Anand is having an area of 2940.31sq.km with the population of 1856712 according to the census data 2001, out of which 156050 of the populations is of the Anand City having an area of 38.58sq.km.

Our study area is located at nearby the CBD area of the Anand city. Study area is stars from the Railway station and ends at the Nimbuwala complex, at and where in between the streets are very busy and congested throughout the day and specially during the Peak hours.

The highlighted portion in the following figure shows the study area,

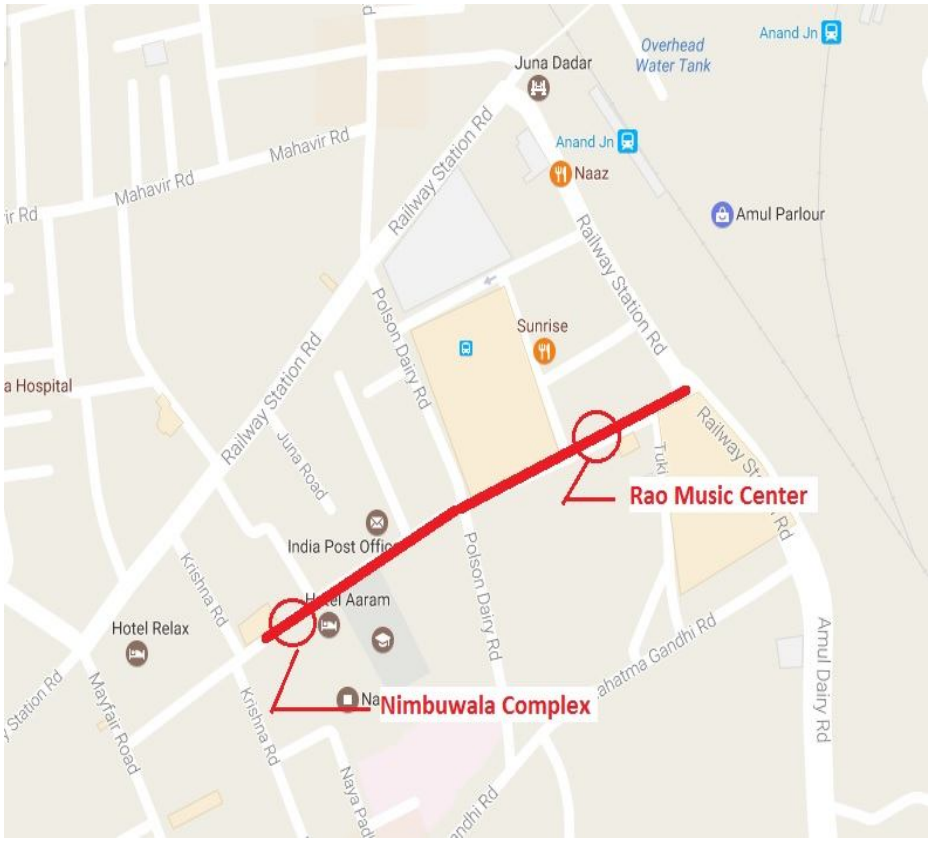


Figure 1 Study Location

IV. DATA COLLECTION

After identifying the location to be surveyed, the next step is to collect the data related to the study. For this purpose, the road measurements like carriage way width footpath width and availability on road parking facility were measured, then the road stretch is marked with white lines drawn on the road with use of chalk or chalk powder, in our case the road stretch is of having length of 10 meters. A vantage point is selected having height of at least 10 meters. The data is recorded for about suitable length of time and the hourly variation in pedestrian flow is recorded. The flexibility with video recording technique is that the data can be easily made available, after recording in soft copy, at any time after the data collection work, for the analysis purpose.

At selected locations video-recording have been carried out for 4-4 hours., as 4 hours on morning peak and 4 hours during the evening peak. Video cameras positioned to capture the desirable view of pedestrians. Continuous video shooting was done from 0900hrs to 1300hrs and 1600hrs to 2000hrs at every location on respective days.

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V. DATA ANALYSIS

The performance measures which are derived after the data analysis for a network or a facility or a portion of it, and if it does not meet with the established standards, we can define the problem occurring in the real situations, and by that we are able to provide an suitable solution for it.

To measure the speed, density, space and flow of the pedestrian traffic, the traditional method of marking a road stretch with use of white lines is been adopted. The following methodology has been adopted to calculate the flow parameters which have been mentioned here:

A. Density

The total number of heads which are in the entrapped area are counted and is been then divided with the total area. The density is then found in the unit of the pedestrian per meter square.

B. Space

The total number of pedestrian divide by the area bounded by the selected stretch gives the space in the unit of the meter square per pedestrian.

C. Speed

For the selected stretch of the study area the time taken for a pedestrian to pass it is measured and division of the trap length and time taken is found as the speed in terms of the m/s. a random person is been selected for the analysis and the average of the total number of the pedestrian is found as the average pedestrian speed.

The sample of the data analysed for average speed and other pedestrian flow parameters at two locations is presented in Table 1 to 4 for location of Rao Music Centre and at Nimbuwala Complex. The effective width of the roadway is the portion of the carriageway which is effectively available to the pedestrians for movement. It can be calculated by subtracting the width of side friction. The effective width of all location has been calculated as below.

Location 1: @ Rao Music Centre

Effective width = Road width – Side friction

Effective width = 9.0 – 2(1.2)

= 6.6 m

Location 3: @Nimbuwal Complex

Effective width = Road width – Side friction

= 10.0 – 2(1.5)

=7.0 m

D. Calculation of Average Speed

At each minute, 10 persons are observed walking, and the time (sec) taken by them to walk up to a distance of 10 m is noted down, and the speed is found out for all 10. The average of the 10 observations gives average speed of pedestrians at that moment of time. The sample of average speed at both the locations is given in table 1 and 3 respectively.

Location 1 : @ Rao music centre					**Pedestrian Speed Data**																
Time (hrs)	**Time taken by Pedestrian to cover the distance of 10 meters (sec)**										**Pedestrian Speed (m/s)**										**Average Speed (m/s)**
	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	
900	14	14	14	14	9	11	11	10	15	8	0.71	0.71	0.71	0.71	1.11	0.91	0.91	1.00	0.67	1.25	0.87
901	11	10	9	8	8	12	14	13	14	10	0.91	1.00	1.11	1.25	1.25	0.83	0.71	0.77	0.71	1.00	0.96
902	10	13	12	11	10	9	13	14	14	14	1.00	0.77	0.83	0.91	1.00	1.11	0.77	0.71	0.71	0.71	0.85
903	8	12	14	9	12	11	14	11	12	10	1.25	0.83	0.71	1.11	0.83	0.91	0.71	0.91	0.83	1.00	0.91
904	10	12	11	12	11	14	9	14	12	15	1.00	0.83	0.91	0.83	0.91	0.71	1.11	0.71	0.83	0.67	0.85
905	9	13	11	9	14	9	10	10	12	13	1.11	0.77	0.91	1.11	0.71	1.11	1.00	1.00	0.83	0.77	0.93

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906	14	9	11	10	12	14	11	13	11	13	0.71	1.11	0.91	1.00	0.83	0.71	0.91	0.77	0.91	0.77	0.86
907	14	15	13	11	13	11	9	9	9	11	0.71	0.67	0.77	0.91	0.77	0.91	1.11	1.11	1.11	0.91	0.90
908	10	15	14	9	9	11	12	13	13	11	1.00	0.67	0.71	1.11	1.11	0.91	0.83	0.77	0.77	0.91	0.88
909	10	12	10	13	12	14	11	10	13	12	1.00	0.83	1.00	0.77	0.83	0.71	0.91	1.00	0.77	0.83	0.87
910	9	13	10	9	10	14	14	8	15	12	1.11	0.77	1.00	1.11	1.00	0.71	0.71	1.25	0.67	0.83	0.92
911	10	13	14	8	10	11	15	8	15	15	1.00	0.77	0.71	1.25	1.00	0.91	0.67	1.25	0.67	0.67	0.89
912	12	9	12	13	8	8	15	13	15	15	0.83	1.11	0.83	0.77	1.25	1.25	0.67	0.77	0.67	0.67	0.88
913	13	11	12	9	10	10	10	8	10	14	0.77	0.91	0.83	1.11	1.00	1.00	1.00	1.25	1.00	0.71	0.96
914	11	12	10	11	12	13	10	11	8	10	0.91	0.83	1.00	0.91	0.83	0.77	1.00	0.91	1.25	1.00	0.94
915	11	11	13	10	15	14	10	10	10	10	0.91	0.91	0.77	1.00	0.67	0.71	1.00	1.00	1.00	1.00	0.90
916	8	11	13	14	12	13	14	9	10	12	1.25	0.91	0.77	0.71	0.83	0.77	0.71	1.11	1.00	0.83	0.89
917	13	14	9	9	13	13	14	12	15	12	0.77	0.71	1.11	1.11	0.77	0.77	0.71	0.83	0.67	0.83	0.83
918	11	13	8	13	11	10	12	9	14	12	0.91	0.77	1.25	0.77	0.91	1.00	0.83	1.11	0.71	0.83	0.91
919	8	15	15	11	13	9	8	9	11	9	1.25	0.67	0.67	0.91	0.77	1.11	1.25	1.11	0.91	1.11	0.98
920	8	8	10	10	8	8	10	9	12	12	1.25	1.25	1.00	1.00	1.25	1.25	1.00	1.11	0.83	0.83	1.08

Table 1 : Pedestrian Speed Data @ Location 1 : Rao Music Center

Location 1: Rao Music centre			Calculation of pedestrian flow parameters				
Time (hrs)	Area	Pedestrians	Pedestrian Density	Pedestrian Space	Speed		Pedestrian Flow
					(m/s)	(m/min)	(p/min/m)
900	66	27	0.41	2.44	0.87	52.22	21.36
901	66	15	0.23	4.40	0.96	57.31	13.02
902	66	37	0.56	1.78	0.85	51.21	28.71
903	66	20	0.30	3.30	0.91	54.65	16.56
904	66	32	0.48	2.06	0.85	51.15	24.80
905	66	44	0.67	1.50	0.93	55.97	37.31
906	66	45	0.68	1.47	0.86	51.83	35.34
907	66	38	0.58	1.74	0.90	53.88	31.02
908	66	48	0.73	1.38	0.88	52.76	38.37
909	66	48	0.73	1.38	0.87	51.97	37.80
910	66	33	0.50	2.00	0.92	55.02	27.51
911	66	43	0.65	1.53	0.89	53.36	34.76
912	66	39	0.59	1.69	0.88	52.90	31.26
913	66	20	0.30	3.30	0.96	57.52	17.43
914	66	17	0.26	3.88	0.94	56.48	14.55
915	66	15	0.23	4.40	0.90	53.81	12.23
916	66	40	0.61	1.65	0.89	53.42	32.38
917	66	39	0.59	1.69	0.83	49.75	29.40
918	66	46	0.70	1.43	0.91	54.59	38.05
919	66	22	0.33	3.00	0.98	58.52	19.51
920	66	28	0.42	2.36	1.08	64.67	27.43

Table 2 : Pedestrian Flow Parameters @ Location 1 : Rao Music Center

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Location 2: Nimbuwala Complex											Pedestrian Speed Data										
Time (hrs)	Time taken by Pedestrian to cover the distance of 10 meters (sec)										Pedestrian Speed (m/s)										Average Speed (m/s)
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	
900	9	9	12	10	13	8	10	8	12	12	1.11	1.11	0.83	1.00	0.77	1.25	1.00	1.25	0.83	0.83	0.999
901	9	9	9	13	11	11	11	11	10	9	1.11	1.11	1.11	0.77	0.91	0.91	0.91	0.91	1.00	1.11	0.985
902	9	8	9	9	12	9	9	9	10	9	1.11	1.25	1.11	1.11	0.83	1.11	1.11	1.11	1.00	1.11	1.086
903	12	9	9	9	13	8	10	8	8	10	0.83	1.11	1.11	1.11	0.77	1.25	1.00	1.25	1.25	1.00	1.069
904	11	12	12	8	12	13	12	10	11	9	0.91	0.83	0.83	1.25	0.83	0.77	0.83	1.00	0.91	1.11	0.928
905	10	9	10	10	9	9	13	11	10	11	1.00	1.11	1.00	1.00	1.11	1.11	0.77	0.91	1.00	0.91	0.992
906	12	12	12	10	8	11	10	12	10	9	0.83	0.83	0.83	1.00	1.25	0.91	1.00	0.83	1.00	1.11	0.960
907	10	12	9	9	11	11	13	9	9	11	1.00	0.83	1.11	1.11	0.91	0.91	0.77	1.11	1.11	0.91	0.977
908	13	10	8	9	11	10	10	13	10	11	0.77	1.00	1.25	1.11	0.91	1.00	1.00	0.77	1.00	0.91	0.972
909	12	9	9	12	10	10	11	11	9	12	0.83	1.11	1.11	0.83	1.00	1.00	0.91	0.91	1.11	0.83	0.965
910	10	8	12	8	11	13	9	11	10	12	1.00	1.25	0.83	1.25	0.91	0.77	1.11	0.91	1.00	0.83	0.987
911	9	12	9	13	13	13	12	8	10	13	1.11	0.83	1.11	0.77	0.77	0.77	0.83	1.25	1.00	0.77	0.922
912	10	11	10	8	13	13	8	10	11	10	1.00	0.91	1.00	1.25	0.77	0.77	1.25	1.00	0.91	1.00	0.986
913	9	12	8	11	9	13	11	11	11	11	1.11	0.83	1.25	0.91	1.11	0.77	0.91	0.91	0.91	0.91	0.962
914	10	9	10	13	12	11	13	12	13	10	1.00	1.11	1.00	0.77	0.83	0.91	0.77	0.83	0.77	1.00	0.899
915	9	12	12	11	9	12	9	12	11	10	1.11	0.83	0.83	0.91	1.11	0.83	1.11	0.83	0.91	1.00	0.948
916	11	11	9	11	10	10	12	13	8	13	0.91	0.91	1.11	0.91	1.00	1.00	0.83	0.77	1.25	0.77	0.946
917	10	10	12	11	9	9	12	12	11	10	1.00	1.00	0.83	0.91	1.11	1.11	0.83	0.83	0.91	1.00	0.954
918	9	10	9	10	11	9	9	10	12	9	1.11	1.00	1.11	1.00	0.91	1.11	1.11	1.00	0.83	1.11	1.030
919	9	9	12	12	12	12	10	13	9	11	1.11	1.11	0.83	0.83	0.83	0.83	1.00	0.77	1.11	0.91	0.934
920	11	10	10	13	10	13	10	13	10	9	0.91	1.00	1.00	0.77	1.00	0.77	1.00	0.77	1.00	1.11	0.933

Table 3 : Pedestrian Speed Data @ Location 2 : Nimbuwala Complex

Location 2: Nimbuwala Complex			Calculation of pedestrian flow parameters				
Time	Area	Pedestrians	Pedestrian Density	Space	speed		Pedestrian Flow (p/min/m)
					(m/s)	(m/min)	
900	70	26	0.3714	2.692	0.999	59.94	22.26
901	70	22	0.3143	3.182	0.985	59.10	18.57
902	70	27	0.3857	2.593	1.086	65.16	25.13
903	70	20	0.2857	3.500	1.069	64.11	18.31
904	70	23	0.3286	3.043	0.928	55.69	18.29
905	70	19	0.2714	3.684	0.992	59.52	16.15

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906	70	26	0.3714	2.692	0.960	57.62	21.40
907	70	18	0.2571	3.889	0.977	58.64	15.08
908	70	20	0.2857	3.500	0.972	58.30	16.65
909	70	24	0.3429	2.917	0.965	57.90	19.85
910	70	19	0.2714	3.684	0.987	59.19	16.06
911	70	28	0.4000	2.500	0.922	55.29	22.11
912	70	20	0.2857	3.500	0.986	59.13	16.89
913	70	23	0.3286	3.043	0.962	57.72	18.96
914	70	30	0.4286	2.333	0.899	53.96	23.12
915	70	23	0.3286	3.043	0.948	56.90	18.69
916	70	20	0.2857	3.500	0.946	56.76	16.21
917	70	29	0.4143	2.414	0.954	57.24	23.71
918	70	19	0.2714	3.684	1.030	61.78	16.77
919	70	24	0.3429	2.917	0.934	56.06	19.22
920	70	30	0.4286	2.333	0.933	55.96	23.98

Table 4 : Pedestrian Flow Parameters @ Location 2 : Nimbuwala Complex

VI. DETERMINATION OF PLOS

The Pedestrian Level of Service at study locations are established in context of (i) IRC103 (2012) for space and flow rate space and flow rate, v/c Ratio (ii) Parida (2014) for space, speed and flow rate and (iii) HCM 2000 for speed, space, flow rate and v/c Ratio and compared in following tables on location 1 and location 2. Table 5 to 10.

As per HCM 2000			Location 1: Rao Music Centre		Time: 9:00AM - 1:00PM		
PLOS	Space (m2/p)	Speed (m/sec)	Flow Rate (p/min/m)	v/c Ratio	Frequency distribution		
					Space	Speed	Flow rate
A	>5.6	>1.3	≤16	≤0.21	0	0	30
B	5.6 - 3.70	>1.27 - 1.3	≤16-23	>0.21-0.31	17	0	64
C	3.70 - 2.2	>1.22 -1.27	≤23-33	>0.31-0.44	91	0	77
D	2.2 - 1.40	>1.14 - 1.22	≤33-49	>0.44-0.65	105	0	69
E	1.4 - 0.75	>0.75 -1.14	≤49-75	>0.65-1.0	27	240	0
F	<= 0.75	<= 0.75	Variable	Variable	0	0	0

Table 5 : PLOS as pr HCM 2000 @ Location 1 : Rao Music Centre

As per IRC 103 - 2012		Location 1: Rao Music Centre		Time: 9:00AM - 1:00PM
PLOS	Space (m2/p)	Flow rate (p/m/min)	Frequency Distribution	
			Space	Flow Rate
A	>4.9	≤12	0	1
B	>3.3-4.9	>12-15	32	23
C	>1.9-3.3	>15-21	97	48
D	>1.3-1.9	>21-27	111	48
E	>0.6-1.3	>27-45	0	120
F	≤0.6	Variable	0	0

Table 6 : PLOS as per IRC 103- 2012 @ Location 1 : Rao Music Centre

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As per Parida		Location 1: Rao Music Centre		Time: 9:00AM - 1:00PM		
PLOS	Space (m2/p)	Flow rate (p/m/min)	Speed (m/min)	Frequency Distribution		
				Space	Flow rate	Speed
A	>5.45	≤14	>77	0	11	0
B	3.55 – 5.45	21 – 14	74 – 77	23	61	0
C	2.05 – 3.55	34 – 21	69 – 74	94	107	0
D	1.25 – 2.05	49 – 34	61 – 69	123	61	4
E	0.6 – 1.25	68 – 49	40 – 61	0	0	236
F	≤0.60	Variable	<40	0	0	0

Table 7 : PLOS as pe Parida @ Location 1 : Rao Music Center

As per HCM 2000		Location 2: Nimbuwala Complex			Time: 9:00AM - 1:00PM		
PLOS	Space (m2/p)	Speed (m/sec)	Flow Rate (p/min/m)	v/c Ratio	Frequency distribution		
					Space	Speed	Flow rate
A	>5.6	>1.3	≤16	≤0.21	0	0	45
B	5.6 - 3.70	>1.27 - 1.3	≤16-23	>0.21-0.31	29	0	146
C	3.70 - 2.2	>1.22 -1.27	≤23-33	>0.31-0.44	203	0	47
D	2.2 - 1.40	>1.14 - 1.22	≤33-49	>0.44-0.65	8	0	2
E	1.4 - 0.75	>0.75 -1.14	≤49-75	>0.65-1.0	0	240	0
F	<= 0.75	<= 0.75	Variable	Variable	0	0	0

Table 8 : PLOS as per HCM 2000 @ Location 2: Nimbuwala Complex

As per IRC 103 - 2012		Location 2: Nimbuwala Complex		Time: 9:00AM - 1:00PM
PLOS	Space (m2/p)	Flow rate (p/m/min)	Frequency Distribution	
			Space	Flow Rate
A	>4.9	≤12	0	0
B	>3.3-4.9	>12-15	83	20
C	>1.9-3.3	>15-21	152	128
D	>1.3-1.9	>21-27	5	84
E	>0.6-1.3	>27-45	0	8
F	≤0.6	Variable	0	0

Table 9 : PLOS as per IRC 103 – 2012 @ Location 2: Nimbuwala Complex

As per Parida		Location 2: Nimbuwala Complex		Time : 9:00 AM - 1:00PM		
PLOS	Space (m2/p)	Flow rate (p/m/min)	Speed (m/min)	Frequency Distribution		
				Space	Flow rate	Speed
A	>5.45	≤14	>77	0	3	0
B	3.55 – 5.45	21 – 14	74 – 77	50	145	0
C	2.05 – 3.55	34 – 21	69 – 74	184	90	0
D	1.25 – 2.05	49 – 34	61 – 69	6	2	49
E	0.6 – 1.25	68 – 49	40 – 61	0	0	191
F	≤0.60	Variable	<40	0	0	0

Table 10 : PLOS as per Parida @ Location 2: Nimbuwala Complex

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For, Location 1: Rao Music centre the PLOS for speed is E, for space LoS is D, and for the Flow rate the LoS varies as C as per HCM 2000 & Parida (2014) and D as per IRC 103 – 2012.

For, Location 2: Nimbuwala Complex the PLOS for speed is E, for space it is C, and for the flow rate the LOS varies between B and C under all LOS criteria.

VII. CONCLUSION

From the Videography survey carried out for the chosen locations, following conclusions are drawn:

A. The PLOS as per all the standards considered do give us the relatively different output but varies only little.

B. The Pedestrian Density near the Rao Music centre, a place near to the Railway station have the maximum pedestrian density under the heterogeneous traffic condition.

C. While, going far from the Railway station the traffic density in context of the pedestrian reduces.

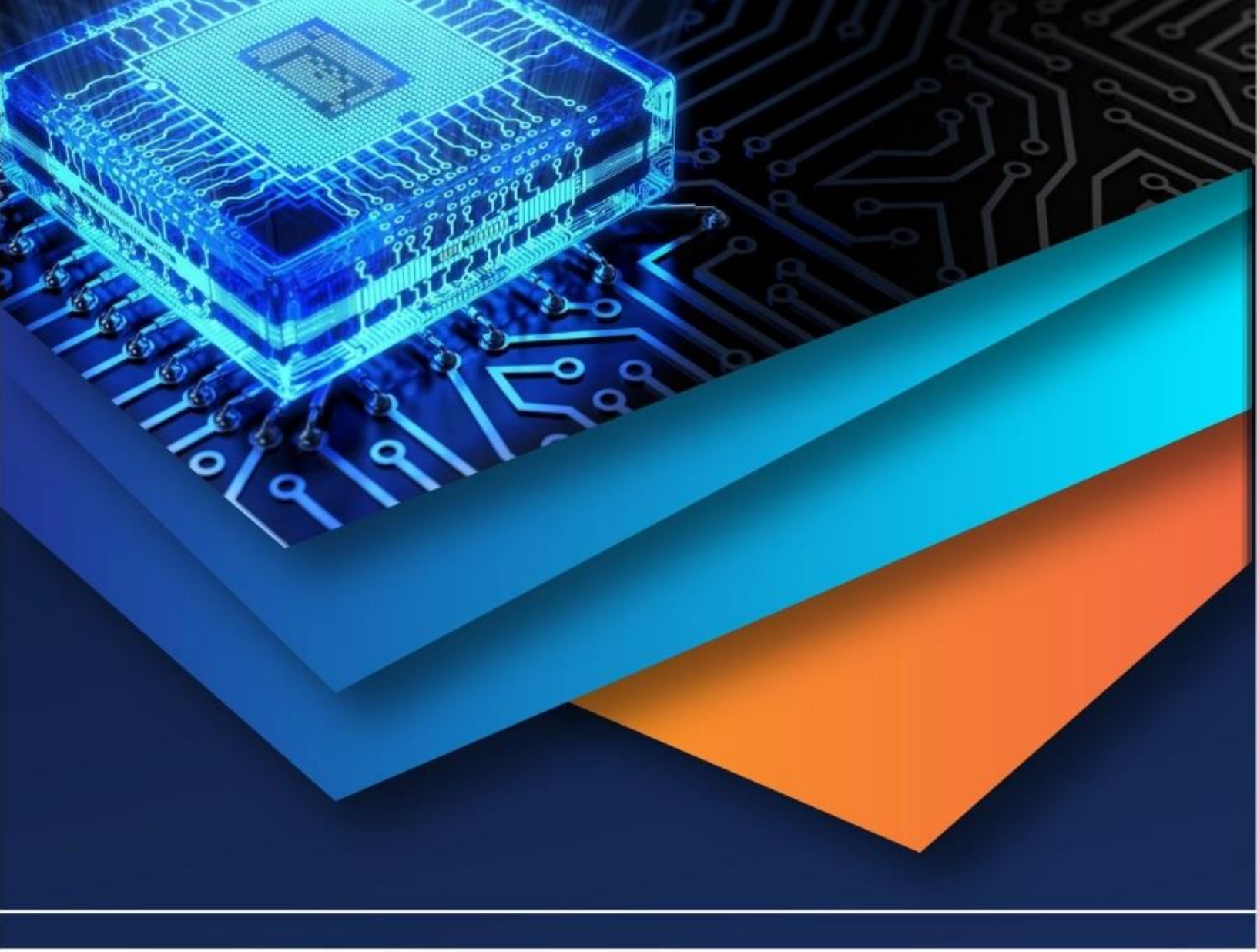
D. The pedestrian level of service as per seen is gets the highest during the morning period of 10:00AM to 12:00AM,and during the evening period of 5:00PM to 7:00PM.

E. The pedestrian speed mostly stays at the LOS of E and D, even if the space and density of the pedestrian stays at LOS b and C, under this we can conclude that the pedestrian at nearby the study arear do shows the behaviour of walking slow, and get affected by the on-going vehicular traffic.

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