Measurement of Pedestrian Flow Parameters – Case study of Dakor, Gujarat

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Abstract: - In India, for different religious reasons, people walk to certain places for worship. On few specific events, this gathering used to be very large and needs special attention with respect to pedestrians' facilities on road for walking safely and comfortably. The design of a roadway/ highway facility is possible only when capacity is related to the projected requirements of traffic. The design features governed by capacity are the highway type, number of lanes, width of lanes, intersections and weaving sections. By comparing the present traffic volume with the capacity of existing roadway networks, their adequacy or deficiency can be assessed.

In this paper one such location of Kheda district of Gujarat, 'Dakor' was studied at the time of peak hours for Level of Service offered by the road segment. The results were compared with both National and International standards.

Key words:India, Roadway/Highway facility, Intersection, Pedestrians.

1. INTRODUCTION

The desires of people to move and their need for goods create the demand for transportation. People's preferences in terms of time, money, comfort and convenience prescribe the mode of transportation used, provided of course, that such a mode is available to the user.

In order to appropriately plan for more walk able environments, methods are required that allow planners and decision-makers to effectively identify and assess the elements of the built environment that support or detract from walking. The quality of the pedestrian environment has been measured for many years using the Level-of-Service (LOS) approach. The LOS for pedestrian facilities is influenced by several of factors and different pedestrians have different perceptions on the LOS.

In India, for different religious reasons, people walk to certain places for worship purpose. On few specific events, this gathering used to be very large and needs special attention with respect to pedestrians' facilities on road for walking safely and comfortably. The design of a roadway/ highway facility is possible only when capacity is related to the projected requirements of traffic. The design features governed by capacity are the highway type, number of lanes, width of lanes, intersections and weaving sections. By comparing the present traffic volume with the capacity of existing highway networks, their adequacy or deficiency can be assessed. The service which a roadway offers to the road users with respect to space, speed, density, flow is termed as 'Level of Service' in transportation. The concept of levels of service is defined as a qualitative measure describing the operational conditions within a traffic stream and the perception of motorists and/or passengers.

1.1 Study Objectives

The objectives of the study are as listed below:

- To identify the peak hours for pedestrians' flow at *Dakor*
- To analyze the pedestrian space, speed, flow and density during peak hours
- To provide the basis for the improvement in transportation condition especially at peak hours at the study location

2. STUDY METHODOLOGY

The video recording technique was adopted for data collection. Study methodology was divided in to two parts.

I) the methodology to have the permission of the video – recording of selected route from Dakor Nagarpalika.

The video camera is fixed on the second floor of selected street.

The shooting was started from 08:10 am up to 12:16 am, to capture pedestrian flow on the selected stretch.

The data was converted in to a C D format.

After the video shooting was done the analysis is carried out by extracting the pedestrian data on computer. Methodology adopted in the study is given in Figure 1 in form of flow diagram.

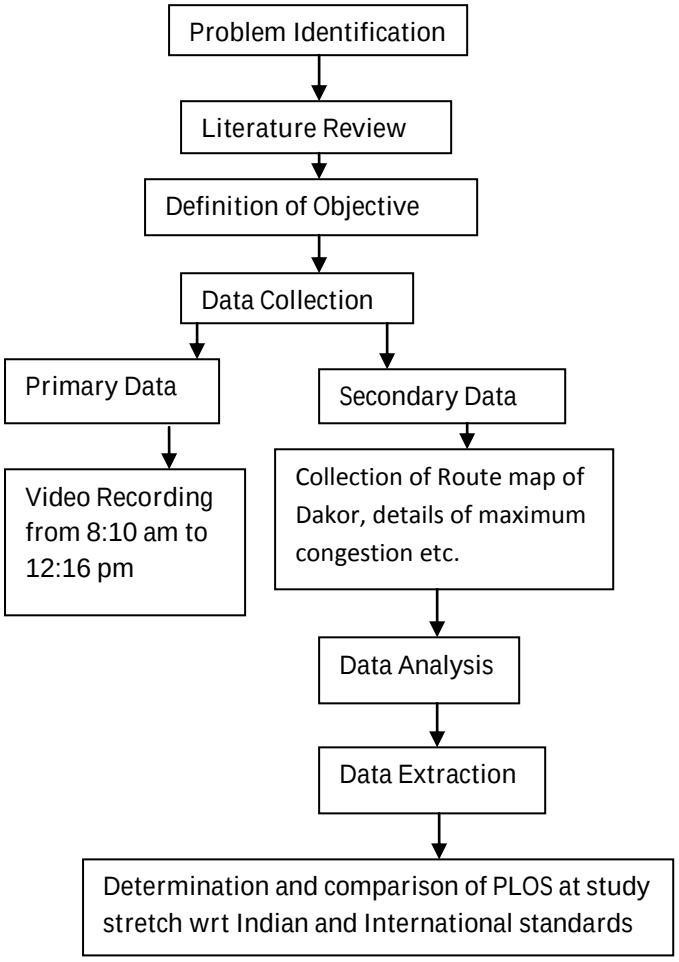

Figure 1. Study Methodology

II) The methodology to analyze the pedestrian data

The procedures given in the various pedestrian related literatures (both Indian and outside) and Highway Capacity Manual 2000 were followed to analyze the obtained site data.

The data is being analyzed for the pedestrian speed, pedestrian space, pedestrian flow and pedestrian density and from that the LOS can be defined at the study stretch after comparing with the standard criteria.

3. STUDY AREA PROFILE

Dakor is one of such place of Kheda district in Gujarat, which is visited by lacs of visitors every year, thousands of visitors every month and hundreds of visitors every day.

No single day is such that Dakor has not received the pilgrims via rail/road.

The major transit facilities in Dakor, currently in use are 2-wheelers, 3-wheelers,4-wheelers,Bus and Trucks.

4. STUDY LOCATION

The study location is provided in the Figure 2 below.

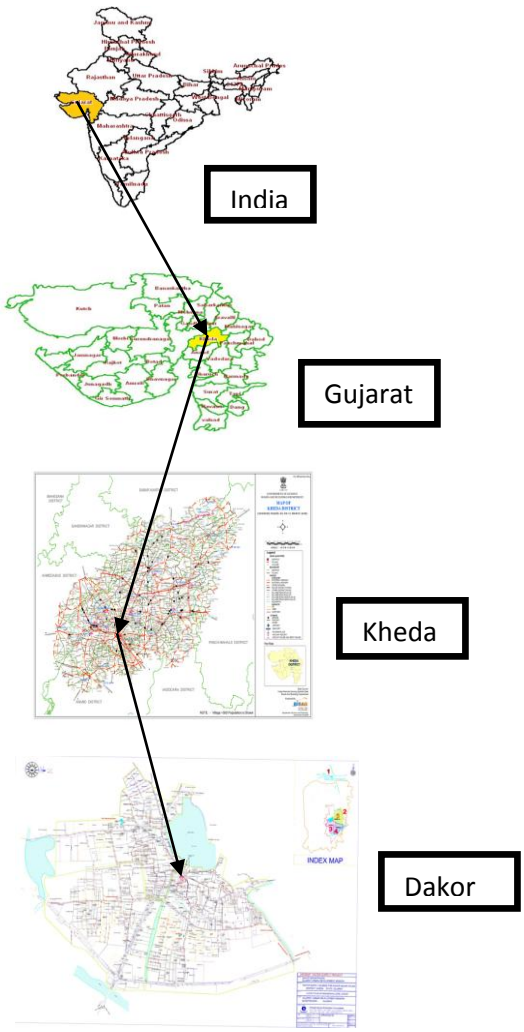

Figure 2. Study Area Location

5. DATA COLLECTION

5.1 Primary Data

The primary data are the major data which form the basis of pedestrian flow measurement analysis. It includes the video-recording at selected location and measurement of length & breadth of the selected stretch. Because of the encroachment of small commercial shops, on both sides of road at all the three locations the width of road is not found to be constant throughout the length of the selected stretch. So, an average value is assumed from the reading taken.

At study location i.e.at Poonam Guest House the average carriage way width is taken as 14.00 m with 1.00 m shoulders on both sides.

5.2 Secondary Data

The secondary data are the data which are of secondary importance to the study, but without which the primary data collection cannot precede.

The secondary data collection includes the following activities:

-Getting the general details of Dakor town from Dakor Nagar Palika.

-Getting the Auto cad map of Dakor town from Dakor Nagar Palika.

-Getting the permission from Dakor Temple Committee & Dakor Nagar Palika for the video-shooting at selected stretch on desired day.

-Getting the permission from the building owner to allow for the video-shooting at selected locations.

6. DATA ANALYSIS

The analysis provides information for decision making. The objectives of doing the analysis is: to identify problems and select countermeasures for the same. Problems usually are identified when performance measures for a network or a service on a facility – or a portion of it – do not meet established standards.

As the congestion of the pedestrian traffic during some periods happens to be so high that the traditional method of marking a particular length of the road stretch with white bands to measure the density, speed, space and flow prove to be unusual. In that case an arbitrary grid is prepared from the known length and width and then dividing them into the same no of divisions, of the length of the road stretch, on a transparent sheet showing the desired road stretch, each box of the grid gives an area of 1m x 1m on the road.

The following methodology is adopted to calculate the above flow parameters.

Density: - The total number of heads within the grid area is to be counted first. The area of the road stretch is known. So, the total number of heads is divided with the area of stretch to have the density in terms of Pedestrians per Meter Square.

Space: - The total area of the selected stretch divided by the number of heads within the boundary of the grid gives the space in terms of Meter Square per Pedestrian.

Speed: - At a particular moment in time, five numbers of pedestrians are observed for a stretch of 10mt length and the time required moving that 10mt is noted down. This data gives the speed of individual pedestrian when 10 meter is divided by the time in seconds to cover that much length. Then, the average of those five speeds gives the average speed of pedestrian at that moment of time.

The data thus evaluated is then compared with (i) the H C M 2000 PLOS criteria for walkway and (ii) PLOS criteria as per Rima Sahani and P.K.Bhuyan (Indian Highways, April 2015) for Urban Off-Street facility.

Table 1 PLOS criteria for Walkways and Sidewalks

LOS	Space (m^2/p)	Flow Rate (p/min/m)	Speed (m/s)	v/c Ratio
A	> 5.6	≤ 16	>1.30	≤0.21
B	>3.7 – 5.6	≤ 16-23	>1.27 – 1.30	>0.21 – 0.31
C	>2.2 – 3.7	≤ 23-33	>1.22 – 1.27	>0.31 – 0.44
D	>1.4 – 2.2	≤ 33-49	>1.14 – 1.22	>0.44 – 0.65
E	>0.75 – 1.4	≤ 49-75	>0.75 – 1.14	>0.65 – 1.0
F	≤0.75	Variable	≤0.75	Variable

(Source: HCM 2000)

Table 2 PLOS Criteria for Urban Off-Street

Pedestrian Facilities at Bhubaneswar & Rourkela

PLOS	Avg. Space (m^2/p)	Flow Rate (P/sec/ m)	Avg. Speed (m/sec)	v/c ratio	Comments
A	>15.67	≤0.063	>1.22	≤0.4	Ability to move in desired path, no need to alter movements
B	>11.94-15.67	>0.063 -0.081	>1.11-1.22	>0.4-0.53	Occasional need to adjust path to avoid conflicts
C	>9.07-11.94	>0.081 -0.103	>0.95-1.11	>0.53-0.68	Frequent need to adjust path to avoid conflicts
D	>6.49-9.07	>0.103 -0.133	>0.78-0.95	>0.68-0.84	Speed and ability to pass slower pedestrians restricted
E	>4.48-6.49	>0.133 -0.145	>0.62-0.78	>0.84-1.00	Speed restricted, very limited ability to pass slower pedestrians
F	≤4.48	>0.145	≤0.62	>1.00	Speed severely restricted, frequent contact with other users

(Source: Rima Sahani and P.K.Bhuyan, IH April 2015)

7. DATA ANALYSIS

The pedestrian data for speed, space and density were analyzed and given in Table 3 and 4 below.

Table 3 Analysis of speed

Time	Time taken by pedestrian (Pi), i=1 to 5 to cover a distance of 10 m (sec)					Speed of Pedestrians (m/sec)					Avg. Speed
	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	m/sec
8:10 AM	18	20	21	20	24	0.556	0.500	0.476	0.500	0.417	0.490
8:11	13	20	16	20	21	0.769	0.500	0.625	0.500	0.476	0.574
8:12	22	24	24	11	21	0.455	0.417	0.417	0.909	0.476	0.535
8:13	32	29	17	28	29	0.313	0.345	0.588	0.357	0.345	0.390
8:14	20	21	20	25	21	0.500	0.476	0.500	0.400	0.476	0.470
8:15	18	23	19	13	24	0.556	0.435	0.526	0.769	0.417	0.541
8:16	15	15	20	20	15	0.667	0.667	0.500	0.500	0.667	0.600
8:17	20	35	20	19	21	0.500	0.286	0.500	0.526	0.476	0.458
8:18	27	38	30	26	26	0.370	0.263	0.333	0.385	0.385	0.347
8:19	15	17	23	19	16	0.667	0.588	0.435	0.526	0.625	0.568
8:20	17	28	28	16	16	0.588	0.357	0.357	0.625	0.625	0.511
8:21	10	19	12	14	14	1.000	0.526	0.833	0.714	0.714	0.758
8:22	13	18	20	20	12	0.769	0.556	0.500	0.500	0.833	0.632
8:23	12	15	12	19	15	0.833	0.667	0.833	0.526	0.667	0.705
8:24	17	12	12	12	11	0.588	0.833	0.833	0.833	0.909	0.799
8:25	15	29	26	19	16	0.667	0.345	0.385	0.526	0.625	0.509
8:26	16	22	22	23	21	0.625	0.455	0.455	0.435	0.476	0.489
8:27	17	16	18	9	17	0.588	0.625	0.556	1.111	0.588	0.694
8:28	23	18	18	24	10	0.435	0.556	0.556	0.417	1.000	0.593

Table 4 Analysis of Density. Space and Speed

Time (min)	Number of Ped. (No.)	Pedestrian Density (P/m2)	Pedestrian Space (m2/p)	Avg. Speed (m/sec)
1	3	4	5	6
8:10 AM	90	0.247	4.053	0.490
8:11	120	0.329	3.040	0.574
8:12	110	0.302	3.316	0.535
8:13	100	0.274	3.648	0.390
8:14	118	0.323	3.092	0.470
8:15	61	0.167	5.980	0.541
8:16	106	0.291	3.442	0.600
8:17	108	0.296	3.378	0.458
8:18	100	0.274	3.648	0.347
8:19	122	0.334	2.990	0.568
8:20	122	0.334	2.990	0.511
8:21	110	0.302	3.316	0.758
8:22	147	0.403	2.482	0.632
8:23	131	0.359	2.785	0.705
8:24	163	0.447	2.238	0.799
8:25	125	0.343	2.918	0.509
8:26	120	0.329	3.040	0.489
8:27	145	0.397	2.516	0.694
8:28	135	0.370	2.702	0.593

7.1 Analysis of Level of Service

Using frequency distribution for data, the PLOS is decided based on Maximum frequency for particular PLOS. The data for the same are given in Table 5 and 6.

7.1.1 As per HCM 2000

Table 5 Frequency distribution wrt PLOS criteria for Space and Speed at study location

PLOS	Space	Speed	Frequency Distribution	
(HCM2000)	(m2/p)	(m/sec)	Space	Speed
A	> 5.6	> 1.3	18	57
B	5.6 - 3.71	> 1.27-1.30	138	7
C	3.70 - 2.21	> 1.22-1.27	91	13
D	2.20 - 1.41	> 1.14-1.22	0	17
E	1.40 - 0.76	> 0.75-1.14	0	121
F	≤ 0.75	≤ 0.75	0	32

While comparing with HCM 2000, PLOS at study stretch ranges between 'B' and 'C' wrt Space.

In Speed, PLOS fluctuates between 'E' for maximum of time, then 'A' and then 'F'.

7.1.2 As per Rima Sahani and P.K.Bhuyan. "Pedestrian LOS Criteria for Urban Off-Street Facilities of Mid-Size Cities **using SOM and ANN". Indian** Highways. April-2015.

Table 6 Frequency distribution wrt PLOS criteria for Space and Speed at study location

PLOS	Space	Speed	Frequency Distribution	
(Rima Sahani et.al.)	(m2/p)	(m/sec)	Space	Speed
A	> 15.67	> 1.22	0	77
B	> 11.94 - 15.67	> 1.11 - 1.22	0	21
C	> 9.07 - 11.94	> 0.95 - 1.11	0	47
D	> 6.49 - 9.07	> 0.78 -0.95	2	64
E	> 4.48 - 6.49	> 0.62 - 0.78	18	20
F	≤ 4.48	≤ 0.62	227	18

The PLOS comes out to be 'F' wrt space in Indian context.

And it is fluctuating between 'A' to 'F' when considered wrt Speed, with 'A' for maximum of times, then 'D' and then 'C'.

8. CONCLUSION

For the same space and speed, difference is observed in the Pedestrian Service Levels at the selected location when compared with both Indian and International standards of PLOS measurements.

This demands a careful study with respect to the comparison of various criteria available in literature for measuring the LOS for pedestrians.

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