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Pedestrian walkability index

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ABSTRACT

The objective of this paper is to study the walkability index and to rate the areas based on safety, security, and convenience to the Pedestrian environment. This study evaluates and reports the existing condition of Pedestrian facilities in the area considered and its analysis from both qualitative and quantitative point of view, comparing it with a study of various standards stipulated by HCM and IRC parameters which could be used for the design of Pedestrian facilities. The survey and analysis are done in city Davangere, Karnataka. To get the overall measure of Pedestrian Walkability Index of the city, it is classified into two different areas i.e. Commercial and Shopping areas, are selected for the study. The Pedestrian Walkability Index (PWI) survey consists of 2 components i.e. Field walkability survey and a Pedestrian interview survey. The Pedestrian LOS and adequacy of footpaths was carried out based on the guidelines of HCM 2000 and IRC:103-1988 respectively. In the selected areas, the length of the stretch and width of the available footpath was measured. The Pedestrian volume counts were taken during peak hours and the average pedestrian walking speed was computed manually. From these data, the Pedestrian flow, density is calculated and the LOS is obtained. And based on the Pedestrian volume in the areas, the adequacy was checked and the recommended footpaths widths were proposed as per the recommendations of IRC. In the widths of the selected areas in Davangere city, only 16.7% are inadequate and the remaining 83.3% is adequate.

Keywords— *Level of service, Pedestrian walkability index*

1. INTRODUCTION

A pedestrian can be defined as "Any person who is a foot or who is on a wheelchair, or by a means of conveyance propelled by human power other than a bicycle". Walkability is a measure of how safe an area is for walking**.** The modal share of pedestrians in developing cities tends to be very high. It is estimated that 25 to 50 % of all the major trips in Indian cities and about 50% of all trips in major African cities is made entirely on foot.

These results in chaotic (disorganized) pedestrian environment, where deteriorating footpaths are encroached by, parked vehicles, trees, and other obstructions. Improper and inadequate planning for pedestrians will lead to many negative consequences like unnecessary facilities and injuries.

1.1 History and growth of Davangere City

Davangere is one of the 30 districts in Karnataka state. With the creation of new districts on 15th Aug 1997 Davangere announced as a district with Davangere as its headquarters. This unique district (Davangere) located in the central part of Karnataka lies on the geographical coordinates of 14°28′0″ N, 75°55′0″E. The district spans over a total geographical area of 5975.99 sq.km and it ranks 16th in the area among 30 districts of the states and measures 117 km from the north to south and 110 km from east to west.

Davangere ranks 22nd place in terms of population in the state. The population of the district according to 2001census is 17,90,952 comprising 9, 17,705 males and 8,73,240 females. According to the 1991 census, the total population of the district was 15,59,222 consisting 9,17,320 males and 8,72,373 females, during 1991-2001 2,31,730 people have been added to the total population constituting a decadal variation of 14.7%.

1.2 Vehicle growth scenario

For transportation purpose, the land is used when land areas are increases with respect to this the traffic is also increasing. When traffic increases the movement of vehicles is also increasing as shown in Table 1.

1.3 Problems due to the growth of road traffic

The following problems are encountered due to the growth in road traffic:

1. Increase in road congestion.
2. Increase in travel time and thereby increase fuel loss.

3. Increase in road accidents and loss of human life.
4. Air pollution and environment degradation.
5. The inadequate width of footpaths for pedestrian due to the widening of roads.

Table 1: Movement of Vehicles

S. No.	Year	Heavy vehicles	Light vehicles	Slow moving vehicles	Total vehicles
1	1970-71	175	164	74	430
2	1975-76	250	158	80	488
3	1981-82	303	260	73	636
4	1987-88	334	377	57	768
5	1992-93	512	673	44	1229
6	1997-98	722	1280	41	2043
7	2002-03	1602	1976	87	3665
8	2004-05	1658	2587	631	4876
9	2009-10	2220	3014	570	5805

1.4 Identified problems faced by pedestrians

1. The inadequate width of the footpath.
2. Bad footpath condition.
3. Encroachment along the footpath.
4. Obstructions along the footpath.
5. No crossing facilities.
6. Parking of vehicles on footpaths.
7. Discontinuity along footpaths.
8. The absence of pedestrian refuge islands.

1.5 Pedestrian Walkway LOS

LOS A:

Pedestrian Space > 5.6 m²/p, Flow Rate ≤ 16 p/min/m: At a walkway LOS A, pedestrians move in desired paths without altering their movements in response to other pedestrians. Walking speeds are freely selected, and conflicts between pedestrians are unlikely. It is shown in Chart-1.

LOS B:

Pedestrian Space > 3.7–5.6 m²/p, Flow Rate > 16–23 p/min/m: At LOS B, there is sufficient area for pedestrians to select walking speeds freely, to bypass other pedestrians, and to avoid crossing conflicts. At this level, pedestrians begin to be aware of other pedestrians and to respond to their presence when selecting a walking path. It is shown in Chart-2.

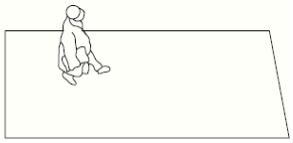

Chart 1: LOS A

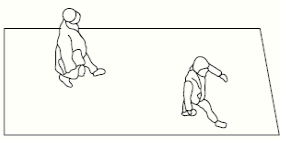

Chart 2: LOS B

LOS C:

Pedestrian Space > 2.2–3.7 m²/p, Flow Rate > 23–33 p/min/m: At LOS C, space is sufficient for normal walking speeds, and for bypassing other pedestrians in primarily unidirectional streams. Reverse-direction or crossing movements can cause minor conflicts, and speeds and flow rate are somewhat lower. It is shown in Chart 3.

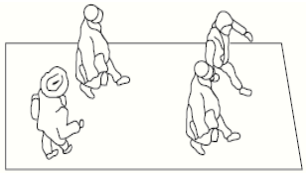

Chart 3: LOS C

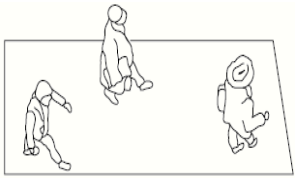

Chart 4: LOS D

LOS D:

Pedestrian Space > 1.4–2.2 m²/p, Flow Rate > 33–49 p/min/m: At LOS D, freedom to select individual walking speed and to bypass other pedestrians is restricted. Crossing or reverse flow movements face a high probability of conflict, requiring frequent changes in speed and position. The LOS provides reasonably fluid flow, but friction and interaction between pedestrians are likely. It is shown in Chart-4.

LOS E:

Pedestrian Space > 0.75–1.4 m²/p, Flow Rate > 49–75 p/min/m: At LOS E, virtually all pedestrians restrict their normal walking speed, frequently adjusting their gait (manner of walking). At the lower range, forward movement is possible only by shuffling. Space is not sufficient for passing slower pedestrians. Cross- or reverse flow movements are possible only with extreme difficulties. Design volumes approach the limit of walkway capacity, with stoppages and interruptions to flow. It is shown in Chart 5.

LOS F:

Pedestrian Space ≤ 0.75 m²/p, Flow Rate varies p/min/m: At LOS F, all walking speeds are severely restricted, and forward progress is made only by shuffling. There is frequent, unavoidable contact with other pedestrians. Cross- and reverse-flow movements are virtually impossible. Flow is sporadic and unstable. Space is more characteristic of queued pedestrians than of moving pedestrian streams. It is shown in Chart 6.

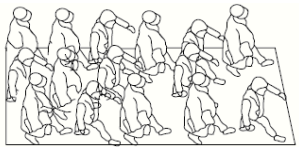

Chart 5: LOS E

Chart 6: LOS F

1.6 Specifications for pedestrian LOS as per HCM

Table 2: LOS as per HCM

LOS	Space (sqm/ped)	Flow(ped/min/m)	Average speed (m/s)
A	> 5.6	<16	>1.3
B	3.7 -5.6	16-23	1.27-1.30
C	2.2-3.7	23-33	1.22-1.27
D	1.4-2.2	33-49	1.14-1.22
E	0.75-1.4	49-75	0.75-1.14
F	<0.75	Car	<0.75

1.7 Capacity of footpaths

Table 3: Capacity of footpaths

The width of footpath (m)	Capacity in number of persons/hr	
	All in one direction	In both the direction
1.5	1200	800
2.0	2400	1600
2.5	3600	2400
3.0	4800	3200
3.5	6000	4000

2. OBJECTIVE

The Specific objectives of the study are:

- To calculate the pedestrian walkability index for the proposed study areas.
- To study and evaluate the existing conditions of pedestrian facilities based on HCM and IRC.

- To calculate the Level of Service (LOS) for the footpaths in the study areas based on HCM.
- To check the adequacy of footpath in the study locations based on IRC.

3. METHODOLOGY

The methodology to obtain walkability index and level of service for the pedestrians. The areas in which the survey was carried out, the Proforma sheets used for the field survey are explained below. This work is mainly carried out in three categories,

1. Pedestrian walkability index.
2. Pedestrian level of service.
3. Adequacy of the footpath.

3.1 Areas of study

Davangere city is divided into Old Davangere and New Davangere by the old Pune-Banglore Road which passes inside the city. This Old Davangere and New Davangere are considered as two study zones. In these zones, again, the areas are further identified for the study.

The locations (areas) were selected for the study such that they provide the overall measure of walkability of the city. Areas with high pedestrian activity were selected based on the reconnaissance survey. Areas with more pedestrian problems were identified and chosen for the study. Complete route assessment was made along the pedestrian routes in all the selected areas. The survey was carried out in 2 different areas:

1. **Commercial Area**
2. **Shopping Area**

In each area, five stretches were selected for the data collection and analysis. The stretches selected are based on the field observation and reconnaissance survey carried out. The field walkability survey and the pedestrian interview survey were carried out in all these zones at peak hours. All the selected zones are in the core of the city where there are more pedestrian problems. For the survey, 3 commercial areas and 3 shopping area where selected. In each area 5 stretches where selected.

3.2 Data collected for the selected stretches

The following data were collected for all the selected stretches

I. The road geometrics
   - A. Length of the stretch selected.
   - B. Length of actual footpath available on either side.
   - C. The width of the footpath.
   - D. Footpath surface condition.
   - E. Crossing facilities.
   - F. Amenities.
   - G. Illumination.
   - H. Presence of trees or any other obstructions.
     a) Encroachment along the footpath.
     b) Pedestrian volume count in peak hours.
     c) Pedestrian walking speed.
     d) Pedestrian interviews for the facility rating.

3.3 Pedestrian interview survey

It consists of interviewing people to find out their opinion on the pedestrian facilities. These interviews were conducted to know the problems faced by the pedestrians and to know their preferences and requirements. A short questionnaire that captures the travel and social characteristics, as well as the preferences of the respondents was prepared. The questionnaires were filled out by the surveyor while interviewing pedestrians. However, sometimes it was difficult for stopping the pedestrians for an interview. In these cases, some other people in the area, like the pedestrians waiting at the bus stops and the pedestrians who were shopping were interviewed. The interview was conducted in all the selected locations during peak hours. An adequate sample size of 300 was taken for the pedestrian preferences survey. A scientific and rational preformed sheet for the pedestrian interview was developed exclusively for study.

3.4 Parameters considered for field walkability survey

Out of these 15 parameters, only 10 important parameters were considered based on the literature review and based on the opinions of the experts. The parameters which are selected will provide the overall measure of pedestrian environment in the selected area. The parameters which are considered

1. Footpath width
2. Footpath surface
3. Continuity
4. Footpath encroachment
5. Obstructions
6. Cleanliness and maintenance of footpath
7. Comfort and walking environment
8. Crossing facilities
9. Lighting facilities along the footpath
10. Pedestrian count

3.5 Gradation of selected locations based on pedestrian walkability index

The gradation process of the locations assists in maneuvering the classification based on their overall pedestrian facility and safety conditions. Assessing a location on safety background supports to suggest measures for improvement which enhance the facilities and safety of the pedestrian.

In the present work, the gradation of the locations depends on the Pedestrian Walkability Index (PWI) obtained from the equation accordingly; the selected locations are graded as **Excellent, Good, Satisfactory, Poor and Very Poor**. This is shown in the table no.4 as given below.

$$PWI = ((\sum (\text{Facility rating} \times \text{length of the stretch} \times \text{pedestrians count} \times 10))/ \text{Number of stretches})/1000$$

Where,
PWI= Pedestrian walkability index
Facility rating= the ratings provided by the pedestrians in the field walkability survey
Length of stretch= field data obtained
A number of stretches= the stretches selected for the study.

Table 4: Gradation of selected locations based on PWI

PWI	Grade
1	Excellent
2	Good
3	Satisfactory
4	Poor
5	Very poor

4. DATA COLLECTION AND ANALYSIS

4.1 Pedestrian Interview survey Data's and Analysis

In this study, 300 pedestrians were interviewed for collecting the information on the pedestrian facilities. 300 interviews were made in six areas of two zones. Each area is divided into five stretches. In each stretch, ten pedestrians were interviewed with the proforma and entering their preferences in that proforma.

The areas are numbered as below:
Area 1: CJ Hospital Surrounding
Area 2: AVK College Surrounding
Area 3: Mandi Pete Surrounding
Area 4: Old BSC Textile Shop Surrounding
Area 5: New BSC Textile Shop Surrounding
Area 6: PJ Extension Surrounding

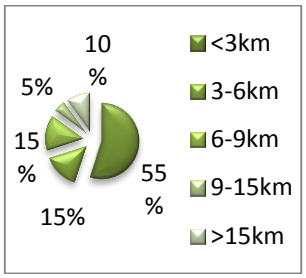

Chart 7: Destinations of the pedestrians

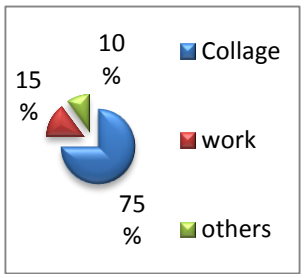

Chart 8: Total travel distance to destination

In Chart-7, Majority 55% of the people stated that their main destination is <3km from their origins. And 15% of the people stated that their main destination is 3-6km from their origins. 15% of the people stated that their main destination is 6-9km from their origins. 5% of the people stated that their main destination is 9-15km from their origins. 10% of people stated that their main destination is >15km from their origins.

Chart-8 shows that most of the respondents stated work 15% as their main destination on a normal day. 75% of the respondents had schools and colleges as their main destination. 10% stated others as their main destination.

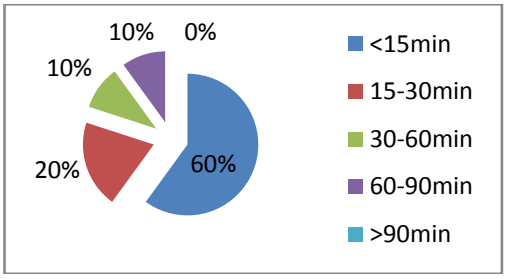

Chart 9: Average travel time to the main destination

Chart 9 shows that a large number of the people interviewed 60% travel <15 minutes to reach their main destination. 20% of people interviewed travel 15-30 minutes to reach their main destination.10% of people interviewed travel 30-60 minutes to reach their main destination. 10% of people interviewed travel 60-90 minutes to reach their main destination and No people are interviewed travel>90 minutes to reach their main destination.

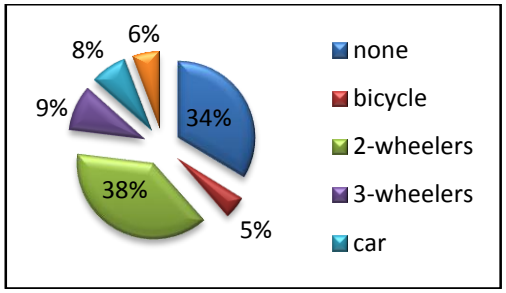

Chart 10: Vehicle ownership of pedestrians interviewed

Chart-10 shows that 38% of the pedestrians interviewed own two-wheelers and 34% of the people reach their destination by walk.

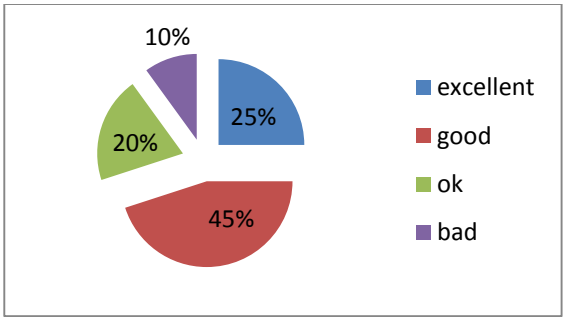

Chart 11: Pedestrian facilities in the city

Chart-11 shows that the pedestrian is not satisfied with the pedestrian facilities in the city. 45% of the people stated that the pedestrian facilities are good and 25% of the people stated that the facilities are said excellent.

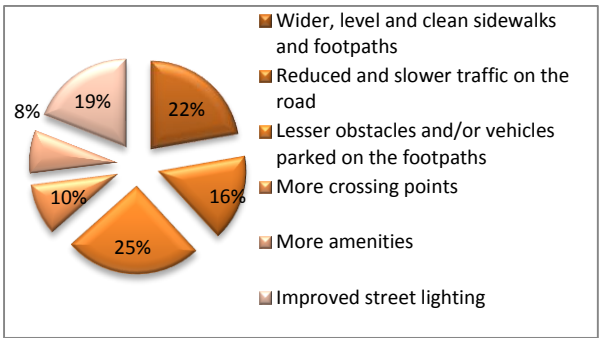

Chart 12: Pedestrian facility improvement ranks

The respondents were given a choice of improvements to make to pedestrian facilities in the city and asked to rank them from 1 (most desired) to 6 (least desired). Chart-12 represents the pedestrian's choices of the most desired improvements. The highest priority for improvement demanded was wider, leveled and clean footpaths followed by more points to cross the road, indicating that current footpaths are not wide, level or clean enough and current crossing facilities are either non-existent or too dangerous. Improved street lighting came lowest in the most preferred priority list.

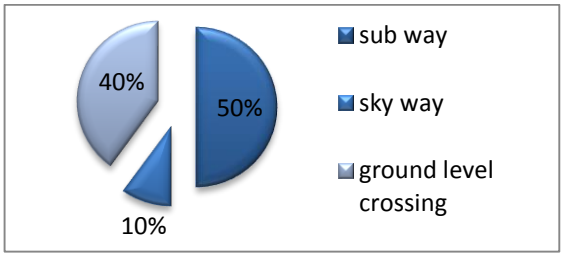

Chart 13: Pedestrian priorities for crossing facilities

Chart 13 shows that when pedestrians were asked about their preferred mode of crossing the road. 50% of the people preferred the pedestrian subway to cross the road. Only 40% of the people preferred sky walk. And 10% of people preferred pedestrian ground level crossing the road.

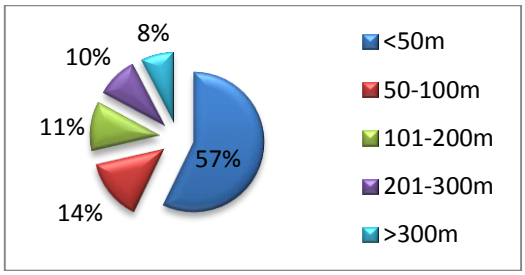

Chart 14: Willingness to walk to cross the street

Chart 14 shows that nearly 57% of the pedestrians interviewed are willing to walk up to a distance of less than 50m to access a pedestrian crossing. But the numbers fall very sharply after that indicating that road crossings must be available not more than 200 m apart.

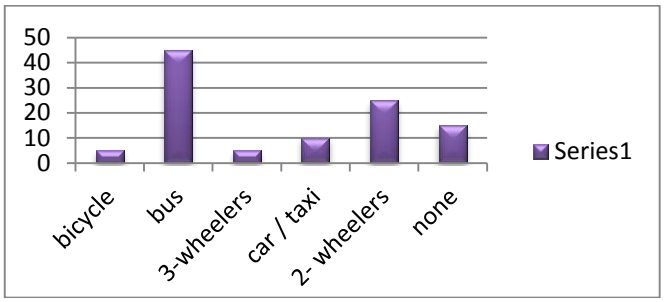

Chart 15: Shifting to another mode of transport

Chart-15 shows the shifting to another mode of transport they interested to shift maximum 45% of peoples are preferred bus and 25% of peoples are preferred two-wheelers.

4.2 Field walkability survey and Average Facility Rating Analysis

Table 5: Proforma for field walkability survey

Stretch 1, Area 1: Peak hour: yes ⬭ no ⬭

Length of the stretch: 1000m, width:1.88m

S. No.	Parameters considered	Number of pedestrians										Average Facility Rate
		1	2	3	4	5	6	7	8	9	10	
1	Footpath surface	2	3	2	3	2	2	2	2	2	3	**2**
2	Footpath width	2	3	3	3	3	3	3	3	3	2	3
3	Continuity	4	5	5	5	5	5	5	5	5	5	5
4	Footpath width encroachment	2	2	2	2	1	1	2	2	2	1	2
5	Obstructions	4	3	4	3	3	3	3	3	3	4	3
6	Cleanliness and maintenance	2	2	2	2	2	2	2	2	2	2	2
7	Comfort and walking environment	2	2	2	2	2	2	3	3	2	2	2
8	Lighting facilities along footpath	5	5	5	5	5	5	5	4	4	4	5
9	Crossing facilities	5	5	5	5	5	5	5	5	5	5	5

In table 5, The Pedestrian gave a rating on Footpath surface, Footpath width, Continuity, Footpath width encroachment, Obstructions, Cleanliness and maintenance, Comfort and walking environment, Lighting facilities along footpath and Crossing facilities. Similarly taking rating by 10 members and averaging each parameter in each streach.

4.3 Pedestrian level of service (LOS)

Level of Service (LOS) in transportation engineering is a term used which describes existing operating conditions (or suitability) for a mode of travel in a transportation system. The Highway capacity manual (HCM) method was used for the analysis of the pedestrian level of service. The HCM's method of analyzing pedestrian LOS is based on the measurement of pedestrian flow rate and sidewalk space. The pedestrian flow rate incorporates pedestrian speed, density, and volume, which is equivalent to vehicular flow. According to the Highway Capacity Manual (HCM), as volume and the density increases, pedestrian speed declines. As density increases and pedestrian space decreases, the degree of mobility afforded to the individual pedestrian declines, as does the average speed of the pedestrian stream.

At all the locations, the pedestrian walking speed was calculated manually. A 10m distance was marked by using a tape in the location. When a pedestrian crosses the 1st point, a stop watch was started and when he reaches the 2nd point, the time required for the pedestrian to travel a distance of 10m was noted down in seconds. Then the pedestrian walking speed was calculated by distance/ time taken. In the beginning, a 20m distance was marked in the locations to calculate the pedestrian walking speed. But it was observed that many pedestrians were scattering and were not following the same lane. Hence a 10m distance was finally fixed to calculate the pedestrian speed. In each stretch, more than 10 pedestrians walking speed was measured and an average walking speed was found out. The pedestrian volume count was done from 5 pm to 8 pm (peak hours) in all the stretches. By knowing the pedestrian volume and calculating the pedestrian speed, the LOS of pedestrians can be calculated by the specifications given in the HCM.

4.4 Adequacy of footpath

The scientific and rational way of providing planning footpath width is based on a number of pedestrians using the facility. In this part of the work, the width of the footpath in all the selected zones was measured and volume counts were made in peak hours in the same locations. Then the footpaths are checked for adequacy based on the number pedestrians using it as per the IRC norms. This study also helps in proposing the new width of footpaths as per the pedestrian requirement based on activities in the area/ vicinity. The capacity of sidewalks as per IRC is shown in the Table-3. The Indian road congress (IRC) specifies that:

1. A minimum width of 1.5m footpath should be provided on both the sides of the street.
2. A dead width of 0.5m and 1m should be provided along the houses, bus stops recreational and commercial areas.
3. The height of footpath should be above the carriageway supported by the un-mountable kerb.

4.5 Pedestrian Walkability index analysis

Table 6: PWI Analysis

PWI= ((∑(facility rating× Length× Ped count×10))/Number of stretches)/1000

S. No	Parameters considered	Number of Stretches					PWI	PWI for the study area
		1	2	3	4	5		
1	Footpath Surface	2	2	2	2	3	0.21	0.3
2	Footpath width	3	4	2	3	2	0.25	
3	Continuity	5	5	4	5	4	0.412	
4	Footpath width encroachment	2	4	4	4	3	0.30	
5	Obstructions	3	5	3	3	3	0.30	
6	cleanliness and maintenance	2	2	2	4	4	0.26	
7	Comfort and walking environment	2	3	2	4	3	0.25	
8	Lighting facilities on the footpath	5	2	5	5	3	0.35	
9	Crossing facilities	5	4	5	5	4	0.41	
10	Pedestrian count	42	50	20	40	38	**Average = 0.3**	

The pedestrian interviews were conducted to know the problems faced by them and to know their preferences and requirements. 300 pedestrians were interviewed and their responses are given below. The data is obtained as presented in Table 2.

The first three questions were aimed at understanding the travel behavior of the people. It was used to determine how much time people are willing to walk and the average travel time to reach their main destination. Their vehicle ownership was also questioned.

4.6 Preferable travel modes by pedestrians for a distance with respect to time

Table 7: Preferable travel modes by pedestrians

Mode	<=15 min	15- 30min	30-60min	>60min
Walk	0.60	0.233	0.066	0.066
Cycle	0.066	0.033	-	-
Two wheeler	0.0166	0.30	0.233	0.30
Car/taxi	0.066	0.266	0.333	0.266
Bus/train	0.10	0.166	0.266	0.366
Total	1	1	1	1

From the proforma, it can be seen that walking is a most preferred mode of traveling especially for distances less than 15 minutes.

4.7 Pedestrian Walkability index

One of the PWI of the CJ Hospital area is given below

Table 8: PWI for CJ Hospital Surrounding Areas

S. No.	Areas	PWI for the study area
1	CJ Hospital Surrounding	0.300
2	AVK College Surrounding	0.288
3	Mandi Pete Surrounding	0.180
4	Old BSC Textile Shop Surrounding	0.920
5	New BSC Textile Shop Surrounding	0.140
6	PJ Extension Surrounding	0.310

Above table shows the Average PWI for the areas.

4.8 Pedestrian level of service

The pedestrian level of service was calculated for all the stretches in selected locations. The pedestrian volume was taken for an interval of 30 minutes for 2 hours in all the locations. The walking speed of 10 persons was taken and an average pedestrian walking speed was calculated manually. Then the pedestrian flow, pedestrian density was calculated.

LOS is determined in all five stretches of six areas. One example of determination of LOS out of all six areas are given below along with graphs.

Table 9: LOS of Stretch 1, Area 1

Length of stretch	1000m
Width of footpath	1.88m
Distance took to calculate pedestrian walking speed	10m

As per the LOS stated in Table 2, the footpath has
LOS – A (Based on Flow)
LOS- E (Based On Pedestrian Walking Speed)

4.9 Adequacy of footpaths

Based on the IRC norms shown in Table 3, the adequacy of the footpath required widths is proposed.

1. Commercial Areas

Table 10: Adequacy of footpaths in the commercial area

Area	Stretch	Volume (per hour)	The width of foot path	Adequacy	Recommended width as per IRC (m)
CJ Hospital Surrounding	1	503	1.88	A	--
	2	450	1.00	A	--
	3	820	2.25	A	--
	4	880	1.30	A	--
	5	880	1.23	A	--
AVK College	1	880	3.00	A	--
	2	1202	1.20	I	1.5
	3	605	0.95	I	1.5
	4	852	3.50	A	--
	5	900	2.50	A	--
Mandipete Surroundings	1	1020	1.30	I	2.00
	2	1200	0.98	I	2.00
	3	200	1.23	A	--
	4	150	1.00	A	--
	5	111	2.20	A	--

Where A- Adequate I - Inadequate

2. Shopping Areas

Table 11: Adequacy of footpaths in the shopping area

Area	Stretch	Volume (per hour)	Width of footpath	Adequacy	Recommended width as per IRC(m)
Old BSC Textile Shop Surrounding	1	2552	0.83	I	2.5
	2	550	0.75	A	--
	3	125	1.00	A	--
	4	855	0.95	A	--
	5	236	0.75	A	--
New BSC Textile Shop Surroundings	1	1552	2.00	A	--
	2	980	0.62	A	--
	3	777	1.40	A	--
	4	552	0.62	A	--
	5	326	0.52	A	--
PJ Extension Surroundings	1	2220	1.50	A	--
	2	444	1.20	A	--
	3	320	1.20	A	--
	4	380	1.37	A	--
	5	230	1.10	A	--

5. RESULTS

The results obtained from the study are tabulated and the suggestive measures to improve the pedestrian environment are explained in this chapter. Based on the results and discussion, the conclusions are given.

5.1 Commercial Area

Table 12: Improved PWI and LOS of CJ hospital surrounding

Stretch No.	Existing LOS as per HCM		Improved LOS as per HCM		Existing PWI	Improved PWI
	Speed	Flow	Speed	Flow		
1	D	A	D	A	0.33	0.33
2	A	B	A	B		
3	B	D	B	D		
4	A	C	A	C		
5	A	C	A	C		

Table 13: Improved PWI and LOS of AVK College Surrounding

Stretch No.	Existing LOS as per HCM		Improved LOS as per HCM		Existing PWI	Improved PWI
	Speed	Flow	Speed	Flow		
1	A	A	A	A	0.28	0.215
2	D	C	C	B		
3	C	D	B	C		
4	B	A	B	A		
5	C	C	C	C		

Table 14: Improved PWI and LOS of Mandi Pete Surroundings

Stretch No.	Existing LOS as per HCM		Improved LOS as per HCM		Existing PWI	Improved PWI
	Speed	Flow	Speed	Flow		
1	C	D	B	C	0.18	0.215
2	B	C	A	B		
3	C	A	C	A		
4	E	B	C	A		
5	D	A	D	A		

5.2 Shopping Zone

Table 15: Improved PWI and LOS of Old BSC Textile Shop Surroundings Area

Stretch No.	Existing LOS as per HCM		Improved LOS as per HCM		Existing PWI	Improved PWI
	Speed	Flow	Speed	Flow		
1	C	B	B	A	0.92	1.02
2	B	C	A	B		
3	C	A	C	A		
4	E	B	C	A		
5	D	A	D	A		

Table 16: Improved PWI and LOS of New BSC Textile Shop Surroundings

Stretch No.	Existing LOS as per HCM		Improved LOS as per HCM		Existing PWI	Improved PWI
	Speed	Flow	Speed	Flow		
1	C	B	B	A	0.94	0.94
2	A	B	A	B		
3	C	A	C	A		
4	B	B	B	B		
5	C	B	C	B		

Table 17: Improved PWI and LOS of PJ Extension Surroundings

Stretch No.	Existing LOS as per HCM		Improved LOS as per HCM		Existing PWI	Improved PWI
	Speed	Flow	Speed	Flow		
1	D	B	D	B	0.31	0.31
2	C	B	C	B		
3	C	A	C	A		
4	B	C	B	C		
5	C	A	C	A		

6. DISCUSSIONS AND CONCLUSIONS

6.1 Discussions

1. CJ Hospital Surrounding Area: Even though the walkability index of CJ Hospital Surrounding Area was found to be good, the field observation shows that it has a shortage of pedestrian facilities. Stretch 1, 2, 3, 4 and 5 had adequate width. These stretches have more than 50% of the pedestrians were found walking on the carriage way. They also have a poor surface, no crossing facilities, no continuity. Hence, the proper crossing facilities and continuity along the footpath, proper barricading has to be provided to avoid pedestrian-vehicle conflict. By providing these suggestive measures, the pedestrian walkability index can be improved. Street lighting facilities have to be provided for pedestrian use.

2. AVK College surrounding Area: In AVK College road the stretch 1, 4 and 5 have an adequate width of the footpath, but having poor footpath surface and bad crossing facilities. There are no crossing facilities at regular intervals and Pedestrians were found crossing the road haphazardly risking their lives. Hence stretch 1, 4 and 5 should be provided with good footpath surface, more crossing facilities and proper barricading. However, stretches 2 and 3 had a different scenario. The footpath width is inadequate, footpath surface is in poor condition, obstructions and encroachment were high in these stretches. Hence adequate width of footpaths should be provided, and the obstructions and encroachment should be cleared.

3. Mandi Pete Surrounding Area: The Mandi Pete Surrounding Area has very high pedestrian volume and fewer pedestrian facilities. Even though the width of the footpaths is sufficient, it was inadequate to accommodate the high pedestrian volume. Stretch number 1 and 2 had a lot of obstructions, lack of good surface condition and crossing facilities for the pedestrians. These stretches have poor illumination, which forces the pedestrians to use the carriageway in evening and nights. This will lead to accidents as the motor traffic movement is more. However, the stretches 3, 4 and 5 have better pedestrian facilities. Hence adequate footpath widths should be provided with good crossing facilities and proper barricading has to be done. The footpaths are occupied by street hawkers and thus it is to be avoided to allow free movement of pedestrians.

4. Old BSC Textile Shop Surrounding Area: The stretches in these areas have very high pedestrian volume. Stretches 2, 3, 4 and 5 lacked good footpath surface, continuity and Crossing facilities. Stretch 1 has very high pedestrian volume, poor footpath facilities, lacked continuity and crossing facilities. Pedestrians were found crossing the road haphazardly. During weekends as the pedestrian movement is more, the vehicle parking places can be converted to footpaths. However, stretch 3 and 4 have adequate width, but with a lot of obstructions. Hence continuous and good footpath surface should be provided with proper barricading to avoid pedestrian-vehicle conflict. More crossing facilities should also be provided. The footpaths are occupied by street hackers and thus it is to be avoided to allow free movement of pedestrians.

5. New BSC Textile Shop Surrounding Area: Near New BSC Textile Shop Surroundings Stretches 1 and 2 had good footpath width, it had a lot of obstructions and encroachment reducing the effective width of the footpath. The footpath surface was also in poor condition. **S**tretches 3, 4 and 5 were inadequate in width. It had a lot of obstructions and very bad surface condition. Improper planning has led to constant repairs on road as well as footpath facilities. Hence in stretch 1 and 2, the obstructions and encroachment have to be cleared and good footpath surface should be provided. In stretch 3, 4 and 5, adequate footpath width should be provided with the good surface condition and crossing facilities.

6. PJ Extension Surrounding Area: All the stretches in PJ Extension Surroundings have an adequate width of footpath and poor footpath surface. Stretch 1, 2 and 3 had more obstructions and poor footpath surface. Stretch 4 and 5 had an adequate width of the footpath, bad footpath surface, obstructions, and lack continuity. Hence adequate, good and continuous footpath has to be provided with more crossing facilities. The walking environment also should be improved.

6.2 Conclusions

- The walkability index values indicate that there is a definite shortage of pedestrian facilities in the urban area and the pedestrians are subjected to high risk which is evident from the pedestrian accidents.
- The studies on walkability will help the city planners to understand the importance of walkability which can be used to improve the PWI to ensure safety.
- The study develops the scientific measurement supported by technical analysis which can be taken for improvements.
- The study conducted acts as a ready reckoner for proposing pedestrian skywalks or subways in selected areas.
- The level of service (LOS) of all the stretches has been obtained and can be improved by avoiding the street hackers.

6.3 Scope for further work

- The walkability study has to be carried out for all the areas in the city.
- Time estimate and cost analysis can be carried out for the various improvement measures for the proposed width of the footpath.
- Suitable measures provided in this study can be adopted to improve the pedestrian facilities for other zones of the city based on the approach developed.
- A software program may be developed for quick measurement of PWI, which helps the planners to know the status of the existing walkways and also to validate the same.
- With the introduction of a number of infrastructural facilities like Metro rail, Mono rail, high capacity buses, grade separators etc, there is a need to carry out BAA(Before and After studies) to study the impact before and after.

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