Development of Sidewalk Evaluation Model for Existing Pedestrian Environment in Indian Cities: Case Example of Pune City, Maharashtra, India

Architecture

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ABSTRACT

The goal of any transportation system is to provide safe, comfortable and efficient mobility to the varied end users. 'Walking' is the basic mode of transportation, and 'Pedestrian' being the end user is provided with limited space in the form of sidewalks in Indian cities. However there are various sidewalk issues which need to be evaluated and addressed. Though Indian Road Congress have provided design guidelines, addressing the physical dimension of sidewalks, they are inadequate from pedestrian point of view and lack evaluation tool for assessing the sidewalk environment. Hence this paper attempts to put forth evaluation method for assessing the performance of sidewalk infrastructure facilities in Indian cities in terms of Gross Sidewalk Walkability Index. This Index will serve as an universal evaluation model for pedestrian environment in any urban areas irrespective of social and environmental context. This model will not only provide the local government with a tool to assess the quality of pedestrian environment but also serve as pioneer method to identify the sidewalk issues in varied context and formulate the design policies and the implementation strategies on priority basis to generate pedestrian responsive environment in any Indian city.

INTRODUCTION

Today with the advent of motor vehicle and fast speeding life dominating the Indian streets, development of sidewalks and pedestrians' needs have been shredded off in the background. The reinstating of sidewalks to encourage pedestrian life and provide them with comfortable and pleasant walking environment is today's urgent need of Indian cities, mostly the commercial streets, where multipurpose activities and varied users dominate the area. Eventually the uncontrollable vehicular growth on city roads has given rise to the various issues related to the sidewalk infrastructure facilities. Such issues need to be evaluated for assessing the quality of the sidewalk environment. Currently there are various qualitative and quantitative evaluation methods developed by western countries so as to create pleasant walking environment. However Indian government is lacking such evaluation tools for Indian streets. There is the need to develop an evaluation method for qualitative and quantitative assessment of the sidewalk environment. This will allow the urban planners to effectively assess the pedestrian environment, identify lacunas, prioritize and suggest improvements in sidewalk infrastructure facilities, which majority of Indian cities are lacking today. Hence this paper attempts to put forth the evaluation model for quantitative as well as qualitative assessment of sidewalk environment which can be applied on streets in any Indian city. This model can generate weighted sidewalk walkability indices for the sidewalk elements and their parameters which can be useful in planning, design and operation of pedestrian facilities as per their weighatge on any Indian street.
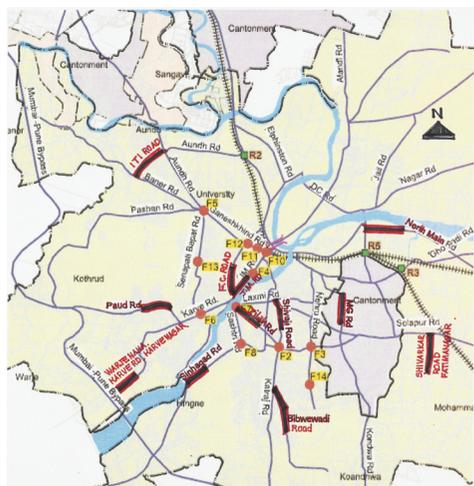

Figure 1: Plan of Pune city presenting the highlighted streets selected for the study of sidewalk condition.

SURVEY DESIGN FOR SIDEWALK WALKABILITY EVALUATION

With the view to evaluate sidewalk elements, nine streets (as listed in Table-1 and Figure-1) spatially distributed all over Pune city areas having different density pattern and having stretch of minimum five hundred meters and maximum one kilometer were identified and delineated for conducting quantitative as well as qualitative survey. The nine streets were also selected on the basis of varying road width and sidewalk width and commercial dominating mixed land use where high pedestrian volumes were observed. The evaluation of performance of sidewalk elements was expressed in terms of Pedestrian Level of Service which was further recorded in the form of Gross Sidewalk Walkability Index (GSWI).

Table-1: Details of Streets for Physical Survey of Sidewalk Environment

Density per Ha (Administrative Ward wise Density per Ha)	Road (Min. 500m to Max. 1000 m)	Road Width (m)	Sidewalk Width (m)
40 to 100 (Wards- Aundh, Yerawada, Hadapsar, Warje, Sangamwadi, Bibwewadi)	ITI Road, Sanewadi	16-20	Less than 1.5m
	Shivarkar Road, Fatimanagar	12-15	1.5 to 2.0m
	Bibwewadi Road	21-30	More than 2.0m
101 to 200 (Wards- Tilak Road, Dhole Patil Road, Ghole Road, Sahakarnagar)	Mahatma Gandhi Road, Camp	16-20	Less than 1.5m
	North Main Road	12-15	1.5 to 2.0m
	F.C. Road	21-30	More than 2.0m
Above 201 (Wards- Karve Road, Vishrambaugwada, Bhavani Peth, Kasba Peth)	Paud Road	21-30	More than 2.0m
	Tilak Road	12-15	1.5 to 2.0m
	Nehru road	16-20	Less than 1.5m

DEVELOPMENT OF SIDEWALK EVALUATION MODEL

One of the simplest and mostly used method for measuring the performance of sidewalk elements is numerical rating scale. This evaluation method employed included following stages:

Identification of sidewalk zones and their elements- Frontage zone, Footpath or Through Route Zone, Street Furniture zone and their physical characteristics in form of twenty one sidewalk parameters under all zones. Table-2 presents the list of sidewalk parameters undertaken for physical survey under each zone.

• Identification of quantitative and qualitative sub-parame-

ters under twenty one parameters for measuring the quantitative and qualitative dimension of sidewalk elements in terms of Pedestrian level of service.

- Weighting of the above twenty one sidewalk parameters and sub-parameters by five experts for measuring the degree of importance of a particular parameter among the twenty one parameters. The importance ratings are called Weights attached to the sidewalk parameters. These weightages of sidewalk parameters are universal and are impartial as they are based on Experts Opinion. Table-2 also presents the weightages of the sidewalk parameters.

- Developing five point ordinal rating scale for the above sidewalk parameters and sub-parameters based on national and international design guidelines of sidewalk infrastructure facilities and approved by five experts from various field such as urban planning, urban design, transportation planning and psychology.

- Application of Weighted Index Method for Calculation of 'Gross Sidewalk Walkability Index' (GSWI) as mentioned as below:

$$GSWI = (\sum W \times R \div \sum W)$$

Where

W = Weightage of the parameter (based on experts' opinion)
R = Weighted Average Rating of the Parameter

- Conducting the physical survey of delineated nine streets and recording the quantitative and qualitative observations of both sides of the sidewalk under identified parameters and sub-parameters and rating the parameters and sub-parameters based on the designed five point rating scale. (as explained in brief in Table-3)

- Arriving at weighted scores by Multiplying the weights attached to the parameter by the rated score of that sidewalk parameter (derived based on primary observation survey and the five point rating scale) (as mentioned in the above formula).

- Evaluating Pedestrian Level of Service Grade of sidewalks of the nine streets (as explained in Table-4) in terms of weighted score and expressed in terms of Gross Sidewalk Walkability Index based on above Weighted Index Method.

The GSWI will put forth the present existing condition of sidewalk, Lowest GSWI – 1 indicates poor sidewalk conditions and Highest GSWI -5 indicates most favourable sidewalk conditions. To improve the sidewalk condition, weighted walkability index of each parameter will indicate which parameter should be addressed or undertaken first for improvement. Even within each parameter, which sub-parameter should be addressed first can be decided using the weightages. Weightages are impartial since they are experts' opinion based. GSWI provides scope for conducting sensitivity analysis of the sidewalk. The application of this method can also be used for comparative analysis of different sidewalks in the city, identifying their lacunas and issues to be dealt with.

Table-2 Physical Survey Table and Weightage (based on Experts' Opinion) Of Sidewalk Parameters Under Each Sidewalk Zone

STREET SIDEWALK ELEMENTS	PHYSICAL CHARACTERISTICS OF STREET SIDEWALK ELEMENTS (PARAMETERS)	WEIGHTAGE BASED ON EXPERTS OPINION
1. THROUGH ROUTE ZONE	1. THROUGH ROUTE WIDTH	16
	2. FOOTPATH KERB HEIGHT	17
	3. FOOTPATH SURFACE	19
	4 FOOTPATH CONTINUITY	20
	5 EFFECTIVE FOOTPATH WIDTH	21
	6 DISABILITY INFRASTRUCTURE	18
2 STREET FURNITURE ZONE	7 PROVISION OF STREET FURNITURE ZONE AND THEIR WIDTH	15
	8 ROAD SIDE PLANTATION	11
	9 BUS STOPS	7
	10 STREET LIGHTING	14
	11 SEATING BENCHES	10
	12 OTHER STREET AMENITIES	13
	13 UNDERGROUND UTILITIES AND OVERHEAD SERVICES	9
	14 STREET VENDING SPACES	12
3. FRONTAGE ZONE	15 FRONTAGE ZONE WIDTH	4
	16 SIGNSCAPE	3
	17 STREETSCAPE	5
	18 STREET ACTIVITIES	8
4. CARRIAGEWAY ELEMENTS (RELATED TO SIDEWALKS)	19 CYCLE TRACK	2
	20 STORM WATER DRAINAGE FACILITY (LOCATION OF STORM WATER DRAINS/CATCH PITS)	6
	21 ON STREET PARKING	1

Table 3- Rating Scale Of Sidewalk Parameters Of Existing Sidewalk Condition

Sidewalk Parameters	Excellent Rating-5 Los –A	Good Rating-4 Los –B	Satisfactory Rating-3 Los –C	Poor Rating-2 Los –D	Very Poor Rating-1 Los –E
Definition Of Sidewalk Condition	Ideal condition is defined as the sidewalk possessing more than 18 of 21 parameters or characteristics as per standards.	Reasonable condition is defined as the sidewalk possessing 15 to 18 of 21 parameters or characteristics as per standards.	Basic condition is defined as the sidewalk possessing 10 to 14 of 21 parameters or characteristics as per standards.	Poor condition is defined as the sidewalk possessing 6 to 9 of 21 parameters or characteristics as per standards.	Unsuitable condition is defined as the sidewalk possessing less than 5 of 21 parameters as per standards.

Table-4 Grading of Gross Sidewalk Walkability Index (GSWI) for defining Pedestrian Level Of Service (PLOS)

Gross Sidewalk Walkability Index (GSWI) (Weighted Score)	Pedestrian Level of Service (PLOS)	Condition	Description
$4.0 \leq GSWI \leq 5.0$	A	EXCELLENT	Ideal sidewalk conditions exist and number of factors that negatively affect PLOS are minimal
$3.0 \leq GSWI < 4.0$	B	VERY GOOD	Reasonable sidewalk conditions exist but a small number of factors impact on pedestrian safety and comfort
$2.0 \leq GSWI < 3.0$	C	SATISFACTORY	Basic sidewalk conditions exist but a significant number of factors affect safety and comfort.
$1.0 \leq GSWI < 2.0$	D	POOR	Poor sidewalk conditions exist.
$GSWI < 1.0$	E	VERY POOR	Existing sidewalk environment is unsuitable.

Table-5 Gross Sidewalk Walkability Index (GSWI) of Selected Street Sidewalks defining the Existing Pedestrian Level Of Service (PLOS) (Derived based on Weighted Index Method)

Road Width	12 TO 15 M			16 TO 20 M			21 TO 30 M		
Sidewalk Width	1.50M TO 2.00M			LESS THAN 1.50M			MORE THAN 2.0M		
Pune City Zone	Outer Pune	Inner Pune	Central Pune	Outer Pune	Inner Pune	Central Pune	Outer Pune	Inner Pune	Central Pune
Street	Shivarkar Road	North Main Road	Tilak Road	Iti Road	M. Gandhi Road	Nehru Road	Bibwewadi Road	Paud Road	Fergusson College Road
Quantitative Swi	2.58	2.60	2.76	3.17	2.79	2.82	3.01	3.37	3.12
Qualitative Swi	2.60	2.98	3.29	3.05	3.30	2.76	3.43	3.37	3.22
Gross Sidewalk Walkability Index (Gswi)	2.59	2.79	3.02	3.11	3.04	2.79	3.22	3.37	3.17
Pedestrian Level Of Service (Plos)	C	C	B	B	B	C	B	B	B

Chart-1- Comparative Analysis of Quantitative, Qualitative and Gross Sidewalk Walkability Index of Delineated Streets in Pune city.
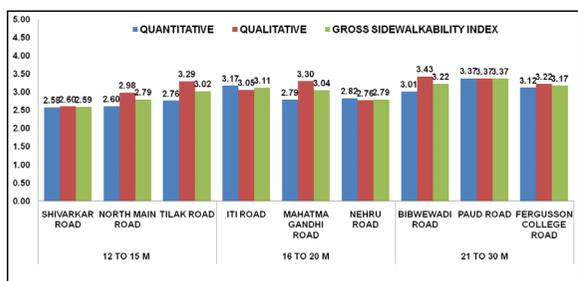
RESULTS

Based on the primary survey and Weighted Index method following are the results recorded as presented in Table-5 and Table-6. Chart-1 presents Comparative Analysis of Quantitative, Qualitative and Gross Sidewalk Walkability Index of Delineated Streets in Pune city. The sidewalks on the road having width 12 to 15m have existing sidewalk conditions below satisfactory level, qualitatively as well as quantitatively. They lack provision of pedestrian infrastructure, amenities and facilities while some of the sidewalks on roads of 16 to 20 m width lack quantitative facilities. The sidewalks on the roads above 21m have satisfactory provision of pedestrian amenities and facilities, quantitatively as well as qualitatively. Most of the street sidewalks have satisfactory Pedestrian level of service which indicates that basic sidewalk infrastructure amenities and facilities have been provided as per design guidelines. However to improve Pedestrian level of service grade above satisfactory level more than fifteen of twenty one parameters need to be addressed on the basis of their weightages (importance).

Table-6- Comparative Analysis of Quantitative, Qualitative and Gross Sidewalk Walkability Index(GSWI) of Delineated Streets presenting the sidewalk parameters to be addressed to improve Existing Pedestrian Level Of Service (PLOS) (Derived based on Weighted Index Method)

	Sidewalk Walkability Index Of All Roads Based On Physical Survey																											
Pune City Area/Zone	Outer Pune									Inner Pune									Central Pune									
Road Width	12 To 15 M			16 To 20 M			21 To 30 M			12 To 15 M			16 To 20 M			21 To 30 M			12 To 15 M			16 To 20 M			21 To 30 M		
Average Footpath Width	1.50M To 2.00M			Less Than 1.50M			More Than 2.0M			1.50M To 2.00M			Less Than 1.50M			More Than 2.0M			1.50M To 2.00M			Less Than 1.50M			More Than 2.0M		
	Shivarkar Road			Iti Road			Bibwewadi Road			North Main Road			Mahatma Gandhi Road			Paud Road			Tilak Road			Nehru Road			Fergusson College Road		
Subparameters	Quantitative	Qualitative	Average	Quantitative	Qualitative	Average	Quantitative	Qualitative	Average	Quantitative	Qualitative	Average	Quantitative	Qualitative	Average	Quantitative	Qualitative	Average	Quantitative	Qualitative	Average	Quantitative	Qualitative	Average	Quantitative	Qualitative	Average
Through Route Width	2.25	Na	2.25	3.58	Na	3.58	4.50	Na	4.50	3.50	Na	3.50	3.00	Na	3.00	4.08	Na	4.08	3.50	Na	3.50	3.50	Na	3.50	4.00	Na	4.00
Footpath Kerb Height	3.67	1.50	2.58	5.00	3.00	4.00	3.67	3.00	3.33	2.33	3.00	2.67	2.33	3.00	2.67	5.33	3.00	4.17	2.33	3.00	2.67	4.00	3.00	3.50	2.67	3.00	2.83
Footpath Surface	3.20	2.83	3.02	4.50	3.80	4.15	4.10	4.20	4.15	3.80	3.83	3.82	4.20	4.20	4.20	5.00	4.60	4.80	3.50	3.73	3.62	3.60	3.53	3.57	4.00	4.53	4.27

Parameter																											
Footpath Continuity	2.38	2.33	2.36	3.21	3.00	3.11	2.50	4.00	3.25	3.17	3.00	3.08	3.62	4.67	4.14	3.76	4.33	4.05	2.93	4.00	3.46	3.52	3.5	3.51	4.00	5.00	4.50
Effective Footpath Width	2.50	Na	2.50	3.50	Na	3.50	3.50	Na	3.50	3.00	Na	3.00	3.00	Na	3.00	4.00	Na	4.00	3.50	Na	3.50	3.50	Na	3.50	4.00	Na	4.00
Disability Infrastructure	1.00	Na	1.00	1.00	Na	1.00	1.00	Na	1.00	1.00	Na	1.00	1.00	Na	1.00	2.00	Na	2.00	1.00	Na	1.00	1.00	Na	1.00	1.00	Na	1.00
Street Furniture Zone																											
1.2.1 Provision Of Street Furniture Zone & Their Width	1.50	2.00	1.75	2.833	3.00	2.92	2.67	2.50	2.58	2.33	2.00	2.17	2.83	3.00	2.92	2.33	1.00	1.67	1.67	2.00	1.83	1.67	2.00	1.83	2.33	1.00	1.67
1.2.2 Road Side Plantation	1.91	4.85	3.38	3.024	3.60	3.31	2.88	4.85	3.87	2.52	3.30	2.91	2.91	4.85	3.88	3.05	4.85	3.95	2.52	3.00	2.76	2.69	2.65	2.67	3.14	4.50	3.82
1.2.3 Bus Stops	2.00	3.00	2.50	2.00	4.00	3.00	1.00	3.50	2.25	1.50	1.50	1.50	1.00	1.00	1.00	1.00	3.00	2.00	1.50	1.50	1.50	2.00	2.00	2.00	3.00	3.00	3.00
1.2.4 Street Lighting	3.33	3.00	3.17	3.67	3.00	3.33	3.00	2.00	2.50	3.33	4.00	3.67	3.67	3.00	3.33	3.00	3.00	3.00	3.00	4.00	3.50	3.17	3.00	3.08	3.33	4.00	3.67
1.2.5 Seating Benches	1.67	1.00	1.33	2.667	3.00	2.83	2.83	4.00	3.42	1.00	1.00	1.00	1.00	1.00	1.00	2.00	4.00	3.00	1.67	3.00	2.33	2.83	3.00	2.92	1.67	1.00	1.33
1.2.6 Other Street Amenities	1.67	1.00	1.33	1.00	1.00	1.00	1.83	2.00	1.92	1.33	3.00	2.17	1.67	1.00	1.33	1.00	1.00	1.00	2.00	2.00	2.00	2.33	1.00	1.67	1.33	1.00	1.17
1.2.7 Underground Utilities And Overhead Services	2.00	3.00	2.50	4.00	3.67	3.83	3.00	3.67	3.33	2.00	2.00	2.00	4.00	3.67	3.83	3.00	4.00	3.50	4.00	3.33	3.67	3.50	2.00	2.75	4.00	2.33	3.17
1.2.8 Street Vending Spaces	3.00	Na	3.00	3.00	Na	3.00	3.33	Na	3.33	2.33	Na	2.33	2.67	Na	2.67	3.00	Na	3.00	3.00	Na	3.00	2.17	Na	2.17	3.67	Na	3.67
Frontage Zone																											
1.3.1 Frontage Zone Width	5.00	Na	5.00	4.50	Na	4.50	5.00	Na	5.00	5.00	Na	5.00	1.00	Na	1.00	5.00	Na	5.00	4.00	Na	4.00	2.50	Na	2.50	5.00	Na	5.00
1.3.2 Signscape	3.58	3.83	3.71	4.08	3.33	3.71	3.50	3.00	3.25	3.92	2.67	3.29	2.67	2.33	2.50	3.50	3.33	3.42	3.42	2.00	2.71	3.00	3.00	3.00	3.33	3.00	3.17

1.3.3 Streetscape	4.00	3.67	3.83	2.20	2.67	2.43	2.65	3.00	2.83	2.60	3.00	2.80	4.70	4.67	4.68	2.70	2.67	2.68	4.20	5.00	4.60	3.60	4.00	3.80	2.90	2.83	2.87
1.3.4 Street Activities	4.33	5.00	4.67	3.667	3.00	3.33	4.67	5.00	4.83	3.00	5.00	4.00	3.67	5.00	4.33	4.00	5.00	4.50	4.00	5.00	4.50	3.67	3.00	3.33	4.83	3.00	3.92
Carriageway Zone																											
2.1 Cycle Track	1.00	Na	1.00	1.00	Na	1.00	2.83	Na	2.83	1.00	Na	1.00	1.00	Na	1.00	4.67	Na	4.67	1.00	Na	1.00	1.00	Na	1.00	1.00	Na	1.00
2.2 Storm Water Drainage	5.00	Na	5.00	3.00	Na	3.00	2.17	Na	2.17	4.00	Na	4.00	3.00	Na	3.00	4.00	Na	4.00	3.00	Na	3.00	2.33	Na	2.33	2.00	Na	2.00
2.3 On Street Parking	3.50	Na	3.50	5.00	Na	5.00	2.00	Na	2.00	1.00	Na	1.00	5.00	Na	5.00	5.00	Na	5.00	5.00	Na	5.00	3.50	Na	3.50	5.00	Na	5.00
Gross Walkability Index	2.57	2.60	2.59	3.169	3.0535	3.1113	3.01	3.425	3.22	2.60	2.9775	2.79	2.78	3.30	3.04	3.37	3.37	3.37	2.76	3.29	3.02	2.8205	2.7635	2.792	3.12	3.22	3.17
Pedestrian Level Of Service Provided (Plos) By The Physical Characteristics Of The Sidewalk Environment	C	C	C	B	B	B	B	B	B	C	C	C	C	B	B	B	B	B	C	B	B	C	C	C	B	B	B

CONCLUSION

Inadequate pedestrian facilities in Indian cities have resulted in a high rate of pedestrian fatalities. Indian Road Congress has stipulated standards for pedestrians' facilities. But pedestrian amenities and context specific standards according to location and hierarchy of streets have not been thought of. The Institute for Transportation and Development Policy (ITDP) and The Environmental Planning Collaborative (EPC) have introduced *Better Streets, Better Cities: A guide for street design in urban India.* This guide provides a framework for understanding various elements of street design and a toolkit for well-designed streets. However Indian Road Congress as well as guide of ITDP, both lack approach towards quantitative and qualitative evaluation of sidewalk elements, amenities and facilities from pedestrians' satisfaction need point of view.

This GSWI evaluation model can generate walkability scores on the basis of not only footpath surface, footpath width, obstructions, encroachment, potential for vehicle conflict, continuity, but also on the basis of provision of street furniture elements such as seating benches, drinking water facilities, street lighting etc., legibility of street facade such as streetscape, signscape and street activities which influence the quality of street environment. This sidewalk evaluation method developed serves as a quantitative as well as qualitative tool for evaluating, assessing existing physical conditions of the sidewalk and is also useful for planning, design and operation of sidewalk elements and facilities.

This GSWI evaluation model serves as a quantitative as well as qualitative tool for assessing existing physical conditions of the sidewalk. GSWI method developed designates a sidewalk condition in terms of a walkability score and Pedestrian level of Service grade for delineated street sidewalks of Pune city depending on the twenty one identified sidewalk parameters. These Walkability scores is effective to compare different design input scenarios (in terms of design guidelines) for planning, design and operation of sidewalk facilities. The application of this evaluation model can also be useful in assessing the effect of change in the sidewalk parameter on quality of pedestrian environment. This model shall be useful to evaluate existing sidewalk conditions and pedestrian infrastructure in any metropolitan cities along with evaluating alternative proposal for improving pedestrian facilities.