MANTECH Publications

Journal of Transportation Engineering and Its Applications
Volume 6, Issue 3, September-December, 2021

Review of Pedestrian Walkways to Make Pedestrians Safe in India

G. Ravi Kishor, B. Sarva Rao
Professor
Department of Civil Engineering
P.D.A College of Engineering Gulbarga
Corresponding Author's E-mail: *braosarvarao@gmail.com*

Abstract

Most Indian towns are concerned about the deterioration of the pedestrian environment and the rising danger of pedestrian accidents. The recent change in priority to motorised transport, as well as the deterioration of existing pedestrian infrastructure, can be attributed to the rise in pedestrian-related accidents in India. Bengaluru City, the nation's IT capital centre, is not much different. The rise in the number of pedestrian accidents in Bengaluru reflects this. To address this issue and provide safe, sustainable, and pedestrian-friendly sidewalks, the Government of Karnataka, India, has introduced a novel pedestrian sidewalks programme known as Tender S.U.R.E. (Specifications for Urban Road Execution) projects. Tender SURE follows special urban street design rules that prioritise pedestrians. The current study provides an assessment of the quality and performance of pedestrian sidewalks, as well as the walkability index of freshly constructed pedestrian-friendly sidewalks. Several physical and environmental elements impacting pedestrian safety are discovered and thoroughly explored. The Pedestrian Level of Service (PLoS) is used to quantify pedestrian mobility, while the Walkability Index is used to calculate pedestrian walking comfort (WI). It has been noticed that the new steps implemented to improve pedestrian safety have been successful in Bengaluru, with a level of Service of 'A' and an excellent WI score.

Keywords: *Pedestrian safety, pedestrian level of service, right of way, Tender SURE, walkability index, walkway facilities.*

Page 134-148 © MANTECH PUBLIATIONS 2021. All Rights Reserved

INTRODUCTION

Because of the social and economic factors, walking is one of the essential ways of transportation in India. However, there is a dearth of attention paid to pedestrians, their problems, and the amenities they require. To create a comfortable walking environment, pedestrians require separated sidewalks that avoid confrontations with other walkers and motor vehicles, safe crossing facilities, and other environmentally friendly walkway infrastructure. The recent change in priority to motorised transportation demands, along with the deterioration of existing pedestrian infrastructure, exacerbated the situation and increased pedestrian risk across the country. Most pedestrian walkways in India today are characterised by insufficient width, a lack of supporting street furniture, regular utility repair work, unlawful parking, and street vendor encroachment, which pushes pedestrians to walk on the roadway, endangering their lives.

Accident data in India show a 2.5 percent rise in road accidents from 4,89,400 in 2014 to 5,014,23 in 2015 [1], [2]. Pedestrians account for 37 percent of traffic fatalities, and roughly 35 percent of pedestrian accidents occur near sidewalks [3]. Karnataka, a popular southern Indian state with a population of 61.09 million, ranks fourth in the country in terms of the number of accidents and deaths reported in 2015. Bengaluru, Karnataka's urban IT capital, had an increase of 4,828 road accidents, including 331 fatal pedestrian accidents [4].

The majority of Bengaluru's urban roadways are examples of traffic pandemonium, damaged walkways, dangling wires, clogged sewers, overflowing sewage, and haphazard street lighting, as well as transformers and telecom fixtures. Temporary remedies based on inadequate design and construction result in recurrent excavations and repairs of the same road, depleting the city's coffers while doing nothing to improve the condition of the roads and, thus, the quality of road users.

The Karnataka government has taken the lead in tackling this massive waste by enhancing the quality of the most basic mobility infrastructure. One such initiative is the Tender SURE (Specifications for Urban Road Execution) project, in which rules for the design of urban roadways have been devised and executed with pedestrians as the primary focus. This was the first initiative of its sort in India, with

Page 134-148 © MANTECH PUBLIATIONS 2021. All Rights Reserved

the goal of improving pedestrian infrastructure and enhancing safety.

The report goes into depth on the Tender SURE design standards and their successful implementation at numerous places around Bengaluru. Some walkability studies were also done to evaluate the functioning of the new infrastructure.

TENDER SURE – A NEW APPROACH TO URBAN STREET DESIGN

Tender SURE is about getting the urban road right by using a completely innovative and sustainable strategy to developing and implementing urban roads. Tender SURE's particular focus is the movement and safety of pedestrians and cyclists, constant traffic flows and travel lane widths, and the intelligent re-laying of all subterranean utilities through collaboration with multiple government authorities. Other pedestrian facilities, such as parking spaces, street landscaping trees, allocated spaces for street sellers, separated trash disposal areas, proper lighting, signs, sloped walkways, and mandatory junction upgrades on highways, were also integrated into the design.

TENDER SURE – PLANNING REQUIREMENTS

The standards supplied for various Right of Way elements are based on the kind of urban road, such as arterial, sub-arterial, collector, and local roads. They are in compliance with Tender SURE and the Ministry of Road Transport and Highways requirements.

A. Public Right of Way

Because the right of way of the road network varied, the design took into account the average or minimum road width in the road segments. The number and breadth of lanes, the width of parking lanes, cycle line, and sidewalk lanes are built based on available space.

B. Design Speed

80 km/h, 60 km/h, 50 km/h, and 30 km/h are the design speeds chosen as the design speed for arterial, sub-arterial, collector street, and local street roads in accordance with Indian Road Congress rules [5].

C. Travel Lane

According to the norms and taking into account the available area, traffic lane widths of 3 m, 3 m, 2.75 m, and 2.5 m were chosen for an arterial, sub-arterial, collector, and local roads, respectively.

Page 134-148 © MANTECH PUBLIATIONS 2021. All Rights Reserved

The width of the traffic lane was meant to be uniform and consistent.

D. Geometric Elements

The horizontal geometry, horizontal and vertical alignment and superelevation were all developed in accordance with IRC standards [5], [6]. The primary vehicle lane has a cross slope of 2.5 percent, while the pedestrian walkway has a cross slope of 3 percent. The road network's alignment was kept in most locations unless it was necessary to change it.

E. On-Street Parking

For the parking lane, parallel parking with a conventional dimension of 2.75x6 m was chosen. Appropriate places in the road network were chosen for public, private, and intermediate transportation vehicles. A few 1x2 m spots are set aside in between for two-wheeler parking.

F. Landscape Strip

On all roads along the street light strip, a landscape strip is provided. Dedicated areas of 1x1 m to 1.5x1.5 m units are created out of the right of way (RoW) at appropriate locations to enable the operations of hawkers/vendors. Public restrooms and solid waste collection containers were also integrated into the design, and appropriate places in the road network were chosen.

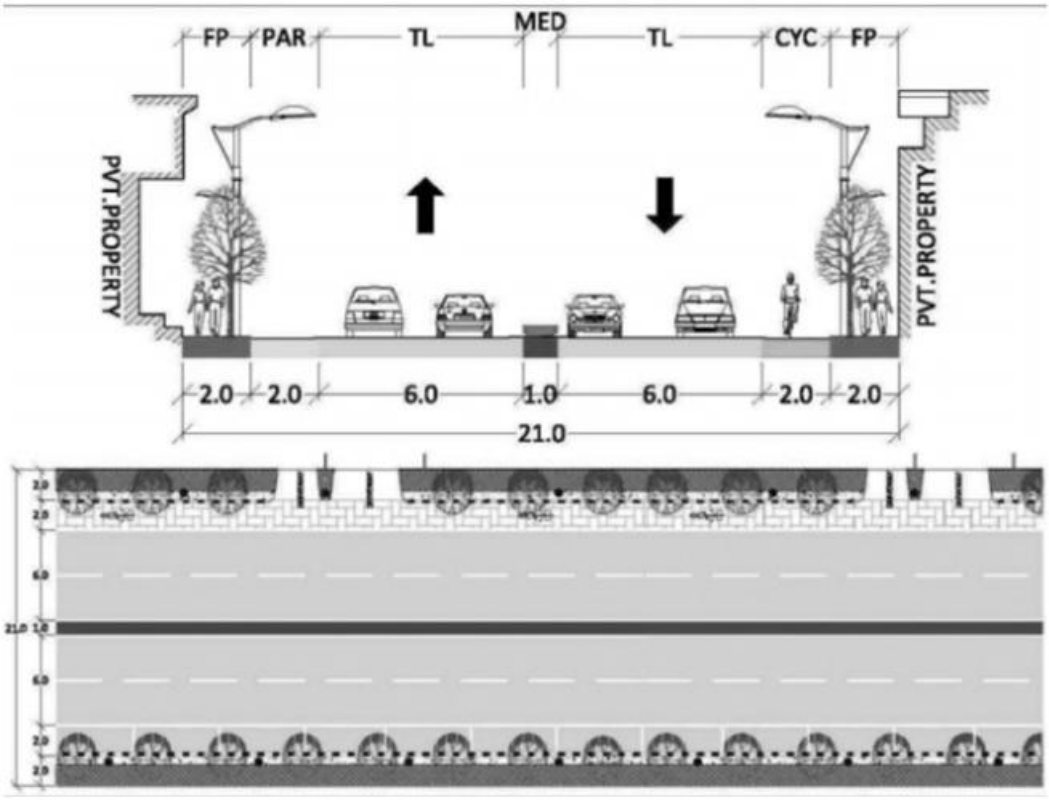

Fig. 1: RoW cross-section based on the Tender SURE Design Guidelines

Page 134-148 © MANTECH PUBLIATIONS 2021. All Rights Reserved

To examine the viable design possibilities, preliminary field experiments were conducted. Before developing the design, topographic studies, traffic and pedestrian volume count surveys, and soil deflection experiments were carried out. The topographic survey recorded site data such as the placement of side drains, existing pavement cross section elements, traffic island, bridge, and flyover positions, property identification, and the location of trees, manholes, utility lines, and other electrical lines.

The current volume/capacity ratio was calculated as a consequence of the traffic volume count survey. The pedestrian volume count study also identified the road network's pedestrian movements. For structural examination of the existing pavement, Benkelman Beam deflection and associated soil tests were performed.

TENDER SURE – DESIGN DEVELOPMENT

The Tender SURE design principles were developed based on the planning requirements, field investigation answers, and data obtained from numerous surveys. The RoW design involves the design of the travel lane, sidewalk, non-motorized lane, utilities and other drains, parking lane, street furniture, signage, and crossroads, as well as their materials and dimensions. The minimum widths specified by the design standard for the travel lane, sidewalk, non-motorized lane, and parking are 3 m, 1.5 m, 3 m, and 1.5 m, respectively. Figure 1 is a typical cross-section of RoW with Tender SURE requirements.

The material specifications and dimensions of the cross-sectional components are also specified in the design guidelines. For example, 60 mm shot-blasted interlocking tiles for the pedestrian walkway and 8 m height LED lighting for improved visibility have been suggested.

In addition to the cross-sectional features, design rules for road design (overlay, paver block, sidewalk, non-motorized lane, parking lane), above grade street fixtures (street lamp, road markings, signs, signal poles), and below-grade utilities have been developed (stormwater drains, water supply drains, sewers, power cables, telecom lines, gas lines, etc.). Fig. 2 depicts more specs information.

Page 134-148 © MANTECH PUBLIATIONS 2021. All Rights Reserved

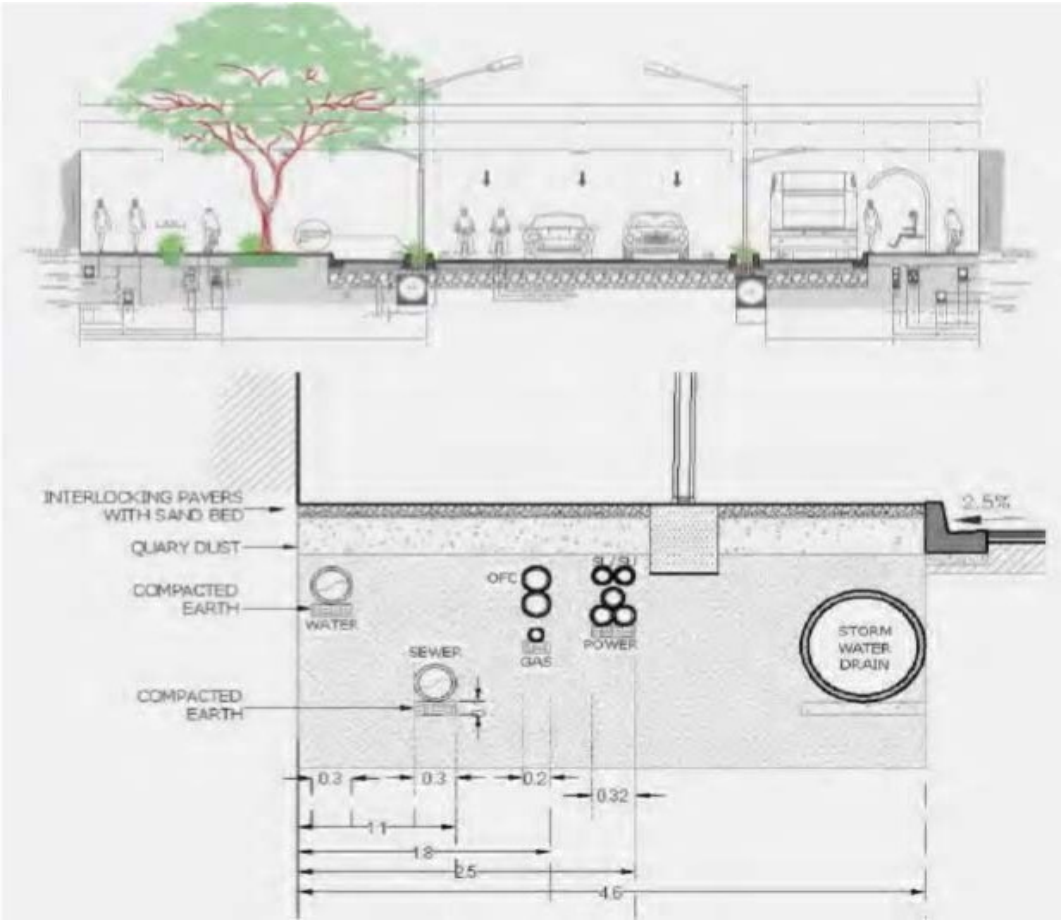

Fig. 2 Tender SURE design guidelines

TENDER SURE - IMPLEMENTATION IN SEVEN BENGALURU CITY LOCATIONS

Tender SURE infrastructure measures are intended to be implemented in stages on numerous metropolitan roadways in Bengaluru, Karnataka. It is now being implemented effectively on seven central business district roads, including Vittal Mallya Hospital Road, Cunningham Road, Residency Road, St. Mark's Road, Museum Road, Commissariat Road, and Richmond Road. The network of these seven highways is crucial in sustaining business/commercial hubs, historical sites, public buildings, and schools, among other things. The goal of the urban street redesign is to serve these functions while also catering to the demands of walkers and non-motorized transit users. Figure 3 depicts the road network chosen for phase one deployment.

The design specifications of the RoW for all seven locations are listed in Table I.

Page 134-148 © MANTECH PUBLIATIONS 2021. All Rights Reserved

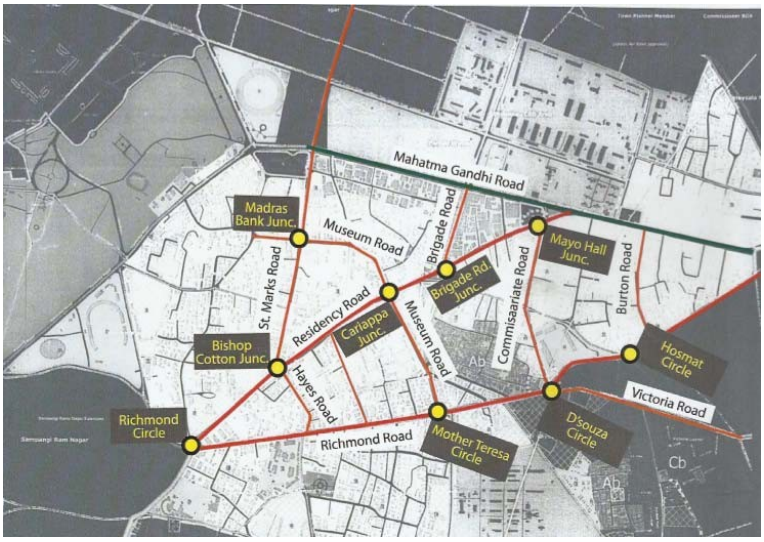

Fig. 3 Tender SURE road network

Table I Tender Sure Design Specifications

Road Name & Type	RoW [A]	Travel Lane	Sidewalk	Cycle Lane	Parking Lane
Residency Road	25 to 31	3L	2 + 2	1.5 + 1.5	2
Richmond Road (arterial)	15 to 24	4L	2 + 2	1.5 + 1.5	2
	11.5 to 15	2L	1.5+ 1.5	1.5 + 1.5	0
St. Mark's road (sub arterial)	15 to 17	2L	2 + 2	2	2
	19 to 23	3L	2 + 2	1.5 + 1.5	0
Cunningham road (sub	19 to 24	2L	2 + 2	1.5 + 1.5	2
Vittal Mallya Hospital	16 to 20	3L	2 + 2	1.5 + 1.5	2
Commissariat road	18 to 21	3L	1.5 + 1.5	1.5 + 1.5	0
Museum road (collector)	13.5 to 18	3L	1.5 + 1	1 + 1	0
	26 to 31	3L+3L	2 + 2	1.5 + 1.5	0

Fig. 4: Tender SURE infrastructure at Richmond road, Bengaluru

The implementation of Tender SURE at the above locations have been photographed and displayed in Fig. 4.

Page 134-148 © MANTECH PUBLIATIONS 2021. All Rights Reserved

WALKABILITY STUDIES ON TENDER SURE SIDEWALKS

Because pedestrian safety is a serious concern, it is vital to evaluate the functioning of the new Tender SURE sidewalks and monitor walking conditions. This type of metric aids in evaluating current sidewalk amenities and

Several indices that analyse and quantify the walkability qualities of a sidewalk have been created during the last two decades [7]-[19]. The majority of these measurements were based on quantitative data to evaluate the extent of a sidewalk's present level of service, but others used pedestrian perception and qualitative criteria to rate the facility. Among the numerous indices, calculating the PLoS and grading the sidewalk by determining the WI is a standard technique for assessing the performance of pedestrian infrastructure. To determine these indices, many approaches have been used [20]. The Highway Capacity Manual is the most frequently cited, having defined the PLoS of sidewalks based on pedestrian density, space, and flow [21].

For Indian settings, guidelines for pedestrian pathways and optimum PLoS levels have been developed [22], [23]. A WI was employed in one of the studies commissioned by the Ministry of Urban Development in India (MOUD). This research rated the walkability of 30 cities of various sizes based on the presence of sidewalks on key arterial routes and the overall facility evaluation by pedestrians [24]. The availability and quality of sidewalks, obstacles, maintenance, lighting, criminal security, crossing safety, and other qualitative characteristics were used to measure pedestrian impression. A low ranking denotes insufficient and unsatisfactory pedestrian infrastructure.

The current study uses PLoS to assess the Tender SURE pedestrian walkway performance and grade the facility based on its WI.

A. Data Collection

The current research looks at the Tender SURE pedestrian infrastructure on four different roads: Vittal Mallya Hospital Road, Cunningham Road, St. Mark's Road, and Residency Road.

B. PLoS of Present Tender SURE Sidewalks

The PLoS level was established after a quantitative assessment of the current pedestrian amenities. On a typical workday, data on pedestrian movements in both directions is gathered during the morning peak hour. At each sidewalk, a

Page 134-148 © MANTECH PUBLIATIONS 2021. All Rights Reserved

pedestrian grid with a known cross sectional area was evaluated. The movements of pedestrians on these grids were videotaped for two hours in the morning (8 a.m. – 10 a.m.). These video files are then used to extract statistics on pedestrian speed, flow, and density. The data extraction procedure is summarised in the next section. Figure 5 is a picture of the pedestrian grid.

Pedestrian Speed: Pedestrian speed is the average pedestrian walking speed (m/s). The following is how the speed data is extracted:

- A random pedestrian about to enter the grid is chosen and tracked for the duration of the grid's length. The pedestrian's entry and exit times in the grid are recorded. Subtracting the grid entering time from the time of leaving yields the walking time. After then, the walking speed is computed by dividing the grid length by the walking duration.
- Pedestrian Space and Density: Pedestrian space is the average area supplied for each pedestrian in a footpath, whereas density is the average number of pedestrians per unit of area inside a footpath. The connection between pedestrian space and density is inverse. The data on pedestrian density is retrieved as follows:
- The density of the area is calculated by dividing the total number of pedestrians in the pedestrian grid by the area of the pedestrian grid. This is computed by picking a random pedestrian in the middle of the pedestrian grid and counting all of the other pedestrians in the grid. The pedestrian density is calculated by dividing the number of pedestrians counted by the grid area. The pedestrian space is defined as the inverse of pedestrian density.

Fig. 5: The pedestrian grid was chosen for the Tender SURE sidewalks

Page 134-148 © MANTECH PUBLIATIONS 2021. All Rights Reserved

Pedestrian flow rate is the number of pedestrians passing a spot per unit time, given as pedestrians per 15 minutes or pedestrians per minute. The steps involved in obtaining pedestrian flow rate data are as follows:

Pedestrians crossing the grid are tallied every 15 minutes during peak hours. The pedestrian flow is determined by dividing the 15-minute pedestrian volume by the grid width. The flow rate in pedestrians/min/m is given by this flow value every minute. The flow rate in pedestrians/min/m is presented as the highest 15-minute volume.

The data was retrieved, and Table II shows the pedestrian characteristics at the four locations. This data is collected in the field and examined to determine the facility's adequacy in terms of the level of service measurement for the recorded pedestrian traffic. To get at the current PLoS level, the Highway Capacity Manual (HCM) and Indian Road Congress (IRC) recommendations on Pedestrian facilities were consulted [21], [22].

A pedestrian volume is presented in pedestrians per hour, [b] pedestrian density is in pedestrians per square meter, [c] pedestrian flow is in pedestrians per meter, [d] pedestrian flow rate is in pedestrians per meter per minute.

The Tender SURE pedestrian sidewalk provides a level of service A and B, which enables pedestrians to move in desired paths without any conflicts with other pedestrians. They are able to walk at a selected speed and enjoy sufficient space for their movement. The details of the qualitative assessment are presented in the next section.

Table II Pedestrian Characteristics at Tender Sure Sidewalks

Road Name	Pedestrian Volume[a]	Pedestrian Density[b]	Flow[c] (p/m)	Flow Rate[d] (p/m/Min)	PLoS
Vittal Mallya	688	0.16	55.71	3.71	A
Cunningham road	995	0.29	104.33	6.96	B
Residency road	287	0.06	13.48	0.9	A
St. Mark’s road	358	0.13	41.67	2.78	A

Page 134-148 © MANTECH PUBLIATIONS 2021. All Rights Reserved

C. Tender SURE Sidewalks WI

The qualitative evaluation of sidewalks is critical for sidewalk evaluation and design. The perception of pedestrians may be used to calculate sidewalk performance. The information gathered from pedestrians is used to anticipate a set of qualitative characteristics that define how well a sidewalk's present level of service matches a pedestrian's expectations. The current study explores the qualitative assessment of Tender SURE sidewalks and computes the WI.

The WI takes into account two factors: the importance of accessible sidewalk facilities and user happiness when using the sidewalk. For the computation of WI, see (1).

$$WI = \sum A_i \times B_i \qquad (1)$$

where Ai is the importance weightage for physical, and user \scharacteristics and Bi is the satisfaction rating for physical and user characteristics. The factors evaluated in physical characteristics were sidewalk surface, sidewalk width, obstruction, the potential for vehicular conflict, continuity and the user factors were encroachment, availability of crossing facilities, security, walk environment and comfort.

The importance weightage was assigned by transportation planners/engineers after field assessment. The satisfactory ratings were collected from the pedestrians through a questionnaire survey. The rating was performed on a scale of 1 to 5 for weightage (1=immaterial, 2=least importance, 3=important, 4= very important and 5=most important) and for satisfaction (1=poor, 2=satisfactory, 3=good, 4=very good, 5=excellent) with respect to 10 sidewalk attributes.

The collective pedestrian satisfactory responses on the physical and user characteristics of Tender SURE sidewalks are summarised and presented in Fig. 6 for one location. Similar exercises were repeated for all the other locations, and the calculated WI is listed in Table III.

The WI value explains the quality of the Tender SURE walkway amenities and the walking environment. A walkability score of 250 would be the highest possible. The current values are closer together, indicating a higher level of service excellence. This study also aids in determining which areas require additional improvement.

Page 134-148 © MANTECH PUBLIATIONS 2021. All Rights Reserved

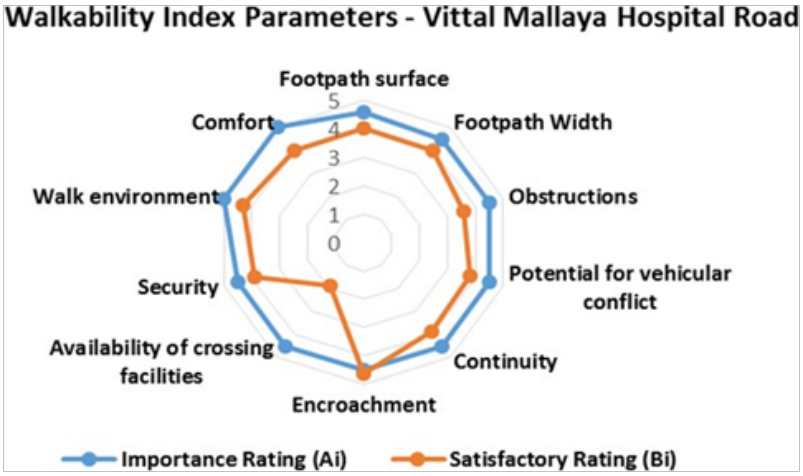

Fig. 6 WI parameters at Vittal Mallya Hospital Road

TABLE III WI of Tender Sure Sidewalks

Road Name	WI
Vittal Mallya Hospital road	176
Cunningham road	174
Residency road	199
St. Mark's road	190

The WI value explains the quality of the Tender SURE walkway amenities and the walking environment. A walkability score of 250 would be the highest possible. The current values are closer together, indicating a higher level of service excellence. This study also aids in determining which areas require additional improvement.

On the sidewalk, a volume of 300-700 people per hour was noted. Each pedestrian has an average space of 4.5 m2/p or greater and walks at speed ranging from 0.7 to 1.9 m/s. The pedestrian per metre per minute flow rate per minute. The present pedestrian flow characteristics were compared with HCM and IRC guidelines and the PLoS was identified as "A" at three locations and "B' at one location. The qualitative analysis through pedestrian rating on a scale of 1-5, resulted in a WI value of 150 and above.

The Karnataka government effort known as Tender SURE projects uses specific design principles to improve urban road design and pedestrian safety. The project has been successfully executed at seven places around Bengaluru City, and it

Page 134-148 © MANTECH PUBLIATIONS 2021. All Rights Reserved

serves as a prime example by considering pedestrian needs first and foremost. The document summarises the design criteria that were used. The walkability evaluations on these pedestrian pathways yielded PLoS levels A and B, as well as a positive public perception, confirming the effectiveness of the Tender SURE effort.

REFERENCES

1. Road Accidents in India. Ministry of Road Transport and Highway, 2015, Government of India, New Delhi.

2. Accidental Deaths and Suicides in India. New Delhi: National Crime Records Bureau, NCRB 2015, Ministry of Home Affairs, India.

3. Mohan, D., G. Tiwari, and K. Bhalla. “Road Safety in India”, Transportation Research and Injury Prevention Programme (TRIPP), New Delhi, India, 2015.

4. Road Accident Statistics, Bengaluru City Traffic Police, 2017.

5. Geometric Design Standards for Urban Roads in Plain. Indian Roads Congress IRC-86, 1983, New Delhi, India.

6. Vertical Curves for Highways, Indian Roads Congress IRC:SP:23-1983 New Delhi, India.

7. Fruin, J. J. Designing for Pedestrians: A Level of Service Concept. In Highway Research Record 355, HRB, National Research Council, Washington, D.C., 1971, pp. 1–15.

8. Polus, A., J. L. Schofer, and A. Ushpiz. Pedestrian Flow and Level of Service. Journal of Transportation Engineering, ASCE, Vol. 109, No. 1, 1983, pp. 46–56.

9. Tanaboriboon, Y., and J. A. Guyano. Level-of-Service Standards for Pedestrian Facilities in Bangkok: A Case Study. ITE Journal, Vol. 59, No. 11, 1989, pp. 39–41.

10. Quality/Level of Service Handbook. Florida Department of Transportation, Tallahassee, 2009.

11. Môri, M., and H. Tsukaguchi. A New Method for Evaluation of

Page 134-148 © MANTECH PUBLIATIONS 2021. All Rights Reserved

Level of Service in Pedestrian Facilities. Transportation Research Part A, Vol. 21, No. 3, 1987, pp. 223–234.

12. Muraleetharan, T., T. Adachi, T. Hagiwara, and S. Kagaya. Method to Determine Overall Level-of-Service of Pedestrian Walkways Based on Total Utility Value. Journal of Infrastructure Planning Review, Vol. 22, No. 3, 2005, pp. 685–693.

13. Huang T. H., Chen-Jr C.: Modeling Level of Service on Pedestrian Environment, Journal of the Eastern Asia Society for Transportation Studies, Vol. 7, 2007.

14. Landis, Bruce, et al.: Modeling the Roadside Walking Environment: A Pedestrian Level of Service, Transportation Research Board 1773, Washington DC, 2001.

15. Tan D, Wang W, Lu J, Bian Y.: Research on Methods of Assessing Pedestrian Level of Service for Sidewalk, Journal of Transportation Systems Engineering and Information Technology, Volume 7, 2007.

16. TRB: Highway Capacity Manual, Transportation Research Board, National Research Council, Washington, 2000.

17. Bandara, S., S. C. Wirasinghe, D. Gurofsky, and P. Chan. 1994. Grade- separated pedestrian circulation systems. Transportation Research Record 1438: 59-66.

18. Bradshaw, C. 1993. Creating and using a rating system for neighborhood walkability: Towards an agenda for ‘‘local heroes.’’ Paper presented at the 14th International Pedestrian Conference, Boulder, CO.

19. Dixon, L. 1996. Bicycle and pedestrian level of service performance measures and standards for congestion management systems. Transportation Research Record 1538: 1-9.

20. Sankaran Marisamynathan and S. Lakshmi, “Method to determine pedestrian level of service for sidewalks in Indian context”, The

Page 134-148 © MANTECH PUBLIATIONS 2021. All Rights Reserved

International Journal of Transportation Research, Transportation Letters, 2016, pp. 1-8.

21. Highway Capacity Manual, Transportation Research Board (TRB): National Research Council. Washington, DC, 2010.

22. Guidelines for Pedestrian Facilities. Indian Road Congress IRC 103-2012, New Delhi, Development of Indian Highway Capacity Manual (Indo-HCM), Capacity Estimation of Pedestrian Facility (WP-7), 2016, unpublished.

23. Study on Traffic and Transportation Policies and Strategies in Urban Areas in India, 2008, Ministry of Urban Development, Government of India.

Page 134-148 © MANTECH PUBLIATIONS 2021. All Rights Reserved