

BENCHMARKING ACCESSIBILITY FOR URBAN MOBILITY SYSTEMS

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ABSTRACT

The growth pattern of the urban complexities reflect and intends the need for addressing issues of urban movement. Access to the urban environment initiates equity and inclusion, therefore accessibility is a quality of system which allows, includes and integrates diverse human forms and users within the system. Benchmarking accessibility of an urban space would lead to identifying, understanding and evaluating various performance measures which affect the urban space mobility, therefore leading to the prognosis stage of enhancing the degree of accessibility. Conventional mobility-based planning places automobiles at the centre of the transport system. The new paradigm places people at the centre.

A method of assessment and benchmarking is required to be able to assess and measure how accessible a particular street or an urban space is. There is a need to identify gaps in the structure, which is gained through the review of the benchmarking tools and assessment of best practises of accessibility measure. The study takes into consideration the accessibility assessment of the selected urban spaces in India and Germany, in order to test various benchmarking tools in order to proceed through a universal approach.

KEYWORDS

Accessibility, Transport, Connectivity, Intelligibility

1. INTRODUCTION

The global urban population had surpassed the rural population, in 2008, for the first time and it is projected that 66% of the world population will be living in the urban areas by 2050 (1). The growth pattern of the urban complexities reflect and intends the need for addressing issues of urban movement.

Access to the urban environment initiates equity and inclusion, therefore accessibility is a quality of system which allows, includes and integrates diverse human forms and users within the system. Accessibility as a term has varied and diverse definitions and understandings, and links itself to varied fields of study. It is important to understand as to what the term 'accessibility' means and how it is perceived with respect to the urban context.

Various disciplines analyze accessibility, but their perspective is often limited :

- Transport planners generally focus on mobility, particularly vehicle travel.
- Land use planners generally focus on geographic accessibility (distances between activities).
- Communications experts focus on telecommunication quality (such as the portion of households with access to telephone, cable and Internet services).
- Social service planners focus on accessibility options for specific groups to specific services (such as disabled people's ability to reach medical clinics and recreation centers). (2)

In order to analyze accessibility, the term is defined through diverse perspectives of the individuals based on their profession and their respective focal points, which in other terms can be regarded as the 'activities or goals' based on the definition by Hansen and Engwicht. An accessible public space is one to where many different people can come, but also one where many different people can do many different things: it is an accessible node, but also an accessible place' (3). With the adjacent perspective, public space is placed as the central node and define the access to the space. Access deals with the ability of diverse people who can access the space, and at the same time are able to interact with their immediate environment and the surrounding elements don't act as barriers. The paper includes introduction of quantitative and graph analytical tools alongside case studies involved, in order to measure accessibility of an urban system.

1.1 Objectives of the study

- Review and assessment of tools and methods of benchmarking urban street systems.
- Identification of diverse parameters responsible to benchmark accessibility in the urban spaces for the users.
- Understanding and correlation of the identified parameters through case studies.

1.2 Methodology

The research methodology is a desk based approach, which has been divided into three phases in continuum with respect to the desired output in each phase. The first phase takes into consideration the review of various benchmarking tools which exist in the field of research, and understanding the core area and the parameter the tool relates to with respect to other identified tools. The second phase initiates with the selected parametric tools and identification of an urban space for which the identified tools would be examined. This mainly leads to the attribute selection under the selected parameters for the urban space, which is assessed with two perspectives. The first perspective takes into consideration the broad eye perspective, which studies the large urban space as a single entity, whereas the second perspective deals with the human plinth (or eye) level perspective that takes into account the urban street and direct human interaction with the space.

The third phase is the future outlook of the prototype developed in the previous steps and takes into consideration the detailed study of the identified tools and the selected urban space, with the comprehensive conclusion of the results obtained and remarks from the data obtained from the selected urban spaces for the research study. Each parameter has its respective sets of attributes, which are to be studied based on the selection of the urban spaces. In this context, accessibility for people is a key priority, and two diverse case studies are taken into consideration which include Luisenplatz located in Darmstadt, Germany and Connaught Place in New Delhi, India. Both the site studies have similar population and focus on a public space in the centre.

2. PARAMETRIC IDENTIFICATION

The evaluation of the indefinite form of accessibility can be defined through the study of the various linked parameters which define the urban fabric and assist in the evaluation. The following parameters have been identified based on the literature studies and their synopsis:

Network Connectivity: It is the measure to acknowledge choice of more pedestrian roads and junctions around a place, offering more degree of freedom of choices for the pedestrians.

With respect to Connectivity index, (4) it is computed by dividing the number of roadway links by the number of roadway nodes. A measure of 1.4 is devised as a good measure for planning purpose.

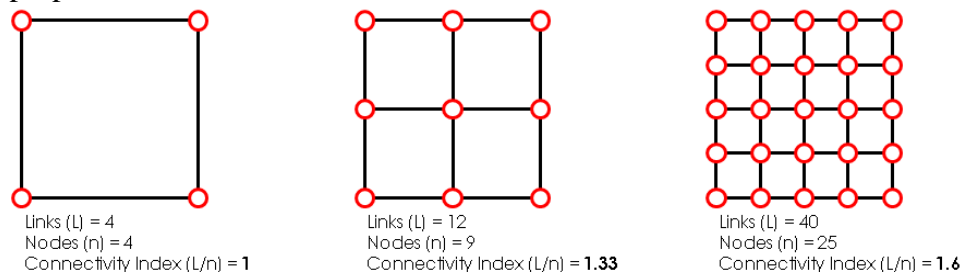


FIGURE 1 Demonstration of calculation of connectivity index for an urban network

Pedestrian Footway Comfort: It refers to the ability to move through the adjoining streets with comfortable width (space) of street available to move through, along with the density of pedestrians using the streets (5). The aim of a pedestrian comfort assessment is to understand the pedestrian experience as people walk along the street. The assessment does not look at the quality of the footway or associated issues such as maintenance that may affect the use of an area.



FIGURE 2 Comfort levels based on pedestrians per metre per minute measure (5)

Public Transport Accessibility Level (PTAL): It is the ease of accessing a public transport service through its service frequency in a day and how far the service stations are located from a point in a place, where service station include tram stations, bus stations etc. PTALs take into consideration the walk access times and the service availability of the transportation modes within a pre-defined zone. Based on the index, the resultant levels are categorized into six levels where 1 is the least level of accessibility and 6 is the excellent level. (6)

Space Element Index: It is the ease of utilizing and accessing the street elements like benches, the information systems, ground surface etc. The index is developed based on the standards, of the respective countries, for the accessibility with respect to Persons with Disabilities (PwDs) in a barrier free environment. The parameters are rated on three levels of safety and standards. If it follows the standard and is safe for utility, then it is rated as '1', if it does not follow the standard but is still safe then it is rated as '0.5' and the least is '0', where it is rated as unsafe. These ratings are carried out for all elements in a selected urban space where resultant cumulative mean of the ratings of all elements (i.e SEI ~ Space element index) lead to identification of factors which need to be upgraded as per standards.

Intelligibility: The ability of a person to understand and navigate within the surroundings in a broad urban space i.e. the ease of how a person can pinpoint his/her location in an urban space. It is based on the Space syntax theory, developed by B. Hillier, where a space is mapped based on the axial lines (lines with maximum line of sight in a selected space) and the overall network of these lines are analyzed with respect to how well integrated each link (or axial line) is with respect to the overall system of axial lines. (7)

3. PARAMETRIC ANALYSIS OF THE URBAN SPACES

3.1 Network Connectivity

Connaught place has a high Nodal density of 128 per unit square kilometre and Link density of 198 per unit square kilometre. The main cul-de-sacs or the dead ends lie within the middle circle of the study area. Based on the literature study, a connectivity index in the close proximity of 1.4 is considered as a good connectivity index (4), and based on the study, the network system has a good connectivity index of 1.5468, which states better connectivity with respect to overall network system.

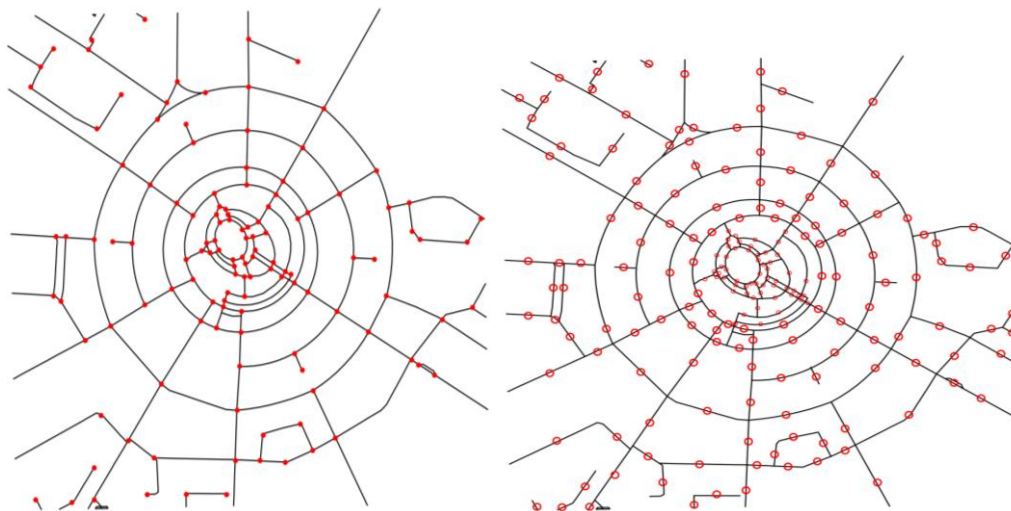


FIGURE 3 Node Density Mapping (left) and link density mapping of Connaught Place (right) within 1 sq. km

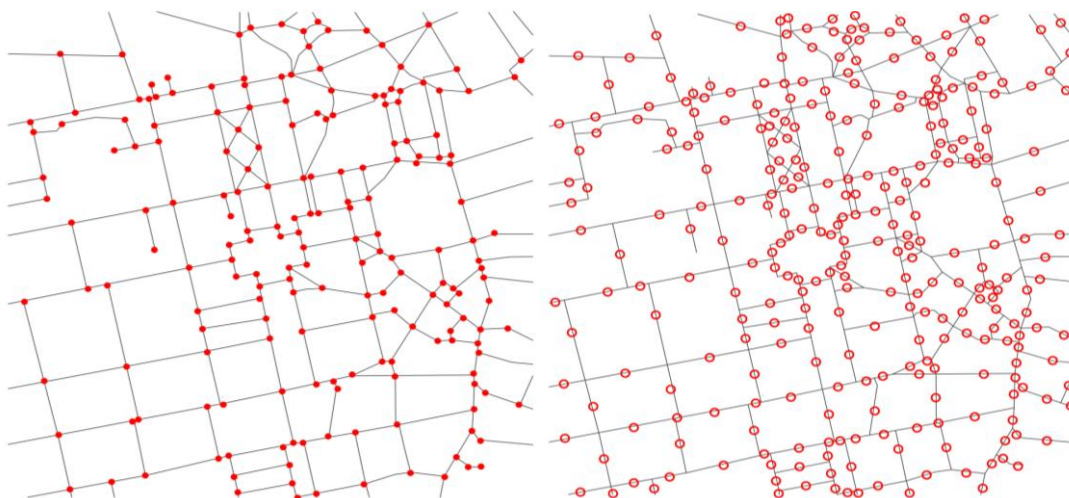


FIGURE 4 Node Density Mapping (left) and link density mapping of Luisenplatz (right) within 1 sq. km

With respect to Luisenplatz, it has a better nodal density of 192 per unit square kilometre and Link density of 296 per unit square kilometre with respect to Connaught Place. The Connectivity index of Luisenplatz is similar to that of the Connaught Place, which is 1.5416, with a mere margin of 0.052 between the two sites taken into the study. The plan has a connected node ratio of 0.96, which is better and above the least limit of 0.7 (4). This states that Luisenplatz has a low density of cul-de-sacs in its proximal area of one square kilometres as compared to Connaught Place. The better nodal density leads to increased permutations of the pattern of links decided by the end users to reach to a specific location and offers more degrees of freedom.

3.2 Public Transport Accessibility Level

The PTAL is calculated with respect to the bus / metro services and train services, which fall within the radius of 640 m and 960 m respectively. With respect to Connaught Place, it is mainly served by 7 bus service stops. Out of the 7 bus service stops only Super Bazar bus stop is stationed within the outer circle of CP. The Rajiv Chowk acts as the central hub of the Delhi Metro station and has two lines running through the Connaught Place underground. The metro services can be accessed by the frontal gates numbered from 1 to 8 which are positioned in front of the blocks facing the inner circle of the site. The data of the service stations, was collected between the morning peak hours of 8am to 9am in the month of August 2016 during the weekdays.

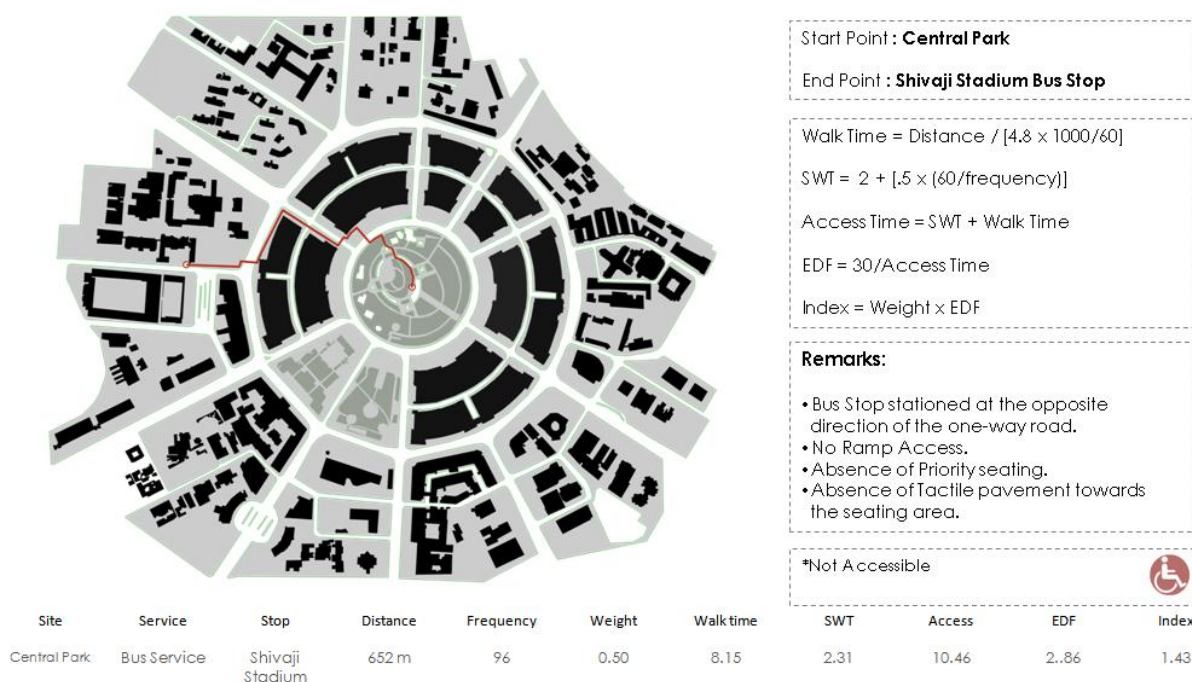


FIGURE 5 Accessibility index for Shivaji Stadium bus station in Connaught Place, where SWT is Standard Waiting Time and EDF is Equivalent Doorstep Frequency

Similarly all the other service stations were assessed and a cumulative index was generated for the study area, as seen in Table 1. The accessibility index especially for the bus services is affected by closed entry points towards the central park. Only two (of five) gates were serving as the entry gates for the central park, therefore increasing the walk access time towards the bus stop stations located around Connaught Place. The overall PTAL for Connaught Place is 16.26, which falls within the range of index 15.01-20.00, indicating 'Good' accessibility level.

TABLE 1 Overall PTAL for Connaught Place, New Delhi

Site	Service	Stop	Distance	Frequency	Weight	Walktime	SWT	Access	EDF	Index
Central Park	Bus Service	Super Bazar	790 m	119	1.00	9.88	2.25	12.13	2.47	2.47
		Kailash Building	704 m	16	0.50	8.80	3.87	12.67	2.36	1.18
		Statesman House	773 m	56	0.50	9.66	2.53	12.19	2.46	1.23
		Palika Kendra	781 m	80	0.50	9.76	2.37	12.13	2.47	1.23
		Shivaji Stadium	652 m	96	0.50	8.15	2.31	10.46	2.86	1.43
		Marina Hotel	655 m	16	0.50	8.18	3.87	12.05	2.49	1.24
		Janpath	592 m	12	0.50	7.40	4.50	11.90	2.52	1.26
	Metro Service	Blue Line	386 m	20	1.00	4.82	2.25	7.07	4.24	4.24
		Yellow Line	426 m	20	.50	5.32	2.25	7.57	3.96	1.98
PTAL : 16.26										

With respect to Luisenplatz, it is mainly served by 7 bus service, out of which, Luisenplatz had the maximum frequency of bus and tram services. The extensive public transport system of Darmstadt is integrated in the RMV (the transportation authority of the Frankfurt Metropolitan Area). There are 5 tram station within the proximity limit of the PTAL, with Luisenplatz having the maximum boarding stations among the 5. The backbone of public transport in Darmstadt is its modern tram system with 9 lines and a local bus service serving all parts of the city.



FIGURE 6 Accessibility index for Luisenplatz bus station in Darmstadt

Similarly all the other service stations were assessed and a cumulative index was generated for the study area, as seen in Table 2. The accessibility index especially for the bus services is positively affected by close proximity of bus stations to the central plaza and with respect to one another. Close proximity of the bus and tram stations within the Luisenplatz increased the accessibility index to great extent and enhanced the overall accessibility index.

Overall PTAL for Luisenplatz is 60.83, which falls within the range of index 40.01 and beyond, indicating 'Excellent' accessibility level.

TABLE 2 Overall PTAL for Luisenplatz, Darmstadt

Site	Service	Stop	Distance	Frequency	Weight	Walktime	SWT	Access	EDF	Index	
Luisenplatz	Bus Service	Luisenplatz	20 m	122	1.00	0.25	2.24	2.49	12.04	12.04	
		Mathildenplatz	230 m	74	0.50	2.88	2.41	5.29	12.04	6.02	
		Willy Brandt Platz	415 m	47	0.50	5.18	2.63	7.81	3.84	1.92	
		Schloss	350 m	80	0.50	4.38	2.38	6.76	4.43	2.21	
		Kongresszentrum	450 m	2	0.50	5.63	17	22.63	1.32	0.66	
		Schulstrasse	625 m	10	0.50	7.81	5	12.81	2.34	1.17	
		Klinikum	520 m	18	0.50	6.50	3.66	10.16	2.95	1.48	
	Tram Service	Luisenplatz	10 m	99	1.00	0.13	1.05	1.18	25.42	25.42	
		Mathildenplatz	230 m	62	0.50	2.86	1.23	4.09	7.33	3.67	
		Willy Brandt Platz	440 m	16	0.50	5.50	2.63	8.13	3.70	1.85	
		Schloss	280 m	29	0.50	3.50	1.78	5.28	5.68	2.84	
		Schulstrasse	625 m	26	0.50	7.81	1.90	9.71	3.09	1.55	
		PTAL : <u>60.83</u>									

3.3 Intelligibility

The axial maps for both sites are created with the enhanced linking of the network links with respect to each other in order to derive the Connectivity and Integration labels to a realistic figure in the DepthmapX 0.30. The Local and the Global integration with respective radii of 3 and n (where n ~ longest radii for the site taken into consideration), would help in defining the correlation and the intelligibility of the site taken into consideration. For the axial map analysis one square kilometre of space is studied and digitized into a vector graph, in order to analyze the integration of the whole network. A strong positive correlation would define an intelligible space where user can identify his/her location easily within the entire network, whereas a weak correlation would define an unintelligible space where user would tend to get lost from their respective space. (7)

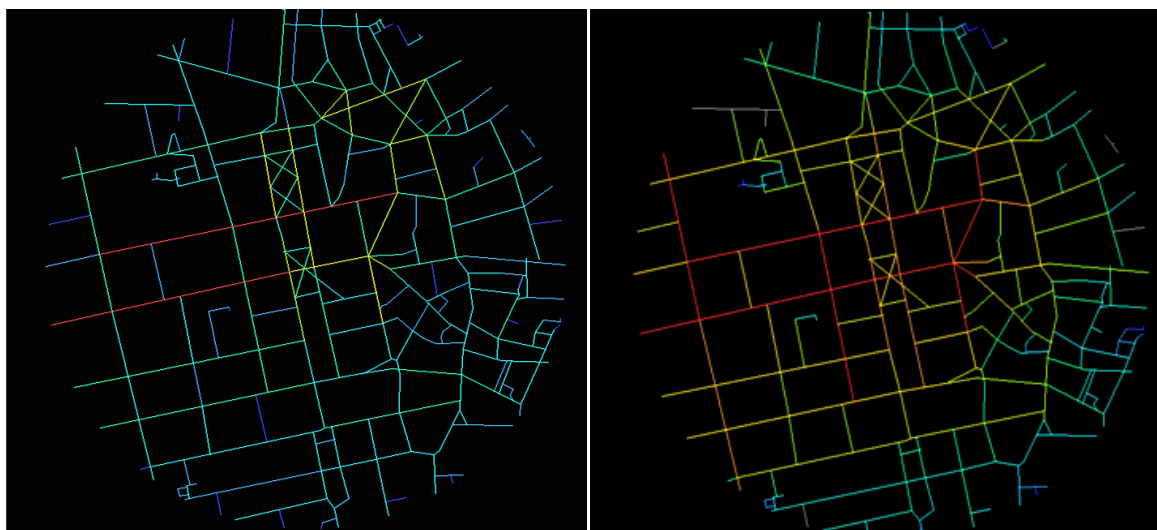


FIGURE 7 Connectivity (left) and Global integration (right) of axial network of Luisenplatz within 1 sq. km

The Figure 7 shows the connectivity of the Luisenplatz, with maximum connectivity at the northern and western end of the axial map of Luisenplatz with a maximum value of 14. The red links in the axial maps show greater connectivity (or integration) whereas blue links show least connectivity (or integration). The Global integration through the Axial Analysis, shows the western links closer to the Luisenplatz i.e. towards the Hauptbahnhof have a better integration to the plaza, as compared to the other links. The positive correlation, with the coefficient of correlation i.e $r = 0.64$, for Global integration and Connectivity of the 1 square km of Luisenplatz shows a positive intelligibility of the surrounding environment.

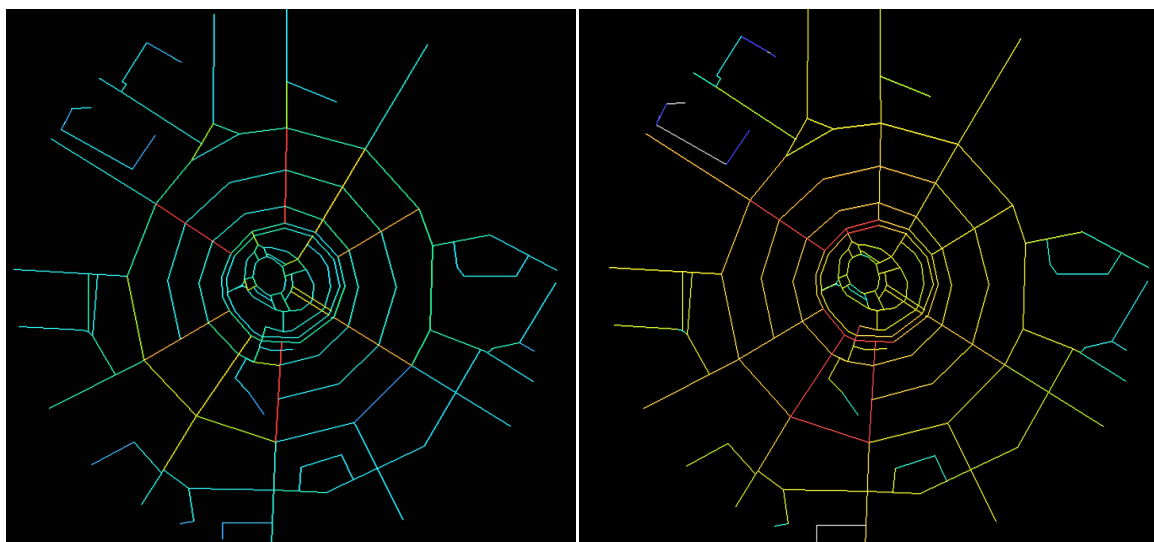


FIGURE 8 Connectivity (left) and Global integration (right) of axial network of Connaught Place within 1 sq. km

The Connaught Place is strongly integrated on the northern and southern ends of the Central Parks, which also serve as the entry points for the green urban space. The coefficient of correlation for CP, between Global and integration and Connectivity, is 0.53. Comparatively, Luisenplatz has better intelligibility as compared to CP. Planning also plays a major role in the output, as the monotonous radial planning of Connaught Place leads to a decrease in the ability of a user to identify his/her location easily within the entire network.

3.4 Pedestrian Footway Comfort

The Pedestrian footway comfort is calculated through all the inviting streets leading to the Luisenplatz and Central Park (Connaught Place). The densities (in persons per metre per minute i.e ppmm) of the pedestrian traffic has been calculated during the utilization of public transport hours and also during the absence of the public transport in the main plaza, due to the on-going strike during the month of January. The subsequent data is recorded utilizing the laser measuring instrument within the range of 60m during daylight, at the peak hours between 14:30-17:30 hours on a Friday.

The peripheral streets around the Luisenplatz have a comfortable pedestrian comfort level ranging from 3.47 ppmm to 0.40 ppmm, whereas in Connaught Place they have a pedestrian comfort level ranging from 2.18 ppmm to 11.86 ppmm.. The maximum movement restriction is limited to 13 % in two streets and is 3% in the remaining seven streets around the Luisenplatz. The presence of public transport has a positive effect on the overall street densities and leads to improved and yet comfortable pedestrian comfort width around the plaza. The available pedestrian width around the Luisenplatz plaza, through the streets, maintains the minimum width of space to be provided for the Persons with disabilities

(PwDs), whereas in CP, the pedestrian area near Palika Bazar is blocked by street vendors. Overall, the pedestrian per minute metre clear footway, considering all the streets, for Luisenplatz is 1.94 i.e a comfortable level of A+ and for Connaught Place it is 5.41 i.e. a comfortable level of A- under the Footway Comfort (5).



FIGURE 9 Overall Pedestrian Comfort Level (in ppm) and Movement Restriction (in %) in Luisenplatz

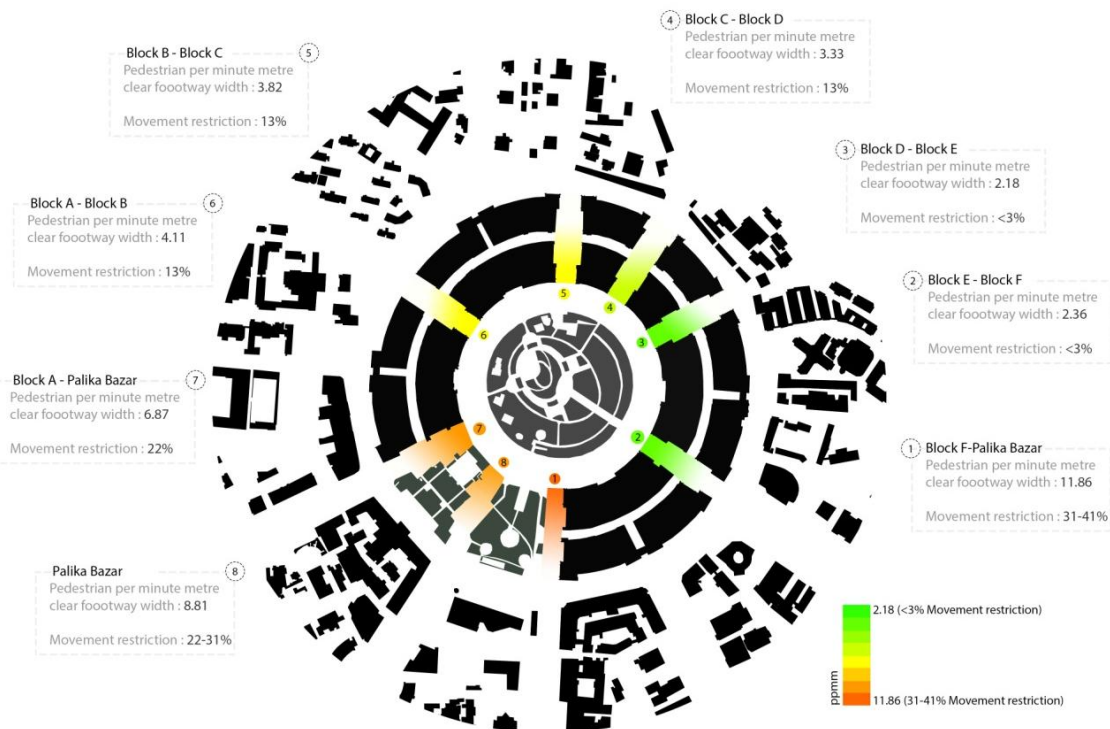


FIGURE 10 Overall Pedestrian Comfort Level (in ppm) and Movement Restriction (in %) in Connaught Place

3.5 Space Element Index

The space element index has been formulated based on the parameters of various elements, which play a vital role in the mobility for the pedestrians in the urban space. The parameters of the space elements, for Germany, are acquired through the legal standard documents through Deutsches Institut fur Normung i.e DIN 2014 (DIN 32975, DIN 18040-3, Berlin Design for All Section I, II, and III.). With respect to India, they are acquired through 'Harmonised Guidelines and Space Standards for Barrier Free Built Environment for Persons with Disability and Elderly Persons 2016' under Ministry of Urban Development, Government of India. With respect to the standards, the elements were rated within the Luisenplatz and Central Park. Element 'Surface design' was rated as per the standards as follows:



FIGURE 11 Space Element index of Surface design for Luisenplatz

Similarly for Connaught place the element was rated, with resultant index of 0.7. In both the studies, the element with least index was 'Staircase and Steps'. In case of Central Park, the stairways lacked the warning tactile and the contrast demarcations, with absence of handrails. With respect to Luisenplatz, in order to restore the architectural heritage of the plaza, the steps were not demarcated in contrast bands, for the persons with visual impairment.

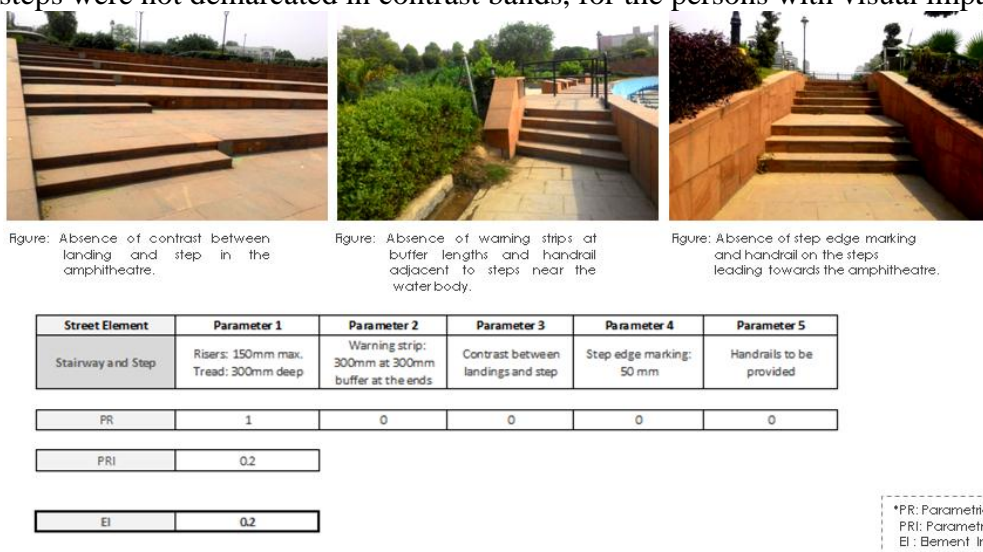


FIGURE 12 Space Element index of Stairway and Steps for Connaught Place

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

- The Luisenplatz PTAL index especially for the bus services is positively affected by close proximity of bus stations to the central plaza and with respect to one another. Close proximity of the bus and tram stations within the Luisenplatz increased the accessibility index to great extent and enhanced the overall accessibility index, whereas the same was negatively affected in case of Connaught Place due to closure of the entrance gates towards the central park and low proximity of the bus service stations from the central park.
- Planning of the space plays an important role for the basis of intelligibility. The monotonous radial planning of Connaught Place leads to the decrease the ability of the user to pin point his/her location on the site, as compared to non-uniform grid-iron pattern planning of Luisenplatz and the immediate area surrounding the public place.
- With respect to the Pedestrian Footway Comfort, the comfort levels and movement restrictions were within the comfortable range in Luisenplatz, but not in Connaught Place.

4.2 Recommendations

- Considering the access to public transport, in case of Connaught Place, the bus stations were stationed at a longer walking distances beyond the outer circle and played a major role in decreasing the overall accessibility level with respect to the bus mode of public transportation. Access to the stops should be made with respect to PwDs, as many stations had lower level of accessibility with respect to the ease of boarding. The closure of gates of central create a barrier, and emphasis should be paid on providing access in order to decrease the overall length journey for the pedestrians.
- With respect to Pedestrian footway comfort in Connaught Place, the major barrier was the reduction of available footway due to factors like the unauthorized parking of the two wheelers, consumption of the pathway due to street vendors forcing the pedestrians to walk on the vehicular roads, and similar barriers leading to increase in the movement restrictions of the pedestrians. In order to decrease the movement restriction, such conditions should to taken into account in order to provide comfortable pedestrian footway density. On the basis of intelligibility for both the case studies, the not so integrated links can be correlated to the physical environment and observed if the information system is well in place or whether people find in easy to navigate in those areas.
- 'Space Element' parameter deals with the immediate environment of a person, and takes into consideration the sub-parameters of the objects with which a PwD interacts with. With respect to the standards, the index can be used to pin point the hazard the element deals with and can be prioritized to upgrade the safety of the persons utilizing the services. The identified parameters can be further studied with respect to varied typology of urban spaces or land use and may not be restricted to the public spaces, which were taken for the research. The prognosis of the research would lie in identifying relative parameters which act as variables in defining the accessibility of an urban space and further correlation in order to benchmark the factors which assist in acquiring access to varied services by the person utilizing it.

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