# Assessing the accessibility of footpaths at the core of old Indian cities:

## *The universal mobility perspective*

インド古都における歩道のアクセシビリティ評価に基づくユニバーサル・モビリティに関する研究

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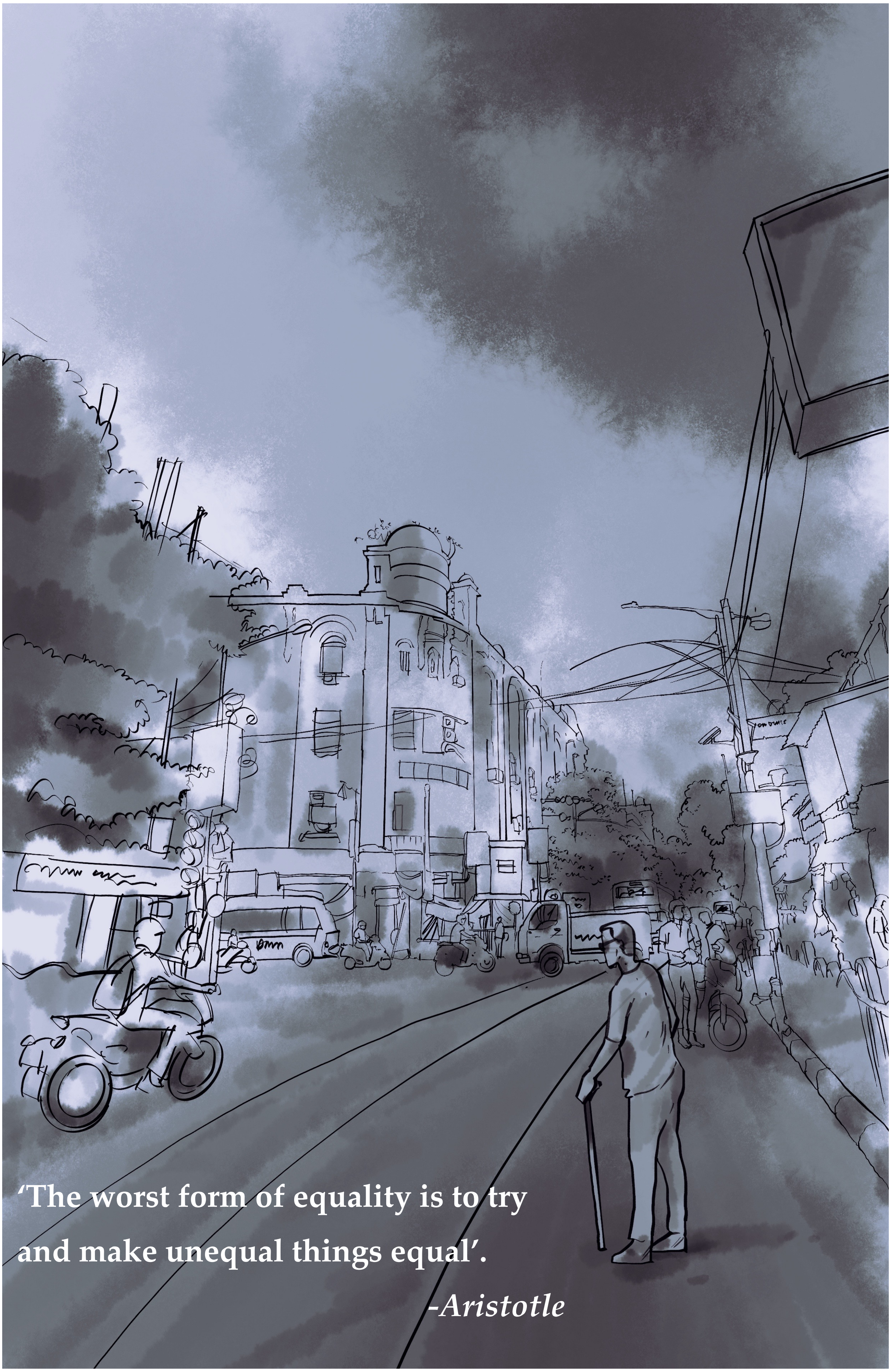
Dedicated to my parents whose whole life is dedicated to make me ‘able’.


'The worst form of equality is to try
and make unequal things equal'.
-Aristotle

# Abstract

Mahatma Gandhi, also known as the father of the nation of India, famously stated that the true measure of any society can be found in how it treats its most vulnerable members. Specially abled and elderly people are vulnerable in the physical and cognitive domains. As per the data of the Census of India from the last 100 years (1911- 2011), the percentage of specially-abled people has phenomenally increased by 737.2% (from 0.26% in 1911 to 2.21% in 2011) in comparison to 284.21% increase in population (from 833,644 in 1911 to 26,814,994 in 2011). Similarly, the percentage of elderly (people aged 60 and above) has increased significantly by 105.25% (4.18% in 1911 to 8.58% in 2011). Indicators 11.2.1 and 11.7.1 within targets 11.2 and 11.7 of the UN-SDG emphasize making the public spaces and transportation system accessible to all (specially-abled and able-bodied), with additional focus on the needs of (a) those in vulnerable situations, (b) women, (c) children, (d) persons with disabilities, and (e) older persons. Additionally, the UN member nations (like India) are also instructed to improve road safety, especially by expanding accessible public transport. In contrast to international guidelines, most of the Indian documents related to universal design/accessible design are mere guidelines and not mandatory rules; thus, their implementation for accomplishing 'barrier-free' or 'inclusive' built environments at the societal and/or urban level has not happened. Especially, pedestrian-level infrastructures in old Indian cities are often affected by poor infrastructure and pose a threat to able-bodied and users with wheelchairs or walking assistance alike.

The aim of this research is to find out strategies to improve the quality of life in congested urban cores by making the footpaths accessible to all under the broader paradigm of urban reforms in India. The dissertation hypothesizes that the strengths of the organically planned old settlements will improve the liveability standards if the accessibility component is inserted into its pedestrian paradigm through architectural planning. The four primary objectives of the research are: (a) To define the role of Architectural Planning in an 'accessibility planning' proposal, (b) To determine the degree of accessibility possible in the footpaths of core areas of an old Indian city by proposing an ideal accessibility audit checklist, (c) To improve cognition at the footpath level in old cities, especially for the specially-abled, and (d) Policy-level recommendations to increase the quality of life in cities by improving the footpaths. The four key research questions are: (a) What is the role of accessibility under the broader domain of universal design in improving the quality of life? (b) What is the degree of accessibility that can be achieved in the public domain of old cities? (c) Can core Indian cities be made inclusive in terms of Universal Mobility? and (d) What degree of cognition can be achieved in the footpaths of old cities? The 2 major domains of research scope are: (a) To explore the potential of inclusiveness in footpaths of congested cores where the density is more concerning the rest of the city, and (b) To furnish a process-oriented approach in the realm of accessibility where the approach is still product oriented. The 3 principal limitations of this research are: (a) Restrict the design intervention to a delineated part of Central Kolkata, (b) Few disabilities shall be prioritized, preferably, Mobility and Physical Impairments, and (c) 'Transportation System Accessibility' involving (vehicular and walkability) will be dealt upon with greater focus.

This dissertation consists of 7 chapters as follows:

Chapter 01: This chapter titled 'Introduction' elaborates on the research background, research outline, key terms used in this research, research methodology, a summary of dissertation chapters, and interpretation of the dissertation chapters.

Chapter 02: In this chapter, users' perception towards Universal Mobility in old core cities of India has been critically analysed. Despite universal design guidelines from the United Nations and the Union Government of India, old cities in India seldom possess Universal Mobility, in effect endangering the lifestyle of senior citizens and specially-abled people. The core of Kolkata Municipal Corporation in Kolkata, India, has been considered a case example for this section. This section has

considered three types of datasets for analysis. First, the authors interviewed 310 respondents from the Indian design fraternity, to understand their opinions on the concept of universal design. The next investigative study of 125 respondents from different wards of Kolkata Municipal Corporation aimed to comprehend people's perceptions regarding walkability and mobility in an old Indian city. In the last visual survey of a stretch in Central Kolkata, the focus was on identifying hindrances in Universal Mobility in an old city core of Indian origin. Significant dissatisfaction was found regarding walkability amongst all user groups, which is linked to poor infrastructural conditions. Furthermore, accessing public transportation is difficult due to improper waiting facilities. However, the design fraternity in India propose the need for separate accessibility guidelines for old and new cities in India. The design fraternity also recommends a customized rating system for accessing universal design. The result of this study indicates a need of recognizing the difficulty in imparting Universal Mobility in old core cities in India. The findings of this chapter can be used for preparing an access audit checklist through Architectural Planning, which is the first step in proposing a framework for Universal Mobility in old core cities in India.

Chapter 03: Old Indian cities are often less accessible due to temporal restrictions and ever-rising pedestrian volume. In this research, the accessibility of the footpath-level walkability condition of old core cities has been assessed through Architectural Planning Research, considering 32 footpath stretches in Central Kolkata, India as a case. The research has considered 3 data sets, (a) 257 experts' opinions about universal mobility, (b) 18 variables for assessing accessibility conditions, and (c) peak hour pedestrian volume. IBM® SPSS® Statistics 26.0 version has been used to validate the findings of the research. It was found that mixed-use buildings demarcate the edge of the footpaths in old cities. 50.6% of Indian experts prioritized the "dimension of the footpath" while assessing universal mobility for pedestrians in the old cities of India. The average accessibility percentage for the entire surveyed stretch is negative which highlights the poor accessibility of the stretch. Pearson's correlation between footpath width and infrastructure score of 0.535 signifies the width of a footpath plays a significant role in determining the level of footpath infrastructure. Thus, the findings of this chapter can be used while preparing accessibility development plans for the study area and other areas of a similar genre.

Chapter 04: In this chapter, the condition of Universal Mobility in the core of old Indian cities has been critically analysed. Implementing universal design guidelines (especially Universal Mobility standards) in the core of old Indian cities is comparatively challenging due to the high-density, ever-increasing population, and organic urban development. The rising number of elderly and specially-abled also adds a demographic challenge to the aspect of Universal Mobility. This research focuses on understanding the extent to which Universal Mobility guidelines can be implemented in the core of old Indian cities. The dataset for this research is derived from the field survey of sixty-nine footpath stretches from the core of five old cities in India, namely Jaipur, Jodhpur, Nagpur, Hyderabad, and Chennai. Footpath stretches in the core of these old cities was evaluated based on several factors in the domain of universally designed infrastructure and Universal Mobility features. Such comprehensive research on Universal Mobility in footpaths of old Indian cities has not been conducted. The findings of this chapter indicate the poor condition of Universal Mobility in the study areas. Furthermore, the results can be useful for assessing the extent of implementation of Universal Mobility in the core of old Indian cities.

Chapter 05: In this chapter, expert opinion on Universal Mobility in the footpaths of urban India has been critically appraised. Universal Mobility (as a component of universal design) is still a largely ignored urban parameter in India despite an increase of 732.20% in the specially-abled and 105.25% 13 in the elderly, between 1911 and 2011. 257 experts from the field of architecture and planning hailing from 66 cities in India were interviewed for this section. It was found that despite nationally implemented universal design guidelines, footpaths in 42.8% of the cities do not include Universal Mobility. 74.7% of the respondents identify the dimension of the footpath as the most important factor for implementing Universal Mobility. The findings of this chapter indicate the importance of universal design in improving the quality of life in Indian cities and urban local bodies can play a significant role in the process using Public Private Partnership models and a new accessibility audit checklist.

Chapter 06: In this chapter, the role of cognition in Universal Mobility at the pedestrian- level has been investigated. A stretch of approximately 850 m in the core of Kolkata Municipal Corporation (in India) has been delineated as the case area for this research. The 02 data sets considered for this research are: 1) Physical data: Pedestrian Count and Vehicular Traffic Volume, and 2) Cognitive data: Light Intensity, Noise, and Thermal Comfort. The authors collected the data from the case area in the years 2020 and 2021. This section initially involves determining the pedestrian "Level of Service" (LOS) based on the pedestrian count. Furthermore, the authors co-relate (Pearson's Correlation with a 95% confidence interval) the LOS data with the light intensity, sound intensity, and temperature data; to establish a relationship between them. This chapter's findings indicate a gap in realizing the potential of walkability in the case area. The authors conclude that the improvement of cognition in pedestrian-level Universal Mobility can lead to a better physical environment for the specially-abled and elderly.

Chapter 07: This chapter titled 'Conclusions and Recommendations' consists of the summary of the research, a compilation of global best practices in relation to the dissertation, a critical appraisal of the global researchers in the context of the dissertation, and the scope of future research.

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# Table of Contents

# List of Figures

# List of Tables

# List of Equations

# CHAPTER 01

- **Chapter Title:** Introduction to the research

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**'First life, then spaces, then buildings – the other way around never works.'**

***- Jan Gehl***

# 1. INTRODUCTION TO THE RESEARCH

The foremost expectations from this research are three major aspects: (a) exploring the concept of disability and its allied impact on the built environment, (b) bringing a positive change in critical design thinking, and (c) innovative mapping exercises with statistical interpretations. This chapter 'Introduction' further elaborates on the (a) research background, (b) research outline, (c) key terms used in this research, (d) research methodology, and (e) a summary of dissertation chapters.

## 1.1. RESEARCH BACKGROUND

The research background for this research has been constituted from the following broad segments: (a) global understanding of accessibility, (b) social model of accessibility, (c) demographic understanding of accessibility, (d) research gap in the field of accessibility, and (e) uniqueness of the study in the Indian context.

### 1.1.1. Global understanding of accessibility

The development of the universal design approach in architectural planning began as mere principles,[1] which developed into a progressive idea,[2] and finally transformed into an interdisciplinary medium with the advent of global initiatives such as the United Nations Convention on the Rights for Persons with Disabilities (hereafter, UN-CRPD).[3] UN-CRPD and its Optional Protocol (A/RES/61/106) were adopted on 13 December 2006 at the United Nations (hereafter, UN) Headquarters in New York, with an aim towards changing global attitudes and approaches towards persons with disabilities. Article 9 of the UN-CRPD proposes equal opportunities for specially-abled people in the following three aspects: (a) physical environment, (b) transportation, and (c) information and communication. Furthermore, Article 9 of the UN-CRPD also directs the member nations to implement 'universally designed' public facilities.[4] United Nations has affirmed that from a social standpoint, inclusiveness is an essential component in achieving sustainability.

Along these lines, Goal Number 11 of the 'United Nations Sustainable Development Goals' (hereafter, the UN-SDG) specifies 'Sustainable Cities and Communities' which aims towards making cities and human settlements inclusive, safe, resilient, and sustainable. Target 11.2 (within Goal Number 11 of the UN-SDG) elaborates that by 2030, all the member nations of the United Nations should provide access to safe, affordable, accessible, and sustainable transport systems for all. In particular, indicators 11.2.1 and 11.7.1 within targets 11.2 and 11.7 of the UN-SDG emphasize making the public spaces and transportation system accessible to all (specially-abled and able-bodied), with additional focus on the needs of (a) those in vulnerable situations, (b) women, (c) children, (d) persons with disabilities, and (e) older persons. [5,6,7] Especially, after the inception of the UN-SDG, the need to implement equitable design is a mandate for member nations such as India. Additionally, the UN member nations are also instructed to improve road safety, especially by expanding accessible public transport.

According to the World Population Prospects (the 2019 Revision), one in six people (16%) in the world will be over age 65 (16%) by 2050, in comparison to the ratio of one in eleven people (9%) in 2019.[8] In addition to this, the number of people requiring assistive technology is proposed to rise to 3.5 billion by 2050.[9] Thus, in these times of globally changing demography, both the UN-CRPD and UN-SDG puts forward the concept of Universal Mobility for enabling movement within a city without discrimination based on physical or mental limitations. India, being a member nation, is required to act on these similar lines of action towards a 'Universally Designed' built environment.

Universal Mobility incorporates the needs of varied users, including the elderly and specially-abled within a designated spatial boundary. On an urban scale, Universal Mobility serves the function of an infrastructural bridge between buildings having universal design/ Barrier-Free features and precincts with inclusive components. In addition to the previous statement, both inclusive buildings and the inclusive precincts shall remain non-utilitarian if they are not connected by a 'Universally-designed' mobility corridor. Thus, Universal Mobility may be categorized as one of the top priorities in the UN-SDG Goal Number 11 which indicates 'Sustainable Cities and Communities'.[10]

The holistic approach to urban development should be to create a liveable city and not mere infrastructural development.[11] Cognition, especially, plays an important role in improving the spaces of public use, including pedestrian spaces.[12] The importance of cognition is well-established in walkability, especially for elderly people. Additionally, mental maps are an effective form of cognitive perception of spaces; thus, serve as an essential tool for specially-abled and elderly.[13] In this context, pedestrians needed to be prioritized in the user group segment of the urban development.

Dr. Suguru Mori, a Professor at the Laboratory of Architectural Planning at Hokkaido University in Sapporo, Japan, has stressed the relationship between human activity and street spaces.[14] Even micro spaces like side setbacks strongly impact the adjacent movement corridor, probably footpaths.[15] Dr. Mori's opinion on the user's conflict in the usage pattern due to different sharing patterns of the street is significant in the context of this research since he advocates the importance of prioritizing the user's opinion.[16] His research also includes the identification of certain factors of the streetscape, like bus stops, sidewalks, fences, etc.[17] Dr. Mori, however, has argued that there cannot be a set research methodology to assess accessibility, especially in developing nations because streets often become a platform for social interaction due to lack of generic open spaces.[18] This research incorporates the learnings from the research of Dr. Mori but prioritizes the need for a contextual framework to access accessibility.

### 1.1.2. The social model of accessibility

Whipping, chaining, and starving to death were communal activities to which the specially-abled were subjected to until at least the 4th Century CE. Most of these cases in Aegean, Pagan, or other evolved religions were under the impression that any form of disability is a direct form of punishment by God to human beings. In other cases, specially-abled people were also forced to beg or were tactically used as court clowns (jesters).[19] After this stage, from the 5th to 13th centuries CE, the torture towards specially-abled people also included death sentences by immersing them in boiling water or oil.[20] Nearly 8 million biological mothers of specially-abled children were labelled as witches before being ceremoniously killed during the period between the 14th to 17th centuries CE in Europe alone. Rather ironically, this period (14–17th century) was known as the Renaissance period and was characterized by political, cultural, architectural, and social awakening.[21] The following period in history, from the 18th to 19th centuries CE, was known as the Industrial Revolution, which saw a few relaxations in terms of torture towards the specially-abled. However, the needs and problems of the cognitively impaired were still largely ignored.[22] Even in modern-day USA, before the advent of the Americans with Disabilities Act (hereafter, ADA) in 1990, there were discriminatory acts such as the Ugly Act, which advocated for the removal of ugly and disabled beggars from the streets; the last convicted specially-abled person, in this case, was as recent as 1974. The USA also had a judicial rule of two-year imprisonment for specially-abled people in case they practice physical intimacy or engage in marriage.[23] Even in terms of etymology, specially-abled people are often addressed as handicapped, disabled, specially-abled, and even persons with a disability.[24]

Indian society has seen specially-abled people from a different viewpoint from times immemorial. Being a society inspired by culture and mythology, stories that showed people losing their mobility or vision due to the act of sinning cultivated an ill sentiment about disability amongst citizens.[25,26] Only after 1947 (independence from the torturous British empire), the implementation of Article 15 empowered the marginalized by removing any restriction whatsoever from using public (government-owned or supported) facilities based on disability.[27]

### 1.1.3. Demographic understanding of accessibility

This approach is particularly substantial in the 21st century due to an estimated 15% specially-abled global population,[28] and an expected rise in the global elderly population to nearly 16% in the year 2050 from merely 6% in 1900.[29] Thus, ensuring accessibility in the built environment is inevitable to ensure sustainability within the global context, especially when researchers validated that ignorance towards disability is a hindrance towards sustainable development.[30] 26.8 million specially-abled people and 103.8 million elderly people are living in India as per the last census in 2011.[31] As per the data of the Census of India from the last 100 years (1911 - 2011), the percentage of specially-abled people has phenomenally increased by 737.2% (from 0.26% in 1911 to 2.21% in 2011) in comparison to 284.21% increase in population (from 833,644 in 1911 to 26,814,994 in 2011).[32] Similarly, the percentage of elderly (people aged 60 and above) has increased significantly by 105.25% (4.18% in 1911 to 8.58% in 2011).[33,34] The reason behind the increase in the number of elderly is primarily due to the declining fertility rate, increased age for legal marriage, increased life expectancy, and international migration.[35]

Between 1891–1991, the population of India has grown by 192% (from 287,179,715 in 1881 to 838,567,936 in 1991).[36,37] The subsequent decadal growth from 1991 to 2001 has been 22.66%, followed by 17.22% from 2001 to 2011 (referring to 1,028,610,328 in 2001 and 1,210,854,977 in 2011).[38] However, between 1891–1991, the disabled population of India grew by 1546.75% (from 856,252 in 1881 to 14,100,344 in 1991). The subsequent decadal growth from 1991 to 2001 has been 55.36%, followed by 22.41% from 2001 to 2011 (referring to 21,906,769 in 2001 and 26,814,99 in 2011). In addition to this, between 1891–1991, the elderly population of India has grown by 737.32% (from 6,769,435 in 1881 to 56,681,640 in 1991). The subsequent decadal growth from 1991 to 2001 has been 35.18%, followed by 35.18% from 2001 to 2011 (referring to 76,622,321 in 2001 and 103,849,040 in 2011).

The medically approved disability categories as per the 2011 Census were (a) vision, (b) auditory, (c) verbal, (d) movement, (e) mental retardation, (f) mental illness, (g) multiple disabilities, and (h) any disabilities other than those indicated but clinically verified. Furthermore, only the people under the aforementioned medically approved categories were considered for the facilities/benefits provided to specially-abled people, as per the Indian guidelines such as 'Article 41 of the Constitution of India' or 'The Person with Disabilities (hereafter, PwD) Act, 1995'.[39] Article 41 of the Indian constitution states:

*'The State shall, within the limits of its economic capacity and development, make effective provision for securing the right to – work, education and public assistance in cases of unemployment, old age, sickness and disablement, and in other cases of undeserved want'.*

Along these lines, the PwD Act of 1995 enlisted seven conditions of disabilities, namely: (a) blindness, (b) low vision, (c) leprosy cured, (d) hearing impairment, (e) locomotive disability, (f) mental retardation, and (g) mental illness. In contrast, the 'Right to Persons with Disabilities Act of 2016' recognizes twenty-one types of health conditions (Ministry of Law and Justice, 2016). Thus, the number of 'medically disabled' in India is substantially higher than the data published in the 2011 Census. In addition to this, the elderly people who must have been facilitated from the same provisions (as specially-abled) were never considered a stakeholder. As a result, the 103.8 million elderly people (as per the 2011 Census) were also not included in the category of receiving facility/benefits.[40] It was observed during this research that one of the hindrances in the Indian disability scenario is the national reluctance towards the shifting of focus from the medical model of disability towards a logical model.

Even if factors such as changing the categorization of disabilities, omission of disability in certain censuses (from 1941-1971 and 1991 census), lack of adequate surveying, and changing land boundaries are taken into consideration, it is still evident that the growth percentages in the number of disabled and elderly people is phenomenal in comparison to the overall population growth of India.

### 1.1.4. Research gap in the field of accessibility

To create public spaces and transportation systems accessible to all, mobility is the foremost concern. When universal design considerations are incorporated into the mobility sector, the term 'universal mobility' evolves. Along similar lines, Ormerod and Newton (2011) explained the need to go beyond the service level benchmarks in universal mobility and seek a contextual approach[41] because significant theoretical and practical gaps exist even after years of research.[42] This research seeks to explore the contextuality of universal mobility in the footpaths of urban India from the opinion of users and experts from India, besides extensive fieldwork.

Historically, amidst iconic placemaking and timeless design, architects and planners have not been able to integrate the entire user group holistically. More specifically, in our history, the elderly, specially-abled, and women were never been dealt with inclusivity.[43] A recent example is the case of the Constitution Bridge on the Grand Canal in Venice, where the Architect Santiago Calatrava was fined seventy-two thousand pounds in 2019 for not creating a citizen-friendly design.[44] Along similar lines, Goldsmith's 'Universal Design Pyramid' model was an endeavour to break away from the stereotyping of the 'ideal' user group, which design professionals often misinterpret.[45] Thus, the generic 'successful' designs (especially Community-level projects) are often deemed misfits when evaluated multidimensionally from the perspective of universal design, with accessibility being a major component.[46] Accessibility, in this case, may be defined as the one which enables people (including specially-abled and elderly) to use, access, and understand a facility/ space without any hindrance. India needs contextual approaches to improve the liveability and quality of life in its cities, primarily through universal design at the pedestrian level.[47] Before rapid industrialization, old Indian cities were essentially walkable and pedestrian-friendly.[48] However, post-independence, rapid urbanization drives often ignored the importance of the pedestrian environment on Indian roads, especially along with mixed-use buildings despite numerous guidelines.[49]

Researchers identified the following reasons behind the low success of Indian disability guidelines in a spatial context: (a) diversity in urban structures (like higher density in old cities compared to new planned cities), (b) autonomy of state governments in land-related issues, (c) lack of national-level data related to disability, and d) non-recognition of the elderly and situationally disabled in the policy level considerations.[50]

Universal Mobility is a fundamental component of 'Sustainable Cities and Communities', which advocates equal mobility preferences for all, devoid of the users' physical conditions. Pedestrian (including wheelchair-bound users) level use of urban areas is a relatively challenging domain of Universal Mobility in India. Specifically, in the old urban areas of India, the Universal Mobility scenario is more complicated due to organic urban development, low temporal changes, and high density. Amongst the numerous factors of pedestrian-level Urban Mobility, 'Cognition' is significantly important. Cognition is important for specially-abled and elderly people alike since it (Cognition) ensures legibility, orientation, and a sense of place. Despite multiple international, national, and state-level guidelines related to Universal Mobility in India, the aspect of cognition has been disregarded in these guidelines. Although there has been immense research on accessibility and universal design in India, the impact of cognition on Universal Mobility at the pedestrian level of old Indian cities is a relatively new research topic. This research focuses on Universal Mobility at the pedestrian level of old cities.

### 1.1.5. The uniqueness of the study in the Indian context

Thus, in the wake of the changing demographics, several guidelines, policies, acts, rules, regulations, notifications, and schemes are constituted to facilitate specially-abled people and the elderly, especially in the fields of architecture, civil engineering, and planning (as stated in **Table 1**). However, these guidelines failed to bring about a radical change in universal mobility vis-à-vis the universal design paradigm of urban India due to multiple administrative reasons.

**Table 1:** Indian guidelines related to inclusiveness.

| S. No. | YEAR | INDIAN GUIDELINES | IMPLEMENTING AGENCY (within Government of India) |
|---|---|---|---|
| 1 | 1950 | Constitution of India, Article 15[51] | Ministry of Law and Justice, Government of India |
| 2 | 1968 | IS 4963; Recommendations for Buildings and Facilities for the Physically Handicapped. Bureau of Indian Standards: New Delhi, India, 1968 (Revised in 1987)[37] | Bureau of Indian Standards (Ministry of Housing and Urban Affairs) |
| 3 | 1970 | National Building Code of India (Revised in 1983, 2005, 2016)[52] | Bureau of Indian Standards |
| 4 | 1983 | IS 7419; Requirements for stairs for physical rehabilitation. Bureau of Indian Standards: New Delhi, India, 1983 (First Revision)[53] | Bureau of Indian Standards |
| 5 | 1987 | The Mental Health Act[54] | Legislative Department, Ministry of Law and Justice |
| 6 | 1991 | IS 8086; Rehabilitation Equipment-Wheelchairs, folding, junior size-Specification. Bureau of Indian Standards: New Delhi, India, 1991 (First Revision)[55] | Bureau of Indian Standards |
| 7 | 1992 | Rehabilitation Council of India Act (Amended in 2000)[56] | Ministry of Law Justice and Company Affairs |
| 8 | 1995 | Persons with Disabilities (Equal Opportunities, Protection of Rights and Full Participation) Act (Replaced in 2017 after RPwD Act)[57] | Department of Empowerment of Persons with disabilities, Ministry of Social Justice and Empowerment |
| 9 | 1997 | Rehabilitation Council of India (Standards of Professional Conduct, Etiquette and Code of Ethics for Rehabilitation Professionals) Regulations (Revised in 1998)[58] | Department of Empowerment of Persons with disabilities, Ministry of Social Justice and Empowerment |
| 10 | 1998 | Guidelines and Space standards for Barrier Free Built Environment for Disabled and Elderly persons[59] | Central Public Works Department, Ministry of Urban Affairs and Employment, |
| 11 | 1999 | The National Trust for Welfare of Persons with Autism, Cerebral Palsy, Mental Retardation and Multiple Disability Act[60] | Legislative Department, Ministry of Law, Justice, and Company Affairs |
| 12 | 2000 | The National Trust for Welfare of Persons with Autism, Cerebral Palsy, Mental Retardation and Multiple Disability Rules (Amended in 2010, 2015) | Ministry of Social Justice and Empowerment |
| 13 | 2001 | The National Trust for Welfare of Persons with Autism, Cerebral Palsy, Mental Retardation and Multiple Disability Regulations[61] | Ministry of Social Justice and Empowerment |
| 14 | 2001 | Board of Trust Regulations (Amended in 2004, 2006, 2010, 2017)[62] | Department of Empowerment of Persons with disabilities, Ministry of Social Justice and Empowerment |
| 15 | 2001 | Planning a Barrier Free Environment[63] | Office of the Chief Commissioner, People with Disability |
| 16 | 2006 | National Policy for Persons with Disabilities[64] | Ministry of Social Justice and Empowerment |
| 17 | 2009 | National Action Plan on Business and Human Rights | Ministry of Corporate Affairs |
| 18 | 2012 | Guidelines for Pedestrian Facilities (IRC: 103–2012)[65] | Indian Roads Congress |

| | | | |
|---|---|---|---|
| 19 | 2012 | Manual on Disability Statistics[66] | Central Statistics Office, Ministry of Statistics and Programme Implementation |
| 20 | 2014 | Handbook of Barrier Free and Accessibility[67] | Central Public Works Department |
| 21 | 2014 | The Rights of Persons with Disabilities Bill | Legislative Department, Ministry of Law and Justice |
| 22 | 2015 | Accessible India Campaign | Department of Empowerment of Persons with Disabilities, Ministry of Social Justice and Empowerment |
| 23 | 2015 | First Country Report on the Status of Disability in India (Submitted in pursuance of Article 35 of the UN Convention on the Rights of Persons with Disabilities) [68] | Department of Empowerment of Persons with Disabilities, Ministry of Social Justice and Empowerment |
| 24 | 2016 | Harmonized guidelines and space standards for Barrier Free Built Environment for People with Disability and Elderly Persons[69] | Ministry of Urban Development |
| 25 | 2016 | The Rights to Persons with Disability (RPwD) Act (enacted on 28.12.2016, came into force from 19.04.2017)[70] | Ministry of Law and Justice |
| 26 | 2016 | Elderly in India[36] | Social Statistics Division, Central Statistics Office, Ministry of Statistics and Programme Implementation |
| 27 | 2016 | Disabled persons in India-A Statistical Profile[71] | Social Statistics Division, Ministry of Statistics and Programme Implementation |
| 28 | 2017 | Rights of Persons with Disabilities Rules (Amended 2020) | Department of Empowerment of Persons with disabilities, Ministry of Social Justice and Empowerment |
| 29 | 2017 | Parallel Report of India on the Convention on the Rights of Persons with Disabilities (CRPD)[72] | National Disability Network and National Committee on the Rights of Persons with Disabilities |
| | 2018 | National Action Plan on Business and Human Rights[73] | Ministry of Corporate Affairs |
| 30 | 2019 | CPWD Works Manual 2019 (including Standard Operating Procedures)[74] | Central Public Works Department |
| 31 | 2020 | Building Accessible, Safe, and Inclusive Indian Cities (BASIIC)[75] | National Institute of Urban Affairs in collaboration with Ministry of Housing and Urban Affairs |
| 32 | 2021 | Harmonised Guidelines and Standards for Universal Accessibility in India 2021 (Revised in 2022)[76] | Ministry of Housing and Urban Affairs |

In contrast to international guidelines (like The American's with Disabilities Act, 1990 of USA or The Equality Act, 1990 of United Kingdom), most of the Indian documents related to universal design/accessible design are mere guidelines and not mandatory rules; thus, their implementation for accomplishing 'barrier-free' or 'inclusive' built environments at the societal and/or urban-level has not happened.[77] Despite being a member nation of the UN and one of the eighty-two signatories in UN-CRPD, India has a gap in the policy framework of universal design's implementation. However, this research also advocates rectifying the gap by strategic interpretation of the latest disability data and considering the needs of Indian citizens. In India, the accessibility conditions are comparatively low in 'old cities' in comparison to accessibility provisions in newly planned cities. However, in the Indian subcontinent, old cities can be defined by multiple definitions. For this research, cities that evolved during the early 18th century (the start of the British Era) are referred to as 'old cities'. As of Census 2011, India's population is over 1210 million, with a decadal growth rate of over 17%. Additionally, India's density increased from 325 person/ sq.km in 2001 to 382 people/sq.km in 2011 (with over a 17.5% increase). The core areas in respective cities are further denser. In the case of Kolkata Municipal Corporation, the density is over 24,200 persons per sq. km. against a national figure of merely 382 persons per sq. km. Owing to the ever-increasing population of India and the high density in its historically-developed organically-planned core cities, 'accessibility' becomes more complex than in most of the countries abroad. 'Accessibility' refers to the provisions for people including both able-bodied and specially-abled for accessing urban facilities without discrimination. Thus, dealing with accessibility in old city parts of India is an interesting as well as an important domain of urban infrastructure.[78] As an example, cities planned after the independence of India (from the British in 1947) such as Chandigarh and Bhubaneswar provide relatively better facilities/options for specially-abled and senior citizens (people above 60 years), than cities such as old parts of imperial Kolkata or colonial Delhi.

As a general practice in urban India, the practices of universal design guidelines or Barrier-Free are comparatively more at the building level, and not at the site/precinct level.[79] Universal Mobility connects the missing links between 'Universally Designed' buildings and 'Universally Designed' premises/precincts and creates accessible urban spaces. In India, a project such as the 'Mass Rapid Transit System' in Delhi (operationalized in 2002) has initiated the process of inclusive transportation.[80] However, on a large scale, the UN-CRPD's focus on Universal Mobility is not yet addressed in Indian guidelines. Likewise, Indian cities are still lagging in creating accessible urban spaces because of practicing 'Inclusive' or 'Accessible Transportation', instead of 'Universal Mobility'. 'Inclusive Transportation' focuses on making the mode of transport accessible to all, for example, accessible railway stations or accessible bus stops. The aspects covered in 'Accessible Transportation' are (a) access to the station, (b) fare payment, (c) travelling information and communication, and (d) interior conditions of the mode of transport.[81] 'Universal Mobility', in contrast, is a policy-level intervention at the city scale ensuring a minimum standard of mobility for all members of society. Thus, 'Universal Mobility' is technically sound than 'Inclusive' or 'Accessible' transportation.

Urban reforms in India particularly focusing on improving the quality of life in an inclusive way substantially increased in recent years. One such initiative has been the 'Accessible India Campaign' (launched in December 2015 by the Ministry of Social Justice and Empowerment, Government of India) in consonance with Article 9 of UN-CRPD. 'Accessible India Campaign' has several components which promote accessibility in (a) built environments, (b) transportation systems, and information and communication ecosystems.[82]

In a similar line, through interviews and surveys during this research, it is inferred that for this research, 'Transportation System Accessibility' (involving vehicular traffic and walkability) be dealt with greater focus than the other two components. At an objective level, the focus of UN-CRPD towards Universal Mobility relates to the 'Transportation System Accessibility' component of the Accessible India Campaign. The global focus and national demand made this research focus on the topic of Universal Mobility rather than any other aspect of universal design for this research. Thus, the inception of this research finds its roots in the form of the demographic and institutional situation of India in the recent past. Also, 'Movement and Transportation Issues' are prioritized since individual building facilities alone cannot create universally designed cities unless those buildings are connected through a 'Universally Designed' movement corridor. The aforementioned 'Universally Designed' movement corridor is also referred to as universal mobility in technical terms. This research endeavours to assess walkability for ensuring universal mobility in historical city centres and then verifies the model in a case area. Thus, this research eventually leads to policy-related intervention, unlike the usual design-oriented approaches in the domain of accessibility. The core of Kolkata (within Kolkata Municipal Corporation limits), India has been selected as a case area for this research.

Pedestrian-level infrastructures in old cities are often affected by poor infrastructure and pose a threat to able-bodied and users with wheelchairs or walking assistance alike. Concerning this, a stretch in Central Kolkata (in India) was considered a case example for this paper as clarified earlier. The typology of urban patterns is complex in old-core Indian cities (like Kolkata) due to the multiplicity of building uses, thus attracting users from diverse age groups. Age diversity presents a challenge to decision-makers regarding the type of facility in the pedestrian environment; on the other hand, it promotes the need for universal mobility. Mahapatra, Mori, and Nomura (2021) establish that the challenges in implementing Universal Mobility in an urban Indian context can be attributed to legislative as well as population density[83]. Old Indian cities are also experiencing degeneration in terms of their urban fabric[84]. Since old cities are often associated with historic value, maintaining physical revitalization is also an added challenge for architects and city officials alike[85]. Furthermore, a unique assessment format is necessary for understanding the context-specific accessibility conditions of old core Indian cities.

## 1.2 RESEARCH OUTLINE

This section explains the outline of the research in terms of (a) aim, (b) hypothesis, (c) objectives, (d) research questions, (e) focus, scope, and (f) limitations.

### 1.2.1. Aim

To find out strategies to improve the quality of life in the congested urban cores by making the footpaths accessible to all under the broader paradigm of urban reforms in India.

### 1.2.2. Hypothesis

The strengths of the organically planned old settlements will improve the liveability standards if the accessibility component is inserted into its pedestrian paradigm through architectural planning.

### 1.2.3. Objectives

The 4 primary objectives of the research are set forward hereafter:

***(a) Objective 1:*** To define the role of Architectural Planning in an 'accessibility planning' proposal.
***(b) Objective 2:*** To determine the degree of accessibility possible in the footpaths of core areas of an old Indian city by proposing an ideal accessibility audit checklist.
***(c) Objective 3:*** To improve cognition at the footpath level in old cities, especially for the specially-abled.
***(d) Objective 4:*** Policy-level recommendations to increase the quality of life in cities by improving the footpaths.

### 1.2.4. Research Questions

The 4 key research questions are indicated hereafter:

***(a) Research Question 1:*** What is the role of accessibility under the broader domain of universal design in improving the quality of life?
***(b) Research Question 2:*** What is the degree of accessibility that can be achieved in the public domain of old cities?
***(c) Research Question 3:*** Can core Indian cities be made inclusive in terms of Universal Mobility?
***(d) Research Question 4:*** What degree of cognition can be achieved in the footpaths of old cities?

### 1.2.5. Focus

The 5 foremost focus areas of this research are indicated hereafter:

***(a) Focus 1:*** Users' perception towards Universal Mobility in old core cities of India.
***(b) Focus 2:*** Accessibility of the footpath-level walkability condition of Kolkata.

***(c) Focus 3:*** Universal Mobility in the footpaths of the core of old Indian cities (survey-based).
***(d) Focus 4:*** Experts' perception towards Universal Mobility in the core of old Indian cities.
***(e) Focus 5:*** Role of cognition in Universal Mobility at the pedestrian level.

#### 1.2.6. Scope

The 2 major domains of research scope are indicated hereafter:

***(a) Scope 1:*** To explore the potential of inclusiveness in footpaths of congested cores where the density is more compared to the rest of the city.
***(b) Scope 2:*** To furnish a process-oriented approach in the realm of accessibility where the approach is still product oriented.

#### 1.2.7. Limitations

The 3 principal limitations of this research are clarified hereafter:

***(a) Limitation 1:*** Restrict the design intervention to a delineated part of Central Kolkata.
***(b) Limitation 2:*** Few disabilities shall be prioritized, preferably, Mobility and Physical Impairments.
***(c) Limitation 3:*** 'Transportation System Accessibility' involving (vehicular and walkability) will be dealt upon with greater focus.

### 1.3. KEY TERMS USED IN THIS RESEARCH

In this section, the important terms used in this research are elaborated. The terms are (a) accessibility; (b) barrier-free architecture; (c) inclusive design; (d) universal design; (e) universal mobility; (f) accessibility audit; (g) footpath; (h) pedestrians; (i) urban; (j) old cities; (k) expert opinion; (l) disability; (m) specially-abled; (n) architectural planning; and (o) cognition.

#### 1.3.1. Accessibility

The process of ensuring equitable accessibility and usability of the physical environment, transportation, and ICT (Information and Communications Technology) to both specially-abled and able-bodied people, is referred to as accessibility.[86,87] Accessibility is the core of all research related to barrier-free architecture, inclusive design, and universal design.[88] On similar lines, in this research, accessibility at the footpath level is focused upon.

#### 1.3.2. Barrier-Free Architecture

A Barrier Free Architecture can be explained as a design for spaces or environments that can allow for free and safe movement, function, and access for all, regardless of age, gender, or condition. This can also be explained as a design for spaces or a set of services which can be accessed by all without any obstructions and with as much independence as possible.[89] The goal of barrier-free architecture is to design spaces to provide an environment which can function independently for individuals so that they can access the built spaces without assistance in everyday life such as activities like procurement[90] of goods and services, community living, employment and leisure.

#### 1.3.3. Inclusive Design

An Inclusive design is a concept which aims to remove barriers that can create undue effort and separation. It enables everyone to participate equally, confidently, and independently in everyday activities.[91] An alternative view about Inclusive design is that it is an overarching means of integrating, not competing with other design factors. A design from the perspective of human diversity provides an alternative strategy for site design, spatial organizations, wayfinding, the design of individual spaces, and the selection of environmental controls and furnishings.[92] The British Standards Institute defines inclusive design as 'the design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible without the need for special adaptation or specialized design'[93] which explains a base and clarifies the perception on Inclusive design.

### 1.3.4. Universal Design

Universal Design can be explained as the process undertaken to design products, buildings, and exterior spaces that are accessible (through usage) by all (able-bodied and specially-abled) to the maximum extent without any specialized design.[94] Universal Design has its root in the principle that a design solution shall serve all user groups without making the specially-abled distinctive.[95] Universal Design takes into consideration usability, inclusivity, and accessibility thereby making built environments usable to all.[96]

### 1.3.5. Universal Mobility

'Universal Mobility', in contrast, is a policy-level intervention at the city scale ensuring a minimum standard of mobility for all members of society.[97] Universal Mobility connects the missing links between 'Universally Designed' buildings and 'Universally Designed' premises/precincts and creates accessible urban spaces.[98] Both the UN-CRPD and the UN-SDG advocates the concept of Universal Mobility for enabling movement within a city without discrimination based on physical or mental limitations. Universal Mobility, especially at the footpath level of old Indian cities, impacts the human dimensions in everyday urban life, which is a determinant as well as a challenge to the architectural planning fraternity.[99,100] As an example of an ideal universally-designed streetscape, a rapid baseline assessment of certain footpath stretches in Sapporo, Japan (Refer to **Figure 1**: a to b) was done. Japan is a country with a large number of elderly (28% of the total population) and 4.3% specially-abled citizens, considering a Universally Designed streetscape as a prerequisite to urban development.[101] As seen in the pictures, the eminent characteristics of the footpath are ideal slope, tactile marking, street signage, proper location of gratings and manholes, and street art. There can be learning from these ideal streetscapes while framing the accessibility audit guidelines in countries like India.


(a) Slope and tactile marking

(b) Street signage

(c) Grating change near trees

(d) Manholes away from kerb or curb (Kerb<150mm)

(e) Closed manhole located on edge (e) Street art

**Figure 1 (a-e):** Location: Footpath near Hokkaido University south gate in-between 'North 7 West 6' and 'North 6 West 5'.

### 1.3.6. Accessibility Audit

Accessibility audit refers to the systematic evaluation of the built environment based on several assessment parameters. [102] Accessibility audits can be conducted at the building or street level. [103] Before conducting such an audit, the factors which need to be determined are: (a) what is to be assessed; (b) what standards it is being assessed against?; (c) timescale & the required outcome?; and (d) for what purpose?[104] The factors in accessibility audit can be the 'presence of a ramp' in the case of a building or the 'presence of tactile marking' in the case of a footpath. The outcome of an accessibility audit is usually both qualitative (observational survey) and quantitative (questionnaire-based fieldwork). [105] It is a complex and scientific process which is ideally conducted by professionals. [106] Accessibility audits are often the initial step in the preparation of an accessibility proposal.[107] In this research, an accessibility audit has been conducted on footpaths in core areas of several old cities in India.

### 1.3.7. Footpath

Footpath (or, pavement) is generally referred to a grade-separated paved passage that is dedicated for the use of pedestrians.[108] A typical footpath is comprised of: (a) frontage or dead width (500 – 1000 mm), (b) pedestrian zone (≥ 1800 mm), and (c) street furniture zone (along the path of travel).[109] Also, the effective (clear) width of a footpath depends on the adjacent land use: (a) 1800 mm for residential/ mixed use areas; (b) 2500 mm for commercial/ mixed use areas; (c) 3500 – 4500 mm for shopping frontages; (d) 3000 mm for bus stops; and e) 4000 mm for high intensity commercial areas. [62] Ownership of the land adjacent to the footpath is a primary factor towards determining the genre of the footpath, especially in developing nations.[110] An example of a footpath surveyed in this research is shown below in **Figures 2 and 3.**

**Figure 2:** Footpath in Bowbazar, Kolkata.

**Figure 3:** Footpath in Bapu Bazar, Jaipur.

### 1.3.8. Pedestrians

The term 'pedestrian' is defined in numerous ways. In addition to able-bodied people commuting by foot, 'pedestrian' also includes people in a non-motorized wheelchair or, driving a motorized wheelchair with a speed of less than 10km/hr on level ground.[14] Although international and national guidelines/goals encourage pedestrianization, poor urban-level pedestrian quality discourages pedestrian activity.[111] In relation to this, the user group explained by Goldsmith in his 'Universal Design Pyramid' can all be included in the category of pedestrians as shown in **Figure 4.** In **Figure 4,** the user groups are categorized into 8 groups where (a) Group 1: fit and agile people; (b) Group 2: able-bodied people; (c) Group 3: able-bodied women; (d) Group 4: elderly people with walking sticks and people with infants in pushchairs; (e) Group 5: ambulant people who have disabilities and visually impaired people; (f) Group 6: independent wheelchair users; (g) Group 7: people who require assistance in wheelchairs and disabled people who drive electric scooters; and (h) Group 8: wheelchair users who need more than one person for assistance.[42]

### 1.3.9. Urban

A geographic entity with a continuous urban settlement pattern and a density greater than the immediate surrounding settlements can be termed an 'urban' area.[112] The concept of urban distinguishes it from the other form of settlements like peri-urban or rural on spatial as well as social grounds.[113,114] According to the Census of India, a settlement can be categorized as urban only if it satisfies all the following criteria: (a) settlements which are recognized by a governing urban local body, like a Municipal Corporation; (b) having a population of more than 5,000; (c) having a population density greater than 400 people per square kilometre; and d) having at least 75% workforce involved non-agricultural activities.[115] This specific definition of urban (as per Census of India) is being considered for this research. An example of the urban areas used for the field survey in this research is shown below in **Figure 5**.

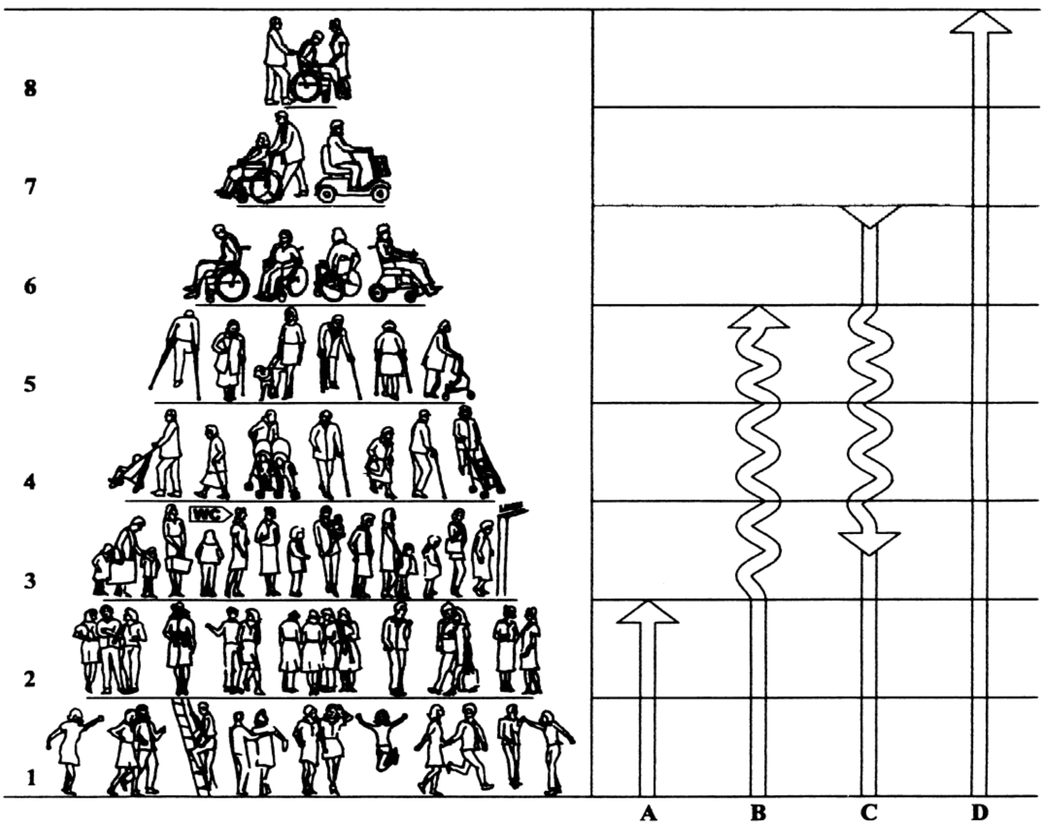


**Figure 4:** Universal Design Pyramid [Source: Goldsmith, 2007].


**Figure 5:** Field survey location in Kolkata, India.

### 1.3.10. Old cities

The case areas considered for this research are old cities in India that are different from most old cities in the world. For this research, cities that evolved during the early 18th century (the start of the British Era) are referred to as 'old cities'. The space structures in old cities of developing nations such as India are complex due to their historic origin. These areas are generally identified with high density, mixed land use, and a lack of space allocated to infrastructure[116]. A photograph representing the old cities dealt with, in this research, are provided below in **Figure 6**.

**Figure 6:** Old parts of Hyderabad near Jama Masjid.

### 1.3.11. Expert Opinion

This research involves the following experts: (a) academicians (professor, associate professor, assistant professor, and Ph.D. scholar in architecture/planning), (b) practitioners (practicing architects, practicing planners, and architects or planners working in private establishments), and (c) government officials related to architecture/planning. The contacts of the experts were acquired from the websites of the universities that are recognized by the Council of Architecture or COA (available at https://www.coa.gov.in/institutionStatus.php, accessed on 7 February 2023) and Institute of Town Planners, India or ITPI (available at https://www.itpi.org.in/uploads/pdfs/2-provisional-list-of-schools-Institutions-and-universitites-planning-courses-approved-by-itpi.pdf, accessed on 6 February 2023). Architects are officially recognized in India only if they are registered under the Council of

Architecture, New Delhi. Similarly, every planner registers themselves with the Institute of Town Planners, India in New Delhi.

### 1.3.12. Disability

Disability in a person can be described as a physical or cognitive/ mental impairment which significantly affects the capability to conduct daily activities.[117] According to World Health Organization (hereafter, WHO), disability can be hierarchically categorized into 3 primary levels: (a) body function or structural impairment, (b) activity-oriented limitations (like restricted mobility), and (c) participatory limitations.[118] Fundamentally, the 3 distinct models of disability are medical, social, and technical.[119] These three models are interrelated, for example, first, it is necessary to understand the physical problems faced by a problem with an impaired limb from a medical standpoint. Only after understanding the problem from a medical standpoint, a designer can design spaces which create equitable access for the specially-abled and elderly. However, before designing the spaces, it is also imperative to understand the social acceptance of the disability as well as the design solution. In the Indian context, 21 types of disabilities are: (a) blindness, b) low vision, c) leprosy-cured people, d) locomotor disability, e) dwarfism, f) intellectual disability, g) mental illness, h) cerebral palsy, i) specific learning disabilities, j) speech and language disability, k) hearing impairment, l) muscular dystrophy, m) acid attack victim, n) Parkinson's diseases, o) multiple sclerosis, p) thalassemia, q) haemophilia, r) sickle cell disease, s) autism spectrum disorder, t) chronic neurological disorder, and u) multiple disabilities.[120] A photograph of elderly and disabled people taken during the fieldwork for this survey is shown in **Figure 7**.

**Figure 7:** A person with mobility impairment in Central Kolkata.

### 1.3.13. Specially-Abled

The term specially-abled refers to people with disabilities and elderly people. In India, people aged 60 and above are referred to as elderly.[121] The condition of a person to be termed as specially-abled is also dependent on whether the disability is: (a) permanent (like blindness), (b) temporary (like a broken arm), (c) situational (like a person carrying a child), or (d) maybe invisible (like, dyslexia).[122] This research promotes the usage of the term 'specially-abled' despite the inclination of the United Nations in using the term 'Persons with disabilities'.[123] The term 'Persons with disabilities' unlike what is being interpreted by the UN, identifies a person with the associated disability, which is not only unnecessary but derogatory as well. The term 'person with disability' is more suited for barrier-free architecture, thus the term 'specially-abled' is better suited in the wake of universal design or universal mobility as well.

### 1.3.14. Architectural planning

Originating in Japan, Architectural Planning Research (hereafter, APR) is a unique academic field which marked the beginning of an academic discipline which scientifically examines architectural design methods.[124] 'Architectural Planning' is a generality-oriented deterministic way of relating physical and spatial factors with human life.[125] APR reflects human behaviour in the built environment. The adequacy and contextuality of APR depend on three primary factors: (a) contextual appropriateness, (b) economic viability, and (c) diversification of the user group. Amongst all, understanding the user group is the key to a successful APR solution [2].[126] The role of universal design is primary in this argument. Universal Design has an essential niche in APR due to a higher degree of psychophysiological quotient than most other design paradigms.

### 1.3.15. Cognition

The understanding of cognition is dependent on the context in which it is interpreted, for example, possessing an improved cognition level is often associated with intelligence and vice versa.[127] Technically, cognition can be described as the psychological procedures undergone by someone in perceiving, learning, remembering, thinking, and understanding a situation; thereby directing an individual's daily activity.[128] The context of cognition in this research can be explained using **Figure 8**. In this diagram, both able-bodied and specially-abled can be observed. During the field survey, the two photographs used in this diagram were taken by the author near Bowbazar Crossing in Kolkata in the year 2020. For the able-bodied (marked with a **blue** arrow), despite the numerous obstacles on the footpath (like a parked bike, encroachment, animals, and ill-placed street furniture) repeated commutation through this route creates an associated memory. This associated memory which is directly linked to sensory experiences helps an able-bodied person to prioritize time over comfort, and thereby use this route despite the obstacles. However, in the case of the specially-abled (marked with a **green** arrow), the same obstacles create a sense of fear due to a lack of sensory/ mobility abilities (like lack of vision in case of vision-impaired). This sense of fear caused by low cognition of the space eventually leads to diminished security after a single or repeated encounter. The sense of diminished security makes the specially-abled panicked and disoriented, preventing them from using this route even if it saves time. Thus, the same infrastructural conditions can directly and distinctively influence the cognitive pattern of able-bodied and specially-abled.[129]

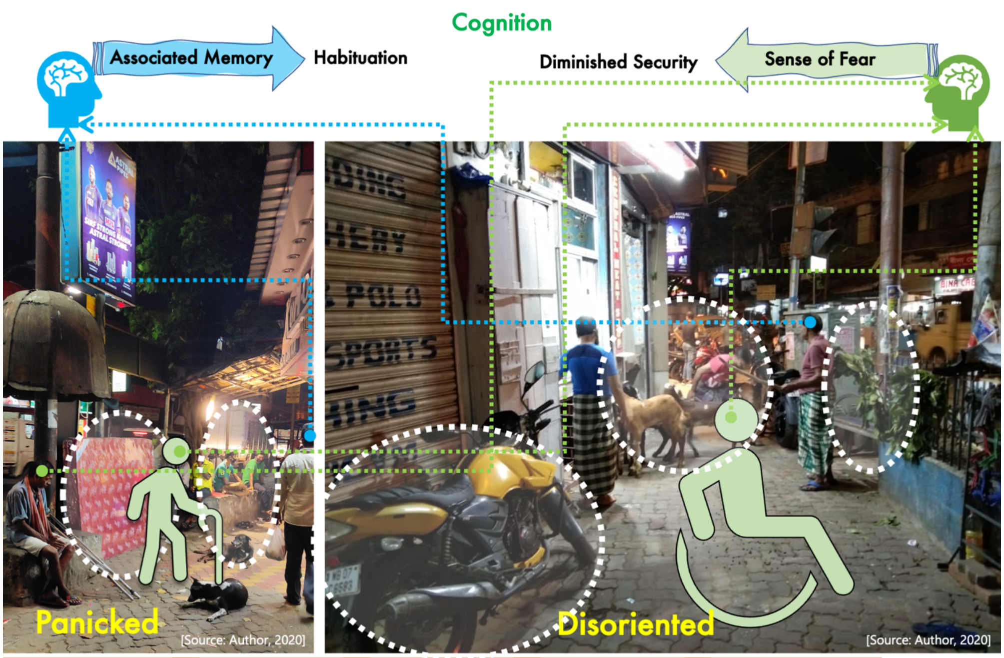


**Figure 8:** Diagrammatic explanation of cognition in this research.

## 1.4. RESEARCH METHODOLOGY

This research follows a complex APR methodology that is dependent on fieldwork. Since this research was further published in peer-reviewed journals, each segment of the research has an individual methodology. However, the methodology represented in **Figure 8** shows the overall research methodology (initial framework) from which the corresponding methodologies were developed. Each segment stated above is elaborated hereafter.

This research begins with the literature study which is comprised of 5 broad segments: (a) global scenario, (b) universal design, (c) universal mobility, (d) accessibility audit and (e) cognitive considerations. Relevant research documents (journals, books, websites, etc.) were shortlisted and the information about the research objectives was summarized from them. The learnings from this section were primarily used to frame the fieldwork criterion and interview questionnaires. The next stage was data collection using primary and secondary methods.

The first set of primary data was collected using the data collected from the fieldwork in footpaths of the following cities in India: (a) Kolkata (32 footpaths), (b) Jaipur (7 footpaths), (c) Jodhpur (16 footpaths), (d) Nagpur (12 footpaths), (e) Hyderabad (12 footpaths), and (f) Chennai (25 footpaths). Another set of primary data was collected by conducting interviews (face to face and online) of the following user groups: (a) 125 residents of Kolkata, (b) 310 people from the design fraternity of India, (c) 257 experts from India, and (d) 41 people undertaken geriatric simulation.

The aforementioned 2 sets of primary data were re-grouped to form 5 data sets, which were used further for data analysis. The 5 data sets are as follows:

***(a) Dataset 1:*** Interview data from 125 residents of Kolkata and 310 people from the design fraternity of India.
***(b) Dataset 2:*** Fieldwork data from 32 footpaths from Kolkata.
***(c) Dataset 3:*** Fieldwork data from Jaipur (7 footpaths), Jodhpur (16 footpaths), Nagpur (12 footpaths), Hyderabad (12 footpaths), and Chennai (25 footpaths).
***(d) Dataset 4:*** Interview data from 310 people from the design fraternity of India**.**
***(e) Dataset 5:*** Fieldwork data from 32 footpaths from Kolkata and interview data from 41 people using a geriatric simulator.

Furthermore, dataset 1 was focused on assessing the Users' perception towards Universal Mobility in old core cities of India. Dataset 2 was used in the accessibility of the footpath-level walkability condition of Kolkata. Universal Mobility in the core of old Indian cities (survey-based) was interpreted using dataset 3. Dataset 4 interpreted Experts' perception towards Universal Mobility in the core of old Indian cities. The role of cognition in Universal Mobility at the pedestrian level was evaluated using dataset 5. Furthermore, dataset 1 to 5 was finally redirected towards publication 1 to 5 respectively. The details of the publications (in international English version peer-reviewed journal) are mentioned hereafter:

(a) Publication 1:

**G. Das Mahapatra**, S. Mori, and R. Nomura, "Universal Mobility in Old Core Cities of India: People's Perception," *Sustainability*, vol. 13, no. 8, p. 4391, Apr. 2021, doi: https://doi.org/10.3390/su13084391. [Impact Factor = 3.9]

(b) Publication 2:

**G. Das Mahapatra**, S. Mori, and R. Nomura, "Evaluating the accessibility of old cities: Case of Central Kolkata, India," *Japan Architectural Review*, vol. 6, no. 1, Mar. 2023, doi: https://doi.org/10.1002/2475-8876.12349. [Impact Factor = 0.9]

(c) Publication 3:

**G. Das Mahapatra**, S. Mori, and R. Nomura, "Reviewing the Universal Mobility of the Footpaths in the Centers of Historic Indian Cities through Field Survey," *Sustainability*, vol. 15, no. 10, p. 8039, Jan. 2023, doi: https://doi.org/10.3390/su15108039. [Impact Factor = 3.9]

(d) Publication 4:

**G. Das Mahapatra**, S. Mori, and R. Nomura, "Interpreting Universal Mobility in the Footpaths of Urban India Based on Experts' Opinion," *Sustainability*, vol. 15, no. 4, p. 3625, Feb. 2023, doi: https://doi.org/10.3390/su15043625. [Impact Factor = 3.9]

(e) Publication 5:

**G. Das Mahapatra**, S. Mori, and R. Nomura, "Role of Cognition in Pedestrian-Level Universal Mobility: Case of Central Kolkata, India," Athens Journal of Architecture, vol. 9, no. 1, pp. 107–128, Jan. 2023, doi: https://doi.org/10.30958/aja.9-1-5.

The next stage was analysing the datasets. The 7 factors for analysis of dataset 1 are: (a) position of universal design in the design domain, (b) prioritization of site and services in universal design, (c) rating national policies, (d) level of difficulty in a universal design scenario in old cities, (e) position of 'Transportation' and 'Accessible Information' in the universal design domain, (f) difference in the universal design scenario between old and new cities, and (g) need for a 'Rating System'. The 5 factors for analysis of dataset 2 are: (a) frequency and purpose of going out; (b) searching/ identification of an address, (c) public transportation, (d) walkability, and (e) awareness about national schemes. The 18 factors for analysis of dataset 3 are: (a) building typology, (b) footpath dimensions, (c) temporary encroachment, (d) permanent encroachment, (e) bus stop, (f) metro rail entrance, (g) railings, (h) stormwater drain, (i) public toilet, (j) trash bins, (k) streetlights, (l) flooring, (m) manholes, (n) kerb (curb), (o) pedestrian crossing, (p) street furniture, (q) safety and security, (r) additional inclusive feature, and (s) contextual features. The 3 major factors for analysis of dataset 4 are: (a) universal design (including footpath condition, major obstacle, quality of life, PPP projects, accessibility audit, and guidelines), (b) universal mobility (including importance, theoretical model, pilot projects, and prioritization of factors). The 2 major factor in dataset 5 are: (a) physical data (pedestrian count and vehicular traffic volume), and (b) cognitive data (light Intensity, noise, and thermal comfort).

Analysing the research data was the next step in the research. Assessing universal mobility in both quantitative and qualitative ways was the first concluding step. This part helps the reader to understand the actual condition of the footpaths of India concerning universal mobility. In every case (during publications), statistical testing was done to test the respective hypothesis. A new accessibility format proposed for the accessibility audit of footpaths in old Indian cities was finalized and it was one of the most important takeaways from this research.

The last part of this research was providing recommendations based on the conclusion section of the research. The recommendation was provided in the form of a commentary which comprises 2 main proposals: (a) User-oriented and (b) Policy-level based. User-oriented recommendations were directed towards understanding how each user group shall benefit from this research. The policy-level based recommendations were directed towards the policymakers in the old Indian cities by giving a direction on how to approach the redevelopment of footpaths to improve their universal mobility aspects.

Finally, the entire methodology seeks to fulfil the aim of finding out strategies to improve the quality of life in congested urban cores by making the footpaths accessible to all under the broader paradigm of urban reforms in India.

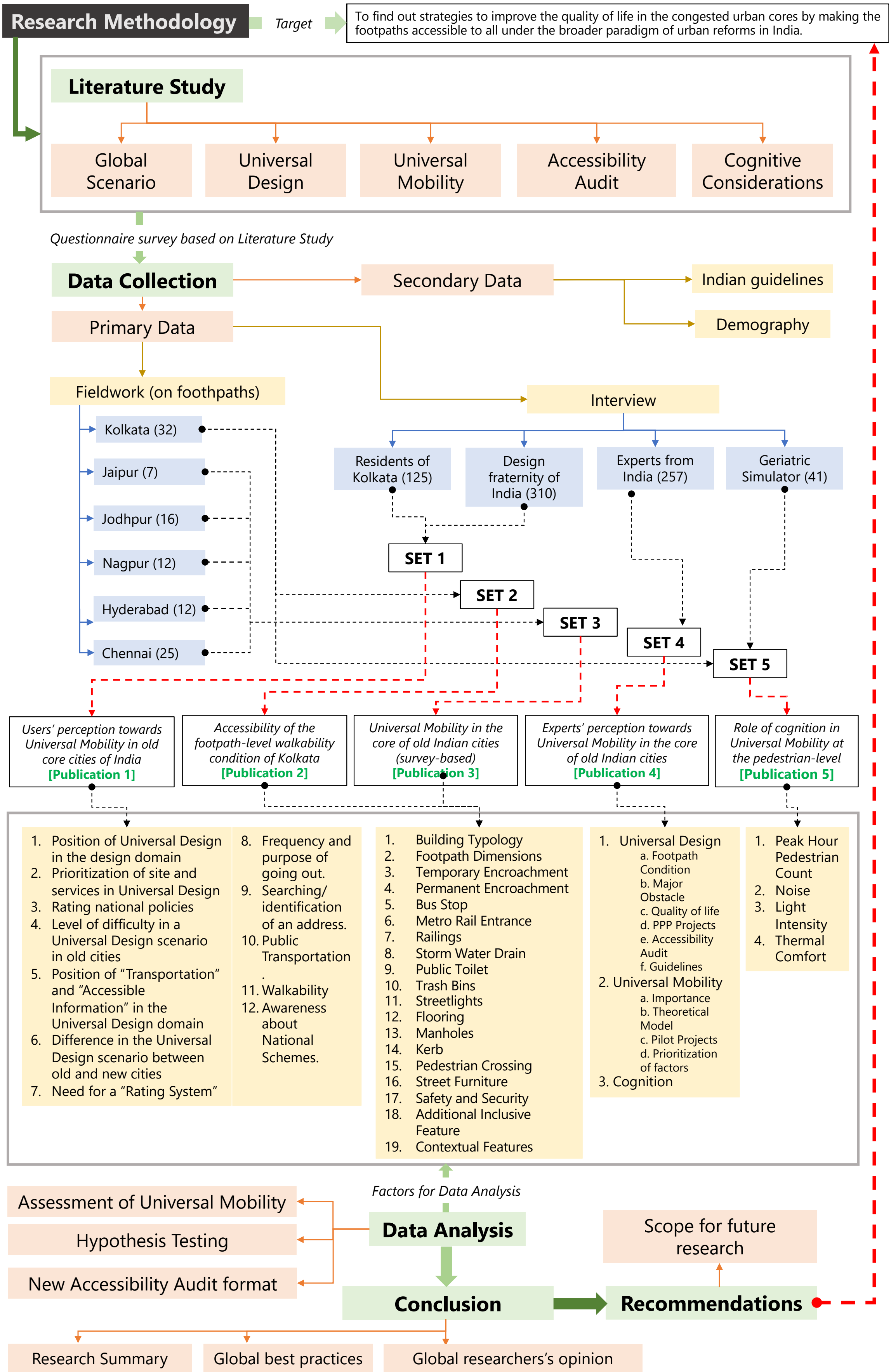


**Figure 9:** Overall research methodology.

## 1.5. DISSERTATION CHAPTERS PUBLISHED IN PEER-REVIEWED JOURNALS

In this section, a summary of the core chapters (the chapters that were also published in peer-reviewed journals as mentioned in the previous sub-section) following this chapter, is detailed. The first chapter 'Introduction' and the last chapter 'Conclusion' is excluded from this explanation.

### 1.5.1. Chapter 2- Understanding the perception of users about Universal Mobility in old core Indian cities

The contents of this chapter were published as: **G. Das Mahapatra**, S. Mori, and R. Nomura, 'Universal Mobility in Old Core Cities of India: People's Perception,' *Sustainability*, vol. 13, no. 8, p. 4391, Apr. 2021, DOI: 10.3390/su13084391. [Impact Factor = 3.9; Citations = 11 (as of July 2023)]
*[N.B. This paper is provided as* ***Appendix 2****].*

In this chapter, users' perception towards Universal Mobility in old core cities of India has been critically analysed. Despite universal design guidelines from the United Nations and the Union Government of India, old cities in India seldom have Universal Mobility, in effect endangering the lifestyle of senior citizens and specially-abled people. The core of Kolkata Municipal Corporation in Kolkata, India, has been considered a case example for this section. This section has considered three types of datasets for analysis. First, the 310 respondents were interviewed from the Indian design fraternity, to understand their opinions on the concept of universal design. In the next investigative study of 125 respondents from different wards of Kolkata Municipal Corporation, the purpose was to comprehend people's perceptions regarding walkability and mobility in an old Indian city. In the last visual survey of a stretch in Central Kolkata, the focus was on identifying hindrances in Universal Mobility in an old city core of Indian origin. Significant dissatisfaction was found regarding walkability amongst all user groups, which is linked to poor infrastructural conditions. Furthermore, accessing public transportation is difficult due to improper waiting facilities. However, the design fraternity in India suggests the need for separate accessibility guidelines for old and new cities in India. The design fraternity also recommends a customized rating system for accessing universal design. The result of this study indicates a need of recognizing the difficulty in imparting Universal Mobility in old core cities in India. The findings of this chapter can be used for preparing an access audit checklist through Architectural Planning, which is the first step in proposing a framework for Universal Mobility in old core cities in India.

### 1.5.2. Chapter 3- Evaluating the accessibility of the footpath in case area (Central Kolkata, India)

The contents of this chapter were published as: **G. Das Mahapatra**, S. Mori, and R. Nomura, 'Evaluating the accessibility of old cities: a case of central Kolkata, India,' *Japan Architectural Review*, vol. 6: e12349, Mar. 2023, DOI: 10.1002/2475-8876.12349. [Impact Factor = 0.9]
*[N.B. This paper is provided as* ***Appendix 3****].*

Old Indian cities are often less accessible due to temporal restrictions and ever-rising pedestrian volume. In this chapter, the accessibility of the footpath-level walkability condition of old core cities has been assessed through APR, considering 32 footpath stretches in Central Kolkata, India as a case. The research has considered 3 data sets, (a) 257 experts' opinions about universal mobility, (b) 18 variables for assessing accessibility conditions, and (c) peak hour pedestrian volume. IBM® SPSS® Statistics 26.0 version has been used to validate the findings of the research. It was found that mixed-use buildings demarcate the edge of the footpaths in old cities. 50.6% of Indian experts prioritized the 'dimension of the footpath' while assessing universal mobility for pedestrians in the old cities of India. The average accessibility percentage for the entire surveyed stretch is negative which highlights the poor accessibility of the stretch. Pearson's correlation between footpath width and infrastructure score of 0.535 signifies the width of a footpath plays a significant role in determining the level of footpath infrastructure. Thus, the findings of this chapter can be used while preparing accessibility development plans for the study area and other areas of a similar genre.

#### 1.5.3. Chapter 4- Testing the research hypothesis in footpaths of old Indian cities other than case area

The contents of this chapter were published as: **G. Das Mahapatra**, S. Mori, and R. Nomura, 'Reviewing the Universal Mobility of the Footpaths in the Centers of Historic Indian Cities through Field Survey,' *Sustainability*, vol. 15, no. 10, p. 8039, May. 2021, DOI: 10.3390/su15108039. [Impact Factor = 3.9]
*[N.B. This paper is provided as* ***Appendix 4****].*

In this chapter, the condition of Universal Mobility in the core of old Indian cities has been critically analysed. Implementing universal design guidelines (especially Universal Mobility standards) in the core of old Indian cities is comparatively challenging due to the high-density, ever-increasing population, and organic urban development. The rising number of elderly and specially-abled also adds a demographic challenge to the aspect of Universal Mobility. The focus of this research is to understand the extent to which Universal Mobility guidelines can be implemented in the core of old Indian cities. The dataset for this research is derived from the field survey of sixty-nine footpath stretches from the core of five old cities in India, namely Jaipur, Jodhpur, Nagpur, Hyderabad, and Chennai. Footpath stretches in the core of these old cities were evaluated based on several factors in the domain of universally designed infrastructure and Universal Mobility features. Such comprehensive research on Universal Mobility in footpaths of old Indian cities has not been conducted. The findings of this chapter indicate the poor condition of Universal Mobility in the study areas. Furthermore, the results can be useful for assessing the extent of implementation of Universal Mobility in the core of old Indian cities.

#### 1.5.4. Chapter 5- Interpreting the perception of experts on Universal Mobility in footpaths of old Indian cities

The contents of this chapter were published as: **G. Das Mahapatra**, S. Mori, and R. Nomura, 'Interpreting Universal Mobility in the footpaths of urban India based on experts' opinion,' *Sustainability*, vol. 15, no. 4, p. 3625, Feb. 2023, DOI 10.3390/su15043625. [Impact Factor = 3.9; Citations = 2 (as of July 2023)]
*[N.B. This paper is provided as* ***Appendix 5****].*

In this chapter, expert opinion on Universal Mobility in the footpaths of urban India has been critically appraised. Universal Mobility (as a component of universal design) is still a largely ignored urban parameter in India despite an increase of 732.20% in the specially-abled and 105.25% 13 in the elderly, between 1911 and 2011. 257 experts from the field of architecture and planning hailing from 66 cities in India were interviewed for this section. It was found that despite nationally implemented universal design guidelines, footpaths in 42.8% of the cities do not have Universal Mobility. 74.7% of the respondents identify the dimension of the footpath as the most important factor for implementing Universal Mobility. The findings of this chapter indicate the importance of universal design in improving the quality of life in Indian cities and urban local bodies can play a significant role in the process using Public Private Partnership (hereafter, PPP) models and a new accessibility audit checklist.

### 1.5.5. Chapter 6- Considering the importance of cognition in footpaths of case area (Central Kolkata, India)

The contents of this chapter were published as: **G. Das Mahapatra**, S. Mori, and R. Nomura, 'Role of Cognition in Pedestrian- Level Universal Mobility: Case of Central Kolkata, India,' *Athens Journal of Architecture*, vol. 9, no. 1, pp. 107–128, Jan. 2023, DOI: 10.30958/aja.9-1-5. [Citations = 1 (as of July 2023)]
*[N.B. This paper is provided as **Appendix 6**].*

In this chapter, the role of cognition in Universal Mobility at the pedestrian- level has been investigated. A stretch of approximately 850 m in the core of Kolkata Municipal Corporation (in India) has been delineated as the case area for this research. The 02 data sets considered for this research are: (a) physical data: pedestrian count and vehicular traffic volume, and (b) cognitive data: light intensity, noise, and thermal comfort. The data was collected from the case area in the years 2020 and 2021. This section initially involves determining the pedestrian 'Level of Service' (hereafter, LOS) based on the pedestrian count. Furthermore, the LOS data was co-related (Pearson's Correlation with a 95% confidence interval) with the light intensity, sound intensity, and temperature data; to establish a relationship between them. The findings of this chapter indicate a gap in realizing the potential of walkability in the case area. It was concluded that the improvement of cognition in pedestrian-level Universal Mobility can lead to a better physical environment for the specially-abled and elderly.

# CHAPTER 02

- **Title:** Understanding the perception of users about Universal Mobility in old core Indian cities.
- **Related Publication:** The contents of this chapter were published as: **G. Das Mahapatra**, S. Mori, and R. Nomura, 'Universal Mobility in Old Core Cities of India: People's Perception,' *Sustainability*, vol. 13, no. 8, p. 4391, Apr. 2021, DOI: 10.3390/su13084391. [Journal Impact Factor = 3.9; Citations = 11 (as of July 2023)]
- **Scope:** To explore the potential of inclusiveness in congested cores where the density is more concerning the rest of the city.
- **Objectives:** To define the role of Architectural Planning in an 'accessibility planning' proposal.
- **Focus:** Users' perception towards Universal Mobility in old core cities of India.
- **Research Questions:** What is the role of accessibility under the broader domain of universal design in improving the quality of life?
- **Data Set:** Design Fraternity (310 people) and Public Opinion (125 people)
- **Keywords:** Universal Design; Mobility; Old core cities; Walkability; Central Kolkata; Architectural Planning

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**'The only disability is when people cannot see the human potential.'**

***– Debra Ruh***

# 2. UNDERSTANDING THE PERCEPTION OF USERS ABOUT UNIVERSAL MOBILITY IN OLD CORE INDIAN CITIES

This chapter aims to determine the status of accessibility in the core areas of an old Indian city by identifying factors for an ideal accessibility audit checklist. An accessibility audit checklist is an audit format to check the condition of spatial accessibility based on parameters (such as the presence of ramps) and their related indicators (such as slopes or material of the ramp). The objectives to strengthen the aim are the following: (1) to ascertain the need for a new dimension in the Indian accessibility scenario, (2) to assess people’s perspective towards universal mobility in core urban areas in India, and (3) to identify the issues in mobility in core urban areas in India. The underlying research question for this chapter was to find out whether core areas of urban India can be made inclusive in terms of accessibility. However, the research shall be limited to core urban areas in India, and the study shall be street-level. The hypothesis considered was that the core cities in the Indian context need to be made accessible through provisions in planning and design. The chapter shall only explore the factors that are required to constitute the parameters in an Accessibility Audit Checklist.

## 2.1. RESEARCH PROCESS

This chapter began with the literature study (explained later in detail in Section 2.2 of this chapter). At the same time, participatory audiences for the research were contacted. For substantiating Objective 1, the interaction was done with the design fraternity in India, and 310 people among those responded through questionnaires. For exploring Objective 2, 125 residents were interviewed from Kolkata Municipal Corporation (hereafter, KMC). KMC is the city of Kolkata's municipal authority, covering an area of 206.08 sq. km. with a population of over 4.5 million and a density of over 24,200 persons per sq. km. KMC’s history dates to 1726, during its formation by a royal charter from erstwhile British Government. As on May 2023, KMC has jurisdiction over 144 wards (the smallest administrative unit in the Indian urban administrative system). For achieving Objective 3, a stretch of nearly 850 m within the KMC limit was visually surveyed.

Summarizing fundamental theories and explanations of experts from the field of universal design and accessibility was the next step in this chapter. This section was further subdivided into three parts according to the genre of the documents referred to (a) universal design theory, (b) fundamental understanding of accessibility, and (c) universal mobility in urban areas. This part is further elaborated in **Section 2.2**.

After the aforementioned stage, the ‘choice of research’ was determined for generating research content through interviews, field studies, and field surveys. Additionally, content analysis was also done based on the research method. The method used for this research by was a ‘Critical Instance Case Study’. ‘Critical Instance Case Study’ methods studies are used to examine situations of unique interest or to challenge a universal or generalized belief. Such studies are not focused to create new generalizations. Rather, several situations or events may be examined to raise questions or challenge previously held assertions. The ‘case study’ type was suitable for this research because this chapter required a detailed analysis of a delineated zone in the core of old cities in India. The specificity of the study area made ‘case study’ method preferable for this research. Additionally, this chapter is aimed towards examining situations of universal Mobility and thus defies the generalized format of mobility planning existing in old core Indian cities. This chapter critically appraises various opinions and scenarios to criticize mobility conditions in old core Indian cities. Thus, the ‘Critical Instance’ sub-type of ‘Case Study Research’ deemed fit for this chapter. The following stage was the operationalization of the research.

The two components of operationalization were (a) measuring the data or creating measurable attributes for the data and (b) designing an appropriate questionnaire. The Likert scale approach and percentage of opinions for solving the first component (i.e., measuring the data or creating measurable attributes for the data) were adopted. Three types of variables are used in this research: (a) categorical,

(b) discrete, and (c) ranked. Categorical variables are used in research when the variables can be compartmentalized into certain categories/groups. In this chapter, categorical variables are used in the study of factors such as the type of disability and the type of infrastructure to be mapped. Discrete variables are used in cases of a limitation or specific value to the variables. In this research, discrete variables are used in factors such as the number of streets. Ranked variables are used when the available data set can be put in a sequence or order. In this chapter, ranked Variables are used in factors involving opinions such as people's opinion on the comfort level in walkability. For the second component (i.e., designing an appropriate questionnaire), the questionnaire from various published research with the feedback from respondents during a pilot survey were compared, before the actual questionnaire survey. This part is further explained in **Section 2.3** of this chapter. The sampling strategy was the next step in the research.

The sampling strategy for this research was determined by a feasibility study. Three types of surveys to assess the feasibility of the project were conducted. First, the 310 samples for taking the opinion of the design fraternity of India were linked to the number of participants who took part in the questionnaire survey provided at the end of certain digital interactions (explained further **in Section 2.3.1**). Second, the 125 samples for understanding people's opinions were collected from different wards on KMC, with most respondents from in and around the central core of Kolkata (explained further in **Section 2.3.2**). Third, the visual observation study was conducted at 850 meters long stretch in the core of Kolkata. This selected stretch in the core of Kolkata has mixed land use, historic origin, and heavy traffic movement (explained further in **Section 2.3.3**).

The collected data were observed and analysed with the aim of 'coding' or interpreting. This part is further explained in **Section 2.3** of this chapter. While interpreting the data, the focus was on identifying the factors affecting universal mobility in the core of old Indian cities.

The following step for this chapter addressed the major findings of the research through data manipulation. The following points in this section were considered: (a) co-relating the survey findings and (b) linking the objectives of the research to the data interpretation. This part is further explained in **Section 2.4** of this chapter.

The last part of the research process was finding out how this research could be fed into further research. This part is further explained in **Section 2.5** of this chapter. In this section, the reason for the gap between existing policies and the on-ground implementation of universal design guidelines in India was explained. Subsequently, the need for an ideal 'accessibility audit format' was also unfolded. Further, the role of 'The Laboratory of Architectural Planning, Hokkaido University' in the field of universal design and accessibility is also summarised briefly. Lastly, it was explained how this research was only the beginning towards addressing the entire issue of accessibility in the core of old Indian cities. Additionally, a methodology for the scope of further research based on the findings from this chapter was furnished.

**Figure 10** summarizes the process undertaken for this research. The column on the left of **Figure 10** shows the research stages and the column on the right explains the activity related to that research stage.

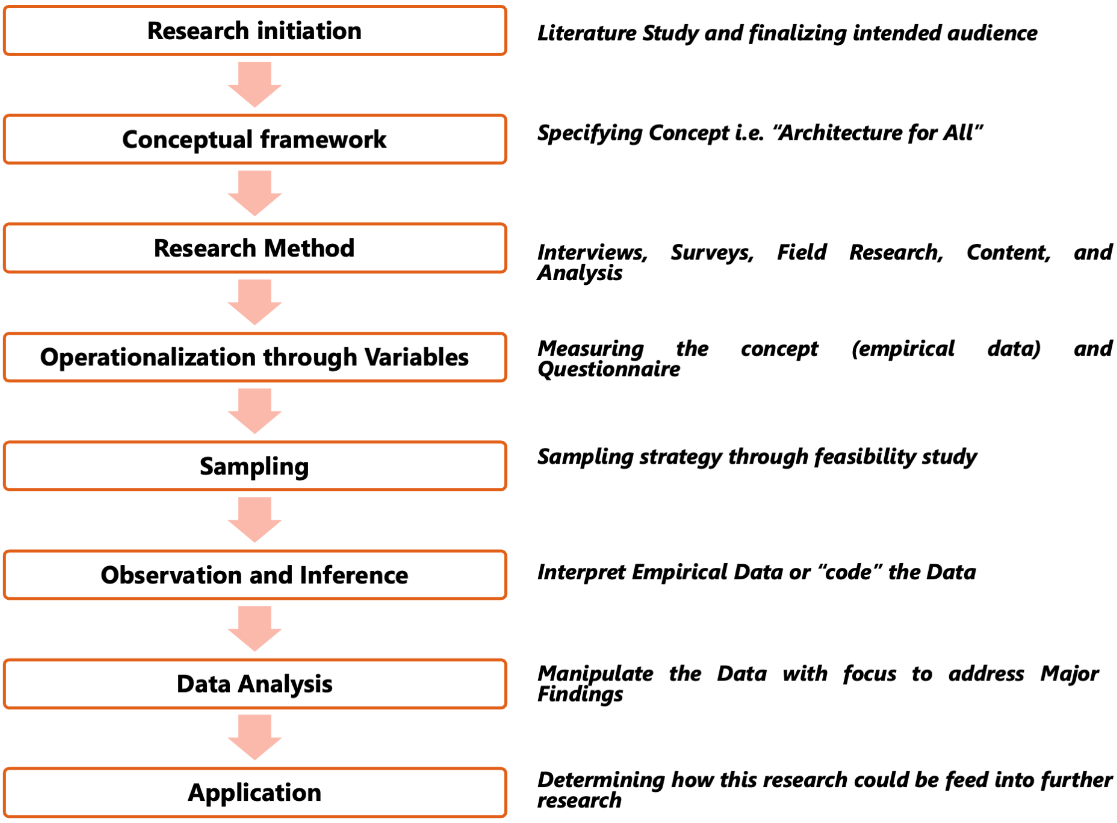



**Figure 10:** Research process followed for this chapter.

### 2.2. LITERATURE

Architect Ronald Mace, who coined the term 'universal design', defines universal design as the design of products and environments that are maximally usable by all people without needing any adaptation or specialized design.[130] The 'International Classification of Functioning, Disability and Health' of the W.H.O. explicates that disability is a phase, and it is not specific to any age or gender.[131] 'Inclusive design features' which focus on disabled-friendly provisions in products and designed space within the built environment, affect the independence of the elderly/specially-abled to a great extent. Additionally, 'exclusive' barrier-free mobility options at the city level (such as ramps and braille signage) improve the quality of life for the elderly/specially-abled. Conversely, hedonic adaptation (the tendency of people to return to a normal state after the occurrence of an extreme positive/negative event and age cohort effects (higher state of satisfaction due to the lower expectation) can undermine the need for such 'exclusive' inclusive features.[132] Thus, instead of focusing on specific facilities for specially-abled and elderly people, encouraging 'universal mobility' uplifts the inclusiveness of urban space.

#### 2.2.1. Universal Design Theory

Goldsmith (2000) establishes the need for a bottom-up route towards universal design and proposes a model called the 'Universal Design Pyramid'. Goldsmith's 'Universal Design Pyramid' indicates that universal design facilitates the able-bodied and specially-abled alike.[133] Universal design implementation on a national or regional scale depends on the pattern in which user-experience-based inputs are implemented into the planning legislation.[134] Likewise, universal design solutions are socially and financially rewarding since they devise spaces easier for everyone to use.[135] Based on inclusive civil engineering guidelines like IS 4963- Recommendations for Building and Facilities for the Physically Handicapped (1968), Guidelines and Space standards for Barrier Free Built Environment for Disabled and Elderly persons (1998), or IRC 103-Guidelines for Pedestrian Facilities (2012), designers in India often provide separate provisions for specially-abled people; without realizing that separate facilities promote societal inequality. Story (1998) clarifies that correctly implemented 'Universal Design' is often undetected since it integrates with the design process.[136] Being accessible to all user groups from the start of the design usability implies seamless implementation of universal design strategies.[137] Thus, developing a facility specifically for the elderly/specially-abled negates the very concept of universal design.

Furthermore, Steinfeld and Danford (1999) establish that despite the origin of universal design since the mid-1970s, universal design concepts still lack practical implementation due to a lack of adequate contextual theory.[138] Similarly, Steinfeld (1975) holds that the inclusion of empirical data gathered from human-centric research related to the spatial behaviour of specially-abled people is an ideal way to implement universal design solutions.[139] Thus, this chapter includes human behaviour and user experience as the base of research.

'Architectural Planning', as described by Professor Dr. Suguru Mori from Hokkaido University is a discipline for 'planning' architecture. It helps in conducting 'practical problem interest (research approaching reality)' rather than 'research problem interest (research for research)'. Architectural planning is probably the ideal pedagogy for research on universal design. In architectural planning, the three levels of design hierarchy are (a) site, (b) services, and (c) building. In universal design professional practice, the building level is better addressed by designers since the scale of the development is smaller in comparison to other factors. However, without inclusive sites and services, the individual buildings will be inaccessible to all; despite an individual building being universally designed.[140] Likewise, during the primary survey for this chapter, even respondents prioritized sites and services for implementing universal design considerations.

Concerning this, universal design considerations in an urban core with historic precincts are more challenging than in any other urban scenario.[141]

### 2.2.2. Fundamental understanding of accessibility

Ideological differences in the way different nations perceive universal design since universal design came into effect in 1985 (originating in the United States) and barrier-free architecture (originating from Machida City, Japan) has existed since 1974. Akiyama and Kim (2005) establish that, unlike the United States where universal design signifies disabled-friendly approaches, in countries such as Japan it is more holistic. Japan uses universal design principles as a mode to facilitate the entire population. Relatively new initiatives such as 'Transportation Accessibility Improvement Law, 2000' or old projects such as 'Welfare model cities for the disabled, 1973' reflect Japan's focus on using universal mobility as an infrastructural as well as a social tool in enabling the environment for all.[142] Along similar lines, physical structure of an urban area directly impacts the walkability scenario.[143]

However, in India, the situation is different from countries such as the United States or Japan. Likewise, Indian universal design principles were published in 2011, which proposed five principles: (a) *Saman* (equitable), (b) *Sahaj* (usable), (c) *Sanskritik* (cultural), (d) *Sasta* (Economic), and (e) *Sundar* (aesthetic). The 'Indian Principles' are different from the 'Seven Principles of Universal Design' (namely, equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort and size and space for approach and use) that were being followed in India until the inception of these principles.[144] Apart from political and administrative difficulties, a cultural stigma is also attached to universal design thinking in Indian mythologies. For example, disability in Indian Hindu philosophy has been associated with past sins, and disabled people are historically ignored in social/religious participation.[145] Thus, implementing universal design guidelines in India is substantially complex and requires an audit to assess the condition of inclusivity before imparting universal design. The aforementioned audit shall specify the degree of accessibility required in a site-specific manner.

In addition, a modified performance assessment by creating a research agenda and involving professionals from different fields is the ideal way to practice universal design.[146] India and many developing nations possess general inception that the user group facilitated by universal design is considerably lesser than the ones 'not facilitated' by its absence. However, the conditions that people experience while they are situationally disabled, such as a fracture, pregnancies, or carrying a child, are seldom considered by these nations in urban-level infrastructural design. Another stigma related to universal design is the myth that it increases the project cost. Nevertheless, considering the global changing demographic pattern and inclusive planning considerations, the cost incurred due to universal design is utilitarian.[147]

### 2.2.3. Universal Mobility in urban areas

Walkability conditions and transportation facilities are the two primary components of urban mobility. Nevertheless, poor infrastructure such as irregular footpath spaces and dissatisfactory pedestrian slope poses threat to the elderly/specially-abled bodied and abled-bodied alike. Additionally, any physical barriers to urban mobility are against the notion of the 'right to city or city for all'. [148] During this research, a similar phenomenon was observed in central Kolkata. The photographs of a stretch in central (core) Kolkata shown in **Figures 28-39** depict the dilapidated mobility conditions.

Along these lines, Frye (2014) argues that the global ageing population complemented by the falling birth rate is posing an infrastructural challenge to the increasing urban population. Frye's research identifies several factors that influence urban mobility: (a) over-crowding of vehicles/terminals, (b) uneven or broken road surfaces, (c) high kerb (curb)/deep storm drains, (d) inaccessible public transport vehicles, (e) cost/affordability of public transport, (f) attitude of drivers and other staff, and (g) lack of accessible information. Frye validated these factors by correlating age and disability.[149] The factors from Frye's research along with a number of contextual factors were used while conducting visual observation of the old core of Kolkata (elaborated in **Section 2.3.3**: Visual observation of an old city core). While transportation is widely researched, 'walkability' for a diverse user group is a relatively restrictive topic in academia to date.

Similarly, Mori (2001) proposes that for research involving a high human behaviour interface, the research methodology should involve the feedback of the end-user from the beginning of the research.[150] Mori (2002) further explains that walkability involves an intricate relationship with space structure and explains the need to include children, the elderly and disabled people in research involving walkability.[151] Factors affecting users' behaviour in urban street spaces induce a positive or negative effect depending on the genre of infrastructure and mobility condition of the user group.[152] APR methods by comparing and/or relating the rational parameters (such as zoning and space allocation) with qualitative factors (such as pedestrian behaviour), is an effective way to urban mobility-related issues in old core cities.[153] The space structures in old cities of developing nations such as India are complex due to their historic origin. These areas are characterised by high density, mixed land use, and a lack of space allocated to infrastructure.

Preiser (2008) argued that no comprehensive audit checklist for accessibility exists and proposed activities such as workshops and research group discussions for contextual accessibility assessments.[154] Inspired by Preiser's work, for this research, eleven digital interactive sessions were conducted across India to gain a contextual perspective on the topic. In addition to this, stakeholder specific approach in urban-level accessibility surveys involving specially-abled people and elderly people enhances the effectiveness of an accessibility survey. [155] Furthermore, interviews held in Kolkata helped to understand the user's perspective on mobility in old Indian cities.

The learning elaborated in Section 2.2.1 (universal design theory), Section 2.2.2 (fundamental understanding of disability), and Section 2.2.3 (universal mobility in urban area) are linked to the objectives, and the linkage is shown in **Figure 11**. Before starting the data collection and analysis, a knowledge base was created that helps to proceed further towards objectives and subsequently answer the research question.

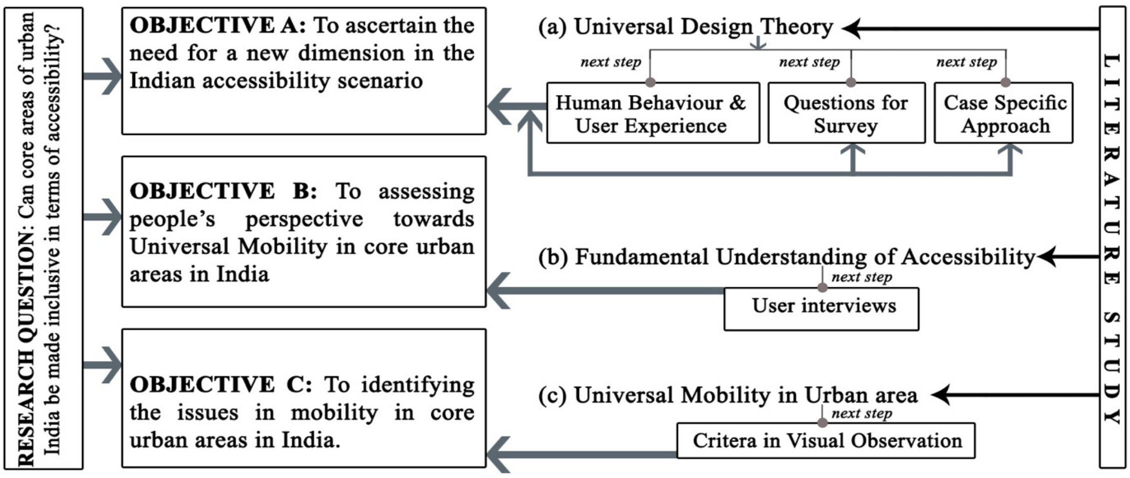



**Figure 11:** Linkage between research question and objectives with findings from the literature study.

## 2.3. SURVEY AND RESULTS

The details of the three surveys as described in **Section 2.1** are elaborated on in this section of the chapter. Each survey is explained in three basic parts: (a) survey process, (b) observation and analysis, and (c) findings and discussion.

### 2.3.1. Opinion of Design Fraternity in India

The design fraternity of a country, which includes architects, planners, designers, and civil engineers, is responsible for the task of nation-building in terms of infrastructure. Thus, the Indian design fraternity's opinion was essential for substantiating the aim of this research. 11 'virtual interactive platforms' were conducted through Zoom Video Communications, Inc. (hereafter, ZOOM) and Google Meet platforms in various parts of India for discussing the intent of this research with the design fraternity of India. The platforms included workshops, seminars, studios, Technical Education Quality Improvement Program (hereafter, TEQIP), and lectures. **Table 2** shows the details of the eleven virtual interactive sessions.

**Table 2:** List of interactive sessions in India between June and November 2020, substantiating the aim of the research.

| S. No. | Date (in 2020) | Type of Session | Title of Session | Location |
|---|---|---|---|---|
| **1** | 25-28 Jun | Summer Studio | Universal Design | SAKHA, Nagpur |
| **2** | 27-29 Jul | Workshop | Being Creatively Rational | School of Architecture and Interior Design, SRM Institute of Science and Technology, Kattankulathur |
| **3** | 07-09 Aug | Technical Education Quality Improvement Programme | Universal Design: Architecture for All | Department of Architecture, Madhav Institute of Technology and Science, Gwalior |
| **4** | 14 Aug | Webinar Series | Universal Design and Accessibility- A route towards Sustainability | Jawaharlal Nehru Architecture and Fine Arts University, Hyderabad |

| | | | | |
|---|---|---|---|---|
| **5** | 19-21 Aug | Workshop | An Architect's Approach towards Universal Design and Accessibility | School of Architecture, DY Patil University, Pune |
| **6** | 28 Aug | Semester Coursework Expert Lecture | Universal Design Approach | Akhil Bharatiya Maratha Sikshan Parishad's Anantarao Pawar College of Architecture, Pune |
| **7** | 05 Oct | Webinar | Universal Design | School of Architecture, Central University, Ajmer |
| **8** | 06 Oct | Guest Lecture | Being Creatively Rational | Rajalakshmi School of Architecture, Mevalurkuppam |
| **9** | 06-08 Oct | Semester Coursework Expert Lecture | Universal Design and Accessibility | Marathwada Mitramandal's Institute of Environment & Design's College of Architecture, Pune |
| **10** | 28-29 Oct | Workshop | Being Creatively Rational | School of Architecture, Delhi Technical Campus, Noida |

Architects, planners, designers, government officials, architecture students, and planning students, attended these virtual interactive platforms. Although there were eleven venues, the participants came from over sixty cities across India. The major content of the workshop included (a) an introduction to universal design and its salient features, (b) the international and national guidelines on universal design, (c) anthropometrics and ergonomics in universal design, (d) the application of universal design in different building types and streetscape, and (e) accessibility audit. Laboratory of Architectural Planning, Hokkaido University was the primary mentor for the sessions, occasionally complemented by other experts from the field of accessibility and spatial design. The major findings from this workshop included (a) consciousness about the dissimilarity between universal design, barrier-free standards, and inclusive design, (b) facilitating participants towards using the 'Universal Design' principles in architectural design and urban planning, and (c) realizing that in architecture and planning, universal design is not a choice, but a prerequisite. Interactive exercises and idea exchange sessions were included in the lecture sessions. At the end of each session, the participants acquired ideas about applying universal design in architectural design/planning. The participants also received the basic idea of accessibility audit as a predecessor for architectural design. **Figures 12 and 13** show a few glimpses of the virtual interactive platforms.


**Figure 12:** Screenshot of the session on day 2 from the Summer Studio by Studio Sakha, Nagpur, India from 25–28 June 2020 (Representative, Laboratory of Architectural Planning: Top left) [Source: Studio Sakha, Nagpur, India].

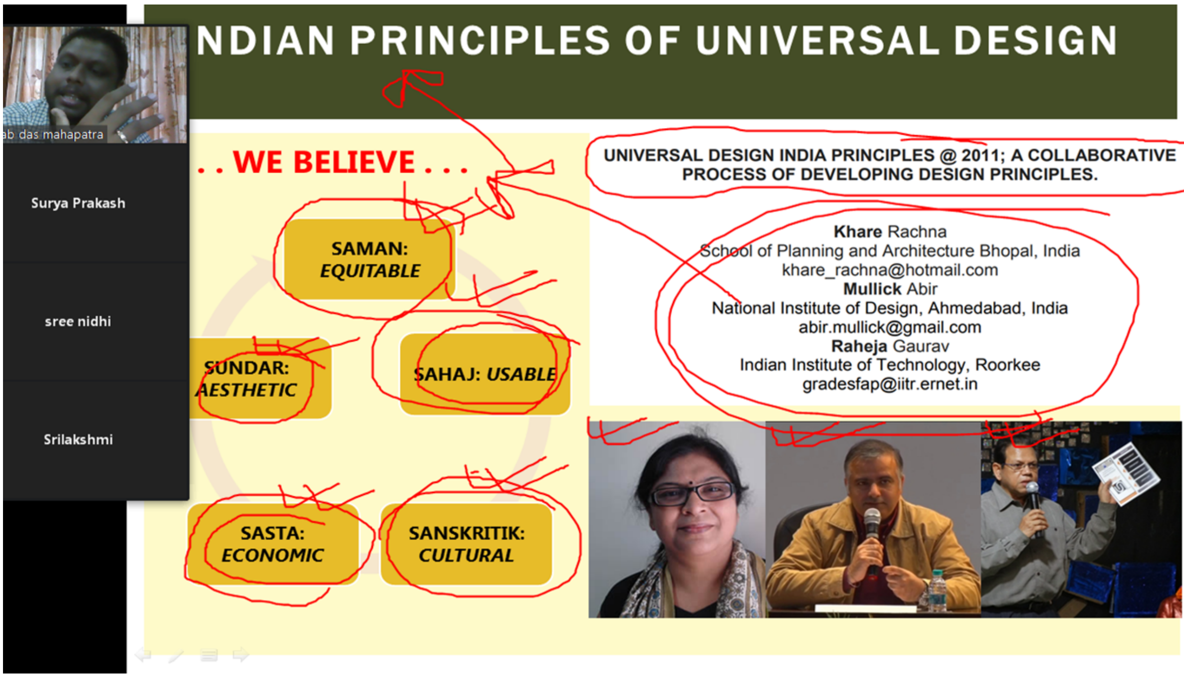



**Figure 13:** Screenshot from the workshop by Rajalakshmi School of Architecture, Mevalurkuppam, India on 6 October 2020 (Representative, Laboratory of Architectural Planning: Top left) [Source: Rajalakshmi School of Architecture, Mevalurkuppam, India].

- *Observation and Analysis*

To further analyse the aforementioned points related to workshop learning, a 'Google Form' questionnaire https://forms.gle/o6wbzbYnDrWdPFVA7 (accessed on 9 March 2023 and available in **Annexure A**) was created for the participants at the end of each session. The questionnaire inquired about certain aspects of universal design: (a) the position of universal design in the design domain, (b) the prioritization of sites and services in universal design, (c) rating national policies, (d) the level of difficulty in a universal design scenario in old cities (e) the position of 'Transportation' and 'Accessible Information' in the universal design domain, (f) the difference in the universal design scenario between old and new cities, and (g) the need for a 'Rating System'. 14 questions ranging from multiple choice questions, dichotomous questions, and Likert scale typology, were used in the questionnaire. The total number of respondents in this Google Form questionnaire was 310. [N.B.: The consolidated data collected during this part of the survey is furnished in **Annexure B**.].

79% of the respondents prioritized universal design, not barrier-free architecture, or inclusive design, in the field of architecture and planning [Refer to **Figure 14**].

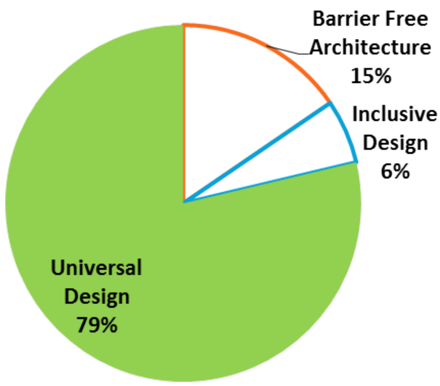
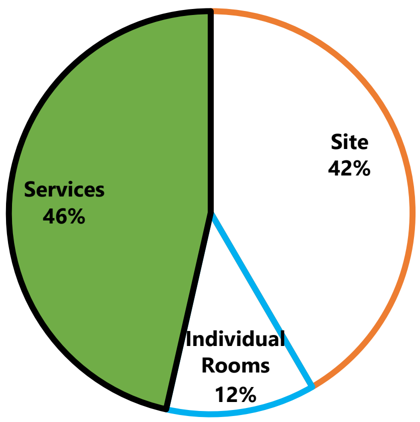
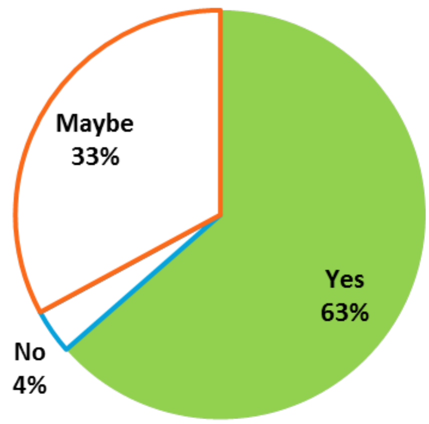



**Figure 14:** Most significant aspects in architecture and planning.

The respondents' priority in universal design in the Indian context was services (prioritized by 46%), followed by the site (prioritized by 42%) [Refer to **Figure 15**]. A significant number (63%) of respondents advocated for different universal design guidelines/principles/audit formats, in old and new cities [Refer to **Figure 16**].




*(From left)*

**Figure 15:** Preferred first rank of importance for the components in universal design in the Indian context: (a) site, (b) individual rooms (individual interior spaces), and (c) services.

**Figure 16:** Is there a need of different universal design guidelines/principles/audit formats for old cities and new cities in India?

Most of the respondents stated that accessibility and universal design scenarios in old core cities of India are difficult to impart [Refer to **Figure 17**]. Other than 8.07% of the respondents, all others specified a difficulty level of 5 or more on a Likert scale of 1–10 (where '1' is the least difficult and '10' is the most difficult).

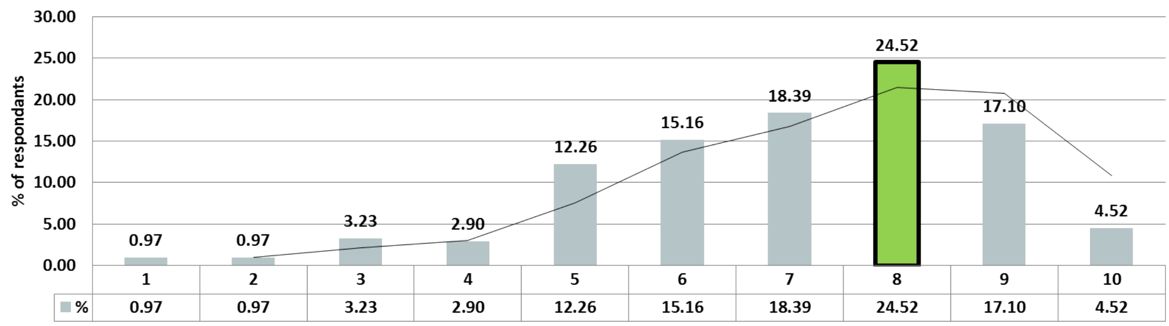



**Figure 17:** How difficult is it to impart the accessibility and universal design scenario in old core cities of India? (1—least difficult; 10—most difficult).

Most of the respondents also affirmed the 'Accessible India Campaign' as of satisfactory status [Refer to **Figure 18**]. A total of 7.42% of respondents scored less than five on a Likert scale of one to ten (where one is least marked and ten is highest).

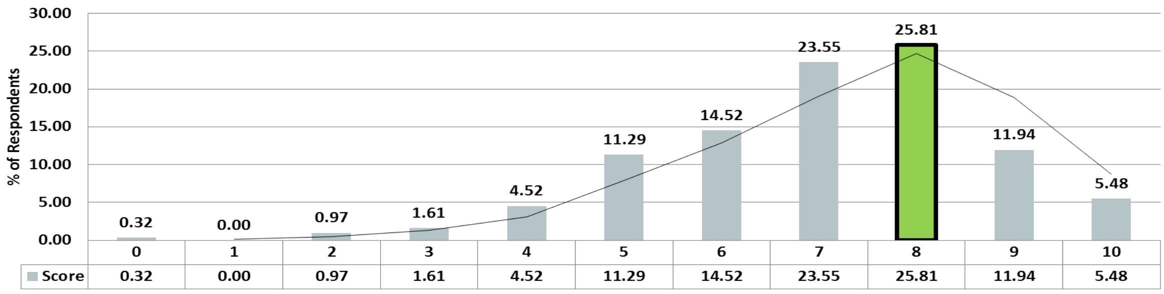



**Figure 18:** How much do you rate the 'Accessible India Campaign' in terms of universal design and accessibility (0—least; 10—highest)?

Out of the three components of the 'Accessible India Campaign', (i.e., built environment accessibility, transportation system accessibility, and information and communication eco-system accessibility), the respondents prioritized transportation system accessibility. Thus, transportation requires accessible and universal design features more than other segments of urban life. During this survey, 97.10% of the respondents also stated that like 'Green Rating' (like LEED of USA, GRIHA of India, or CASBEE of Japan) in sustainable architecture, a customized rating system for universal design is required as well.

- ***Findings and Discussion***

The pan-India data collected from the survey through Google Form questionnaire explicated certain aspects of universal design in the Indian context. The involvement of the Indian design fraternity made the study more fruitful since these are the people who spread awareness of universal design. **Table 3** shows a summary of the findings from this exercise.

**Table 3:** Learning from the interactive sessions in India between June and November 2020 substantiating the aim of the chapter.

| S. No. | Topic | Learning |
|---|---|---|
| 1 | Importance of universal design in architecture and planning | Unlike a few decades back, barrier-free architecture and inclusive design are relatively outdated. The present need for India is universal design. |
| 2 | Prioritization of site level and services in universal design | Universal Design is necessary, and within it, 'SITE and SERVICES' should be the priority. However, the focus of all existing Indian guidelines is 'Building Specific' or rather, towards individual enclosed spaces. |
| 3 | Differences in an accessibility scenario between old core cities and new planned cities in India | In India, new cities and old cities need different universal design guidelines, calling for constructive criticism of the latest national policies. |
| 4 | Level of difficulty in old core cities in India | Different universal design guidelines are required for old and new cities due to their differences in spatial evolution/temporal growth, institutional mechanisms, infrastructural patterns, and demographic reasons. |
| 5 | Impact of present national campaigns towards inclusive planning | Although national policies are satisfactory, initiating a case-specific approach or a flexible assessment pattern is ideal. |
| 6 | Position of 'Transportation and Accessible Information' in universal design | Pan-India, accessible transportation is an issue. Instead of focusing on building or technology-oriented accessibility, the government should focus on making the transportation system accessible. In |

| | | |
|---|---|---|
| | | infrastructural terms, accessible streets and accessible mobility is needed. |
| 7 | Need for customized rating system in universal design | A new 'Rating/Indexing' system in universal design creates the universal design scenario more quantitative in analytical terms. Thus, the scope for intervention in infrastructural terms based on the data derived from rating systems to be used for promoting inclusiveness. |

Each of the findings as tabulated in **Table 3** shall form the basis of further investigation for the respective focus areas.

### 2.3.2. People's Perception in an Old City Regarding Walkability and Mobility

After gathering the Indian design fraternity's opinion, people's perception of walkability and mobility, involving people from Kolkata was surveyed. Kolkata, besides being a British colonial city, is also nearly 350 years old.[156]

Thus, Kolkata serves as an ideal case for studying people's perception of mobility in an old Indian city. Due to the coronavirus pandemic, India experienced a nationwide lockdown (complete and partial) from 22 March 2020 until 30 November 2020; this meant restrictive movement for the fieldwork. Thus, the samples/ dataset were collected over a period of five months from 17 July 2020 until 2 November 2020, via online mode besides face-to-face mode.

This survey recognized (a) the frequency and purpose of out- door mobility, (b) people's perception of a public transportation system, (c) the status of walkability, and (d) awareness of national campaigns.

- *Data Analysis*

Considering the aforementioned intentions, a Google Form questionnaire https://forms.gle/MaVzxymog8JMieCy9 (accessed on 9 March 2023 and available in **Annexure C**) was prepared. Like the previous Google Form in the case of 'Opinion of Design Fraternity in India', the questions in this survey also ranged from Multiple Choice Questions, Dichotomous Questions, and Likert Scale based. The total number of respondents for this survey was 125, which were acquired from 40 wards within KMC limits.

Mr. Deoraj Pande (resident of Ward 44, aged 74) who goes out for his house daily work despite his severe arthritis prefers using private transport for commuting. Mr. Barid Baran Mahaty (resident of Ward 48, aged 58), a 'Person with Disability' (PwD) card-holder, prefers using local trains over any other means of public transport. Mrs. Kanaklata Chakraborty (resident of Ward 50, aged 76), another PwD cardholder, expressed her grief regarding the difficulty in identifying the address which becomes aggravated due to her partial blindness. Mrs. Dugarani Chaudhury (resident of Ward 45, aged 96) has been under restricted movement for the last two decades and avoids public transport in case of occasional outings. Mr. Prasanta Das (resident of Ward 48, aged 61), who received a PwD card after becoming mobility impaired, indicated the dilapidated condition of the streets. Difficulty in the waiting facility in public transportation has been identified as an alarming situation by Mrs. Manisha Roy (resident of Ward 43, aged 72), Mr. Ram Adhikari (resident of Ward 49; aged 67), and many other respondents.

After taking such opinions from respondents, the Google Form was filled out by the surveyors on behalf of the respondents, in their presence. For better communication with locals, the surveyors involved one local architecture student and a retired municipal worker from Kolkata in their survey. Respondents became more vocal about their issues and problems when communicated in the local language by local people than during formal Google-form-based interviews. A bilingual survey format was also used for communicating with locals and their comments were noted in the local language

'Bengali' [shown in **Figure 19**], which was later translated into English, at the 'Laboratory of Architectural Planning' at Hokkaido University.

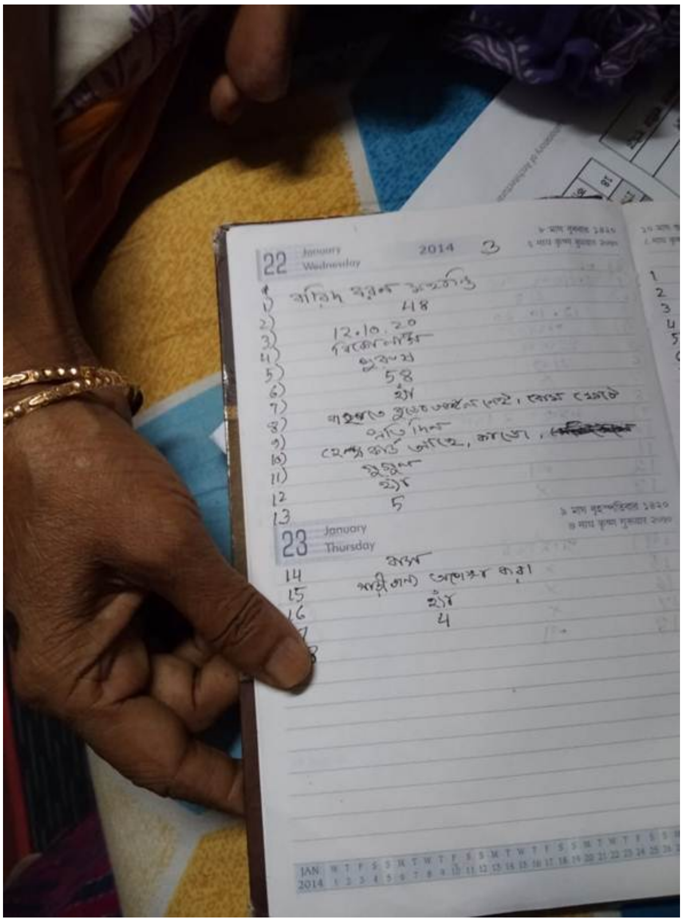



**Figure 19:** Notes were taken in Bengali and later translated into English.

The last survey titled 'Opinion of Design Fraternity in India' indicated universal design as the need of the Indian design scenario. Universal design encompasses the need for a diverse group. Thus, despite focusing on elderly and specially-abled people, samples were collected from all categories.

Out of the 125 respondents, 48% of the respondents were male, 50.40% were female, and one respondent was third gender. However, in terms of age groups, the focus was on the senior citizen [Refer to **Figure 20**]. A total of 33.60% of the respondents were of the age group of sixty years or above, 28.80% from the age group between twenty and thirty-five years, 20.80% from the age group between fifty and sixty years, 16% from the age group between thirty-five and fifty years, and 0.80% from the age group of ten years or below ten years.

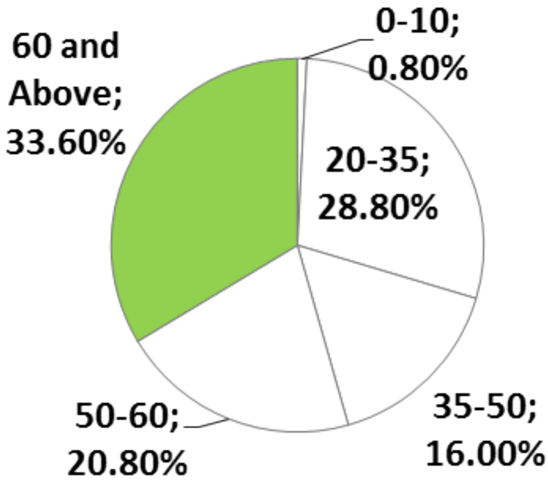



**Figure 20:** Composition of the respondents in terms of age.

Out of the 125 respondents, 83.20% were able-bodied and 16.80% were specially-abled. Out of the 16.80% specially-abled people, only 3.2% of them possessed a 'Person with Disability card'. 'Person with Disability card' that is also known as PH/disability/handicap certificate, and this certificate is issued by a competent medical authority (in India) specifying the type and extent/severity of the cardholder's identity. As of May 2023, the 'Person with Disability card' is being replaced by UDID (Unique Disability Identity) to create a national database for persons with disabilities. 3.2% of the surveyed respondents were 'medically' recognized as 'disabled' or specially-abled, which was above the national percentage of 2.21%.

The types of medical issues that the respondents were facing are (a) low vision, (b) locomotor disability, (c) arthritis, (d) asthma, and (e) terminal illness (cancer). **Table 4** elaborates on the type of disability and recognition status as per the 'Right to Persons with Disabilities Act, 2016'.

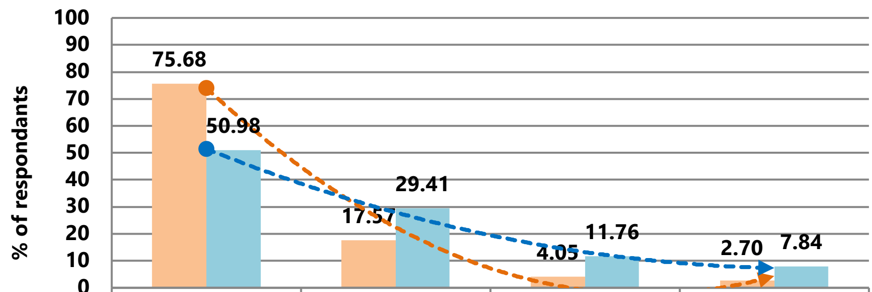
**Table 4:** Types of respondents' disabilities.

| S. No. | Type of Disability | Recognized by 'Right to Persons with Disabilities Act, 2016' | Number of Respondents | Percentage of Respondents |
|---|---|---|---|---|
| 1 | Low Vision | Yes | 6 | 28.57 |
| 2 | Locomotor Disability | Yes | 11 | 52.38 |
| 3 | Arthritis | No | 2 | 9.52 |
| 4 | Asthma | No | 1 | 4.76 |
| 5 | Cancer | No | 1 | 4.76 |

Hereafter, 'senior citizens and specially-abled people' are paired in a single group and compared with 'able-bodied people under the age of sixty'. The 'able-bodied people under the age of sixty' are referred to as 'Category A' and 'senior citizen and specially-abled people' are referred to as 'Category B'. The total number of 'able-bodied people under the age of sixty' was 74, which was 59.2% of the total respondents. The total number of 'senior citizens and specially-abled people' was 51, which was 40.8% of the respondents. For the rest of the discussion about 'People's Perception in an old city about walkability and mobility', the 'Able-bodied people under the age of sixty' and 'senior citizens and specially-abled people' are referred to as 'Category A' and 'Category B' respectively. The various segments of the questionnaire are discussed hereafter:

[N.B.: The consolidated data collected during this part of the survey is furnished in **Annexure D**.]

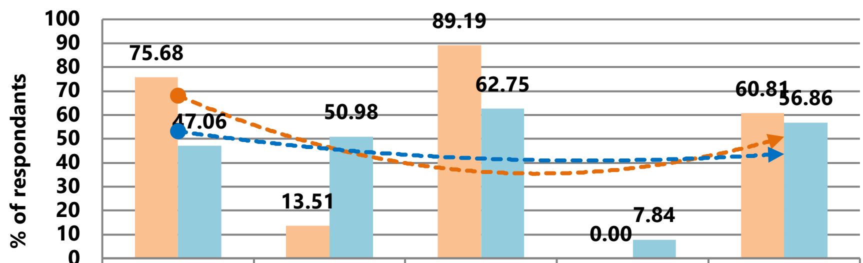
First, the respondents were asked about the frequency of going out of their houses. Only 50.98% of 'Category B' ventured out of their houses daily, in comparison to 75.68% of 'Category A'. Likewise, the 'weekly', 'monthly', and 'yearly' rate of going out was more in 'Category B' as compared to 'Category A'. **Figure 21** shows the options selected by both 'Category A' and 'Category B' regarding their frequency of going out of their respective houses.




| | Daily | Few times in a Week | Few times in a month | Rarely (few times in a year) |
|---|---|---|---|---|
| Category A: Able Bodied (<60 years) % | 75.68 | 17.57 | 4.05 | 2.70 |
| Category B: Senior Citizen and/ or Specially-abled % | 50.98 | 29.41 | 11.76 | 7.84 |

**Figure 21:** Frequency pattern of going out of respective houses among different user groups.

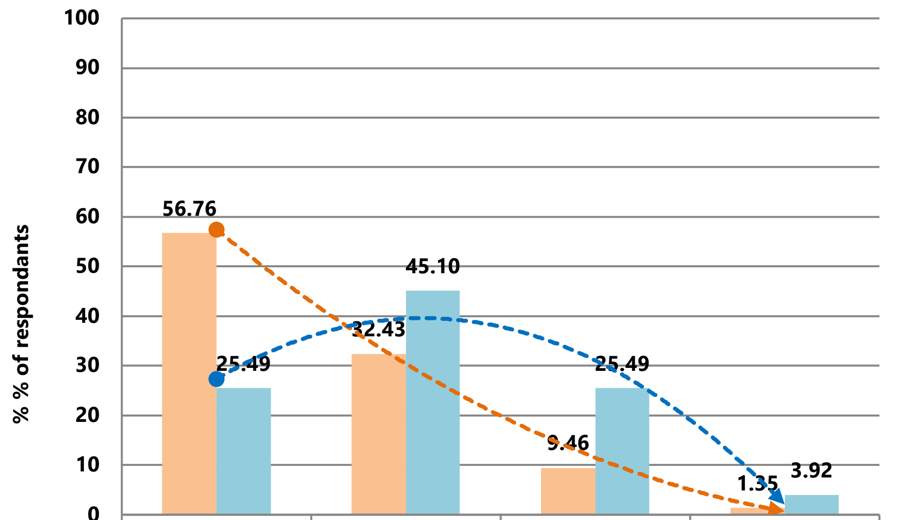
After determining their frequency pattern of going out of their house, the respondents were questioned about their purpose of going out. The options provided were (a) professional/academic, (b) medical reasons, (c) social gathering, (d) availing government benefits (such as health care), and (e) daily household work. The respondents could choose all the applicable options. **Figure 22** shows the options selected by both 'Category A' and 'Category B' concerning their purpose of going out of their respective houses. Both 'Category A' (89.19% of them) and 'Category B' (62.75% of them) set forward 'social gathering' as the most common reason for going out of the house. Respondents from 'Category A' showed a higher share (75.68%) compared to 'Category B' (47.06%), in going out of the house for professional or academic purposes. 'Category B' showed a higher share (50.98%) compared to 'Category A' (13.51%) in medical-related outings. No respondent from 'Category A' went out of the house for availing of Government benefits (such as health cards). A remarkable 56.86% of 'Category B' went out of the house for daily household work, in comparison to 60.81% of 'Category A'.




| | Profession/ Education | Medical Reasons | Social Gathering | Avail Government Benefits (like health card, etc) | Daily Household work |
|---|---|---|---|---|---|
| Category A: Able Bodied (<60 years) % | 75.68 | 13.51 | 89.19 | 0.00 | 60.81 |
| Category B: Senior Citizen and/ or Specially-abled % | 47.06 | 50.98 | 62.75 | 7.84 | 56.86 |

**Figure 22:** Purpose of going out of the house among different user groups.

Next, the street-level cognition was discussed with the respondents. The question was how the respondents usually search/identify an address. The options provided were (a) using online services such as Google maps, (b) asking people on the streets, (c) identifying landmarks (such as the nearest junction or, an old tree or, a famous temple), and (d) referring to street signage. Although people in urban areas frequently use all the aforesaid options, respondents were asked to point out their most preferred option. **Figure 23** shows the options selected by both 'Category A' and 'Category B' concerning their preferred options while searching/identifying an address. Most respondents from 'Category A' (56.76%) preferred 'online services to identify/search for an address. In response, most respondents from 'Category B' (45.10%) choose 'asking people on the streets'. Respondents from both categories showed noticeably less dependence on referring street signage, with 1.35% of respondents from Category A and 3.92% of respondents from Category B. More respondents from 'Category B' (25.49%) preferred 'Identifying landmark (such as the nearest junction or, old tree or, famous temple)' as their means to identify an address, in comparison to only 9.46% of respondents from 'Category A'.




| | Using online services like Google maps, etc | Asking people on the street | Identifying landmark (like nearest junction, old tree, famous temple, etc.) | Referring Street Signage |
|---|---|---|---|---|
| Category A: Able Bodied (<60 years) % | 56.76 | 32.43 | 9.46 | 1.35 |
| Category B: Senior Citizen and/ or Specially-abled % | 25.49 | 45.10 | 25.49 | 3.92 |

**Figure 23:** Preference in the identification of an address.

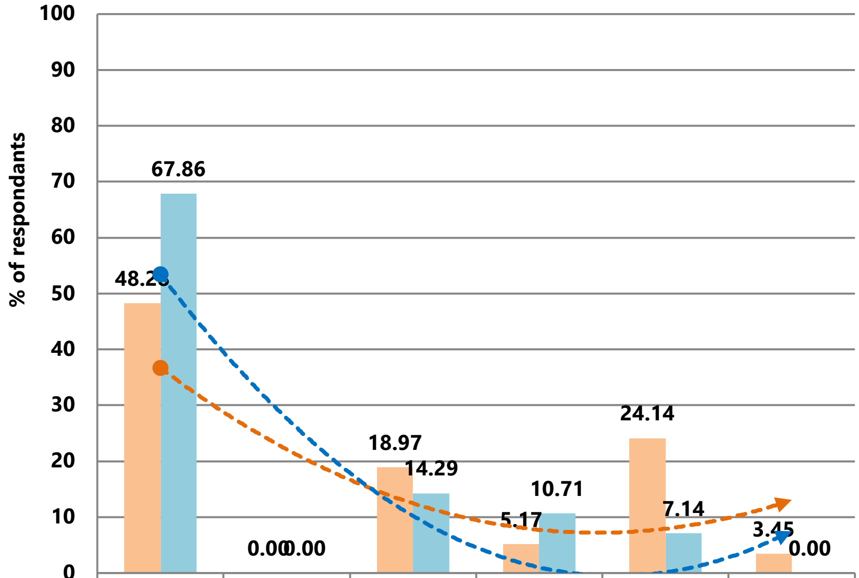
The perception of people in public transportation was the next topic of investigation. For this purpose, respondents from both 'Category A' and 'Category B' were primarily asked if they use public transport. If the respondents did not use public transport daily, frequent, or periodic usage was also taken into consideration for data input. A total of 54.90% of the respondents from 'Category B' used public transport, in contrast to 78.38% of respondents from 'Category A'. The respondents from both categories who do not use public transport are either having their mode of transport (such as a four-wheeler or two-wheeler), or having designated vehicle from their place of work, or are dependent on rental cab services, for example, Uber, Ola, and Rapido.

Thus, for further study on the topic of public transportation, the only 78.38% from 'Category A', i.e., 58 respondents, and 54.90% from 'Category B', i.e., 28 respondents were considered.

The respondents were asked about their comfort level in using public transportation. A Likert scale approach was undertaken for this purpose and respondents rated their comfort level on a scale of one to ten. Score one signified the lowest comfort and score ten signified the most comfort. The weighted mean score was 5.39 for 'Category B' in comparison to 6.17 for 'Category A'.

The next question was about modal preference. The respondents were asked to specify which mode of public transport in their city the respondents often used. The options provided were (a) bus,

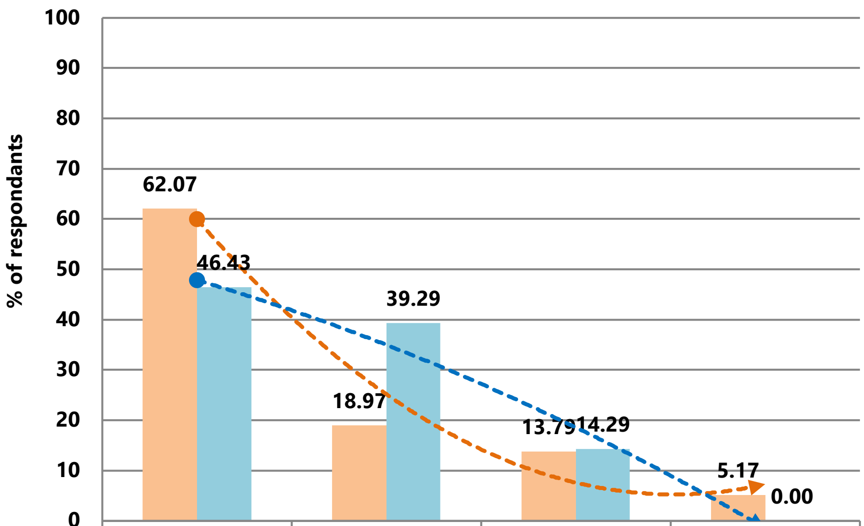
(b) tram, (c) metro rail, (d) local train, (e) auto rickshaw, and (f) cycle/hand-pulled rickshaw. Kolkata having a multiplicity of transport modes and a well-connected transportation network encourages its residents for using multiple modes in a single origin-destination route. However, the respondents were asked to state the mode which they used most. **Figure 24** shows the options selected by both 'Category A' and 'Category B' concerning their most preferred public transportation mode. Respondents from both 'Category A' (48.28% of respondents) and 'Category B' (67.86% of respondents) prioritized Bus as their most preferred mode of public transportation. Tramway, often referred to as the heritage of Kolkata, was not given any preference by either category of respondents. Preference for Metro Rail was comparatively similar in 'Category A' with 18.97% of the respondents and 'Category B' with 14.29%. However, 10.71% of respondents from 'Category B' preferred local trains, in comparison to only 5.17% of respondents from 'Category A'. A total of 24.14% of respondents from 'Category A' and 7.14% of respondents from 'Category B' preferred auto-rickshaws, respectively. Although 3.45% of respondents from 'Category A' choose Cycle/Hand-pulled rickshaw as their preferred mode of public transport, none of the respondents from 'Category B' opted for this.




| | Bus | Tram | Metro Rail | Local Train | Auto Rickshaw | Cycle/ Hand Pulled Rickshaw |
|---|---|---|---|---|---|---|
| Category A: Able Bodied (<60 years) % | 48.28 | 0.00 | 18.97 | 5.17 | 24.14 | 3.45 |
| Category B: Senior Citizen and/ or Specially-abled % | 67.86 | 0.00 | 14.29 | 10.71 | 7.14 | 0.00 |

**Figure 24:** Preference in the usage of transportation mode.

The last question in the category of public transportation was identifying the problem in accessing public transportation, by individual respondents. For this question, the respondents were asked to choose any one option from the following, as their major problem in accessing public transportation: (a) difficulty in the waiting facility (a poorly designed bus stop or, improper visual notification), (b) reaching public transport from home, (c) any other (such as congestion or, misbehaviour by co-passengers), and (d) fare. **Figure 25** shows the options selected by both 'Category A' and 'Category B' concerning their major problem in accessing public transport. Most respondents from both 'Category A' (62.07%) and 'Category B' (46.43%), stated 'Difficulty in the waiting facility (such as a poorly designed bus stop or, improper visual notification),' as their major problem in accessing public transport. The second preference for respondents from both categories (Category A: 18.97%; Category B: 39.29%) was the issue of 'reaching the public transportation from individual homes'. Relatively similar share both the categories, 13.79% of respondents from Category A and 14.29% from Category B selected 'Any other (such as congestion or, misbehaviour by co-passengers)'. Although 5.17% of the respondents from Category A highlighted 'Fare' as their reluctance towards accessing public transport, no respondents from Category B choose this option.




| | Difficulty in waiting facility (like: bus stop, improper visual notification, etc) | Reaching the Public Transport from home | Any other (like: Congestion, Improper Crowd, etc.) | Fare |
|---|---|---|---|---|
| Category A: Able Bodied (<60 years) % | 62.07 | 18.97 | 13.79 | 5.17 |
| Category B: Senior Citizen and/ or Specially-abled % | 46.43 | 39.29 | 14.29 | 0.00 |

**Figure 25:** Difficulty in accessing public transportation.

After acquiring ideas about public transportation, the next investigation was about 'walkability' from all 125 respondents (74 from Category A and 51 from Category B). Only 74.51% of the respondents from Category B walk/access the streets, in comparison to 93.24% of able-bodied people. The people who do not walk are the ones with a constant source of a private vehicle, experiencing medical issues, or are dependent on others for their transportation. For the next question, the respondents considered were only 93.24% from 'Category A', i.e., 69 respondents, and 74.51% from 'Category B', i.e., 38 respondents.

The next inquiry in the walkability segment was related to the respondents' comfort level during walking on the streets. Using a Likert scale approach, the respondents rated their walkability experience on a scale of one to ten. Score one signifies the lowest comfort and score ten signifies the most comfort. The weighted mean score was 4.92 for 'Category B' and 5.0 for 'Category A'.

All the 125 respondents were asked about their awareness of the existing national policies/initiatives related to accessibility and universal design, the latest of which being the 'Accessible India Campaign' or 'Sugamya Bharat Abhiyan'. A total of 92.16% of the respondents from Category B were not aware of the 'Accessible India Campaign', in comparison to 85.14% of able-bodied people.

- ***Findings and Discussion***

The data collected by interviewing 125 people from forty wards of KMC helped in assessing people's perspectives in the domain of universal mobility. The term 'Universal Mobility' was not used during the interview; however, the questions were posed in a strategic pattern for assessing the scope of universal mobility. The four sets of inquiries discussed in **Section 2.3.2** portray an overall negative picture in the mobility domain. **Table 5** shows a summary of findings from the responses recorded during this survey.

**Table 5:** Learning from the interview sessions in Kolkata, India between July, and November 2020 for substantiating the aim of the research.

| S. No. | Topic | Learning |
|---|---|---|
| **1** | Frequency and purpose of going out | • Health-related issues outside the preview of 'registered' disabilities need recognition for availing health benefits. In any case, people with disabilities/senior citizen venture out daily. The rates of going out daily in able-bodied are more than those of their counterparts.<br>• Senior citizens/specially-abled people encounter a higher rate of social gatherings than other purposes, hinting towards a need of promoting 'sociable streets and public environment' which is in coherence with the United Nations Sustainable Development Goals.<br>• Since old cities usually contain all the types of building use (as per occupancy), mobility corridors require equal or equivalent importance. |
| **2** | Searching/ identification of an address | • The affinity of senior citizens/specially-abled people to rely on 'asking people on the streets', is hinting towards the need for inclusive streets which not only enable but empower them as well.<br>• The need for improving street signage (visual and auditory).<br>• The domain of 'online search' in terms of Google Maps can be improved by adding an 'accessibility' layer prepared by architectural planning only.<br>• Despite being developed on the British planning principle, the lack of 'landmarks'<br>• shows the complexity in the urbanscapes, which can be addressed by introducing street elements as new icons of the urbanscape. |
| **3** | Walkability | • Dissatisfaction with the use of public transport is due to (1) poor provision from state/central governments in the field of urban transportation and/or (2) better services from private players, for example, Uber, Ola, and Rapido.<br>• The major transport mode is 'Bus' and multiple locations are present for the bus to halt briefly. However, 'bus stop' or 'bus shelter' was scantily present. Clearly, the survey explains the need for prioritizing bus-related accessible infrastructure before developing any other modes.<br>• The proposal for developing 'Urban Accessibility Facility' can be prioritized in the topic of improving the 'waiting facility' for bus.<br>• The target for architects and planners should be facilitating the waiting time and emergency requirements especially for elderly and specially-abled.<br>• The reason for the underutilization of Para-transits can be dealt with in a separate survey. |
| **4** | Awareness about National Schemes | • A large percentage of walkability despite dissatisfactory pedestrian facilities proves that in developing countries, infrastructure is less considerable than daily need.<br>• When people commute despite poor infrastructure, the marginalized users are compromised.<br>• Relating to the fact that people are unaware of national policies and unknown about the scopes of better design, the motto of this research is 'To create a market for the design, rather than designing for the market'. |

### 2.3.3. Visual Observation of an Old City Core

Taking indications from the survey involving 125 people from Kolkata, a stretch located within the core of Kolkata was selected for further investigation. The focus of this exercise was assessing the universal mobility conditions in the old core of Indian cities. A visual survey for the selected stretch was conducted in the month of September and November 2020. The selected stretch is a part of Bipin Behari Ganguly Street (Google Map link: https://goo.gl/maps/ph8wWJWiCzY1TgEH8 (accessed on 1 March 2021). In the Master Plan of Kolkata, the land use for this area is demarcated as 'Mixed Use'.[157] It is to be noted that mixed land use refers to the co-existence of more than one land use on a single stretch: for example, residential and industrial buildings in a single street. Mixed-use also refers to the presence of multiple 'single buildings' with different building use on different floors. The selected stretch is observed in multiple old cartographic pieces of evidence of Kolkata since 1785 CE, as shown in **Figure 26**.

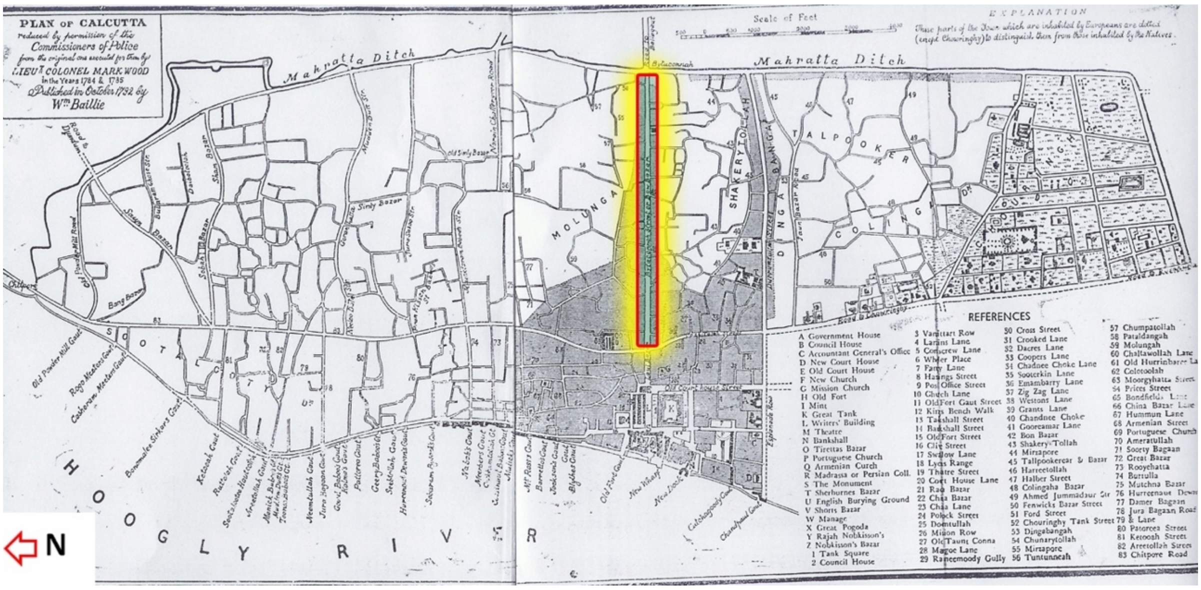



**Figure 26:** Map of Kolkata (Calcutta) by Lt. Col. Mark Wood in 1785; the study stretch selected for the visual survey is demarcated is highlighted [Source: Harvard Library Online].

- *Visual Survey*

A part of the 300-year-old stretch (shown in **Figure 27**) was selected for the visual survey. This stretch has undergone minimum temporal change due to its historic nature. The stretch is further shown in Figure 18, where 'A' and 'B' are starting and ending points of the study stretch, respectively. Point A is Bowbazar Crossing, and Point B is Bentinck Street Crossing.

In the policy document for the 'Accessible India Campaign', the component of 'Transportation System Accessibility' has the objectives of enhancing proportions of (a) accessible airports, (b) railway stations, and (c) public transport. The part of Kolkata, which is being proposed for the Research, does not include an airport, however, one Railway Station and multiple Underground Metro Rail Stations are present. Further, multiple modes of other transport are available here, including (a) tramways, (b) buses, (c) auto, (d) hand-pulled rickshaws, and (e) taxis/cabs. In the city land-use master plan, this area of Kolkata is demarcated as a mixed land-use zone. The stretch predominantly consists of buildings with multiple uses, mostly residential buildings clubbed with business/commercial establishments. However, buildings with institutional, educational, assembly, mercantile, and storage uses were also present. Moreover, a substantial number of buildings in this stretch were heritage buildings [refer to **Figure 28**].

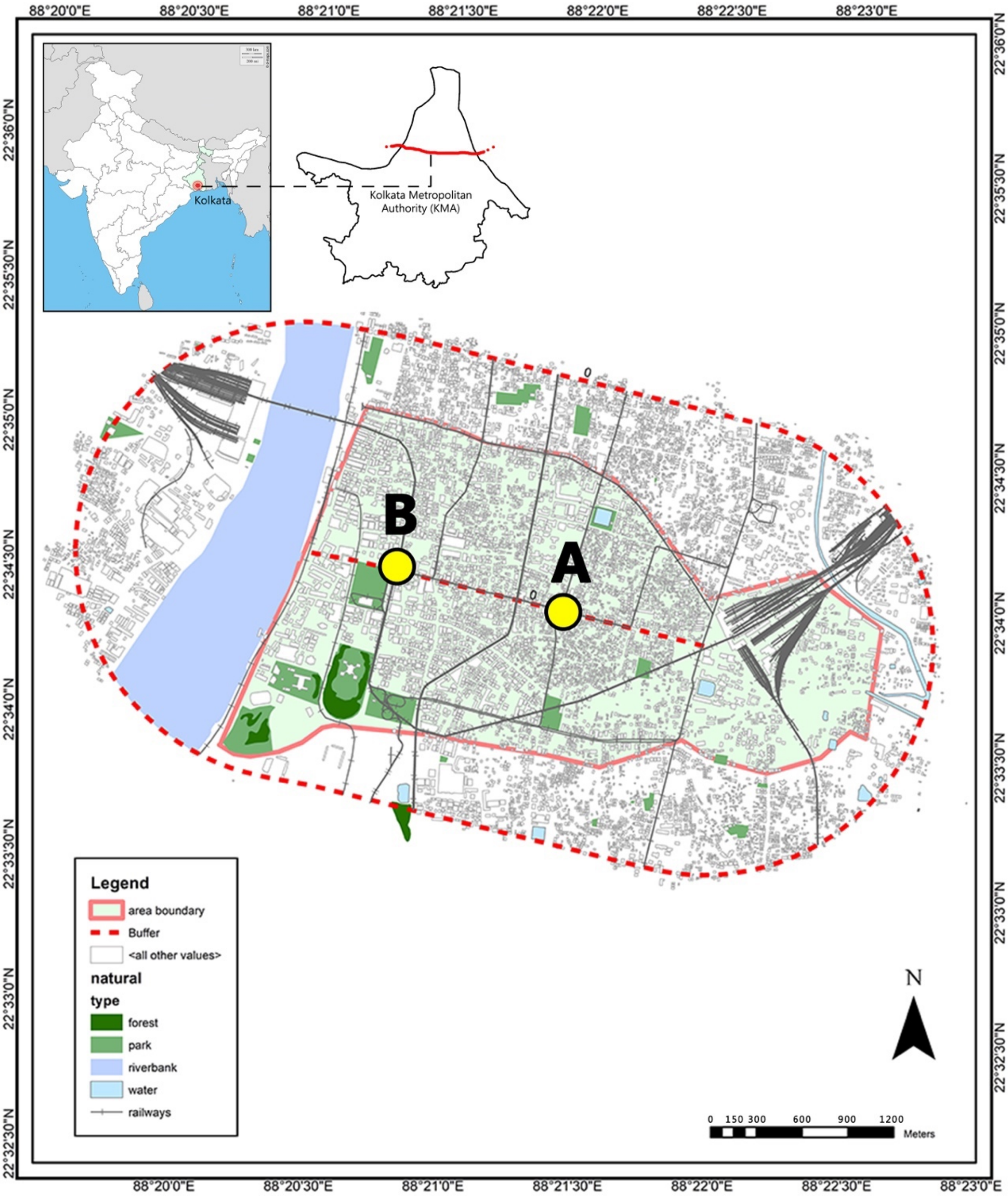



**Figure 27:** The location for the visual survey (between points A and B); map prepared in ARC-GIS.

Multiplicity in building use causes heavy pedestrian footfall throughout the day in this stretch. Thus, this stretch serves as a suitable location for a visual survey for the assessment of mobility conditions in an old Indian city. A social worker from Kolkata assisted the surveyors in identifying issues from a local perspective. The photographs taken during the visual survey were later interpreted at the Laboratory of Architectural Planning, Hokkaido University. **Figures 29–39** illustrate how the stretch is unfavourable for universal mobility.

**Figure 28:** Mercantile Building (Centre) built in the early 1900s: an example of built heritage.



*(From left)*

**Figure 29:** A cobbler occupying a footpath stretch along the external wall of Bowbazar Post Office.

**Figure 30:** The shop on the left of the picture was using its products for display, in the pedestrian space.

*(From left)*

**Figure 31:** Homeless people sleeping on the streets (right) and at the unused entrance of Gate 4 of Central Metro.

**Figure 32:** Open public bath still in operation at Bentinck Street, also capturing a part of the footpath as well as disturbing the vehicular stretch.

*(From left)*

**Figure 33:** Almost 500-year-old temple 'Firangi Kali Bari': a place where primarily Hindus gather during prayer.

**Figure 34:** A bus stop between Central Avenue Crossing and Bow Street has bedding of homeless people stored above the seating area.

*(From left)*

**Figure 35:** Railing near Gangadhar Babu Lane used by vendors as an edge for their storage.

**Figure 36:** Entrance to Bibi Rozio Lane, showing poor Kerb and drainage conditions.

**Figure 37:** Informal parking of private and commercial vehicles consumes at least 25% of the available pedestrian space in Kenderdine Lane. Residents use extended plinths from heritage buildings as shaded seating spaces.


*(From left)*

**Figure 38:** At The entrance of Phears Lane during the evening peak hour, a multiplicity of transport modes, absence of signals and improper pedestrian facilities create a chaotic environment.

**Figure 39:** Poor lighting conditions in a stretch between New Bowbazar Lane and Kenderdine Lane.

- ***Observation and Analysis***

The distance between Point A and Point B (as shown in **Figure 27**) is 850 m, and it takes about fourteen minutes for an able-bodied person for covering the distance. The stretch is oriented in North-East to South-West direction and has eighteen junctions of different scales; based on the (a) width of the streets converging in the junction, (b) height of the buildings along the streets, and (c) predominant type of activities). The surveyed locations are Nirmal Chandra Dey Street, New Bowbazar lane, Kenderdine Lane, Central Avenue (Gate 4 near Yogayog Bhawan), Central Metro (Gate 1 near Indian Airlines), Bow Street, Metcalfe Street, Bentick Street, Rabindra Sarani Rd., Chatawalla Gully, Phears Bye Lane, Phears Lane, Giri Babu lane, Central Metro (Gate 2 near Lalbazar), Central Avenue (Gate 3 near RITES), Gangadhar Babu lane, Bibi Rozio Lane, and College Street. Observational walks were conducted along this stretch and captured the photographs. Observations were recorded at various intervals of the day at: (a) 13:00 IST, when school finishes, (b) 18:00 IST when offices close for the day, and (c) 21:00 IST when commercial establishments shut down for the day. The observations made during the survey are explained hereafter.

[N.B.: IST refers to Indian Standard Time which is UTC +05:30; where UTC stands for Coordinated Universal Time].

Unorganized informal vending and encroachment by existing establishments occupied nearly every street [refer to **Figures 29 and 30**, respectively]. Complemented by this, numerous beggar/homeless people were occupying a share of the pedestrian space (often near non-operating Metro rail gates) [refer to **Figure 31**]. Communal open baths, which were a scene from yesteryear, were also present in certain areas [refer to **Figure 32**]. A mix of Hindu, Muslim and Christian religious places were present in the stretch [refer to **Figure 33**]. In terms of transportation, the bus stops were in poor infrastructural condition [refer to **Figure 34**]. Informal vendors used the railings along the footpath for their personal use [refer to **Figure 35**]. Additionally, the kerb (curb) along the footpaths was in dilapidated condition [refer to **Figure 36**]. Informal parking was observed in largely the entire stretch [refer to **Figure 37**]. The lack of signals at crucial intersections created chaos, especially during peak hour traffic, as depicted in **Figure 38**. Poor functioning of streetlights was observed at multiple locations such as the one photographed in **Figure 39**.

- *Findings and Discussion*

The visual survey helped in finding certain issues in basic mobility which require thorough examination before interpreting universal mobility. **Table 6** shows the observations from this visual survey. 'Universal Mobility' can be interpreted for this stretch only after assessing minimum mobility standards. Thus, these observations are the first stage for apprehending the mobility issues in this stretch.

**Table 6:** Learning from the visual survey in Bipin Behari Ganguly Street in Central Kolkata, India between September, and November 2020 to assess universal mobility conditions.

| S. No. | Topic | Inference |
|---|---|---|
| 1 | Predominant building use | The mixed land use and multiplicity of usage in a single building creates a complex structure of users. A different activity such as educational, business and others create multiple 'peak hour traffic' which the present infrastructure is not adequate to cater. |
| 2 | Heritage buildings | Many heritage buildings fostered low temporal change and is also restricting alteration in the width of carriageways. Typical heritage buildings with no setback and footpaths are not segregated from the building entrances creates a pedestrian discomfort in this stretch. |
| 3 | Informal Vending | Since the inception of this stretch, informal vending has been a characteristic feature. However, with increasing population and vehicular pressure, the informal vendors are presently a threat to mobility. |

| | | |
|---|---|---|
| 4 | Encroachment | Encroachment is a policy failure. Illegally occupied spaces within footpath create severe problems during peak hours. |
| **5** | Beggar/ Homeless/ Child Labour | Beggar/homeless/child labour is a social issue. Only socio-political intervention can facilitate the process of emptying the streets of these user groups. |
| **6** | Communal open bath | Communal open baths are obsolete in most parts of the city except central part of Kolkata. These communal open baths (often at the edge of footpath and street) serve as an important functional social infrastructure due to the presence of many daily wage workers and floating population. On the contrary, the baths are posing threat to mobility on both footpath and street. The common baths create an extra crowd and spilt water, both of which are threatening to the pedestrian environment. |
| **7** | Religious establishments | Being an organically developed area within historic core, Hindu, Muslim, and Christian crowds are proportionately present. The 'Firangi Kali Bari' Temple and 'St. Xavier's Church' are examples of religious structures. The problems with these locations are their presence along the footpath and absence of alternative entry. As a consequence, during prayers hours, a conflict in pedestrian movement due to different user group at the same line of movement is observed. |
| **8** | Bus Stop | The bus stops are in dilapidated condition and used by homeless people to store their belongings. Provision of information display is absent in bus stops; rather, the bus stops are used more for advertising purposes. A bus stop without facilities and improper information display is of seldom use in the 21st century. |
| **9** | Metro Stations | The unused metro station gates are occupied by homeless people as their temporary shelter. These issues are to be solved at the policy and socio-political level. |
| **10** | Signalized Intersections | Allocation of signals at intersections in this stretch was done decades ago in this stretch. The new zones of pedestrian and vehicular traffic were not considered in the recent past. Due to different building use, the volume of traffic is varying. The concept of allocating signals based on road width are not suitable for this area. Rather, signals based on traffic volume and predominant building uses are apt for this stretch. |
| **11** | Railing | Informal vendors occupied the railings in most parts of the stretch. Neither a clear demarcation for the pedestrian and vehicular traffic, nor scope for elderly/specially-abled people who ought to hold the railing, is present. A clear edge is essential for an ideal streetscape. |
| **12** | Kerb | Kerb which essentially provides gradation in street-level mobility is in extremely dilapidated condition in this stretch. As a result, neither able-bodied pedestrians nor specially-abled people can move freely in the footpaths. The scenario worsens at night due to lack of adequate light. |
| **13** | Storm Water Drains | Storm water circulation in this part of Central Kolkata is better than most of the parts; however, the location of storm water drains is a matter of major concern. The location, grating style and the slope is dangerous for pedestrian, especially the ones with walking cane. |

| | | |
|---|---|---|
| **14** | Signage | There was no directional signage in the entire stretch. Public utilities are not demarcated. The historic buildings had their description engraved near the entrance. However, other places of public interest are not having any information. Thus, for people new to this area and people with cognitive issues, they face difficulty in traversing the stretch. |
| **15** | Public Toilet, Drinking water facilities, and resting facilities | Only one public toilet was observed in the entire stretch of 850 m in which visual observation was undertaken and no drinking water facility was present. Public facilities such as drinking water and public toilets complemented by street furniture are components of a healthy street. Mobility without public facilities is unreasonable in the urban scenario. |
| **16** | Trash Bins | According to the latest 'Swachh Survekshan' programme or Clean India Campaign launched in 2016, Trash bins are to be placed at fifty meters interval along urban streets. However, in this stretch, hardly any trash bins were observed and as a result, littering was observed. Clean streets promote increased mobility and should be taken care of. |
| **17** | Streetlights | Although streetlights are present all throughout the stretch, the requisite lighting intensity was not present. When checked using the 'Light meter' application, most of the streets showed a lux level of less than ten, which is not ideal for a safe pedestrian environment. The fact that this stretch experiences a heavy pedestrian footfall, poor lighting creates it even more vulnerable to users with cognitive difficulties. |

## 2.4. MAJOR FINDINGS

In this section, the arguments and discussions in this research are summarized by establishing the relationship between the 'objectives' and 'the survey undertaken'.

### 2.4.1. Finding 01

The first objective of this chapter (i.e., to ascertain the need for a new dimension in the Indian accessibility scenario) was substantiated through the first survey (as elaborated in **Section 2.3.1**) involving the design fraternity of India. Taking a cue from the first study about the focus area of accessibility in transportation, the next step was exploring the second objective (i.e., what is people's perception regarding mobility in an old Indian city?).

### 2.4.2. Finding 02

The second objective of this chapter (i.e., to assess people's perspective towards universal mobility in core urban areas in India) was verified through the findings from the survey involving the residents of Kolkata (as elaborated in **Section 2.3.2**). Once this scenario was clear, the next steps were choosing a particular stretch in the old core of Kolkata and conducting a visual observation which would explain a part or whole of people's opinions regarding mobility in an old Indian city.

### 2.4.3. Finding 03

The third objective of this chapter (i.e., to identify the issues in mobility in core urban areas in India) was advocated through the inferences from the visual survey of a stretch in the old core of Kolkata (as elaborated in **Section 2.3.3**). The observations and inferences through this visual survey indicated that mobility conditions are not in a positive state in this stretch. Basic infrastructural issues are in downtrodden conditions. Thus, re-imagining this stretch with universal mobility concerns is a difficult task altogether. To initiate the process of universal mobility features in this stretch, however, a need for further analysis of this stretch was necessary.

Thus, it was inferred that the reluctance of people in old cities towards walkability and usage of public transport was directly linked to poor infrastructural conditions. The historic origin of the old core in Indian cities and their organic pattern of development generate a chaotic urban scenario. Presently, dissatisfactory levels of cognition at the street level, which is not an ideal scenario for able-bodied and specially-abled alike, are persistent. Elderly people additionally face problems due to this dilapidated state.

## 2.5. CONCLUSIONS

Despite several policies and programs related to accessibility at the national level, old Indian cities are often ignored. The reason for this phenomenon is largely the Indian Constitution. According to the Seventh Schedule (Article 246) of the Indian Constitution, 'Land' is a state subject. It implies that a decision regarding urban development is a matter of the individual state.[158] Thus, maintaining coherence with national policies is a political choice for the Chief Minister of a state. Kolkata is in the state of West Bengal and as of May 2023, the state-ruling electoral party (Trinamool Congress with Smt. Mamata Banerjee as the state's Chief minister) is not in alliance with the central-level ruling party (Bhartiya Janata Party, with Shri. Narendra Modi as the country's Prime Minister). Thus, it was not unnatural when 92.16% of the respondents from the elderly/specially-abled and 85.14% of able-bodied people responded during the survey that they were unaware of the Accessible India Campaign.

Thus, identifying a custom-made access audit format specifically for a particular stretch shall be beneficial for the old core cities, in terms of its practical applicability by avoiding political complications. At the same time, it will also serve as an altered guideline for old cities, rather than the generic national guideline. A total of 63% of respondents from the architecture fraternity during the survey indicated the same suggestion.

For further research in the same domain, a checklist-based assessment could be undertaken by interested researchers. This checklist, as defined in the aims of this chapter, shall contain the factors for an ideal accessibility audit checklist which is to be used in old core Indian cities. Further research could be based on three distinct lines of action. The three lines of action are (a) universal mobility features, (b) cognitive factors, and (c) traffic volume. The last survey in this research (as detailed in **Section 2.3.3**) titled 'Visual Observation of an Old City Core' which was undertaken in Bipin Behari Ganguly Street in Kolkata surfaced issues related to the infrastructural conditions in old core cities in India [Refer to **Figures 28–39**]. First, based on these issues, an in-depth analysis of each street and footpath stretches (space between the junction of a street and another) could be conducted to quantitatively determine the infrastructural level. Second, the cognitive factors could be examined and thereby used for determining the linkage between the five senses and pedestrian behaviour. However, these two types of study will be incomplete if these studies are not correlated to the traffic volume. The traffic volume, consisting of pedestrian and vehicular volume shall help in assessing the level of service for the study stretch. **Figure 40** illustrates the methodology that could be adopted for further study based on the findings of this chapter. This further research based on the findings of this chapter will foster the preparation of a rating system for universal mobility in the core of old Indian cities.

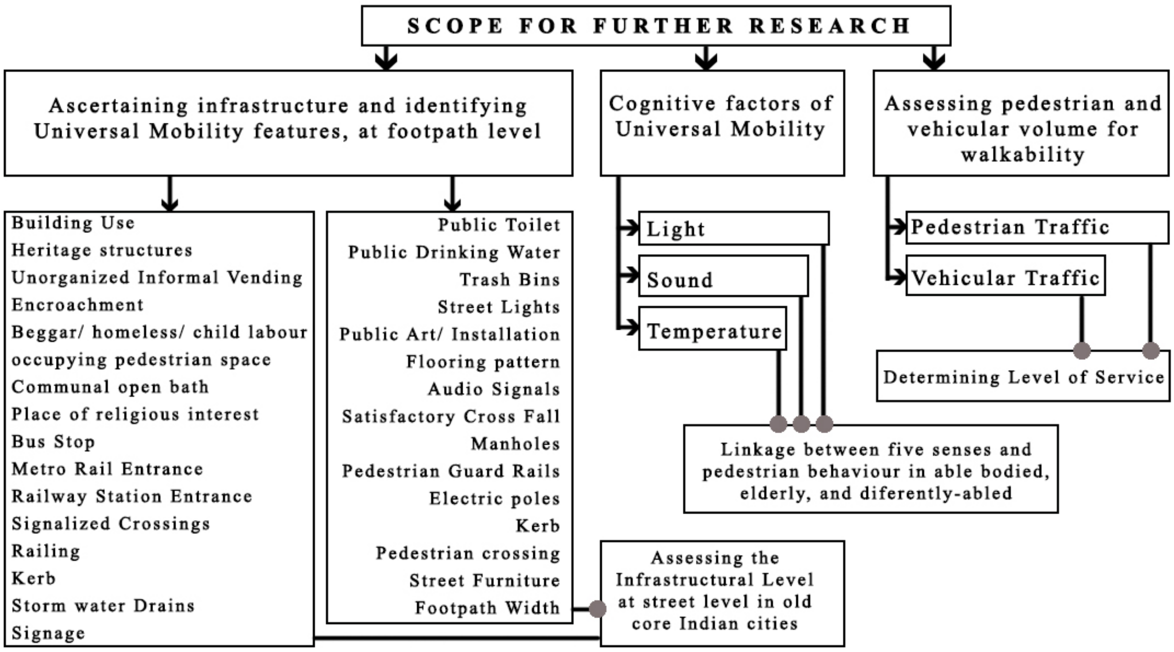



**Figure 40:** Methodology showing the scope of further research based on the findings from this chapter.

Thus, the answer to the research question for this chapter, i.e., 'to find out whether core areas of urban India can be made inclusive in terms of accessibility' was 'yes'. Inclusivity can prevail in the old core of Indian cities provided a methodical approach towards universal mobility is practiced, as elaborated in this chapter.

As seen in **Figure 40** 'scope for further research', the part titled 'ascertaining infrastructure and identifying Universal Mobility features, at footpath level' is used in the **Chapter 3 and 4** of this research for assessing the footpath conditions in Indian cities. Furthermore, the part titled 'cognitive factors of Universal Mobility' and 'assessing pedestrian and traffic volume for walkability' is used in **Chapter 6** of this research.

# CHAPTER 03

- **Title:** Evaluating the accessibility of the footpath in case area (Central Kolkata, India)
- **Related Publication: G. Das Mahapatra**, S. Mori, and R. Nomura, 'Evaluating the accessibility of old cities: a case of central Kolkata, India,' *Japan Architectural Review*, vol. 6: e12349, Mar. 2023, DOI: 10.1002/2475-8876.12349. [Journal Impact Factor = 0.9]
- **Scope:** To furnish a process-oriented approach in the realm of accessibility where the approach is still product oriented.
- **Objectives:** (a) To determine the degree of accessibility possible in the footpaths of core areas of an old Indian city by proposing an ideal accessibility audit checklist; and b) Policy-level recommendations to increase the quality of life in cities by improving the footpaths.
- **Focus:** Accessibility of the footpath-level walkability condition of Kolkata
- **Research Questions:** What is the degree of accessibility that can be achieved in the public domain of old cities?
- **Data Set:** Footpaths in central Kolkata (32 footpath stretches)
- **Keywords:** Walkability; Central Kolkata; Accessibility; Accessibility Audit; Universal Mobility

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**'Diversity is a fact. Equity is a choice. Inclusion is an action. Belonging is an outcome'.**

***- Arthur Chan***

# 3. EVALUATING THE ACCESSIBILITY OF THE FOOTPATH IN CASE AREA (CENTRAL KOLKATA, INDIA)

Assessment of the accessibility of the footpath-level walkability condition of old core cities has been covered in this chapter. The case area considered are 32 footpath stretches in Central Kolkata, India.

Gregg and Hess (2019) argue about the contextual analysis of public policies related to street-level research. The understanding of a complete (ideal) street is based on the street's components or induced; not necessarily based on a generic guideline.[159] Dividing the case area into multiple segments helps to understand the components of 'time and rhythm' in public space.[160] Identifying the functionality associated with each sub-section of a relatively long stretch of street, and classifying individual infrastructural needs based on this hierarchy is an alternative way of analysing urban mobility.[161] Taking a cue from this, this research divided the study stretch into smaller spatial fragments (shown later in Section 3.2.2., **Figure 43**) for survey purposes.

Martires (2017) emphasises connecting urban history with the street genre and street pattern. The transformation of the urban fabric concerning temporal change is an essential consideration in architectural planning for urban mobility.[162] Along similar lines, according to the theory of Natural Movement (Space Syntax), the urban spatial structure influences the movement pattern.[163] Mahdzar (2013) suggests empirical observation of pedestrian activities before mapping the surveyed stretch.[164] Identical research also indicates the categorization of physical elements of analysis into 1) Buildings, 2) Streets, and 3) Land Use. Similarly, to assess the universality of space, it should be analysed from the perspective of element spaces.[165] This research eventually incorporated these learnings while framing the parameters for the survey in this chapter.

Through observational audit and strategic mapping, the macro and micro-elements (and attributes) of a street can be assessed.[166] To correctly assess the situation, accessibility audits in different parts of the same region must foster a tailor-made or site-specific recommendation for accessibility audits.[167] However, the technically apt methodology to impart urban-level accessibility is to develop a framework for 'level of service' based on parameters (and their respective indicators) that influence universal mobility. The parameters (and their respective indicators) should be evaluated through an objective scoring/ ranking/ rating system, which in turn can be determined by a pilot survey. In addition to these, the identification of essential/ critical parameters (and their respective indicators) whose presence ensures universal mobility and vice-versa, is also recommended.[168] In this chapter, weak parameters in the case area and their respective position or ranking among other parameters are identified.

Mobility in pedestrian areas (footpaths) in core cities includes parameters like (a) traffic factors (like car parking), (b) geometry/ environmental/ footpath factors (like, pavement conditions), and (c) pedestrian movement factors (like pedestrian volume).[169] Story and Mueller (2014) indicates the need for explicit consideration of parameters for pedestrian-focused universal mobility solutions, like (a) footpath gradient, (b) Tactile Surface Ground Indicators (TGSIs), (c) gratings, (d) kerb (curb) ramp, (e) signage, and (f) public art. They also identify indicators for each parameter in the form of key design features; for example, one of the indicators for the parameter 'Gradient' is cross fall less than 1:40.[170] Several meso-level and micro-level dimensions of the built environment, like (a) land use and diversity, (b) accessibility, (c) street connectivity, (d) safety and security, (e) pedestrian facilities, (f) comfort, and (g) streetscape design, incorporate a substantial influence on urban walkability.[171] Most of the factors thus discussed in this discussion are included as parameters in the survey format used for this chapter.

Mahapatra, Mori, and Nomura (2021) in their paper 'Universal Mobility in Old Core Cities of India: People's Perception' used 'Critical Instance' Case Study-type research for a similar genre of research, indicating a need for framing a new assessment framework for assessing the scope of universal mobility in old Indian cities. Along similar lines, deteriorated mobility conditions pose a threat to people with functional and cognitive limitations, including elderly people. Furthermore, research of this genre requires a specific approach toward the site context and thus cannot be conducted using generic research methods (from the familiar methods of research design). The research design for this chapter has considered: the Literature Study, previous research, and the historical context of the study area.

### 3.1. CASE AREA

As clarified earlier, the old city core selected for this research is Kolkata, which is the capital of the state of West Bengal in India. The urban form in this part of Kolkata is complex due to its long history, high density, and decaying urban core. Furthermore, in comparison with India's density of 382 people per square kilometre, Kolkata has a density of over 24,300 people per square kilometre.[172] Kolkata was the capital of British India until 1911.[173] The old (central) part of Kolkata, which has traditionally been the administrative, commercial, and educational hub has been historically associated with congestion and unhealthy living conditions.[174] Presently, the Kolkata Municipal Corporation (established in 1876) is currently responsible for the administration of the delineated case area. The case area selected for this research spans nearly 850m and is aligned in a North-East to South-West direction. The specifically surveyed stretch was the footpath (pedestrian area) on both sides of the case area. Since the inception of Kolkata in the late 17th century, this case area has been the centre of multiple activities and associated traffic loads. The temporal change of this area (especially the 'right of way' or 'R.O.W.') has not been proportional to the increase in population as well as associated activities. The population of Kolkata in 1911 was 896,067 in comparison with 4,496,694 as per the 2011 census. However, the average density of Kolkata (Municipal limits) in 1913 was approximately 26,500 people per square kilometre, in comparison with 24,252 (as per the 2011 census). The case area for this research is shown in **Figure 41 (a, b, and c)**.

The case area selected for this research was further subdivided into thirty-two stretches (explained elaborately in **Section 3.2** of this chapter to strengthen the specificity of the research. The stretches are comprised of 1) Arterial Streets, and 2) Footpath stretches between two adjacent arterial streets. Apart from these stretches, this stretch surpasses three major junctions: Bowbazar Crossing, Central Avenue Crossing, and Bentinck Street Crossing. The entire study area has a predominance of mixed-use buildings (Refer to **Figure 42**).

In all the thirty-two stretches delineated for survey in this research, the presence of Residential and Business building use was observed. Buildings with Mercantile building use are present in 71.88% (23 nos.) of the stretches. Subsequently, in 50% (16 nos.) of the stretches, Institutional building use was observed. Other building uses in the thirty-two stretches are as follows: (a) Educational - 12.50% (4 nos.), (b) Assembly – 6.25% (2 nos.), and (c) Industrial and Storage – 3.13% (1 no.). Hazardous Building Use was not observed in any of the stretches. The presence of different building uses in the case area was shown in **Figure 42**.

The understanding of the building use in the study area was important for this chapter since the 'Indian Road Congress Guidelines for Pedestrian Facilities' specify an ideal footpath width based on the predominant adjacent building use.[175] Since all the footpath stretches shows the presence of mixed types of building usage, the minimum footpath width should be 2500 mm. Thus, understanding the adjacent building's use was one of the primary considerations of the research methodology for this chapter. In relation to this, research work in a similar case area, titled 'Interpreting Universal Mobility in the Footpaths of Urban India Based on Experts' Opinion', has concluded that the greatest problem in walkability is as follows: (a) Lack of proper footpath- for able-bodied people, and (b) Encroachment by Vendors- for specially-abled people.[176] Also, visual observations reflect that the present condition of the case area is not adequate for pedestrians, and the issue of universal mobility seems like a daunting task.

[N.B.: The consolidated data for building use is furnished in **Annexure E**.]

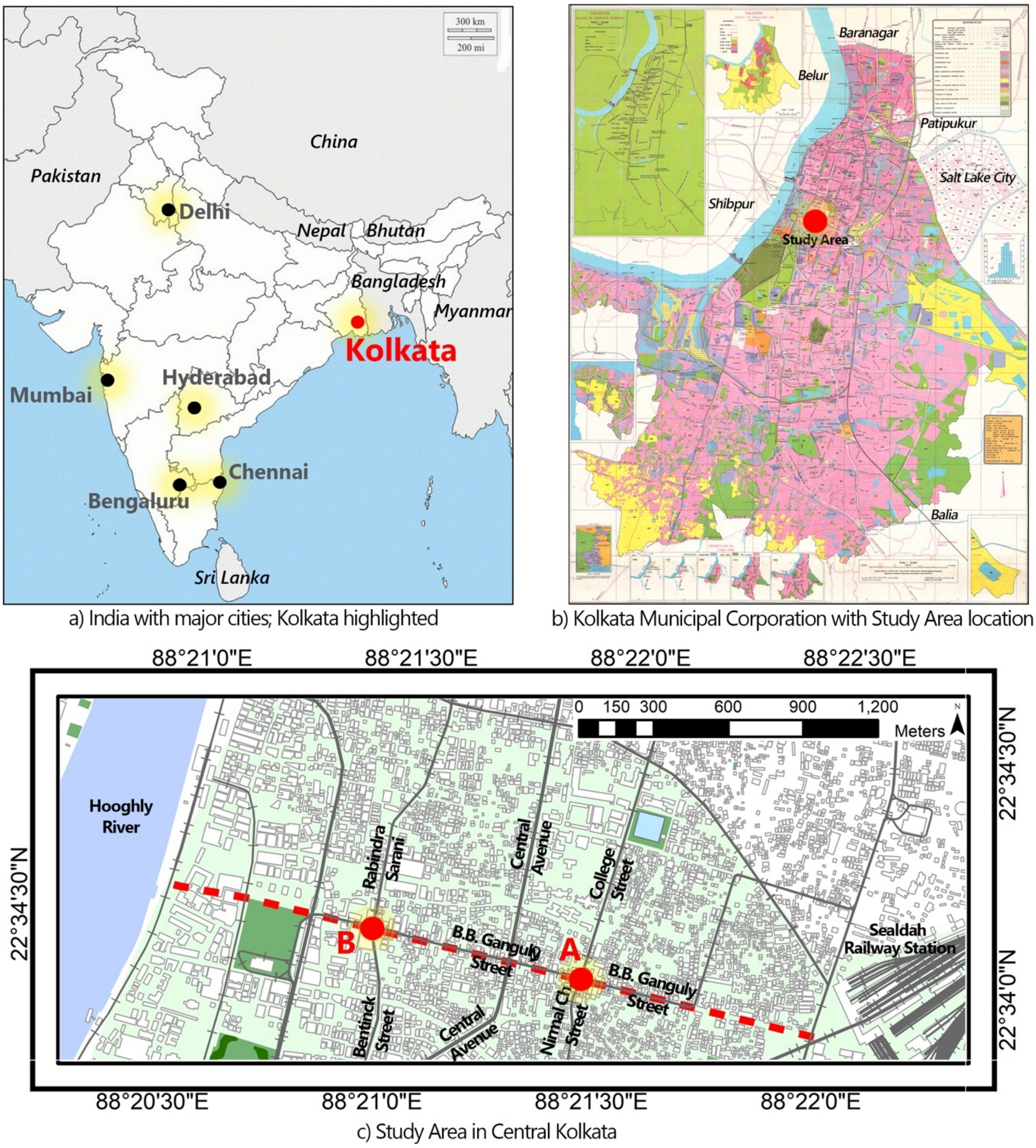


**Figure 41:** The research area chosen for this study. In Figure 41(c), the case area is demarcated with Point A at one end and Point B on the other side. The stretch is about 850m in length, oriented in the Northeast – Southwest direction; and has a walking time of about 15 minutes for able-bodied people [Source for Fig. a: Overlaying on the open-source data available on https://www.mapsofindia.com; Source for Fig. b: P. Nag (2010). City of Calcutta and its Environs (3rd Edition). Kolkata: National Atlas and Thematic Mapping Organization.; Source for Fig. c: Self, using Geographic Information System].

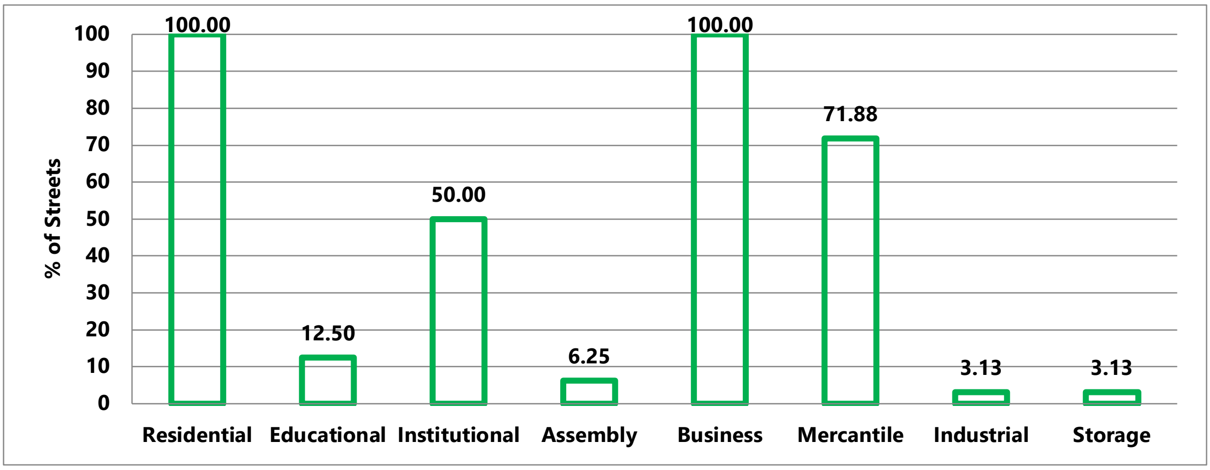


**Figure 42:** Percentage of streets with various building uses in the selected case area.

### 3.2. DATA AND METHODS

The hypothesis considered for this chapter is that the footpaths in the old core areas of Kolkata are poor in terms of universal mobility standards. Furthermore, this research promotes the need to frame a new assessment framework for universal mobility for these old Indian cities, since the usual (generic) factors of walkability impose no/ negligible influence on the pedestrian volume in these areas. The inquiry mode for this chapter is 'Structured'. In structured research methods, the analysis is dependent on the type of data collected. The three types of surveys conducted are implied below:

#### 3.2.1. Expert Opinion

To understand the opinion of experts about universal design and universal mobility conditions in their city, 257 Indian experts from the fields of Architecture and Planning were surveyed. Among the 257 participants, 10.12% (26 nos.) were professors, 8.56% (22 nos.) were associate professors, 22.18% (57 nos.) were assistant professors, 22.57% (58 nos.) were practising Architects, 10.51% (27 nos.) were practising Planners, 8.17% (21 nos.) were Ph.D. Scholars in Architecture/Planning, and 4.67% (12 nos.) were government officials. The remaining 13.23% (34 nos.) were from professions other than the ones stated. Furthermore, the respondents were from 20 states (out of 28) and one union territory (out of eight) in India. An online Google form questionnaire was used for this survey that continued from 17$^{th}$ August 2021, till 4$^{th}$ October 2021. The questionnaire is available at https://forms.gle/kqpFSkvyEDdUdvVHA (accessed on 22nd February 2023 and available in **Annexure F**). The respondents were asked to mark any of the five most important factors while assessing universal mobility for pedestrians in the Old Cities of India from a pool of factors including building typology of stretch, footpath dimensions, temporary encroachment, any many more. The most important factor while assessing universal mobility for pedestrians in the old cities of India, according to the experts, was the key result of this survey.

#### 3.2.2. Infrastructure Mapping

Consequently, an 'Infrastructural Conditions mapping' was conducted in the case area, which was further subdivided into thirty-two stretches. For mapping 'Infrastructural Conditions' for this chapter, field surveys were conducted between 1st August 2020 and 2nd September 2020. The surveys were conducted with the help of several local people (students and professionals) who were acquainted with the surveyed study area. **Figure 43** indicates the locations selected for the survey using the variables considered.

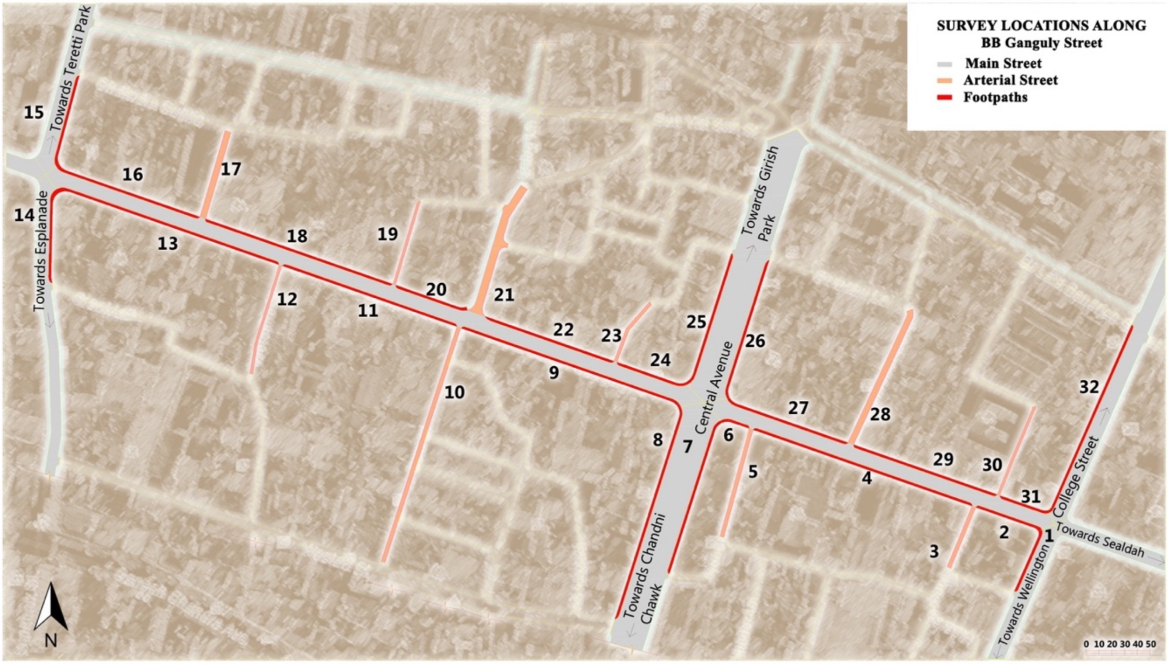


**Figure 43:** Survey Locations (1-32) [Source: Overlaying on the open-source data available on Google Earth.]

The 'Infrastructural Conditions mapping' segment comprises of eighteen categorical variables. These variables are derived from the study of various projects, guidelines, and research in the field of a similar genre as this research, most of which are elaborated on in the literature study section of this chapter. These variables are the metrics that should are used to evaluate pedestrian accessibility in the project area.

These categorical variables (considered as 'Criteria' during the survey and analysis hereafter) are as follows: (a) building typology of stretch, (b) footpath dimensions, (c) temporary encroachment, (d) permanent encroachment, (e) bus stop, (f) metro rail entrance, (g) railings, (h) storm water drains, (i) public toilet, (j) trash bins, (k) street lights, (l) flooring, (m) manholes, (n) kerb (curb), (o) pedestrian crossing, (p) street furniture, (q) safety and security (surveillance and fire-safety oriented), and (r) additional inclusive features. These criteria are further subdivided into respective sub-criteria (fifty in total). These sub-criteria can be further grouped into two types of variables: Independent, and Dependent.

As an example, for one of the categorical variables (criteria) 'Public Toilets', the associated sub-criteria are 1) the presence of a Public Toilet, and 2) a Functional Public Toilet. In this example, the first sub-criteria 'Presence of a Public Toilet' is independent of any factor which means whether a public toilet is present or absent is the decisive factor in the assessment. However, the second sub-criteria i.e. 'Functional' condition of the public toilet can be assessed only if the public toilet is present at all. It means, if the public toilet is not present in the first place, then the functionality of the public toilet cannot be assessed at all. For this reason, this sub-criterion is dependent on the previous sub-criteria. Since the sub-criterion 'Presence of Public Toilet' is an independent variable, and 'Functional Public Toilet' is a dependent variable, their weightage would be different.

The subsequent survey format for understanding 'Infrastructural Conditions' (through primary observation) was framed based on these criteria and sub-criteria. Post-survey, the observations were further analysed using a scoring pattern. The sub-criteria were scored based on their associated variable type (independent or dependent). The presence of a sub-criterion is scored as '+0.50' if the associated variable is an Independent Variable. Along similar lines, a sub-criterion is scored as '+0.25' if the associated variable is a Dependent Variable. Similarly, the absence of a sub-criterion is scored as '-0.50' for Independent Variables and '-0.25' for Dependent Variables respectively. Thus, weighting is used for further analysis.[177] Since each sub-criterion is essential for a stretch to qualify as a Universally Designed space, the sub-criterion is given equal weightage, i.e., +0.50 for the independent variable and +0.25 for the dependent variable.

For any study stretch surveyed using this framework, the consolidated highest score can be 20 (and subsequently, the lowest can be -20). It is to be noted that although all these variables are not equally important for pedestrian activity, the negative impact of any one of them could lead to inadequate universal mobility standards. **Table 7** elaborately shows the Variables (Criteria and Sub-criteria), Types of Variables (Independent/ Dependent), Scoring Logic, and Individual Scores for all 18 categorical variables used in this chapter.

**Table 7.** Variables (Criteria and Sub-criteria), Types of Variables (Independent/ Dependent), Scoring Logic, and the Individual Scores.

| Criteria | | Sub-Criteria | | Variable Type | Scoring Logic | Individual Associated Score | |
|---|---|---|---|---|---|---|---|
| **S. No** | **Details** | **S. No** | **Details** | | | *If Yes* | *If No* |
| **A** | Building Typology of Stretch | **1** | Buildings that are having 'two or more' building uses within a single building | Independent | Beneficial if Absent | +0.50 | -0.50 |
| | | **2** | Heritage/ historic buildings | Independent | Beneficial if Absent | +0.50 | -0.50 |
| **B** | Footpath Dimension | **3** | Footpath Width >2500 mm | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **4** | Unobstructed width of 1800 mm | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **5** | Unobstructed clear height of 2200 mm | Independent | Beneficial if Present | +0.50 | -0.50 |
| **C** | Temporary Encroachment | **6** | Unorganized Informal Vendors functional during day/ night | Independent | Beneficial if Absent | +0.50 | -0.50 |
| | | **7** | Unorganized Informal Vendors/ hawkers away from the line of pedestrian flow (if Vendors are present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| | | **8** | Beggar/ homeless/ child labour occupying a part of the footpath as their homes | Independent | Beneficial if Absent | +0.50 | -0.50 |
| **D** | Permanent Encroachment | **9** | Place of religious interest (temple/ churches/ mosque) within or along the footpath? | Independent | Beneficial if Absent | +0.50 | -0.50 |
| | | **10** | 'Encroachment' by existing establishments on to the footpath | Independent | Beneficial if Absent | +0.50 | -0.50 |
| | | **11** | 'Communal open bath' within or along the footpath | Independent | Beneficial if Absent | +0.50 | -0.50 |
| **E** | Bus Stop | **12** | Informal stoppage for Bus | Independent | Beneficial if Absent | +0.50 | -0.50 |
| | | **13** | Bus Shelter (if Bus Stops) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| | | **14** | Is 'Bus Shelter' functional (if Bus Shelter is present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| **F** | Metro Rail Entrance | **15** | Entrance connected to the footpath | Independent | Beneficial if Absent | +0.50 | -0.50 |
| | | **16** | Is the Entrance functional (if Metro Rail Entrance is present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| **G** | Railings | **17** | Railings (pedestrian guard rails) on the edge of the footpath | Independent | Beneficial if Present | +0.50 | -0.50 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | **18** | Thorough railings with minimum 1500 mm height and clear visibility (if Railings are present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| **H** | Storm Water Drains | **19** | Storm Water Drains along footpath | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **20** | Functional Storm Water Drains (if Storm Water Drains are present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| **I** | Public Toilet (Restroom) | **21** | Public Toilet within the footpath | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **22** | Functional Public Toilet (if Public Toilet is present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| **J** | Trash Bins | **23** | Trash Bins within the footpath | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **24** | Functional Trash Bins (if Trash Bins are present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| | | **25** | Trash Bins located away from the line of pedestrian flow (if Trash Bins present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| **K** | Streetlights | **26** | Streetlights within the footpath | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **27** | Functional Street Lights (if Street Lights are present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| | | **28** | Light Poles away from pedestrian flow or if present, is demarcated with a tactile marking of a minimum 600 mm around it (if Street Lights are present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| **L** | Flooring | **29** | Satisfactory Cross Fall (i.e. <1:50) | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **30** | Tactile Marking | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **31** | Anti-skid/ matt finish tiles in footpath and Kerb (curb) | Independent | Beneficial if Present | +0.50 | -0.50 |
| **M** | Manholes | **32** | Manholes within/ along the footpath | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **33** | Drain type' manholes flushed with the pavement surface (if Manholes are present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| | | **34** | Grating' type manholes sited away from the pedestrian walkway (if Manholes are present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| **N** | Kerb (curb) | **35** | Kerb (curb) on the edge of footpath | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **36** | Kerb (curb) Height of not more than 150 mm from the road level (if Kerb (curb) is present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| | | **37** | Minimum 1200 mm width and tactile warning (if Kerb/ curb) is present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| | | **38** | Corned Kerb (curb) radius more than 6m (if Kerb/ curb) is present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| **O** | Pedestrian crossing | **39** | ‘At-grade' pedestrian crossing (MID-BLOCK crossing) at all intersections along the walkway | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **40** | Signalized Intersection (if Crossing is present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| | | **41** | Functional Signalized Intersection (if Crossing is present) | Dependent | Beneficial if Present | +0.25 | -0.25 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | **42** | Audio Signal (if Crossing is present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| **P** | Street furniture | **43** | Street furniture in the footpath | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **44** | Street furniture having a knee clearance of a minimum of 700 mm and wheelchair space of 1000 mm (if Street Furniture is present) | Dependent | Beneficial if Present | +0.25 | -0.25 |
| **Q** | Safety and Security | **45** | Fire Hydrant | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **46** | Security Camera | Independent | Beneficial if Present | +0.50 | -0.50 |
| **R** | Additional Inclusive features | **47** | Signage | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **48** | Bicycle Track | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **49** | Public Drinking Water Facility | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | **50** | Street Art | Independent | Beneficial if Present | +0.50 | -0.50 |
| | | | **Maximum/ Minimum Total Score** | | | **+20** | **-20** |

Each of the thirty–two stretches in the delineated case area within Central Kolkata was surveyed based on the above methodological framework using the 'Online Google Form' type survey format. The type of questionnaire used is the 'Dichotomous Close-Ended' type. The Google Form is available online at https://forms.gle/1f8HxXE62WM6GpWc6 (accessed on 22nd February 2023 and available in **Annexure G**). Quantitative scores associated with each footpath stretch in the case area were the key outcome of this survey.

[N.B.: The consolidated data collected during this part of the survey is furnished in **Annexure H**.]

### 3.2.3. Pedestrian Mapping

Furthermore, the peak-hour (15-minute interval) Pedestrian Volume Data were recorded three times in 2020 (on 14.10.2020, 25.10.2020, and 02.11.2020) and once in 2021 (on 24.09.2021). On each of the days, the data were recorded twice a day– at the Morning Peak Hour (9:00 IST – 11:00 IST) and the Evening Peak Hour (18:00 IST – 19:00 IST). Arithmetic means of the morning and evening peak hour pedestrian volume readings for each footpath stretch in the case area were the key takeaways from this survey.

[N.B.: The questionnaire used for this survey and the consolidated data collected during this part of the survey is furnished in **Annexure I and Annexure J, respectively**.]

### 3.2.4. Methodology

Thus, the key takeaways from the three aforesaid surveys are as follows:

***(a) The most important factor while assessing universal mobility for pedestrians in the old cities of India,***
***(b) Quantitative scores associated with each footpath stretch in the case area, and,***
***(c) Arithmetic Means of the morning and evening peak hour pedestrian volume readings for each footpath stretch in the case area.***

Finally, these three data points were correlated using Pearson's Correlation with a 95% confidence interval. The research methodology used in this chapter is further summarized diagrammatically in **Figure 44**.

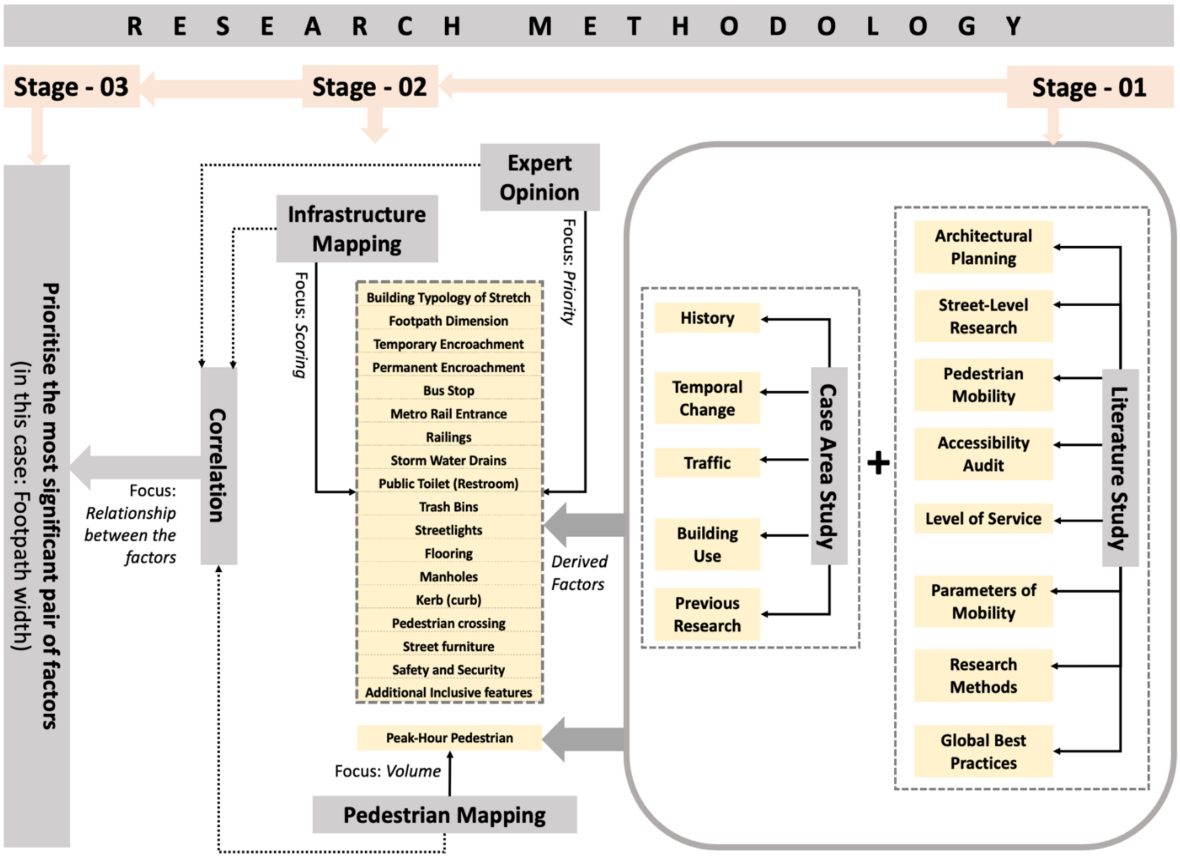


**Figure 44:** Research Methodology.

## 3.3. RESULTS ACHIEVED

This section of the chapter initially elaborates on the details of the surveys that were conducted and then emphasises the results that were deduced.

### 3.3.1. Expert Opinion

The 257 experts were asked to assign the most important factors of universal mobility among a pool of 18 factors. Mr. Subhasish, a practising architect from Kolkata, indicated that footpath width in Central Kolkata has always been a challenge to pedestrians since the width of the footpath is fixed despite the rise in the number of activities and vehicular traffic. Dr. Kshama Puntambekar, a professor from the School of Planning and Architecture (SPA-B) and co-author of the book 'Reinterpreting Urban Fabric in Cities with Living Heritage – A Case of Central Kolkata' identifies the impact of poor footpath dimension as the reason behind multiple other factors which creates unsuitable pedestrian quality in central Kolkata. Architect Shriya Banerjee, a Ph.D. Scholars from the Indian Institute of Technology (IIT-KGP) stated that the historic organic development of the city is a major obstacle to re-designing the footpath which in turn influences the age-old problem of encroachment at the footpath level. Architect Shreya Ghosh Dastidar, an officer from the Public Works Department of the Government of West Bengal highlights the critically poor conditions of footpaths in Central Kolkata and the critical footpath-level conditions despite which pedestrians commute every day along this area in Central Kolkata. In summary, the experts prioritised the following 5 factors as the most important factors while assessing universal mobility for pedestrians in the old cities of India: (a) dimension of the footpath, (b) temporary encroachment, (c) permanent encroachment, (d) transport stops, and (e) pedestrian crossings. Furthermore, 50.6% of the respondents indicated Footpath Dimension as the first option among the five prioritised factors. Thus, this factor was used for the correlation at a later stage in this chapter.

### 3.3.2. Infrastructure Survey

This section elaborates on each criterion and sub-criterion. The pictorial representation is shown in **Figure 45** as well.

Among the thirty-two stretches selected for the survey, 100% of them bear the presence of buildings having 'two or more' building uses within a single building. The building's use ranges from: (a) residential, (b) educational, (c) institutional, (d) assembly, (e) business, (f) mercantile, (g) industrial, (h) storage, and (g) hazardous. In addition to this, heritage structures are present in 84.4% (27 nos.) of the stretch.

Based on the adjacent predominant 'commercial/mixed' land-use (as per IRC-2012) in the surveyed stretch, the ideal width of the footpath is 2500 mm. The ideal footpath width is not just for a section of the footpath, but for the entire stretch. Moreover, since the pedestrian stretches are adjacent to the buildings, a 'Dead Width' of 500 mm should be present over and above the 2500 mm.[17] However, among the thirty-two surveyed stretches, 78.1% (25 nos.) of them had a width of less than 2500 mm. 65.6% (21 nos.) among the thirty-two surveyed stretches do not possess an unobstructed width of 1800 mm. However, in 71.9% (23 no.) of the surveyed stretch, an unobstructed clear height of 2200 mm is observed (refer to **Figure 46**).

Unorganized Informal Vending was observed in 46.9% (17 nos.) of the thirty-two stretches that were surveyed. However, Informal vendors/ hawkers are away from the line of pedestrian flow in 18.8% (6 nos.) of the surveyed stretches. Beggar, and/or Homeless people, and/ or Child Labour can be found in 21.9% (7 nos.) of the entire surveyed stretch (refer to **Figure 47**).

Places of religious interest are present in 68.8% (22 nos.) of the surveyed stretches. The eminent ones are 'Saint Francis Xavier' Church, 'Firingi Kali Bari' Temple, 'Sri Sri Ghanteshwar Mahadev' Temple, and 'Carey Baptist' Church. 78.1% (25 nos.) of the surveyed stretch was encroached on by existing establishments. In 21.9% (7 nos.) of the surveyed stretch, Communal Open Baths are present and functional (refer to **Figure 48**).

Among the thirty-two surveyed stretches, public buses stop informally at 50% (16 nos.) during various times of the day. However, only 3.1% (1 no.) include a bus stop, and that one was not functioning according to standard Indian design standards.

'Central Metro' is the corresponding Metro Rail/ Subway station in the surveyed stretch. The four gates of Central Metro are present in the stretch: (a) Gate 1-Indian Airlines, (b) Gate 2-Lalbazar, (c) Gate 3-RITES, and (d) Gate 4-Yogayog Bhawan. Concerning that, 25% (8 nos.) stretches include a Metro Rail Entrance at least at one end of the stretch. However, Metro Rail entrances in working conditions are observed in 15.6% (5 nos.) of the eight stretches.

Railings are present along 40.6% (13 of the thirty-two surveyed stretches) of the surveyed stretches. Thorough pedestrian guard rails (with a minimum height of 1500 mm) and clear visibility are present at 15.6% (5 no.) of the thirty-two surveyed stretches (refer to **Figure 49**).

Among the surveyed thirty-two stretches, Storm Water Drains are present in 90.6% (29 nos.). Except in one stretch, Storm Water Drains are working at 87.50% (28 nos.).

Only one (3.13%) Public Toilet was present in the surveyed stretch, and it was in working condition.

Trash Bins were present in 12.5% (4 nos.) of the surveyed stretches. Except in one stretch, Trash Bins were working in 9.4% (3 nos.) stretches. These municipal garbage bins were away from the line of pedestrian flow in 12.5% (4 nos.) of the surveyed stretch.

Streetlights were present in all thirty-two surveyed stretches. Except for two stretches, Street Lights were working at 93.8% (30 nos.). In 93.8% (30 nos.) of the surveyed stretches, the electric poles were neither placed away from the pedestrian flow nor demarcated with a tactile marking of a minimum of 600 mm around the poles (refer to **Figure 50**).

Satisfactory cross-fall (i.e., 1:50) was present in 62.5% (20 of the thirty-two surveyed stretches). In addition to this, tactile paving was not present in any of the surveyed stretches. Anti-skid/ matt finish tiles on the footpath and Kerb (curb) were absent in 75% (24 nos.) of the thirty-two surveyed stretches.

Although Manholes are present in each of the thirty-two surveyed stretches. The 'drain type' manholes are flushed with the pavement surface in 87.5% (28 nos.). In 71.9% (23 nos.) of the thirty-two surveyed stretches, the 'grating' type manholes are sited away from the respective pedestrian walkway.

In 71.9% (23 nos.), Kerb (curb) alongside surveyed stretches was observed. Among the thirty-two surveyed stretches, the Kerb (curb) was not at a height of more than 150 mm from the road in 75% (24 nos.). Additionally, the Kerb (curb) ramps present in the 32 stretches neither possess a minimum width of 1200 mm nor include a tactile warning (refer to **Figure 51**). Concerning this, a cornered Kerb (curb) radius of more than 600 mm was also not present in the thirty-two surveyed stretches.

'At-grade' pedestrian crossing (MID-BLOCK crossing) at intersections along the walkway was present in all the thirty-two surveyed stretches since the delineation of survey stretches was made by fragmenting the footpath from one end of a street's entrance to the entrance of the next street. Signalized crossings, on the contrary, were present in 50% (16 nos.) of the thirty-two surveyed stretches. Except in one stretch, signalized stretch were working at 46.89% (15 nos.). Audio signals were not present in 96.9% (31 nos.) of the surveyed stretches.

In 34.4% (11 nos.) of the surveyed stretches, street furniture was present. Additionally, in 25% (8 nos.) of the stretches, the street furniture had knee clearance of a minimum of 700 mm and wheelchair space of 1000 mm.

Along similar lines, the stretches did not include fire hydrants or security cameras.

In all the thirty-two surveyed stretches, additional inclusive features like street signage, bicycle track, and public drinking water facility were absent. However, street art was present in one (3.1%) of the surveyed stretch.

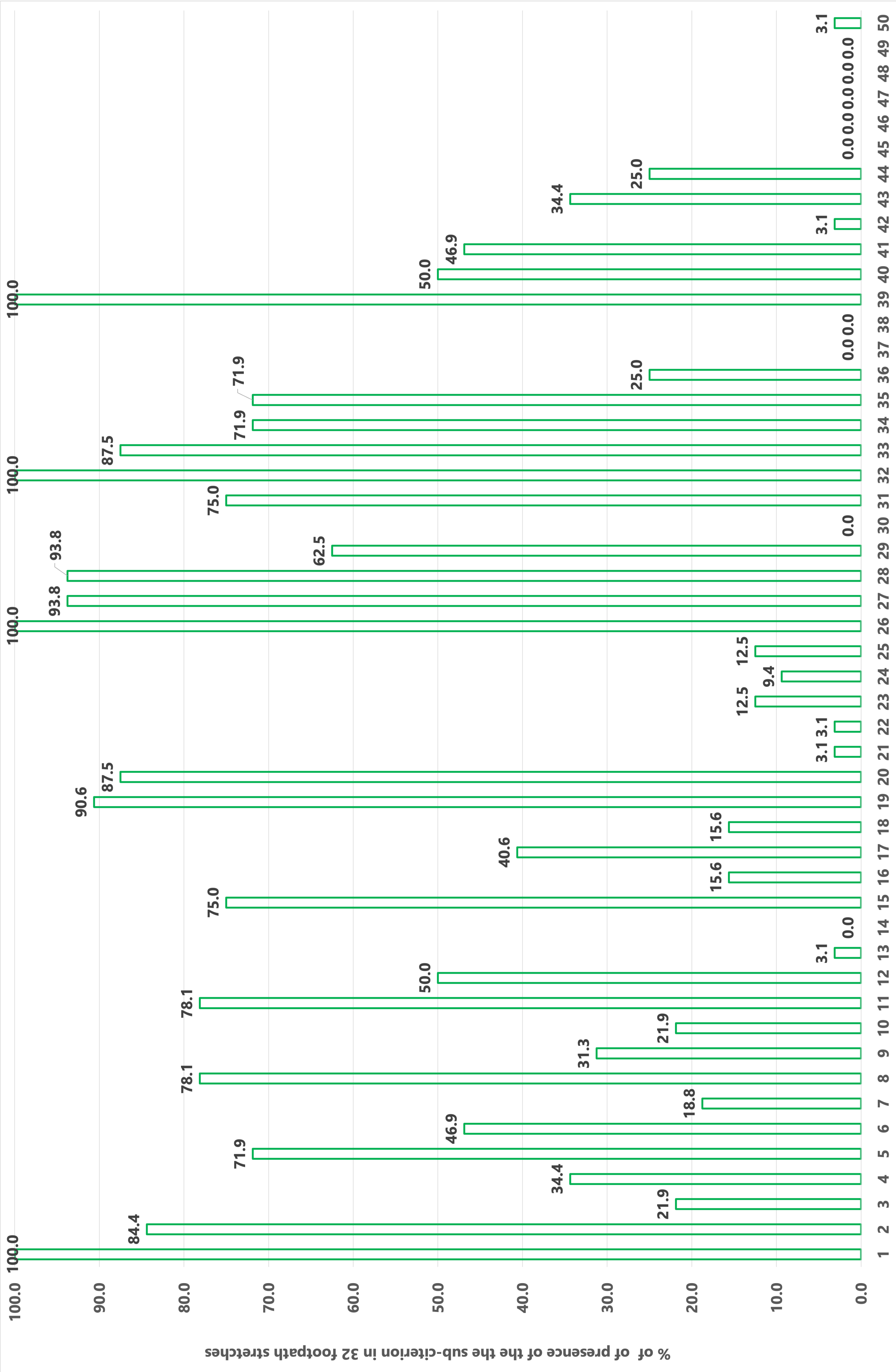


**Figure 45.** Percentage of the presence of the 50 sub-criteria for the total study area.



***[From left]***

**Figure 46.** Footpath Obstruction.

**Figure 47.** People who are homeless.

**Figure 48.** Open Public Bath.

**Figure 49.** Footpaths (and railings) are blocked by the encroachment.


*[From left]*

**Figure 50.** Streetlights inside footpath.

**Figure 51.** Improper Kerb.

The total (cumulative) accessibility score of each footpath stretch is enlisted in **Table 8**.

**Table 8.** Framework for internal consistency.

| S. No | Surveyed Stretch | Total Accessibility Score *(maximum score is +20/ minimum score is -20)* |
|---|---|---|
| **1** | Nirmal Chandra Dey Street | -5.00 |
| **2** | Bowbazar Crossing to New Bowbazar Lane | -3.50 |
| **3** | New Bowbazar lane | 0.00 |
| **4** | New Bowbazar Lane to Kenderdine Lane | -7.50 |
| **5** | Kenderdine Lane | -0.50 |
| **6** | Kenderdine Lane to Central Avenue | -6.00 |
| **7** | Central Avenue (GATE 4: Yogayog Bhawan) | -5.00 |
| **8** | Central Metro (GATE 1: Indian Airlines) | -3.00 |
| **9** | Central Avenue to Bow Street | -3.00 |
| **10** | Bow Street | 2.00 |
| **11** | Bow Street to Metcalfe Street | -3.00 |
| **12** | Metcalfe Street | 0.00 |
| **13** | Metcalfe Street to Bentinck Street | -3.50 |
| **14** | Bentinck Street | -5.50 |
| **15** | Rabindra Sarani Rd. | -2.50 |
| **16** | Rabindra Sarani Rd. to Chatawalla Gully | -2.50 |
| **17** | Chatawalla Gully | 0.00 |
| **18** | Chatawalla Gully to Phears Bye Lane | -1.50 |
| **19** | Phears Bye Lane | -1.50 |
| **20** | Phears Bye Lane to Phears Lane | -5.00 |
| **21** | Phears Lane | 0.50 |

| | | |
|---|---|---|
| **22** | Phears Lane to Giri Babu lane | -2.50 |
| **23** | Giri Babu lane | -2.50 |
| **24** | Giri Babu lane to Central Avenue | -5.50 |
| **25** | Central Metro (GATE 2: Lalbazar) | -2.50 |
| **26** | Central Avenue (GATE 3: RITES) | -3.50 |
| **27** | Central Avenue to Gangadhar Babu Lane | -9.50 |
| **28** | Gangadhar Babu lane | -2.50 |
| **29** | Gangadhar Babu Lane to Bibi Rozio Lane | -9.50 |
| **30** | Bibi Rozio Lane | -6.00 |
| **31** | Bibi Rozio Lane to Bowbazar Crossing | -2.00 |
| **32** | College Street | -11.50 |

Hereafter, the total accessibility score of the 32 survey locations concerning the 18 criteria (or, 50 sub-criteria) was used for the Cronbach's Alpha analysis of internal consistency using IBM® SPSS® Statistics 26.0 version. The Cronbach's Alpha for the dataset is 0.901, reflecting the highest order of internal consistency. Thus, this part of the research concludes that the overall accessibility condition of the footpaths is similar.

### 3.3.3. Pedestrian Survey

On average (arithmetic mean value), the recorded Peak Hour (15-min interval) Pedestrian Count in the Study Area was 223 people in the morning and 201 people in the evening, respectively. The high pedestrian flow in the morning peak hour can be attributed to the presence of morning schools, offices, churches, and related informal vending during those hours. However, the flow is consistent during the evening due to the crowd returning from offices, shops, and informal vending too. Nearly 800 pedestrians (derived by multiplying the 'Peak Hours 15-minute interval Pedestrian Count' by four) commute through the study area per hour (during peak hours).

Thus, this part of Kolkata can be considered successful in terms of pedestrian traffic which creates the study interesting because the pedestrian traffic is predominantly able-bodied individuals. The debate which this chapter poses is how much improvement will happen if the needs of specially-abled and/or elderly are implemented in the present infrastructural condition through universal accessibility.

## 3.4. DISCUSSION

The thirty-two surveyed stretches were scored as per the methodology elaborated in **Table** 7. As per the explanation within **Segment 3.2** (Data and Methods) of this chapter and in **Table 7**, for any study stretch surveyed using the framework used for this chapter, the consolidated highest score can be twenty (and subsequently, the lowest can be -20). In relation to this, none of the thirty-two surveyed stretches in this research had a positive score. Thus, the hypothesis considered for this chapter that the footpaths in the old core areas of Kolkata are poor in terms of universal mobility standards holds true.

**Table 9** represents the surveyed stretches with their corresponding: (a) footpath width, (b) infrastructure score (represented in the percentage), and (c) peak hour volume (average of morning and evening peak hours per 15 min). Footpath width (represented in mm) was measured physically during surveys of the footpaths. The infrastructure score (in %) is calculated by dividing the 'total accessibility score of all 18 criteria (or, 50 sub-criteria) for each of the 32 stretches' by the maximum accessibility score (i.e., 20) and multiplying by 100. The peak hour volume (recorded on-site during the primary survey) is expressed as the average of the morning and evening peak hour pedestrian volume.

**Table 9.** Stretch-wise data summary.

| S. No | Surveyed Stretch | Footpath Width (in mm) | Infrastructure score (in %) | Peak Hour Volume (average of morning and evening peak hours per 15 min) |
|---|---|---|---|---|
| 1 | Nirmal Chandra Dey Street | 2100 | -25.00 | 178 |
| 2 | Bowbazar Crossing to New Bowbazar Lane | 2000 | -17.50 | 272 |
| 3 | New Bowbazar lane | 5000 | 0.00 | 245 |
| 4 | New Bowbazar Lane to Kenderdine Lane | 2000 | -37.50 | 198 |
| 5 | Kenderdine Lane | 3000 | -2.50 | 210 |
| 6 | Kenderdine Lane to Central Avenue | 2100 | -30.00 | 178 |
| 7 | Central Avenue (GATE 4: Yogayog Bhawan) | 2100 | -25.00 | 99 |
| 8 | Central Metro (GATE 1: Indian Airlines) | 2100 | -15.00 | 230 |
| 9 | Central Avenue to Bow Street | 2000 | -15.00 | 303 |
| 10 | Bow Street | 3800 | 10.00 | 312 |
| 11 | Bow Street to Metcalfe Street | 2000 | -15.00 | 273 |
| 12 | Metcalfe Street | 3500 | 0.00 | 240 |
| 13 | Metcalfe Street to Bentinck Street | 2100 | -17.50 | 247 |
| 14 | Bentinck Street | 2100 | -27.50 | 281 |
| 15 | Rabindra Sarani Rd. | 1900 | -12.50 | 245 |
| 16 | Rabindra Sarani Rd. to Chatawalla Gully | 2100 | -12.50 | 266 |
| 17 | Chatawalla Gully | 3500 | 0.00 | 254 |
| 18 | Chatawalla Gully to Phears Bye Lane | 2000 | -7.50 | 259 |
| 19 | Phears Bye Lane | 2000 | -7.50 | 194 |
| 20 | Phears Bye Lane to Phears Lane | 2000 | -25.00 | 261 |
| 21 | Phears Lane | 4800 | 2.50 | 273 |
| 22 | Phears Lane to Giri Babu lane | 2100 | -12.50 | 288 |
| 23 | Giri Babu lane | 2400 | -12.50 | 215 |
| 24 | Giri Babu lane to Central Avenue | 2100 | -27.50 | 217 |
| 25 | Central Metro (GATE 2: Lalbazar) | 1900 | -12.50 | 196 |
| 26 | Central Avenue (GATE 3: RITES) | 1800 | -17.50 | 89 |
| 27 | Central Avenue to Gangadhar Babu Lane | 2100 | -47.50 | 147 |
| 28 | Gangadhar Babu lane | 5000 | -12.50 | 160 |
| 29 | Gangadhar Babu Lane to Bibi Rozio Lane | 2000 | -47.50 | 191 |
| 30 | Bibi Rozio Lane | 1800 | -30.00 | 143 |
| 31 | Bibi Rozio Lane to Bowbazar Crossing | 1900 | -10.00 | 142 |
| 32 | College Street | 1900 | -57.50 | 256 |

[N.B.: The 'width' refers to the predominant width that the footpath has and was measured physically at different sections of the same footpath during the primary survey. The respective widths were measured physically on-site during the primary survey. The 'length' refers to the measurement of the external Kerb (curb) of the footpath that is connected to the adjacent road and was measured using satellite imagery.].

Finally, Pearson's Correlation with a 95% confidence interval was used to interpret the relationship between (a) footpath width, (b) infrastructure score, and (c) pedestrian count (peak hour volume). **Table 10** shows Pearson's Correlation:

**Table 10.** The Correlation between the factors.

| | Footpath Width | Infrastructure Score | Peak Hour Volume |
|---|---|---|---|
| **Footpath Width** | - | 0.547 | 0.183 |
| **Infrastructure Score** | 0.547 | - | 0.328 |
| **Peak Hour Volume** | 0.183 | 0.328 | - |

As observed in **Table 10**, a significant correlation exists between the footpath width and the infrastructural condition. This indicates that the width of a footpath plays a significant role in determining the level of infrastructure that is present in the footpath of the surveyed stretch.

## 3.5. CONCLUSION

On similar lines, 78.1% of the case area had a footpath width of less than 2500 mm. Furthermore, the traffic intensity map prepared by E.P. Richards in the year 1913 for Calcutta (previous name of Kolkata) Improvement Trust shows that even 100 years ago, the study area maintained a traffic intensity of 500 vehicles per hour. Subsequently, in this case, area, there has been an addition of the Metro Rail (underground rail/ subway) in the early 1990s; followed by mobile application-based rental cab services post-2000s. However, the case area has had largely the same R.O.W. since 1913. In relation to this, a vehicular traffic count survey conducted in the month of September 2020 shows the number of total vehicles in peak hours as: (a) 2,110 vehicles in Bowbazar Crossing, (b) 5,483 vehicles in Central Avenue Crossing, and (c) 11,211 vehicles in Bentinck Street Crossing. It should also be noted that due to the coronavirus pandemic, several building uses (including schools and private institutions) were not functioning regularly, thus considerably reducing the peak hour vehicular traffic volume recorded. Thus, the pieces of evidence depict that despite having the same density, the number of vehicles per hour has increased manifold; thus, putting infrastructural pressure (specifically walkability) on the sidewalks. Indian cities reflect a multiplicity of administrative settings and an inherently complex social model of disability. Next, it is important to discuss how the findings of this chapter helps to improve the conditions seen in **Figures 46-51** and other instances explained in **Section 3.3.2**.

The first suggestion is directed toward the ward-level/ legislative assembly-level administration. The infrastructural level deficiency can be improved on a case-by-case basis using the Councillor (head of the administrative ward)/ MLA (minister of the legislative assembly) fund. Although this process is quick, it will not contribute to the improvement of the overall accessibility of the stretch.

The second suggestion is primarily directed toward the urban administration (in this case, KMC). The case area is in the core of an old city that has an organically planned and well-established urban form. Thus, in cases where the footpath width cannot be altered to improve the infrastructural quality of the stretch, the development approach cannot be the regular precinct-based approach to urban development. The ideal approach for this case area would be the 'Case-Based approach' (based on the score of the individual surveyed stretch evaluated using the research framework). This approach is based on the prioritization of the most problematic areas in the surveyed stretch. The stretches with the lowest scores can be prioritized while taking up infrastructural assignments. Each stretch can be improved as much as possible (based on the specific context) before taking up the next stretch.

The third suggestion is directed towards researchers in the field of architecture and planning. In future research in the same domain in the same case area, the factor of footpath width should be prioritized over other factors.

Furthermore, the responsibility for ensuring accessibility in old core cities is allocated to specific departments in the Urban/ Municipal administrative setting, which shall enhance the chances of making a citizen-friendly pedestrian streetscape. This process, in turn, will ensure the achievement of UN-SDG 11: Sustainable Cities and Communities. Finally, the investigation of this chapter indicates that the theoretical, ideological, and methodological learnings from this chapter (results furnished in this chapter and methodology for future research) can be referred to by researchers for further investigation into accessibility issues in old core Indian cities.

In the next chapter, the findings of this chapter by assessing 32 footpath stretches in Kolkata are further verified by assessing 69 other footpaths from Jaipur, Jodhpur, Nagpur, Hyderabad, and Chennai. The accessibility checklist used in this chapter is further modified and the highest accessibility score for each footpath in the next chapter was 16.50 in comparison to the highest score of 20 in this chapter.

# CHAPTER 04

- **Title:** Testing the research hypothesis in footpaths of old Indian cities other than case area
- **Related Publication:** The contents of this chapter were published as: **G. Das Mahapatra**, S. Mori, and R. Nomura, 'Reviewing the Universal Mobility of the Footpaths in the Centers of Historic Indian Cities through Field Survey,' *Sustainability*, vol. 15, no. 10, p. 8039, May. 2021, DOI: 10.3390/su15108039. [Journal Impact Factor = 3.9]
- **Scope:** To furnish a process-oriented approach in the realm of accessibility where the approach is still product oriented.
- **Objectives:** To determine the degree of accessibility possible in the footpaths of core areas of an old Indian city by proposing an ideal accessibility audit checklist.
- **Focus:** Universal Mobility in the core of old Indian cities (survey based).
- **Research Questions:** Can core Indian cities be made inclusive in terms of Universal Mobility?
- **Data Set:** (a) footpaths in Jaipur (7 footpaths); (b) footpaths in Jodhpur (16 footpaths); (c) footpaths in Nagpur (12 footpaths); (d) footpaths in Hyderabad (9 footpaths); (e) footpaths in Chennai (25 footpaths).
- **Keywords:** Universal Design; Universal Mobility; Footpath; India; Old Cities.

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**'There is no such thing as an average user.'**

***- Susana Lauren***

# 4. TESTING THE RESEARCH HYPOTHESIS IN FOOTPATHS OF OLD INDIAN CITIES OTHER THAN CASE AREA

In this chapter, 69 footpath stretches from five different old cities in India were evaluated in regard to their accessibility conditions.

India presents classic examples of cities with historic and degraded pedestrian areas. Transformation dynamics plays a major role in the complex urban structure of historic Indian cities, which, in turn, often creates unfavourable pedestrian conditions. [178] In the aforementioned sentence, the term 'complex' specifically refers to conditions such as (a) minimal temporal changes in the centres of historic cities, (b) organic mixed-use development, and (c) encroached footpaths. Universal mobility (facilities that cater to the needs of able-bodied as well as specially-abled people) is a determinant whose improvement can positively influence the decaying centres of historic core cities in India.

Even institutionally, significant challenges in transforming existing historic cities into age-friendly/disability-friendly cities exists. [179] In particular, cities with historic centres face major challenges in the implementation of any kind of development plan for restoration/revitalization/rejuvenation at the street level. [180, 181] The pedestrian movement of the specially-abled and elderly is significantly impacted by poor/unsuitable pedestrian zone quality, [182] which is not desirable with respect to Sustainable Development Goal Number 11 (target numbers 11.2 and 11.7). [183]

Thus, it is also evident that every successful streetscape has recognized that shortcomings in universal design create a negative impact on the commuting of the elderly and specially-abled, [184] in addition to being a factor in pedestrian accidents. [185,186] Since mobility remains a major challenge for the elderly and specially-abled population, [187] the challenge in this research is to define the degree of accessibility[188] and the ways in which the experience [189] of a street can be similar for those who are able-bodied as well as specially-abled. The 'degree of accessibility' in this research refers to the possibility of accessible options available in the surveyed stretches, and the extent to which accessibility may be increased during redevelopment. The 'experience', in the context of this research, refers to how pedestrians perceive the footpaths, cognitively and physically.

## 4.1. RESEARCH BACKGROUND

In this chapter, the factors preferable for implementing universal mobility were further subjected to a case-by-case investigation in five other historic cities in India. The hypothesis, considered for this chapter is that the footpaths in the centres of historic urban areas in India are poor in terms of universal mobility. This research focuses on understanding which factors are responsible for reducing the universal mobility standards in footpaths in the centres of historic urban areas in India.

This chapter aims to investigate the universal mobility conditions of the footpaths in the centres of historic urban areas in India. The objectives of the chapter were: (a) to determine the extent of accessibility in the footpaths in the centres of historic core cities in India, and (b) to check the correlation between the accessibility score and numerous indicators of universal mobility, such as footpath width. The scope of this research includes an assessment at the footpath level and 19 defined criteria (including 52 indicators) for analysis. The limitations of this research are that it is limited to the historic Indian cities with at least 100 years of documented heritage and also, the investigation is to be only at the pedestrian level.

In the publication titled 'Universal Mobility in Old Core Cities of India: People's Perception', it was depicted that the walkability conditions in the footpaths of old cities in India are poor in terms of both basic walkability standards and Universal Mobility considerations as well.[190] Along similar lines, in the publication 'Inclusivity in Spatial Standards: A Changing Paradigm in Accessibility Scenario in India', the challenges of implementing universal design standards in the mobility sector in India were critically appraised.[191] Additionally, in the work titled 'Re-inventing Urban Spaces by accessing accessibility in old city core - A Case of Kolkata', and 'Accessibility in core areas of cities; Case Study: Road Stretches in Shimla, Himachal Pradesh, India' the contextual factors of accessibility in the core of old Indian cities were analysed.[192,193] Furthermore, in the book 'Reinterpreting Urban Fabric in Cities with Living Heritage: The Case of Kolkata' the uniqueness of the core of old Indian cities was documented.[194]

## 4.2. MATERIALS AND METHODS

To assess the baseline situation of footpaths in the centres of historic core cities in India, a survey was conducted from 11 December 2021, till 30 March 2022. The case areas considered for this research are historic cities which are at least 100 years old. Historic cities in India are different from most historic cities in the world. For this research, cities that evolved during the early 18th century (the start of British rule) are referred to as 'historic cities'. The space structures in historic cities of developing nations, such as India, are complex, due to their historic origin. These central areas of these cities are characterised by high density, mixed land use, and a lack of space allocated to infrastructure compared to the rest of the city.

However, numerous cities in India fits the aforementioned criteria. This research also had to take into consideration the availability of personnel in India who would be able to assist in acquiring survey permissions and establishing contact with locals.

Thus, the Indian cities where the survey was conducted, as shown in **Figure 52**, were: (a) Jodhpur (located in the western part of India; founded in mid-15th century CE), (b) Jaipur (located in the western part of India; founded in early 18th century CE), (c) Hyderabad (located in the central part of India; founded in late 16th century CE), (d) Chennai (located in the southern part of India; founded in early 17th century CE), and (e) Nagpur (located in the central part of India; founded in 10th century CE). Thereafter, using the 'paradigmatic case sampling' sub-type of the 'purposive sampling' technique, the rhizome (temporal boundary) selected for the survey was 69 footpath stretches from the centres of the selected cities, with a total length of 15.48 km. Paradigmatic case sampling is considered when the researcher has focused the research on one specific category, such as historic cities in this case. Furthermore, the footpath stretches complied with the following conditions: (a) located at the city centre, (b) a commercially important location, (c) predominantly mixed-use buildings, and (d) easy access through public transport.


**Figure 52:** Map of India showing the survey locations [Source of the map in the centre top: Overlaying on the open-source data available on https://www.mapsofindia.com.]

The details of individual locations (Locality name, number of surveyed stretches of footpath, total length of surveyed stretches, and average width of the footpath) are tabulated below in **Table 11**.

**Table 11:** Details of Survey Locations.

| S. No. | City | Locality | Number of Footpaths Stretches | Total Length of Stretch (in m) | Average Width of the Footpath (in m) |
|---|---|---|---|---|---|
| 1 | Jodhpur | Sardar Market | 16 | 443.60 | 1.97 |
| 2 | Jaipur | Bapu Bazaar | 07 | 897.90 | 1.20 |
| 3 | Hyderabad | Charminar | 09 | 9002.70 | 2.43 |
| 4 | Chennai | Mylapore | 25 | 2564.20 | 1.44 |
| 5 | Nagpur | Gandhisagar Lake | 12 | 2571.40 | 1.53 |

Finally, the research methodology adopted for this research is illustrated in **Figure 53**. The research is primarily divided into three segments: (a) Stage 1, consisting of the literature review, (b)

Stage 2, consisting of the primary survey of the case areas; and (c) Stage 3, consisting of the summary of the findings. All these segments finally led to the confirmation of the hypothesis.

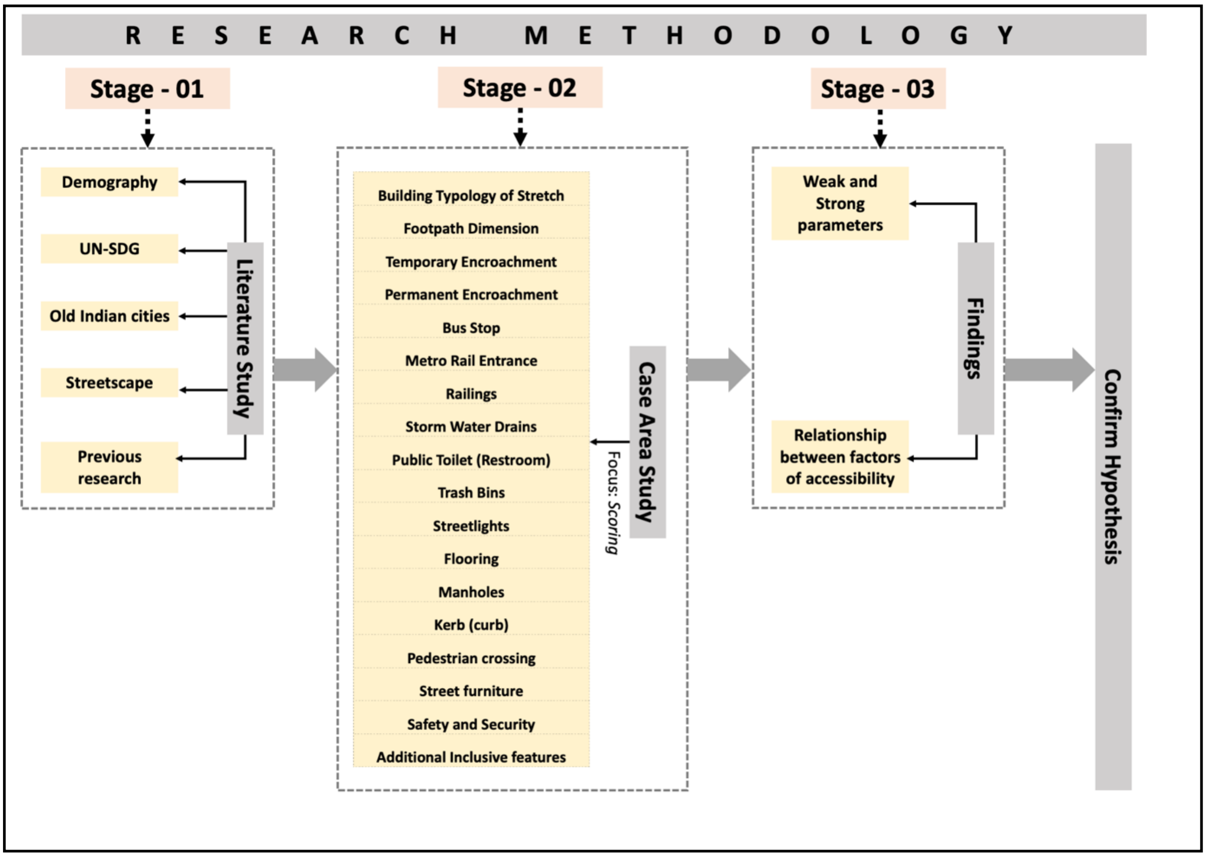


**Figure 53:** Research Methodology.

### 4.2.1. Survey questionnaire and scoring pattern

Before conducting this survey, a pilot survey was conducted in Kolkata, and the findings were published.[195] A survey format, consisting of 19 defined criteria (comprising 52 indicators, including one contextual criterion), was used for this survey. The choice of survey technique was observational, using a structured dichotomous questionnaire. The questionnaire is available at https://forms.gle/hDVduWAARes75JrbA (accessed on 25 February 2023 and available in **Annexure K**).

The 19 categorical variables (criteria) are as follows: (a) building typology of stretch, (b) footpath dimensions, (c) temporary encroachment, (d) permanent encroachment, (e) bus stop, (f) metro rail entrance, (g) railings, (h) storm water drains, (i) public toilet, (j) trash bins, (k) street lights, (l) flooring, (m) manholes, (n) Kerb (curb), (o) pedestrian crossing, (p) street furniture, (q) safety and security (surveillance and fire-safety oriented), (r) additional inclusive features, and (s) contextual factors. Within the 19 criteria, 52 indicators can be distinguished into independent and dependent variables, respectively. Similar factors were also used in the previous chapter to assess the accessibility of 32 footpath stretches in Kolkata. However, the addition of ''contextual factors' was done in this chapter for a more detailed assessment.

As an example, one of the categorical variables (criteria) 'railings', has associated indicators as: (a) the presence of a railing (pedestrian guard rails) on the edge of the footpath, and (b) the presence of thorough railings with a minimum of 150 cm height and clear visibility. In this case, the first indicator 'presence of railing (pedestrian guard rails) on the edge of the footpath' is independent of any factor, which means that whether a railing is present or absent is the decisive factor in the assessment. However, regarding the second indicator, i.e., 'presence of thorough railings with a minimum of 150 cm height and clear visibility', the condition of the railing can be assessed only if the railing is present at all. This means that if a railing is not present in the first place, then the functionality of the railing cannot be assessed at all. Therefore, this indicator is dependent on the previous sub-criteria. Since the indicator, 'presence of railing (pedestrian guard rails) on the edge of the footpath', is an independent variable, and 'presence of thorough railings with a minimum of 150 cm height and clear visibility' is a dependent variable, their weighting would be different.

Thus, the indicators were scored based on their associated variable type (i.e., independent, or dependent). If the associated variable is an independent variable, the presence of an indicator is scored as '+0.50'. Along similar lines, if the associated variable is a dependent variable, an indicator is scored as '+0.25'. Similarly, the absence of an indicator is scored as '−0.50' for independent variables and '−0.25' for dependent variables, respectively. Thus, weighting is used for further analysis. It should be noted that although all these indicators are not equally important for pedestrian activity, the negative impact of any one of them could lead to inadequate universal mobility standards. Thus, similar indicators are given equal weighting, i.e., +0.50 for the independent variable and +0.25 for the dependent variable.

**Table 12** shows the variables (criteria and indicator), types of associated variables (independent/dependent), scoring logic, and the individual scores used in this research. For any study stretch surveyed using this framework, the consolidated highest score can be +16.50 (and subsequently, the lowest can be −16.50).

**Table 12:** Details of Variables (Criteria and Indicator), Variable Type (Independent/Dependent), Scoring Logic, and the Individual Scores used in the research.

| S. No. | Criterion | Indicator | Variable Type | Scoring Logic | Individual Associated Score | |
|---|---|---|---|---|---|---|
| | | | | | If Yes | If No |
| 1 | Building Typology of Stretch | (1) Buildings with two or more uses | Independent | Beneficial if Absent | −0.50 | +0.50 |
| | | (2) Heritage/historic buildings | Independent | Beneficial if Absent | −0.50 | +0.50 |
| 2 | Footpath Dimension | (3) Footpath Width > 2500 mm | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (4) Unobstructed width of 1800 mm | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (5) Unobstructed clear height of 2200 mm | Independent | Beneficial if Present | +0.50 | −0.50 |
| 3 | Temporary Encroachment | (6) Informal Vendors/Beggar/homeless/child labour occurring during the day/night | Independent | Beneficial if Absent | −0.50 | +0.50 |
| | | (7) Informal Vendors/ hawkers away from the line of pedestrian flow (if Vendors are present) | Dependent | Beneficial if Absent | −0.25 | +0.25 |
| | | (8) Beggar/homeless/child labour occupying a part of the footpath as their homes | Dependent | Beneficial if Absent | −0.25 | +0.25 |
| 4 | Permanent Encroachment | (9) Place of religious interest (temple/churches/mosque) within or along the footpath | Independent | Beneficial if Absent | −0.50 | +0.50 |
| | | (10) Encroachment by existing establishments on to the footpath | Independent | Beneficial if Absent | −0.50 | +0.50 |
| | | (11) 'Communal open bath' within or along the footpath | Independent | Beneficial if Absent | −0.50 | +0.50 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | Bus Stop | (12) Informal stoppage for Bus | Independent | Beneficial if Absent | −0.50 | +0.50 |
| | | (13) Bus Shelter (if Bus Stops are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| | | (14) Is 'Bus Shelter' functional (if Bus Shelter is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 6 | Metro Rail Entrance | (15) Entrance connected to the footpath | Independent | Beneficial if Absent | −0.50 | +0.50 |
| | | (16) Is the Entrance functional (if Metro Rail Entrance is present)? | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 7 | Railings | (17) Railings (pedestrian guard rails) on the edge of the footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (18) Thorough railings with minimum 150 cm height and clear visibility (if Railings are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 8 | Storm Water Drains | (19) Storm Water Drains along footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (20) Functional Storm Water Drains (if Storm Water Drains are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 9 | Public Toilet (Restroom) | (21) Public Toilet within the footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (22) Functional Public Toilet (if Public Toilet is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 10 | Trash Bins | (23) Trash Bins within the footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (24) Functional Trash Bins (if Trash Bins are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| | | (25) Trash Bins located away from the line of pedestrian flow (if Trash Bins are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 11 | Streetlights | (26) Streetlights within the footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (27) Functional Street Lights (if Street Lights are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| | | (28) Light Poles situated away from pedestrian flow or, if present, demarcated with a tactile marking of a minimum of 60 cm around them (if Street Lights are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 12 | Flooring | (29) Satisfactory Cross Fall (i.e., <1:50) | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (30) Tactile Marking | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (31) Anti-skid/matte-finish tiles in footpath and Curb | Independent | Beneficial if Present | +0.50 | −0.50 |
| 13 | Manholes | (32) Manholes within/along the footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (33) Drain-type manholes flush with the pavement surface (if Manholes are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | (34) Grating-type manholes situated away from the pedestrian walkway (if Manholes are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 14 | Kerb (Curb) | (35) Curb on the edge of footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (36) Curb Height of no more than 150 mm from the road level (if Curb is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| | | (37) Minimum 1200 mm width and tactile warning (if Curb is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| | | (38) Cornered Curb radius more than 6 m (if Curb is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 15 | Pedestrian crossing | (39) 'At-grade' pedestrian crossing (MID-BLOCK crossing) at all intersections along the walkway | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (40) Signalized Intersection (if Crossing is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| | | (41) Functional Signalized Intersection (if Crossing is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| | | (42) Audio Signal (if Crossing is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 16 | Street furniture | (43) Street Furniture in the footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (44) Street furniture having a knee clearance of a minimum of 70 cm and wheelchair space of 100 cm (if Street Furniture is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 17 | Safety and Security | (45) Fire Hydrant | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (46) Security Camera | Independent | Beneficial if Present | +0.50 | −0.50 |
| 18 | Additional Inclusive features | (47) Signage | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (48) Bicycle Track | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (49) Public Drinking Water Facility | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (50) Street Art/Sculpture | Independent | Beneficial if Present | +0.50 | −0.50 |
| 19 | Contextual Factors | (51) Is the surveyed location within a high-pedestrian zone? | Independent | Beneficial if Absent | −0.50 | +0.50 |
| | | (52) Is/are there any other contextual factors, such as potholes, parking, etc., affecting the high-pedestrian zone? | Dependent | Beneficial if Absent | −0.25 | +0.25 |
| | | **Maximum/ Minimum Total Score** | | | + 16.50 | -16.50 |

### 4.2.2. Observation

The average footpath width among the 69 footpath-stretches across the 5 selected cities, is 1.71m. **Table 13** elaborates on the findings from the 69 footpath stretches across the 5 selected cities using the 19 criteria-based survey format.

**Table 13:** Observation from surveys.

| S. No. | Category (Parameters) | Findings (Indicator Based) |
|---|---|---|
| **1** | Building Typology | 1. 42.03% had buildings with two or more uses.<br>2. 53.62% had Heritage/historic buildings. |
| **2** | Footpath Dimensions | 3. 15.94% had a Footpath Width >2500 mm.<br>4. 14.49% had an unobstructed width of 1800 mm.<br>5. 52.17% had an unobstructed clear height of 2200 mm. |
| **3** | Temporary Encroachment | 6. 68.12% had Informal Vendors/Beggar/homeless/child labour occurring during day/night.<br>7. 44.93% had Informal Vendors/hawkers away from the line of pedestrian flow (if Vendors are present).<br>8. 24.64% had Beggar/homeless/child labour occupying a part of the footpath as their homes. |
| **4** | Permanent Encroachment | 9. Places of religious interest (temple/churches/mosque) within or along the footpath were present in 15.94%.<br>10. 75.36% had Encroachment by existing establishments onto the footpath is present on 75.36%.<br>11. 'Communal open bath' within or along the footpath were present on 2.90%. |
| **5** | Bus Stop | 12. 11.59% had informal stoppage for Bus.<br>13. 10.14% had Bus Shelter (if Bus Stops).<br>14. In 10.14%, the 'Bus Shelter' was functional (if Bus Shelter is present). |
| **6** | Metro Rail Entrance | 15. In 1.45%, the Entrance was connected to the footpath.<br>16. In 1.45%, the Entrance was functional (if Metro Rail Entrance is present). |
| **7** | Railings (pedestrian guard rails) | 17. 5.80% had railings (pedestrian guard rails) on the edge of the footpath.<br>18. None of them had thorough railings with a minimum 1500 mm height and clear visibility (if Railings are present). |
| **8** | Storm Water Drains | 19. 60.87% had Storm Water Drains along footpaths.<br>20. 2.90% had functional Storm Water Drains (if Storm Water Drains were present). |
| **9** | Public Toilet (Restroom) | 21. 4.35% had Public Toilets within the footpath.<br>22. 2.90% had functional Public Toilets (if Public Toilets are present). |
| **10** | Trash Bins | 23. 18.84% had Trash Bins within the footpath.<br>24. 14.49% were Functional Trash Bins (if Trash Bins were present).<br>25. 7.25% had Trash Bins located away from the line of pedestrian flow (if Trash Bins were present). |
| **11** | Streetlights | 26. 88.41% had Streetlights within the footpath.<br>27. 86.96% had Functional Street Lights (if Street Lights were present).<br>28. 21.74% had Light Poles situated away from pedestrian flow or, if present, demarcated with a tactile marking of a minimum of 600 mm around them (if Street Lights were present). |
| **12** | Flooring | 29. 26.09% had Satisfactory Cross Fall (i.e., <1:50).<br>30. 13.04% had Tactile Marking.<br>31. 57.97% had Anti-skid/matte-finish tiles in footpath and Curb. |
| **13** | Manholes | 32. 60.87% had Manholes within/along the footpath.<br>33. 56.52% had Drain-type manholes flushed with the pavement surface (if Manholes were present). |

| | | |
|---|---|---|
| | | 34. 34.78% had Grating-type manholes sited away from the pedestrian walkway (if Manholes were present). |
| **14** | Kerb (Curb) | 35. 91.30% had a Curb on the edge of the footpath.<br>36. 72.46% had a Curb Height of not more than 150 mm from the road level (if Curb was present).<br>37. 4.35% had a tactile warning (if Curb was present).<br>38. 11.59% had a Curb radius of more than 6m at the corner (if Curb was present). |
| **15** | Pedestrian Crossing | 39. 5.80% had 'At-grade' pedestrian crossing (MID-BLOCK crossing) at all intersections along walkway.<br>40. 10.14% had Signalized Intersection (if Crossing was present).<br>41. 13.04% had Functional Signalized Intersection (if Crossing was present).<br>42. 1.45% had Audio Signal (if Crossing was present). |
| **16** | Street Furniture | 43. 7.25% had Street Furniture on the footpath.<br>44. 1.45% had Street furniture having a knee clearance of a minimum of 700 mm and wheelchair space of 1000 mm (if Street Furniture was present). |
| **17** | Safety and Security | 45. 1.45% had a Fire Hydrant.<br>46. 36.23% had a Security Camera. |
| **18** | Additional Inclusive Features | 47. 27.54% had Signage.<br>48. 2.90% had Bicycle Track.<br>49. 2.90% had Public Drinking Water Facilities.<br>50. 5.80% had Street Art. |
| **19** | Contextual Factors | 51. 100% were located within high-pedestrian zone.<br>52. 42.03% had contextual factors (such as potholes, terrain, etc.). |

### 4.2.3. Results

In continuation of the explanation in the previous sections, the step after the observation was the scoring of the footpath stretches. This was conducted in two parts. The first part was observing the results from the perspective/ consideration of the 52 indicators. The second part was understanding the results from the perspective of the 69 footpaths.

Figure 3 represents the score of the 52 individual indicators, across the 69 footpath stretches, in the 5 cities in India. The values represented across each indicator in **Figure 54** were derived by using the following formula:

**Equation 01:** Formula to calculate the Percentage Score of the 52 indicators across 69 footpaths in India.

$$S_P = (S_T/S_M) \times 100$$

where,

$S_P$ = percentage score of individual indicators across the entire case area, or 69 footpaths

$S_T$ = summation of the score of each indicator across the entire case area, or 69 footpaths

$S_M$ = maximum score of the indicators across the entire case area, or 69 footpaths

The details of this calculation are summarised in **Annexure L** and a summary is illustrated in **Figure 54**. **Figure 54** indicates that only 32.69% (17 out of 52) of the parameters are in the positive score domain, out of which only 15.38% (8 out of 52) scored above the 50% mark.

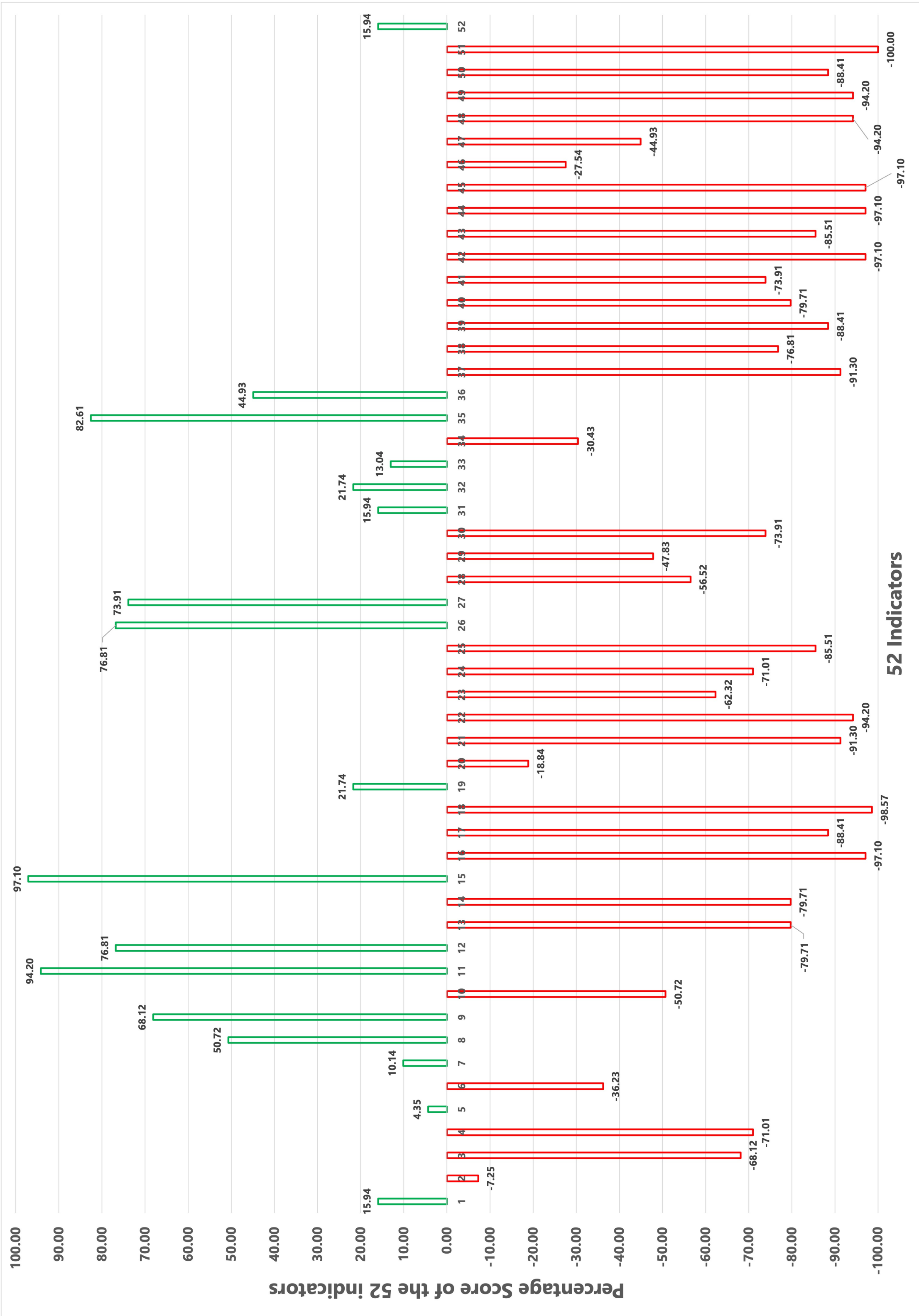


**Figure 54:** Percentage Score of the 52 indicators across 69 footpaths in India *(read the figure in landscape format)*

**Figure 55** represents the score of the 69 footpath stretches in the 5 cities in India, depending on the presence/absence of the parameter (with indicators). The values represented across each indicator in **Figure 55** were derived by using the following formula:

**Equation 02:** Formula to calculate the percentage score of 69 footpath stretches in 5 cities in India, depending on the presence/absence of the parameter.

$$A = (B/C) \times 100$$

where,

A = percentage score of each 69 footpaths

B = individual score of 69 footpaths

C = maximum positive score of a footpath, i.e., 16.5

The details of this calculation are summarised in **Annexure M** and a summary is illustrated in **Figure 55**. Furthermore, it is evident from **Figure 55** that, if evaluated with the standard parameters of accessibility, the conditions of the surveyed footpath stretches are extremely poor. Only 4.35% (3 instances) of the surveyed stretches are in the positive score domain; the rest are in the negative, implying dilapidated footpath conditions.

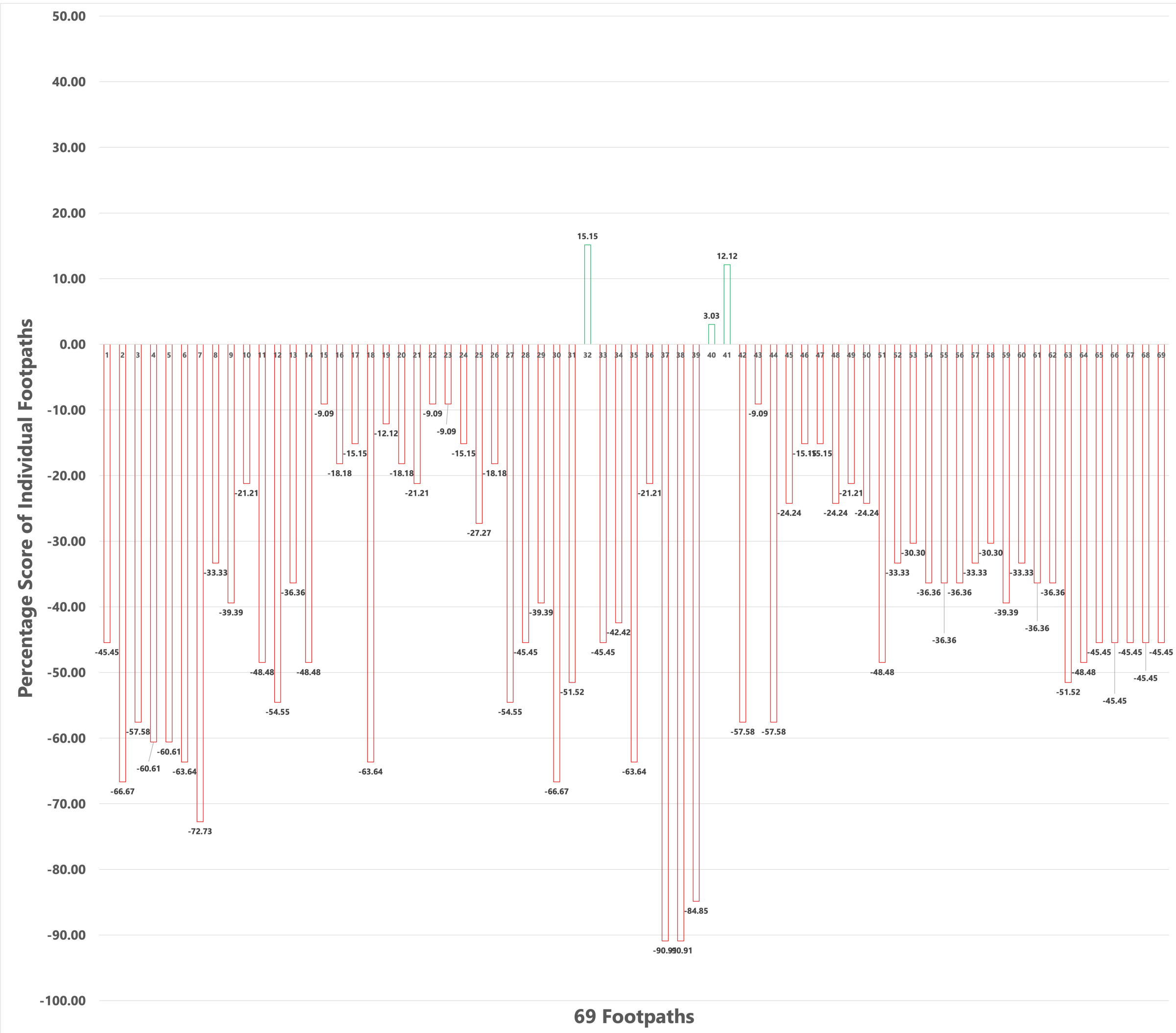


**Figure 55:** The percentage score of 69 footpath stretches in 5 cities in India, depending on the presence/absence of the parameter.

### 4.2.4. Data Validation

The next step was to validate the internal consistency of the data to validate the performance of the indicators in the 69 footpaths, across the 5 case cities. The average of the accessibility scores of each parameter, for each of the five case cities, were first enlisted in **Table 14**.

**Table 14:** Average consolidated scores for each parameter for the 5 cities.

| S. No. | Parameters | Jodhpur | Jaipur | Hyderabad | Chennai | Nagpur |
|---|---|---|---|---|---|---|
| **1** | Building Typology | −0.143 | −0.143 | 0.444 | 0.240 | −0.333 |
| **2** | Footpath Dimension | −0.500 | −0.500 | −1.056 | −0.700 | −0.667 |
| **3** | Temporary Encroachment | −0.429 | −0.429 | 0.444 | −0.020 | −0.292 |
| **4** | Permanent Encroachment | 0.500 | 0.500 | 0.611 | 0.500 | 0.417 |
| **5** | Bus Stop | 0.000 | 0.000 | 0.000 | −0.040 | 0.000 |
| **6** | Metro Rail | 0.250 | 0.250 | 0.250 | 0.230 | 0.250 |
| **7** | Railings | −0.750 | −0.750 | −0.750 | −0.590 | −0.750 |
| **8** | SWD | 0.250 | 0.250 | −0.639 | −0.010 | −0.125 |
| **9** | Public Toilet | −0.750 | −0.750 | −0.750 | −0.750 | −0.500 |
| **10** | Trash Bins | −1.000 | −1.000 | −1.000 | −0.660 | 0.000 |
| **11** | Streetlights | 0.500 | 0.500 | −0.556 | 0.480 | 0.708 |
| **12** | Flooring | −0.500 | −0.500 | −0.500 | −0.300 | −1.167 |
| **13** | Manholes | 0.286 | 0.286 | −0.444 | −0.100 | −0.500 |
| **14** | Kerb (Curb) | 0.250 | 0.250 | 0.139 | 0.090 | −0.167 |
| **15** | Pedestrian Crossing | −1.250 | −1.250 | −1.250 | −0.890 | −1.042 |
| **16** | Street Furniture | −0.750 | −0.750 | −0.750 | −0.690 | −0.500 |
| **17** | Safety Security | −1.000 | −1.000 | −0.889 | −0.280 | −0.417 |
| **18** | Additional Features | −2.000 | −2.000 | −2.000 | −1.240 | −1.417 |
| **19** | Contextual Factors | −0.679 | −0.679 | −0.472 | −0.390 | −0.375 |

Hereafter, the percentage distribution of the 5 survey locations concerning the 19 factors point of reference was used for the Cronbach's Alpha analysis of internal consistency using IBM® SPSS® Statistics 26.0 version. The Cronbach's Alpha for the dataset is 0.951, reflecting the highest order of internal consistency.

Based on the data analysis till this stage, the hypothesis (footpaths in the core of old urban areas in India are poor in terms of Universal Mobility) holds true.

## 4.3. CONCLUSION

The next step was to critically analyse the data collected in this research. Thus, the correlation in the 2 sets of data was checked using Pearson's correlation, with a confidence interval of 95%. The first was the correlation between the 19 parameters used in the field survey for this research. The second was the average accessibility percentage and the average footpath width of the five surveyed cities. The last part of this section highlights the major findings of this research.

### 4.3.1. Correlation between the 19 Parameters Used in the Field Survey

The cumulative score of the accessibility survey, across all 5 cities during the survey, was considered alongside the data associated with each of the 19 parameters. The results are shown in **Figure 56**.

**Pearson's Correlation**

| | Factors | Footpath Width | Footpath Length | Building Typology | Footpath Dimension | Temporary Encroachment | Permanent Encroachment | Bus Stop | Metro Rail | Railings | SWD | Public Toilet | Trash Bins | Streetlights | Flooring | Manholes | Kerb | Pedestrian Crossing | Street Furniture | Safety Security | Additional Features | Contextual Factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Footpath Width | 1.000 | 0.310 | -0.219 | 0.421 | -0.285 | -0.120 | 0.001 | -0.189 | -0.155 | 0.065 | 0.101 | -0.044 | -0.265 | -0.090 | -0.120 | 0.099 | -0.266 | 0.161 | -0.230 | -0.255 | -0.173 |
| 2 | Footpath Length | 0.310 | 1.000 | -0.130 | -0.260 | -0.154 | 0.053 | -0.093 | -0.061 | -0.090 | -0.443 | -0.062 | -0.018 | -0.614 | -0.005 | -0.231 | -0.013 | -0.126 | -0.092 | -0.068 | -0.151 | -0.027 |
| 3 | Building Typology | -0.219 | -0.130 | 1.000 | -0.106 | 0.231 | 0.140 | 0.024 | -0.179 | -0.175 | 0.164 | 0.217 | 0.157 | 0.171 | 0.077 | 0.198 | 0.003 | -0.050 | 0.057 | 0.099 | 0.036 | 0.057 |
| 4 | Footpath Dimension | 0.421 | -0.260 | -0.106 | 1.000 | -0.026 | -0.150 | -0.013 | -0.135 | -0.025 | 0.224 | 0.332 | -0.029 | 0.179 | -0.169 | -0.061 | 0.286 | 0.146 | 0.334 | -0.019 | -0.170 | -0.077 |
| 5 | Temporary Encroachment | -0.285 | -0.154 | 0.231 | -0.026 | 1.000 | 0.058 | 0.265 | -0.021 | -0.079 | -0.099 | 0.099 | 0.103 | 0.067 | -0.161 | -0.171 | -0.117 | 0.210 | 0.067 | 0.173 | 0.101 | 0.138 |
| 6 | Permanent Encroachment | -0.120 | 0.053 | 0.140 | -0.150 | 0.058 | 1.000 | 0.189 | 0.012 | 0.024 | 0.131 | 0.149 | 0.234 | -0.139 | 0.080 | 0.048 | 0.020 | -0.099 | 0.108 | 0.270 | 0.280 | -0.159 |
| 7 | Bus Stop | 0.001 | -0.093 | 0.024 | -0.013 | 0.265 | 0.189 | 1.000 | -0.043 | 0.115 | 0.152 | 0.183 | 0.172 | 0.131 | 0.124 | -0.027 | -0.207 | 0.072 | 0.311 | 0.115 | 0.363 | -0.015 |
| 8 | Metro Rail | -0.189 | -0.061 | -0.179 | -0.135 | -0.021 | 0.012 | -0.043 | 1.000 | 0.489 | 0.123 | -0.025 | -0.057 | 0.016 | 0.004 | 0.060 | 0.035 | 0.376 | -0.033 | 0.156 | 0.102 | -0.103 |
| 9 | Railings | -0.155 | -0.090 | -0.175 | -0.025 | -0.079 | 0.024 | 0.115 | 0.489 | 1.000 | 0.115 | -0.052 | -0.117 | 0.087 | 0.227 | 0.159 | 0.072 | 0.332 | 0.252 | 0.063 | 0.378 | -0.086 |
| 10 | SWD | 0.065 | -0.443 | 0.164 | 0.224 | -0.099 | 0.131 | 0.152 | 0.123 | 0.115 | 1.000 | 0.214 | 0.047 | 0.442 | 0.406 | 0.678 | 0.328 | -0.058 | 0.280 | -0.159 | 0.224 | -0.002 |
| 11 | Public Toilet | 0.101 | -0.062 | 0.217 | 0.332 | 0.099 | 0.149 | 0.183 | -0.025 | -0.052 | 0.214 | 1.000 | 0.089 | 0.144 | -0.024 | -0.106 | 0.114 | 0.034 | 0.213 | -0.001 | 0.320 | -0.179 |
| 12 | Trash Bins | -0.044 | -0.018 | 0.157 | -0.029 | 0.103 | 0.234 | 0.172 | -0.057 | -0.117 | 0.047 | 0.089 | 1.000 | 0.216 | 0.111 | -0.042 | 0.161 | 0.029 | 0.268 | 0.514 | 0.285 | -0.333 |
| 13 | Streetlights | -0.265 | -0.614 | 0.171 | 0.179 | 0.067 | -0.139 | 0.131 | 0.016 | 0.087 | 0.442 | 0.144 | 0.216 | 1.000 | 0.056 | 0.262 | 0.027 | 0.283 | 0.125 | 0.047 | 0.283 | 0.032 |
| 14 | Flooring | -0.090 | -0.005 | 0.077 | -0.169 | -0.161 | 0.080 | 0.124 | 0.004 | 0.227 | 0.406 | -0.024 | 0.111 | 0.056 | 1.000 | 0.393 | 0.316 | -0.086 | 0.039 | 0.097 | 0.464 | 0.029 |
| 15 | Manholes | -0.120 | -0.231 | 0.198 | -0.061 | -0.171 | 0.048 | -0.027 | 0.060 | 0.159 | 0.678 | -0.106 | -0.042 | 0.262 | 0.393 | 1.000 | 0.197 | -0.081 | 0.166 | -0.195 | 0.063 | 0.122 |
| 16 | Curb | 0.099 | -0.013 | 0.003 | 0.286 | -0.117 | 0.020 | -0.207 | 0.035 | 0.072 | 0.328 | 0.114 | 0.161 | 0.027 | 0.316 | 0.197 | 1.000 | 0.193 | 0.181 | -0.014 | 0.097 | -0.106 |
| 17 | Pedestrian Crossing | -0.266 | -0.126 | -0.050 | 0.146 | 0.210 | -0.099 | 0.072 | 0.376 | 0.332 | -0.058 | 0.034 | 0.029 | 0.283 | -0.086 | -0.081 | 0.193 | 1.000 | 0.177 | 0.302 | 0.216 | -0.156 |
| 18 | Street Furniture | 0.161 | -0.092 | 0.057 | 0.334 | 0.067 | 0.108 | 0.311 | -0.033 | 0.252 | 0.280 | 0.213 | 0.268 | 0.125 | 0.039 | 0.166 | 0.181 | 0.177 | 1.000 | 0.096 | 0.299 | -0.133 |
| 19 | Safety Security | -0.230 | -0.068 | 0.099 | -0.019 | 0.173 | 0.270 | 0.115 | 0.156 | 0.063 | -0.159 | -0.001 | 0.514 | 0.047 | 0.097 | -0.195 | -0.014 | 0.302 | 0.096 | 1.000 | 0.446 | -0.299 |
| 20 | Additional Features | -0.255 | -0.151 | 0.036 | -0.170 | 0.101 | 0.280 | 0.363 | 0.102 | 0.378 | 0.224 | 0.320 | 0.285 | 0.283 | 0.464 | 0.063 | 0.097 | 0.216 | 0.299 | 0.446 | 1.000 | -0.135 |
| 21 | Contextual Factors | -0.173 | -0.027 | 0.057 | -0.077 | 0.138 | -0.159 | -0.015 | -0.103 | -0.086 | -0.002 | -0.179 | -0.333 | 0.032 | 0.029 | 0.122 | -0.106 | -0.156 | -0.133 | -0.299 | -0.135 | 1.000 |
| | Legend | -1 | -0.9 | -0.8 | -0.7 | -0.6 | -0.5 | -0.4 | -0.3 | -0.2 | -0.1 | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1 |
| | | Very Strong Negative | | Strong Negative | | | Moderate Negative | | Weak Negative | | | Weak Positive | | | | Moderate Positive | | Strong Positive | | | Very Strong Positive | |

**Figure 56:** Correlation among the parameters.

As seen in **Figure 56** above, a significant correlation exists only amongst the following:

- ***Strong negative correlation: Streetlight and Footpath Length, and***
- ***Strong positive correlation: (a) Manholes and Storm Water Drains, and (b) Safety and Security and Trash Bins.***

Thus, the aforementioned factors may be prioritized in the preparation of development plans.

### 4.3.2. Correlation between the Accessibility Score of the Five Cities and Footpath Width

The average accessibility scores of the 5 cities and the average footpath widths, concerning their respective footpath stretches, were considered as the data associated with each of the 19 parameters. The dataset is shown in **Table 15**.

**Table 15:** Dataset for correlation study.

| S. No. | City | Average Footpath Width (in mm) | Average Accessibility Percentage |
|---|---|---|---|
| 1 | Jodhpur | 1970 | −27.96 |
| 2 | Jaipur | 1200 | −25.51 |
| 3 | Hyderabad | 2430 | −48.25 |
| 4 | Chennai | 1440 | −26.95 |
| 5 | Nagpur | 1530 | −36.18 |

The correlation coefficient is −0.79, which indicates a strong negative relationship. Thus, the evidence of the survey in this chapter concludes that in historic cities, the footpaths with lesser widths relate to greater accessibility, which is rather unconventional. Future research can be conducted on discovering the reason behind this relationship.

### 4.3.3. Major Findings

In this research, the major findings are:

- ***Field-survey-based proof of the fact that the footpaths in the centres of historic urban areas in India are poor in terms of universal mobility. Thus, the degree of accessibility, as discussed in the Introduction section of this research, was understood based on these findings too, and***
- ***Analytical findings of the status of the different parameters of the footpath infrastructure in the historic cities of India.***

This research is particularly beneficial for policymakers since it will enable them to understand the weak survey parameters within a particular urban area, and thus be able to prioritize urban development from a survey-parameter-based perspective. Additionally, they will also be able to prioritize the weaker stretches if the development plans are focussed on spatial demarcation, rather than survey parameters. Thus, the improvement of universal mobility can be deterministic rather than probabilistic.

It is important to note that this research also had certain limitations, such as (a) including cognitive factors in the survey format, (b) including pedestrian count as a parameter in the research, and (c) comparing the research area in the historic part of the city with a relatively newer locality in the city. Further research in this field can be conducted by including these limitations in the already surveyed stretches, or by delineating a stretch in other historic cities in India, then verifying the hypothesis.

Although universal design can be best understood by people who experienced any sort of disability, it is the ethical responsibility of every architect/ planner/ designer to provide an inclusive built environment.[196,197] If there would be a Johari Window[198] for Streetscape (considering 'Self' as the majority of able-bodied people), universal design would still be in the 'Unknown Area'.[199] A multistakeholder approach will be fruitful in preparing a holistic accessibility plan for the old core cities discussed in this chapter[200,201]; especially with the users/ citizen at the top of the stakeholder list[202]

After comprehensive understanding of the accessibility conditions of footpaths of old cities in India, the opinion of experts from the field of design in India is interpreted.

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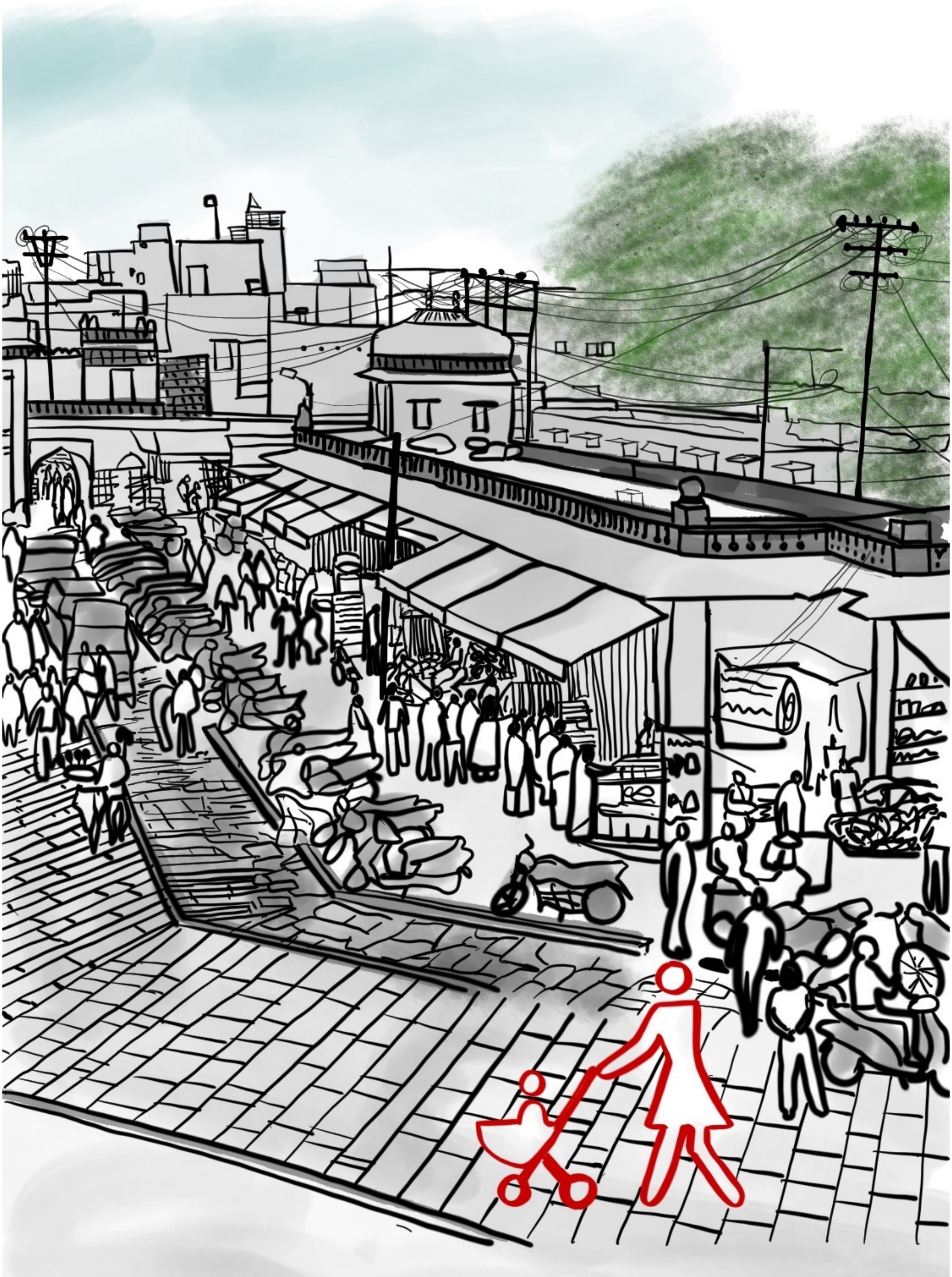
# CHAPTER 05

- **Title:** Interpreting the perception of experts on Universal Mobility in footpaths of old Indian cities.
- **Related Publication: G. Das Mahapatra**, S. Mori, and R. Nomura, 'Interpreting Universal Mobility in the footpaths of urban India based on experts' opinion,' *Sustainability*, vol. 15, no. 4, p. 3625, Feb. 2023, DOI: 10.3390/su15043625. [Journal Impact Factor = 3.9; Citations = 2 (as of July 2023)]
- **Scope:** To furnish a process-oriented approach in the realm of accessibility where the approach is still product oriented.
- **Objectives:** To determine the degree of accessibility possible in the footpaths of core areas of an old Indian city by proposing an ideal accessibility audit checklist.
- **Focus:** Universal Mobility in the core of old Indian cities (survey based).
- **Research Questions:** Can core Indian cities be made inclusive in terms of Universal Mobility?
- **Data Set:** Expert opinion (257 people).
- **Keywords:** Universal Mobility; Footpath; Specially-Abled; Elderly; Expert Opinion; Urban India.



**'We need to make every single thing accessible to every single person with a disability.'**

***- Stevie Wonder***

# 5. INTERPRETING THE PERCEPTION OF EXPERTS ON UNIVERSAL MOBILITY IN FOOTPATHS OF OLD INDIAN CITIES.

In this chapter, the perception/ viewpoint of Indian experts regarding Universal Mobility in footpaths of old Indian cities is evaluated.

The accessibility guidelines in India (as tabulated in **Table 1** in **Chapter 1** of this research) are published by government agencies, but often involve experts from the field of architecture, civil engineering, and urban planning, including experts such as academics, practitioners, and government officials. Thus, this research involves the following experts: academics (professor, associate professor, assistant professor, and Ph.D. scholar in architecture/planning), practitioners (practicing architects, practicing planners, and architects or planners working in private establishments), and government officials related to architecture/planning. The research questions for this chapter are:

- ***Which factors of universal mobility should be prioritized during a renewal/greenfield project related to footpaths in urban India?***
- ***Which sector of administration should focus on decision-making related to statutory administration related to footpaths in urban India?***
- ***What genre of urban development should be used in the case of implementing universal mobility in footpaths in urban India?***

## 5.1. RESEARCH METHODOLOGY

In this chapter, the factors preferable for implementing Universal Mobility were further subjected to a case-by-case investigation in seven other old cities in India. Thus, the appropriate choice of the investigation was the 'Critical Instance' sub-type of the 'Case Study' type of research. As the hypothesis, it is considered that the footpaths in the core of old urban areas in India are poor in terms of Universal Mobility. The research question for this chapter is to understand which factors are responsible for weakening the Universal Mobility standards in footpaths in the core of old urban areas in India.

The survey and data collection were done digitally by explaining the intent and content of the research with the link to the questionnaire attached digitally using the following mediums:

(a) Sending electronic mail (e-mail) to the academics (professors, associate professors, assistant professors, and research scholars). The contacts of the respondents in this category were acquired from the websites of the universities that are recognized by the Council of Architecture or COA (available at https://www.coa.gov.in/institutionStatus.php, accessed on 7 February 2023) and Institute of Town Planners, India or ITPI (available at https://www.itpi.org.in/uploads/pdfs/2-provisional-list-of-schools-Institutions-and-universitites-planning-courses-approved-by-itpi.pdf, accessed on 6 February 2023).

(b) Sharing via social media platforms, which comprises a large share of Indian architects (licensed from the COA) or Indian planners (registered with ITPI); for example, 'Conscious Urbanism', 'The Switch', 'Planning India', etc. This approach has helped to gather responses from practicing architects, practicing planners, and architects or planners working in private establishments.

(c) Contacting government officials through personal connections established (by the Laboratory of Architectural Planning) in India, such as the Delhi Development Authority and Public Works Department in the Government of West Bengal.

The questionnaire used in this research is available at https://forms.gle/FK6FpSrHvoVy3Po88 (accessed on 6 February 2023) and the questions are also tabulated in **Table 16**. The questionnaire was shared with the respondents online using Google forms from 14th October 2021 to 17th November 2022. A sample of the questionnaire and the consolidated survey data is available respectively in **Annexure N and Annexure O** of this research.

**Table 16:** Questionnaire used in the research.

| S. No | Category | Question | Options |
|---|---|---|---|
| 1 | *Respondent details* | Name | N/A |
| 2 | | Affiliated Institute (Presently Engaged/ Last Academic Institute/ Own Company) | N/A |
| 3 | | Designation | • Professor<br>• Associate professor<br>• Assistant professor<br>• Ph.D. scholar in architecture/ planning<br>• Practicing architect<br>• Practicing planner<br>• Architects or planners working in private establishments.<br>• Government official |
| 4 | | Name one Indian City (where you are born/ working/ educated) | N/A |
| 5 | | The above-mentioned City falls in which State/ Union Territory of India? | N/A |
| 6 | *Universal Design* | Are the footpaths in your above-mentioned city Universally Designed? | • No, not at all Universally Designed<br>• Partially Universally Designed<br>• Yes, Completely Universally Designed |
| 7 | | Which is the major obstacle in the implementation of universal design in the pedestrian areas of your city? | • Central Government<br>• State Government<br>• Urban Local Body<br>• Private enterprises/organizations<br>• Residents of your city |
| 8 | | How much would you rate the impact of universal design on Indian Urban Quality of Life? | Likert Scale (On a scale of 1–10; 1 being least significant and 10 being most significant) |
| 9 | | Is there a need for the involvement of Private establishments or PPP models in the field of universal design in Urban India? | • Yes<br>• No |
| 10 | *Accessibility Audit* | Do you think that the Accessibility Audit checklists presently available in India are completely adequate for assessing accessibility in Urban India? | • Yes<br>• No |
| 11 | | Do we need separate universal design guidelines for Old Cities and New Cities in India | • Yes<br>• No |
| 12 | *Universal Mobility* | On a scale of 1–10, how important is universal mobility in realizing universal design in Urban India? | Likert Scale (On a scale of 1–10; 1 being least significant and 10 being most significant) |
| 13 | | Is the authentication of a theoretical model important for ensuring the universal mobility scenario in Urban India? | • Yes<br>• No |
| 14 | | Is prioritizing stretches in Old Indian cities (like a pilot project) important for ensuring better implementation of universal mobility? | • Yes<br>• No |
| 15 | | On a scale of 1–10, what is the importance of Cognitive Elements (like Temperature, Sound, Texture, Landmarks, etc.) in ensuring universal mobility? | Likert Scale (On a scale of 1–10; 1 being least significant and 10 being most significant) |

| | | |
|---|---|---|
| **16** | Mark any 05 (ONLY FIVE) of the MOST IMPORTANT of the factors while assessing universal mobility for pedestrians in Old Cities of India | Adjacent Building Typology (Mixed Use and Historic Buildings); Dimension of the Footpath (Clear width and height); Temporary Encroachment (Informal Vendors, Beggars, Homeless and Child Labours); Permanent Encroachment (Places of Religious Interest, Business Establishments and Open Bath); Transport Stops (Bus Stop, Metro Rail Entrance, etc.); Railings (Pedestrian Guard Rails); Storm Water Drains; Public Toilets; Trash Bins (Garbage Bin); Streetlights; Flooring (Surface Finish); Manholes (Drain-Type and Grating-Type); Kerb (curb); Pedestrian Crossing (Signalized Crossing and Audio-assistance); Street Furniture; Safety and Security (Fire Hydrant and Security Camera); Additional Inclusive Features (Signage, Bicycle Track, Public Drinking Water Facility, and Street Art); Contextual Factors (like Topography, etc.) |

The research methodology for this chapter is in three major parts: (a) research background, (b) primary survey, and (c) findings.

The research background consists of an understanding of topics such as the global need for universal mobility, the social model of disability, demographic studies, and statutory guidelines, all of which were discussed in **Chapter 1**. The primary survey involves the survey of 257 experts from 21 states and 1 union territory in India. The findings of the primary survey are elaborated on in **Section 5.2.**

The findings of this research suggest answers to the primary questions indicated in the methodology: (a) Which factors to prioritize? (b) Which sector of administration to focus on? (c) What genre of urban development to opt for? The findings are elaborated on in **Section 5.2** and further discussed in **Section 5.3** of this chapter. The research methodology used in this chapter is illustrated in **Figure 57**.

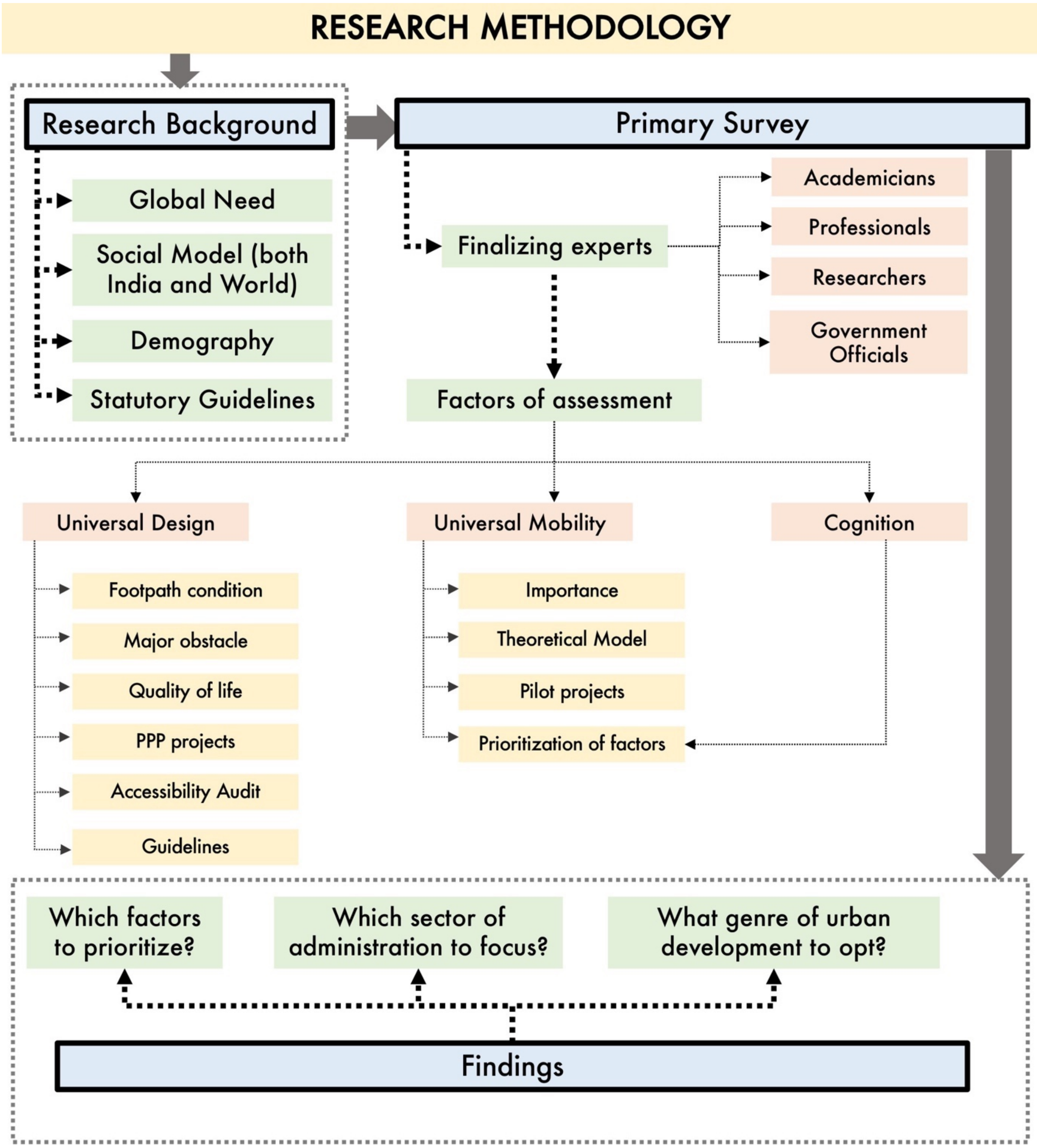



**Figure 57:** Research Methodology.

## 5.2. MATERIALS AND METHODS

The research methodology is further explained in this section.

### 5.2.1. Sample description

- *The expertise of the respondents*

In this study, 257 experts were chosen from the fields of architecture and planning. The compositions of the respondents are as follows: professors (26 nos.), associate professors (22 nos.), assistant professors (57 nos.), Ph.D. scholars in architecture/ planning (21 nos.), practicing architects (58 nos.), practicing planners (27 nos.), government officials related to architecture/planning (12 nos.), and architects or planners working in private establishments (34 nos.). **Figure 58** shows the percentage share of each category of respondents.

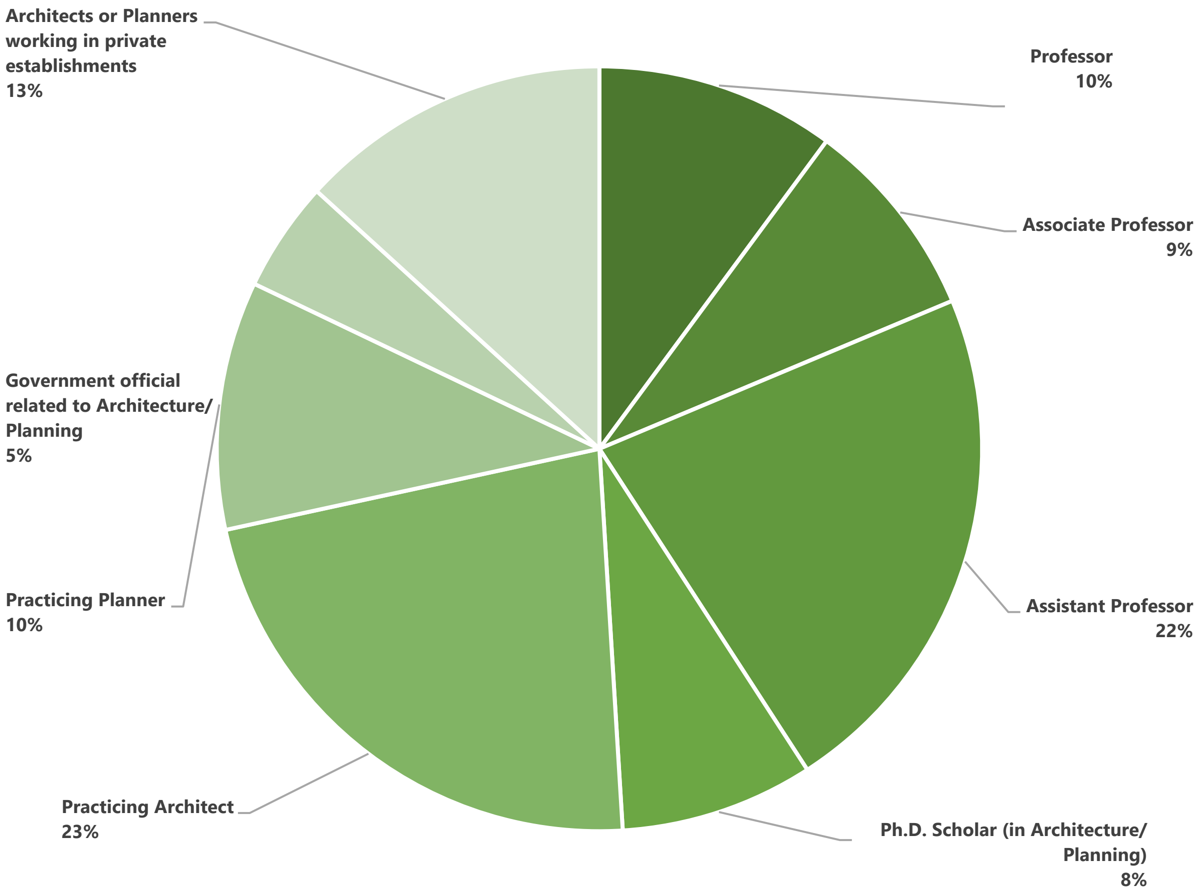



**Figure 58:** The percentage share of each category of respondents.

- *Geographical Distribution*

The respondents for the primary survey in this research were from 21 out of 28 states and 1 out of 8 union territories in India. The compositions of the respondents across the states (in alphabetical order) are as follows: Andhra Pradesh (11 nos.), Assam (6 nos.), Bihar (3 nos.), Chhattisgarh (2 nos.), Gujarat (2 nos.), Haryana (8 nos.), Jammu and Kashmir (1 no.), Jharkhand (2 nos.), Karnataka (8 nos.), Kerala (6 nos.), Madhya Pradesh (17 nos.), Maharashtra (17 nos.), Odisha (30 nos.), Punjab (5 nos.), Rajasthan (1 no.), Tamil Nadu (15 nos.), Telangana (9 nos.), Tripura (1 no.), Uttar Pradesh (17 nos.), Uttarakhand (1 no.), and West Bengal (68 nos.). In addition to this, 27 respondents were from the union territory of the National Capital Territory (hereafter, NCT) of Delhi. **Figure 59** shows the distribution of the respondents across India.

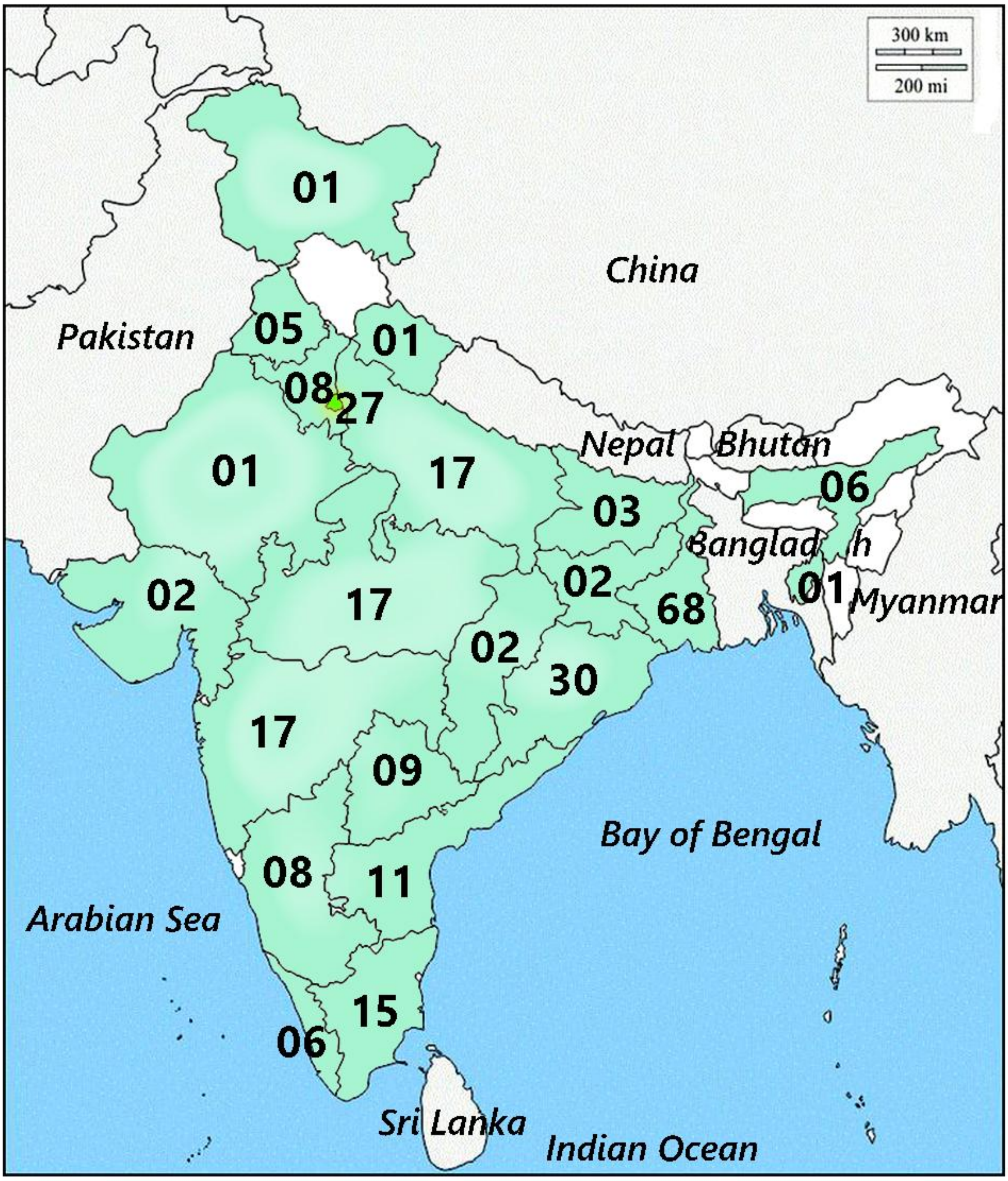



**Figure 59:** Distribution of the respondents across India. The numbers in each state refer to the share of respondents from each state.

### 5.2.2. Survey Observations

- ***Universal Design in Indian Footpaths (Data Type: Ordinal Data)***

The respondents were asked about the status of universal design in the footpaths of their respective cities. Only 2.72% (7 nos.) of the respondents said that the footpaths were completely universally designed and 42.80% (110 nos.) of the respondents said that the footpaths were partially universally designed; in contrast, 54.47% (140 nos.) of the respondents confirmed that the footpaths were not at all universally designed.

- *The Major Obstacle in the Implementation of universal design (Data Type: Ordinal Data)*

A total of 135 respondents felt that the major obstacle to the implementation of universal design in their city is an urban local body. Following this, 50 respondents blamed residents, 39 respondents accused the state government, 22 respondents attributed private enterprises/ organizations, and 11 respondents thought the central government were the major obstacle in the implementation of universal design in their city. **Figure 60** shows the percentage share of each category of respondents.

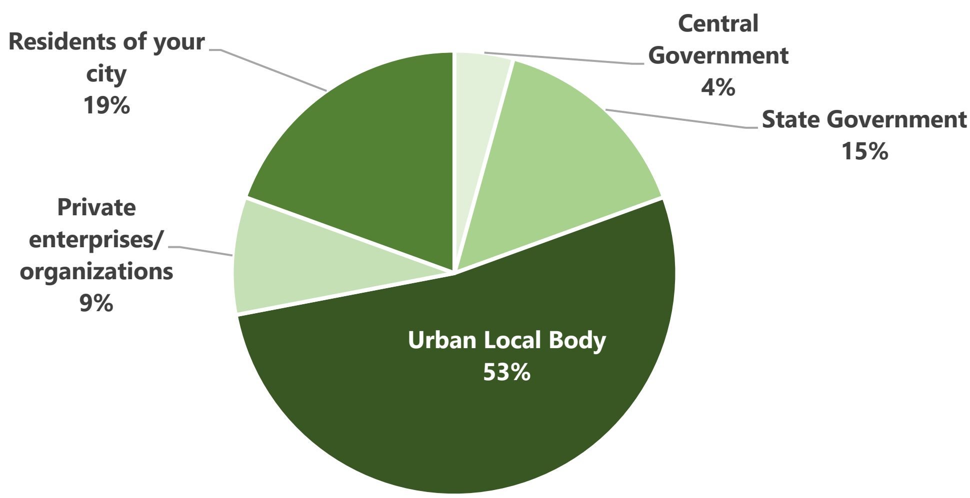



**Figure 60:** Percentage of the respondents regarding major obstacles in the implementation of universal design.

- *Impact of universal design on Urban Quality of Life (Data Type: Ordinal Data)*

More than 74% of the respondents allocated a score of 7 or more when the respondents were asked to rate the impact of universal design on Indian urban quality of life on a scale of 1–10 (1 being least significant and 10 being most significant). **Figure 61** shows the distribution of the respondents regarding the impact of universal design on urban quality of life.

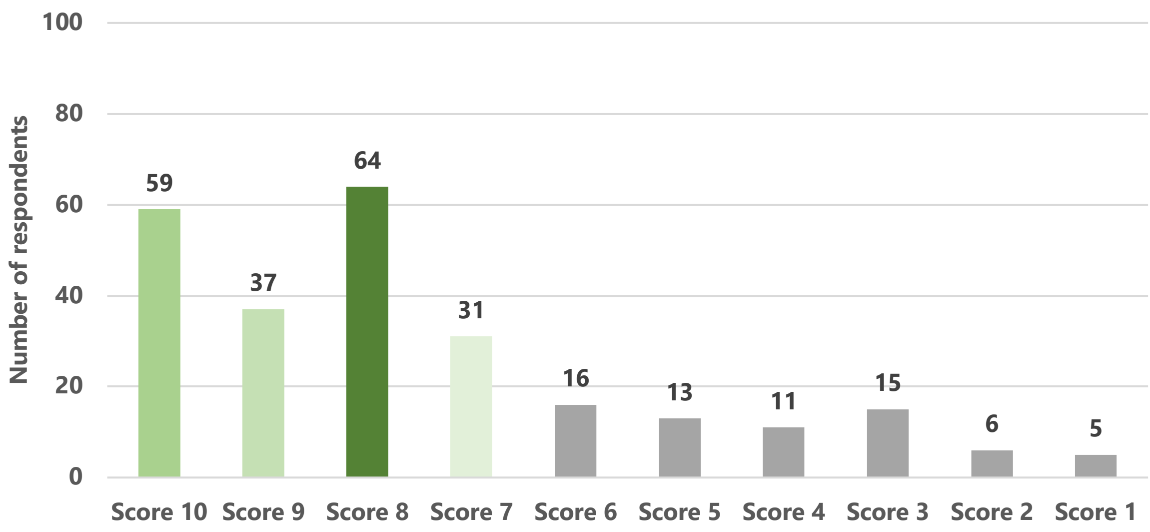



**Figure 61:** Distribution of the respondents regarding the impact of universal design on urban quality of life. The green shades emphasize the respondents who scored 7 and above.

The median score for academics (professors, associate professors, assistant professors, and researchers) and practitioners (architects, planners, and private employees) is 8. However, the median score for government officials is 9.

- ***Need for the Involvement of Private Establishments or PPP Models in the Field of universal design (Data Type: Nominal Data)***

A total of 91.44% of respondents (235 respondents) confirmed about the need for the involvement of PPP models in the field of universal design in urban India.

- ***Adequacy of Accessibility Audit Checklists in India (Data Type: Nominal Data)***

A total of 80.93% of respondents (208 respondents) stated that the accessibility audit checklists presently available in India are not completely adequate for assessing accessibility in urban India.

- ***Separate universal design Guidelines for Old Cities and New Cities (Data Type: Nominal Data)***

A total of 94.55% of respondents (243 respondents) proposed a need for separate universal design guidelines for old cities and new cities in India.

- ***Importance of Universal Mobility in Realizing universal design in Urban India (Data Type: Ordinal Data)***

More than 91% of the respondents apportioned a score of 7 or more when the respondents were asked to rate the importance of universal mobility in realizing universal design in urban India on a scale of 1–10 (1 being least significant and 10 being most significant). **Figure 62** shows the distribution of the respondents regarding the impact of universal design on urban quality of life.

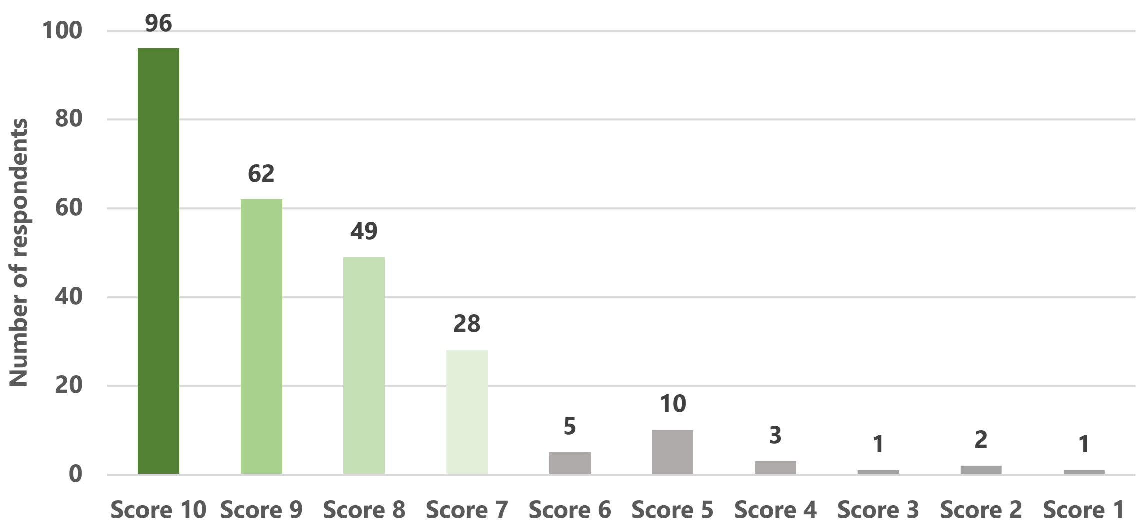



**Figure 62:** Distribution of the respondents regarding the importance of universal mobility in realizing universal design in urban India. The green shades emphasize the respondents who scored 7 and above.

The median score for academics (professors, associate professors, assistant professors, and researchers) and practitioners (architects, planners, and private employees) is 9. However, the median score for government officials is 10.

- ***Authentication of a Theoretical Model Is Important for Ensuring the Universal Mobility Scenario (Data Type: Nominal Data)***

A total of 87.16% of respondents (224 respondents) confirmed that authentication of a theoretical model was important for ensuring the universal mobility scenario in urban India.

- ***Prioritizing Stretches in Old Indian Cities (Pilot Project) Is Important for Ensuring Better Implementation of Universal Mobility (Data Type: Nominal Data)***

A total of 96.50% of respondents (248 respondents) established that prioritizing stretches in old Indian cities (such as a pilot project) is important for ensuring better implementation of universal mobility.

- ***Importance of Cognitive Elements (Temperature, Sound, Texture, Landmarks, etc.) in Ensuring Universal Mobility (Data Type: Ordinal Data)***

Nearly 86% of the respondents allocated a score of 7 or more when the respondents were asked to rate the importance of cognitive elements (temperature, sound, texture, landmarks, etc.) in ensuring universal mobility on a scale of 1–10 (1 being least significant and 10 being most significant). **Figure 63** shows the distribution of the respondents regarding the importance of cognitive elements (temperature, sound, texture, landmarks, etc.) in ensuring universal mobility.

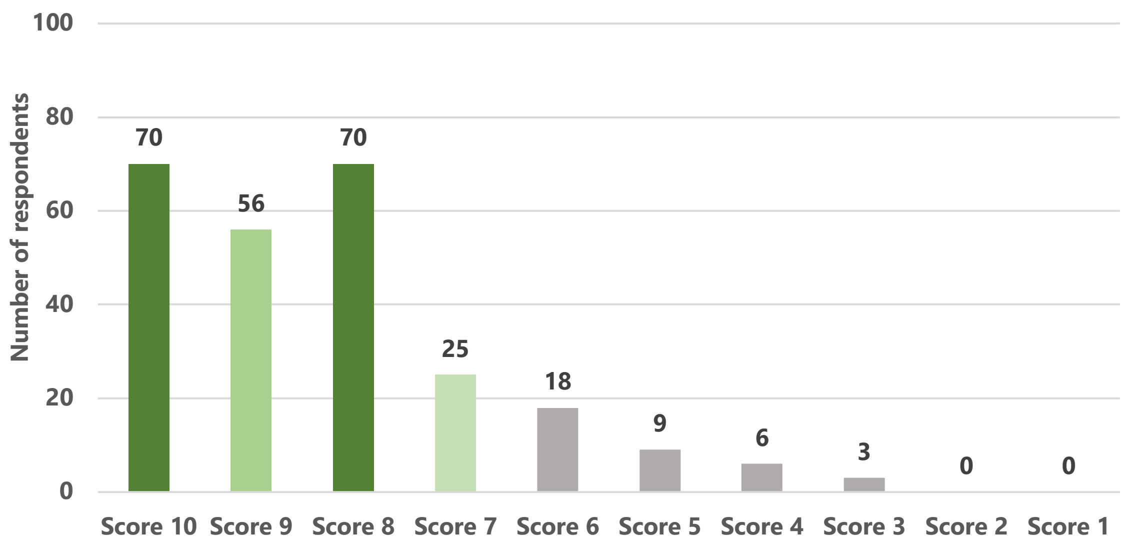



**Figure 63:** Distribution of the respondents regarding the importance of cognitive elements (temperature, sound, texture, landmarks, etc.) in ensuring universal mobility. The green shades emphasize the respondents who scored 7 and above.

The median score for academics (professors, associate professors, assistant professors, and researchers) and government officials is 8. However, the median score for practitioners (architects, planners, and private employees) is 9.

- ***Factors of Universal Mobility (Cognitive. Prioritization, etc.)***

The respondents were asked to mark any 5 (only five) of the most important of factors while assessing universal mobility for pedestrians in old cities in India. The respondents were given a choice from eighteen factors, as summarised in **Annexure N** previously (Question Number 5a).

A total of 50.58% (130 nos.) of the respondents ranked the 'dimension of the footpath (Clear width and height)' as the most important question of the factors while assessing universal mobility for pedestrians in old cities in India, while 35.41% (91 nos.) of the respondents ranked adjacent building typology (mixed-use and historic buildings). Other respondents preferred: temporary encroachment (informal vendors, beggars, homeless and child labours), 5.06% (13 nos.); transport stops (bus stop, metro rail twist entrance, etc), 3.50% (9 nos.); railings (pedestrian guard rails), 2.72% (7 nos.); permanent encroachment (places of religious interest, business establishments and open baths), 1.56% (4 nos.); storm water drains, 0.78% (2 nos.) and public toilets, 0.39% (1 no.). **Figure 64** shows the distribution of respondents in choosing the first and most important of the factors. None of the respondents opted for trash bins (garbage bin), streetlights, flooring (surface finish), manholes (drain-type and grating-type), kerb (curb), pedestrian crossing (signalised crossing and audio assistance), street furniture, safety and security (fire hydrant and security camera), additional inclusive features, signage, bicycle track, public drinking water facilities, street art, and contextual factors (such as Topography, etc).

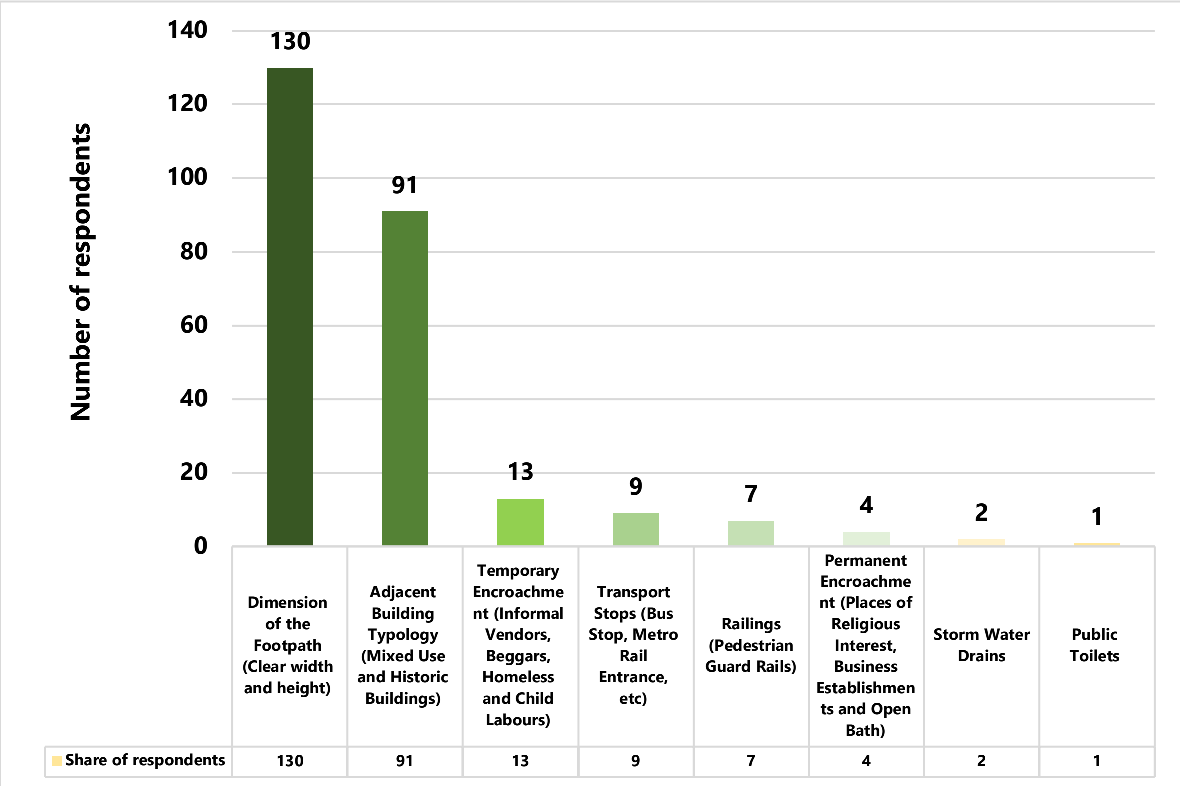



**Figure 64:** Distribution of the respondents regarding the most important of factors while assessing universal mobility for pedestrians in old cities of India.

### 5.2.3. Data Validation

Despite differences in the opinion between different categories of respondents, validating the internal consistency of the data collected so that this research can validate the opinions of the experts to be used in policymaking was conducted. Thus, Cronbach's Alpha was used for this purpose. Since the respondents are already categorized into (a) academics (professors, associate professors, assistant professors, and researchers), (b) practitioners (architects, planners, and private employees), and (c) government officials, the next steps are explained hereafter. Due to the 3 types of questions in the survey format, the first step was to categorise them into: (a) multiple Choice, (b) Likert Scale, and (c) dichotomous.

To analyse the distribution of respondents: (a) the first choice of the respondents was the factor used for the multiple-choice type questions, (b) the majority choice of the responses was the factor used for the dichotomous type questions, (c) respondents who selected the score of 7 and above were the factor used for Likert Scale-type questions. As an example, among the 140 respondents who selected that the footpaths in their city are not at all universally designed, (a) 54.35% (69 nos.) were academics,

(b) 55.46 (66 nos.) were practitioners, and (c) 41.67 (5 nos.) were government officials. **Table 17** shows the type, followed by their point of analysis, and the distribution of respondents for all questions.

**Table 17:** Framework for assessment of internal consistency.

| S. No | Question No. | Type of Question | Point of Analysis | Percentage Category of Respondents | | |
|---|---|---|---|---|---|---|
| | | | | Academics | Practitioners | Government Officials |
| **1** | 5.2.2.1 | Multiple Choice | The first choice amongst the options *(i.e., No, not at all Universally Designed)* | 54.76 | 55.46 | 41.67 |
| **2** | 5.2.2.2 | Multiple Choice | The first choice amongst the options *(i.e., Urban Local Body)* | 56.35 | 49.58 | 41.67 |
| **3** | 5.2.2.3 | Likert Scale | Respondents who selected score of 7 and above | 76.19 | 73.11 | 66.67 |
| **4** | 5.2.2.4 | Dichotomous | Majority of response *(i.e., Yes)* | 91.27 | 92.44 | 83.33 |
| **5** | 5.2.2.5 | Dichotomous | Majority of response *(i.e., No)* | 79.37 | 82.35 | 83.33 |
| **6** | 5.2.2.6 | Dichotomous | Majority of response *(i.e., Yes)* | 93.65 | 94.96 | 100.00 |
| **7** | 5.2.2.7 | Likert Scale | Respondents who selected score of 7 and above | 93.65 | 89.92 | 83.33 |
| **8** | 5.2.2.8 | Dichotomous | Majority of response *(i.e., Yes)* | 84.92 | 89.92 | 83.33 |
| **9** | 5.2.2.9 | Dichotomous | Majority of response *(i.e., Yes)* | 97.62 | 95.80 | 91.67 |
| **10** | 5.2.2.10 | Likert Scale | Respondents who selected score of 7 and above | 88.10 | 83.19 | 91.67 |
| **11** | 5.2.2.11 | Likert Scale | Respondents who selected score of 7 and above | 55.56 | 46.22 | 41.67 |

Hereafter, the percentage distribution of respondents regarding the selected point of reference was used for the Cronbach's Alpha analysis of internal consistency using IBM® SPSS® Statistics 26.0 version. The Cronbach's Alpha for the dataset is 0.981, reflecting the highest order of internal consistency. Furthermore, the inference of this research (i.e., cumulative opinion of the experts including academics, practitioners, and government officials) can be used as a component in the policymaking of urban guidelines related to universal mobility.

## 5.3. DISCUSSION

Rhoads et al. (2023) debated the adaptability of footpaths concerning diverse mobility conditions, which is close to the concept of universal mobility that this research primarily focuses on.[203] In continuation to this, this section primarily focuses on comparing this research with relevant, earlier published research. This section further critically examines the possibility of implementing universal mobility in urban India.

Solanki and Khare (2018) concluded the status of building-standard-oriented accessibility guidelines in India.[204] In addition to this, Chapter 1 of this research elaborates on the different inclusive guidelines. However, due to socio-political reasons, the implementation of universal design guidelines in urban India has not been a reality. Due to the decentralised politics of India, the schemes and programmes at the central government level often receives ignorance at the state government level, especially if the ruling political party is not the same at both levels.[205] This research identifies the urban local body as the major obstacle in the implementation of universal design guidelines, which is understandable because the local municipal corporation or municipality is responsible for checking, authorising, legitimizing, and supervising any construction in the city limits. This chapter raises questions on the challenging yet essential component of urban quality of life, which is especially significant in the wake of the growing urban population.[206] Lee and Park (2023) maintained that urban guidelines are significant in maintaining walkability standards. Sustainable urban development in the

21st century is often unimaginable without the involvement of private enterprises with public entities, thus creating Public Private Partnerships or PPP.[207,208,209] Along similar lines, involving the PPP models in the field of universal design in urban India deems necessary. The only government-recognized comprehensive accessibility audit checklist available in India was made available in 2015 vis-à-vis the Accessible India Campaign.[210] However, the checklist is a mere holistic one[211] and depending on the criticality of urban India, this research confirms that accessibility audit checklists presently available in India are not completely adequate for assessing accessibility in urban India. Duman and Asilsoy (2022) maintained the evidence-based approach,[212] and Lid (2013) has preferred a literature-based approach towards establishing universal mobility.[213] This research argues that an expert opinion-based approach is apt for the Indian context. Decision makers around the world prefers to implement pilot projects in the case of urban-level universal design programmes.[214,215] Respondents in this research also confirmed this fact in the urban Indian context, as elaborated in **Section 5.2**. The cognitive component of this research confirms the impact of cognition at the pedestrian level for universal mobility.[216,217] Indian cities are unique due to their historic temporal developments,[218] and researchers have published a set of contextual factors for assessing/observing the footpaths.[219] This chapter further investigates the various factors of assessing the footpaths in the Indian context and establishes that besides finding the factors for assessment, prioritizing them is equally important for devising decisions at urban levels.

Aligned with the findings of this research, other research on universal mobility done in the past decade also reflects the critical condition of footpaths in urban India, especially in old cities. [3,4,14,16,17] **Figures 65 and 66** show a few footpath conditions in various cities in India.

**Figure 65:** Kolkata.

**Figure 66:** Visakhapatnam.

These pictures are evidence that basic mobility is a challenge in urban India, let alone universal mobility. Thus, India should undertake a complete overhaul in its developmental approach towards universal mobility if it aims to arrive close to the deadline of SDG 11 to provide an inclusive urban environment for all users regardless of their physical and cognitive abilities by 2030.

One important point that this research highlight is the role of urban local bodies in ensuring the implementation of universal design in pedestrian areas. Furthermore, the land is a state subject in India and owing to the decentralised political system in India, the state administration works independently from the central administration. In addition to this, India is a country with numerous urban contexts depending on the climate, language, topography, social, and political issues. Taking a cue from this, future research can focus on the location-specific analysis of universal mobility issues, where the respondents should ideally be from the same urban local body where the research is being conducted. Another possible and essential scope of future research is the addition of environmental factors along with cognitive and infrastructural factors in the fieldwork survey; open-ended questions can be added in future research.

## 5.4. CONCLUSION

Based on the survey described in **Section 5.2**, the findings from the viewpoint of experts are elaborated hereafter. Despite the significant impact on the urban quality of life, the footpaths in urban India exist with no/minimal universal design considerations and urban local bodies are primarily responsible for the lack of implementation of universal design in their respective jurisdictions. Thus, the involvement of private establishments or PPP models can positively influence universal design in urban India. Subsequently, the accessibility audit checklists presently available in India are not completely adequate for assessing accessibility in urban India, thereby suggesting a separate universal design guidelines for old and new cities in India. Along similar lines, universal mobility is essential in realizing universal design in urban India. However, authentication of a theoretical model is important for ensuring the universal mobility scenario in urban India. Moreover, prioritizing stretches in old Indian cities (such as a pilot project) is important for ensuring better implementation of universal mobility. Additionally, cognitive elements (temperature, sound, texture, landmarks, etc.) are significant in ensuring universal mobility. Finally, the most important factors while assessing universal mobility for pedestrians in old cities of India are (1) the dimension of the footpath (clear width and height) and (2) adjacent building typology (mixed-use and historic buildings). In addition, academics and private practitioners tend to agree more with each other in comparison to government officials. The next section answers the three research questions for this chapter.

First, based on the expert opinions elaborated in Sections **5.2**, in the case of approaching an urban area to incorporate universal mobility, the dimension of the footpath and adjacent building typology should be prioritized. In relation to this, the Indian Road Congress (2012) has indicated 1800 mm as the clear width and 2200 mm as the clear height for an ideal walking zone in the streetscape. In addition to this, the required width of the footpath as per adjacent land use is also specified. Examples include a minimum of 2500 mm clear width for footpaths is mandatory in areas with commercial/mixed-use adjacent building typology.[220] Many other guidelines, as elaborated in **Chapter 1**, also focus on the quantitative guidelines for footpaths. However, these guidelines lack the acknowledgement of cognitive factors such as sound and temperature, as well as contextual factors such as temporary encroachment, permanent encroachments, and transport stops. Thus, this research argued that a qualitative study of footpaths in urban India is necessary, as well as a quantitative assessment during any development plans.

The second step was to identify which sector of administration to focus on. The land-related policies in India fall under the jurisdiction of state administration as per the directions of the Seventh Schedule (Article 246).[221] If the state and central administration are not from the same political party, the guidelines (as tabulated in **Chapter 1**) are often not implemented due to political bottlenecks.[222] Thus, based on the expert opinions elaborated in **Sections 5.2**, reforms in the statutory functioning of the urban local body (under state government) will be beneficial for the footpaths to bear universal mobility. In addition to this, PPP models shall be beneficial where local businesses consult Corporate Social Responsibility (hereafter, CSR) or any other suitable models such as Build-Operate-Transfer (hereafter, BOT).

The third step was to determine what urban development genre to choose. Based on the expert opinions, the ideal development model is to create a new research-based accessibility audit checklist suitable for urban India, verify the same on a case area, and prioritize stretches (such as a pilot project).

After comprehensive understanding of the accessibility conditions of footpaths of old cities in India, the cognitive assessment is undertaken in the next chapter.

# CHAPTER 06

- **Title:** Considering the importance of cognition in footpaths of case area (Central Kolkata, India).

- **Related Publication: G. Das Mahapatra**, S. Mori, and R. Nomura, 'Role of Cognition in Pedestrian- Level Universal Mobility: Case of Central Kolkata, India,' *Athens Journal of Architecture*, vol. 9, no. 1, pp. 107–128, Jan. 2023, DOI: 10.30958/aja.9-1-5. [Citations = 1 (as of July 2023)]
- **Scope:** To explore the potential of inclusiveness in congested cores where the density is more concerning the rest of the city.
- **Objectives:** To improve cognition at the footpath level in old cities, especially for the specially-abled.
- **Focus:** Role of cognition in Universal Mobility at the pedestrian-level**.**
- **Research Questions:** What degree of cognition can be achieved in the footpaths of old cities?
- **Data Set:** Footpaths in central Kolkata (32 footpath stretches); and Geriatric Simulation (41 people)
- **Keywords:** Cognition, Universal Mobility, Pedestrian, Central Kolkata, India, Elderly, Specially-Abled

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**'I wish for a world that views disability, mental or physical, not as a hindrance but as unique attributes that can be seen as powerful assets if given the right opportunities'.**

***– Oliver Sacks***

# 6. CONSIDERING THE IMPORTANCE OF COGNITION IN FOOTPATHS OF CASE AREA (CENTRAL KOLKATA, INDIA)

In this chapter the impact of cognition on the pedestrian environment in the footpaths of old core cities in India is investigated taking case area (in Kolkata) as a case.

This chapter is apportioned into three segments (a) materials and methods, (b) major findings, and (c) proposals. The data sets are dealt with in the 'Analysis' segment, are (a) pedestrian volume, and (b) cognitive data (comprising noise, light, and thermal comfort data). In 'Major Findings', the following points are highlighted: (a) the importance of light in cognition, (b) the impact of sound on walkability. and (c) the influence of temperature on mobility. In the last part of the chapter 'Conclusion', the linkage between the five senses in humans and their pedestrian behaviour and the roles of hormones in facilitating cognition in streetscape for specially-abled people, is unfolded. Additionally, the importance of Assistive Technology in achieving Service Level Benchmarks (hereafter, SLBs) is also discussed in the last leg of the chapter. The details of the survey and the findings are explicated henceforward.

## 6.1. MATERIALS AND METHOD

The data collected in the case area for this research are: (a) pedestrian volume and (b) cognitive data including noise, light intensity, and thermal comfort. The locations where the data were collected along the study area are represented in **Figure 67** and elaborated in **Table 18** thereafter.

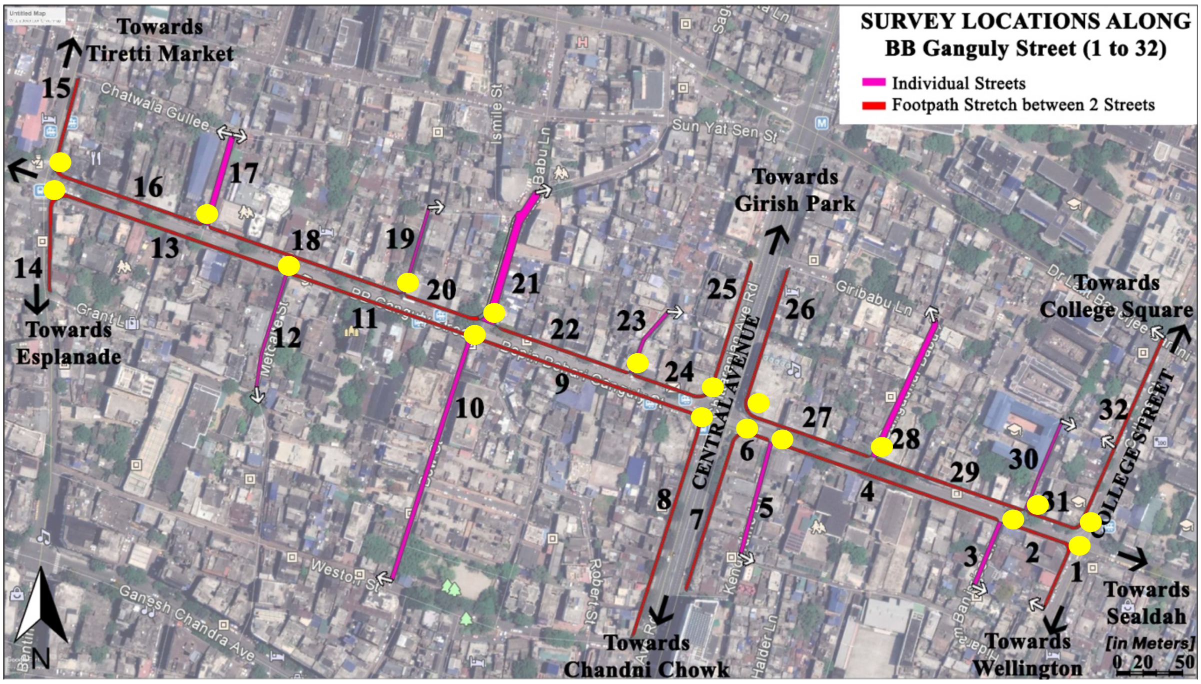



**Figure 67:** Survey Locations [Source: Overlaying on the open-source data available on google maps].

The station points for the 'Cognitive' survey were midway in several footpaths shown as number 1 to 32 as shown in **Figure 67**. The names of the footpaths selected (with corresponding footpath widths) for the survey are tabulated in **Table 18**. Furthermore, the station points for the 'Pedestrian Volume' survey were done at the yellow points shown in **Figure 67**.

**Table 18:** Name of Station points for Survey.

| Corresponding Numbers in Figure 1 | Name of Station Points | Footpath Width (in mm) |
|---|---|---|
| **1** | Nirmal Chandra Dey Street | 2100 |
| **3** | New Bowbazar lane | 5000 |
| **5** | Kenderdine Lane | 3000 |
| **7** | Central Avenue (GATE 4: Yogayog Bhawan) | 2100 |
| **8** | Central Metro (GATE 1: Indian Airlines) | 2100 |
| **10** | Bow Street | 3800 |
| **12** | Metcalfe Street | 3500 |
| **14** | Bentinck Street | 2100 |
| **15** | Rabindra Sarani Rd. | 1900 |
| **17** | Chatawalla Gully | 3500 |
| **19** | Phears Bye Lane | 2000 |
| **21** | Phears Lane | 4800 |
| **23** | Giri Babu lane | 2400 |
| **25** | Central Metro (GATE 2: Lalbazar) | 1900 |
| **26** | Central Avenue (GATE 3: RITES) | 1800 |
| **28** | Gangadhar Babu lane | 5000 |
| **30** | Bibi Rozio Lane | 1800 |
| **32** | College Street | 1900 |

### 6.1.1. Pedestrian Volume [Peak Hour 15-minute interval]

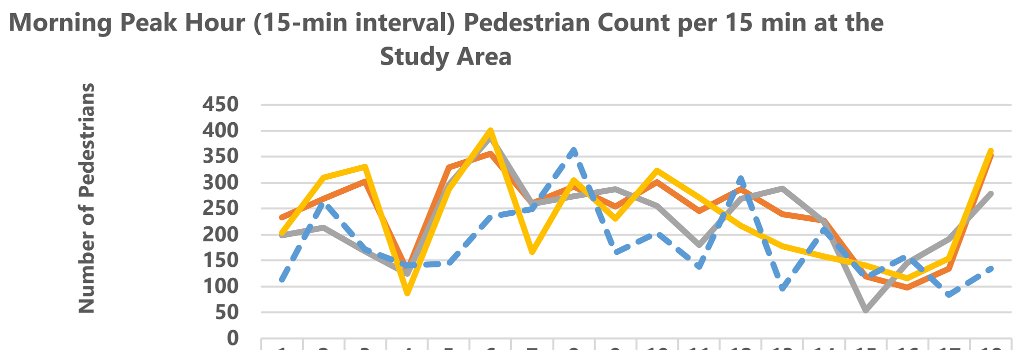
The peak-hour (15-minute interval) Pedestrian Volume Data were recorded three times in 2020 (on 14.10.2020, 25.10.2020, and 02.11.2020) and once in 2021 (on 24.09.2021). On each of the days, the data was recorded twice a day: (a) at Morning Peak Hour (09:00 IST – 11:00 IST) and (b) Evening Peak Hour (18:00 JST – 19:00 IST). In the morning, the educational institutions and businesses begin functioning around 09:00 IST. The offices start slightly later around 10:00 IST. The educational institutions close around 14:00 IST – 16:00 IST. However, the offices and businesses start closing around 19:00 IST. This is also the time when a significant number of informal shopping functions. Thus, depending on the mixed land use genre of the space, multiple peak hours are set for the survey. The format used for the Survey is tabulated in **Table 19**.

**Table 19:** Survey format for Pedestrian Count.

| **Peak Hour Pedestrian Count Survey** [15-minute interval] | |
|---|---|
| Date of Survey | |
| Time | |
| Name of the street | |
| Latitude and Longitude | |
| Width of the street | |

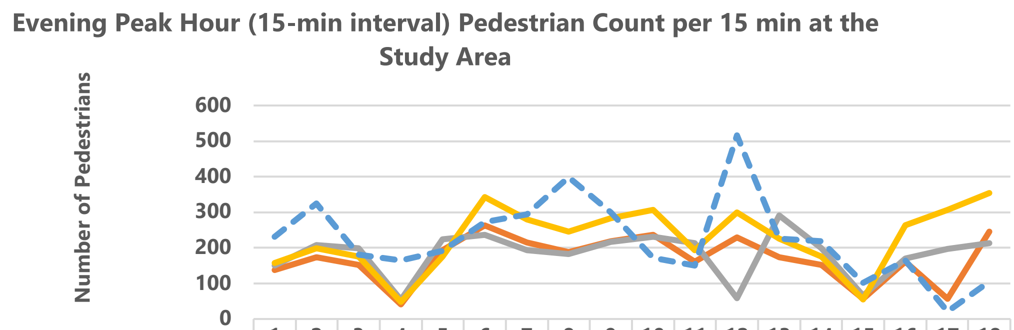
| | Pedestrians coming towards the surveyor | Pedestrians going away from the surveyor | |
|---|---|---|---|
| Morning Peak Hour<br>( - ) | | | |
| Evening Peak Hour<br>( - ) | | | |
| How many bicycles did you see during the survey? | | | |
| Did you see any specially-abled/ elderly people? | | | |
| *Surveyed By:* | | *Checked By:* | |

**Figure 68** and **Figure 69** represent the pattern of pedestrian traffic in the study area at morning peak hour and evening peak hour respectively.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 01 Morning Peak Hour | 233 | 269 | 302 | 131 | 329 | 356 | 260 | 293 | 254 | 301 | 245 | 287 | 239 | 227 | 119 | 98 | 134 | 353 |
| Day 02 Morning Peak Hour | 198 | 213 | 168 | 125 | 296 | 388 | 259 | 274 | 288 | 255 | 180 | 269 | 289 | 225 | 54 | 146 | 191 | 279 |
| Day 03 Morning Peak Hour | 203 | 310 | 331 | 87 | 287 | 401 | 166 | 305 | 231 | 323 | 271 | 217 | 178 | 158 | 141 | 116 | 154 | 361 |
| Day 04 Morning Peak Hour | 114 | 264 | 171 | 141 | 144 | 234 | 249 | 363 | 165 | 204 | 138 | 309 | 96 | 210 | 117 | 159 | 84 | 135 |

**Figure 68:** Morning Peak Hour (15-min interval) Pedestrian Count per 15 minutes at the Study Area.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 01 Evening Peak Hour | 137 | 173 | 152 | 41 | 194 | 263 | 215 | 188 | 218 | 236 | 161 | 230 | 173 | 152 | 56 | 161 | 56 | 245 |
| Day 02 Evening Peak Hour | 151 | 208 | 198 | 54 | 224 | 237 | 194 | 183 | 216 | 231 | 213 | 58 | 291 | 198 | 65 | 170 | 197 | 213 |
| Day 03 Evening Peak Hour | 158 | 199 | 175 | 48 | 175 | 342 | 280 | 245 | 284 | 307 | 194 | 299 | 225 | 175 | 55 | 264 | 306 | 354 |
| Day 04 Evening Peak Hour | 231 | 324 | 180 | 165 | 192 | 273 | 294 | 399 | 300 | 171 | 150 | 516 | 225 | 219 | 102 | 165 | 21 | 105 |

**Figure 69:** Evening Peak Hour (15-min interval) Pedestrian Count per minute at the Study Area.

On average (mean value), the recorded Peak Hour (15-min interval) Pedestrian Count at the Study Area was 223 people in the morning and 201 people in the evening respectively. The average pedestrian flow in morning peak hours can be attributed to the presence of morning schools, offices, churches, and related informal vending during those hours. However, the flow is consistent during the evening due to the crowd returning from offices, shops, and informal vending too. Thus, nearly 800 pedestrians (derived by multiplying the 'Peak Hours 15-minute interval Pedestrian Count' by four) commute through the study area during peak hours.

### 6.1.2. Cognitive Data

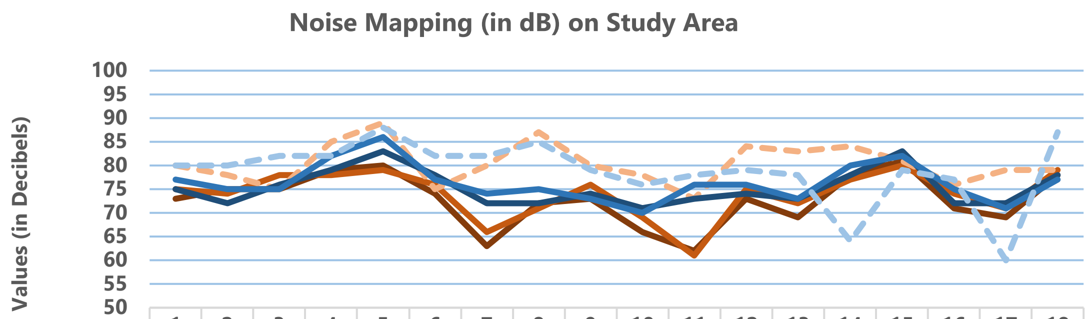
The next set of data for cognitive data (shown in **Table 20**) involving noise, light intensity, and thermal comfort were recorded at the same time (peak hour) and date as the pedestrian volume survey. The data was recorded using mobile-based applications.

**Table 20:** Survey format for Cognitive Data.

| **Cognitive Survey** [Sound, Light and Temperature Data at Peak Hour] | | |
|---|---|---|
| | **Morning** | **Evening** |
| Name of Surveyor | | |
| Name of the street | | |
| Date of Survey | | |
| Time | | |
| Sound Intensity (in Decibel) | | |
| Light Intensity (in Lux) | | |
| Temperature (in Degree Centigrade) | | |
| *Checked By:* | | |

- ***Sound Intensity***

**Figure 70** illustrates the Noise (Sound Intensity in Decibel) in the Study Area. The data were recorded using 'Sound Meter', a mobile-based application.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 1 | 73 | 75 | 75 | 79 | 80 | 74 | 63 | 72 | 73 | 66 | 62 | 73 | 69 | 78 | 81 | 71 | 69 | 78 |
| Day 2 | 75 | 74 | 78 | 78 | 79 | 76 | 66 | 71 | 76 | 69 | 61 | 75 | 72 | 77 | 80 | 74 | 71 | 79 |
| Day 3 | 80 | 78 | 75 | 85 | 89 | 75 | 80 | 87 | 80 | 78 | 73 | 84 | 83 | 84 | 81 | 76 | 79 | 79 |
| Evening 1 | 75 | 72 | 76 | 79 | 83 | 78 | 72 | 72 | 74 | 71 | 73 | 74 | 73 | 78 | 83 | 72 | 72 | 78 |
| Evening 2 | 77 | 75 | 75 | 82 | 86 | 77 | 74 | 75 | 73 | 70 | 76 | 76 | 73 | 80 | 82 | 75 | 71 | 77 |
| Evening 3 | 80 | 80 | 82 | 82 | 88 | 82 | 82 | 85 | 79 | 76 | 78 | 79 | 78 | 64 | 79 | 77 | 60 | 87 |

**Figure 70:** Noise Mapping on Study Area.

Exposure over 85dB does damage to hearing over prolonged exposure[223], which has been observed in 04 out of 18 surveyed locations. The infrastructure and pedestrian environment need a more sensitive approach.

- *Light Intensity*

The Light Intensity (in Lux) in the Study Area during Day and Evening respectively are illustrated in **Figure 71** and **Figure 72**. The data were recorded using a mobile-based application 'Light Meter'. The focus of this study was to understand whether the light intensity is satisfactory for people, especially during the evening/night.

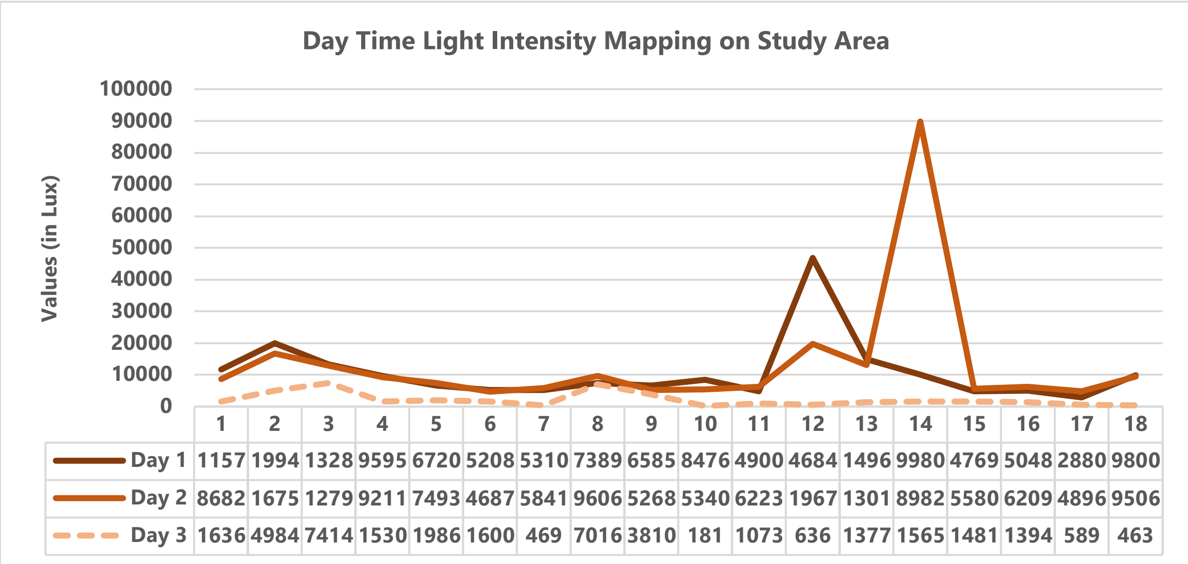



**Figure 71:** Day Time Light Intensity Mapping on Study Area.

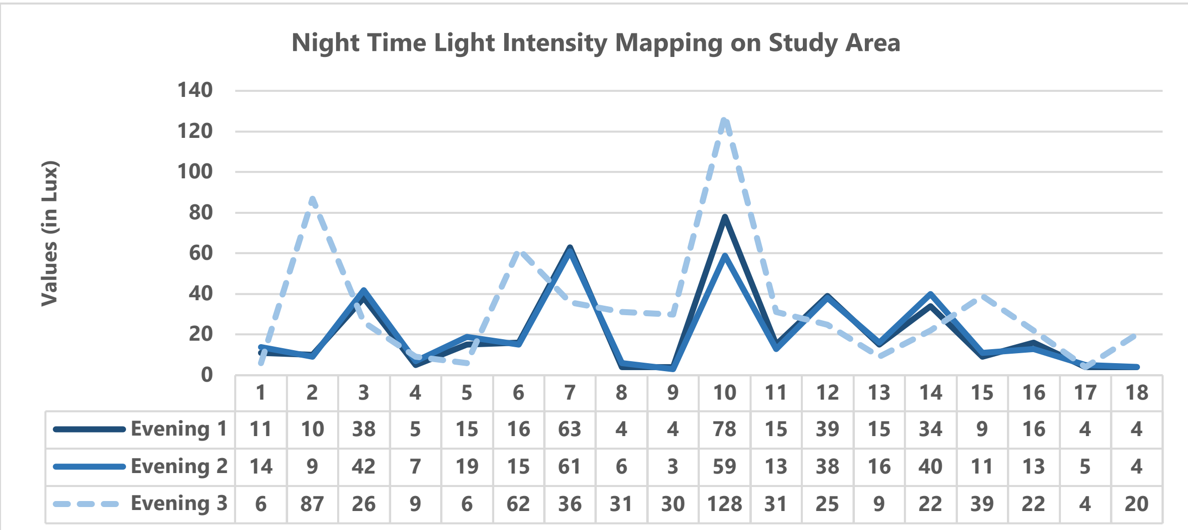
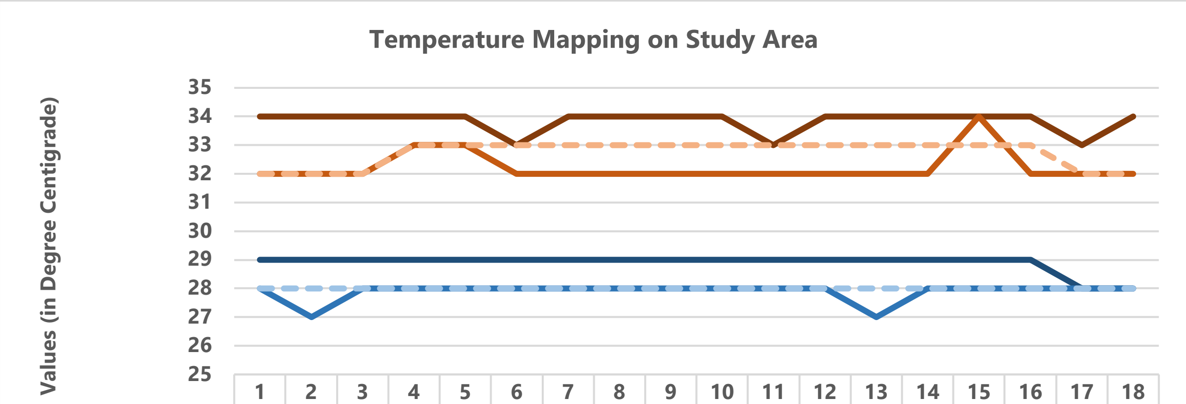



**Figure 72:** Evening Time Light Intensity Mapping on Study Area.

Despite having 93.75% of the streetlights in working condition (observed during the primary survey), instances show that there was >10lux illumination in certain pedestrian areas; thus, hinting towards a need for improved 'urban evening lighting'. The drastic differences in day and evening lighting create cognitive difficulties, especially for the elderly and specially-abled.

- *Thermal Comfort*

The Temperature (in Degree Centigrade) in Study Area during Day and Evening respectively are illustrated in **Figure 73**. The data (in degrees Centigrade) were recorded using 'Outside Temperature', a mobile-based application. This study was conducted mainly to access the real-time situation of pedestrians.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 1 | 34 | 34 | 34 | 34 | 34 | 33 | 34 | 34 | 34 | 34 | 33 | 34 | 34 | 34 | 34 | 34 | 33 | 34 |
| Day 2 | 32 | 32 | 32 | 33 | 33 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 34 | 32 | 32 | 32 |
| Day 3 | 32 | 32 | 32 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 32 | 32 |
| Evening 1 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 28 | 28 |
| Evening 2 | 28 | 27 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 27 | 28 | 28 | 28 | 28 | 28 |
| Evening 3 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |

**Figure 73:** Temperature Mapping on Study Area.

Despite minimal differences in day and evening temperatures during the surveyed dates, the actual scenarios are different. In summer, the temperature in Kolkata rises to 44 °C, complemented by 83% humidity: making the non-shadowed areas extremely uncomfortable. Additionally, considerations like apparent temperature, sensation and perception, time required to feel the temperature change, cardinal direction, and 'felt' temperature are significantly important.

The aspects of light, sound, and temperature are related to the senses of vision, hearing, and touch, which need to be complemented with smell (landscape probably) to create an enhanced cognitive experience.

## 6.2. RESULTS

This section discusses two major things: (a) criticism of the level of service based on the pedestrian data, and (b) correlating various attributes of the field survey.

### 6.2.1. Criticism of the Level of Service

As per the Indian Road Congress (hereafter, IRC) guidelines, pedestrian areas in India must abide by certain ideal guidelines. IRC defines Level of Service (hereafter, LOS) using the 'Pedestrian Space' method, which follows the formula:

**Equation 03:** Formula to calculate the LOS using Pedestrian Space method.

***Pedestrian Space = Area / Peak Hour Volume.***

As per IRC, another way of calculating LOS using the 'Flow Rate' method involves the formula:

**Equation 04:** Formula to calculate the LOS using Flow Rate method.

***Pedestrian Unit Flow Rate = Peak 15-min Flow Rate/ (15 x Effective Walkway Width).***

However, for this chapter, the 'Pedestrian Space' method is being used, where:

***Pedestrian Space= Area of Footpath/ Peak Hour Volume.***

Likewise, the LOS thus determined is designated as LOS A, LOS B, LOS C, LOS D, LOS E, and LOS F, with LOS A being the best. The detail of the LOS is tabulated in **Table 21**.

**Table 21:** Level of Service [Source: Guidelines for Pedestrian Facilities-IRC 103-2012, Indian Road Congress].

| S. No | Level of Service (LOA) | Pedestrian Space (area/peak hour volume) | Flow Rate (peak pedestrian flow rate/ effective walkway width) | Pedestrian Condition |
|---|---|---|---|---|
| 1 | LOS A | > 4.9 | < 12 | Ideal Pedestrian Condition |
| 2 | LOS B | > 3.3 - 4.9 | < 12 – 15 | Acceptable |
| 3 | LOS C | > 1.9 - 3.3 | < 15 – 21 | Just Satisfactory |
| 4 | LOS D | > 1.3 - 1.9 | < 21 - 27 | Poor |
| 5 | LOS E | > 0.6 - 1.3 | < 27 – 45 | Unsuitable |
| 6 | LOS F | < 0.6 | Varying | Severely Restricted |

[N.B.: The 'width' is footpath width and is calculated in meters; and the 'area' signifies footpath area (width x length) and is calculated in square meters.]

After interpreting the data collected during the survey in the case area, LOS F or severely restricted pedestrian conditions was present in only seventeen out of the eighteen footpath stretches. The one remaining footpath stretch is bearing the tag of LOS E or unsuitable pedestrian conditions. Thus, none of the footpath stretches possess ideal/ acceptable/ satisfactory pedestrian conditions as per the guidelines laid by IRC. **Tables 22 and 23** represents the LOS for each of the eighteen surveyed footpath stretches during the morning and evening peak hours. The following abbreviations are used in **Tables 22 and 23**:

| | | | |
|---|---|---|---|
| $W_E$ | = | Effective Walkway Width | (in m) |
| $L_E$ | = | Effective Walkway Length | (in m) |
| $A_E$ | = | Effective Walkway Area | (in m) |
| $V_{15}$ | = | Peak 15-min Flow Rate | (in p) |
| $V_{60}$ | = | Peak Hour Flow Rate | (in p) |
| $PS_D$ | = | Daytime Pedestrian Space Value | (in sqm/ p) |
| $PS_N$ | = | Daytime Pedestrian Space Value | (in sqm/ p) |

The $W_E$ and $L_E$ data were collected during the primary survey. $A_E$ was calculated thereafter. $V_{15}$ has been derived by taking the average of the Peak Hour (15-min interval) Pedestrian Count for the morning peak hour and evening peak hour respectively. $V_{60}$ was determined by multiplying $V_{15}$ by 4. $PS_D$ and $PS_N$ have been calculated by dividing the $A_E$ by $V_{60}$. The data has been elaborated in **Table 22**, and **Table 23** respectively.

**Table 22:** Level of Service at Morning Peak Hour.

| MORNING TIME: Determining Quantitative Level of Service (LOS) through PEDESTRIAN SPACE METHOD | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Street Name** | **$W_E$** | **$L_E$** | **$A_E$** | **$V_{15}$** | **$V_{60}$** | **$PS_D$** | **Corresponding LOS** |
| Nirmal Chandra Dey Street | 2.1 | 51.49 | 108.13 | 187 | 748 | 0.14 | **LOS F** |
| New Bowbazar lane | 5.0 | 51.68 | 258.40 | 264 | 1056 | 0.24 | **LOS F** |
| Kenderdine Lane | 3.0 | 87.62 | 262.86 | 243 | 972 | 0.27 | **LOS F** |
| Central Avenue (GATE 4: Yogayog Bhawan) | 2.1 | 126.43 | 265.50 | 121 | 484 | 0.55 | **LOS F** |
| Central Metro (GATE 1: Indian Airlines) | 2.1 | 176.77 | 371.22 | 264 | 1056 | 0.35 | **LOS F** |
| Bow Street | 3.8 | 26.84 | 101.99 | 345 | 1379 | 0.07 | **LOS F** |
| Metcalfe Street | 3.5 | 89 | 311.50 | 234 | 934 | 0.33 | **LOS F** |
| Bentick Street | 2.1 | 72.04 | 151.28 | 309 | 1235 | 0.12 | **LOS F** |
| Rabindra Sarani Rd. | 1.9 | 72.37 | 137.50 | 235 | 938 | 0.15 | **LOS F** |
| Chatawalla Gully | 3.5 | 70.94 | 248.29 | 271 | 1083 | 0.23 | **LOS F** |
| Phears Bye Lane | 2.0 | 66.03 | 132.06 | 209 | 834 | 0.16 | **LOS F** |
| Phears Lane | 4.8 | 57.85 | 277.68 | 271 | 1082 | 0.26 | **LOS F** |
| Giri Babu lane | 2.4 | 54.62 | 131.09 | 201 | 802 | 0.16 | **LOS F** |
| Central Metro (GATE 2: Lalbazar) | 1.9 | 110.67 | 210.27 | 205 | 820 | 0.26 | **LOS F** |
| Central Avenue (GATE 3: RITES) | 1.8 | 115.52 | 207.94 | 108 | 431 | 0.48 | **LOS F** |
| Gangadhar Babu lane | 5.0 | 109.26 | 546.30 | 130 | 519 | 1.05 | LOS E |
| Bibi Rozio Lane | 1.8 | 72.5 | 130.50 | 141 | 563 | 0.23 | **LOS F** |
| College Street | 1.9 | 163.12 | 309.93 | 282 | 1128 | 0.27 | **LOS F** |

**Table 23:** Level of Service at Evening Peak Hour.

| EVENING TIME: Determining Quantitative Level of Service (LOS) through PEDESTRIAN SPACE METHOD | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Street Name** | **$W_E$** | **$L_E$** | **$A_E$** | **$V_{15}$** | **$V_{60}$** | **$PS_N$** | **Corresponding LOS** |
| Nirmal Chandra Dey Street | 2.1 | 51.49 | 108.13 | 169 | 677 | 0.16 | **LOS F** |
| New Bowbazar lane | 5.0 | 51.68 | 258.40 | 226 | 904 | 0.29 | **LOS F** |
| Kenderdine Lane | 3.0 | 87.62 | 262.86 | 176 | 705 | 0.37 | **LOS F** |
| Central Avenue (GATE 4: Yogayog Bhawan) | 2.1 | 126.43 | 265.50 | 77 | 308 | 0.86 | **LOS F** |
| Central Metro (GATE 1: Indian Airlines) | 2.1 | 176.77 | 371.22 | 196 | 785 | 0.47 | **LOS F** |
| Bow Street | 3.8 | 26.84 | 101.99 | 279 | 1115 | 0.09 | **LOS F** |
| Metcalfe Street | 3.5 | 89 | 311.50 | 246 | 983 | 0.32 | **LOS F** |
| Bentick Street | 2.1 | 72.04 | 151.28 | 254 | 1015 | 0.15 | **LOS F** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Rabindra Sarani Rd. | 1.9 | 72.37 | 137.50 | 255 | 1018 | 0.14 | **LOS F** |
| Chatawalla Gully | 3.5 | 70.94 | 248.29 | 236 | 945 | 0.26 | **LOS F** |
| Phears Bye Lane | 2.0 | 66.03 | 132.06 | 180 | 718 | 0.18 | **LOS F** |
| Phears Lane | 4.8 | 57.85 | 277.68 | 276 | 1103 | 0.25 | **LOS F** |
| Giri Babu lane | 2.4 | 54.62 | 131.09 | 229 | 914 | 0.14 | **LOS F** |
| Central Metro (GATE 2: Lalbazar) | 1.9 | 110.67 | 210.27 | 186 | 744 | 0.28 | **LOS F** |
| Central Avenue (GATE 3: RITES) | 1.8 | 115.52 | 207.94 | 70 | 278 | 0.75 | **LOS F** |
| Gangadhar Babu lane | 5.0 | 109.26 | 546.30 | 190 | 760 | 0.72 | LOS E |
| Bibi Rozio Lane | 1.8 | 72.5 | 130.50 | 145 | 580 | 0.23 | **LOS F** |
| College Street | 1.9 | 163.12 | 309.93 | 229 | 917 | 0.34 | **LOS F** |

For a day (morning survey) as well as evening in the eighteen surveyed stretches in the case area, none of them is of Level of Service A or B or C or even D. Only one (5.6%) of the surveyed stretches is of LOS E which represents unsuitable pedestrian conditions. The remaining case area has LOS F which represents severely restricted pedestrian conditions.

### 6.2.2. Correlating various attributes of field survey

In this section of the chapter, the pedestrian data is correlated with the other factors in this research- (a) footpath width, (b) noise, (c) light intensity, and (d) thermal comfort. Pearson's Correlation with a 95% confidence interval has been used in this research. **Tables 24 and 25** elaborate on the correlation between Peak Hour Volume (15 min) and Variables in daytime and evening time, respectively.

**Table 24:** Level of Service at Evening Peak Hour.

| **DAY TIME: Correlation between Peak Hour Volume (15 min) and Variables:** | | | |
|---|---|---|---|
| **S. No.** | **Variable** | **Correlation Coefficient** | **Relationship** |
| **1** | Footpath Width (in Metres) | 0.25 | Weak positive |
| **2** | Avg. Sound Intensity (in Decibel) | -0.07 | Weak negative |
| **3** | Avg. Light Intensity (in Lux) | 0.11 | Weak positive |
| **4** | Avg. Temperature (in degree Centigrade) | -0.30 | Weak negative |

**Table 25:** Level of Service at Evening Peak Hour.

| **EVENING TIME: Correlation between Peak Hour Volume (15 min) and Variables:** | | | |
|---|---|---|---|
| **S. No.** | **Variable** | **Correlation Coefficient** | **Relationship** |
| **1** | Footpath Width (in Metres) | 0.44 | Moderate positive |
| **2** | Avg. Sound Intensity (in decibels) | -0.17 | Weak negative |
| **3** | Avg. Light Intensity (Average Day Time) | 0.35 | Moderate positive |
| **4** | Avg. Temperature (in degree Centigrade) | -0.06 | Weak negative |

In most urban areas with planned layouts and systematic transportation schemes, there exists a strong correlation between the pedestrian count and other related factors. However, in this research, strong correlation between the pedestrian count and the other factors of the field survey is absent.

### 6.2.3. Further linking the Level of Service with previous research

However, research in the same case area involving 125 individuals (74 able-bodied people under the age of sixty and 51 people from the senior citizen and specially-abled people category) from the case area shows that the users are not comfortable with the pedestrian environment[224]. Only 74.51% of the respondents from the senior citizens and specially-abled categories can use the pedestrian facility, in comparison to 93.24% of the able-bodied people under the age of sixty. Furthermore, on inquiring the respondents (who use the pedestrian facility) about pedestrian comfortability using a Likert Scale approach (1 being the worst and 10 being the best) the weighted mean score of their (senior citizen and specially-abled category) response was 4.92 out of 10, which is a poor score in terms of walkability standards. The response from able-bodied people under the age of sixty was also below satisfactory standards. The aforementioned research also reflects the lack of Universal Mobility standards in terms of infrastructure in the case area.

Thus, the available data indicates due to no correlation between the LOS and the pedestrian count, the full potential of the walkable population is not explored due to the lack of proper pedestrian facilities.

## 6.3. DISCUSSION

At the urban level, design elements (like buildings, road patterns, or sculptures) can induce both positive and negative effects on human psychology[225]. Pritzker Award (1980 edition) winning architects like Luis Barragan emphasized the emotional aspect of design. Similarly, Indian architect Pramod Beri has put forward the theory of 'Form follows Feelings'. Additionally, the role of four out of five fundamental human senses: vision, touch, smell, and hearing influences pedestrian movement. Thus, in the wake of the 21st -century's global focus on Universal Mobility, Architectural Planning should take into consideration the parameters of design that could positively influence pedestrians by targeting specific hormonal secretions. The role of assistive technology can be crucial in this process.

The way human beings behave in a particular socio-environmental setting is based on the type and rate of hormones that they secrete[226]. The hormone plays an important role in the ageing process too[227]. Even for specially-abled people, the hormonal aspects are comparatively more important since they are having compromised physical and/or mental states[228]. Hormones impact human behaviour[229]. It can also influence the cognition of humans in different physical environments[230]. Stimulus is received by the brain when a person walks in an environment and accordingly, the body responds, thus creating an associated memory leading to habituation. In contrast to the above, when a person walks in an environment that has a certain level of difficulty walking (like potholes, high sound of traffic, or poor visibility) a sense of fear is generated which leads to a sense of diminished security. The sense of fear is neurologically caused due to over-secretion of Epinephrine (Adrenalin and Cortisol) leading to an increased heart and breath rate[231]. In addition to this, the over-secretion of Epinephrine dilates the blood vessels in the lungs and muscles. Thus, specially-abled and elderly people often disorient and panic themselves when subjected to critical pedestrian conditions[232]. APR can help human behaviour by identifying and later influencing hormone secretion through architectural planning interventions[233]. Furthermore, it is suggested that Assistive Technologies proves beneficial for improving the behaviour of the specially-abled and elderly in pedestrian environments.

Assistive Technology is essentially any technology or method to improve the daily life of specially-abled people[234]. The primary focus of assistive technology is to remove obstacles and foster the functional ability of a diverse user group[235]. Assistive Technology should be affordable and mandatory since it is considered a human right rather than a mere additional facility in the context of 21st-century urbanization[236]. Although various assistive/ interactive technologies like HADRIAN, VERITAS, Inclusive CAD, SEE-IT, and the University of Cambridge fostered Inclusive Design Toolkit exist, their usage is highly dubious in the pedestrian context of developing nations[237]. Additionally, street-level assistive technology focused on specific disabilities like the visually impaired or auditory impaired.

To foster the use of assistive technology at the street level, further investigation in the same domain is proposed, which is established hereafter.

## 6.4. CONCLUSION

For understanding the pedestrian behaviour of the elderly alongside others, a simulation study is being conducted. In the first phase, the study involves 25 individuals from 16 different nationalities. A survey format (shown in **Table 26**) was used to record the participants' data.

**Table 26:** Survey Format for understanding pedestrian behaviour.

| **Survey Format for understanding pedestrian behaviour** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Date of Survey** | | | | | | | |
| **Time** | | | | | | | |
| **Temperature (in degrees Centigrade)** | | | | | | | |
| **Wind Speed (in meter/second)** | | | | | | | |
| **Humidity (in %)** | | | | | | | |
| **Precipitation** | | | YES | | NO | | |
| **Snowfall** | | | YES | | NO | | |
| **Participant** | | | | | | | |
| **Name** | | | **Country** | | | **Age** | |
| **Gender** | MALE | | FEMALE | | TRANSGENDER | | |
| **Travel Reading** | | | | | | | |
| **With a prosthetic suit** | | While going | | seconds | While coming | | seconds |
| **Without a prosthetic suit** | | While going | | seconds | While coming | | seconds |
| Surveyed By: | | | | Checked By: | | | |

A footpath stretches of approximately 150 meters within the Hokkaido University campus between Seicomart and the Graduate School of Engineering (shown in **Figure 74**) was selected, and the participants were asked to casually walk up and down in that stretch. This stretch has a relatively higher pedestrian footprint in comparison to the other parts of the university. The participants were further made to walk the same stretch (up and down) wearing a geriatric simulator, which made them behave like elderly people.

Apart from other deductions, on average, the time taken by an individual in a simulated elderly condition is 2.11 times more than the time taken under an able-bodied condition.

[N.B.: The consolidated data collected during this part of the survey is furnished in **Annexure P**.]

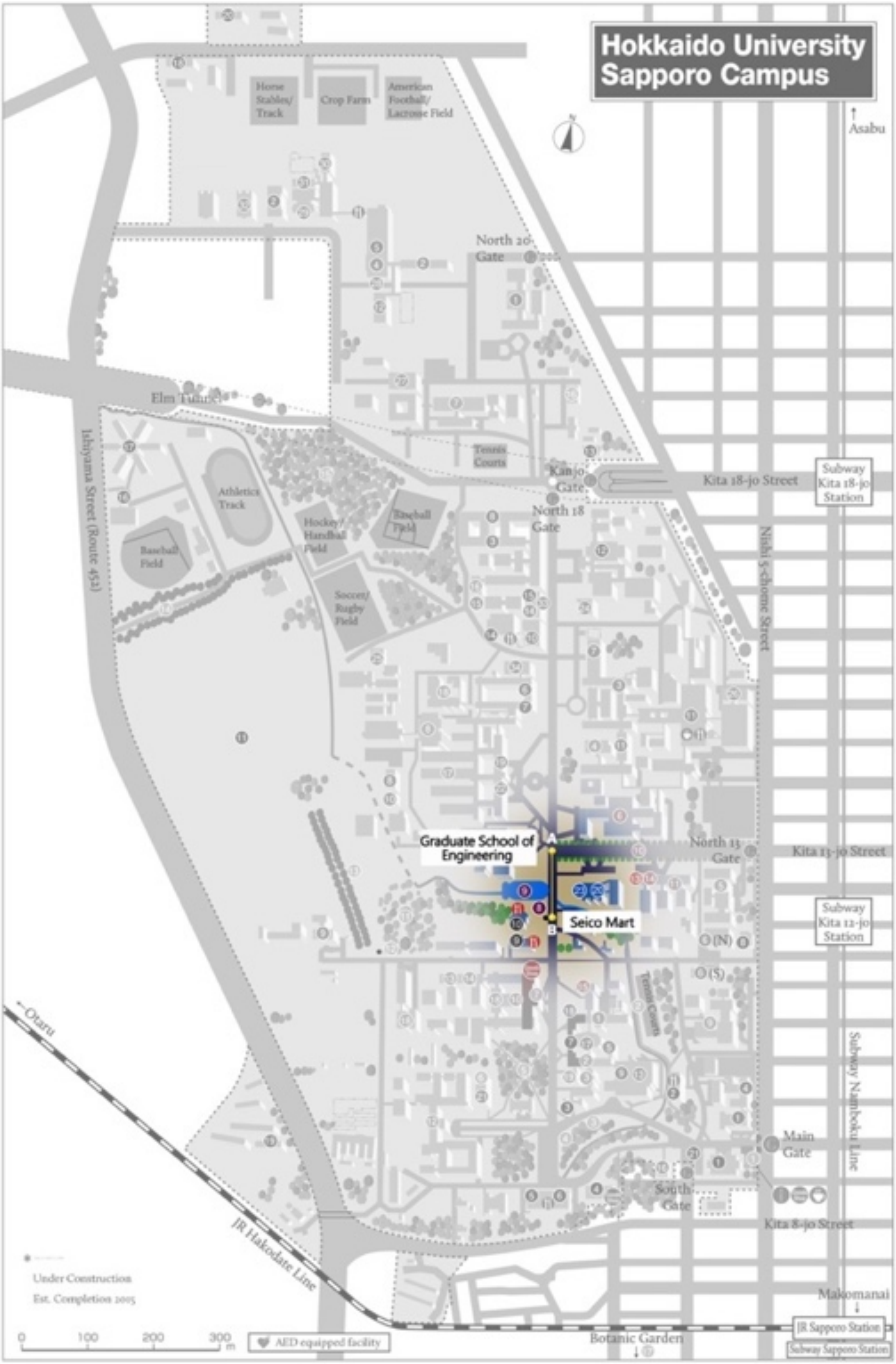



**Figure 74:** Survey Location in Hokkaido University [Source: Hokkaido University Official Website https://www.global.hokudai.ac.jp/about/publications/campus-map/, accessed on 28th April 2022.]

**Figure 75** shows the different components that the geriatric simulator is composed of. **Figures 76 and 77** show a few pictures from the survey wearing the simulation suit and general conditions respectively.


*(From left)*

**Figure 75:** Simulation Suit.

**Figure 76:** Survey.

**Figure 77:** Winter Survey.

Apart from this, the application of the Impairment Simulator Software developed by the researchers at the Engineering Design Centre in the Department of Engineering, University of Cambridge[238] is further explored. The software is used to generate alternate scenarios (like for specially-abled and elderly) and thereby open paths for strategic intervention.

Finally, the methodological framework from this chapter (results furnished in this chapter and methodology for future research) shall be beneficial for researchers while designing/ planning for improving cognition in pedestrian-level Universal Mobility in other old cities of India.

# CHAPTER 07

- **Title:** Conclusion and Recommendations

---

**'People ignore design that ignores people'.**

*– Frank Chimero*

# 7. CONCLUSION AND RECOMMENDATIONS

This chapter discusses the following: (a) a summary of the research, (b) global best practices and discussion with the dissertation, (c) global researchers' opinions and discussion with the dissertation in relation to architectural planning, d) conclusion, and (e) scope of future research. In the summary of the research, the interpretation of the dissertation chapters is elaborated by linking the following points with each chapter (Chapters 2-6): Objectives and Scope, Focus and Research Questions, and Data Set.

Next, the following examples from global best practices and the learnings which could be incorporated into this research are discussed: Jungali Maharaj Street (India), Las Ramblas Street (Spain), Avenue Paulista (Brazil), SW Moody Avenue (USA), Jackson Street (USA), and Between North 7 West 6' and 'North 6 West 5' (Sapporo, Japan), Berlin (Germany), Melbourne (Australia), and Gdniya (Poland).

In the last phase, the works of the following researchers are discussed in relation to this research: Suguru Mori, Rachna Khare, Gaurav Raheja, Elaine Ostroff, Selwyn Goldsmith, and Wolfgang Preiser. The perspective of these stalwarts and the uniqueness of this research is specified in this segment.

## 7.1. RESEARCH SUMMARY

This section interprets the dissertation chapters by associating them with the research scopes and research objectives. Furthermore, the linkage between the research focus and research questions with the chapters is suggested. Finally, the datasets related to each chapter are stated, followed by the research findings.

### 7.1.1. Objectives and Scope related to each chapter

The relationship between the chapters with the objectives and scope laid out for this research is set forward in the table below:

**Table 27:** Relationship between the chapters with objectives and scopes of this research.

| Chapter Title | Scope | Objectives |
|---|---|---|
| **Chapter 2: Universal Mobility in Old Core Cities of India: People's Perception** | **Scope 1:** To explore the potential of inclusiveness in congested cores where the density is more concerning the rest of the city. | **Objective 1:** To define the role of Architectural Planning in an 'accessibility planning' proposal. |
| **Chapter 3: Evaluating the accessibility of old cities: a case of central Kolkata, India** | **Scope 2:** To furnish a process-oriented approach in the realm of accessibility where the approach is still product oriented. | **Objective 2:** To determine the degree of accessibility possible in the footpaths of core areas of an old Indian city by proposing an ideal accessibility audit checklist.<br>**Objective 4:** Policy-level recommendations to increase the quality of life in cities by improving the footpaths. |
| **Chapter 4: Reviewing Universal Mobility of the footpaths in the core of old** | **Scope 2:** To furnish a process-oriented approach in the realm of accessibility | **Objective 2:** To determine the degree of accessibility possible in the footpaths of core areas of an old Indian city by proposing an ideal accessibility audit checklist. |

| | | |
|---|---|---|
| **Indian cities through field survey** | where the approach is still product oriented. | |
| **Chapter 5: Interpreting Universal Mobility in the footpaths of urban India based on experts' opinion** | **Scope 2:** To furnish a process-oriented approach in the realm of accessibility where the approach is still product oriented. | **Objective 2:** To determine the degree of accessibility possible in the footpaths of core areas of an old Indian city by proposing an ideal accessibility audit checklist. |
| **Chapter 6: Role of Cognition in Pedestrian-Level Universal Mobility: Case of Central Kolkata, India** | **Scope 1:** To explore the potential of inclusiveness in congested cores where the density is more concerning the rest of the city. | **Objective 3:** To improve cognition at the footpath level in old cities, especially for the specially-abled. |

### 7.1.2. Focus and Research Questions for each chapter

The relationship between the chapters with the focus and research questions assigned for this research is stated in the table below:

**Table 28:** Relationship between the chapters with focus and research questions of this research.

| Chapter Title | Focus | Research Question |
|---|---|---|
| **Chapter 2: Universal Mobility in Old Core Cities of India: People's Perception** | **Focus 1:** Users' perception towards Universal Mobility in old core cities of India | **Research Question 1:** What is the role of accessibility under the broader domain of universal design in improving the quality of life? |
| **Chapter 3: Evaluating the accessibility of old cities: a case of central Kolkata, India** | **Focus 2:** Accessibility of the footpath-level walkability condition of Kolkata | **Research Question 2:** What is the degree of accessibility that can be achieved in the public domain of old cities? |
| **Chapter 4: Reviewing Universal Mobility of the footpaths in the core of old Indian cities through field survey** | **Focus 3:** Universal Mobility in the core of old Indian cities (survey based) | **Research Question 3:** Can core Indian cities be made inclusive in terms of Universal Mobility? |
| **Chapter 5: Interpreting Universal Mobility in the footpaths of urban India based on experts' opinion** | **Focus 4:** Experts' perception towards Universal Mobility in the core of old Indian cities | **Research Question 3:** Can core Indian cities be made inclusive in terms of Universal Mobility? |
| **Chapter 6: Role of Cognition in Pedestrian-Level Universal Mobility: Case of Central Kolkata, India** | **Focus 5:** Role of cognition in Universal Mobility at the pedestrian-level | **Research Question 4:** What degree of cognition can be achieved in the footpaths of old cities? |

### 7.1.3. Data Set associated with each chapter

For this research, the opinion of 733 individuals and observations from 101 footpaths in 5 different Indian cities were considered as data sets. The major data sets associated with each chapter are shown in the table below:

**Table 29:** Relationship between the chapters and the data set of this research.

| Chapter Title | Data Set (Sample Size) |
|---|---|
| **Chapter 2: Universal Mobility in Old Core Cities of India: People's Perception** | (a) Public Opinion (125 people)<br>(b) Design Fraternity (310 people) |
| **Chapter 3: Evaluating the accessibility of old cities: a case of central Kolkata, India** | Footpaths in central Kolkata (32 footpath stretches) |
| **Chapter 4: Reviewing Universal Mobility of the footpaths in the core of old Indian cities through field survey** | (a) Footpaths in Jaipur (7 footpaths)<br>(b) Footpaths in Jodhpur (16 footpaths)<br>(c) Footpaths in Nagpur (12 footpaths)<br>(d) Footpaths in Hyderabad (9 footpaths)<br>(e) Footpaths in Chennai (25 footpaths) |
| **Chapter 5: Interpreting Universal Mobility in the footpaths of urban India based on experts' opinion** | Expert opinion (257 people) |
| **Chapter 6: Role of Cognition in Pedestrian-Level Universal Mobility: Case of Central Kolkata, India** | (a) Footpaths in central Kolkata (32 footpath stretches)<br>(b) Geriatric Simulation (41 people) |

## 7.2. GLOBAL BEST PRACTICES AND DISCUSSION WITH THE DISSERTATION

Ample design-level examples at both footpath and urban levels in old cities reflects that walkability in an urban location can include universal design considerations if designed per available guidelines and contextual demands. This statement can be further verified through the best practices explained hereafter.

In Jungali Maharaj Street (Pune, India), the designers focused on the safety of pedestrians and cyclists and redeveloped a stretch of 1800m with simple design elements like (a) a wide pedestrian, (b) the slope between vehicular and pedestrian pathway, (c) anti-skid flooring, (d) streetlights to ensure the safety of citizens, (e) trees for proper shading, and (f) guiding blocks (for the visually impaired).[239,240] Similarly, on a 1250m stretch in Las Ramblas Street (Barcelona, Spain), the policy makers incorporated the following to ensure hassle-free walkability: (a) a walkway in the centre and vehicular in the sideways, (b) canopy for light filter and protection from traffic, (c) anti-skid flooring, (d) ample sitting areas, (e) building height permitting sun during winter, and (f) drinking facility at the accessible height.[241,242] Prioritizing enhanced mobility system, a 2500m stretch in Avenue Paulista (Sao Paulo, Brazil) has been developed using the following: (a) smooth, continuous walking surface, (b) wide sidewalks to accommodate pedestrians moving at different speeds, (c) accommodating informal vendors, (d) contrasting colour and tactile markings in pavements for continuous visibility, (e) clear differentiation at intersection and crosswalks, (f) alignment and location of kerb (curb) ramps, and (g) continuous walk to ease crossing the wide avenue.[243,244] A 1000m long stretch in SW Moody Avenue (Portland, USA) was prioritized based on the segregation of pedestrians and cyclists using the incorporation of the following design elements: (a) colourful signage, (b) tactile and activity-wise segregated walkways, (c) wide pedestrian pathway for wheelchair users, (d) anti-skid flooring surface, (e) signage in combination with small kerb (curb) radii, distinctive materials, and other visual cues for making it non-accessible for vehicles, (f) handrails in the crossway at different levels, (g) tactical and demarcation of routes in the crossways, and railing all over the street side and provision of slopes.[245,246]

On similar lines, in Jackson Street (Minnesota, USA), the designers redefined a 1700m stretch based on 'deafscape' or design enabling users with auditory impairment using the following: (a) street trees and green infrastructure to provide wildlife habitat, reduce the heat island effect, street noise buffer and increased pedestrian safety, (b) wide pedestrian walkways, (c) places to rest for older and mobility disabled pedestrians, (d) tactile and high contrast paving, and (e) seating to accommodate different group sizes.[247,248]

Similarly, multiple instances around the world at the urban/ city level in old cities shows how the existing spaces for public walkability are made inclusive, thereby increasing the potential of universal mobility.

In Berlin, Germany the focus is on accessible transportation. The features implemented in Berlin are: (a) Mobidat database: it offers information on accessibility and on-site conditions at Berlin sights and other locations, (b) most of the U-Bahn (tube) stations, the S-Bahn (city railway), (c) Berlin's public transport services' bus and ferries are all wheelchair accessible, (d) the Wheel Map online application provides an accessible map where locations with full, partial, and not wheelchair accessible can be found out, (e) free mobility assistance services for buses and trains are available online and can be booked via call also, (f) provision of wheelchair taxis, (g) accessible toilets are marked on the access Berlin application, (h) around 1300 publicly accessible parking spaces available in the city.[249,250] In Melbourne, Australia, prioritizing creating a mobility map for the city centre, the policymakers did the following: (a) access and mobility maps for the city centre, (b) the interactive access map shows disabled parking, accessible toilets, mobility recharging points, public seating, drinking fountains, train, bus, and tram station entrances and street gradients, and (c) the printable access maps are available in the city of Melbourne website.[251,252] In Gdniya, Poland making the city core accessible creates it an ideal best practice. The major initiatives in Gdniya are (a) accessible sports hall: a special audience for specially-abled and audio description for the blind used during sports events, (b) railway stations: fully accessible for specially-abled people, (c) marina and sea beach: wooden ramp for wheelchair users, large playgrounds for children who are specially-abled, (d) buses and trolleybuses: low floors for wheelchair access, (e) bus stops: modernized to be more friendly for elderly people and specially-abled people, (f) special transportation system: offered on-demand services for specially-abled people who cannot use public transport, and (g) the high accessibility of public transport is the reason why the percentage of households with access to a passenger car is lower than in the whole city.[253,254]

Thus, the designers need to understand that Universal Mobility cannot constitute a standard formula. The need of every urban context is different, and the designers need to be flexible in implanting the standards. Especially for old cities, where the pedestrian flow is relatively higher, understanding the local context is important. The field survey results need to be critically understood to propose conclusive recommendations.

## 7.3. WORKS OF THE RESEARCHERS IN RELATION TO THIS RESEARCH

Since the inception of inclusive design approaches, designers or academicians or researchers advocated the concept. Academicians and researchers developed the notion of inclusiveness into universal design or universal mobility from the initial ideas like barrier-free architecture. This section shall critically discuss the works of a number of eminent global researchers and how this research relates to them.

Dr. Rachna Khare, a Professor and Head of the Department of Design at the School of Planning and Architecture in Bhopal, India is a pioneer in the field of universal design, especially in the Indian context. She founded the 'Centre for Human-Centric Research' for research on universal design. Her research focuses on the interior planning for autism-friendly spaces[255,256] and the use of geospatial techniques in assessing accessibility in heritage locations.[257,258] Dr. Khare has been advocating inclusion through educational space design. Another researcher from India who has established his expertise in the field of universal design is Prof. Dr. Gaurav Raheja (Head, Department of Architecture and

Planning, Indian Institute of Technology at Roorkee, India). Dr. Raheja's expertise is on the universal design aspects in rural areas[259] and his 'Laboratory of Inclusive Design' continues doing innovative research[260]. Dr. Raheja has been involved in preparing the policy documents for the government of India, including research on urban mobility[261]. Both Dr. Khare and Dr. Raheja were part of the team which developed the Indian principles of universal design, namely: *Saman* (Equitable), *Sahaj* (Usable), *Sanskritik* (Cultural), *Sasta* (Economic), and *Sundar* (Aesthetic). [262] However, the specific role of accessibility at the footpath level is not dealt with in their research. Elaine Ostroff, the co-founder of the Institute for Human-Centred Design at Boston (U.S.A.) and former director of training for the Massachusetts Department of Mental Health was one of the first experts to ensure awareness for non-experts in the field.[263] She has introduced human-centred design into professional design education.[264] Ostroff has argued that the paradigm of universal design is ever-evolving and that the seven principles of universal design (developed in the USA) are not be necessarily applicable in developing nations. This research has recognized the need for a contextual accessibility framework. Architect Selwyn Goldsmith, who himself was specially-abled since his graduation days was instrumental in developing the concept of dropped Kerb or Curb (Kerb flushed with road at certain sections for easy movement). Amongst numerous standards[265], Goldsmith's most prominent contribution is the 'Universal Design Pyramid' where he specified different user groups[266]. Goldsmith's work does not include the complexities of old cities with mixed-use developments, rather it focuses on providing universal guidelines in developed nations. This research recognizes the need for service-level benchmarks for all elements on the street (like footpath width, railings, etc.) with respect to user groups in the Indian context. Prof. Dr. Wolfgang F.E. Preiser from the University of Cincinnati at Ohio, U.S.A. has done extensive research on universal design over the past few decades. Dr. Preiser recognizes the lack of a comprehensive accessibility audit checklist and has given several directions like the inclusion of the following in the data gathering for accessibility audit: (a) behavioural observations, (b) mechanical recordings, (c) visual recordings, (d) verbal response measurement, and e) physical measurements[267,268].

## 7.4. CONCLUSION

As responsible professionals in the field of architecture and planning, this research is a part of the movement that aims towards creating a built environment 'For All'. Built environment 'For All' takes into attention the needs of able-bodied as well as elderly/specially-abled people. The role of the Laboratory of Architectural Planning, Hokkaido University under the supervision of Professor Dr. Mori and Associate Professor Dr. Nomura is specifically noteworthy in this discussion. This laboratory focuses on 'planning architecture' based on 'practical problem interest'. One of the research themes of this laboratory is 'research on the ideal living environments for minorities', with a sub-theme titled 'Environment design that realises safe and comfortable going out for the physically vulnerable'. This enabled to conduct this research fruitfully in this laboratory. Moreover, the focus of this laboratory is also on coherence with Goal Number 11 of the United Nations Sustainable Development Goals (UN-SDG). The title of the goal 'Sustainable cities and communities' highlights the need to provide (a) access to safe, affordable, accessible, and sustainable transport systems for all and (b) improve road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons. This goal indicates the need for universal design and universal mobility, in a global society. In 2020, Hokkaido University collaborated with twenty-seven other Japanese Universities to participate in United Nations University's 'Sustainable Development Goals University Platform' (SDG-UP). This platform established by the UN-University Institute for the Advanced Study of Sustainability (UNU-IAS) emphasizes global development in sustainable terms. Thus, the 'Laboratory of Architectural Planning' can prove an essential resource body in assessing the universal mobility conditions in old core cities by aligning its research interest with global concerns in the field of universal design.

Capacity building and research on universal design is an effective tool for creating global awareness about the need for universal design in architecture and planning.[269] Along similar lines, the Ministry of Housing and Urban Affairs, Government of India, in collaboration with- Indian Institute of Technology Roorkee (hereafter, IIT-R), National Institute of Urban Affairs (hereafter, NIUA), and All

India Institute of Local Self Governance (hereafter, AIILSG), has launched an initiative titled 'Building Accessible, Safe, and Inclusive Indian Cities' (hereafter, BASIIC). Functionally started in 2020, the BASIIC project is supported by the 'Department for International Development' (hereafter, DFID), currently known as 'Foreign, Commonwealth and Development Office' (hereafter, FCDO) fund of the United Kingdom (hereafter, UK) government. This project aims towards framing disabled-friendly guidelines and policy recommendations that can be implemented through the already functioning Smart Cities Mission.[270] The major objectives of the project include (a) training and capacity building of government officials and (b) sensitizing citizens of India about the importance of universal design. Eminent architects and planners are engaged by NIUA and AIILSG in this project, from the initial stage of preparing posters for universal design awareness until the final preparation of the course modules. Laboratory of Architectural Planning was engaged as the content curator and one of the module development experts for this project. Unlike previous projects of the Government of India, the BASIIC project focuses on the concept of spreading awareness of universal design through education and research. Thus, in the coming years, accessibility conditions will improve in urban areas of India.

Sharing knowledge on universal design through research and interaction increases the possibility of an inclusive society. Such a society shall ensure the same standard of urban infrastructure for both able-bodied and specially-abled. However, capacity building alone cannot bring about a radical change in critical universal design thinking. Thus, the findings for this research are comparatively the beginning of a quest towards assessing accessibility in the core city areas in the Indian context.

Finally, to summarize, there are two major fronts towards which the recommendations are directed. First, the suggestion is related to footpath accessibility. As per the existing guidelines, urban areas are planned according to urban level development guidelines (like Comprehensive Mobility Plan). This research suggests stretch based approach by prioritizing the context of development is the ideal way to bring universal mobility at urban level, especially in old Indian cities. The second suggestion is related to urban reforms. Any country relies on urban reforms for radical changes in the urban development scenario. Unlike the existing uniform Pan-India guidelines (like Harmonised Guidelines and Standards for Universal Accessibility in India, 2021), this research suggests separate guidelines for old and new cities in India. Furthermore, this research seeks a shift from existing guideline-focussed accessibility assessment towards a new audit-focussed accessibility assessment (as practiced during this research).

Thus, this research adds value/contributes to these major fronts:

(a) The researchers/academics can use the findings and even refer to the methodology used in this research to conduct more investigations for improving the research domain in universal design/mobility in Indian cities.

(b) Government officials can interpret how to distribute funding and resources based on the prioritization of universal mobility issues.

(c) Furthermore, the policymakers can understand the viewpoint of the experts in the field of universal design and include them more in the process of framing guidelines (as explained in Section 5.2.3).

In addition, it is ethically imperative for an architect/planner to be rational before approaching any design solution at an urban level to ensure that the proposed design solution should be both creative and inclusive to ensure sustainability in the domain of the built environment.

## 7.5. SCOPE FOR FUTURE RESEARCH

Through the process of this research, it is understood that the concept of accessibility is complex. Specifically speaking, every footpath stretches in old Indian cities vary in characteristics and pose multiple complexities in ensuring universal mobility for its users. Thus, it is recommended that the study be done in a more detailed and context-specific form for further research in this domain.

First, one ought to identify/ earmark a particular footpath stretch and conduct a generic/ preliminary survey using the survey formats (infrastructural and cognitive) as used in this research.

Second, there can be another section of the survey for understanding the impact of the following on pedestrian movement: (a) Illumination, (b) Thermal Comfort, and (c) Noise. In the study of illumination, the daytime condition of the predominant lux level, its corresponding spread of light, and the associated glare should be prioritized. These factors considerably impact the pedestrian environment. The next study of thermal comfort should ideally contain the readings of felt temperature, related comfort index, locational urban heat island and surface temperature, and finally shadow analysis. Considering the high humidity and high temperature in most old cities in India, especially in summer, it is important to study the felt temperature and other factors as indicated herewith. The noise level study would help determine the local signals' audio level. Examples include, due to different audio levels on different roads adjacent to the footpath owing to the corresponding traffic conditions, there can be a proposal to implement audio signals with varying sound levels.

Third, the aforementioned survey readings can be used to create scenario analysis. Two different scenarios for able-bodied and specially-abled can be generated using software such as DIALUX or LADYBUG. Two distinct scenarios namely the time required to travel through the footpath and the movement pattern undertaken, can be generated to understand the difference in the pedestrian quality of the existing footpath condition and the improved footpath condition.

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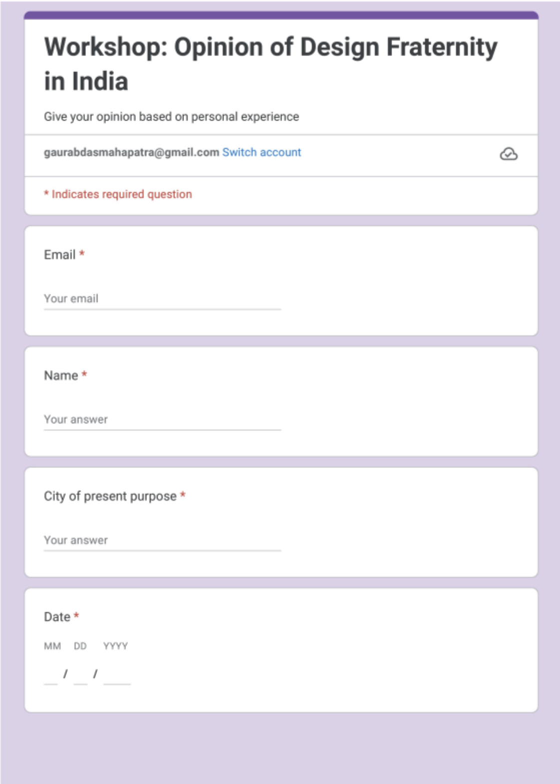
# Annexures

| S. No. | Related Chapter | Title |
|---|---|---|
| Annexure A | 02 | Questionnaire used in assessing the opinion of 310 respondents from the design fraternity in India regarding universal design. |
| Annexure B | 02 | Consolidated data of the opinion of 310 respondents from the design fraternity in India regarding universal design. |
| Annexure C | 02 | Questionnaire used in assessing the 125 people's perception regarding walkability and mobility in Kolkata. |
| Annexure D | 02 | Consolidated data of the opinion of the 125 people's perception regarding walkability and mobility in Kolkata. |
| Annexure E | 03 | Consolidated data related to the building use of the 32 footpath stretches in Central Kolkata, India. |
| Annexure F | 03 | Questionnaire used in assessing the opinion of the 257 Indian experts from the fields of Architecture and Planning regarding five most important factors while assessing universal mobility for pedestrians in the Old Cities of India |
| Annexure G | 03 | Questionnaire used in mapping the infrastructure in the footpaths of Central Kolkata, India based on 50 sub-criteria. |
| Annexure H | 03 | Consolidated data for the mapping of the infrastructure in the footpaths of Central Kolkata, India based on 50 sub-criteria. |
| Annexure I | 03 | Questionnaire used in pedestrian mapping in the 32 footpath stretches in Central Kolkata, India. |
| Annexure J | 03 | Consolidated data for the pedestrian mapping in the 32 footpath stretches in Central Kolkata, India. |
| Annexure K | 04 | Questionnaire used in mapping the infrastructure in the 69 footpaths in 5 different cities of India based on 19 parameters (52 indicators). |
| Annexure L | 04 | Calculation related to scoring of the individual survey indicators across the 69 footpath stretches in 5 cities in India. |
| Annexure M | 04 | Calculation related to scoring of 69 footpath stretches in 5 cities in India, depending on the presence/absence of the parameter. |
| Annexure N | 05 | Questionnaire used in assessing the opinion of the 257 Indian experts from the fields of Architecture and Planning regarding universal design and universal mobility conditions in their city. |

| | | |
|---|---|---|
| Annexure O | 05 | Consolidated data of the opinion of the 257 Indian experts from the fields of Architecture and Planning regarding universal design and universal mobility conditions in their city. |
| Annexure P | 06 | Consolidated data of the geriatric simulation of the 25 individuals from 16 different countries |

**Annexure A:** Questionnaire used in assessing the opinion of 310 respondents from the design fraternity in India regarding universal design.



## Workshop: Opinion of Design Fraternity in India

Give your opinion based on personal experience

gaurabdasmahapatra@gmail.com Switch account

* Indicates required question

Email *

Your email

Name *

Your answer

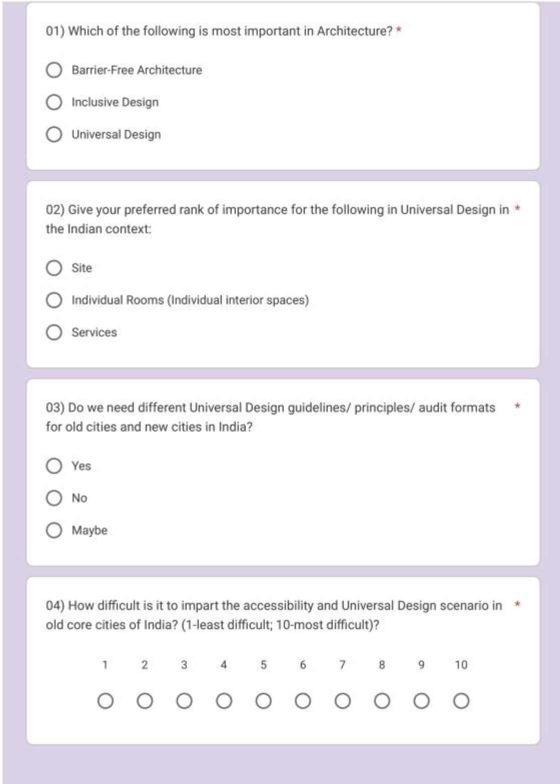
City of present purpose *

Your answer

Date *

MM DD YYYY

__ / __ / ____



01) Which of the following is most important in Architecture? *

- Barrier-Free Architecture
- Inclusive Design
- Universal Design

02) Give your preferred rank of importance for the following in Universal Design in the Indian context: *

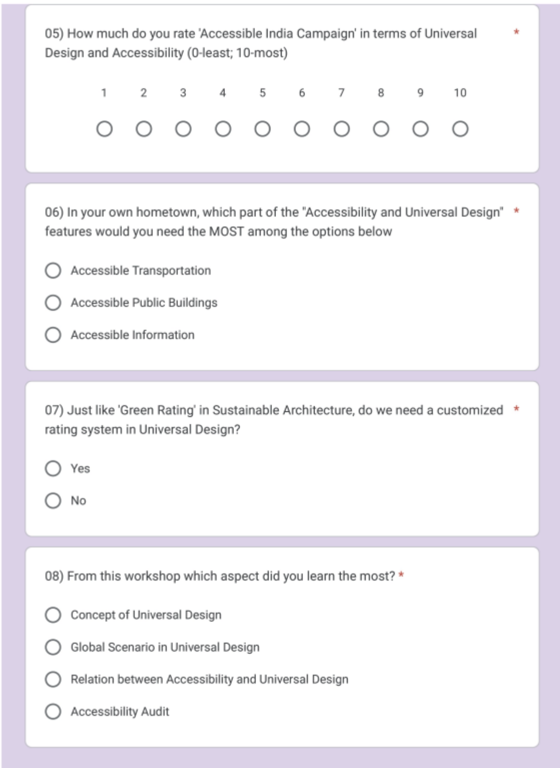
- Site
- Individual Rooms (Individual interior spaces)
- Services

03) Do we need different Universal Design guidelines/ principles/ audit formats for old cities and new cities in India? *

- Yes
- No
- Maybe

04) How difficult is it to impart the accessibility and Universal Design scenario in old core cities of India? (1-least difficult; 10-most difficult)? *

1 2 3 4 5 6 7 8 9 10



05) How much do you rate 'Accessible India Campaign' in terms of Universal Design and Accessibility (0-least; 10-most) *

1 2 3 4 5 6 7 8 9 10

06) In your own hometown, which part of the "Accessibility and Universal Design" features would you need the MOST among the options below *

- Accessible Transportation
- Accessible Public Buildings
- Accessible Information

07) Just like 'Green Rating' in Sustainable Architecture, do we need a customized rating system in Universal Design? *

- Yes
- No

08) From this workshop which aspect did you learn the most? *

- Concept of Universal Design
- Global Scenario in Universal Design
- Relation between Accessibility and Universal Design
- Accessibility Audit

**Annexure B:** Consolidated data of the opinion of 310 respondents from the design fraternity in India regarding universal design.

**Survey Question 1:** Which of the following is most important in Architecture?

| | | No. of Respondents | % |
|---|---|---|---|
| 1. | Barrier Free Architecture | 48 | 15.48 |
| 2. | Inclusive Design | 18 | 5.81 |
| 3. | Universal Design | 244 | 78.71 |

**Survey Question 2:** Give your preferred first rank of importance for the following in Universal Design in the Indian context: (a) Site, (b) Individual Rooms (individual interior spaces), and (c)Services

| | No. of Respondents | % |
|---|---|---|
| Site | 129 | 41.61 |
| Individual Rooms | 37 | 11.94 |
| Services | 144 | 46.45 |

**Survey Question 3:** Do we need different Universal Design guidelines/ principles/ audit formats for old cities and new cities in India?

| | | No. of Respondents | % |
|---|---|---|---|
| 1. | Yes | 197 | 63.55 |
| 2. | No | 11 | 3.55 |
| 3. | Maybe | 102 | 32.90 |

**Survey Question 4:** Survey Question 4: How difficult is it to impart the accessibility and Universal Design scenario in old core cities of India? (1-least difficult; 10-most difficult)

| Score | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| No. of Respondants | 3 | 3 | 10 | 9 | 38 | 47 | 57 | 76 | 53 | 14 |
| % | 0.97 | 0.97 | 3.23 | 2.90 | 12.26 | 15.16 | 18.39 | 24.52 | 17.10 | 4.52 |

**Survey Question 5:** How much do you rate 'Accessible India Campaign' in terms of Universal Design and Accessibility (0-least; 10-most)?

| Score | **No. of Respondents** | % |
|---|---|---|
| 0 | 1 | 0.32 |
| 1 | 0 | 0.00 |
| 2 | 3 | 0.97 |
| 3 | 5 | 1.61 |
| 4 | 14 | 4.52 |
| 5 | 35 | 11.29 |
| 6 | 45 | 14.52 |
| 7 | 73 | 23.55 |
| 8 | 80 | 25.81 |
| 9 | 37 | 11.94 |
| 10 | 17 | 5.48 |

**Survey Question 6:** In your own hometown, which part of "Accessibility and Universal Design" features would you need the MOST among the options below?

| | **No. of Respondents** | % |
|---|---|---|
| 1. Accessible Information | **40** | **12.90** |
| 2. Accessible Public Buildings | **101** | **32.58** |
| 3. Accessible Transportation | **169** | **54.52** |

**Survey Question 7:** Just like 'Green Rating' in Sustainable Architecture, do we need a customized rating system in Universal Design?

| | **No. of Respondents** | % |
|---|---|---|
| 1. Yes | 301 | 97.10 |
| 2. No | 9 | 2.90 |

**Annexure C:** Questionnaire used in assessing the 125 people's perception regarding walkability and mobility in Kolkata.

## People's Perception in an Old City Regarding Walkability and Mobility

Give your opinion based on personal experience

gaurabdasmahapatra@gmail.com Switch account

* Indicates required question

Email *

Your email

Name of the surveyor *

Your answer

Location of Survey (Ward Number) *

Your answer

Date *

MM DD YYYY

__ / __ / ____

1) User Category *

- Able-Bodied
- Specially-abled

2) Gender of the interviewee *

- Male
- Female
- Transgendered
- Not willing to reveal

3) Age of the interviewee *

- 0-10
- 10-20
- 20-35
- 35-50
- 50-60
- 60 and Above

4) Recognized Disability (i.e. PwD cardholder) *

- Yes
- No

5) [If Yes] Type of Disability *

- Blindeness
- Low Vision
- Leprosy Cured persons
- Locomotor Disability
- Dwarfism
- Intellectual Disability
- Mental Illness
- Cerebral Palsy
- Specific Learning Disabilities
- Speech and Language disability
- Hearing Impairment ( Deaf and Hard of Hearing)
- Muscular Dystrophy
- Acid Attack Victim
- Parkinson's disease
- Multiple Sclerosis
- Thalassemia
- Hemophilia
- Sickle Cell disease
- Autism Spectrum Disorder
- Chronic Neurological conditions
- Multiple Disabilities including Deaf Blindness
- Other

6) How often do you go out of your home? *

- Daily
- Once in a week
- Few times in a month
- Rarely (a few times a year)

7) Why do you go out of your home? *

- Work
- Medical Reasons
- Social Gathering
- Avail Government Benefits (like health card, etc.)
- Daily household work

8) How do you usually remember/ search/ identify an address? *

- Using online services like Google maps, etc.
- Asking people on the streets
- Referring Street Signage
- Identifying landmarks (like the nearest junction, old tree, famous temple, etc.)

9) Do you use Public Transport *

- ◯ Yes
- ◯ No

10) If Yes, how comfortable are you with taking Public Transport? [On a scale of 1 to 10; where 10 is most comfortable and 1 is least comfortable] *

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

11) Which Public Transport do you usually use? *

- ◯ Bus
- ◯ Tram
- ◯ Metro Rail
- ◯ Local Train
- ◯ Auto Rickshaw
- ◯ Cycle Rickshaw

12) What is the major problem in accessing Public Transport? *

- ◯ Reaching the Public Transport from home
- ◯ Difficulty in waiting for facilities (like bus stops, improper visual notification, etc.)
- ◯ Fare
- ◯ Any other

13) Do you walk on the streets? *

- ◯ Yes
- ◯ No

14) If, Yes; How comfortable are you walking on the streets? [On a scale of 1to 10; where 10 is most comfortable and 1is least comfortable] *

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

15) Have you heard of"Sugamya Bharat Abhiyan" (or "Accessible India Campaign")? *

- ◯ Yes
- ◯ No

**Annexure D:** Consolidated data of the opinion of the 125 people's perception regarding walkability and mobility in Kolkata.

**Survey Question 6: How often do you go out of your home?**

| | | Category A: Able Bodied (≤60 years) | | Category B: Senior Citizen and/ or Specially-abled | |
|---|---|---|---|---|---|
| | | **No. of Respondents** | **%** | **No. of Respondents** | **%** |
| 1. | Daily | 56 | 75.68 | 26 | 50.98 |
| 2. | Few times in a Week | 13 | 17.57 | 15 | 29.41 |
| 3. | Few times in a month | 3 | 4.05 | 6 | 11.76 |
| 4. | Rarely (few times in a year) | 2 | 2.70 | 4 | 7.84 |

**Survey Question 7: Why do you go out of your home?**

| | | Category A: Able Bodied (≤60 years) | | Category B: Senior Citizen and/ or Specially-abled | |
|---|---|---|---|---|---|
| | | **No. of Respondents** | **%** | **No. of Respondents** | **%** |
| 1. | Profession/ Education | 56 | 75.68 | 24 | 47.06 |
| 2. | Medical Reasons | 10 | 13.51 | 26 | 50.98 |
| 3. | Social Gathering | 66 | 89.19 | 32 | 62.75 |
| 4. | Avail Government Benefits (like health card, etc) | 0 | 0.00 | 4 | 7.84 |
| 5. | Daily Household work | 45 | 60.81 | 29 | 56.86 |

**Survey Question 8: How do you usually remember/ search/ identify an address?**

| | Category A: Able Bodied (≤60 years) | | Category B: Senior Citizen and/ or Specially-abled | |
|---|---|---|---|---|
| | **No. of Respondents** | **%** | **No. of Respondents** | **%** |
| Using online services like Google maps, etc | 42 | 56.76 | 13 | 25.49 |
| Asking people on the street | 24 | 32.43 | 23 | 45.10 |
| Identifying landmark (like nearest junction, old tree, famous temple, etc.) | 7 | 9.46 | 13 | 25.49 |
| Referring Street Signage | 1 | 1.35 | 2 | 3.92 |

**Survey Question 9: Do you use Public Transport?**

| | Category A: Able Bodied (≤60 years) | | Category B: Senior Citizen and/ or Specially-abled | |
|---|---|---|---|---|
| | **No. of Respondents** | **%** | **No. of Respondents** | **%** |
| **Yes** | 58 | 78.38 | 28 | 54.90 |
| **No** | 16 | 21.62 | 23 | 45.10 |

**Survey Question 10:** If Yes, how comfortable are you in taking Public Transport? [On a scale of 1 to 10; where 10 is most comfortable and 1 is least comfortable]

| | | Category A: Able Bodied (≤60 years) | | | | Category B: Senior Citizen and/ or Specially-abled | |
|---|---|---|---|---|---|---|---|
| | | **Value** | **Weighted value** | | | **Value** | **Weighted value** |
| Score | 1 | 0 | 0 | Score | 1 | 0 | 0 |
| Score | 2 | 1 | 2 | Score | 2 | 1 | 2 |
| Score | 3 | 2 | 6 | Score | 3 | 4 | 12 |
| Score | 4 | 4 | 16 | Score | 4 | 3 | 12 |
| Score | 5 | 11 | 55 | Score | 5 | 4 | 20 |
| Score | 6 | 14 | 84 | Score | 6 | 11 | 66 |
| Score | 7 | 17 | 119 | Score | 7 | 3 | 21 |
| Score | 8 | 6 | 48 | Score | 8 | 0 | 0 |
| Score | 9 | 2 | 18 | Score | 9 | 2 | 18 |
| Score | 10 | 1 | 10 | Score | 10 | 0 | 0 |

**Survey Question 11:** Which Public Transport do you use the most?

| | Category A: Able Bodied (≤60 years) | | Category B: Senior Citizen and/ or Specially-abled | |
|---|---|---|---|---|
| | **No. of Respondents** | **%** | **No. of Respondents** | **%** |
| 1. Bus | 28 | 48.28 | 19 | 67.86 |
| 2. Tram | 0 | 0.00 | | 0.00 |
| 3. Metro Rail | 11 | 18.97 | 4 | 14.29 |
| 4. Local Train | 3 | 5.17 | 3 | 10.71 |
| 5. Auto Rickshaw | 14 | 24.14 | 2 | 7.14 |
| 6. Cycle/ Hand Pulled Rickshaw | 2 | 3.45 | 0 | 0.00 |

**Survey Question 12:** What is the major problem in accessing Public Transport?

| | Category A: Able Bodied (≤60 years) | | Category B: Senior Citizen and/ or Specially-abled | |
|---|---|---|---|---|
| | **No. of Respondents** | **%** | **No. of Respondents** | **%** |
| 1. Difficulty in waiting facility (like: bus stop, improper visual notification, etc) | 36 | 62.07 | 13 | 46.43 |
| 2. Reaching the Public Transport from home | 11 | 18.97 | 11 | 39.29 |
| 3. Any other (like: Congestion, Improper Crowd, etc.) | 8 | 13.79 | 4 | 14.29 |
| 4. Fare | 3 | 5.17 | 0 | 0.00 |

**Survey Question 13: Do you Walk on the streets?**

| | Category A: Able Bodied (≤60 years) | | Category B: Senior Citizen and/ or Specially-abled | |
|---|---|---|---|---|
| | **No. of respondents** | **%** | **No. of respondents** | **%** |
| Yes | 69 | 93.24 | 38 | 74.51 |
| No | 5 | 6.76 | 13 | 25.49 |

**Survey Question 14:** How comfortable are you walking on the streets [On a scale of 1 to 10; where 10 is most comfortable and 1 is least comfortable]?

| | | Category A: Able Bodied (≤60 years) | | | | Category B: Senior Citizen and/ or Specially-abled | |
|---|---|---|---|---|---|---|---|
| | | **Value** | **Weighted value** | | | **Value** | **Weighted value** |
| Score | 1 | 3 | 3 | Score | 1 | 0 | 0 |
| Score | 2 | 4 | 8 | Score | 2 | 2 | 4 |
| Score | 3 | 5 | 15 | Score | 3 | 2 | 6 |
| Score | 4 | 15 | 60 | Score | 4 | 13 | 52 |
| Score | 5 | 15 | 75 | Score | 5 | 8 | 40 |
| Score | 6 | 11 | 66 | Score | 6 | 8 | 48 |
| Score | 7 | 11 | 77 | Score | 7 | 3 | 21 |
| Score | 8 | 4 | 32 | Score | 8 | 2 | 16 |
| Score | 9 | 1 | 9 | Score | 9 | 0 | 0 |
| Score | 10 | 0 | 0 | Score | 10 | 0 | 0 |

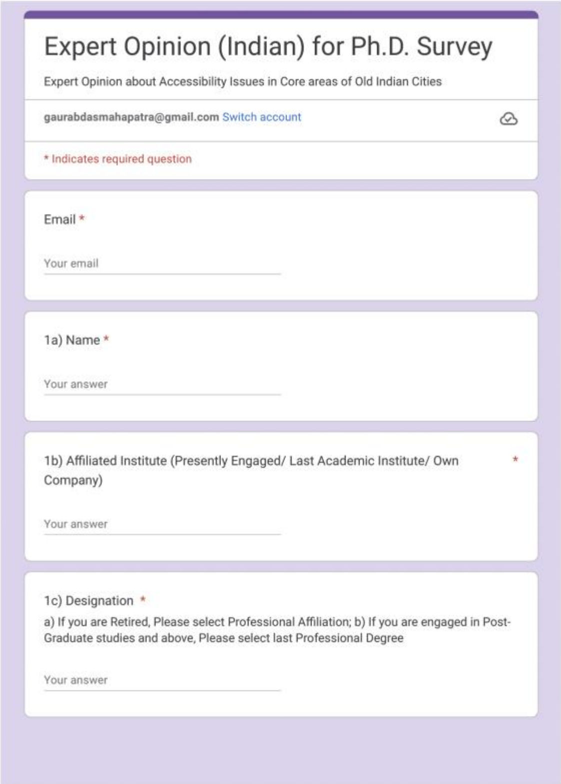
**Survey Question 15:** Have you heard of "Sugamya Bharat Abhiyan" (or "Accessible India Campaign")?

| | Category A: Able Bodied (≤60 years) | | Category B: Senior Citizen and/ or Differently Abled | |
|---|---|---|---|---|
| | **No. of respondents** | **%** | **No. of respondents** | **%** |
| Yes | 11 | 14.86 | 4 | 7.84 |
| No | 63 | 85.14 | 47 | 92.16 |

**Annexure E:** Consolidated data related to the building use of the 32 footpath stretches in Central Kolkata, India.

| S. No. | Street Details | Residential | Educational | Institutional | Assembly | Business | Mercantile | Industrial | Storage | Hazardous |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Nirmal Chandra Dey Street | **Yes** | | | **Yes** | **Yes** | **Yes** | | | |
| 2 | Bowbazar Crossing to New Bowbazar Lane | **Yes** | | **Yes** | | **Yes** | | | | |
| 3 | New Bowbazar lane | **Yes** | | | | **Yes** | **Yes** | | | |
| 4 | New Bowbazar Lane to Kenderdine Lane | **Yes** | **Yes** | | **Yes** | **Yes** | **Yes** | | | |
| 5 | Kenderdine Lane | **Yes** | | | | **Yes** | **Yes** | | | |
| 6 | Kenderdine Lane to Central Avene | **Yes** | **Yes** | | | **Yes** | | | | |
| 7 | Central Avenue (GATE 4_Yogayog Bhawan) | **Yes** | | | | **Yes** | **Yes** | | | |
| 8 | Central Metro(GATE Yes_Indian Airlines) | **Yes** | | **Yes** | | **Yes** | **Yes** | | **Yes** | |
| 9 | Central Avenue to Bow Street | **Yes** | **Yes** | | | **Yes** | **Yes** | | | |
| 10 | Bow Street | **Yes** | | | | **Yes** | | | | |
| 11 | Bow Street to Metcalfe Street | **Yes** | | | | **Yes** | **Yes** | | | |
| 12 | Metcalfe Street | **Yes** | | **Yes** | | **Yes** | | | | |
| 13 | Metcalfe Street to Bentick Street | **Yes** | | | | **Yes** | | | | |
| 14 | Bentick Street | **Yes** | | | | **Yes** | **Yes** | | | |
| 15 | Rabindra Sarani Rd. | **Yes** | | | | **Yes** | **Yes** | | | |
| 16 | Rabindra Sarani Rd. to Chatawalla Gully | **Yes** | | | | **Yes** | **Yes** | | | |
| 17 | Chatawalla Gully | **Yes** | | | | **Yes** | **Yes** | | | |
| 18 | Chatawalla Gully to Phears Bye Lane | **Yes** | **Yes** | **Yes** | | **Yes** | **Yes** | | | |
| 19 | Phears Bye Lane | **Yes** | | **Yes** | | **Yes** | **Yes** | | | |
| 20 | Phears Bye Lane to Phears Lane | **Yes** | | **Yes** | | **Yes** | **Yes** | | | |
| 21 | Phears Lane | **Yes** | | **Yes** | | **Yes** | **Yes** | **Yes** | | |
| 22 | Phears Lane to Giri Babu lane | **Yes** | | | | **Yes** | **Yes** | | | |
| 23 | Giri Babu lane | **Yes** | | | | **Yes** | | | | |
| 24 | Giri Babu lane to Central Avenue | **Yes** | | **Yes** | | **Yes** | **Yes** | | | |
| 25 | Central Metro (GATE 2_Lalbazar) | **Yes** | | **Yes** | | **Yes** | **Yes** | | | |
| 26 | Central Avenue (GATE 3_RITES) | **Yes** | | **Yes** | | **Yes** | **Yes** | | | |
| 27 | Central Avenue to Gangadhar Babu Lane | **Yes** | | **Yes** | | **Yes** | **Yes** | | | |
| 28 | Gangadhar Babu lane | **Yes** | | **Yes** | | **Yes** | **Yes** | | | |
| 29 | Gangadhar Babu Lane to Bibi Rozio Lane | **Yes** | | **Yes** | | **Yes** | | | | |
| 30 | Bibi Rozio Lane | **Yes** | | **Yes** | | **Yes** | | | | |
| 31 | Bibi Rozio Lane to Bowbazar Crossing | **Yes** | | **Yes** | | **Yes** | | | | |
| 32 | College Street | **Yes** | | **Yes** | | **Yes** | **Yes** | | | |

**Annexure F:** Questionnaire used in assessing the opinion of the 257 Indian experts from the fields of Architecture and Planning regarding five most important factors while assessing universal mobility for pedestrians in the Old Cities of India.



Expert Opinion (Indian) for Ph.D. Survey

Expert Opinion about Accessibility Issues in Core areas of Old Indian Cities

gaurabdasmahapatra@gmail.com Switch account

* Indicates required question

Email *

Your email

1a) Name *

Your answer

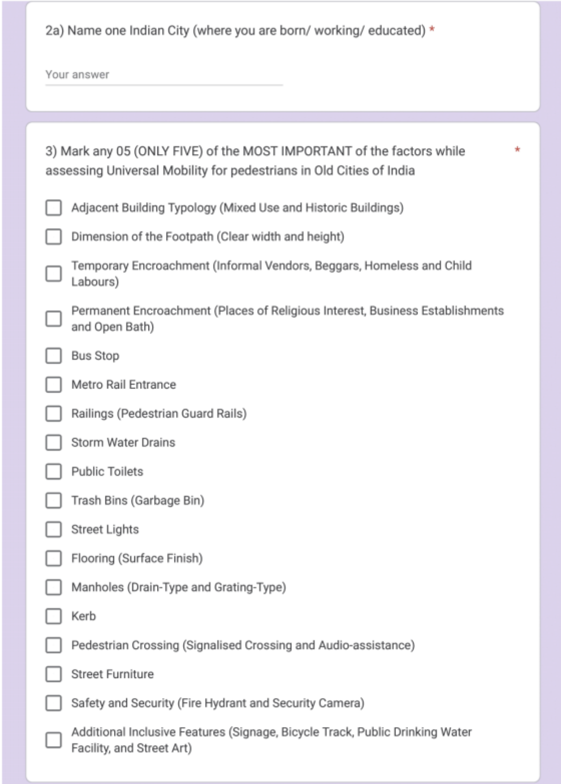
1b) Affiliated Institute (Presently Engaged/ Last Academic Institute/ Own Company) *

Your answer

1c) Designation *

a) If you are Retired, Please select Professional Affiliation; b) If you are engaged in Post-Graduate studies and above, Please select last Professional Degree

Your answer



2a) Name one Indian City (where you are born/ working/ educated) *

Your answer

3) Mark any 05 (ONLY FIVE) of the MOST IMPORTANT of the factors while assessing Universal Mobility for pedestrians in Old Cities of India *

- ☐ Adjacent Building Typology (Mixed Use and Historic Buildings)
- ☐ Dimension of the Footpath (Clear width and height)
- ☐ Temporary Encroachment (Informal Vendors, Beggars, Homeless and Child Labours)
- ☐ Permanent Encroachment (Places of Religious Interest, Business Establishments and Open Bath)
- ☐ Bus Stop
- ☐ Metro Rail Entrance
- ☐ Railings (Pedestrian Guard Rails)
- ☐ Storm Water Drains
- ☐ Public Toilets
- ☐ Trash Bins (Garbage Bin)
- ☐ Street Lights
- ☐ Flooring (Surface Finish)
- ☐ Manholes (Drain-Type and Grating-Type)
- ☐ Kerb
- ☐ Pedestrian Crossing (Signalised Crossing and Audio-assistance)
- ☐ Street Furniture
- ☐ Safety and Security (Fire Hydrant and Security Camera)
- ☐ Additional Inclusive Features (Signage, Bicycle Track, Public Drinking Water Facility, and Street Art)

**Annexure G:** Questionnaire used in mapping the infrastructure in the footpaths of Central Kolkata, India based on 50 sub-criteria.

## Evaluating the accessibility of old cities: Case of Central Kolkata, India

Click **YES** or **NO**

gaurabdasmahapatra@gmail.com Switch account

* Indicates required question

Email *

Your email

Code of the footpath stretch *

Your answer

1a) Is there a **predominance of buildings with 'two or more' building uses** within a single building? *

- Yes
- No

1b) Are there **Heritage/ historic buildings** on the stretch? *

- Yes
- No

2a) Is the **Footpath Width ≥2500mm**? *

- Yes
- No

2b) Is there an **unobstructed footpath width of 1800mm**? *

- Yes
- No

2c) Is there an **unobstructed clear footpath height of 2200mm**? *

- Yes
- No

3a) Is there presence of **Unorganized Informal Vendors** functional during day/ night? *

- Yes
- No

3b) Are there **Unorganized Informal Vendors/ hawkers** away from the line of pedestrian flow (if Vendors are present)? *

- Yes
- No

3c) Are there **Beggars/ homeless/ child labour** occupying a part of the footpath as their homes? *

- Yes
- No

4a) Are there **places of religious interest (temple/ churches/ mosque)** within or along the footpath? *

- Yes
- No

4b) Is there **'Encroachment' by existing establishments** on to the footpath? *

- Yes
- No

4c) Is there **'Communal open bath'** within or along the footpath? *

- Yes
- No

5a) Is there **informal stoppage** for Bus? *

- Yes
- No

5b) Is there a **Bus Shelter** (in case bus stops)? *

- Yes
- No

5c) Is there the presence of a **functional 'Bus Shelter'** (if a bus shelter is present)? *

- Yes
- No

6a) Is the **Metro Rail Entrance** connected to the footpath? *

- Yes
- No

6b) Is the **Metro Rail Entrance** functional (if Metro Rail Entrance is present) *

- Yes
- No

7a) Is there presence of **Railings (pedestrian guard rails)** on the edge of the footpath? *

- Yes
- No

7b) Are the **thorough railings with a minimum 1500 mm** height and clear visibility * (if Railings are present)

- Yes
- No

8a) Are there **storm water drains** along footpath? *

- Yes
- No

8b) Are the **Storm Water Drains functional** (if Storm Water Drains are present) *

- Yes
- No

9a) Is there a **Public Toilet**? *

- Yes
- No

9b) Is the Public Toilet **functional**? *

- Yes
- No

10a) Are there **Trash Bins** present? *

- Yes
- No

10b) Are the **Trash Bins functional** (if Trash Bins are present)? *

- Yes
- No

10c) Are the Trash Bins **located away from the line of pedestrian flow** (if trash bins are present)? *

- Yes
- No

11a) Are there **presence of streetlights**? *

- Yes
- No

11b) Are the **streetlights functional** (if Street Lights are present)? *

- Yes
- No

11c) Are the **Light Poles away from pedestrian flow** or if present, is demarcated with a **tactile marking** of a minimum 600 mm around it (if Street Lights are present)? *

- Yes
- No

12a) Is there a **Satisfactory Cross Fall** (i.e. <1:50)? *

- Yes
- No

12b) Is there a presence of **tactile paving**? *

- Yes
- No

12c) Are there **Anti-skid/ matt finish tiles** in the footpath and kerb? *

- Yes
- No

13a) Are there **Manholes** within/ along the footpath? *

- Yes
- No

13b) Are there **'Drain' type manholes** flushed with the pavement surface (if manholes are present)? *

- Yes
- No

13c) Are there **'Grating' type manholes** sited away from the pedestrian walkway (if Manholes are present)? *

- Yes
- No

14a) Is there **Kerb** on the edge of the footpath? *

- Yes
- No

14b) Is the **Kerb Height** not more than 150 mm from the road level (if Kerb is present)? *

- Yes
- No

14c) Is there a **Minimum 1200 mm width and tactile warning** (if Kerb is present)? *

- Yes
- No

14d) Is there a **Corned Kerb radius** of more than 6m (if Kerb is present)? *

- Yes
- No

15a) Is there **'At-grade' pedestrian crossing** (MID-BLOCK crossing) at all intersections along the walkway? *

- Yes
- No

15b) Are there **Signalized Intersections** (if Crossing is present)? *

- Yes
- No

15c) Are the **Signalized Intersections functional** (if Crossing is present) *

- Yes
- No

15d) Is there **Audio Signal** (if Crossing is present)? *

- Yes
- No

16a) Is there **street furniture** on the footpath? *

- Yes
- No

16b) Does the **Street furniture have a knee clearance** of a minimum of 700 mm and wheelchair space of 1000 mm (if Street Furniture is present)? *

- Yes
- No

17a) Are there **Fire Hydrants** along the footpath? *

- Yes
- No

17b) Are there **Security Cameras** along the footpath? *

- Yes
- No

18a) Is there **Presence of Signage** on the footpath? *

- Yes
- No

18b) Is there **Presence of Bicycle Track** on the footpath? *

- Yes
- No

18c) Is there **Presence of a Public Drinking Water Facility** on the footpath? *

- Yes
- No

18d) Is there **Presence of Street Art** on the footpath? *

- Yes
- No

**Annexure H:** Consolidated data for the mapping of the infrastructure in the footpaths of Central Kolkata, India based on 50 sub-criteria.

| S.No | Criterion | S. No | Sub Criteria | Presence of the the sub-citerion in 32 footpath stretches | |
|---|---|---|---|---|---|
| | | | | No. of footpaths | % |
| **1** | Building Typology of Stretch | 1 | Absence of Buildings that are having 'two or more' building uses within a single building | **32** | 100.0 |
| | | 2 | Absence of Heritage/ historic buildings | **27** | 84.4 |
| **2** | Footpath Dimension | 3 | Footpath Width >2500mm | **7** | 21.9 |
| | | 4 | Unobstructed width of 1800mm | **11** | 34.4 |
| | | 5 | Unobstructed clear height of 2200mm | **23** | 71.9 |
| **3** | Temporary Encroachment | 6 | Absence of Unorganized Informal Vendors functional during day/ night | **15** | 46.9 |
| | | 7 | Absence of Unorganized Informal Vendors/ hawkers away from the line of pedestrian flow (if Vendors are present) | **6** | 18.8 |
| | | 8 | Absence of Beggar/ homeless/ child labour occupying a part of the footpath as their homes | **25** | 78.1 |
| **4** | Permanent Encroachment | 9 | Absence of Place of religious interest (temple/ churches/ mosque) within or along the footpath? | **10** | 31.3 |
| | | 10 | Absence of 'Encroachment' by existing establishments on to the footpath | **7** | 21.9 |
| | | 11 | Absence of 'Communal open bath' within or along the footpath | **25** | 78.1 |
| **5** | Bus Stop | 12 | Absence of Informal stoppage for Bus | **16** | 50.0 |
| | | 13 | Bus Shelter (if Bus Stops) | **1** | 3.1 |
| | | 14 | Is 'Bus Shelter' functional (if Bus Shelter is present) | **0** | 0.0 |
| **6** | Metro Rail Entrance | 15 | Absence of Entrance connected to the footpath | **24** | 75.0 |
| | | 16 | Is the Entrance functional (if Metro Rail Entrance is present) | **5** | 15.6 |
| **7** | Railings | 17 | Railings (pedestrian guard rails) on the edge of the footpath | **13** | 40.6 |
| | | 18 | Thorough railings with minimum 1500mm height and clear visibility (if Railings are present) | **5** | 15.6 |
| **8** | | 19 | Storm Water Drains along footpath | **29** | 90.6 |

| | | | | | |
|---|---|---|---|---|---|
| | Storm Water Drains | 20 | Functional Storm Water Drains (if Storm Water Drains are present) | **28** | 87.5 |
| **9** | Public Toilet (Restroom) | 21 | Public Toilet within the footpath | **1** | 3.1 |
| | | 22 | Functional Public Toilet (if Public Toilet is present) | **1** | 3.1 |
| **10** | Trash Bins | 23 | Trash Bins within the footpath | **4** | 12.5 |
| | | 24 | Functional Trash Bins (if Trash Bins are present) | **3** | 9.4 |
| | | 25 | Trash Bins located away from the line of pedestrian flow (if Trash Bins present) | **4** | 12.5 |
| **11** | Street Lights | 26 | Street Lights within the footpath | **32** | 100.0 |
| | | 27 | Functional Street Lights (if Street Lights are present) | **30** | 93.8 |
| | | 28 | Light Poles away from pedestrian flow or if present, is demarcated with a tactile marking of a minimum 600mm around it (if Street Lights are present) | **30** | 93.8 |
| **12** | Flooring | 29 | Satisfactory Cross Fall (i.e. <1:50) | **20** | 62.5 |
| | | 30 | Tactile Marking | **0** | 0.0 |
| | | 31 | Anti-skid/ matt finish tiles in footpath and kerb | **24** | 75.0 |
| **13** | Manholes | 32 | Manholes within/ along the footpath | **32** | 100.0 |
| | | 33 | Drain type' manholes flushed with the pavement surface (if Manholes are present) | **28** | 87.5 |
| | | 34 | Grating' type manholes sited away from the pedestrian walkway (if Manholes are present) | **23** | 71.9 |
| **14** | Kerb | 35 | Kerb on the edge of footpath | **23** | 71.9 |
| | | 36 | Kerb Height of not more than 150mm from the road level (if Kerb is present) | **8** | 25.0 |
| | | 37 | Minimum 1200mm width and tactile warning (if Kerb is present) | **0** | 0.0 |
| | | 38 | Corned kerb radius more than 6m (if Kerb is present) | **0** | 0.0 |
| **15** | Pedestrian crossing | 39 | ‘At-grade' pedestrian crossing (MID-BLOCK crossing) at all intersections along the walkway | **32** | 100.0 |
| | | 40 | Signalized Intersection (if Crossing is present) | **16** | 50.0 |
| | | 41 | Functional Signalized Intersection (if Crossing is present) | **15** | 46.9 |
| | | 42 | Audio Signal (if Crossing is present) | **1** | 3.1 |
| **16** | Street furniture | 43 | Street Furniture in the footpath | **11** | 34.4 |
| | | 44 | Street furniture having a knee clearance of a minimum of 700mm and wheelchair | **8** | 25.0 |

| | | | | | |
|---|---|---|---|---|---|
| | | | space of 1000mm (if Street Furniture is present) | | |
| **17** | Safety and Security | 45 | Fire Hydrant | **0** | 0.0 |
| | | 46 | Security Camera | **0** | 0.0 |
| **18** | Additional Inclusive features | 47 | Signage | **0** | 0.0 |
| | | 48 | Bicycle Track | **0** | 0.0 |
| | | 49 | Public Drinking Water Facility | **0** | 0.0 |
| | | 50 | Street Art | **1** | 3.1 |

**Annexure I:** Questionnaire used in pedestrian mapping in the 32 footpath stretches in Central Kolkata, India.

## Pedestrian Count Survey

| | | |
|---|---|---|
| Name of Surveyor | | |
| Date of Survey | | |
| Time | | |
| **Name of the street** | | |
| Side of the street (w.r.t. North) | | |
| Latitude and Longitude | | |
| Landmark | | |
| Width of the street | | |
| **Time** | **Towards You** | **Away From You** |
| **07:45 - 08:00** | | |
| **08:00 - 08:15** | | |
| **09:45 - 10:00** | | |
| **10:00 - 10:15** | | |
| **13:30 - 13:45** | | |
| **13:45 - 14:00** | | |
| **17:45 - 18:00** | | |
| **18:00 - 18:15** | | |
| **18:45 - 19:00** | | |
| **19:00 - 19:15** | | |
| **21:45 - 22:00** | | |
| **22:00 - 22:15** | | |
| *Sign of Surveyor:* | | |

**Did you see any differently abled people on the street?**

**Annexure J:** Consolidated data for the pedestrian mapping in the 32 footpath stretches in Central Kolkata, India.

| S. No | Street Name *(where the readings were taken from)* | Day 01 | | Day 02 | | Day 03 | | Average | |
|---|---|---|---|---|---|---|---|---|---|
| | | Day 01 Morning Peak Hour | Day 01 Evening Peak Hour | Day 02 Morning Peak Hour | Day 02 Evening Peak Hour | Day 03 Morning Peak Hour | Day 03 Evening Peak Hour | Average Morning Peak Hour | Average Evening Peak Hour |
| 1 | Nirmal Chandra Dey Street | 233 | 137 | 198 | 151 | 203 | 158 | 211 | 149 |
| 2 | New Bowbazar lane | 269 | 173 | 213 | 208 | 310 | 199 | 264 | 193 |
| 3 | Kenderdine Lane | 302 | 152 | 168 | 198 | 331 | 175 | 267 | 175 |
| 4 | Central Avenue (GATE 4_Yogayog Bhawan) | 131 | 41 | 125 | 54 | 87 | 48 | 114 | 48 |
| 5 | Central Metro (GATE 1_Indian Airlines) | 329 | 194 | 296 | 224 | 287 | 175 | 304 | 198 |
| 6 | Bow Street | 356 | 263 | 388 | 237 | 401 | 342 | 382 | 281 |
| 7 | Metcalfe Street | 260 | 215 | 259 | 194 | 166 | 280 | 228 | 230 |
| 8 | Bentick Street | 293 | 188 | 274 | 183 | 305 | 245 | 291 | 205 |
| 9 | Rabindra Sarani Rd. | 254 | 218 | 288 | 216 | 231 | 284 | 258 | 239 |
| 10 | Chatawalla Gully | 301 | 236 | 255 | 231 | 323 | 307 | 293 | 258 |
| 11 | Phears Bye Lane | 245 | 161 | 180 | 213 | 271 | 194 | 232 | 189 |
| 12 | Phears Lane | 287 | 230 | 269 | 58 | 217 | 299 | 258 | 196 |
| 13 | Giri Babu lane | 239 | 173 | 289 | 291 | 178 | 225 | 235 | 230 |
| 14 | Central Metro (GATE 2_Lalbazar) | 227 | 152 | 225 | 198 | 158 | 175 | 203 | 175 |
| 15 | Central Avenue (GATE 3_RITES) | 119 | 56 | 54 | 65 | 141 | 55 | 105 | 59 |
| 16 | Gangadhar Babu lane | 98 | 161 | 146 | 170 | 116 | 264 | 120 | 198 |
| 17 | Bibi Rozio Lane | 134 | 56 | 191 | 197 | 154 | 306 | 160 | 186 |
| 18 | College Street | 353 | 245 | 279 | 213 | 361 | 354 | 331 | 271 |

**Annexure K:** Questionnaire used in mapping the infrastructure in the 69 footpaths in 5 different cities of India based on 19 parameters (52 indicators).

## Reviewing Universal Mobility of the footpaths in the core of old Indian cities through field survey

Click **YES** or **NO**

gaurabdasmahapatra@gmail.com Switch account

* Indicates required question

Email *

Your email

Name of the surveyor *

Your answer

Date of survey *

MM DD YYYY

__ / __ / ____

Time of Survey *

Time

__ : __ AM

Name of the city? *

- Kolkata
- Visakhapatnam
- Hyderabad
- Nagpur
- Jaipur
- Jodhpur

Ward Number *

Your answer

Name of the street/ road where the surveyed stretch of the footpath is located *

Your answer

Survey Code of the surveyed stretch of the footpath (as per the map of the surveyor) *

Your answer

Width of the Footpath (in meters) *

Your answer

Length of the Stretch (in meters) *

Your answer

1) Buildings that are having 'two or more' building uses within a single building *

- Yes
- No

2) Heritage/ historic buildings *

- Yes
- No

3) Footpath Width of more than 2500mm *

- Yes
- No

4) Unobstructed width of more than 1800mm *

- Yes
- No

5) Unobstructed clear height of more than 2200mm *

- Yes
- No

6) Unorganized Informal Vendors functional during day/ night *

- Yes
- No

7) Unorganized Informal Vendors/ hawkers away from the line of pedestrian flow (if Vendors are present) *

- Yes
- No

8) Beggar/ homeless/ child labour occupying a part of the footpath as their homes *

- Yes
- No

9) Place of religious interest (temple/ churches/ mosque) within or along the footpath? *

- Yes
- No

10) 'Encroachment' by existing establishments (commercial, etc.) on the footpath *

- Yes
- No

11) 'Communal open bath' within or along the footpath *

- Yes
- No

12) Informal/ Formal stoppage for Bus *

- Yes
- No

13) Bus Shelter (if Bus Stops) *

- Yes
- No

14) Is 'Bus Shelter' functional (if Bus Shelter is present) *

- Yes
- No

15) Metro Rail Entrance connected to the footpath *

- Yes
- No

16) Is the Entrance functional (if Metro Rail Entrance is present) *

- Yes
- No

17) Railings (pedestrian guard rails) on the edge of the footpath *

- Yes
- No

18) Thorough railings with minimum 1500mm height and clear visibility (if Railings are present) *

- Yes
- No

19) Storm Water Drains along footpath *

- Yes
- No

20) Functional Storm Water Drains (if Storm Water Drains are present); [Note: Water Logging represents poor functionality] *

- Yes
- No

21) Public Toilet within the footpath *

- Yes
- No

22) Functional Public Toilet (if Public Toilet is present) *

- Yes
- No

23) Trash Bins within the footpath *

- Yes
- No

24) Functional Trash Bins (if Trash Bins are present) *

- Yes
- No

25) Trash Bins located away from the line of pedestrian flow (if Trash Bins are present) [Note: if there is a clear width of 1800mm after the trash bin, it can be considered away from the line of pedestrian flow] *

- Yes
- No

26) Streetlights within the footpath *

- Yes
- No

27) Functional Street Lights (if Street Lights are present) *

- Yes
- No

28) Light Poles away from pedestrian flow or if present, is demarcated with a tactile marking of a minimum of 600mm around it (i Street Lights are present) [Note: if there is a clear width of 1800mm after the street light, it can be considered away from the line of pedestrian flow] *

- Yes
- No

29) Satisfactory Cross Fall (i.e. <1:50) *

- Yes
- No

30) Tactile Marking *

- Yes
- No

31) Anti-skid/ matt finish tiles in footpath and kerb *

- Yes
- No

32) Manholes within/ along the footpath *

- Yes
- No

33) "Drain type" manholes flushed with the pavement surface (if Manholes are present) *

- Yes
- No

34) "Grating" type manholes sited away from the pedestrian walkway (if Manholes are present) *

- Yes
- No

35) Kerb on the edge of footpath *

- Yes
- No

36) Kerb Height of not more than 150mm from the road level (if Kerb is present) *

- Yes
- No

37) Minimum 1200mm width and tactile warning (if Kerb is present) *

- Yes
- No

38) Corner kerb radius more than 6m (if Kerb is present) *

- Yes
- No

39) 'At-grade' pedestrian crossing (MID-BLOCK crossing) at all intersections along the walkway *

- Yes
- No

40) Signalized Intersection (if Crossing is present) *

- Yes
- No

41) Functional Signalized Intersection (if Crossing is present) *

- Yes
- No

42) Audio Signal (if Crossing is present) *

- Yes
- No

43) Street Furniture in the footpath *

- Yes
- No

44) Street furniture having a knee clearance of a minimum of 700mm and wheelchair space of 1000mm (if Street Furniture is present) *

- Yes
- No

45) Fire Hydrant *

- Yes
- No

46) Security Camera *

- Yes
- No

47) Signage *

- Yes
- No

48) Bicycle Track *

- Yes
- No

49) Public Drinking Water Facility *

- Yes
- No

50) Street Art/ Sculpture *

- Yes
- No

51) Is/ are there any contextual factors? *

- Yes
- No

52) Name the Contextual Factor/s [if any] *

- Yes
- No

**Annexure L:** Calculation related to scoring of the individual survey indicators across the 69 footpath stretches in 5 cities in India.

| Parameters | Indicators | Total Score | Maximum Score (Unit Score x No. of Samples) | Percentage (Total Score/Max. Score x 100) |
|---|---|---|---|---|
| (1) Building Typology | (1.a.) Buildings that are having 'two or more' building uses within a single building | 5.50 | 34.50 | 15.94 |
| | (1.b.) Heritage/ historic buildings | -2.50 | 34.50 | -7.25 |
| (2) Foothpath Dimensions | (2.a.) Footpath Width more than 2500mm | -23.50 | 34.50 | -68.12 |
| | (2.b.) Unobstructed width of more than 1800mm | -24.50 | 34.50 | -71.01 |
| | (2.c.) Unobstructed clear height of more than 2200mm | 1.50 | 34.50 | 4.35 |
| (3) Temporary Encroachment | (3.a.) Unorganized Informal Vendors functional during day/ night | -12.50 | 34.50 | -36.23 |
| | (3.b.) Unorganized Informal Vendors/ hawkers away from the line of pedestrian flow (if Vendors are present) | 1.75 | 17.25 | 10.14 |
| | (3.c.) Beggar/ homeless/ child labour occupying a part of the footpath as their homes | 8.75 | 17.25 | 50.72 |
| (4) Permanent Encroachment | (4.a.) Place of religious interest (temple/ churches/ mosque) within or along the footpath? | 23.50 | 34.50 | 68.12 |
| | (4.b.) 'Encroachment' by existing establishments (commercial, etc.) on the footpath | -17.50 | 34.50 | -50.72 |
| | (4.c.) 'Communal open bath' within or along the footpath | 32.50 | 34.50 | 94.20 |
| (5) Bus Stop | (5.a.) Informal/ Formal stoppage for Bus | 26.50 | 34.50 | 76.81 |
| | (5.b.) Bus Shelter (if Bus Stops) | -13.75 | 17.25 | -79.71 |
| | (5.c.) Is 'Bus Shelter' functional (if Bus Shelter is present) | -13.75 | 17.25 | -79.71 |
| (6) Metro Rail Entrance | (6.a.) Metro Rail Entrance connected to the footpath | 33.50 | 34.50 | 97.10 |
| | (6.b.) Is the Entrance functional (if Metro Rail Entrance is present) | -16.75 | 17.25 | -97.10 |
| (7) Railings | (7.a.) Railings (pedestrian guard rails) on the edge of the footpath | -30.50 | 34.50 | -88.41 |
| | (7.b.) Thorough railings with minimum 1500mm height and clear visibility (if Railings are present) | -17.25 | 17.50 | -98.57 |
| (8) Storm Water Drains | (8.a.) Storm Water Drains along footpath | 7.50 | 34.50 | 21.74 |

| | | | | |
|---|---|---|---|---|
| | (8.b.) Functional Storm Water Drains (if Storm Water Drains are present); [Note: Water Logging represents poor functionality] | -3.25 | 17.25 | -18.84 |
| (9) Public Toilet | (9.a.) Public Toilet within the footpath | -31.50 | 34.50 | -91.30 |
| | (9.b.) Functional Public Toilet (if Public Toilet is present) | -16.25 | 17.25 | -94.20 |
| (10) Trash Bins | (10.a.) Trash Bins within the footpath | -21.50 | 34.50 | -62.32 |
| | (10.b.) Functional Trash Bins (if Trash Bins are present) | -12.25 | 17.25 | -71.01 |
| | (10.c.) Trash Bins located away from the line of pedestrian flow (if Trash Bins are present) [Note: if there is a clear width of 1800mm after the trash bin, it can be considered away from the line of pedestrian flow] | -14.75 | 17.25 | -85.51 |
| (11) Street Lights | (11.a.) Streetlights within the footpath | 26.50 | 34.50 | 76.81 |
| | (11.b.) Functional Street Lights (if Street Lights are present) | 12.75 | 17.25 | 73.91 |
| | (11.c.) Light Poles away from pedestrian flow or if present, is demarcated with a tactile marking of a minimum of 600mm around it (if Street Lights are present) [Note: if there is a clear width of 1800mm after the street light, it can be considered away from the line of pedestrian flow] | -9.75 | 17.25 | -56.52 |
| (12) Flooring | (12.a.) Satisfactory Cross Fall (i.e. <1:50) | -16.50 | 34.50 | -47.83 |
| | (12.b.) Tactile Marking | -25.50 | 34.50 | -73.91 |
| | (12.c.) Anti-skid/ matt finish tiles in footpath and kerb | 5.50 | 34.50 | 15.94 |
| (13) Manholes | (13.a.) Manholes within/ along the footpath | 7.50 | 34.50 | 21.74 |
| | (13.b.) Drain type manholes flushed with the pavement surface (if Manholes are present) | 2.25 | 17.25 | 13.04 |
| | (13.c.) Grating type manholes sited away from the pedestrian walkway (if Manholes are present) | -5.25 | 17.25 | -30.43 |
| (14) Kerb | (14.a.) Kerb on the edge of footpath | 28.50 | 34.50 | 82.61 |
| | (14.b.) Kerb Height of not more than 150mm from the road level (if Kerb is present) | 7.75 | 17.25 | 44.93 |
| | (14.c.) Minimum 1200mm width and tactile warning (if Kerb is present) | -15.75 | 17.25 | -91.30 |

| | | | | |
|---|---|---|---|---|
| | (14.d.) Corner kerb radius more than 6m (if Kerb is present) | -13.25 | 17.25 | -76.81 |
| (15) Pedestrian Crossing | (15.a.) At-grade' pedestrian crossing (MID-BLOCK crossing) at all intersections along the walkway | -30.50 | 34.50 | -88.41 |
| | (15.b.) Signalized Intersection (if Crossing is present) | -13.75 | 17.25 | -79.71 |
| | (15.c.) Functional Signalized Intersection (if Crossing is present) | -12.75 | 17.25 | -73.91 |
| | (15.d.) Audio Signal (if Crossing is present) | -16.75 | 17.25 | -97.10 |
| (16) Street Furniture | (16.a.) Street Furniture in the footpath | -29.50 | 34.50 | -85.51 |
| | (16.b.) Street furniture having a knee clearance of a minimum of 700mm and wheelchair space of 1000mm (if Street Furniture is present) | -16.75 | 17.25 | -97.10 |
| (17) Safety and Security | (17.a.) Fire Hydrant | -33.50 | 34.50 | -97.10 |
| | (17.b.) Security Camera | -9.50 | 34.50 | -27.54 |
| (18) Additional Inclusive Features | (18.a.) Signage | -15.50 | 34.50 | -44.93 |
| | (18.b.) Bicycle Track | -32.50 | 34.50 | -94.20 |
| | (18.c.) Public Drinking Water Facility | -32.50 | 34.50 | -94.20 |
| | (18.d.) Street Art/ Sculpture | -30.50 | 34.50 | -88.41 |
| (19) Contextual Features | (19.a.) Is the surveyed location within high pedestrian zone? | -34.50 | 34.50 | -100.00 |
| | (19.b.) Is/ are there any other contextual factors like potholes, parking etc.? | 2.75 | 17.25 | 15.94 |

**Annexure M:** Calculation related to scoring of 69 footpath stretches in 5 cities in India, depending on the presence/absence of the parameter.

| Footpath No. | Location | Score of each stretch out of 16.5 | Percentage |
|---|---|---|---|
| 1 | Hyderabad | -7.5 | -45.45 |
| 2 | Hyderabad | -11 | -66.67 |
| 3 | Hyderabad | -9.5 | -57.58 |
| 4 | Hyderabad | -10 | -60.61 |
| 5 | Hyderabad | -10 | -60.61 |
| 6 | Hyderabad | -10.5 | -63.64 |
| 7 | Hyderabad | -12 | -72.73 |
| 8 | Hyderabad | -5.5 | -33.33 |
| 9 | Hyderabad | -6.5 | -39.39 |
| 10 | Chennai | -3.5 | -21.21 |
| 11 | Chennai | -8 | -48.48 |
| 12 | Chennai | -9 | -54.55 |
| 13 | Chennai | -6 | -36.36 |
| 14 | Chennai | -8 | -48.48 |
| 15 | Chennai | -1.5 | -9.09 |
| 16 | Chennai | -3 | -18.18 |
| 17 | Chennai | -2.5 | -15.15 |
| 18 | Chennai | -10.5 | -63.64 |
| 19 | Chennai | -2 | -12.12 |
| 20 | Chennai | -3 | -18.18 |
| 21 | Chennai | -3.5 | -21.21 |
| 22 | Chennai | -1.5 | -9.09 |
| 23 | Chennai | -1.5 | -9.09 |
| 24 | Chennai | -2.5 | -15.15 |
| 25 | Chennai | -4.5 | -27.27 |
| 26 | Chennai | -3 | -18.18 |
| 27 | Chennai | -9 | -54.55 |
| 28 | Chennai | -7.5 | -45.45 |
| 29 | Chennai | -6.5 | -39.39 |
| 30 | Chennai | -11 | -66.67 |
| 31 | Chennai | -8.5 | -51.52 |
| 32 | Chennai | 2.5 | 15.15 |
| 33 | Chennai | -7.5 | -45.45 |
| 34 | Chennai | -7 | -42.42 |
| 35 | Nagpur | -10.5 | -63.64 |
| 36 | Nagpur | -3.5 | -21.21 |
| 37 | Nagpur | -15 | -90.91 |
| 38 | Nagpur | -15 | -90.91 |
| 39 | Nagpur | -14 | -84.85 |
| 40 | Nagpur | 0.5 | 3.03 |
| 41 | Nagpur | 2 | 12.12 |

| | | | |
|---|---|---|---|
| 42 | Nagpur | -9.5 | -57.58 |
| 43 | Nagpur | -1.5 | -9.09 |
| 44 | Nagpur | -9.5 | -57.58 |
| 45 | Nagpur | -4 | -24.24 |
| 46 | Nagpur | -2.5 | -15.15 |
| 47 | Jodhpur | -2.5 | -15.15 |
| 48 | Jodhpur | -4 | -24.24 |
| 49 | Jodhpur | -3.5 | -21.21 |
| 50 | Jodhpur | -4 | -24.24 |
| 51 | Jodhpur | -8 | -48.48 |
| 52 | Jodhpur | -5.5 | -33.33 |
| 53 | Jodhpur | -5 | -30.30 |
| 54 | Jodhpur | -6 | -36.36 |
| 55 | Jodhpur | -6 | -36.36 |
| 56 | Jodhpur | -6 | -36.36 |
| 57 | Jodhpur | -5.5 | -33.33 |
| 58 | Jodhpur | -5 | -30.30 |
| 59 | Jodhpur | -6.5 | -39.39 |
| 60 | Jodhpur | -5.5 | -33.33 |
| 61 | Jodhpur | -6 | -36.36 |
| 62 | Jodhpur | -6 | -36.36 |
| 63 | Jaipur | -8.5 | -51.52 |
| 64 | Jaipur | -8 | -48.48 |
| 65 | Jaipur | -7.5 | -45.45 |
| 66 | Jaipur | -7.5 | -45.45 |
| 67 | Jaipur | -7.5 | -45.45 |
| 68 | Jaipur | -7.5 | -45.45 |
| 69 | Jaipur | -7.5 | -45.45 |

**Annexure N:** Questionnaire used in assessing the opinion of the 257 Indian experts from the fields of Architecture and Planning regarding universal design and universal mobility conditions in their city.

## Expert Opinion (Indian) for Ph.D. Survey

Expert Opinion about Accessibility Issues in Core areas of Old Indian Cities

gaurabdas.mahapatra.z8@elms.hokudai.ac.jp Switch accounts

* Indicates required question

Email *

Your email address

1a) Name *

Your answer

1b) Affiliated Institute (Presently Engaged/ Last Academic Institute/ Own Company) *

Your answer

1c) Designation *

a) If you are Retired, Please select Professional Affiliation; b) If you are engaged in Post-Graduate studies and above, Please select last Professional Degree

Your answer

2a) Name one Indian City (where you are born/ working/ educated) *

Your answer

2b) The above-mentioned City falls in which State/ Union Territory of India? *

Your answer

2c) Are the footpaths in your above-mentioned city Universally Designed? *

- No, Not at all Universally Designed
- Partially Universally Designed
- Yes, Completely Universally Designed

2d) Which is the major obstacle in the implementation of Universal Design in the pedestrian areas of your city? *

- Central Government
- State Governmnet
- Urban Local Body
- Private enterprises/organisations
- Residents of your city

3a) On a scale of 1-10 (1 being least significant and 10 being most significant), how much would you rate the impact of Universal Design on Indian Urban Quality of Life? *

1 2 3 4 5 6 7 8 9 10

3b) Is there a need for the involvement of Private establishments or PPP models in the field of Universal Design in Urban India? *

- Yes
- No

3c) Do you think that the Accessibility Audit checklists presently available in India are completely adequate for assessing accessibility in Urban India? *

- Yes
- No

3d) Do we need separate Universal Design guidelines for Old Cities and New Cities in India? *

- Yes
- No

4a) On a scale of 1-10, how important is Universal Mobility in realizing Universal Design in Urban India? *

1 2 3 4 5 6 7 8 9 10

4b) Is the authentication of a theoretical model important for ensuring the Universal Mobility scenario in Urban India? *

- Yes
- No

4c) Is prioritizing stretches in Old Indian cities (like a pilot project) important for ensuring better implementation of Universal Mobility? *

- Yes
- No

4d) On a scale of 1-10, what is the importance of Cognitive Elements (like Temperature, Sound, Texture, Landmarks, etc.) in ensuring Universal Mobility? *

1 2 3 4 5 6 7 8 9 10

5a) Mark any 05 (ONLY FIVE) of the MOST IMPORTANT of the factors while assessing Universal Mobility for pedestrians in Old Cities of India *

- ☐ Adjacent Building Typology (Mixed Use and Historic Buildings)
- ☐ Dimension of the Footpath (Clear width and height)
- ☐ Temporary Encroachment (Informal Vendors, Beggars, Homeless and Child Labours)
- ☐ Permanent Encroachment (Places of Religious Interest, Business Establishments and Open Bath)
- ☐ Transport Stops (Bus Stop, Metro Rail Entrance, etc)
- ☐ Railings (Pedestrian Guard Rails)
- ☐ Storm Water Drains
- ☐ Public Toilets
- ☐ Trash Bins (Garbage Bin)
- ☐ Street Lights
- ☐ Flooring (Surface Finish)
- ☐ Manholes (Drain-Type and Grating-Type)
- ☐ Kerb
- ☐ Pedestrian Crossing (Signalised Crossing and Audio-assistance)
- ☐ Street Furniture
- ☐ Safety and Security (Fire Hydrant and Security Camera)
- ☐ Additional Inclusive Features (Signage, Bicycle Track, Public Drinking Water Facility, and Street Art)
- ☐ Contextual Factors (like Topography, etc)

5b) Mark any 05 (ONLY FIVE) of the LEAST IMPORTANT of the factors while assessing Universal Mobility for pedestrians in Old Cities of India *

- ☐ Adjacent Building Typology (Mixed Use and Historic Buildings)
- ☐ Dimension of the Footpath (Clear width and height)
- ☐ Temporary Encroachment (Informal Vendors, Beggars, Homeless and Child Labours)
- ☐ Permanent Encroachment (Places of Religious Interest, Business Establishments and Open Bath)
- ☐ Transport Stops (Bus Stop, Metro Rail Entrance, etc)
- ☐ Railings (Pedestrian Guard Rails)
- ☐ Storm Water Drains
- ☐ Public Toilets
- ☐ Trash Bins (Garbage Bin)
- ☐ Street Lights
- ☐ Flooring (Surface Finish)
- ☐ Manholes (Drain-Type and Grating-Type)
- ☐ Kerb
- ☐ Pedestrian Crossing (Signalised Crossing and Audio-assistance)
- ☐ Street Furniture
- ☐ Safety and Security (Fire Hydrant and Security Camera)
- ☐ Additional Inclusive Features (Signage, Bicycle Track, Public Drinking Water Facility, and Street Art)
- ☐ Contextual Factors (like Topography, etc)

**Annexure O:** Consolidated data of the opinion of the 257 Indian experts from the fields of Architecture and Planning regarding universal design and universal mobility conditions in their city.

**Survey Question 2c:** Are the footpaths in your above-mentioned city Universally Designed?

| | Status | No. of Respondents | % |
|---|---|---|---|
| 1 | Yes, Completely Universally Designed | 7 | 2.72 |
| 2 | Partially Universally Designed | 110 | 42.80 |
| 3 | No, Not at all Universally Designed | 140 | 54.47 |

**Survey Question 2d:** Which is the major obstacle in the implementation of Universal Design in the pedestrian areas of your city?

| | Status | No. of Respondents | % |
|---|---|---|---|
| 1 | Central Government | 11 | 4.28 |
| 2 | State Government | 39 | 15.18 |
| 3 | Urban Local Body | 135 | 52.53 |
| 4 | Private enterprises/ organizations | 22 | 8.56 |
| 5 | Residents of your city | 50 | 19.46 |

**Survey Question 3a:** On a scale of 1-10 (1 being least significant and 10 being most significant), how much would you rate the impact of Universal Design on Indian Urban Quality of Life?

| | Score | No. of Respondents | % |
|---|---|---|---|
| 1 | Score 10 | 59 | 22.96 |
| 2 | Score 9 | 37 | 14.40 |
| 3 | Score 8 | 64 | 24.90 |
| 4 | Score 7 | 31 | 12.06 |
| 5 | Score 6 | 16 | 6.23 |
| 6 | Score 5 | 13 | 5.06 |
| 7 | Score 4 | 11 | 4.28 |
| 8 | Score 3 | 15 | 5.84 |
| 9 | Score 2 | 6 | 2.33 |
| 10 | Score 1 | 5 | 1.95 |

**Survey Question 3b:** Is there a need for the involvement of Private establishments or PPP models in the field of Universal Design in Urban India?

| | No. of Respondents | % |
|---|---|---|
| Yes | 235 | 91.44 |
| No | 22 | 8.56 |

| **Survey Question 3c:** Do you think that the Accessibility Audit checklists presently available in India are completely adequate for assessing accessibility in Urban India? | | |
|---|---|---|
| | **No. of Respondents** | **%** |
| Yes | 49 | 19.07 |
| No | 208 | 80.93 |

| **Survey Question 3d:** Do we need separate Universal Design guidelines for Old Cities and New Cities in India? | | |
|---|---|---|
| | **No. of Respondents** | **%** |
| Yes | 243 | 94.55 |
| No | 14 | 5.45 |

| **Survey Question 4a:** On a scale of 1-10, how important is Universal Mobility in realizing Universal Design in Urban India? | | | |
|---|---|---|---|
| | **Score** | **No. of Respondents** | **%** |
| 1 | Score 10 | 96 | 37.35 |
| 2 | Score 9 | 62 | 24.12 |
| 3 | Score 8 | 49 | 19.07 |
| 4 | Score 7 | 28 | 10.89 |
| 5 | Score 6 | 5 | 1.95 |
| 6 | Score 5 | 10 | 3.89 |
| 7 | Score 4 | 3 | 1.17 |
| 8 | Score 3 | 1 | 0.39 |
| 9 | Score 2 | 2 | 0.78 |
| 10 | Score 1 | 1 | 0.39 |

| **Survey Question 4b:** Is the authentication of a theoretical model important for ensuring the Universal Mobility scenario in Urban India? | | |
|---|---|---|
| | **No. of Respondents** | **%** |
| Yes | 224 | 87.16 |
| No | 33 | 12.84 |

| **Survey Question 4c:** Is prioritizing stretches in Old Indian cities (like a pilot project) important for ensuring better implementation of Universal Mobility? | | |
|---|---|---|
| | **No. of Respondents** | **%** |
| Yes | 248 | 96.50 |
| No | 9 | 3.50 |

**Survey Question 4d:** On a scale of 1-10, what is the importance of Cognitive Elements (like Temperature, Sound, Texture, Landmarks, etc.) in ensuring Universal Mobility?

| | Score | No. of Respondents | % |
|---|---|---|---|
| 1 | Score 10 | 70 | 27.24 |
| 2 | Score 9 | 56 | 21.79 |
| 3 | Score 8 | 70 | 27.24 |
| 4 | Score 7 | 25 | 9.73 |
| 5 | Score 6 | 18 | 7.00 |
| 6 | Score 5 | 9 | 3.50 |
| 7 | Score 4 | 6 | 2.33 |
| 8 | Score 3 | 3 | 1.17 |
| 9 | Score 2 | 0 | 0.00 |
| 10 | Score 1 | 0 | 0.00 |

**Survey Question 5a:** Which are your top priority factors while assessing Universal Mobility for pedestrians in Old Cities of India?

| | Factor | No. of Respondents | % |
|---|---|---|---|
| 1 | Adjacent Building Typology (Mixed Use and Historic Buildings) | 91 | 35.41 |
| 2 | Dimension of the Footpath (Clear width and height) | 130 | 50.58 |
| 3 | Temporary Encroachment (Informal Vendors, Beggars, Homeless and Child Labours) | 13 | 5.06 |
| 4 | Permanent Encroachment (Places of Religious Interest, Business Establishments and Open Bath) | 4 | 1.56 |
| 5 | Transport Stops (Bus Stop, Metro Rail Entrance, etc) | 9 | 3.50 |
| 6 | Railings (Pedestrian Guard Rails) | 7 | 2.72 |
| 7 | Storm Water Drains | 2 | 0.78 |
| 8 | Public Toilets | 1 | 0.39 |
| 9 | Trash Bins (Garbage Bin) | 0 | 0.00 |
| 10 | Street Lights | 0 | 0.00 |
| 11 | Flooring (Surface Finish) | 0 | 0.00 |
| 12 | Manholes (Drain-Type and Grating-Type) | 0 | 0.00 |
| 13 | Kerb | 0 | 0.00 |
| 14 | Pedestrian Crossing (Signalised Crossing and Audio-assistance) | 0 | 0.00 |
| 15 | Street Furniture | 0 | 0.00 |
| 16 | Safety and Security (Fire Hydrant and Security Camera) | 0 | 0.00 |
| 17 | Additional Inclusive Features (Signage, Bicycle Track, Public Drinking Water Facility, and Street Art) | 0 | 0.00 |
| 18 | Contextual Factors (like Topography, etc) | 0 | 0.00 |

| | **Survey Question 5b:** Which are your lowest priority factors while assessing Universal Mobility for pedestrians in Old Cities of India? | | |
|---|---|---|---|
| | **Factor** | **No. of Respondents** | **%** |
| 1 | Adjacent Building Typology (Mixed Use and Historic Buildings) | 103 | 40.08 |
| 2 | Dimension of the Footpath (Clear width and height) | 17 | 6.61 |
| 3 | Temporary Encroachment (Informal Vendors, Beggars, Homeless and Child Labours) | 30 | 11.67 |
| 4 | Permanent Encroachment (Places of Religious Interest, Business Establishments and Open Bath) | 15 | 5.84 |
| 5 | Transport Stops (Bus Stop, Metro Rail Entrance, etc) | 13 | 5.06 |
| 6 | Railings (Pedestrian Guard Rails) | 32 | 12.45 |
| 7 | Storm Water Drains | 27 | 10.51 |
| 8 | Public Toilets | 7 | 2.72 |
| 9 | Trash Bins (Garbage Bin) | 6 | 2.33 |
| 10 | Street Lights | 3 | 1.17 |
| 11 | Flooring (Surface Finish) | 1 | 0.39 |
| 12 | Manholes (Drain-Type and Grating-Type) | 2 | 0.78 |
| 13 | Kerb | 1 | 0.39 |
| 14 | Pedestrian Crossing (Signalised Crossing and Audio-assistance) | 0 | 0.00 |
| 15 | Street Furniture | 0 | 0.00 |
| 16 | Safety and Security (Fire Hydrant and Security Camera) | 0 | 0.00 |
| 17 | Additional Inclusive Features (Signage, Bicycle Track, Public Drinking Water Facility, and Street Art) | 0 | 0.00 |
| 18 | Contextual Factors (like Topography, etc) | 0 | 0.00 |

**Annexure P:** Consolidated data of the geriatric simulation of the 25 individuals from 16 different countries

| Respondent No. | Gender | Nationality | **Simulated Condition: with Geriatric Suit** | | **General Condition: without Geriatric suit** | |
|---|---|---|---|---|---|---|
| | | | **Going** | **Coming** | **Going** | **Coming** |
| 1 | Male | Japan | 2 min 29 sec | 2 min 43 sec | 1 min 45 sec | 1 min 45 sec |
| 2 | Male | Angola | 3 min 10 sec | 2 min 41 sec | 1 min 41 sec | 1 min 45 sec |
| 3 | Female | Japan | 5 min 16 sec | 6 min 59 sec | 2 min 11 sec | 2 min 13 sec |
| 4 | Male | India | 2 min 37 sec | 2 min 35 sec | 1 min 30 sec | 1 min 35 sec |
| 5 | Male | India | 2 min 42 sec | 2 min 28 sec | 1 min 36 sec | 1 min 42 sec |
| 6 | Male | Cambodia | 4 min 09 sec | 4 min 01 sec | 1 min 36 sec | 1 min 54 sec |
| 7 | Female | India | 3 min 03 sec | 3 min 13 sec | 2 min 57 sec | 2 min 58 sec |
| 8 | Male | England | 3 min 34 sec | 3 min 47 sec | 1 min 27 sec | 1 min 26 sec |
| 9 | Female | China | 3 min 42 sec | 3 min 17 sec | 1 min 40 sec | 1 min 39 sec |
| 10 | Male | Nigeria | 2 min 02 sec | 2 min 21 sec | 1 min 39 sec | 1 min 35 sec |
| 11 | Male | Guinea | 6 min 02 sec | 5 min 09 sec | 1 min 49 sec | 1 min 48 sec |
| 12 | Female | Tunisia | 3 min 45 sec | 3 min 42 sec | 1 min 41 sec | 1 min 39 sec |
| 13 | Female | Japan | 2 min 21 sec | 2 min 25 sec | 1 min 36 sec | 1 min 38 sec |
| 14 | Male | Japan | 5 min 42 sec | 3 min 46 sec | 1 min 25 sec | 1 min 23 sec |
| 15 | Male | Japan | 2 min 31 sec | 2 min 15 sec | 1 min 39 sec | 1 min 38 sec |
| 16 | Male | Zimbawe | 2 min 49 sec | 3 min 45 sec | 1 min 45 sec | 2 min 00 sec |
| 17 | Male | India | 2 min 55 sec | 2 min 57 sec | 1 min 40 sec | 1 min 40 sec |
| 18 | Male | Bangladesh | 4 min 37 sec | 3 min 30 sec | 2 min 03 sec | 2 min 02 sec |
| 19 | Female | Japan | 4 min 55 sec | 4 min 57 sec | 1 min 48 sec | 1 min 48 sec |
| 20 | Male | Brasil | 3 min 19 sec | 3 min 49 sec | 1 min 25 sec | 1 min 28 sec |
| 21 | Female | Mayanmar | 2 min 57 sec | 2 min 35 sec | 1 min 56 sec | 1 min 52 sec |
| 22 | Female | Finland | 3 min 09 sec | 4 min 42 sec | 1 min 39 sec | 1 min 38 sec |
| 23 | Male | France | 2 min 49 sec | 2 min 09 sec | 1 min 35 sec | 1 min 32 sec |
| 24 | Male | India | 8 min 22 sec | 3 min 29 sec | 1 min 33 sec | 1 min 29 sec |
| 25 | Female | China | 3 min 48 sec | 5 min 30 sec | 1 min 52 sec | 1 min 47 sec |

# Appendices

| S. No. | Title | Contents |
| --- | --- | --- |
| Appendix 1 | Activities undertaken during the research (2020-2023) | a) Field Surveys<br>b) Public Presentations in Japan<br>c) International Conferences<br>d) Professional Engagements<br>e) Lectures and Invited Talks |
| Appendix 2 | Peer reviewed referred journal publication 1 | Published paper |
| Appendix 3 | Peer reviewed referred journal publication 2 | Published paper |
| Appendix 4 | Peer reviewed referred journal publication 3 | Published paper |
| Appendix 5 | Peer reviewed referred journal publication 4 | Published paper |
| Appendix 6 | Peer reviewed referred journal publication 5 | Published paper |

*[N.B.: For Appendix 2-6, the first page of the published paper is attached. The whole paper can be downloaded/ accessed from the DOI given. All the papers are in Open Access domain.]*

## Appendix 1: Some of the activities undertaken during the research (2020-2023)

### a) FIELD SURVEY

i. Public Opinion (125 people)
ii. Design Fraternity (310 people)
iii. Footpaths in central Kolkata (32 footpath stretches)
iv. Footpaths in Jaipur (7 footpaths)
v. Footpaths in Jodhpur (16 footpaths)
vi. Footpaths in Nagpur (12 footpaths)
vii. Footpaths in Hyderabad (9 footpaths)
viii. Footpaths in Chennai (25 footpaths)
ix. Expert opinion (257 people)
x. Footpaths in central Kolkata (32 footpath stretches)
xi. Geriatric Simulation (41 people)

**Figure 1:** Public Opinion Survey in Kolkata, India. *[blurred for privacy]*

**Figure 2:** Simulation Study, Sapporo.


**Figure 3:** Testing the simulation suit on self.

**Figure 4:** Footpath survey in Chennai, India. *[blurred for privacy]*

### b) PUBLIC RESEARCH PRESENTATIONS

i. Event on SDGs in FMI Building (HU North Campus) on 3-4 June **2023**, organized by Hokkaido University.
ii. "Research Presentations to Contribute to the SDGs" in Chikaho (Sapporo station Ekimae odori) on 17-18 December **2022**, organized by Hokkaido University.


**Figure 5:** Presentation at Chikaho.

### c) INTERNATIONAL CONFERENCES

i. "12th Annual International Conference on Urban Studies and Planning" in Athens (Greece) on 30 May – 2 June **2022**, organized by Athens Institute for Education and Research.
ii. "International Conference on Urban Studies and Planning" in Athens (Greece) on 20-23 June **2022**, organized by Athens Institute for Education and Research.
iii. "International Conference on Built Environment Science & Technology" in on 20-21 February **2021**, School of Architecture and Interior Design, SRM Institute of Science and Technology.
iv. "International Conference on Resilient & Liveable City Planning (RLCP 2020): Transforming Urban Systems" in Vijaywada (India) on 10-13 February **2021**, organized by Department of Planning, School of Planning & Architecture, Vijayawada.


**Figure 6:** Presentation at Athens.

## d) PROFESSIONAL ENGAGEMENTS

| S. No. | Start and End Date | Job Title | Employer details | Supervisor | Description |
|---|---|---|---|---|---|
| **1** | 01.06.2021 - Present | Research Assistant (R.A.) | Graduate School of Engineering, Hokkaido University, Sapporo, Japan | Dr. Suguru Mori (Professor, Hokkaido University) | Special Lecture and Fieldwork Assistance in "Architecture and Human Behaviour"; |
| **2** | December 2021 | Intern | Hikokonishi Architecture Inc., Sapporo, Japan | Architect Hikohito Konishi (C.E.O., Hikokonishi Architecture Inc.) | Doctoral Internship |
| **3** | January – June, 2021 | Primary Content Creator | All India Institute of Local Self Government, New Delhi, India | Hitesh Vaidya (Director, National Institute of Urban Affairs, India) | Primary Content Creator for BASIIC (Building Accessible, Safe, and Inclusive Indian Cities) |
| **4** | October 2021 – June 2022 | Teacher (Part Time) | Pera Pera English Kindergarten, Sapporo, Japan | Ms. Yumiko Shiraki (Director, Pera Pera Kids College) | Teaching and communicating with specially-abled kids (especially ADHD) |

**Figure 7:** With Architect Konishi.

**Figure 8:** Simulation Exercise as R.A.

**Figure 9 and Figure 10:** Interacting with specially-abled kids. *[blurred for privacy]*

## e) LECTURES DELIVERED

i. Academic coursework expert lecture on “Universal Accessibility” for B.Arch Students and researchers organized by Gopalan School of Architecture and Planning (Bangalore, India) on 10th December **2022**.

ii. Academic coursework expert lecture on “Barrier Free Architecture” for 2nd and 3rd Year B.Arch Students of MMIED College of Architecture (Pune, India) from 02-04 February **2022**.

iii. Introduction to Universal Design, Hakodate Chubu High School, Hakodate (Japan), 02 October **2021**

iv. Invited lecture: The First Mile of Young Professionals, Indian Institute of Technology, Roorkee (India), 14 April **2021**

v. Invited lecture: Assessing accessibility for equitable planning; with focus on disabled and elderly, Institute of Town Planners (West Bengal Regional Chapter), Kolkata (India), 8 November, **2020**

vi. Invited lecture: Being Creatively Rational, DTC, Noida (India), 28-29 October, **2020**

vii. Invited lecture: Being Creatively Rational, RSA, Mevalurkuppam (India), 6 October, **2020**

viii. Invited lecture: Universal Design, Central University, Ajmer (India), 5 October, **2020**

ix. Academic coursework expert lecture on “Universal Design Approach” for 2nd and 3rd Year B.Arch Students of Anantrao Pawar College Of Architecture (Pune, India) from 28-30 August **2020.**

x. Invited lecture: Design Perspective of Urban Spaces: UNIVERSAL DESIGN, Studio SAKHA Summer Studio, Nagpur (India), 21-22 August, **2021.**

xi. Invited lecture: An Architect’s approach towards Universal Design and Accessiblity, DYPU, Pune (India), 19-21 August, **2020.**

xii. Invited lecture: Universal Design and Accessibility – A route towards Sustainability, JNFAU, Hyderabad (India), 14 August, **2020.**

xiii. Technical Quality Improvement Programme on “Universal Design: Architecture For All” for Teachers and Thesis Students of the Department of Architecture and Planning, MITS (Gwalior, India) from 07-09 August **2020.**

xiv. Academic coursework expert lecture on “Universal Design and Accessibility” for 2nd and 3rd Year B.Arch Students of MMIED College of Architecture (Pune, India) from 06-08 August **2020.**

xv. Invited lecture: Being Creatively Rational, SAID, Kattankulathur (India), 27-29 July, **2020.**

xvi. Invited lecture: UNIVERSAL DESIGN, Studio SAKHA Summer Studio, Nagpur (India), 25-28 June, **2020.**

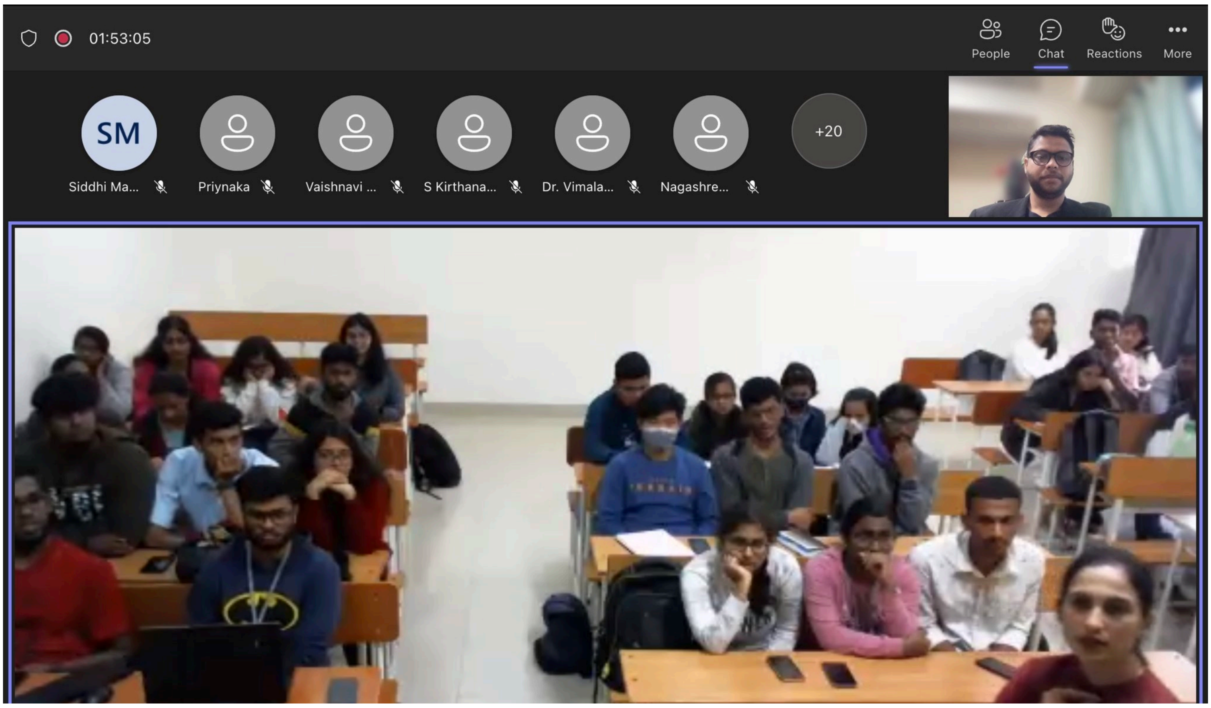


Figure 11: Session with Gopalan School of Architecture and Planning, India

Figure 12: Session with Hakodate Chubu High School, Japan

## Appendix 2: 1st Peer reviewed referred journal publication

**G. Das Mahapatra**, S. Mori, and R. Nomura, 'Universal Mobility in Old Core Cities of India: People's Perception,' *Sustainability*, vol. 13, no. 8, p. 4391, Apr. 2021, doi: 10.3390/su13084391. [Impact Factor = 3.9; Citations = 11 (as of July 2023)]

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IMPACT FACTOR 3.889

CITESCORE 5.0

Article

# Universal Mobility in Old Core Cities of India: *People's Perception*

Gaurab Das Mahapatra, Suguru Mori and Rie Nomura

Special Issue
Smart Cities 3.0: Citizens, Space and Sustainable Mobility for the Future City

Edited by
Dr. Chiara Garau, Prof. Dr. Claudia Yamu, Dr. Vicenza Torrisi, Prof. Dr. Michela Tiboni and Prof. Dr. Margarida Coelho

MDPI

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*Article*

# Universal Mobility in Old Core Cities of India: *People's Perception*

**Gaurab Das Mahapatra** *, **Suguru Mori and Rie Nomura**

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**Abstract:** In this research, users' perception towards Universal Mobility in old core cities of India has been critically analyzed. Despite Universal Design guidelines from the United Nations and Union Government of India, old cities in India seldom have Universal Mobility, in effect endangering the lifestyle of senior citizens and differently-abled people. The core of Kolkata Municipal Corporation in Kolkata, India, has been considered a case example for this research. This research has considered three types of datasets for analysis. First, the authors interviewed 310 respondents from the Indian design fraternity, with the objective of understanding their opinions on the concept of Universal Design. In the next investigative study of 125 respondents from different wards of Kolkata Municipal Corporation, the purpose was to comprehend people's perception regarding walkability and mobility in an old Indian city. In the last visual survey of a stretch in Central Kolkata, the focus was on identifying hindrances in Universal Mobility in an old city core of Indian origin. Significant dissatisfaction was found regarding walkability amongst all user groups, which is linked to poor infrastructural conditions. Furthermore, accessing public transportation is difficult due to improper waiting facilities. However, the design fraternity in India suggests the need of separate accessibility guidelines for old and new cities in India. The design fraternity also recommends a customized rating system for accessing Universal Design. The result of this study indicates a need of recognizing the difficulty in imparting Universal Mobility in old core cities in India. This information can be used for preparing an access audit checklist through Architectural Planning, which is the first step in proposing a framework for Universal Mobility in old core cities in India.

**Keywords:** Universal Design; mobility; old core cities; walkability; Central Kolkata; Architectural Planning



**Citation:** Mahapatra, G.D.; Mori, S.; Nomura, R. Universal Mobility in Old Core Cities of India: *People's Perception*. *Sustainability* **2021**, *13*, 4391. https://doi.org/10.3390/su13084391

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## 1. Introduction

According to the 2011 Census of India, 2.21% of the Indian population, or 26.8 million people, are disabled [1]. The medically approved disability categories as per the 2011 Census were (a) vision, (b) auditory, (c) verbal, (d) movement, (e) mental retardation, (f) mental illness, (g) multiple disabilities, and (h) any disabilities other than those mentioned but clinically verified. Furthermore, only the people under the aforementioned medically approved categories were considered for the facilities/benefits provided to differently-abled people, as per the Indian guidelines such as "Article 41 of Constitution of India" or "The Person with Disabilities (PwD) Act, 1995" [2]. Article 41 of Indian constitution states that "The State shall, within the limits of its economic capacity and development, make effective provision for securing the right to work, to education and to public assistance in cases of unemployment, old age, sickness and disablement, and in other cases of undeserved want". The PwD Act, 1995 enlisted seven conditions of disabilities, namely: (a) blindness, (b) low vision, (c) leprosy cured, (d) hearing impairment, (e) locomotive disability, (f) mental retardation, and (g) mental illness. In contrast, the "Right to Persons with Disabilities Act, 2016" recognizes twenty-one types of health conditions (Ministry of Law and Justice, 2016). Thus, the number of "medically disabled" in India is substantially higher than the data published in the 2011 Census. In addition to this, the elderly people who might have been facilitated from the same provisions (as of differently-abled) were never considered as a stakeholder. As a result, the 103.8 million elderly people (as per the 2011 Census) were also not included in the category of receiving facility/benefit [3]. One of the hindrances in the Indian disability scenario is the national reluctance towards the shifting of focus from the medical model of disability towards a logical model.

"United Nations Convention on the Rights of Persons with Disabilities" (hereafter, UN-CRPD) and its Optional Protocol (A/RES/61/106) were adopted on 13 December 2006 at the United Nations Headquarters in New York, with an aim towards changing global attitudes and approaches towards persons with disabilities. Article 9 of the UN-CRPD suggests equal opportunities for differently-abled people in the following three aspects: (a) physical environment, (b) transportation, and (c) information and communication. Article 9 of the UN-CRPD also directs the member nations to implement "universally designed" public facilities [4]. Along these lines, Goal Number 11 of the "United Nations Sustainable Development Goals" (hereafter, the UN-SDG) specifies "Sustainable Cities and Communities" which aims towards making cities and human settlements inclusive, safe, resilient, and sustainable. Target 11.2 (within Goal Number 11 of the UN-SDG) elaborates that by 2030, all the member nations of the United Nations should provide access to safe, affordable, accessible, and sustainable transport systems for all. Additionally, the member nations should improve road safety, especially by expanding accessible public transport. Furthermore, goal 11 specifies that the aforementioned developments should be carried out with special/distinctive attention to the needs of (a) those in vulnerable situations, (b) women, (c) children, (d) persons with disabilities, and (e) older persons [5]. According to the data from World Population Prospects (the 2019 Revision), one in six people (16%) in the world will be over age 65 (16%) by 2050; in comparison to the ratio of one in eleven people (9%) in 2019. The main factors behind this phenomenon are declining fertility, increasing longevity, and international migration. Thus, in these times of globally changing demography, both the UN-CRPD and UN-SDG suggest the concept of Universal Mobility for enabling movement within a city without discrimination on the basis of physical or mental limitations. India, being a member nation, is required to act on these similar lines of action towards an "Universally Designed" built environment.

In contrast, most of the Indian documents related to Universal Design/accessible design are mere guidelines and not mandatory rules; thus, their implementation for accomplishing "barrier-free" or "inclusive" built environments at the societal and/or urban-level has not happened [6]. The authors further argue that in spite of being a member nation of the UN and one of the eighty-two signatories in UN-CRPD, India has a gap in the policy framework of Universal Design's implementation. However, the authors also suggest rectifying the gap by strategic interpretation of the latest disability data and taking into account the needs of Indian citizens. In India, the accessibility conditions are comparatively low in "old cities" in comparison to accessibility provisions in newly planned cities. However, in the Indian subcontinent, old cities can have multiple definitions. For this research, cities evolved during the early 18th century (start of British Era) are referred to as "old cities". As of Census 2011, India's population is over 1210 million, with a decadal growth rate of over 17%. Additionally, India's density increased from 325 person/ sq.km in 2001 to 382 people/sq.km in 2011 (with over 17.5% increase). The core areas in respective cities are further denser. In the case of Kolkata Municipal Corporation, the density is over 24,200 persons per sq. km. against a national figure of just 382 persons per sq. km. Owing to the ever-increasing population of India and high density in its historically-developed organically-planned core cities, "accessibility" becomes more complex than most of the countries abroad. "Accessibility" refers to the provisions for people including both able-bodied and differently-abled for accessing the urban facilities without discrimination. Thus, dealing with accessibility in old city parts of India is an interesting as well as an important domain of urban infrastructure [7]. As an example, cities planned after independence of India (from British in 1947) such as Chandigarh and Bhubaneswar have relatively better facilities/options for differently-abled and senior citizens (people above 60 years), than cities such as old parts of imperial Kolkata or colonial Delhi.

As a general practice in urban India, the practices of Universal Design guidelines or Barrier-Free are comparatively more at Building level, and not at site/precinct level [8]. Universal Mobility connects the missing links between "Universally Designed" buildings and "Universally Designed" premises/precincts and creates accessible urban spaces. In India, a project such as "Mass Rapid Transit System" in Delhi (operationalized in 2002) has initiated the process of inclusive transportation [9]. However, on a large scale, the UN-CRPD's focus on Universal Mobility is not yet addressed in Indian guidelines. Likewise, Indian cities are still lagging behind in creating accessible urban spaces because of practicing "Inclusive" or "Accessible" Transportation", instead of "Universal Mobility". "Inclusive Transportation" focuses on making the mode of transport accessible to all, for example, accessible railway stations or accessible bus stops. The aspects covered in "Accessible Transportation" are (a) access to the station, (b) fare payment, (c) travelling information and communication, and (d) interior conditions of the mode of transport [10]. "Universal Mobility", in contrast, is a policy level intervention at the city scale ensuring a minimum standard of mobility for all members of society [11]. Thus, "Universal Mobility" is technically sound than "Inclusive "or "Accessible" Transportation".

Urban reforms in India particularly focusing on improving the quality of life in an inclusive way has substantially increased in recent years. One of such initiatives has been the "Accessible India Campaign" (launched in December 2015 by Ministry of Social Justice and Empowerment, Government of India) in consonance with Article 9 of UN-CRPD. "Accessible India Campaign" has a number of components which promote accessibility in (a) built environments, (b) transportation systems, and information and communication eco-systems [12].

In a similar line, through interviews and surveys during this research, the authors inferred that for this research, "Transportation System Accessibility" (involving vehicular traffic and walkability) be dealt with greater focus than the other two components. At an objective level, the focus of UN-CRPD towards Universal Mobility relates to the "Transportation System Accessibility" component of the Accessible India Campaign. The global focus and national demand made the authors focus on the topic of Universal Mobility rather than any other aspect of Universal Design for this research.

### *1.1. Research Components*

This section specifies the following for this paper: (a) aims, (b) objectives, (c) research questions, (d) limitations, and (e) hypothesis.

The aim of this paper is to determine the status of accessibility in the core areas of an old Indian city by identifying factors for an ideal accessibility audit checklist. An accessibility audit checklist is an audit format to check the condition of spatial accessibility based on parameters (such as the presence of ramps) and their related indicators (such as slopes or material of the ramp).

The objectives to strengthen the aim are the following: (a) to ascertain the need for a new dimension in the Indian accessibility scenario, (b) to assess people's perspective towards Universal Mobility in core urban areas in India, and (c) to identify the issues in mobility in core urban areas in India.

The underlying research question for this paper is to find out whether core areas of urban India can be made inclusive in terms of accessibility. However, the research shall be limited to core urban areas in India, and the study shall be street level.

The hypothesis considered for this research is that the core cities in the Indian context need to be made accessible through provisions in planning and design. The paper shall only explore the factors that are required to constitute the parameters in an Accessibility Audit Checklist.

*1.2. Research Process*

This research paper began with the literature study (explained later in detail in Section 2 of this paper). At the same time, participatory audiences for the research were contacted. For substantiating Objective 1 (as mentioned in Section 1.1), the authors interacted with the design fraternity in India, and 310 people among those responded through questionnaires. For exploring Objective 2 (as mentioned in Section 1.1), the authors interviewed 125 residents from Kolkata Municipal Corporation (hereafter KMC). KMC is the municipal authority for the city of Kolkata which covers an area of 206.08 sq. km. with a population over 4.5 million and density of over 24,200 persons per sq. km. KMC's history dates back to 1726, during its formation by a royal charter from British Government. As on January 2021, KMC has jurisdiction of 144 wards (smallest administrative unit in Indian urban administrative system). For achieving Objective 3 (as mentioned in Section 1.1), a stretch of nearly 850 m within KMC limit was visually surveyed by the authors.

Summarizing fundamental theories and explanations of experts from the field of Universal Design and Accessibility was the next step in the research process. This section was further subdivided into three parts according to the genre of the documents referred: (a) Universal Design Theory, (b) Fundamental Understanding of Accessibility, (c) Universal Mobility in Urban Areas. This part is further elaborated in Section 2.

After the aforementioned stage, "choice of research" was determined by the authors for generating research content through interviews, field study, and field surveys. Additionally, content analysis was also done based on the research method. The method used for this research by the authors was "Critical Instance Case Study". "Critical Instance Case Study" methods studies are used to examine situations of unique interest, or to challenge an universal or generalized belief. Such studies are not focussed to create new generalizations. Rather, several situations or events may be examined to raise questions or challenge previously held assertions. Case Study type was suitable for this research because this paper required a detailed analysis of a delineated zone in core of old cities in India. The specificity of the study area made the authors prefer the "case study" method of research. Additionally, this research is aimed towards examining situations of Universal Mobility and thus defies the generalized format of mobility planning existing in old core Indian cities. This research critically appraises various opinions and scenarios to criticize mobility conditions in old core Indian cities. Thus, "Critical Instance" sub-type of "Case Study Research" deemed fit for this paper. The following stage was operationalization of the research.

The two components of operationalization were (a) measuring the data or creating measurable attributes for the data and (b) designing an appropriate questionnaire. The authors adopted the Likert scale approach and percentage of opinions for solving the first component (i.e., measuring the data or creating measurable attributes for the data). Three types of variables are used in this research: (a) categorical, (b) discrete, and (c) ranked. Categorical variables are used in a research when the variables can be compartmentalized into certain categories/groups. In this paper, categorical variables are used in the study of factors such as type of disability and type of infrastructure to be mapped. Discrete variables are used when there is a limitation or specific value to the variables. In this research, discrete variables are used in factors such as number of streets. Ranked variables are used when the available data set can be put in a sequence or order. In this paper, ranked Variables are used in factors involving opinions such as people's opinion on comfort level in walkability. For the second component (i.e., designing an appropriate questionnaire), the authors compared the questionnaire from various published research with the feedback from respondents during a pilot survey, before the actual questionnaire survey. This part is further explained in Section 3.1.1, Section 3.2.1, and Section 3.3.1 of this paper. Sampling strategy was the next step in the research.

Sampling strategy for this research was determined by feasibility study. The authors conducted three types of surveys to assess the feasibility of the project. First, the 310 samples for taking opinion of the design fraternity of India were linked to the number of participants who took part in the questionnaire survey provided by the authors at the end of certain digital interactions (explained further in Section 3.1). Second, the 125 samples for understanding people's opinion were collected by the authors from different wards on KMC, with majority of respondents from in and around the central core of Kolkata (explained further in Section 3.2). Third, the visual observation study was conducted by the authors at an 850 m long stretch in the core of Kolkata. This selected stretch in the core of Kolkata has mixed land use, historic origin, and heavy traffic movement (Explained further in Section 3.3).

The authors observed and analyzed the collected data with an aim of "coding" or interpreting. This part is further explained in Section 3.1.2, Section 3.2.2, and Section 3.3.2 of this paper. While interpreting the data, the focus was on identifying the factors affecting Universal Mobility in the core of old Indian cities.

The following step for this paper addressed the major findings of the research through data manipulation. The authors considered the following points in this section: (a) co-relating the survey findings and (c) linking the objectives of the research to the data interpretation. This part is further explained in Section 4 of this paper.

The last part of the research process was finding out how this research could be fed into further research. This part is further explained in Section 5 of this paper. In this section, authors have mentioned the reason for the gap between existing policies and on-ground implementation of Universal Design guidelines in India. Subsequently, the need of an ideal "accessibility audit format" is also mentioned. Further, the role of "Laboratory of Architectural Planning, Hokkaido University" in the field of Universal Design and Accessibility is also mentioned briefly by the authors. Lastly, the authors explain how this research is just a beginning towards addressing the entire issue of accessibility in the core of old Indian cities. Additionally, a methodology for the scope of further research based on the findings from this paper is furnished by the authors.

Figure 1 summarizes the process undertaken for this research. The column on the left of Figure 1 shows the research stages and the column on the right explains the activity related to that research stage.

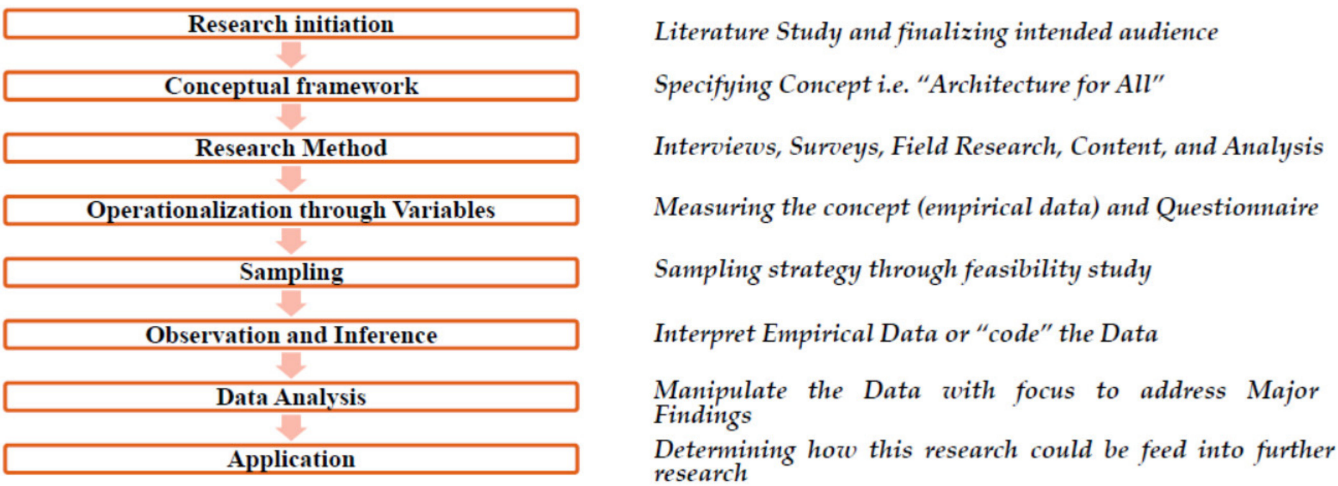



**Figure 1.** Research process followed for this paper (Source: Author).

## 2. Literature

Architect Ronald Mace, who coined the term Universal Design, defines Universal Design as the design of products and environments which is maximally usable by all people without the need for any adaptation or specialized design [13]. The "International Classification of Functioning, Disability and Health" of the "World Health Organization" (or, W.H.O.) mentions that disability is a phase, and it is not specific to any age or gender [14]. "Inclusive design features" which focusses on disabled friendly provisions in products and designed space within the built environment, affects the independence of elderly/differently-abled to a great extent. Additionally, "exclusive" barrier-free mobility options at the city level (such as ramps and braille signage) improve the quality of life for the elderly/differently-abled. Conversely, hedonic adaptation (tendency of people to return to normal state after the occurrence of an extreme positive/negative event and age cohort effects (higher state of satisfaction due to the lower expectation) can undermine the need for such "exclusive" inclusive features [15]. Thus, the authors further state that instead of focusing on specific facilities for differently-abled and elderly people, encouraging "Universal Mobility" uplifts the inclusiveness of urban space.

### *2.1. Universal Design Theory*

Goldsmith (2000) establishes the need for a bottom-up route towards Universal Design and proposes a model called "Universal Design Pyramid". Goldsmith's "Universal Design Pyramid" indicates that Universal Design facilitates the able-bodied and differently-abled alike [16]. Universal Design implementation on a national or regional-scale depends on the pattern in which user-experience based inputs are implemented into the planning legislation [17]. Likewise, Universal Design solutions are socially and financially rewarding since they make spaces easier for everyone to use [18]. Based on the inclusive civil engineering guidelines like IS 4963- Recommendations for Building and Facilities for the physically handicapped (1968), or Guidelines and Space standards for Barrier Free Built Environment for Disabled and Elderly persons (1998), or IRC 103-Guidelines for Pedestrian Facilities (2012), designers in India often provide separate provisions for differently-abled people; without realizing that separate facilities promote societal inequality. Story (1998) clarifies that correctly implemented "Universal Design" is often undetected since it integrates with the design process [19]. Being accessible to all user groups from the start of the design usability implies seamless implementation of Universal Design strategies [20]. Thus, suggesting a facility specifically for elderly/differently-abled negates the very concept of Universal Design.

Furthermore, Steinfeld and Danford (1999) establish that in spite of the origin of Universal Design since the mid-1970s, Universal Design concepts still lack practical implementation due to lack of adequate contextual theory [21]. Similarly, Steinfeld (1975) holds that the inclusion of empirical data gathered from human-centric research related to spatial behavior of differently-abled people is an ideal way to implement Universal Design solutions [22]. Thus, this paper includes human behavior and user experience as the base of research.

Architectural Planning, as described by Professor Dr. Suguru Mori from Hokkaido University is a discipline for "planning" architecture. It helps in conducting "practical problem interest (research approaching reality)" rather than "research problem interest (research for research)". Architectural Planning is probably the ideal pedagogy for research on Universal Design. In Architectural Planning, the three levels of design hierarchy are (a) site, (b) services, and (c) building. In Universal Design professional practice, the building level is better addressed by designers since the scale of the development is smaller in comparison to other factors. However, without inclusive sites and services, the individual buildings will be inaccessible to all; in spite of the individual building being universally designed [23]. Likewise, during the primary survey for this paper, even respondents prioritized site and services for implementing Universal Design considerations.

In relation to this, Universal Design considerations in an urban core with historic precincts are more challenging than any other urban scenario [24].

### *2.2. Fundamental Understanding of Accessibility*

There are ideological differences in the way different nations perceive Universal Design, since Universal Design came into effect from 1985 (originating in the United States) and Barrier-Free Architecture has existed since 1974 (originating from Machida City, Japan). Akiyama and Kim (2005) establish that unlike the United States where Universal Design signifies disabled-friendly approaches, in countries such as Japan it is more holistic. Japan uses Universal Design principles as a mode to facilitate the entire population. Relatively new initiatives such as “Transportation Accessibility Improvement Law, 2000” or old projects such as “Welfare model cities for the disabled, 1973” reflects Japan’s focus on using Universal Mobility as an infrastructural as well as a social tool in enabling the environment for all [25]. In the similar lines, the authors also considered that the physical structure of an urban area directly impacts the walkability scenario [26].

However, in India, the situation is different from countries such as the United States or Japan. Likewise, Indian Universal Design Principles were published in 2011, which proposed five principles: (a) *Saman* (equitable), (b) *Sahaj* (usable), (c) *Sanskritik* (cultural), (d) *Sasta* (Economic), and (e) *Sundar* (aesthetic). The “Indian Principles” are different from the Seven Principles of Universal Design that were being followed in India until the inception of these principles [27]. Apart from political and administrative difficulties, a cultural stigma is also attached to the Universal Design thinking in India. Disability in India has been associated with past sins, and the disabled people are historically ignored in social/religious participation [28]. Thus, implementing Universal Design guidelines in India is substantially complex and requires an audit to assess the condition of inclusivity before imparting Universal Design. The audit shall specify the degree of accessibility required in a site-specific manner.

In addition, a modified performance assessment by creating a research agenda and involving professionals from different fields is the ideal way to practice Universal Design [29]. India and many developing nations have a general inception that the user group facilitated by Universal Design is considerably lesser than the ones “not facilitated” by its absence. However, the conditions that people experience while they are situationally disabled, such as a fracture, or pregnancies, or carrying a child, are seldom considered by these nations in urban-level infrastructural design. Another stigma related to Universal Design is the myth that it increases the project cost. Nevertheless, considering the global changing demographic pattern and inclusive planning considerations, the cost incurred due to Universal Design is utilitarian [30].

### *2.3. Universal Mobility in Urban Areas*

Walkability conditions and transportation facilities are the two primary components of urban mobility. Nevertheless, poor infrastructure such as irregular footpath spaces and dissatisfactory pedestrian slope poses threat to elderly/differently-abled bodied and abled bodied alike. Additionally, any physical barriers in urban mobility are against the notion of “right to city or city for all” [31]. In the course of this research, the authors observed a similar phenomenon in central Kolkata. The photographs of a stretch in central (core) Kolkata showed in Figures 19–30 depict the dilapidated mobility conditions.

Along these lines, Frye (2014) argues that the global ageing population complemented by the falling birth rate is posing an infrastructural challenge to the increasing urban population. Frye’s research identifies several factors that influence urban mobility: (a) overcrowding of vehicles/terminals, (b) uneven or broken road surfaces, (c) high kerbs/deep storm drains, (d) inaccessible public transport vehicles, (e) cost/affordability of public transport, (f) attitude of drivers and other staff, and (g) lack of accessible information. Frye validated these factors by correlating age and disability [32]. The authors used the factors from Frye’s paper along with some contextual factors while conducting visual observation of the old core of Kolkata (elaborated in Section 3.3: Visual observation of an old city core). While transportation is widely researched, “walkability” for a diverse user group is a relatively restrictive topic in academia till date.

Similarly, Mori (2001) proposes that for researches involving a high human behavior interface, the research methodology should involve the feedback of the end-user from the beginning of the research [33]. Mori (2002) further explains that walkability involves an intricate relationship with space structure and mentions the needs to include children, elderly and disabled people in researches involving walkability [34]. Factors affecting user’s behavior in urban street spaces have a positive or negative effect depending on the genre of infrastructure and mobility condition of the user group [35]. Architectural planning research methods by comparing and/or relating the rational parameters (such as zoning and space allocation) with qualitative factors (such as pedestrian behavior), is an effective way to urban mobility-related issues in old core cities [36]. The space structures in old cities of developing nations such as India are complex due to their historic origin. These areas have high density, mixed land use, and a lack of space allocated to infrastructure.

Preiser (2008) argued that there is no comprehensive audit checklist for accessibility, and suggests that activities such as workshop and research group discussions for contextual accessibility assessments [37]. The authors took inspiration from Preiser's work and conducted eleven digital interactive sessions all across India to gain a contextual perspective on the topic. In addition to this, stakeholder specific approach in urban-level accessibility surveys by involving differently-abled people and elderly people enhances the effectiveness of an accessibility survey [38]. Furthermore, interviews held in Kolkata helped the authors understand the user's perspective about mobility in old Indian cities.

The learning elaborated in the Section 2.1 (Universal Design Theory), Section 2.2 (Fundamental Understanding of Disability), and Section 2.3 (Universal Mobility in Urban Area) are linked to the objectives, and the linkage is shown in Figure 2. Before starting the data collection and analysis, the authors for this paper created a knowledge base that helps to proceed further towards objectives, and subsequently answer the research question.

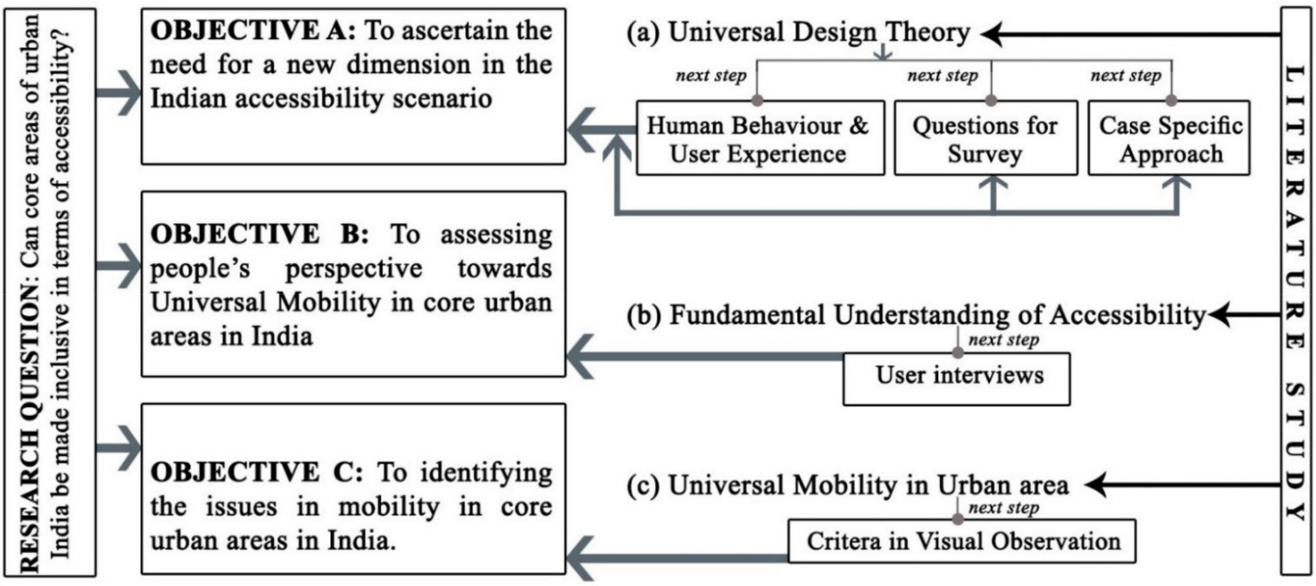



**Figure 2.** Linkage between research question and objectives with findings from the literature study (Source: Author).

## 3. Survey and Results

The details of the three surveys as mentioned in Section 2 are elaborated in this section of the paper. The authors have explained each survey in three basic parts: (a) survey process, (b) observation and analysis, and (c) findings and discussion.

### *3.1. Opinion of Design Fraternity in India*

The design fraternity of a country, which includes architects, planners, designers, and civil engineers, are responsible for the task of nation-building in terms of infrastructure. Thus, the Indian design fraternity's opinion was essential for substantiating the aim of this research. The authors conducted eleven "virtual interactive platforms" (through ZOOM and Google Meet platforms) in various parts of India for discussing the intent of this research with the design fraternity of India. The platforms included workshops, seminars, studio, Technical Education Quality Improvement Program (TEQIP), and lectures. Table 1 shows the details of the eleven virtual interactive sessions.

**Table 1.** List of interactive sessions in India between June and November 2020, for substantiating the aim of the research (Source: Author).

| S. no. | Date | Type of Session | Title of Session | Location |
|---|---|---|---|---|
| 1 | 25–28 June | Summer Studio | Universal Design | SAKHA, Nagpur |
| 2 | 27–29 July | Workshop | Being Creatively Rational | School of Architecture and Interior Design, SRM Institute of Science and Technology, Kattankulathur |
| 3 | 07–09 August | Technical Education Quality Improvement Programme | Universal Design: Architecture for All | Department of Architecture, Madhav Institute of Technology and Science, Gwalior |
| 4 | 14 August | Webinar Series | Universal Design and Accessibility—A route towards Sustainability | Jawaharlal Nehru Architecture and Fine Arts University, Hyderabad |
| 5 | 19–21 August | Workshop | An Architect's Approach towards Universal Design and Accessibility | School of Architecture, DY Patil University, Pune |
| 6 | 28 August | Semester Coursework Expert Lecture | Universal Design Approach | Akhil Bharatiya Maratha Sikshan Parishad's Anantarao Pawar College of Architecture, Pune |
| 7 | 05 October | Webinar | Universal Design | School of Architecture, Central University, Ajmer |
| 8 | 06 October | Guest Lecture | Being Creatively Rational | Rajalakshmi School of Architecture, Mevalurkuppam |
| 9 | 06–08 October | Semester Coursework Expert Lecture | Universal Design and Accessibility | Marathwada Mitramandal's Institute of Environment and Design's College of Architecture, Pune |
| 10 | 28–29 October | Workshop | Being Creatively Rational | School of Architecture, Delhi Technical Campus, Noida |
| 11 | 08 November | Institute of Town Planning Annual Lecture | Assessing accessibility for equitable planningwith focus on disabled and elderly | Institute of Town Planners India, Kolkata |

Architects, planners, designers, government officials, architecture students, and planning students, attended these virtual interactive platforms. Although there were eleven venues, the participants came from over sixty cities across India. The major content of the workshop included (a) introduction to Universal Design and its salient features, (b) the International and National Guidelines on Universal Design, (c) anthropometrics and ergonomics in Universal Design, (d) the application of Universal Design in different building types and streetscape, and (e) accessibility audit. The authors were the primary mentors for the sessions, occasionally complemented by other experts from the field of accessibility and spatial design. The major findings from this workshop included (a) consciousness about the dissimilarity between Universal Design, Barrier-Free Standards, and Inclusive Design, (b) facilitating participants towards using the "Universal Design" principles in Architectural Design and Urban Planning, and (c) realizing that in architecture and planning, Universal Design is not a choice, but a prerequisite. The authors included interactive exercises and idea exchange sessions in the lecture sessions. At the end of each session, the participants acquired ideas about applying Universal Design in Architectural Design/Planning. The participants also received the basic idea of Accessibility Audit as a predecessor for Architectural Design. Figures 3 and 4 show some glimpses from the "virtual interactive platforms".

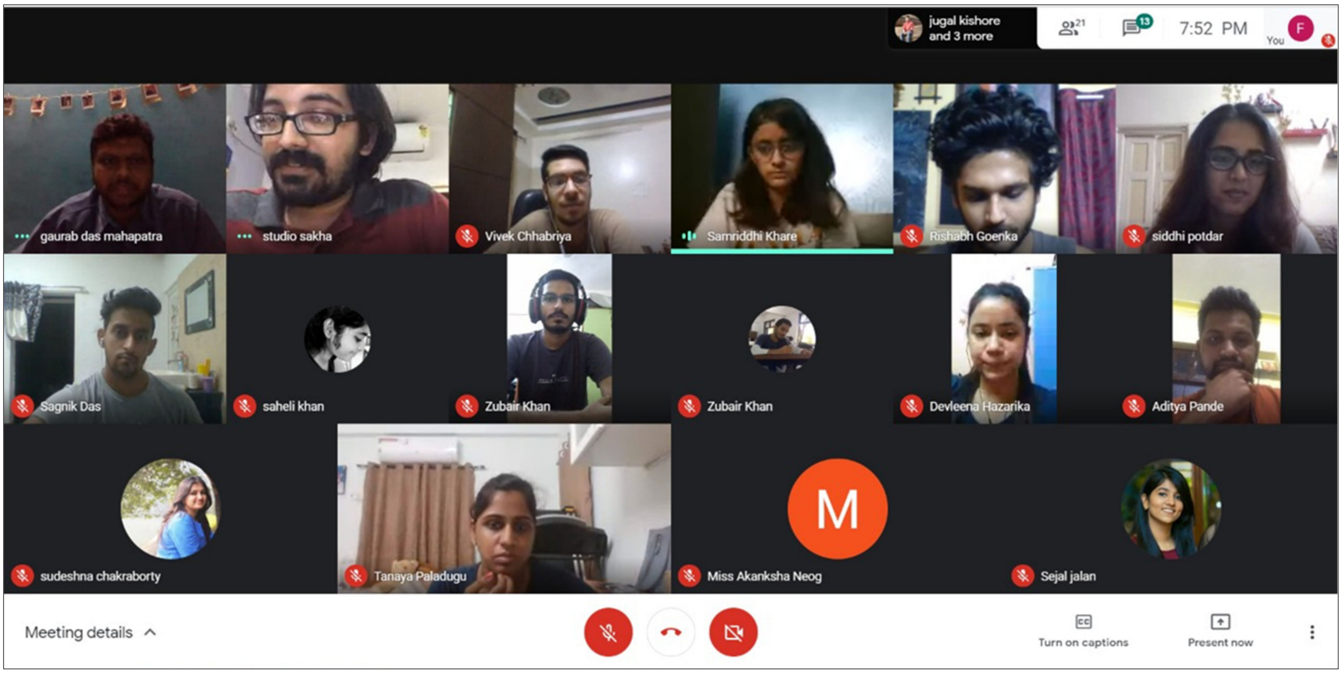



**Figure 3.** Screenshot of session on day 2 from the Summer Studio by Studio Sakha, Nagpur, India from 25–28 June 2020 (Author: Top left) (Source: Author).

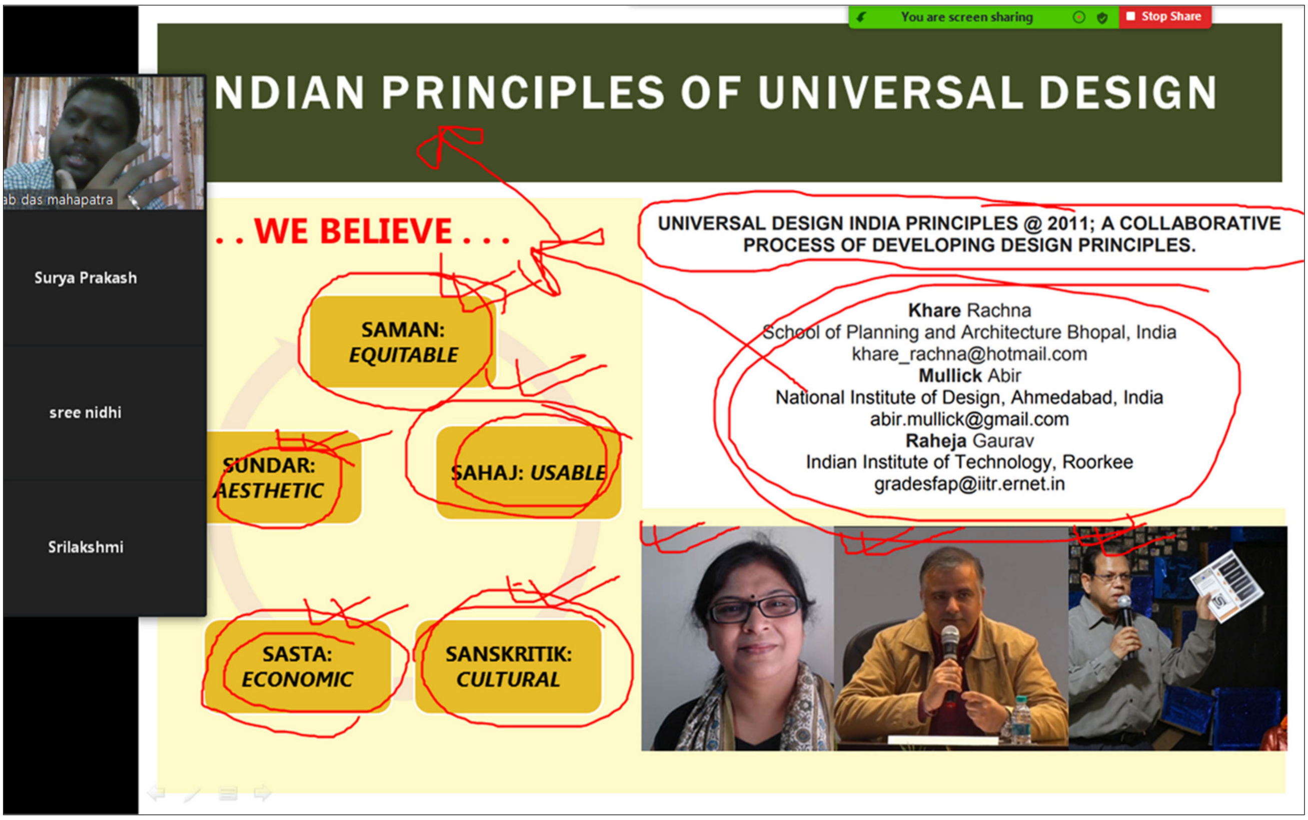



**Figure 4.** Screenshot from the workshop by Rajalakshmi School of Architecture, Mevalurkuppam, India on 6 October 2020 (Author: Top left) (Source: Author).

### 3.1.1. Observation and Analysis

To further analyze the aforementioned points related to workshop learning, the authors created a "Google Form" questionnaire (https://forms.gle/Cx5v4VNsiTV8LQQ28 (accessed on 1 March 2021) for the participants at the end of each session. The questionnaire inquired about certain aspects of Universal Design: (a) position of Universal Design in the design domain, (b) the prioritization of site and services in Universal Design, (c) rating national policies, (d) the level of difficulty in a Universal Design scenario in old cities, (e) the position of "Transportation" and "Accessible Information" in the Universal Design domain, (f) the difference in the Universal Design scenario between old and new cities, and (g) the need for a "Rating System". 14 questions ranging from multiple choice questions, dichotomous questions and Likert scale typology, were used in the questionnaire. The total number of respondents in this Google Form questionnaire was 310.

A total of 79% of the respondents prioritized Universal Design, and not Barrier-Free Architecture or Inclusive Design, in the field of Architecture and Planning [Refer to Figure 5].

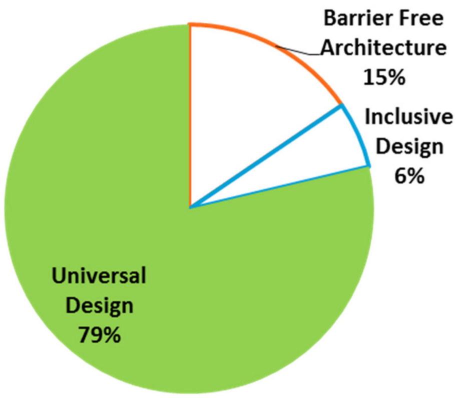



**Figure 5.** Most significant aspects in Architecture and Planning (Source: Author).

The respondents' priority in Universal Design in the Indian context is services (prioritized by 46%), followed by site (prioritized by 42%) [Refer to Figure 6]. A significant number (63%) of respondents advocated for different Universal Design guidelines/principles/audit formats, in old and new cities [Refer to Figure 7].

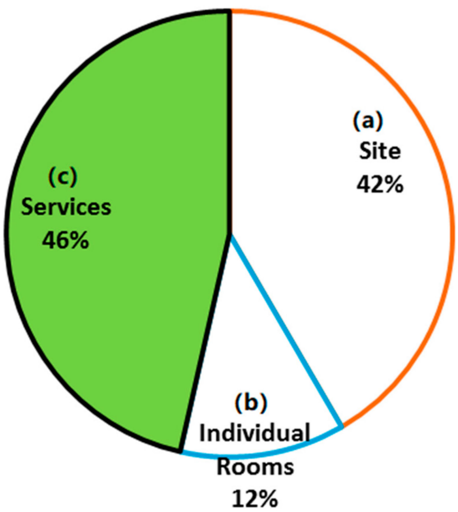



**Figure 6.** Preferred first rank of importance for the components in Universal Design in the Indian context: (**a**) site, (**b**) individual rooms (individual interior spaces), and (**c**) services (Source: Author).

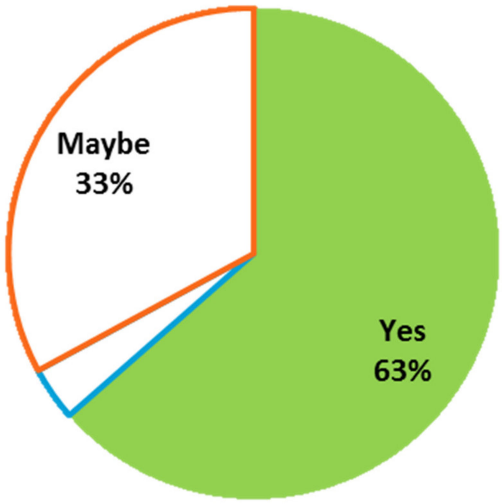
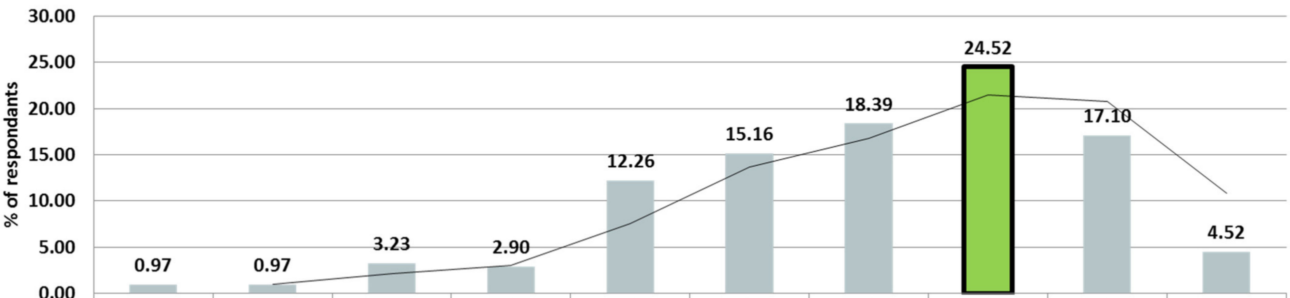



**Figure 7.** Do we need different Universal Design guidelines/principles/audit formats for old cities and new cities in India? (Source: Author).

The majority of the respondents stated that accessibility and Universal Design scenario in old core cities of India are difficult to impart [Refer to Figure 8]. Other than 8.07% of the respondents, all others specified a difficulty level of 5 or more on a Likert scale of 1–10 (where "1" is least difficult and "10" is most difficult).




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| % | 0.97 | 0.97 | 3.23 | 2.90 | 12.26 | 15.16 | 18.39 | 24.52 | 17.10 | 4.52 |

**Figure 8.** How difficult is it to impart the accessibility and Universal Design scenario in old core cities of India? (1—least difficult; 10—most difficult) (Source: Author).

The majority of the respondents also affirmed the Accessible India Campaign as of satisfactory status [Refer to Figure 9]. A total of 7.42% of respondents scored less than five on a Likert scale of one to ten (where one is least marked and ten is highest).

Out of the three components of the Accessible India Campaign, (i.e., built environment accessibility, transportation system accessibility, and information and communication ecosystem accessibility), the respondents prioritized transportation system accessibility. Thus, transportation requires accessible and Universal Design features more than other segments of urban life. During this survey, 97.10% of the respondents also stated that like "Green Rating" (like LEED of USA, or GRIHA of India, or CASBEE of Japan) in Sustainable Architecture, a customized rating system for Universal Design is required as well.

#### 3.1.2. Findings and Discussion

The pan-India data collected from the survey through Google Form questionnaire explicated certain aspects of Universal Design in the Indian context. The involvement of the Indian design fraternity made the study more fruitful, since these are the people who spread the awareness of Universal Design. Table 2 shows a summary of the findings from this exercise.

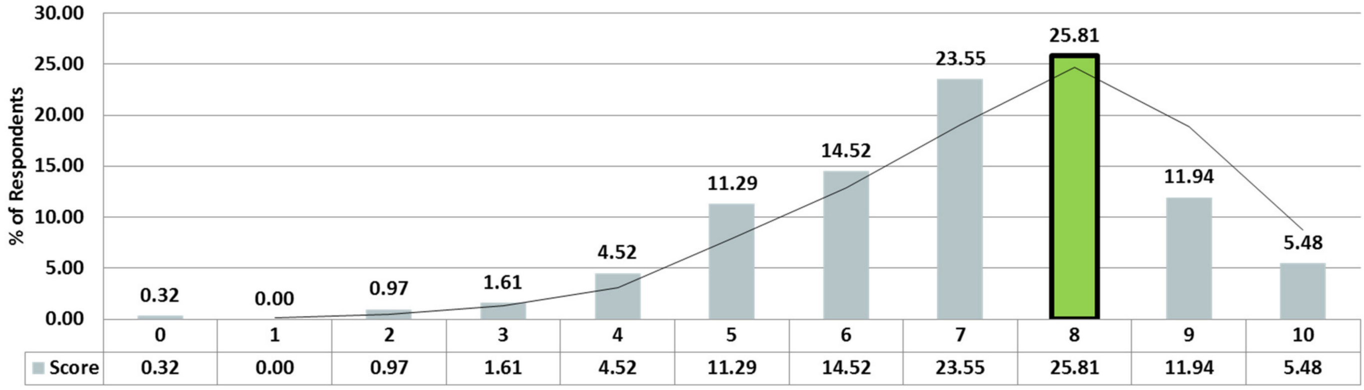



**Figure 9.** How much do you rate "Accessible India Campaign" in terms of Universal Design and Accessibility (0—least; 10—highest) (Source: Author).

**Table 2.** Learning from the interactive sessions in India between June and November 2020 for substantiating the aim of the research (Source: Author).

| S. No | Topic | Learning |
|---|---|---|
| 1 | Importance of Universal Design in Architecture and Planning | Unlike a few decades back, Barrier-Free architecture and Inclusive Design are relatively outdated. The present need for India is Universal Design. |
| 2 | Prioritization of site level and services in Universal Design | Universal Design is necessary, and within it, "SITE and SERVICES" should be the priority. However, the focus of all existing Indian guidelines is "Building Specific" or rather, towards Individual enclosed spaces. |
| 3 | Differences in an accessibility scenario between old core cities and new planned cities in India | In India, new cities and old cities need different Universal Design guidelines, calling for constructive criticism of the latest national policies. |
| 4 | Level of difficulty in old core cities in India | Different Universal Design guidelines are required for old and new cities due to their differences in spatial evolution/temporal growth, institutional mechanisms, infrastructural patterns, and demographic reasons. |
| 5 | Impact of present national campaigns towards inclusive planning | Although National Policies are satisfactory, initiating a case-specific approach or a flexible assessment pattern is ideal. |
| 6 | Position of "Transportation and Accessible Information" in Universal Design | Pan-India, accessible transportation is an issue. Instead of focusing on building or technology-oriented accessibility, the government should focus on making the transportation system accessible. In infrastructural terms, accessible streets and accessible mobility is needed. |
| 7 | Need for customized rating system in Universal Design | A new "Rating/Indexing" system in Universal Design makes the Universal Design scenario more quantitative in analytical terms. Thus, the scope for intervention in infrastructural terms based on the data derived from rating systems might be used for promoting inclusiveness. |

Each of the findings as mentioned in Table 2 shall form the basis of further investigation for respective focus area.

### *3.2. People's Perception in an Old City Regarding Walkability and Mobility*

After gathering the Indian design fraternity's opinion, the authors conducted a survey for accessing people's perception about walkability and mobility, involving people from Kolkata. Kolkata, besides being a British colonial city, is also nearly 350 years old [39].

Thus, Kolkata serves as an ideal case for studying people's perception of mobility in an Indian old city. Due to coronavirus pandemic, India experienced a nationwide lockdown (complete and partial) from 22 March 2020 until 30 November 2020; this meant restrictive movement for the authors. Thus, the authors collected samples over a period of five months from 17 July 2020 until 2 November 2020, via online mode besides face-to-face mode.

The intention of this survey was to recognize (a) the frequency and purpose of outdoor mobility, (b) people's perception of a public transportation system, (c) the status of walkability, and (d) awareness of national campaigns.

3.2.1. Data Analysis

Considering the aforementioned intentions, the authors prepared a Google Form questionnaire (https://forms.gle/oB9MvhWSfQ6PZAKk9 (accessed on 1 March 2021)). Like the previous Google Form in the case of "Opinion of Design Fraternity in India", the questions in this survey also ranged from Multiple Choice Questions, Dichotomous Questions, and Likert Scale based. The total number of respondents for this survey was 125, which were acquired from 40 wards within KMC limits.

Mr. Deoraj Pande (resident of Ward 44, aged 74) who goes out for his house daily work in spite of his severe arthritis prefers using private transport for commuting. Mr. Barid Baran Mahaty (resident of Ward 48, aged 58), a "Person with Disability" (PwD) cardholder, prefers using local trains over any other means of public transport. Mrs. Kanaklata Chakraborty (resident of Ward 50, aged 76), another PwD cardholder, expressed her grief regarding the difficulty in identifying address which becomes aggravated due to her partial blindness. Mrs. Dugarani Chaudhury (resident of Ward 45, aged 96) has been under restricted movement for the last two decades and avoids public transport in case of occasional outings. Mr. Prasanta Das (resident of Ward 48, aged 61), who received a PwD card after becoming mobility impaired, mentioned about the dilapidated condition of the streets. Difficulty in the waiting facility in public transportation has been identified as an alarming situation by Mrs. Manisha Roy (resident of Ward 43, aged 72), Mr. Ram Adhikari (resident of Ward 49; aged 67), and many other respondents.

After taking such opinions from respondents, the authors filled the Google Form for the respondents, in their presence. for better communication with locals, the authors involved one local architecture student (named Ms. Disha Maity) and a retired municipal worker from Kolkata(named Mrs. Manorama Mahanty) in their survey. Respondents became more vocal about their issues and problems when communicated in the local language by local people, than during formal Google-form based interview. A bilingual survey format was also used for communicating with locals and their comments were noted in the local language "Bengali" [shown in Figure 10], which was later translated into English, at the "Laboratory of Architectural Planning" at Hokkaido University.

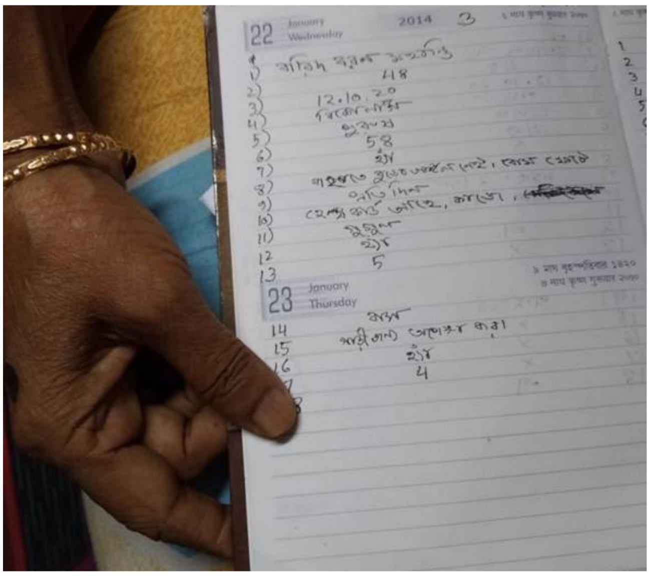



**Figure 10.** Notes were taken in Bengali and later translated into English (Source: Author).

The last survey titled "Opinion of Design Fraternity in India" indicated Universal Design as the need of Indian design scenario. Universal Design encompasses the need for a diverse group. Thus, in spite of focusing on elderly and differently-abled people, the authors collected samples from all categories.

Out of the 125 respondents, 48% of the respondents were male, 50.40% were female, and one respondent belonged to the third gender. However, in terms of age groups, the focus was on the senior citizen [Refer to Figure 11]. A total of 33.60% of the respondents belonged to the age group of sixty years or above sixty years, 28.80% from the age group between twenty and thirty-five years, 20.80% from the age group between fifty and sixty years, 16% from the age group between thirty-five and fifty years, and 0.80% from the age group of ten years or below ten years.

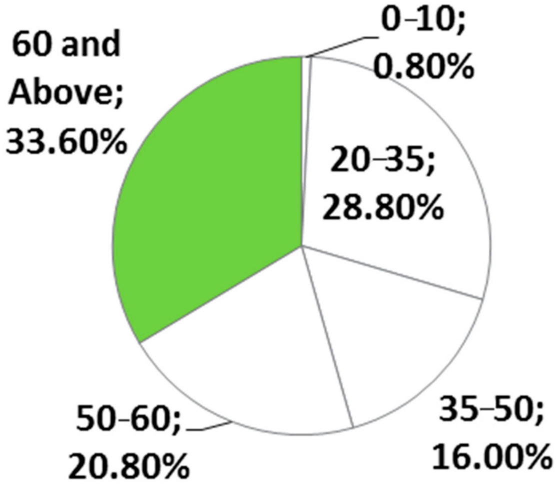



**Figure 11.** Composition of the respondents in terms of age (Source: Author).

Out of the 125 respondents, 83.20% were able-bodied and 16.80% were differently-abled. Out of the 16.80% differently-abled people, only 3.2% of them possessed a "Person with Disability card". "Person with Disability card" is also known as PH/disability/handicap certificate, and this certificate is issued by competent medical authority (in India) specifying the type and extent/severity of the cardholder's identity. As of January 2021, "Person with Disability card" is being replaced by UDID (Unique Disability Identity) with a view of creating a national database for persons with disabilities. 3.2% of the surveyed respondents were "medically" recognized "disabled" or differently-abled, which is above the national percentage of 2.21%.

The types of medical issues that the respondents were facing are (a) low vision, (b) locomotor disability, (c) arthritis, (d) asthma and (e) terminal illness (cancer). Table 3 elaborates the type of disability and recognition status as per "Right to Persons with Disabilities Act, 2016".

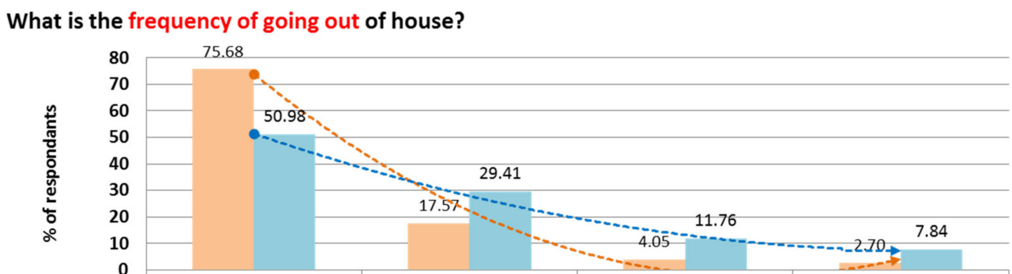
**Table 3.** Types of respondents' disabilities (Source: Author).

| S.No | Type of Disability | Recognized by "Right to Persons with Disabilities Act, 2016" | Number of Respondents | Percentage of Respondents |
|---|---|---|---|---|
| 1 | Low Vision | Yes | 6 | 28.57 |
| 2 | Locomotor Disability | Yes | 11 | 52.38 |
| 3 | Arthritis | No | 2 | 9.52 |
| 4 | Asthma | No | 1 | 4.76 |
| 5 | Cancer | No | 1 | 4.76 |

Hereafter, "senior citizen and differently-abled people" are paired in a single group and compared with "able-bodied people under the age of sixty". The "able-bodied people under the age of sixty" are referred to as "Category A" and "senior citizen and differently-abled people" are referred to as "Category B". The total number of "able-bodied people under the age of sixty" was 74, which is 59.2% of the total respondents. The total number of "senior citizen and differently-abled people" was 51, which is 40.8% of the respondents. For the rest of the discussion about "People's Perception in an old city about walkability and mobility", the "Able-bodied people under the age of sixty" and "senior citizen and differently-abled people" are referred to as "Category A" and "Category B" respectively. The various segments of the questionnaire are discussed hereafter:

- Frequency and purpose of going out.

First, the authors asked the respondents about the respondents' frequency of going out of their house. Only 50.98% of "Category B" ventured out of their houses on a daily basis, in comparison to 75.68% of "Category A". Likewise, the "weekly", "monthly", and "yearly" rate of going out was more in "Category B" as compared to "Category A". Figure 12 shows the options selected by both "Category A" and "Category B" regarding their frequency of going out of respective houses.



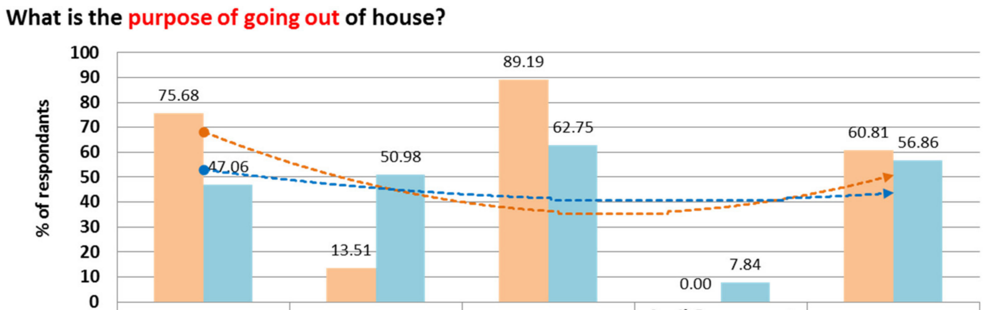

| | Daily | Few times in a Week | Few times in a month | Rarely (few times in a year) |
|---|---|---|---|---|
| Category A: Able Bodied (<60 years) % | 75.68 | 17.57 | 4.05 | 2.70 |
| Category B: Senior Citizen and/ or Differently Abled % | 50.98 | 29.41 | 11.76 | 7.84 |

**Figure 12.** Frequency pattern of going out of respective house among different user groups (Source: Author).

After determining their frequency pattern of going out of their house, the authors questioned respondents about their purpose of going out. The options provided were (a) professional/academic, (b) medical reasons, (c) social gathering, (d) availing government benefits (such as health cards), and (e) daily household work. The respondents could choose all the options that were applicable. Figure 13 shows the options selected by both "Category A" and "Category B" in relation to their purpose of going out of respective houses. Both "Category A" (89.19% of them) and "Category B" (62.75% of them), mentioned "social gathering" as the most common reason for going out of the house. Respondents from "Category A" showed a higher share (75.68%) compared to "Category B" (47.06%), in going out of the house for professional or academic purposes. "Category B" showed a higher share (50.98%) compared to "Category A" (13.51%) in medical-related outings. No respondent from "Category A" went out of the house for availing Government benefits (such as health cards). A remarkable 56.86% of "Category B" went out of the house for daily household works, in comparison to 60.81% of "Category A".

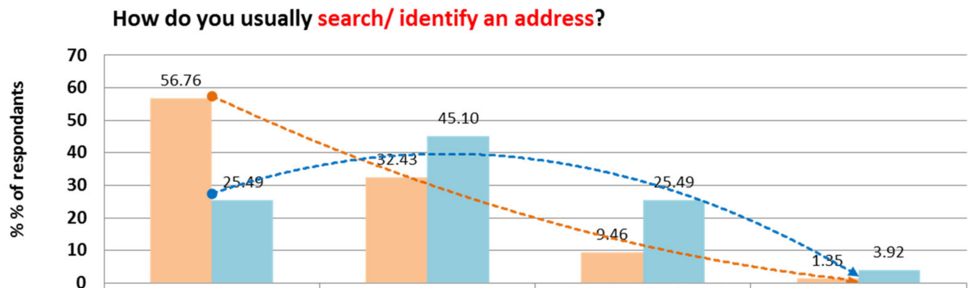
- Searching/identification of an address.

Next, the authors discussed street-level cognition with the respondents. The question was how the respondents usually search/identify an address. The options provided were (a) using online services such as Google maps, (b) asking people on the streets, (c) identifying landmark (such as the nearest junction or, old tree or, famous temple), and (d) referring to street signage. Although people in urban areas frequently use all the aforesaid options, the authors asked respondents to mention their most preferred option. Figure 14 shows the options selected by both "Category A" and "Category B" in relation to their preferred options while searching/identifying an address. The majority of respondents from "Category A" (56.76%) preferred "online services" to identify/search an address. In response, the majority of respondents from "Category B" (45.10%) choose "asking people on the streets". Respondents from both the categories showed noticeably less dependence on referring street signage, with 1.35% of respondents from Category A and 3.92% of respondents from Category B. More respondents from "Category B" (25.49%) preferred "Identifying landmark (such as the nearest junction or, old tree or, famous temple)" as their means to identify an address, in comparison to only 9.46% of respondents from "Category A".




| | Profession/ Education | Medical Reasons | Social Gathering | Avail Government Benefits (like health card, etc) | Daily Household work |
|---|---|---|---|---|---|
| Category A: Able Bodied (<60 years) % | 75.68 | 13.51 | 89.19 | 0.00 | 60.81 |
| Category B: Senior Citizen and/ or Differently Abled % | 47.06 | 50.98 | 62.75 | 7.84 | 56.86 |

**Figure 13.** Purpose of going out of the house among different user groups (Source: Author).




| | Using online services like Google maps, etc | Asking people on the street | Identifying landmark (like nearest junction, old tree, famous temple, etc.) | Referring Street Signage |
|---|---|---|---|---|
| Category A: Able Bodied (<60 years) % | 56.76 | 32.43 | 9.46 | 1.35 |
| Category B: Senior Citizen and/ or Differently Abled % | 25.49 | 45.10 | 25.49 | 3.92 |

**Figure 14.** Preference in the identification of an address (Source: Author).

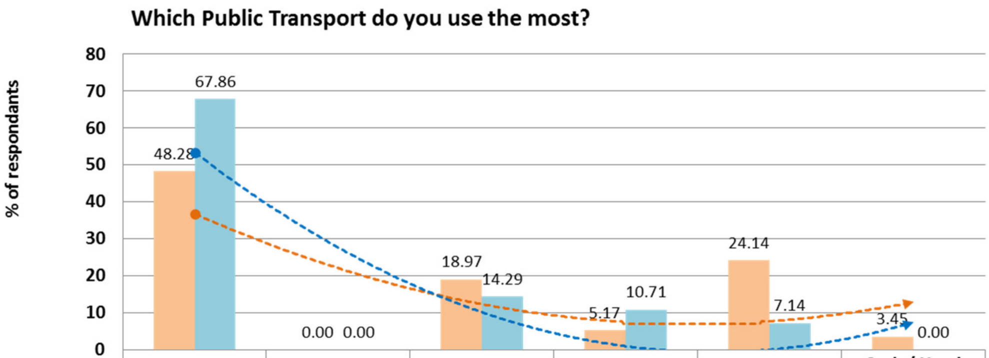
- Public Transportation.

The perception of people in public transportation was the next topic of investigation. For this purpose, respondents from both "Category A" and "Category B" were primarily asked if they use public transport. If the respondents did not use public transport on a daily basis, frequent or periodic usages were also taken into consideration for data input. A total of 54.90% of the respondents from "Category B" used public transport, in contrast to 78.38% of respondents from "Category A". The respondents from both categories who do not use public transports are either having their own mode of transport (such as four-wheeler or two-wheeler), or having designated vehicle from their place of work, or are dependent on rental cab services, for example, Uber, Ola, and Rapido).

Thus, for further study on the topic of public transportation, the authors considered only 78.38% from "Category A", i.e., 58 respondents, and 54.90% from "Category B", i.e., 28 respondents.

The authors asked these respondents about their comfort level in using public transportation. A Likert scale approach was undertaken for this purpose and respondents rated their comfort level on a scale of one to ten. Score one signified lowest comfort and score ten signified most comfort. The weighted mean score is 5.39 for "Category B" in comparison to 6.17 for "Category A".

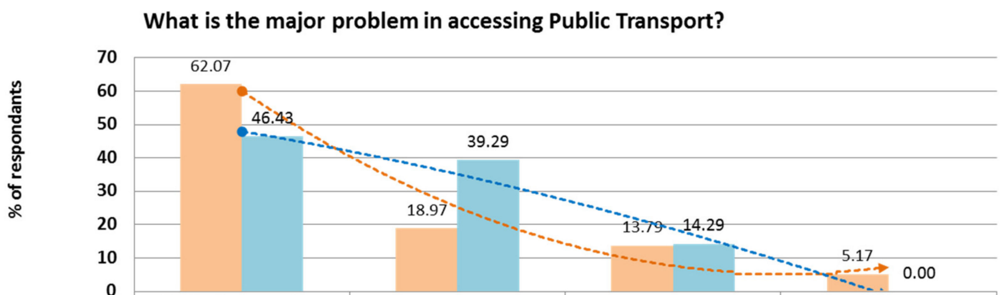
The next question was about modal preference. The authors asked these respondents for specifying which mode of public transport in their city the respondents often used. The options provided were (a) bus, (b) tram, (c) metro rail, (d) local train, (e) auto rickshaw, and (f) cycle/hand-pulled rickshaw. Kolkata having a multiplicity of transport mode and a well-connected transportation network encourages its residents for using multiple modes in a single origin-destination route. However, the authors asked respondents to mention the mode which they used most. Figure 15 shows the options selected by both "Category A" and "Category B" in relation to their most preferred public transportation mode. Respondents from both "Category A" (48.28% of respondents) and "Category B" (67.86% of respondents) mentioned Bus as their most preferred mode of public transportation. Tramway, often referred to as the heritage of Kolkata, was not given any preference by either category of respondents. Preference of Metro Rail was comparatively similar in "Category A" with 18.97% of the respondents and "Category B" with 14.29%. However, 10.71% of respondents from "Category B" preferred local train, in comparison to only 5.17% of respondents from "Category A". A total of 24.14% of respondents from "Category A" and 7.14% of respondents from "Category B" preferred auto-rickshaw, respectively. Although 3.45% of respondents from "Category A" choose Cycle/Hand-pulled rickshaw as their preferred mode of public transport, none of the respondents from "Category B" opted for this.




| | Bus | Tram | Metro Rail | Local Train | Auto Rickshaw | Cycle/ Hand Pulled Rickshaw |
|---|---|---|---|---|---|---|
| Category A: Able Bodied (<60 years) % | 48.28 | 0.00 | 18.97 | 5.17 | 24.14 | 3.45 |
| Category B: Senior Citizen and/ or Differently Abled % | 67.86 | 0.00 | 14.29 | 10.71 | 7.14 | 0.00 |

**Figure 15.** Preference in the usage of transportation mode (Source: Author).

The last question in the category of public transportation was identifying the problem in accessing public transportation, by individual respondents. For this question, the authors asked the respondents for choosing any one option from the following, as their major problem in accessing public transportation: (a) difficulty in the waiting facility (a poorly designed bus stop or, improper visual notification), (b) reaching public transport from home, (c) any other (such as congestion or, misbehavior by co-passengers), and (d) fare. Figure 16 shows the options selected by both "Category A" and "Category B" in relation to their major problem in accessing public transport. The majority of respondents from both "Category A" (62.07%) and "Category B" (46.43%), stated "Difficulty in the waiting facility (such as a poorly designed bus stop or, improper visual notification)," as their major problem in accessing public transport. The second preference for respondents from both categories (Category A: 18.97%; Category B: 39.29%) was the issue of "reaching the public transportation from individual homes". Relatively similar share both the categories, 13.79% respondents from Category A and 14.29% from Category B, selected "Any other (such as congestion or, misbehavior by co-passengers)". Although 5.17% of the respondents from Category A mentioned "Fare" as their reluctance towards accessing public transport, no respondents from Category B choose this option.




| | Difficulty in waiting facility (like: bus stop, improper visual notification, etc) | Reaching the Public Transport from home | Any other (like: Congestion, Improper Crowd, etc.) | Fare |
|---|---|---|---|---|
| Category A: Able Bodied (<60 years) % | 62.07 | 18.97 | 13.79 | 5.17 |
| Category B: Senior Citizen and/ or Differently Abled % | 46.43 | 39.29 | 14.29 | 0.00 |

**Figure 16.** Difficulty in accessing public transportation (Source: Author).

- Walkability

After acquiring ideas about public transportation, the authors investigated "walkability" from all 125 respondents (74 from Category A and 51 from Category B). Only 74.51% of the respondents from Category B walk/access the streets, in comparison to 93.24% of able-bodied people. The people who do not walk are the ones with a constant source of a private vehicle, having medical issues, or are dependent on others for their transportation. For the next question, the authors considered only that 93.24% from "Category A", i.e., 69 respondents, and 74.51% from "Category B", i.e., 38 respondents.

The next inquiry in the walkability segment was related to the respondents' comfort level during walking on the streets. Using a Likert scale approach, the respondents rated their walkability experience on a scale of one to ten. Score one signifying lowest comfort and score ten signifying most comfort. The weighted mean score is 4.92 for "Category B" and 5.0 for "Category A".

- Awareness about National Schemes.

The authors asked all the 125 respondents about their awareness about the existing national policies/initiatives related to accessibility and Universal Design, the latest of which being "Accessible India Campaign" or "Sugamya Bharat Abhiyan". A total of 92.16% of the respondents from Category B were not aware about the "Accessible India Campaign", in comparison to 85.14% of able-bodied people.

### 3.2.2. Findings and Discussion

The data collected by interviewing 125 people from forty wards of KMC helped in assessing people's perspective in the domain of Universal Mobility. The term "Universal Mobility" was not used during the interview; however, the authors posed the questions in a strategic pattern for assessing the scope of Universal Mobility. The four sets of inquiries as discussed in Section 3.2.1 portray an overall negative picture in the domain of mobility. Table 4 shows a summary of findings from the responses recorded by the authors during this survey.

**Table 4.** Learning from the interview sessions in Kolkata, India between July and November 2020 for substantiating the aim of the research (Source: Author).

| S.No | Topic | Learning |
|---|---|---|
| 1 | Frequency and purpose of going out | • Health-related issues outside the preview of "registered" disabilities need recognition for availing health benefits. In any case, people with disabilities/senior citizen venture out daily. The rates of going out daily in able-bodied are more than those of their counterparts.<br>• Senior citizens/differently-abled people have a higher rate of social gatherings than other purposes, hinting towards a need of promoting "sociable streets and public environment" which is in coherence with the United Nations Sustainable Development Goals.<br>• Since old cities usually contain all the types of building use (as per occupancy), mobility corridors require equal or equivalent importance. |
| 2 | Searching/ identification of an address | • The affinity of senior citizens/differently-abled people to rely on "asking people on the streets", is hinting towards the need for inclusive streets which not only enables but empower them as well.<br>• The need for improving street signage (visual and auditory).<br>• The domain of "online search" in terms of Google Maps can be improved by adding "accessibility" layer prepared by Architectural Planning only.<br>• In spite of being developed on the British planning principle, the lack of "landmarks" shows the complexity in the urbanscapes, which can be addressed by introducing street elements as new icons of the urbanscape. |
| 3 | Walkability | • Dissatisfaction with the use of public transport is due to (1) poor provision from state/central governments in the field of urban transportation and/or (2) better services from private players, for example, Uber, Ola, and Rapido.<br>• The major transport mode is "Bus" and multiple locations are present for the bus to halt briefly. However, "bus stop" or "bus shelter" was scantily present. Clearly, the survey explains the need for prioritizing bus-related accessible infrastructure before developing any other modes.<br>• The proposal for developing "Urban Accessibility Facility" can be prioritized in the topic of improving the "waiting facility" for bus.<br>• The target for architects and planners should be facilitating the waiting time and emergency requirements especially for elderly and differently-abled.<br>• The reason for the underutilization of Para-transits can be dealt with in a separate survey. |
| 4 | Awareness about National Schemes | • A large percentage of walkability in spite of dissatisfactory pedestrian facilities proves that in developing countries, infrastructure is less considerable than daily need.<br>• When people commute in spite of poor infrastructure, the marginalized users are compromised.<br>• Relating to the fact that people are unaware of national policies and unknown about the scopes of better design, the motto of this research is "To create a market for the design, rather than designing for the market". |

### *3.3. Visual Observation of an Old City Core*

Taking indications from the survey involving 125 people from Kolkata, a stretch located within the core of Kolkata was selected by the authors for further investigation. The focus of this exercise was assessing the Universal Mobility conditions in the old core of Indian cities. A visual survey for the selected stretch was conducted in the month of September and November 2020. The selected stretch is a part of Bipin Behari Ganguly Street (Google Map link: https://goo.gl/maps/ph8wWJWiCzY1TgEH8 (accessed on 1 March 2021). In the Master Plan of Kolkata, the land use for this area is demarcated as "Mixed Use" [40]. It is to be noted that mixed land use refers to the co-existence of more than one land use on a single stretch; for example, residential and industrial buildings in a single street. Mixed-use also refers to the presence of multiple "single buildings" with different building use on different floors.

The selected stretch is observed in multiple old cartographic evidences of Kolkata since 1785 CE, as shown in Figure 17.

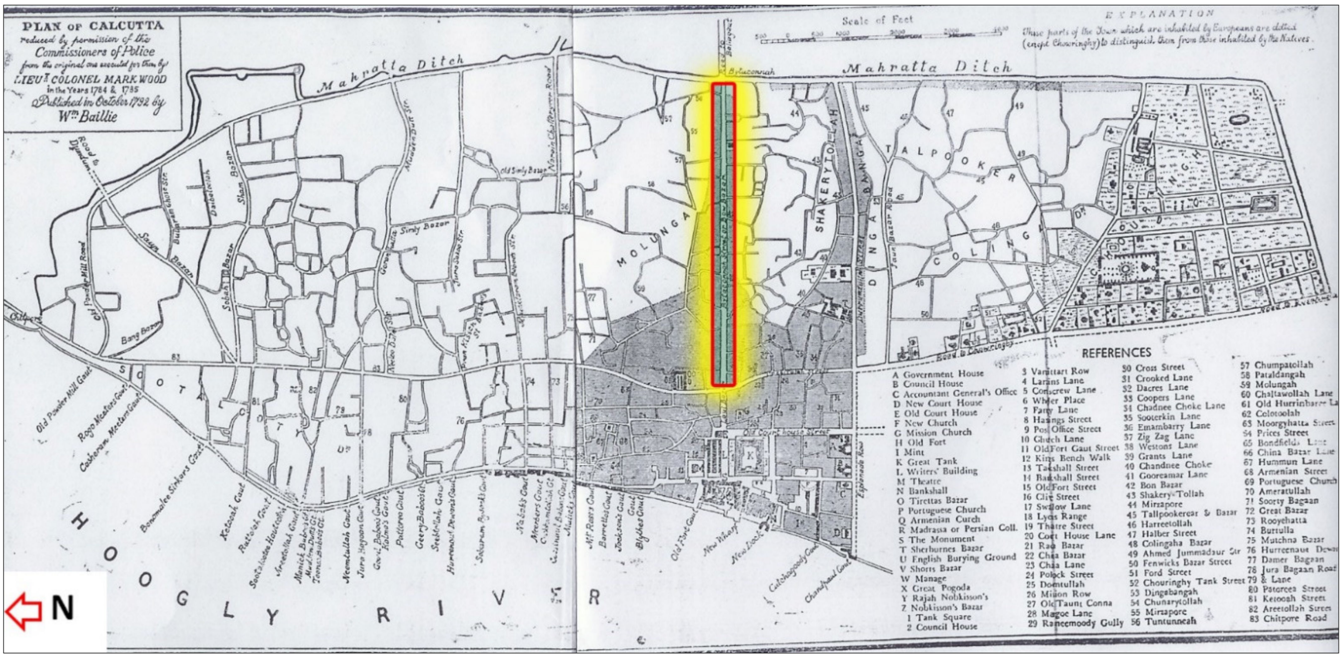



**Figure 17.** Map of Kolkata (Calcutta) by Lt. Col. Mark Wood in 1785; the study stretch selected for the visual survey is demarcated is highlighted. (Source: Harvard Library Online).

3.3.1. Visual Survey

The authors selected a part of the 300-year-old stretch (shown in Figure 17) for the visual survey. This stretch has undergone minimum temporal change due to its historic nature. The stretch is further shown in Figure 18, where "A" and "B" are starting and ending point of the study stretch, respectively. Point A is Bowbazar Crossing and Point B is Bentinck Street Crossing.

In the policy document for "Accessible India Campaign", the component of "Transportation System Accessibility" has the objectives of enhancing proportions of (a) accessible airports, (b) railway stations, and (c) public transport. The part of Kolkata, which is being proposed for the Research, does not have an airport, however, there is a Railway Station and multiple Underground Metro Rail Stations. Further, there are multiple modes of other transport available here, including (a) tramways, (b) bus, (c) auto, (d) hand-pulled rickshaw, and (c) taxi/cab. In the city land-use master plan, this area of Kolkata is demarcated as mixed land use zone. The stretch predominantly consists of buildings with multiple uses, mostly residential buildings clubbed with business/commercial establishments. However, buildings with institutional, educational, assembly, mercantile, and storage uses were also present. Moreover, a substantial number of buildings in this stretch were heritage buildings [refer to Figure 19].

Multiplicity in building use causes heavy pedestrian footfall throughout the day in this stretch. Thus, this stretch serves as a suitable location for a visual survey for the assessment of mobility conditions in an old Indian city. A social worker (named Mr. Akash Das) from Kolkata assisted the authors in identifying issues from a local perspective. The photographs taken during the visual survey were later interpreted at the Laboratory of Architectural Planning, Hokkaido University. Figures 20–30 illustrates how the stretch is unfavorable for Universal Mobility.

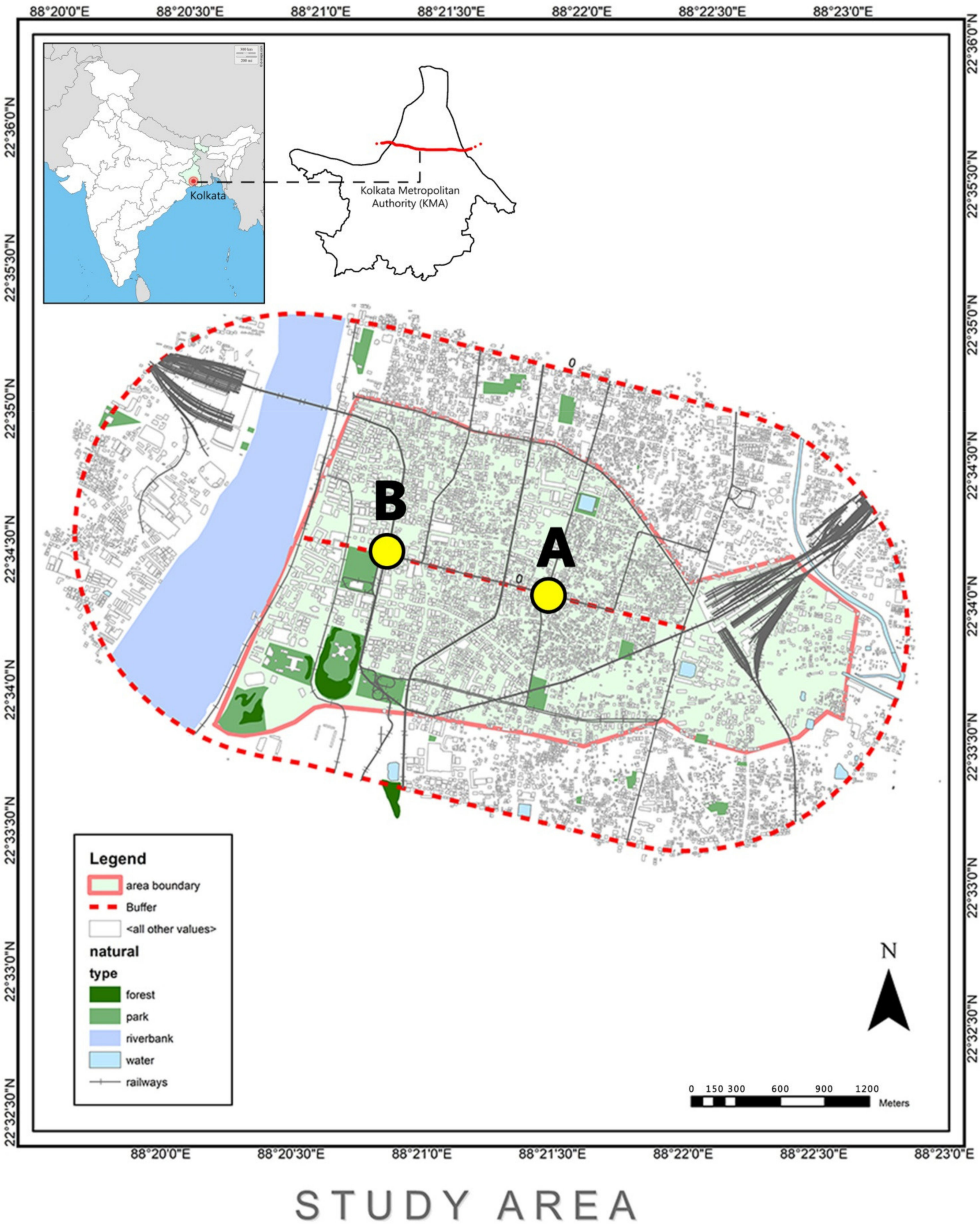



**Figure 18.** The location for the visual survey (between point A and B); map prepared in ARC-GIS (Source: Author).

**Figure 19.** Mercantile Building (center) built in the early 1900s: an example of built heritage (Source: Author).


**Figure 20.** A cobbler occupying a footpath stretch along the external wall of Bowbazar Post Office (Source: Author).


**Figure 21.** The shop on the left of the picture is using their products for display, on the pedestrian space (Source: Author).


**Figure 22.** Homeless people sleeping on the streets (right) and also at the unused entrance of Gate 4 of Central Metro (Source: Author).

**Figure 23.** Open public bath still in operation at Bentinck Street, also capturing a part of the footpath as well as disturbing the vehicular stretch (Source: Author).


**Figure 24.** Almost 500-year-old temple "Firinghi Kali Bari": a place where primarily Hindus gather during prayer (Source: Author).


**Figure 25.** A bus stop between Central Avenue Crossing and Bow Street having bedding of homeless people stored above the seating area (Source: Author).

**Figure 26.** Railing near Gangadhar Babu Lane used by vendors as an edge for their storage (Source: Author).

**Figure 27.** Entrance to Bibi Rozio Lane, showing poor kerb and drainage conditions (Source: Author).


**Figure 28.** Informal parking of private and commercial vehicles consumes at least 25% of the available pedestrian space in Kenderdine Lane. Residents use extended plinths from heritage buildings as shaded seating space. (Source: Author).

**Figure 29.** At The entrance of Phears Lane during evening peak hour, a multiplicity of transport modes, absence of signals and, improper pedestrian facilities creates a chaotic environment. (Source: Author).


**Figure 30.** Poor lighting conditions in a stretch between New Bowbazar Lane and Kenderdine Lane (Source: Author).

3.3.2. Observation and Analysis

The distance between Point A and Point B (as shown in Figure 18) is 850 m, and it takes about fourteen minutes for an able-bodied person for covering the distance. The stretch is oriented in North-East to South-West direction and has eighteen junctions of different scale; based on the (a) width of the streets converging in the junction, (b) height of the buildings along the streets, and (c) predominant type of activities). The surveyed locations are Nirmal Chandra Dey Street, New Bowbazar lane, Kenderdine Lane, Central Avenue (GATE 4_Yogayog Bhawan), Central Metro (GATE 1_Indian Airlines), Bow Street, Metcalfe Street, Bentick Street, Rabindra Sarani Rd., Chatawalla Gully, Phears Bye Lane, Phears Lane, Giri Babu lane, Central Metro (GATE 2_Lalbazar), Central Avenue (GATE 3_RITES), Gangadhar Babu lane, Bibi Rozio Lane, and College Street. The authors conducted observational walks along this stretch and captured the photographs. The authors recorded observations at various intervals of the day at: (a) 1300 h, when school finishes, (b) 1800 h when offices close for the day, and (c) 2100 h when commercial establishments shut down for the day. The observations made by the authors are explained hereafter.

Unorganized informal vending and encroachment by existing establishments occupied nearly every street [refer to Figures 20 and 21, respectively]. Complemented by this, numerous beggar/homeless people were occupying a share of the pedestrian space (often near non-operating Metro rail gates) [refer to Figure 22]. Communal open baths, which were a scene from yesteryear, were also present in certain areas [refer to Figure 23]. A mix of Hindu, Muslim and Christian religious places were present in the stretch [refer to Figure 24]. In terms of transportation, the bus stops were in poor infrastructural condition [refer to Figure 25]. Informal vendors used the railings along the footpath for their personal use [refer to Figure 26]. Additionally, the kerb along the footpaths was in dilapidated condition [refer to Figure 27]. Informal parking was observed in almost the entire stretch [refer to Figure 28]. Lack of signals at crucial intersections created chaos, especially during peak hour traffic, as depicted in Figure 29. Poor functioning of street lights were observed at multiple locations such as the one photographed in Figure 30.

3.3.3. Findings and Discussion

The visual survey helped the authors in finding certain issues in basic mobility which requires thorough examination before interpreting Universal Mobility. Table 5 shows the observations from this visual survey. “Universal Mobility” can be interpreted for this stretch only after assessing minimum mobility standards. Thus, these observations are the first stage for apprehending the mobility issues in this stretch.

**Table 5.** Learning from the visual survey in Bipin Behari Ganguly Street in Central Kolkata, India between September and November 2020 to assess Universal Mobility conditions (Source: Author).

| S.No | Topic | Inference |
|---|---|---|
| 1 | Predominant building use | The mixed land use and multiplicity of usage in a single building creates a complex structure of users. A different activity such as educational, business and others create multiple “peak hour traffic” which the present infrastructure is not adequate to cater. |
| 2 | Heritage buildings | A large number of Heritage buildings fostered low temporal change and is also restricting alteration in the width of carriageways. Typical heritage buildings with no setback and footpaths are not segregated from the building entrances creates a pedestrian discomfort in this stretch. |
| 3 | Informal vending | Since the inception of this stretch, informal vending has been a characteristic feature. However, with increasing population and vehicular pressure, the informal vendors are presently a threat to mobility. |
| 4 | Encroachment | Encroachment is a policy failure. Illegally occupied spaces within footpath create severe problems during peak hours. |
| 5 | Beggar/homeless/child labour | Beggar/homeless/child labour is a social issue. Only socio-political intervention can facilitate the process of emptying the streets of these user groups. |
| 6 | Communal open bath | Communal open baths are obsolete in most parts of the city except central part of Kolkata. These communal open baths (often at the edge of footpath and street) serve as an important functional social infrastructure due to the presence of many daily wage workers and floating population. On the contrary, the baths are posing threat to mobility on both footpath and street. The common baths create an extra crowd and spilt water, both of which are threatening to the pedestrian environment. |
| 7 | Religious establishments | Being an organically developed area within historic core, Hindu, Muslim and Christian crowds are proportionately present. The “Firinghi Kali Bari” Temple and “St. Xavier’s Church” are examples of religious structures. The problems with these locations are their presence along the footpath and absence of alternative entry. So, during prayers hours, a conflict in pedestrian movement due to different user group at the same line of movement is observed. |
| 8 | Bus stop | The bus stops are in dilapidated condition and used by homeless people to store their belongings. Provision of information display is absent in bus stops; rather, the bus stops are used more for advertising purposes. A bus stop without facilities and improper information display is of seldom use in the 21st century. |
| 9 | Metro stations | The unused metro station gates are occupied by homeless people as their temporary shelter. These issues are to be solved at the policy and socio-political level. |
| 10 | Signalized intersections | Allocation of signals at intersections in this stretch was done decades ago in this stretch. The new zones of pedestrian and vehicular traffic have not been considered in the recent past. Due to different building use, the volume of traffic is varying. The concept of allocating signals based on road width might not be suitable for this area. Rather, signals based on traffic volume and predominant building uses are apt for this stretch. |
| 11 | Railing | Informal vendors occupied the railings in most parts of the stretch. Neither a clear demarcation for the pedestrian and vehicular traffic, nor scope for elderly/differently-abled people who needs to hold the railing, is present. A clear edge is essential for an ideal streetscape. |
| 12 | Kerb | Kerb which essentially provides gradation in street-level mobility is in extremely dilapidated condition in this stretch. As a result, neither able-bodied pedestrians nor differently-abled people are able to move freely in the footpaths. The scenario worsens at night due to lack of adequate light. |
| 13 | Storm water drains | Storm water circulation in this part of Central Kolkata is better than most of the parts; however, the location of storm water drains are a matter of major concern. The location, grating style and the slope is dangerous for pedestrian, especially the ones with walking cane. |

**Table 5.** *Cont.*

| S.No | Topic | Inference |
|---|---|---|
| 14 | Signage | There was no directional signage in the entire stretch. Public utilities are not demarcated. The historic buildings had their description engraved near the entrance. However, other places of public interest are not having any information. Thus, for people new to this area and people with cognitive issues, they face difficulty in traversing the stretch. |
| 15 | Public Toilet, Drinking water facilities, and resting facilities | Only one public toilet was observed in the entire stretch of 850 m in which visual observation was undertaken and no drinking water facility was present. Public facilities such as drinking water and public toilets complemented by street furniture are components of a healthy street. Mobility without public facilities is unreasonable in the urban scenario. |
| 16 | Trash Bins | According to the latest "Swachh Survekshan" programme or Clean India Campaign launched in 2016, Trash bins are to be placed at fifty meters interval along urban streets. However, in this stretch, hardly any trash bins were observed and as a result, a littering was observed. Clean streets promote increased mobility and should be taken care of. |
| 17 | Street Lights | In spite of the fact that street lights are present all throughout the stretch, the requisite lighting intensity was not present. When checked using the "Light meter" application, most of the streets showed a lux level of less than ten, which is not ideal for a safe pedestrian environment. The fact that this stretch experiences a heavy pedestrian footfall, poor lighting makes it even more vulnerable to users with cognitive difficulties. |

## 4. Major Findings

In this section, the arguments and discussions in this research are summarized by establishing the relationship between the "objectives" and "survey undertaken" by the authors.

### *4.1. Finding 01*

The first objective of this research paper (i.e., to ascertain the need for a new dimension in the Indian accessibility scenario) was substantiated through the first survey (as elaborated in Section 3.1) involving the design fraternity of India. Taking a cue from the first study about the focus area of accessibility in transportation, the next step was exploring the second objective (i.e., what is people's perception regarding mobility in an Indian old city?).

### *4.2. Finding 02*

The second objective of this research paper (i.e., to assess people's perspective towards Universal Mobility in core urban areas in India) was verified through the findings from the survey involving the residents of Kolkata (as elaborated in Section 3.2). Once this scenario was clear, the next steps were choosing a particular stretch in the old core of Kolkata and conducting a visual observation which would explain a part or whole of people's opinions regarding mobility in an Indian old city.

### *4.3. Finding 03*

The third objective of this research paper (i.e., to identify the issues in mobility in core urban areas in India) was advocated through the inferences from the visual survey of a stretch in the old core of Kolkata (as elaborated in Section 3.3). The observations and inferences through this visual survey indicated that mobility conditions are not in a positive state in this stretch. Basic infrastructural issues are in downtrodden conditions. Thus, re-imagining this stretch with Universal Mobility concerns is a difficult task altogether. In order to initiate the process of Universal Mobility features in this stretch, however, a need for further analysis of this stretch was necessary.

Thus, it is inferred that the reluctance of people in old cities towards walkability and usage of public transport is directly linked to the poor infrastructural conditions. The historic origin of the old core in Indian cities and their organic pattern of development generate a chaotic urban scenario. Presently, dissatisfactory levels of cognition at street level, which is not an ideal scenario for able-bodied and differently-abled alike, are persistent. Elderly people additionally face problems due to this dilapidated state.

## 5. Conclusions

In spite of a number of policies and programs related to accessibility at the national level, Indian old cities are often ignored. The reason for this phenomenon is largely the Indian Constitution. According to the Seventh Schedule (Article 246) of the Indian Constitution, "Land" is a state subject. It implies that a decision regarding urban development is a matter of individual state [41]. Thus maintaining coherence with national policies is a political choice for the Chief Minister of a state. Kolkata is located in the state of West Bengal and as of January 2021, the state-ruling electoral party (Trinamool Congress with Smt. Mamata Banerjee as the state's Chief Minister) is not in alliance with the central-level ruling party (Bharatiya Janata Party, with Shri. Narendra Modi as the country's Prime Minister). Thus, it was not unnatural when 92.16% of the respondents from elderly/differently-abled and 85.14% of able-bodied people responded during the survey that they have not heard about the Accessible India Campaign.

Thus, identifying a custom-made access audit format specifically for a particular stretch shall be beneficial for the old core cities, in terms of its practical applicability by avoiding political complications. At the same time, it will also serve an altered guideline for old cities, rather than the generic national guideline. A total of 63% of respondents from the architecture fraternity during the survey mentioned the same suggestion.

As responsible professionals in the field of Architecture and Planning, the authors are taking part in the movement of creating a built environment "For All". Built environment "For All" takes into attention the needs of able-bodied as well as elderly/differently-abled people. The role of the Laboratory of Architectural Planning, Hokkaido University under the supervision of Professor Dr. Mori and Associate Professor Dr. Nomura is specifically noteworthy in this discussion. This laboratory focuses on "planning architecture" based on "practical problem interest". One of the research themes of this laboratory is "research on the ideal living environments for minorities", with a sub-theme titled "Environment design that realizes safe and comfortable going out for the physically vulnerable". This enabled the authors to conduct this research in this laboratory. Moreover, the focus of this laboratory is also in coherence with Goal Number 11 of United Nations Sustainable Development Goals (UN-SDG). The title of the goal "Sustainable cities and communities" mentions the need to provide (a) access to safe, affordable, accessible, and sustainable transport systems for all and to (b) improve road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons. This goal indicates the need for Universal Design and Universal Mobility, in a global society. In 2020, Hokkaido University collaborated with twenty-seven other Japanese Universities for participation in United Nations University "Sustainable Development Goals University Platform" (SDG-UP). This platform established by the UN-University-Institute for the Advanced Study of Sustainability (UNU-IAS) emphasizes global development in sustainable terms. Thus, "Laboratory of Architectural Planning" can prove an essential resource body in assessing the Universal Mobility conditions in old core cities by aligning its research interest with global concerns in the field of Universal Design.

Capacity building and research on Universal Design is an effective tool for creating global awareness about the need of Universal Design in Architecture and Planning [42]. Along similar lines, the Ministry of Housing and Urban Affairs, Government of India, in collaboration with- IIT (Indian Institute of Technology) Roorkee, NIUA (National Institute of Urban Affairs) and AIILSG (All India Institute of Local Self Governance), has launched an initiative titled BASIIC (Building Accessible, Safe, and Inclusive Indian Cities). Functionally started in 2020, the BASIIC project is supported by the DFID (Department for International Development, now known as FCDO or Foreign, Commonwealth and Development Office fund of the UK government. This project aims towards framing disabled-friendly guidelines and policy recommendations that can be implemented through the already functioning Smart Cities Mission [43]. The major objectives of the project include (a) training and capacity building of government officials and (b) sensitizing citizens of India about the importance of Universal Design. Eminent architects and planners are engaged by NIUA and AIILSG in this project, from the initial stage of preparing posters for Universal Design awareness until final preparation of the course modules. The first author is presently engaged as the content curator and one of the module development experts for this project. Unlike previous projects of Government of India, BASIIC project focuses on the concept of spreading awareness on Universal Design through education and research. Thus, in the coming years, accessibility conditions might improve in urban areas of India.

The authors believe that sharing knowledge on Universal Design through research and interaction increases the possibility for an inclusive society. Such a society shall ensure the same standard to urban infrastructure for both able-bodied and differently-abled. However, capacity building alone cannot bring about a radical change in critical Universal Design thinking. Thus, the authors state that the findings for this paper are comparatively the beginning of a quest towards assessing accessibility in the core city areas in Indian context.

For further research in the same domain, a checklist-based assessment could be undertaken by interested researchers. This checklist, as mentioned in the aims for this paper, shall contain the factors for an ideal accessibility audit checklist which is to be used in old core Indian cities. Further research could be based on three distinct lines of action. The three lines of action are a) Universal Mobility features, b) cognitive factors, and c) traffic volume. The last survey in this research (as detailed in Section 3.3) titled "Visual Observation of an Old City Core" which was undertaken in Bipin Behari Ganguly Street in Kolkata surfaced issues related to the infrastructural conditions in old core cities in India [Refer to Figures 19–30]. First, based on these issues, an in-depth analysis of each street and footpath stretches (space between the junction of a street and another) could be conducted for determining the infrastructural level in a quantitative manner. Second, the cognitive factors could be examined and thereby used for determining the linkage between five senses and pedestrian behavior. However, these two types of study will be incomplete if these studies are not correlated to the traffic volume. The traffic volume, consisting of pedestrian and vehicular volume shall help in assessing the level of service for the study stretch. Figure 31 illustrates the methodology that could be adopted for further study based on the findings of this paper. This further research based on the findings of this paper will foster the preparation of a rating system for Universal Mobility in the core of old Indian cities.

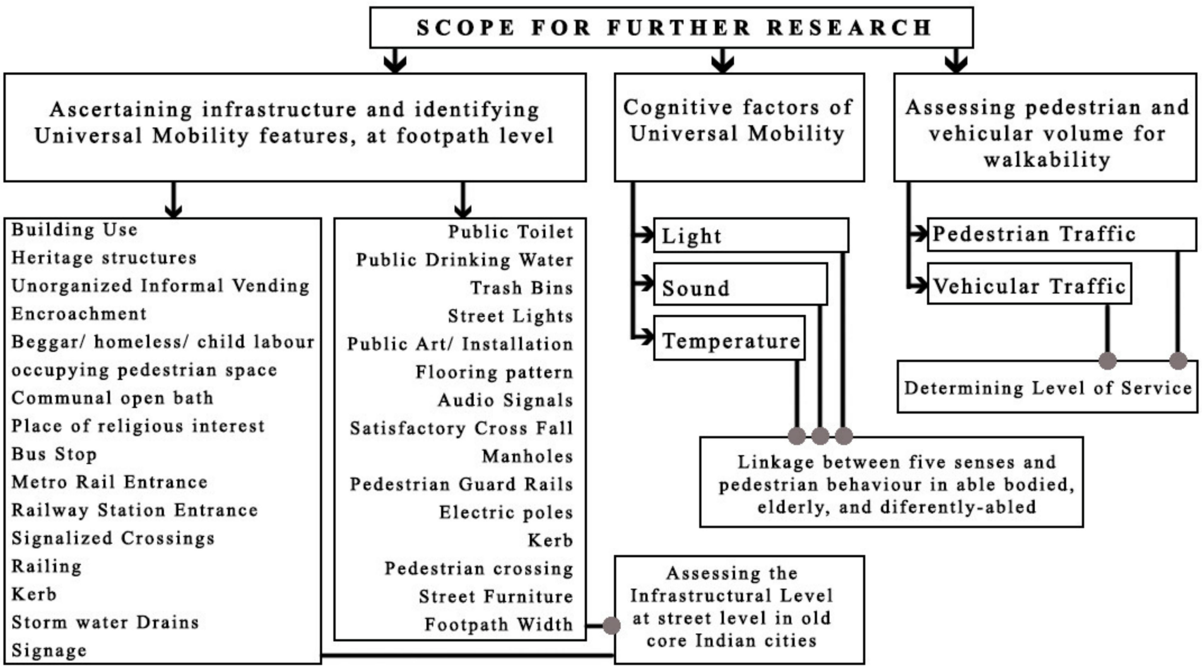



**Figure 31.** Methodology showing scope of further research based on the findings from this paper. (Source: Author).

Thus, the answer to the research question for this paper, i.e., "to find out whether core areas of urban India can be made inclusive in terms of accessibility" is "yes". Inclusivity can prevail in the old core of Indian cities provided a methodical approach towards Universal Mobility is practiced, as elaborated in this paper.

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## Appendix 3: 2nd Peer reviewed referred journal publication

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*Original Paper*

# Evaluating the accessibility of old cities: Case of Central Kolkata, India

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**Abstract**

**Old Indian cities are often less accessible due to temporal restrictions and ever-rising pedestrian volume. In this research, the accessibility of the footpath-level walkability condition of old core cities has been assessed through Architectural Planning Research, considering 32 footpath stretches in Central Kolkata, India, as a case. The research has considered 3 data sets, (a) 257 experts' opinions about universal mobility, (b) 18 variables for assessing accessibility conditions, and (c) peak hour pedestrian volume. IBM® SPSS® Statistics 26.0 version has been used to validate the findings of the research. It was found that mixed-use buildings demarcate the edge of the footpaths in old cities. 50.6% of Indian experts have prioritized the "dimension of the footpath" while assessing universal mobility for pedestrians in the old cities of India. The average accessibility percentage for the entire surveyed stretch is negative which highlights the poor accessibility of the stretch. Pearson's correlation between footpath width and infrastructure score of 0.535 signifies the width of a footpath plays a significant role in determining the level of footpath infrastructure. Thus, the findings of this research can be used while preparing accessibility development plans for the study area and other areas of a similar genre. In this research, the accessibility of the footpath-level walkability condition of old core cities has been assessed through Architectural Planning Research, considering Central Kolkata, India, as a case. The findings of this research prove the relationship between footpath width and the footpath infrastructure.**

**Keywords**
accessibility, accessibility audit, Central Kolkata, universal mobility, walkability

## 1. Introduction

Historically, amidst iconic placemaking and timeless design, architects and planners have not been able to integrate the entire user group holistically. More specifically, the elderly, specially-abled, and women have never been inclusively dealt with in our history.[1] A recent example is the case of the Constitution Bridge on the Grand Canal in Venice, where the Architect Santiago Calatrava was fined seventy-two thousand pounds in 2019 for not creating a citizen-friendly design.[2] Along similar lines, Goldsmith's "Universal Design Pyramid" model is an attempt to break away from the stereotyping of the "ideal" user group, which design professionals often misinterpret.[3] Thus, the generic "successful" designs (especially Community-level projects) are often deemed misfits when evaluated multidimensionally from the perspective of universal design (hereafter, referred to as UD), with accessibility being a major component.[4]

Accessibility, in this case, may be defined as the one which enables people (including specially-abled and elderly) to use, access, and understand a facility/space without any hindrance. India needs contextual approaches to improve the liveability and quality of life in its cities, primarily through universal design at the pedestrian level.[5,6] Before rapid industrialization, old Indian cities were essentially walkable and pedestrian-friendly.[7] However, post-independence, rapid urbanization drives often ignored the importance of the pedestrian environment on Indian roads, especially along with mixed-use buildings despite numerous guidelines.[8] Researchers have identified the following reasons behind the low success of Indian disability guidelines in a spatial context: (a) diversity in urban structures (like higher density in old cities compared to new planned cities), (b) autonomy of state governments in land-related issues, (c) lack of national-level data related to disability, and (d) non-recognition of the elderly and situationally disabled in the policy level considerations.[9]

Among numerous domains of universal design like "Building level factors," "Information and Communication segment," "Movement and Transportation Issues," and "Site Level features," the topic of "Movement and Transportation Issues" has been dealt with major focus in this research. "Movement and Transportation Issues" are prioritized since individual building facilities alone cannot create universally designed cities unless those buildings are connected through a "Universally Designed" movement corridor. The aforementioned "Universally Designed" movement corridor is also referred to as universal mobility in technical terms. This research attempts to assess walkability for ensuring universal mobility in historical city centres and then verifies the model in a case area. Thus, the paper leads to policy-related intervention, unlike the usual design-oriented approaches in the domain of accessibility. Thirty-two footpath stretches in the core of Kolkata (within Kolkata Municipal Corporation limits), India, have been selected as a case area for this research.

It is to be mentioned that the context of "mobility" used in this research refers to the mobility of all users including the specially-abled and elderly people. This is mainly because the authors are in favor of universal mobility (which considers the need of diverse user groups) rather than the traditional barrier-free approach (which focuses on the disabled).

## 2. Literature Study

Gregg and Hess argue about the contextual analysis of public policies related to street-level research. The understanding of a complete (ideal) street is based on the components that the street has or might be induced, not necessarily based on a generic guideline. Dividing the case area into multiple segments helps to understand the components of "time and rhythm" in public space.[10] Identifying the functionality associated with each sub-section of a relatively long stretch of street, and classifying individual infrastructural needs based on this hierarchy is an alternative way of analyzing urban mobility.[11] Taking a cue from this, the authors have divided the study stretch into smaller spatial fragments (shown later in Section 4, Figure 3) for survey purposes.

Martire emphasizes connecting urban history with the street genre and street pattern. The transformation of the urban fabric concerning temporal change is an essential consideration in architectural planning for urban mobility.[12] Along similar lines, according to the theory of Natural Movement (Space Syntax), the urban spatial structure influences the movement pattern.[13] Mahdzar suggests empirical observation of pedestrian activities before mapping the surveyed stretch.[14] Identical research also mentions the categorization of physical elements of analysis into (1) Buildings, (2) Streets, and (3) Land use. Similarly, to assess the universality of space, it should be analyzed from the perspective of element spaces.[15] The authors have incorporated these learnings while framing the parameters for the survey in this research.

Through observational audit and strategic mapping, the macro- and micro-elements (and attributes) of a street can be assessed.[16] To correctly assess the situation, accessibility audits in different parts of the same region must foster a tailor-made or site-specific recommendation for accessibility audits.[17] However, the technically apt methodology to impart urban-level accessibility is to develop a framework for "level of service" based on parameters (and their respective indicators) that influence universal mobility. The parameters (and their respective indicators) should be evaluated through an objective scoring/ranking/rating system, which in turn can be determined by a pilot survey. Besides these, the identification of essential/critical parameters (and their respective indicators) whose presence ensures universal mobility and vice-versa is also recommended.[18] In this research paper, the authors identify weak parameters in the case area and their respective position or ranking among other parameters.

Mobility in pedestrian areas (footpaths) in core cities includes parameters like (1) Traffic factors (like car parking), (2) Geometry/Environmental/Footpath factors (like, pavement conditions), and (3) Pedestrian Movement factors (like pedestrian volume).[19] Story and Mueller indicates the need for explicit consideration of parameters for pedestrian-focused universal mobility solutions, like (1) Footpath Gradient, (2) Tactile Surface Ground Indicators (TGSIs), (3) Gratings, (4) Kerb (curb) Ramp, (5) Signage, and (6) Public Art. They also identify indicators for each parameter in the form of key design features; for example, one of the indicators for the parameter "Gradient" is cross fall <1:40.[20] Several meso-level and micro-level dimensions of the built environment, like (1) Land Use and Diversity, (2) Accessibility, (3) Street Connectivity, (4) Safety and Security, (5) Pedestrian facilities, (6) Comfort, and (7) Streetscape Design, have a substantial influence on urban walkability.[21] Most of the factors thus discussed in this discussion are included as parameters in the survey format used for this research.

Mahapatra et al. in their paper "Universal Mobility in Old Core Cities of India: People's Perception" used "Critical Instance" Case Study-type research for a similar genre of research, suggesting that there is a need for framing a new assessment framework for assessing the scope of universal mobility in old Indian cities. Along similar lines, deteriorated mobility conditions pose a threat to people with functional and cognitive limitations, including elderly people. Furthermore, research of this genre requires a specific approach toward the site context and thus cannot be conducted using generic research methods (from the familiar methods of research design). The research design for this research has considered: the Literature Study, previous research by the authors, and the historical context of the study area.

## 3. Case Area

The old city core selected for this research is in Kolkata, which is the capital of the state of West Bengal in India. The urban form in this part of Kolkata is complex due to its long history, high density, and decaying urban core. Furthermore, in comparison with India's density of 382 people per square kilometer, Kolkata has a density of over 24 300 people per square kilometer.[22] Kolkata was the capital of British India until 1911.[23] The old (central) part of Kolkata, which has traditionally been the administrative, commercial, and educational hub, has been historically associated with congestion and unhealthy living conditions.[24] Presently, the Kolkata Municipal Corporation (established in 1876) is currently responsible for the administration of the delineated case area. The case area selected for this research spans nearly 850 m and is aligned in a North-East to South-West direction. The footpath (pedestrian area) on both sides of the case area is the specifically surveyed stretch. Since the inception of Kolkata in the late 17th century, this case area has been the center of multiple activities and associated traffic loads. The temporal change of this area (especially the "right of way" or "R.O.W.") has not been proportional to the increase in population as well as associated activities. The population of Kolkata in 1911 was 896 067 in comparison with 4 496 694 as per the 2011 census. However, the average density of Kolkata (Municipal limits) in 1913 was approximately 26 500 people per square kilometer, in comparison with 24 252 (as per the 2011 census). The case area for this research is shown in Figure 1A–C.

The case area selected for this research is further subdivided into thirty-two stretches (explained elaborately in Section 4.2

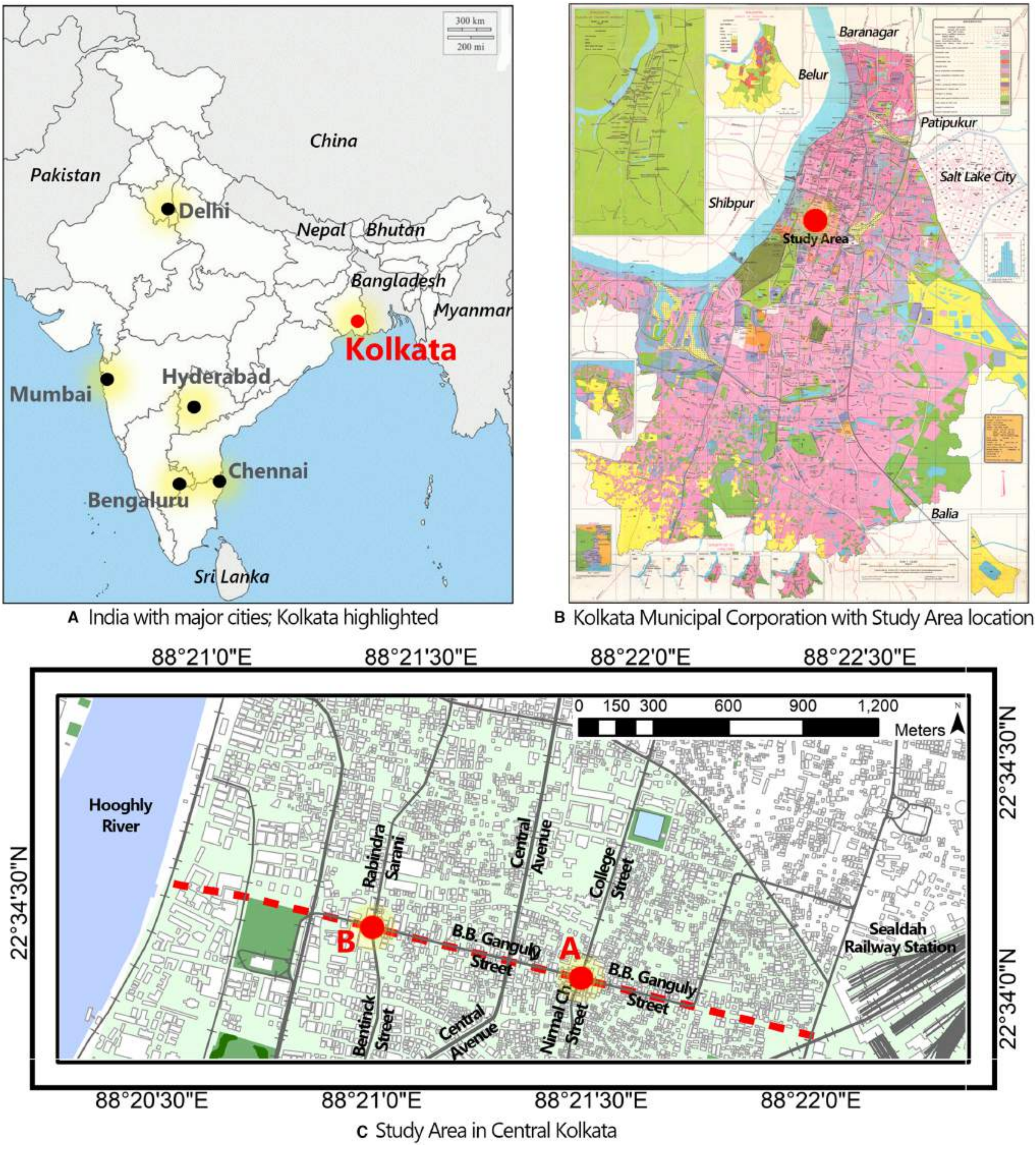


**FIGURE 1.** (A-C) The research area chosen for this study. In Figure C, the case area is demarcated with Point A at one end and Point B on the other side. The stretch is about 850 m in length, oriented in the Northeast–Southwest direction; and has a walking time of about 15 min for able-bodied people. *Source* for Fig. A: Author; *Source* for Fig. B: P. Nag (2010). City of Calcutta and its Environs (3rd Edition). Kolkata: National Atlas and Thematic Mapping Organization; *Source* for Fig. C: Author, using Geographic Information System

of this paper to strengthen the specificity of the research). The stretches are comprised of (1) Arterial Streets and (2) Footpath stretches between two adjacent arterial streets. Apart from these stretches, there are three major junctions that this stretch surpasses: Bowbazar Crossing, Central Avenue Crossing, and Bentinck Street Crossing. The entire study area has a predominance of mixed-use buildings (Refer to Figure 2).

In all the thirty-two stretches delineated for survey in this research, the presence of Residential and Business building use is observed. Buildings with Mercantile building use are present in 71.88% (23 nos.) of the stretches. Subsequently, in 50% (16 nos.) of the stretches, Institutional building use is observed. Other building uses in the thirty-two stretches are as follows: (a) Educational—12.50% (4 nos.), (b) Assembly—6.25% (2 nos.), and (c) Industrial and Storage—3.13% (1 no.). Hazardous Building Use is not observed in any of the stretches. The presence of different building uses in the case area is shown in Figure 2.

The understanding of the building use in the study area is important for this research since the "Indian Road Congress Guidelines for Pedestrian Facilities" specify an ideal footpath width based on the predominant adjacent building use.[25] Since all the footpath stretches have the presence of mixed types of building usage, the minimum footpath width should be 2500 mm. Thus, understanding the adjacent building's use is one of the primary considerations of the research methodology for this paper. In relation to this, research work in a similar case area, titled "Interpreting Universal Mobility in the Footpaths of Urban India Based on Experts' Opinion," has concluded that the greatest problem in walkability is as follows: (1) Lack of proper footpath—for able-bodied people, and (2) Encroachment by Vendors—for specially abled people.[26] Also, visual observations by the authors reflect that the present condition of the case area is not adequate for pedestrians, and the issue of universal mobility seems like a daunting task.

## 4. Data and Methods

The hypothesis considered by the authors states that the footpaths in the old core areas of Kolkata are poor in terms of universal mobility standards. Furthermore, there is a need to frame a new assessment framework for universal mobility for these old Indian cities, since the usual (generic) factors of walkability have no/negligible influence on the pedestrian volume in these areas. The inquiry mode for this research is "Structured." In structured research methods, the analysis is dependent on the type of data collected. The three types of surveys conducted are mentioned below:

### 4.1 Expert opinion

To understand the opinion of experts about universal design and universal mobility conditions in their city, 257 Indian experts from the fields of Architecture and Planning were surveyed. Among the 257 participants, 10.12% (26 nos.) were professors, 8.56% (22 nos.) were associate professors, 22.18% (57 nos.) were assistant professors, 22.57% (58 nos.) were practising Architects, 10.51% (27 nos.) were practising Planners, 8.17% (21 nos.) were Ph.D. Scholars in Architecture/Planning, and 4.67% (12 nos.) were government officials. The remaining 13.23% (34 nos.) were from professions other than the ones mentioned. Furthermore, the respondents were from 20 states (out of 28) and one union territory (out of eight) in India. An online Google form questionnaire was used for this survey that continued from August 17, 2021, till October 4, 2021. The questionnaire is available at https://forms.gle/kqpFSkvyEDdUdvVHA (accessed on February 22, 2023). The respondents were asked to mark any of the five most important factors while assessing universal mobility for pedestrians in the Old Cities of India from the following factors: (1) Building Typology of Stretch, (2) Footpath Dimensions, (3) Temporary Encroachment, (4) Permanent Encroachment, (5) Bus Stop, (6) Metro Rail Entrance, (7) Railings, (8) Storm Water Drains, (9) Public Toilet, (10) Trash Bins, (11) Street Lights, (12) Flooring, (13) Manholes, (14) Kerb (curb), (15) Pedestrian Crossing, (16) Street Furniture, (17) Safety and Security (surveillance and fire-safety oriented), and (18) Additional Inclusive Features. The most important factor while assessing universal mobility for pedestrians in the old cities of India, according to the experts, was the key result of this survey which is later elaborated on in Section 5.1 of this paper.

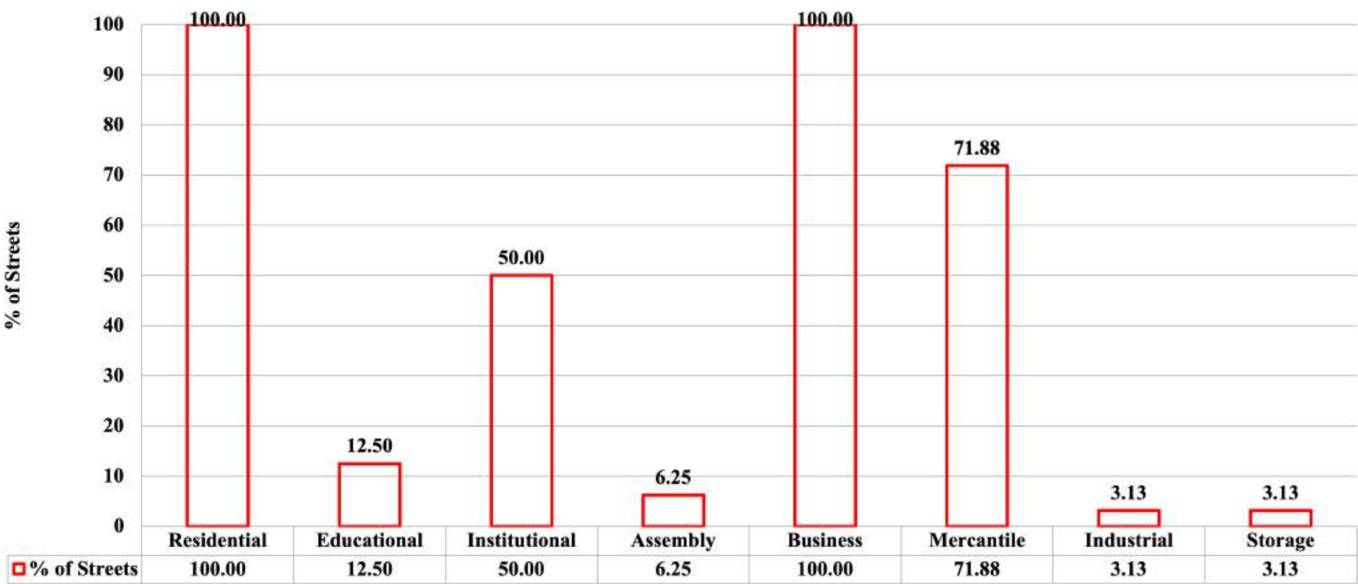


**FIGURE 2.** Percentage of streets with various building uses in the selected case area. *Source*: Author

### 4.2 Infrastructure mapping

Consequently, an "Infrastructural Conditions mapping" was conducted in the case area, which was further subdivided into thirty-two stretches. For mapping "Infrastructural Conditions" for this research, field surveys were conducted between August 1, 2020, and September 2, 2020. The surveys were conducted with the help of some local people (students and professionals) who were acquainted with the surveyed study area. The details of the local people who helped the authors are duly mentioned in the acknowledgement section. Figure 3 indicates the locations selected for the survey using the variables considered.

The "Infrastructural Conditions mapping" segment is composed of eighteen categorical variables. These variables are derived from the study of various projects, guidelines, and research in the field of a similar genre as this research, most of which are elaborated on in the literature study section of this paper. These variables are the metrics that should are used to evaluate pedestrian accessibility in the project area.

These categorical variables (considered as "Criteria" during the survey and analysis hereafter) are as follows: (1) Building Typology of Stretch, (2) Footpath Dimensions, (3) Temporary Encroachment, (4) Permanent Encroachment, (5) Bus Stop, (6) Metro Rail Entrance, (7) Railings, (8) Storm Water Drains, (9) Public Toilet, (10) Trash Bins, (11) Street Lights, (12) Flooring, (13) Manholes, (14) Kerb (curb), (15) Pedestrian Crossing, (16) Street Furniture, (17) Safety and Security (surveillance and fire-safety oriented), and (18) Additional Inclusive Features. These criteria are further subdivided into respective sub-criteria (fifty in total). This sub-criteria can be further grouped into two types of variables: Independent and Dependent.

As an example, let us consider one of the categorical variables (criteria) "Public Toilets," whose associated sub-criteria are (1) The presence of a Public Toilet and (2) Functional Public Toilet. In this example, the first sub-criteria "Presence of a Public Toilet" are independent of any factor which means whether a public toilet is present or absent is the decisive factor in the assessment. However, the second sub-criteria, that is, "Functional" condition of the public toilet can be assessed only if the public toilet is present at all. It means, if the public toilet is not present in the first place, then the functionality of the public toilet cannot be assessed at all. So, this sub-criterion is dependent on the previous sub-criteria. Since the sub-criterion "Presence of Public Toilet" is an independent variable, and "Functional Public Toilet" is a dependent variable, their weightage would be different.

The subsequent survey format for understanding "Infrastructural Conditions" (through primary observation) was framed based on these criteria and sub-criteria. Post-survey, the observations were further analyzed using a scoring pattern. The sub-criteria were scored based on their associated variable type (independent or dependent). The presence of a sub-criterion is scored as "+0.50" if the associated variable is an Independent Variable. Along similar lines, a sub-criterion is scored as "+0.25" if the associated variable is a dependent variable. Similarly, the absence of a sub-criterion is scored as "−0.50" for independent variables and "−0.25" for dependent variables, respectively. Thus, weighting is used for further analysis.[27] Since each sub-criterion is essential for a stretch to qualify as a Universally Designed space, the sub-criterion is given equal weightage, that is, +0.50 for the independent variable and +0.25 for the dependent variable.

For any study stretch surveyed using this framework, the consolidated highest score can be 20 (and subsequently, the lowest can be −20). It is to be noted that although all these variables are not equally important for pedestrian activity, the negative impact of any one of them could lead to inadequate

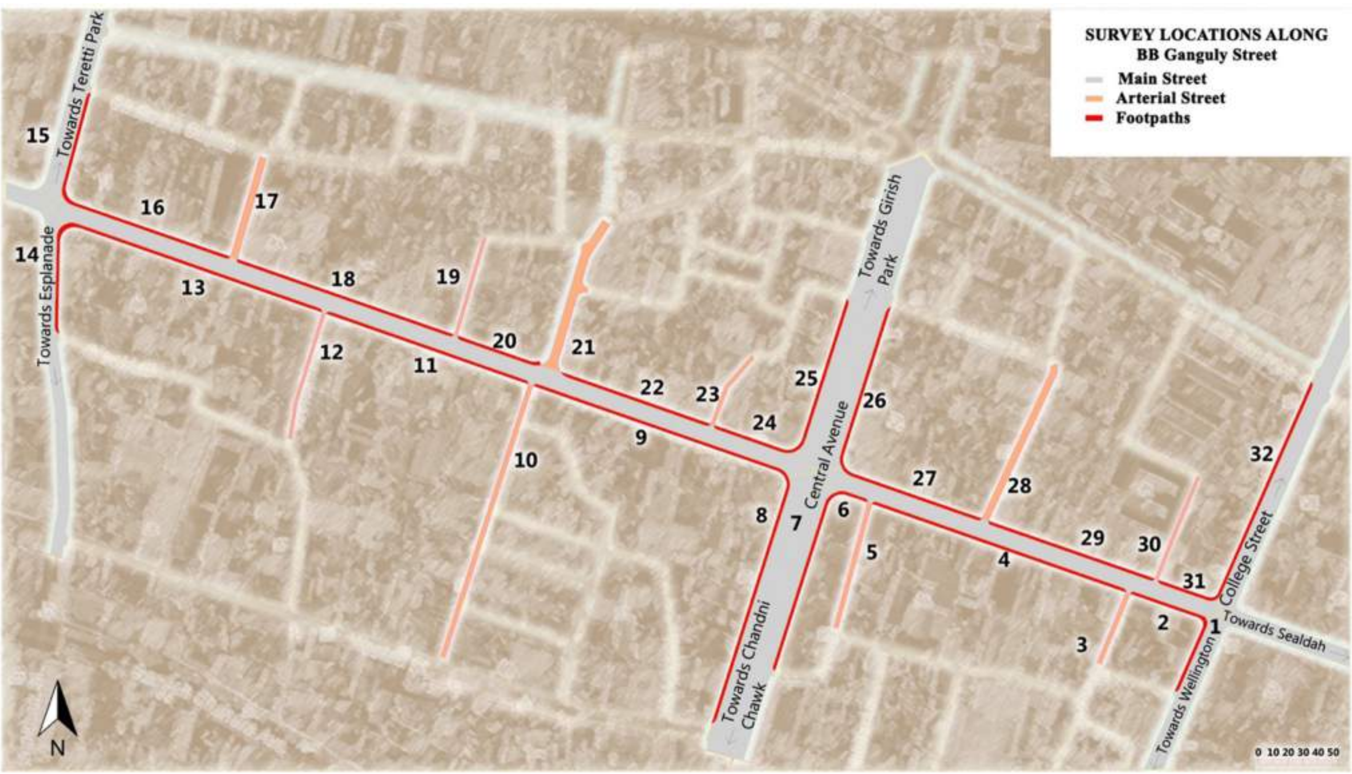


**FIGURE 3.** Survey locations (1–32). *Source*: Google Map overlayed by the author

**TABLE 1. Variables (criteria and sub-criteria), types of variables (independent/dependent), scoring logic, and the individual scores**

| Criteria | | Sub-criteria | | | | Individual associated score | |
|---|---|---|---|---|---|---|---|
| S. No | Details | S. No | Details | Variable type | Scoring logic | If yes | If no |
| A | Building typology of stretch | 1 | Buildings that are having "two or more" building uses within a single building | Independent | Beneficial if absent | +0.50 | −0.50 |
| | | 2 | Heritage/historic buildings | Independent | Beneficial if absent | +0.50 | −0.50 |
| B | Footpath dimension | 3 | Footpath width > 2500 mm | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 4 | Unobstructed width of 1800 mm | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 5 | Unobstructed clear height of 2200 mm | Independent | Beneficial if present | +0.50 | −0.50 |
| C | Temporary encroachment | 6 | Unorganized informal vendors functional during day/night | Independent | Beneficial if absent | +0.50 | −0.50 |
| | | 7 | Unorganized informal vendors/hawkers away from the line of pedestrian flow (if vendors are present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| | | 8 | Beggar/homeless/child labor occupying a part of the footpath as their homes | Independent | Beneficial if absent | +0.50 | −0.50 |
| D | Permanent encroachment | 9 | Place of religious interest (temple/churches/mosque) within or along the footpath? | Independent | Beneficial if absent | +0.50 | −0.50 |
| | | 10 | "Encroachment" by existing establishments on to the footpath | Independent | Beneficial if absent | +0.50 | −0.50 |
| | | 11 | "Communal open bath" within or along the footpath | Independent | Beneficial if absent | +0.50 | −0.50 |
| E | Bus stop | 12 | Informal stoppage for bus | Independent | Beneficial if absent | +0.50 | −0.50 |
| | | 13 | Bus shelter (if bus stops) | Dependent | Beneficial if present | +0.25 | −0.25 |
| | | 14 | Is "bus shelter" functional (if bus shelter is present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| F | Metro rail entrance | 15 | Entrance connected to the footpath | Independent | Beneficial if absent | +0.50 | −0.50 |
| | | 16 | Is the entrance functional (if metro rail entrance is present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| G | Railings | 17 | Railings (pedestrian guard rails) on the edge of the footpath | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 18 | Thorough railings with minimum 1500 mm height and clear visibility (if railings are present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| H | Storm water drains | 19 | Storm water drains along footpath | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 20 | Functional storm water drains (if storm water drains are present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| I | Public toilet (restroom) | 21 | Public toilet within the footpath | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 22 | Functional public toilet (if public toilet is present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| J | Trash bins | 23 | Trash bins within the footpath | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 24 | Functional trash bins (if trash bins are present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| | | 25 | Trash bins located away from the line of pedestrian flow (if trash bins present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| K | Streetlights | 26 | Streetlights within the footpath | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 27 | Functional street lights (if street lights are present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| | | 28 | Light poles away from pedestrian flow or if present, is demarcated with a tactile marking of a minimum 600 mm around it (if street lights are present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| L | Flooring | 29 | Satisfactory cross fall (i.e., <1:50) | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 30 | Tactile Marking | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 31 | Anti-skid/matt finish tiles in footpath and Kerb (curb) | Independent | Beneficial if present | +0.50 | −0.50 |

**Table 1. (Continued)**

| Criteria | | Sub-criteria | | | | Individual associated score | |
|---|---|---|---|---|---|---|---|
| S. No | Details | S. No | Details | Variable type | Scoring logic | If yes | If no |
| M | Manholes | 32 | Manholes within/along the footpath | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 33 | Drain type' manholes flushed with the pavement surface (if manholes are present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| | | 34 | Grating' type manholes sited away from the pedestrian walkway (if manholes are present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| N | Kerb (curb) | 35 | Kerb (curb) on the edge of footpath | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 36 | Kerb (curb) height of not more than 150 mm from the road level (if Kerb (curb) is present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| | | 37 | Minimum 1200 mm width and tactile warning (if Kerb/curb) is present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| | | 38 | Corned Kerb (curb) radius more than 6 m (if Kerb/curb) is present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| O | Pedestrian crossing | 39 | "At-grade" pedestrian crossing (mid-block crossing) at all intersections along the walkway | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 40 | Signalized intersection (if crossing is present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| | | 41 | Functional signalized intersection (if crossing is present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| | | 42 | Audio signal (if crossing is present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| P | Street furniture | 43 | Street furniture in the footpath | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 44 | Street furniture having a knee clearance of a minimum of 700 mm and wheelchair space of 1000 mm (if street furniture is present) | Dependent | Beneficial if present | +0.25 | −0.25 |
| Q | Safety and security | 45 | Fire hydrant | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 46 | Security camera | Independent | Beneficial if present | +0.50 | −0.50 |
| R | Additional inclusive features | 47 | Signage | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 48 | Bicycle track | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 49 | Public drinking water facility | Independent | Beneficial if present | +0.50 | −0.50 |
| | | 50 | Street art | Independent | Beneficial if present | +0.50 | −0.50 |
| | | | Maximum total score | | | +20 | −20 |

*Source*: Author.

universal mobility standards. Table 1 elaborately shows the Variables (Criteria and Sub-criteria), Types of Variables (Independent/Dependent), Scoring Logic, and Individual Scores for all 18 categorical variables used in this research.

Each of the thirty-two stretches in the delineated case area within Central Kolkata was surveyed based on the above methodological framework using the "Online Google Form" type survey format. The type of questionnaire used is the "Dichotomous Close-Ended" type. The Google Form is available online at https://forms.gle/1f8HxXE62WM6GpWc6 (accessed on February 22, 2023). Quantitative scores associated with each footpath stretch in the case area were the key outcome of this survey.

### 4.3 Pedestrian mapping

Furthermore, the peak-hour (15-min interval) Pedestrian Volume Data were recorded three times in 2020 (on 25.10.2020, 14.10.2020, and 02.11.2020) and once in 2021 (on 24.09.2021). On each of the days, the data were recorded twice a day—at the Morning Peak Hour (9:00 a.m.–11:00 am) and the Evening Peak Hour (6 p.m.–7 p.m.). Arithmetic means of the morning and evening peak hour pedestrian volume readings for each footpath stretch in the case area were the key takeaways from this survey.

### 4.4 Methodology

Thus, the key takeaways from the three aforesaid surveys are as follows:

a The most important factor while assessing universal mobility for pedestrians in the old cities of India,
b Quantitative scores associated with each footpath stretch in the case area, and,
c Arithmetic Means of the morning and evening peak hour pedestrian volume readings for each footpath stretch in the case area.

Finally, these three data points were correlated using Pearson's Correlation with a 95% confidence interval. The methodology is further summarized diagrammatically in Figure 4.

## 5. Results Achieved

This section of the paper initially elaborates on the details of the surveys that were conducted and then emphasizes the results that were deduced.

### 5.1 Expert opinion

The 257 experts were asked to assign the most important factors of universal mobility among a pool of 18 factors. Mr. Subhasish, a practising architect from Kolkata, mentioned that footpath width in Central Kolkata has always been a challenge to pedestrians since the width of the footpath is fixed despite the rise in the number of activities and vehicular traffic. Dr. Kshama Puntambekar, a professor from the School of Planning and Architecture (SPA-B) and co-author of the book "Reinterpreting Urban Fabric in Cities with Living Heritage – A Case of Central Kolkata" identifies the impact of poor footpath dimension as the reason behind multiple other factors which creates unsuitable pedestrian quality in central Kolkata. Architect Shriya Banerjee, a Ph.D. Scholars from the Indian Institute of Technology (IIT-KGP) stated that the historic organic development of the city is a major obstacle to re-designing the footpath which in turn influences the age-old problem of encroachment at the footpath-level. Architect Shreya Ghosh Dastidar an officer from the Public Works Department of the Government of West Bengal highlights the critically poor conditions of footpaths in Central Kolkata and the critical footpath-level conditions despite which pedestrians commute every day along this area in Central Kolkata. In summary, the experts prioritized the following 5 factors as the most important factors while assessing universal mobility for pedestrians in the old cities of India: Dimension of the Footpath, Temporary Encroachment, Permanent Encroachment, Transport Stops, and Pedestrian Crossings. Furthermore, 50.6% of the respondents mentioned Footpath Dimension as the first option among the five prioritized factors. Thus, this factor was used for the correlation at a later stage in this research.

### 5.2 Infrastructure survey

This section elaborates on each criterion and sub-criterion. The pictorial representation is shown in Figure 5 as well.

Among the thirty-two stretches selected for the survey, 100% of them bear the presence of buildings having "two or more" building uses within a single building. The building's use ranges from (a) Residential, (b) Educational, (c) Institutional, (d) Assembly, (e) Business, (f) Mercantile, (g) Industrial, (h) Storage, and (g) Hazardous. In addition to this, heritage structures are present in 84.4% (27 nos.) of the stretch.

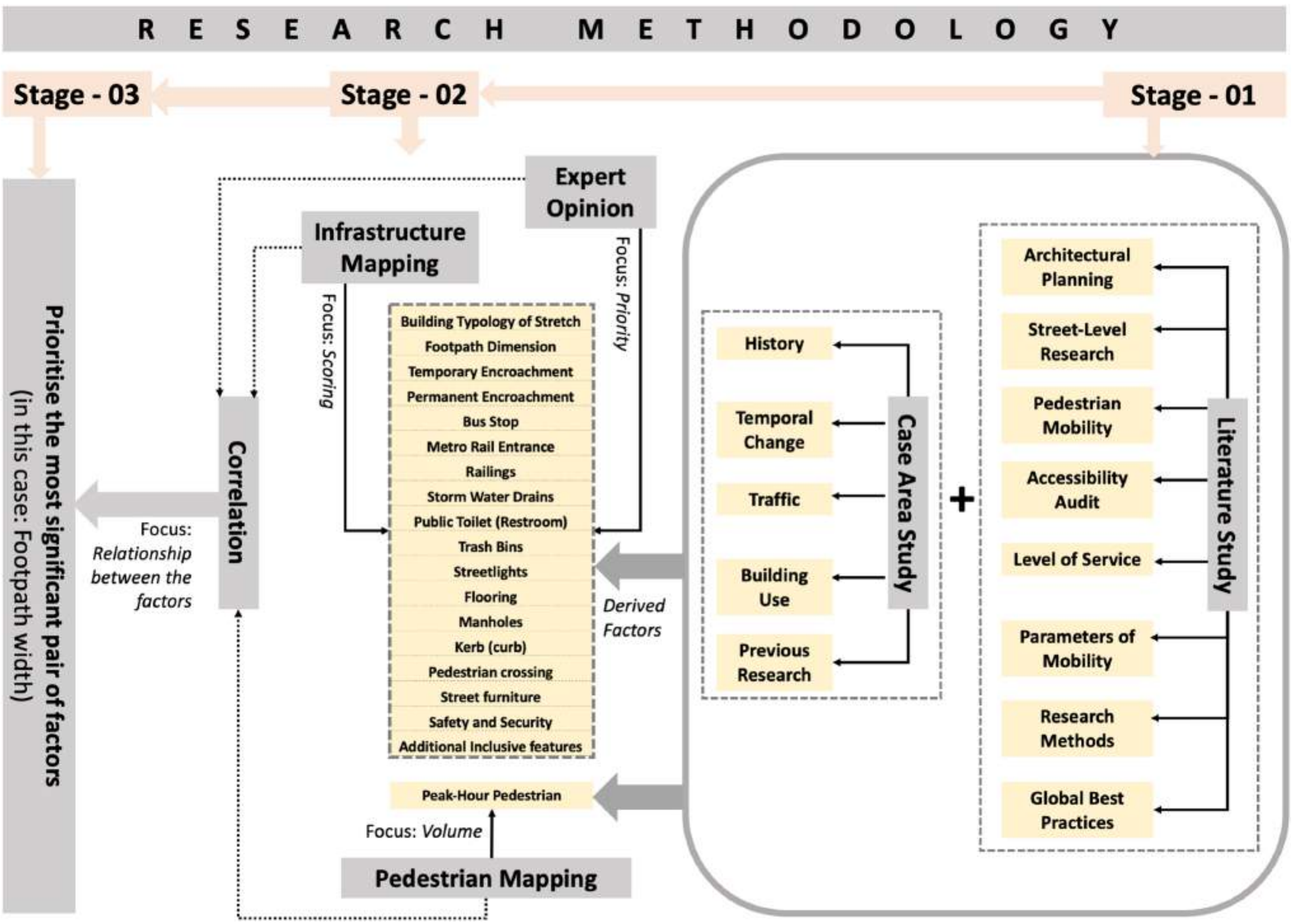


FIGURE 4. Research methodology. *Source*: Author

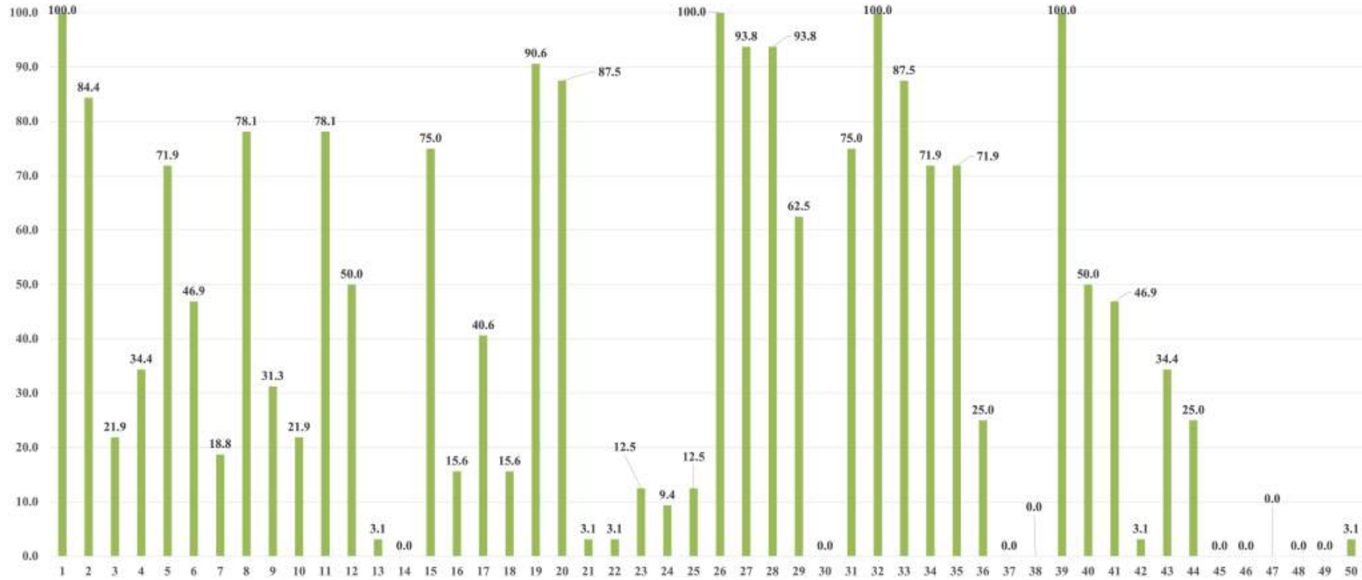


**FIGURE 5.** Percentage of the presence of the 50 sub-criteria for the total study area. *Source*: Author, 2021

Based on the adjacent predominant "commercial/mixed" land-use (as per IRC-2012) in the surveyed stretch, the ideal width of the footpath should have been 2500 mm. The ideal footpath width is not just for a section of the footpath, but for the entire stretch. Moreover, since the pedestrian stretches are adjacent to the buildings, a "Dead Width" of 500 mm should be present over and above the 2500 mm.[25] However, among the thirty-two surveyed stretches, 78.1% (25 nos.) of them had a width of <2500 mm. 65.6% (21 nos.) among the thirty-two surveyed stretches do not have an unobstructed width of 1800 mm. However, in 71.9% (23 no.) of the surveyed stretch, there is an unobstructed clear height of 2200 mm (refer to Figure 6).

Unorganized Informal Vending is observed in 46.9% (17 nos.) of the thirty-two stretches that were surveyed. However, Informal vendors/hawkers are away from the line of pedestrian flow in 18.8% (6 nos.) of the surveyed stretches. Beggar, and/or Homeless people, and/or Child Labour can be found in 21.9% (7 nos.) of the entire surveyed stretch (refer to Figure 7).

Places of religious interest are present in 68.8% (22 nos.) of the surveyed stretches. The eminent ones are "Saint Francis Xavier" Church, "Firingi Kali Bari" Temple, "Sri Sri Ghanteshwar Mahadev" Temple, and "Carey Baptist" Church. 78.1% (25 nos.) of the surveyed stretch was encroached on by existing establishments. In 21.9% (7 nos.) of the surveyed stretch, Communal Open Baths are present and functional (refer to Figure 8).

Among the thirty-two surveyed stretches, public buses stop informally at 50% (16 nos.) during various times of the day. However, only 3.1% (1 no.) have a bus stop, and that one is not functioning according to standard Indian design standards.

"Central Metro" is the corresponding Metro Rail/Subway station in the surveyed stretch. The four gates of Central Metro are present in the stretch: (a) Gate 1-Indian Airlines, (b) Gate 2-Lalbazar, (c) Gate 3-RITES, and (d) Gate 4-Yogayog Bhawan. Concerning that, 25% (8 nos.) stretches have the presence of a Metro Rail Entrance at least at one end of the stretch. However, Metro Rail entrances in working conditions are observed in 15.6% (5 nos.) of the eight stretches.


**FIGURE 6.** Footpath obstruction. *Source*: Author, 2021

Railings are present along 40.6% (13 of the thirty-two surveyed stretches) of the surveyed stretches. There are thorough pedestrian guard rails (with a minimum height of 1500 mm) and clear visibility at 15.6% (5 no.) of the thirty-two surveyed stretches (refer to Figure 9).


**FIGURE 7.** People who are homeless. *Source*: Author, 2021

**FIGURE 8.** Open public bath. *Source*: Author, 2021

Among the surveyed thirty-two stretches, Storm Water Drains are present in 90.6% (29 nos.). Except in one stretch, Storm Water Drains are working at 87.50% (28 nos.).

Only one (3.13%) Public Toilet is present in the surveyed stretch, and it is in working condition.

Trash Bins are present in 12.5% (4 nos.) of the surveyed stretches. Except in one stretch, Trash Bins are working in 9.4% (3 nos.) stretches. These municipal garbage bins are away from the line of pedestrian flow in 12.5% (4 nos.) of the surveyed stretch.

Streetlights are present in all thirty-two surveyed stretches. Except for two stretches, Street Lights are working at 93.8% (30 nos.). In 93.8% (30 nos.) of the surveyed stretches, the electric poles are neither placed away from the pedestrian flow nor demarcated with a tactile marking of a minimum of 600 mm around the poles (refer to Figure 10).

Satisfactory cross-fall (i.e., 1:50) is present in 62.5% (20 of the thirty-two surveyed stretches). In addition to this, tactile paving is not present in any of the surveyed stretches. 75% (24 nos.) of the thirty-two surveyed stretches do not have anti-skid/matt finish tiles on the footpath and Kerb (curb).

Although Manholes are present in each of the thirty-two surveyed stretches. The "drain type" manholes are flushed with the pavement surface in 87.5% (28 nos.). In 71.9% (23 nos.) of the thirty-two surveyed stretches, the "grating" type manholes are sited away from the respective pedestrian walkway.

**FIGURE 9.** Footpaths (and railings) are blocked by the encroachment. *Source*: Author, 2021


**FIGURE 10.** Streetlights inside footpath. *Source*: Author, 2021


**FIGURE 11.** Improper Kerb. *Source*: Author, 2021

In 71.9% (23 nos.), Kerb (curb) alongside surveyed stretches is observed. Among the thirty-two surveyed stretches, the Kerb (curb) is not at a height of more than 150 mm from the road in 75% (24 nos.). Additionally, the Kerb (curb) ramps present in the 32 stretches neither have a minimum width of 1200 mm nor have a tactile warning (refer to Figure 11). Concerning this, a cornered Kerb (curb) radius of more than 600 mm is also not present in the thirty-two surveyed stretches.

"At-grade" pedestrian crossing (MID-BLOCK crossing) at intersections along the walkway is present in all the thirty-two surveyed stretches since the delineation of survey stretches was made by fragmenting the footpath from one end of a street's entrance to the entrance of the next street. Signalized Crossings, on the contrary, are present in 50% (16 nos.) of the thirty-two surveyed stretches. Except in one stretch, Signalized Stretches are working at 46.89% (15 nos.). Audio Signals are not present in 96.9% (31 nos.) of the surveyed stretches.

In 34.4% (11 nos.) of the surveyed stretches, street furniture is present. Additionally, in 25% (8 nos.) of the stretches, the street furniture has knee clearance of a minimum of 700 mm and wheelchair space of 1000 mm.

Along similar lines, the stretches do not have Fire Hydrants or Security Cameras.

In all the thirty-two surveyed stretches, additional inclusive features like Street Signage, Bicycle Track, and Public Drinking Water facility are absent. However, Street Art is present in one (3.1%) of the surveyed stretch.

The total (cumulative) accessibility score of each footpath stretch is enlisted in Table 2.

Hereafter, the total accessibility score of the 32 survey locations concerning the 18 criteria (or, 50 sub-criteria) was used for the Cronbach's Alpha analysis of internal consistency using IBM® SPSS® Statistics 26.0 version. The Cronbach's Alpha for the dataset is 0.901, reflecting the highest order of internal consistency. Thus, it can be concluded that the overall accessibility condition of the footpaths is similar.

### 5.3 Pedestrian survey

On average (arithmetic mean value), the recorded Peak Hour (15-min interval) Pedestrian Count in the Study Area was 223 people in the morning and 201 people in the evening, respectively. The high pedestrian flow in the morning peak hour can be attributed to the presence of morning schools, offices, churches, and related informal vending during those hours. However, the flow is consistent during the evening due to the crowd returning from offices, shops, and informal vending too. Nearly 800 pedestrians (derived by multiplying the "Peak Hours 15-minute interval Pedestrian Count" by four) commute through the study area per hour (during peak hours). Thus, this part of Kolkata can be considered successful in terms of pedestrian traffic which fact makes the study interesting because the pedestrian traffic is predominantly able-bodied individuals. The debate which this research paper poses is how much improvement will happen if the needs of differently abled and/or elderly are implemented in the present infrastructural condition through universal accessibility.

## 6. Discussion

The thirty-two surveyed stretches were scored as per the methodology elaborated in Table 1. As per the explanation within Segment 4 (Research Design) of this paper and in Table 1, for any study stretch surveyed using the framework used for this research, the consolidated highest score can be twenty (and subsequently, the lowest can be −20). In relation to this, none of the thirty-two surveyed stretches in this research had a positive score. Thus, the hypothesis considered by the authors that the footpaths in the old core areas of Kolkata are poor in terms of universal mobility standards holds true.

Table 3 represents the surveyed stretches with their corresponding: Footpath width, Infrastructure score (represented in the percentage), and peak hour volume (average of morning

**TABLE 2. Framework for internal consistency**

| S. No | Surveyed stretch | Total accessibility score (maximum score is +20/ minimum score is −20) |
|---|---|---|
| 1 | Nirmal Chandra Dey street | −5.00 |
| 2 | Bowbazar crossing to New Bowbazar lane | −3.50 |
| 3 | New Bowbazar lane | 0.00 |
| 4 | New Bowbazar lane to Kenderdine lane | −7.50 |
| 5 | Kenderdine lane | −0.50 |
| 6 | Kenderdine lane to central avenue | −6.00 |
| 7 | Central avenue (GATE 4_Yogayog Bhawan) | −5.00 |
| 8 | Central metro (GATE 1_Indian Airlines) | −3.00 |
| 9 | Central avenue to Bow street | −3.00 |
| 10 | Bow street | 2.00 |
| 11 | Bow street to Metcalfe street | −3.00 |
| 12 | Metcalfe street | 0.00 |
| 13 | Metcalfe street to Bentinck street | −3.50 |
| 14 | Bentinck street | −5.50 |
| 15 | Rabindra Sarani road | −2.50 |
| 16 | Rabindra Sarani road to Chatawalla gully | −2.50 |
| 17 | Chatawalla gully | 0.00 |
| 18 | Chatawalla gully to Phears bye lane | −1.50 |
| 19 | Phears bye lane | −1.50 |
| 20 | Phears bye lane to Phears lane | −5.00 |
| 21 | Phears lane | 0.50 |
| 22 | Phears lane to Giri Babu lane | −2.50 |
| 23 | Giri Babu lane | −2.50 |
| 24 | Giri Babu lane to central avenue | −5.50 |
| 25 | Central metro (GATE 2_Lalbazar) | −2.50 |
| 26 | Central avenue (GATE 3_RITES) | −3.50 |
| 27 | Central avenue to Gangadhar Babu lane | −9.50 |
| 28 | Gangadhar Babu lane | −2.50 |
| 29 | Gangadhar Babu lane to Bibi Rozio lane | −9.50 |
| 30 | Bibi Rozio lane | −6.00 |
| 31 | Bibi Rozio lane to Bowbazar crossing | −2.00 |
| 32 | College street | −11.50 |

*Source*: Author.

and evening peak hours per 15 min). Footpath width (represented in mm) was measured physically during surveys of the footpaths. The infrastructure score (in %) is calculated by dividing the “total accessibility score of all 18 criteria (or, 50 sub-criteria) for each of the 32 stretches” by the maximum accessibility score (i.e., 20) and multiplying by 100. The peak hour volume (recorded on-site during the primary survey) is expressed as the average of the morning and evening peak hour pedestrian volume.

Finally, Pearson’s correlation with a 95% confidence interval was used to interpret whether there is any relationship between Footpath Width, Infrastructure Score, and Pedestrian Count (Peak Hour Volume). Table 4 shows Pearson’s correlation:

As observed in Table 4, a significant correlation exists between the footpath width and the infrastructural condition.

**TABLE 3. Stretch-wise data summary**

| S. No | Surveyed stretch | Footpath width (in mm) | Infrastructure score (in %) | Peak hour volume (average of morning and evening peak hours per 15 min) |
|---|---|---|---|---|
| 1 | Nirmal Chandra Dey street | 2100 | −25.00 | 178 |
| 2 | Bowbazar crossing to New Bowbazar lane | 2000 | −17.50 | 272 |
| 3 | New Bowbazar lane | 5000 | 0.00 | 245 |
| 4 | New Bowbazar lane to Kenderdine lane | 2000 | −37.50 | 198 |
| 5 | Kenderdine lane | 3000 | −2.50 | 210 |
| 6 | Kenderdine lane to central avenue | 2100 | −30.00 | 178 |
| 7 | Central avenue (GATE 4_Yogayog Bhawan) | 2100 | −25.00 | 99 |
| 8 | Central metro (GATE 1_Indian Airlines) | 2100 | −15.00 | 230 |
| 9 | Central avenue to bow street | 2000 | −15.00 | 303 |
| 10 | Bow street | 3800 | 10.00 | 312 |
| 11 | Bow street to Metcalfe street | 2000 | −15.00 | 273 |
| 12 | Metcalfe street | 3500 | 0.00 | 240 |
| 13 | Metcalfe street to Bentinck street | 2100 | −17.50 | 247 |
| 14 | Bentinck street | 2100 | −27.50 | 281 |
| 15 | Rabindra Sarani road | 1900 | −12.50 | 245 |
| 16 | Rabindra Sarani road to Chatawalla gully | 2100 | −12.50 | 266 |
| 17 | Chatawalla gully | 3500 | 0.00 | 254 |
| 18 | Chatawalla gully to Phears bye lane | 2000 | −7.50 | 259 |
| 19 | Phears bye lane | 2000 | −7.50 | 194 |
| 20 | Phears bye lane to Phears lane | 2000 | −25.00 | 261 |
| 21 | Phears lane | 4800 | 2.50 | 273 |
| 22 | Phears lane to Giri Babu lane | 2100 | −12.50 | 288 |
| 23 | Giri Babu lane | 2400 | −12.50 | 215 |
| 24 | Giri Babu lane to central avenue | 2100 | −27.50 | 217 |
| 25 | Central metro (GATE 2_Lalbazar) | 1900 | −12.50 | 196 |
| 26 | Central avenue (GATE 3_RITES) | 1800 | −17.50 | 89 |
| 27 | Central avenue to Gangadhar Babu lane | 2100 | −47.50 | 147 |
| 28 | Gangadhar Babu lane | 5000 | −12.50 | 160 |

**Table 3. (Continued)**

| S. No | Surveyed stretch | Footpath width (in mm) | Infrastructure score (in %) | Peak hour volume (average of morning and evening peak hours per 15 min) |
|---|---|---|---|---|
| 29 | Gangadhar Babu lane to Bibi Rozio lane | 2000 | −47.50 | 191 |
| 30 | Bibi Rozio lane | 1800 | −30.00 | 143 |
| 31 | Bibi Rozio lane to Bowbazar crossing | 1900 | −10.00 | 142 |
| 32 | College street | 1900 | −57.50 | 256 |

*Note*: The "width" refers to the predominant width that the footpath has and is measured physically at different sections of the same footpath during the primary survey. The respective widths are measured physically on-site during the primary survey. The "length" refers to the measurement of the external Kerb (curb) of the footpath that is connected to the adjacent road and is measured using satellite imagery.
*Source*: Author.

**TABLE 4. Correlation between the factors**

| | Footpath width | Infrastructure score | Peak hour volume |
|---|---|---|---|
| Footpath width | – | 0.547 | 0.183 |
| Infrastructure score | 0.547 | – | 0.328 |
| Peak hour volume | 0.183 | 0.328 | – |

*Source*: Author.

This suggests that the width of a footpath plays a significant role in determining the level of infrastructure that is present in the footpath of the surveyed stretch.

## 7. Conclusion

On similar lines, 78.1% of the case area had a footpath width of <2500 mm. Furthermore, the traffic intensity map prepared by E.P. Richards in the year 1913 for Calcutta (previous name of Kolkata) Improvement Trust shows that even 100 years ago, the study area maintained a traffic intensity of 500 vehicles per hour. Subsequently, in this case, area, there has been an addition of the Metro Rail (underground rail/subway) in the early 1990s, followed by mobile application-based rental cab services post-2000s. However, the case area has had almost the same R.O.W. since 1913. In relation to this, a vehicular traffic count survey conducted by the authors in the month of September 2020 shows the number of total vehicles in peak hours as (1) 2110 vehicles in Bowbazar Crossing, (2) 5483 vehicles in Central Avenue Crossing, and (3) 11 211 vehicles in Bentinck Street Crossing. It should also be noted that due to the coronavirus pandemic, several building uses (including schools and private institutions) were not functioning regularly, thus considerably reducing the peak hour vehicular traffic volume recorded by the authors. Thus, it can be concluded that, despite having the same density, the number of vehicles per hour has increased manifold; thus, putting infrastructural pressure (specifically walkability) on the sidewalks. Indian cities have a multiplicity of administrative settings and an inherently complex social model of disability. Next, it is important to discuss how the research findings help improve conditions seen in Figures 6–11 and other instances mentioned in Section 5.2.

The first suggestion is directed toward the ward-level/legislative assembly level administration. The infrastructural level deficiency can be improved on a case-by-case basis using the Councillor (head of the administrative ward)/MLA (minister of the legislative assembly) fund. Although this process is quick, it might not contribute to the improvement of the overall accessibility of the stretch.

The second suggestion is primarily directed toward the urban administration (in this case, Kolkata Municipal Corporation). The case area is in the core of an old city that has an organically planned and well-established urban form. Thus, in cases where the footpath width cannot be altered to improve the infrastructural quality of the stretch, the development approach cannot be the regular precinct-based approach to urban development. The ideal approach for this case area would be the "Case-Based approach" (based on the score of the individual surveyed stretch evaluated using the research framework). This approach is based on the prioritization of the most problematic areas in the surveyed stretch. The stretches with the lowest scores can be prioritized while taking up infrastructural assignments. Each stretch can be improved as much as possible (based on the specific context) before taking up the next stretch.

The third suggestion is directed toward researchers in the field of architecture and planning. In future research in the same domain in the same case area, the factor of footpath width should be prioritized over other factors.

Furthermore, the responsibility for ensuring accessibility in old core cities is allocated to specific departments in the Urban/Municipal administrative setting, which shall enhance the chances of making a citizen-friendly pedestrian streetscape. This process, in turn, will ensure the achievement of UN-SDG 11: Sustainable Cities and Communities. Finally, the authors state that the theoretical, ideological, and methodological learnings from this paper (results furnished in this paper and methodology for future research) can be referred to by researchers for further investigation into accessibility issues in old core Indian cities.

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## Disclosure

The authors have no conflict of interest.

### Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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## Appendix 4: 3rd Peer reviewed referred journal publication

**G. Das Mahapatra**, S. Mori, and R. Nomura, 'Reviewing the Universal Mobility of the Footpaths in the Centers of Historic Indian Cities through Field Survey,' *Sustainability*, vol. 15, no. 10, p. 8039, May. 2021, doi: 10.3390/su15108039. [Impact Factor = 3.9]

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*Article*

# Reviewing the Universal Mobility of the Footpaths in the Centers of Historic Indian Cities through Field Survey

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**Abstract:** In this research, the condition of universal mobility, in the centers of historic Indian cities, has been critically analyzed. Implementing universal design guidelines (especially universal mobility standards) in the centers of historic Indian cities is comparatively challenging, due to the high-density, ever-increasing population, and organic urban development. The rising number of elderly and specially abled people also add a demographic challenge to universal mobility. The focus of this research is to understand the extent to which universal mobility guidelines can be implemented in the centers of historic Indian cities. The dataset for this research is derived from a field survey of 69 footpath stretches from the centers of 5 historic cities in India, namely Jaipur, Jodhpur, Nagpur, Hyderabad, and Chennai. Footpath stretches in the centers of these historic cities were evaluated based on several factors pertaining to universally designed infrastructure and universal mobility features. Such comprehensive research on universal mobility in footpaths of historic Indian cities has not been previously conducted. The findings of this research indicate the poor condition of universal mobility in the studied areas. Furthermore, the results can be useful for assessing the extent of implementation of universal mobility in the centers of other historic Indian cities.

**Keywords:** universal design; universal mobility; footpath; India; historic cities



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## 1. Introduction

Mahatma Gandhi, also known as the father of the nation of India, famously stated that the true measure of any society can be found in how it treats its most vulnerable members. Specially abled and elderly people are vulnerable in the physical and cognitive domains. As per the data of the Census of India from the last 100 years (1911–2011), the percentage of specially abled people have increased dramatically, by 737.2% (from 0.26% in 1911 to 2.21% in 2011), in comparison to a 284.21% increase in population (from 833,644 in 1911 to 26,814,994 in 2011) [1]. Similarly, the percentage of elderly people (those aged 60 and above) has increased significantly by 105.25% (4.18% in 1911 to 8.58% in 2011) [2,3]. The reason behind the increase in the number of elderly people is primarily due to the declining fertility rate, increased age for legal marriage, and increasing life expectancy [4].

India has always been proactive in the participation of United Nations Sustainable Development Goals (hereafter, UN-SDGs). For instance, (a) India is a member of the Open Working Group (OWG), which prepares the proposal on SDGs, (b) India has institutionally set up the 'NITI (National Institution for Transforming India) Aayog', which connects the SDGs with central ministries and national schemes. The NITI Aayog has also published the SDG India Index: Baseline Report 2018, and (c) The Ministry of Statistics and Programme Implementation, Government of India has finalized 306 national indicators for India that are in accordance with the 169 SDG targets. Furthermore, India, being a member of the United Nations, is more likely to follow Goal Number 11 (specifically, target numbers 11.2 and 11.7) of the United Nations Sustainable Development Goals (UN-SDGs) that targets making cities and human settlements inclusive, safe, resilient, and sustainable, with a particular focus on the needs of elderly and specially abled people [5]. Thus, the inception of this research, related to universal design, is based on the demographic situation in India in the recent past. Universal design can be explained as the process undertaken to design products, buildings, and exterior spaces that are accessible (through usage) by all (able-bodied and specially abled people) to the maximum extent, without any specialized design [6]. Universal design has its root in the principle that a design solution should serve all user groups without making the specially abled feel distinctive [7]. Universal design takes into consideration usability, inclusivity, and accessibility, thereby making built environments usable for all [8]. However, this research is more inclined towards one aspect of universal design termed 'universal mobility'.

Universal mobility is a policy-level intervention at the city scale, ensuring a minimum standard of mobility for all members of society [9]. Universal mobility connects the missing links between universally designed buildings and universally designed premises/precincts, and creates accessible urban spaces [10]. Both the UN-CRPD and the UN-SDG suggest the concept of universal mobility for enabling movement within a city, without discrimination based on physical or mental limitations. Universal mobility, especially at the footpath level of historic Indian cities, impacts the urban experience, which has been a determinant as well as a challenge to the architectural planning sector [11,12].

India presents classic examples of cities with historic and degraded pedestrian areas. Transformation dynamics have played a major role in the complex urban structure of historic Indian cities, which, in turn, have often created unfavorable pedestrian conditions [13]. In the aforementioned sentence, the term 'complex' specifically refers to conditions such as (a) minimal temporal changes in the centers of historic cities, (b) organic mixed-use development, and (c) encroached footpaths. Universal mobility (facilities that cater to the needs of able-bodied as well as specially abled people) might be a determinant whose improvement can positively influence the decaying centres of historic core cities in India.

Even institutionally, there are significant challenges in transforming existing historic cities into age-friendly/disability-friendly cities [14]. In particular, cities with historic centers face a major challenge in the implementation of any kind of development plan for restoration/revitalization/rejuvenation at street level [15,16]. The pedestrian movement of the specially abled and elderly is significantly impacted by poor/unsuitable pedestrian zone quality [17], which is not desirable with respect to Sustainable Development Goal Number 11 (target numbers 11.2 and 11.7) [18].

Thus, it is also evident that every successful streetscape has recognized that shortcomings in universal design create a negative impact on the commuting of the elderly and specially abled [19], in addition to being a factor in pedestrian accidents [20,21]. Since mobility remains a major challenge for the elderly and specially abled population [22], the challenge in this research is to define the degree of accessibility [23] and the ways in which the experience [24] of a street can be similar for those who are able-bodied as well as specially abled. The 'degree of accessibility' in this research refers to the possibility of accessible options available in the surveyed stretches, and the extent which accessibility may be increased during redevelopment. The 'experience', in the context of this research, refers to how pedestrians perceive the footpaths, cognitively and physically.

In this research, the factors preferable for implementing universal mobility were further subjected to a case-by-case investigation in seven other historic cities in India. As the hypothesis, the authors have considered that the footpaths in the centers of historic urban areas in India are poor in terms of universal mobility. The focus of this research is to understand which factors are responsible for reducing the universal mobility standards in footpaths in the centers of historic urban areas in India.

This paper aims to investigate the universal mobility conditions of the footpaths in the centers of historic urban areas in India. The objectives of the research were: (a) to determine the extent of accessibility in the footpaths in the centers of historic core cities in India, and (b) to check whether there is a correlation between the accessibility score and some indicators of universal mobility, such as footpath width. The scope of this research includes an assessment at the footpath level and 19 defined criteria (including 52 indicators) for analysis. The limitations of this research are that it is limited to the historic Indian cities with at least 100 years of documented heritage and also, the investigation is to be only at the pedestrian level.

In their previous publications, the authors summarized that the walkability conditions in the footpaths of historic cities in India are poor in terms of both basic walkability standards and universal mobility considerations, as well as taking Kolkata as a case study [25]. The authors have further critically appraised the challenges of implementing universal design standards in the mobility sector in India [26] and the contextual factors of accessibility in the centers of historic Indian cities [27,28]. Furthermore, in their book, *Reinterpreting Urban Fabric in Cities with Living Heritage: The Case of Kolkata*, the uniqueness of the centers of historic Indian cities was documented [29]. In this paper, the authors further verify the assumptions of substandard universal mobility, by conducting field studies in other historic Indian cities.

The next section explains the materials and methods for this research, including the (a) survey questionnaire and scoring pattern, (b) observation, (c) results, and (d) data validation.

## 2. Materials and Methods

To assess the baseline situation of footpaths in the centers of historic core cities in India, a survey was conducted from 11 December 2021, till 30 March 2022. The case areas considered for this research are historic cities which are at least 100 years old. Historic cities in India are different from most historic cities in the world. For this research, cities that evolved during the early 18th century (the start of British rule) are referred to as “historic cities”. The space structures in historic cities of developing nations, such as India, are complex, due to their historic origin. These central areas of these cities have high density, mixed land use, and a lack of space allocated to infrastructure compared to the rest of the city.

However, there are numerous cities in India which fit the aforementioned criteria. The authors also had to take into consideration the availability of personnel in India who would be able to assist in acquiring survey permissions and establishing contact with locals.

Thus, the Indian cities where the survey was conducted, as shown in Figure 1, were: (a) Jodhpur (located in the western part of India; founded in mid-15th century CE), (b) Jaipur (located in the western part of India; founded in early 18th century CE), (c) Hyderabad (located in the central part of India; founded in late 16th century CE), (d) Chennai (located in the southern part of India; founded in early 17th century CE), and (e) Nagpur (located in the central part of India; founded in 10th century CE). Thereafter, using the ‘paradigmatic case sampling’ sub-type of the ‘purposive sampling’ technique, the rhizome (temporal boundary) selected for the survey was 69 footpath stretches from the centers of the selected cities, with a total length of 15.48 km. Paradigmatic case sampling is considered when the researcher has focused the research on one specific category, such as historic cities in this case. Furthermore, the footpath stretches complied with the following conditions: (a) located at the city center, (b) a commercially important location, (c) predominantly mixed-use buildings, and, (d) easy access through public transport.

The details of individual locations (locality name, number of surveyed footpath stretches, total length of surveyed stretches, and average width of the footpath) are mentioned below in Table 1.


**Figure 1.** Map of India showing the survey locations (Source: Author).

**Table 1.** Details of Survey Locations (Source: Author).

| S. No. | City | Locality | Number of Footpaths Stretches | Total Length of Stretch (in m) | Average Width of the Footpath (in m) |
|---|---|---|---|---|---|
| 1 | Jodhpur | Sardar Market | 16 | 443.60 | 1.97 |
| 2 | Jaipur | Bapu Bazaar | 07 | 897.90 | 1.20 |
| 3 | Hyderabad | Charminar | 09 | 9002.70 | 2.43 |
| 4 | Chennai | Mylapore | 25 | 2564.20 | 1.44 |
| 5 | Nagpur | Gandhisagar Lake | 12 | 2571.40 | 1.53 |

Finally, the research methodology adopted for this research is illustrated in Figure 2. The research is primarily divided into three segments: Stage 1, consisting of the literature review; Stage 2, consisting of the primary survey of the case areas; and Stage 3, consisting of the summary of the findings. All these segments finally led to the confirmation of the hypothesis.

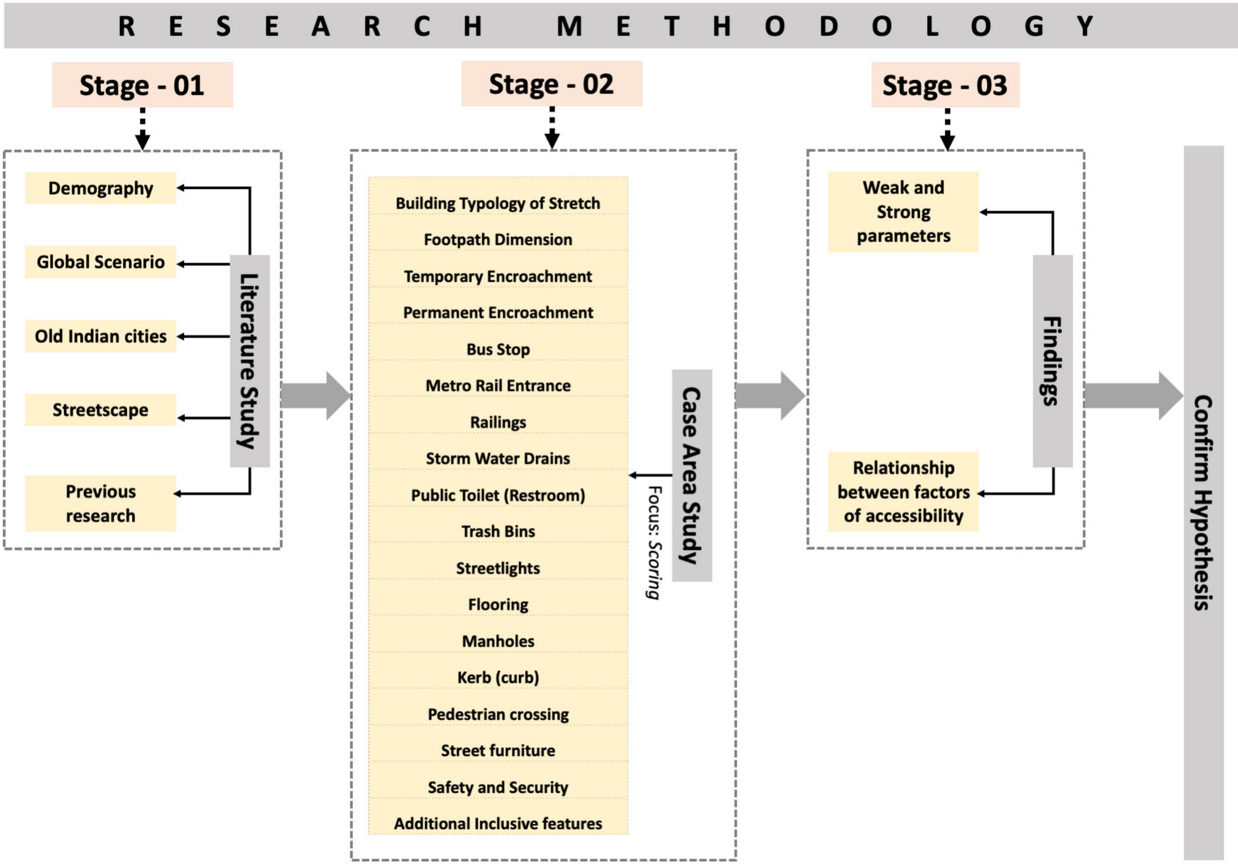


**Figure 2.** Research Methodology (Source: Author).

*2.1. Survey Questionnaire and Scoring Pattern*

Before conducting this survey, the authors had conducted a pilot survey in Kolkata, and the findings were published [30]. A survey format, consisting of 19 defined criteria (comprising 52 indicators, including one contextual criterion), was used for this survey. The choice of survey technique was observational, using a structured dichotomous questionnaire. The questionnaire is available at https://forms.gle/hDVduWAARes75JrbA (accessed on 25 February 2023).

The categorical variables (criteria) are as follows: (1) building typology of stretch, (2) footpath dimensions, (3) temporary encroachment, (4) permanent encroachment, (5) bus stop, (6) metro rail entrance, (7) railings, (8) storm water drains, (9) public toilet, (10) trash bins, (11) street lights, (12) flooring, (13) manholes, (14) curb, (15) pedestrian crossing, (16) street furniture, (17) safety and security (surveillance and fire-safety oriented), (18) additional inclusive features, and (19) contextual factors. Within the 19 criteria, 52 indicators can be distinguished into independent and dependent variables, respectively.

As an example, one of the categorical variables (criteria) "railings", has associated indicators as: (a) presence of a railing (pedestrian guard rails) on the edge of the footpath, and (b) presence of thorough railings with a minimum of 150 cm height and clear visibility. In this case, the first indicator "presence of railing (pedestrian guard rails) on the edge of the footpath" is independent of any factor, which means that whether a railing is present or absent is the decisive factor in the assessment. However, with regard to the second indicator, i.e., "presence of thorough railings with a minimum of 150 cm height and clear visibility", the condition of the railing can be assessed only if the railing is present at all. This means that if a railing is not present in the first place, then the functionality of the railing cannot be assessed at all. Therefore, this indicator is dependent on the previous sub-criteria. Since the indicator, "presence of railing (pedestrian guard rails) on the edge of the footpath", is an independent variable, and "presence of thorough railings with a minimum of 150 cm height and clear visibility" is a dependent variable, their weighting would be different.

Thus, the indicators were scored based on their associated variable type (i.e., independent or dependent). If the associated variable is an independent variable, the presence of an indicator is scored as "+0.50". Along similar lines, if the associated variable is a dependent variable, an indicator is scored as "+0.25". Similarly, the absence of an indicator is scored as "−0.50" for independent variables and "−0.25" for dependent variables, respectively. Thus, weighting is used for further analysis. It should be noted that although all these indicators are not equally important for pedestrian activity, the negative impact of any one of them could lead to inadequate universal mobility standards. Thus, similar indicators are given equal weighting, i.e., +0.50 for the independent variable and +0.25 for the dependent variable.

Table 2 shows the variables (criteria and indicator), types of associated variables (independent/dependent), scoring logic, and the individual scores used in this research. For any study stretch surveyed using this framework, the consolidated highest score can be +16.50 (and subsequently, the lowest can be −16.50).

**Table 2.** Details of Variables (Criteria and Indicator), Variable Type (Independent/Dependent), Scoring Logic, and the Individual Scores used in the research (Source: Author).

| S. No. | Criterion | Indicator | Variable Type | Scoring Logic | Individual Associated Score | |
|---|---|---|---|---|---|---|
| | | | | | If Yes | If No |
| 1 | Building Typology of Stretch | (1) Buildings with two or more uses | Independent | Beneficial if Absent | −0.50 | +0.50 |
| | | (2) Heritage/historic buildings | Independent | Beneficial if Absent | −0.50 | +0.50 |
| 2 | Footpath Dimension | (3) Footpath Width >2500 mm | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (4) Unobstructed width of 1800 mm | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (5) Unobstructed clear height of 2200 mm | Independent | Beneficial if Present | +0.50 | −0.50 |
| 3 | Temporary Encroachment | (6) Informal Vendors/Beggar/homeless/child labor occurring during the day/night | Independent | Beneficial if Absent | −0.50 | +0.50 |
| | | (7) Informal Vendors/ hawkers away from the line of pedestrian flow (if Vendors are present) | Dependent | Beneficial if Absent | −0.25 | +0.25 |
| | | (8) Beggar/homeless/child labor occupying a part of the footpath as their homes | Dependent | Beneficial if Absent | −0.25 | +0.25 |
| 4 | Permanent Encroachment | (9) Place of religious interest (temple/churches/mosque) within or along the footpath | Independent | Beneficial if Absent | −0.50 | +0.50 |
| | | (10) Encroachment by existing establishments on to the footpath | Independent | Beneficial if Absent | −0.50 | +0.50 |
| | | (11) 'Communal open bath' within or along the footpath | Independent | Beneficial if Absent | −0.50 | +0.50 |
| 5 | Bus Stop | (12) Informal stoppage for Bus | Independent | Beneficial if Absent | −0.50 | +0.50 |
| | | (13) Bus Shelter (if Bus Stops are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| | | (14) Is 'Bus Shelter' functional (if Bus Shelter is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |

**Table 2.** *Cont.*

| S. No. | Criterion | Indicator | Variable Type | Scoring Logic | Individual Associated Score | |
|---|---|---|---|---|---|---|
| | | | | | If Yes | If No |
| 6 | Metro Rail Entrance | (15) Entrance connected to the footpath | Independent | Beneficial if Absent | −0.50 | +0.50 |
| | | (16) Is the Entrance functional (if Metro Rail Entrance is present)? | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 7 | Railings | (17) Railings (pedestrian guard rails) on the edge of the footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (18) Thorough railings with minimum 150 cm height and clear visibility (if Railings are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 8 | Storm Water Drains | (19) Storm Water Drains along footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (20) Functional Storm Water Drains (if Storm Water Drains are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 9 | Public Toilet (Restroom) | (21) Public Toilet within the footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (22) Functional Public Toilet (if Public Toilet is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 10 | Trash Bins | (23) Trash Bins within the footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (24) Functional Trash Bins (if Trash Bins are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| | | (25) Trash Bins located away from the line of pedestrian flow (if Trash Bins are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 11 | Streetlights | (26) Streetlights within the footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (27) Functional Street Lights (if Street Lights are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| | | (28) Light Poles situated away from pedestrian flow or, if present, demarcated with a tactile marking of a minimum of 60 cm around them (if Street Lights are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 12 | Flooring | (29) Satisfactory Cross Fall (i.e., <1:50) | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (30) Tactile Marking | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (31) Anti-skid/matte-finish tiles in footpath and Curb | Independent | Beneficial if Present | +0.50 | −0.50 |
| 13 | Manholes | (32) Manholes within/along the footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (33) Drain-type manholes flush with the pavement surface (if Manholes are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| | | (34) Grating-type manholes situated away from the pedestrian walkway (if Manholes are present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 14 | Curb | (35) Curb on the edge of footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (36) Curb Height of no more than 150 mm from the road level (if Curb is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| | | (37) Minimum 1200 mm width and tactile warning (if Curb is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| | | (38) Cornered Curb radius more than 6 m (if Curb is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |

**Table 2.** *Cont.*

| S. No. | Criterion | Indicator | Variable Type | Scoring Logic | Individual Associated Score | |
|---|---|---|---|---|---|---|
| | | | | | If Yes | If No |
| 15 | Pedestrian crossing | (39) 'At-grade' pedestrian crossing (MID-BLOCK crossing) at all intersections along the walkway | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (40) Signalized Intersection (if Crossing is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| | | (41) Functional Signalized Intersection (if Crossing is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| | | (42) Audio Signal (if Crossing is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 16 | Street furniture | (43) Street Furniture in the footpath | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (44) Street furniture having a knee clearance of a minimum of 70 cm and wheelchair space of 100 cm (if Street Furniture is present) | Dependent | Beneficial if Present | +0.25 | −0.25 |
| 17 | Safety and Security | (45) Fire Hydrant | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (46) Security Camera | Independent | Beneficial if Present | +0.50 | −0.50 |
| 18 | Additional Inclusive features | (47) Signage | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (48) Bicycle Track | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (49) Public Drinking Water Facility | Independent | Beneficial if Present | +0.50 | −0.50 |
| | | (50) Street Art/Sculpture | Independent | Beneficial if Present | +0.50 | −0.50 |
| 19 | Contextual Factors | (51) Is the surveyed location within a high-pedestrian zone? | Independent | Beneficial if Absent | −0.50 | +0.50 |
| | | (52) Is/are there any other contextual factors, such as potholes, parking, etc., affecting the high-pedestrian zone? | Dependent | Beneficial if Absent | −0.25 | +0.25 |

### 2.2. Observation

The average footpath width among the 69 footpath stretches, across the 5 selected cities, is 1.71 m. Table 3 elaborates on the findings from the 69 footpath stretches, across the 5 selected cities, using the 19 criteria-based survey format.

**Table 3.** Observation from surveys (Source: Author).

| S. No. | Category (Parameters) | Findings (Indicator Based) |
|---|---|---|
| 1 | Building Typology | 1. 42.03% have buildings with two or more uses.<br>2. 53.62% have Heritage/historic buildings. |
| 2 | Footpath Dimensions | 3. 15.94% have a Footpath Width >2500 mm.<br>4. 14.49% have an unobstructed width of 1800 mm.<br>5. 52.17% have an unobstructed clear height of 2200 mm. |
| 3 | Temporary Encroachment | 6. 68.12% have Informal Vendors/Beggar/homeless/child labor occurring during day/night.<br>7. 44.93% have Informal Vendors/hawkers away from the line of pedestrian flow (if Vendors are present).<br>8. 24.64% have Beggar/homeless/child labor occupying a part of the footpath as their homes. |

**Table 3.** *Cont.*

| S. No. | Category (Parameters) | Findings (Indicator Based) |
|---|---|---|
| 4 | Permanent Encroachment | 9. Places of religious interest (temple/churches/mosque) within or along the footpath are present in 15.94%.<br>10. 75.36% have Encroachment by existing establishments onto the footpath is present on 75.36%.<br>11. 'Communal open bath' within or along the footpath is present on 2.90%. |
| 5 | Bus Stop | 12. 11.59% have informal stoppage for Bus.<br>13. 10.14% have Bus Shelter (if Bus Stops).<br>14. In 10.14%, the 'Bus Shelter' is functional (if Bus Shelter is present). |
| 6 | Metro Rail Entrance | 15. In 1.45%, the Entrance is connected to the footpath.<br>16. In 1.45%, the Entrance is functional (if Metro Rail Entrance is present). |
| 7 | Railings (pedestrian guard rails) | 17. 5.80% have railings (pedestrian guard rails) on the edge of the footpath.<br>18. None of them have thorough railings with a minimum 1500 mm height and clear visibility (if Railings are present). |
| 8 | Storm Water Drains | 19. 60.87% have Storm Water Drains along footpaths.<br>20. 2.90% have functional Storm Water Drains (if Storm Water Drains are present). |
| 9 | Public Toilet (Restroom) | 21. 4.35% have Public Toilets within the footpath.<br>22. 2.90% have functional Public Toilets (if Public Toilets are present). |
| 10 | Trash Bins | 23. 18.84% have Trash Bins within the footpath.<br>24. 14.49% are Functional Trash Bins (if Trash Bins are present).<br>25. 7.25% have Trash Bins located away from the line of pedestrian flow (if Trash Bins are present). |
| 11 | Streetlights | 26. 88.41% have Streetlights within the footpath.<br>27. 86.96% have Functional Street Lights (if Street Lights are present).<br>28. 21.74% have Light Poles situated away from pedestrian flow or, if present, demarcated with a tactile marking of a minimum of 600 mm around them (if Street Lights are present). |
| 12 | Flooring | 29. 26.09% have Satisfactory Cross Fall (i.e., <1:50).<br>30. 13.04% have Tactile Marking.<br>31. 57.97% have Anti-skid/matte-finish tiles in footpath and Curb. |
| 13 | Manholes | 32. 60.87% have Manholes within/along the footpath.<br>33. 56.52% have Drain-type manholes flushed with the pavement surface (if Manholes are present).<br>34. 34.78% have Grating-type manholes sited away from the pedestrian walkway (if Manholes are present). |
| 14 | Curb | 35. 91.30% have a Curb on the edge of the footpath.<br>36. 72.46% have a Curb Height of not more than 150 mm from the road level (if Curb is present).<br>37. 4.35% have a tactile warning (if Curb is present).<br>38. 11.59% have a Curb radius of more than 6m at the corner (if Curb is present). |
| 15 | Pedestrian Crossing | 39. 5.80% have 'At-grade' pedestrian crossing (MID-BLOCK crossing) at all intersections along walkway.<br>40. 10.14% have Signalized Intersection (if Crossing is present).<br>41. 13.04% have Functional Signalized Intersection (if Crossing is present).<br>42. 1.45% have Audio Signal (if Crossing is present). |
| 16 | Street Furniture | 43. 7.25% have Street Furniture on the footpath.<br>44. 1.45% have Street furniture having a knee clearance of a minimum of 700 mm and wheelchair space of 1000 mm (if Street Furniture is present). |
| 17 | Safety and Security | 45. 1.45% have a Fire Hydrant.<br>46. 36.23% have a Security Camera. |

**Table 3.** *Cont.*

| S. No. | Category (Parameters) | Findings (Indicator Based) |
|---|---|---|
| 18 | Additional Inclusive Features | 47. 27.54% have Signage.<br>48. 2.90% have Bicycle Track.<br>49. 2.90% have Public Drinking Water Facilities.<br>50. 5.80% have Street Art. |
| 19 | Contextual Factors | 51. 100% were located within high-pedestrian zone.<br>52. 42.03% have contextual factors (such as potholes, terrain, etc.). |

### *2.3. Results*

In continuation of the explanation in the previous sections, the step after the observation was the scoring of the footpath stretches. This was conducted in two parts. The first part was observing the results from the point of view of the 52 indicators. The second part was understanding the results from the perspective of the 69 footpaths.

Figure 3 represents the score of the 52 individual indicators, across the 69 footpath stretches, in the 5 cities in India. The values represented across each indicator in Figure 3 were derived by using the following formula:

$$S_P = (S_T/S_M) \times 100$$

where,
$S_P$ = percentage score of individual indicators across the entire case area, or 69 footpaths
$S_T$ = summation of the score of each indicator across the entire case area, or 69 footpaths
$S_M$ = maximum score of the indicators across the entire case area, or 69 footpaths

The details of this calculation are mentioned in Appendix A and a summary is illustrated in Figure 3. Figure 3 indicates that only 32.69% (17 out of 52) of the parameters are in the positive score domain, out of which only 15.38% (8 out of 52) have a score above the 50% mark.

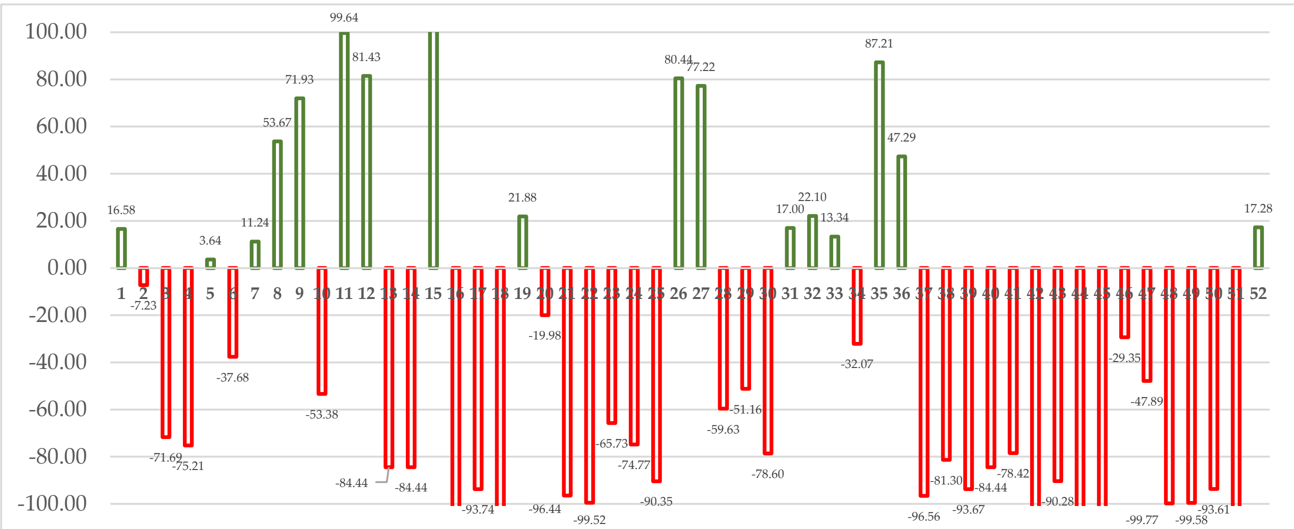


**Figure 3.** Score of the individual survey indicators across the 69 footpath stretches in 5 cities in India (Source: Author).

Figure 4 represents the score of the 69 footpath stretches in the 5 cities in India, depending on the presence/absence of the parameter (with indicators). The values represented across each indicator in Figure 4 were derived by using the following formula:

$$A = (B/C) \times 100$$

where,
A = percentage score of each 69 footpaths
B = individual score of 69 footpaths
C = maximum positive score of a footpath, i.e., 16.5

The details of this calculation are mentioned in Appendix B a summary is illustrated in Figure 4. Furthermore, it is evident from Figure 4 that, if evaluated with the standard parameters of accessibility, the conditions of the surveyed footpath stretches are extremely poor. Only 4.35% (3 instances) of the surveyed stretches are in the positive score domain; the rest are in the negative, implying dilapidated footpath conditions.

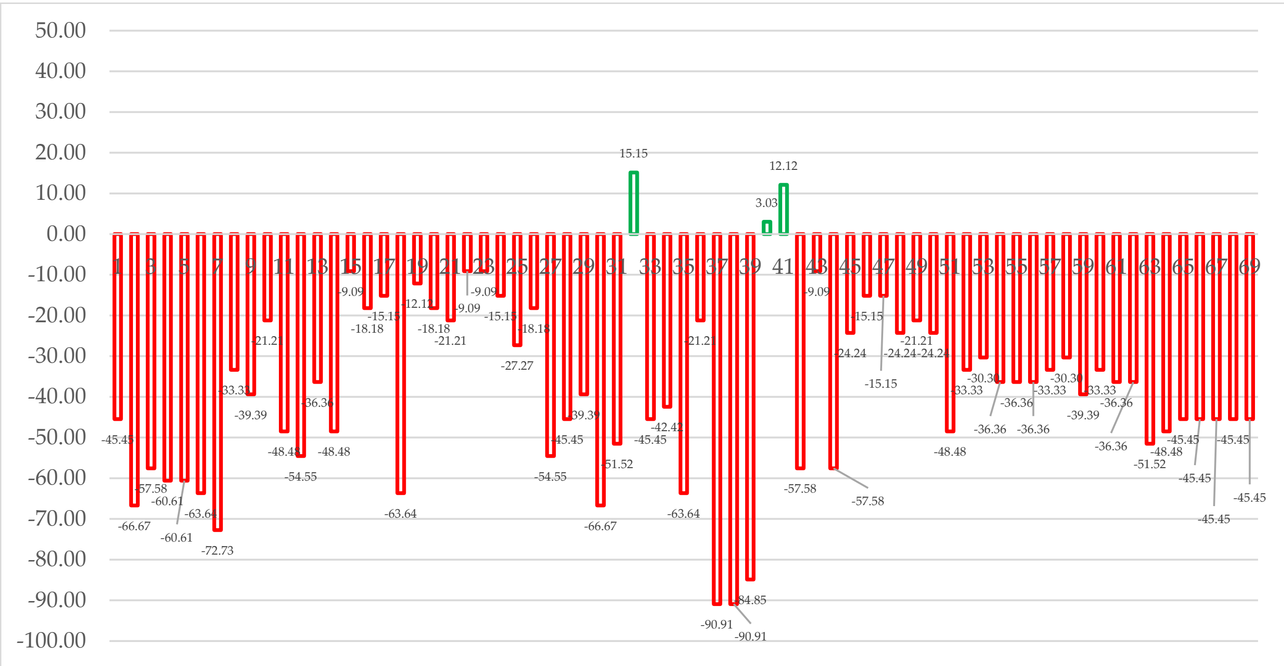


**Figure 4.** Score of 69 footpath stretches in 5 cities in India, depending on the presence/absence of the parameter (Source: Author).

## 2.4. Data Validation

The next step was to validate the internal consistency of the data to validate the performance of the indicators in the 69 footpaths, across the 5 case cities. The average of the accessibility scores of each parameter, for each of the five case cities, were first enlisted in Table 4.

Hereafter, the percentage distribution of the 5 survey locations, concerning the 19-factor point of reference, was used for the Cronbach's alpha analysis of internal consistency, using IBM® SPSS® Statistics version 26.0. The Cronbach's alpha for the dataset is 0.951, indicating the highest order of internal consistency.

Based on the data analysis up until this stage, it can be stated that the hypothesis (footpaths in the centers of historic urban areas in India are poor in terms of universal mobility) holds true.

**Table 4.** Average consolidated scores for each parameter for the five cities (Source: Author).

| S. No. | Parameters | Jodhpur | Jaipur | Hyderabad | Chennai | Nagpur |
|---|---|---|---|---|---|---|
| 1 | Building Typology | −0.143 | −0.143 | 0.444 | 0.240 | −0.333 |
| 2 | Footpath Dimension | −0.500 | −0.500 | −1.056 | −0.700 | −0.667 |
| 3 | Temporary Encroachment | −0.429 | −0.429 | 0.444 | −0.020 | −0.292 |
| 4 | Permanent Encroachment | 0.500 | 0.500 | 0.611 | 0.500 | 0.417 |
| 5 | Bus Stop | 0.000 | 0.000 | 0.000 | −0.040 | 0.000 |
| 6 | Metro Rail | 0.250 | 0.250 | 0.250 | 0.230 | 0.250 |
| 7 | Railings | −0.750 | −0.750 | −0.750 | −0.590 | −0.750 |
| 8 | SWD | 0.250 | 0.250 | −0.639 | −0.010 | −0.125 |
| 9 | Public Toilet | −0.750 | −0.750 | −0.750 | −0.750 | −0.500 |
| 10 | Trash Bins | −1.000 | −1.000 | −1.000 | −0.660 | 0.000 |
| 11 | Streetlights | 0.500 | 0.500 | −0.556 | 0.480 | 0.708 |
| 12 | Flooring | −0.500 | −0.500 | −0.500 | −0.300 | −1.167 |
| 13 | Manholes | 0.286 | 0.286 | −0.444 | −0.100 | −0.500 |
| 14 | Curb | 0.250 | 0.250 | 0.139 | 0.090 | −0.167 |
| 15 | Pedestrian Crossing | −1.250 | −1.250 | −1.250 | −0.890 | −1.042 |
| 16 | Street Furniture | −0.750 | −0.750 | −0.750 | −0.690 | −0.500 |
| 17 | Safety Security | −1.000 | −1.000 | −0.889 | −0.280 | −0.417 |
| 18 | Additional Features | −2.000 | −2.000 | −2.000 | −1.240 | −1.417 |
| 19 | Contextual Factors | −0.679 | −0.679 | −0.472 | −0.390 | −0.375 |

## 3. Discussion

There are numerous design-level examples at both footpath and urban levels in historic cities, indicating that walkability in an urban location can have universal design considerations if designed per the available guidelines and contextual demands. This statement can be further verified through the best practices mentioned hereafter.

In Jungali Maharaj Street (Pune, India), the designers have focussed on the safety of pedestrians and cyclists, and have redeveloped a stretch of 1800 m with simple design elements such as (a) a wide pedestrian area, (b) a slope between vehicular and pedestrian pathway, (c) anti-skid flooring, (d) streetlights to ensure the safety of citizens, (e) trees for proper shading, and (f) guiding blocks (for the visually impaired) [31,32]. Similarly, on a 1250 m stretch in Las Ramblas Street (Barcelona, Spain), the policy makers incorporated the following to ensure hassle-free walkability: (a) a walkway in the center and an area for motorists to the side, (b) a canopy for light filtration and protection from traffic, (c) anti-skid flooring, (d) ample sitting areas, (e) a building height which allows sun during winter, and (f) drinking facilities at an accessible height [33,34]. Prioritizing an enhanced mobility system, a 2500 m stretch in Avenue Paulista (Sao Paulo, Brazil) has been developed using the following: (a) a smooth, continuous walking surface, (b) wide sidewalks to accommodate pedestrians moving at different speeds, (c) the accommodation of informal vendors, (d) contrasting colour and tactile markings on the pavement for continuous visibility, (e) clear differentiation at intersections and crosswalks, (f) deliberate alignment and location of curb ramps, and (g) continuous walkways to facilitate crossing at wide avenues [35,36]. A 1000 m long stretch in SW Moody Avenue (Portland, OR, USA) was prioritized, based on the segregation of pedestrians and cyclists, incorporating the following design elements: (a) colourful signage, (b) tactile and activity-wise segregated walkways, (c) a wide pedestrian pathway for wheelchair users, (d) an anti-skid flooring surface, (e) signage in combination with small curb radii, distinctive materials, and other visual cues for making it inaccessible for vehicles, (f) handrails at the crossway at different levels, (g) tactical and demarcated routes in the crossways, railings all over the street side, and provision of slopes at crossing points [37,38]. Similarly, in Jackson Street (Saint Paul, MI, USA), the designers refined a 1700 m stretch, based on 'deafscape' or design enabling users with auditory impairment, using the following: (a) street trees and green infrastructure to provide wildlife habitat, reduce the heat island effect, provide a buffer for, and increase pedestrian safety, (b) wide pedestrian walkways, (c) places to rest for older and disabled pedestrians, (d) tactile and high-contrast paving, and (e) seating to accommodate different group sizes [39,40].

As an ideal/inclusive streetscape, the authors performed a rapid baseline assessment of certain footpath stretches in Sapporo, Japan (see Figure 5a,b). Japan is a country with a large number of elderly people (28% of the total population) and 4.3% differently abled citizens; thus, a universally designed streetscape is a prerequisite for urban development [41]. The prominent characteristics of the footpath, as seen in the pictures, are the ideal slope, tactile marking, street signage, proper location of grates and manholes, and street art. The authors propose much can be learned from these ideal streetscapes, while framing the accessibility audit guidelines in countries such as India.

(**a**) Slope and Tactile Marking

(**b**) Street Signage

(**c**) Grating Change near Trees

(**d**) Manholes away from Curb (< 150 mm)

(**e**) Closed Manhole located on edge

(**f**) Street Art

**Figure 5.** (**a**–**f**): Location: Footpath near Hokkaido University South Gate in-between 'North 7 West 6′ and 'North 6 West 5′ (Source: Author).

Similarly, there are multiple instances around the world, at the urban level in historic cities, which show how the existing spaces for public walkability have been made inclusive, thereby increasing the potential of universal mobility, as shown in Table 5.

**Table 5.** Dataset for Correlation Study (Source: Author).

| S. No. | City | Average Footpath Width (in Meters) | Average Accessibility Percentage |
|---|---|---|---|
| 1 | Jodhpur | 1.97 | −27.96 |
| 2 | Jaipur | 1.20 | −25.51 |
| 3 | Hyderabad | 2.43 | −48.25 |
| 4 | Chennai | 1.44 | −26.95 |
| 5 | Nagpur | 1.53 | −36.18 |

There are some examples of universal mobility at the urban level. In Berlin, Germany, the focus is on accessible transportation. The features implemented in Berlin are: (a) Mobidat database, which offers information on accessibility and on-site conditions at Berlin sites and other locations, (b) most of the U-Bahn stations and the S-Bahn (city railway) are accessible, (c) Berlin's public bus and ferry services are all wheelchair accessible, (d) the Wheel Map online application provides an accessible map where locations which are fully, partially, and not wheelchair accessible can be determined, (e) free mobility assistance services for buses and trains are available online and can be booked via call, (f) the provision of wheelchair taxis, (g) accessible toilets are marked on the Access Berlin application, and (h) around 1300 publicly accessible parking spaces are available in the city [42,43]. In Melbourne, Australia, prioritizing the creation of a mobility map for the city center, policymakers have done the following: (a) access and mobility maps for the city center, (b) an interactive access map showing disabled parking; accessible toilets; mobility recharging points; public seating; drinking fountains; train, bus, and tram station entrances; and street gradients, and (c) printable access maps which are available on the City of Melbourne website [44,45]. In Gdniya, Poland, making the city center accessible is considered best practice. The major initiatives in Gdniya are: (a) an accessible sports hall with special audio facilities for those who are specially abled and audio description for the visually impaired used during sports events, (b) railway stations which are fully accessible, (c) marina and sea beach with a wooden ramp for wheelchair users and large playgrounds for children who are specially abled, (d) buses and trolleybuses which have low floors for wheelchair access, (e) bus stops which have been modernized to be more accessible for elderly and specially abled people, (f) a special transportation system offering on-demand services for specially abled people who cannot use public transport, and (g) the high accessibility of public transport, which is the reason why the percentage of households with access to a passenger car is lower than in the whole city [46,47].

Thus, designers need to understand that there cannot be a standard formula for universal mobility. The need of every urban context is different, and the designers need to be flexible in implanting the standards. Especially in historic cities, where the pedestrian flow is relatively high, an understanding of the local context is important. The field survey results need to be critically understood to implement recommendations.

## 4. Conclusions

The next step was to critically analyze the data collected in this research. Thus, the correlation in the 2 sets of data was checked using Pearson's correlation, with a confidence interval of 95%. The first was the correlation between the 19 parameters used in the field survey for this research. The second was the average accessibility percentage and the average footpath width of the five surveyed cities. The last part of this section highlights the major findings of this research.

### *4.1. Correlation between the 19 Parameters Used in the Field Survey*

The cumulative score of the accessibility survey, across all 5 cities during the survey, was considered alongside the data associated with each of the 19 parameters. The results are shown in Figure 6.

As seen in Figure 6 above, a significant correlation exists only amongst the following:

- Strong negative correlation: Streetlight and Footpath Length;
- Strong positive correlation: (a) Manholes and Storm Water Drains, and (b) Safety and Security and Trash Bins.

Thus, the aforementioned factors may be prioritized in the preparation of development plans.

**Pearson's Correlation**

| | Factors | Footpath Width | Footpath Length | Building Typology | Footpath Dimension | Temporary Encroachment | Permanent Encroachment | Bus Stop | Metro Rail | Railings | SWD | Public Toilet | Trash Bins | Streetlights | Flooring | Manholes | Kerb | Pedestrian Crossing | Street Furniture | Safety Security | Additional Features | Contextual Factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Footpath Width | 1.000 | 0.310 | -0.219 | 0.421 | -0.285 | -0.120 | 0.001 | -0.189 | -0.155 | 0.065 | 0.101 | -0.044 | -0.265 | -0.090 | -0.120 | 0.099 | -0.266 | 0.161 | -0.230 | -0.255 | -0.173 |
| 2 | Footpath Length | 0.310 | 1.000 | -0.130 | -0.260 | -0.154 | 0.053 | -0.093 | -0.061 | -0.090 | -0.443 | -0.062 | -0.018 | -0.614 | -0.005 | -0.231 | -0.013 | -0.126 | -0.092 | -0.068 | -0.151 | -0.027 |
| 3 | Building Typology | -0.219 | -0.130 | 1.000 | -0.106 | 0.231 | 0.140 | 0.024 | -0.179 | -0.175 | 0.164 | 0.217 | 0.157 | 0.171 | 0.077 | 0.198 | 0.003 | -0.050 | 0.057 | 0.099 | 0.036 | 0.057 |
| 4 | Footpath Dimension | 0.421 | -0.260 | -0.106 | 1.000 | -0.026 | -0.150 | -0.013 | -0.135 | -0.025 | 0.224 | 0.332 | -0.029 | 0.179 | -0.169 | -0.061 | 0.286 | 0.146 | 0.334 | -0.019 | -0.170 | -0.077 |
| 5 | Temporary Encroachment | -0.285 | -0.154 | 0.231 | -0.026 | 1.000 | 0.058 | 0.265 | -0.021 | -0.079 | -0.099 | 0.099 | 0.103 | 0.067 | -0.161 | -0.171 | -0.117 | 0.210 | 0.067 | 0.173 | 0.101 | 0.138 |
| 6 | Permanent Encroachment | -0.120 | 0.053 | 0.140 | -0.150 | 0.058 | 1.000 | 0.189 | 0.012 | 0.024 | 0.131 | 0.149 | 0.234 | -0.139 | 0.080 | 0.048 | 0.020 | -0.099 | 0.108 | 0.270 | 0.280 | -0.159 |
| 7 | Bus Stop | 0.001 | -0.093 | 0.024 | -0.013 | 0.265 | 0.189 | 1.000 | -0.043 | 0.115 | 0.152 | 0.183 | 0.172 | 0.131 | 0.124 | -0.027 | -0.207 | 0.072 | 0.311 | 0.115 | 0.363 | -0.015 |
| 8 | Metro Rail | -0.189 | -0.061 | -0.179 | -0.135 | -0.021 | 0.012 | -0.043 | 1.000 | 0.489 | 0.123 | -0.025 | -0.057 | 0.016 | 0.004 | 0.060 | 0.035 | 0.376 | -0.033 | 0.156 | 0.102 | -0.103 |
| 9 | Railings | -0.155 | -0.090 | -0.175 | -0.025 | -0.079 | 0.024 | 0.115 | 0.489 | 1.000 | 0.115 | -0.052 | -0.117 | 0.087 | 0.227 | 0.159 | 0.072 | 0.332 | 0.252 | 0.063 | 0.378 | -0.086 |
| 10 | SWD | 0.065 | -0.443 | 0.164 | 0.224 | -0.099 | 0.131 | 0.152 | 0.123 | 0.115 | 1.000 | 0.214 | 0.047 | 0.442 | 0.406 | 0.678 | 0.328 | -0.058 | 0.280 | -0.159 | 0.224 | -0.002 |
| 11 | Public Toilet | 0.101 | -0.062 | 0.217 | 0.332 | 0.099 | 0.149 | 0.183 | -0.025 | -0.052 | 0.214 | 1.000 | 0.089 | 0.144 | -0.024 | -0.106 | 0.114 | 0.034 | 0.213 | -0.001 | 0.320 | -0.179 |
| 12 | Trash Bins | -0.044 | -0.018 | 0.157 | -0.029 | 0.103 | 0.234 | 0.172 | -0.057 | -0.117 | 0.047 | 0.089 | 1.000 | 0.216 | 0.111 | -0.042 | 0.161 | 0.029 | 0.268 | 0.514 | 0.285 | -0.333 |
| 13 | Streetlights | -0.265 | -0.614 | 0.171 | 0.179 | 0.067 | -0.139 | 0.131 | 0.016 | 0.087 | 0.442 | 0.144 | 0.216 | 1.000 | 0.056 | 0.262 | 0.027 | 0.283 | 0.125 | 0.047 | 0.283 | 0.032 |
| 14 | Flooring | -0.090 | -0.005 | 0.077 | -0.169 | -0.161 | 0.080 | 0.124 | 0.004 | 0.227 | 0.406 | -0.024 | 0.111 | 0.056 | 1.000 | 0.393 | 0.316 | -0.086 | 0.039 | 0.097 | 0.464 | 0.029 |
| 15 | Manholes | -0.120 | -0.231 | 0.198 | -0.061 | -0.171 | 0.048 | -0.027 | 0.060 | 0.159 | 0.678 | -0.106 | -0.042 | 0.262 | 0.393 | 1.000 | 0.197 | -0.081 | 0.166 | -0.195 | 0.063 | 0.122 |
| 16 | Curb | 0.099 | -0.013 | 0.003 | 0.286 | -0.117 | 0.020 | -0.207 | 0.035 | 0.072 | 0.328 | 0.114 | 0.161 | 0.027 | 0.316 | 0.197 | 1.000 | 0.193 | 0.181 | -0.014 | 0.097 | -0.106 |
| 17 | Pedestrian Crossing | -0.266 | -0.126 | -0.050 | 0.146 | 0.210 | -0.099 | 0.072 | 0.376 | 0.332 | -0.058 | 0.034 | 0.029 | 0.283 | -0.086 | -0.081 | 0.193 | 1.000 | 0.177 | 0.302 | 0.216 | -0.156 |
| 18 | Street Furniture | 0.161 | -0.092 | 0.057 | 0.334 | 0.067 | 0.108 | 0.311 | -0.033 | 0.252 | 0.280 | 0.213 | 0.268 | 0.125 | 0.039 | 0.166 | 0.181 | 0.177 | 1.000 | 0.096 | 0.299 | -0.133 |
| 19 | Safety Security | -0.230 | -0.068 | 0.099 | -0.019 | 0.173 | 0.270 | 0.115 | 0.156 | 0.063 | -0.159 | -0.001 | 0.514 | 0.047 | 0.097 | -0.195 | -0.014 | 0.302 | 0.096 | 1.000 | 0.446 | -0.299 |
| 20 | Additional Features | -0.255 | -0.151 | 0.036 | -0.170 | 0.101 | 0.280 | 0.363 | 0.102 | 0.378 | 0.224 | 0.320 | 0.285 | 0.283 | 0.464 | 0.063 | 0.097 | 0.216 | 0.299 | 0.446 | 1.000 | -0.135 |
| 21 | Contextual Factors | -0.173 | -0.027 | 0.057 | -0.077 | 0.138 | -0.159 | -0.015 | -0.103 | -0.086 | -0.002 | -0.179 | -0.333 | 0.032 | 0.029 | 0.122 | -0.106 | -0.156 | -0.133 | -0.299 | -0.135 | 1.000 |

| Legend | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | -1 | -0.9 | -0.8 | -0.7 | -0.6 | -0.5 | -0.4 | -0.3 | -0.2 | -0.1 | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1 |
| | Very Strong Negative | | Strong Negative | | | Moderate Negative | | Weak Negative | | | Weak Positive | | | | Moderate Positive | | Strong Positive | | | Very Strong Positive | |

**Figure 6.** Correlation among the parameters (Source: author).

*4.2. Correlation between the Accessibility Score of the Five Cities and Footpath Width*

The average accessibility scores of the 5 cities and the average footpath widths, concerning their respective footpath stretches, were considered as the data associated with each of the 19 parameters. The dataset is shown in Table 5.

The correlation coefficient is −0.79, which indicates a strong negative relationship. Thus, it can be concluded that, in the historic cities, the footpaths with lesser widths have greater accessibility, which is rather unconventional. Future research can be conducted on discovering the reason behind this relationship.

*4.3. Major Findings*

In this research, the major findings are:

- Field-survey-based proof of the fact that the footpaths in the centers of historic urban areas in India are poor in terms of universal mobility. Thus, the degree of accessibility, as discussed in the Introduction section of this research, was understood based on these findings too;
- Analytical findings of the status of the different parameters of the footpath infrastructure in the historic cities of India.

This research is particularly beneficial for policymakers, since it will enable them to understand the weak survey parameters within a particular urban area, and thus be able to prioritize urban development from a survey-parameter-based perspective. Additionally, they will also be able to prioritize the weaker stretches if the development plans are focussed on spatial demarcation, rather than survey parameters. Thus, the improvement of universal mobility can be deterministic rather than probabilistic.

It is important to note that this research also had certain limitations, such as (a) including cognitive factors in the survey format, (b) including pedestrian count as a parameter in the research, and (c) comparing the research area in the historic part of the city with a relatively newer locality in the city. Further research in this field can be conducted by including these limitations in the already surveyed stretches, or by delineating a stretch in other historic cities in India, then verifying the hypothesis.

Although universal design can be best understood by people who have experienced some sort of disability, it is the ethical responsibility of every architect/planner/designer to provide an inclusive built environment [48,49]. If there were a Johari window [50] for streetscapes (considering "self" as the majority of able-bodied people), universal design would still be in the "unknown area" [51]. A multistakeholder approach might be fruitful in preparing a holistic accessibility plan for the centers of historic cities discussed in this research [52,53], especially with its users/citizens at the top of the stakeholder list [54].

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## Appendix A

Appendix A shows the tabulation of the data used in creating Figure 3.

| S. No. | Criterion | Indicator | Total Score | Maximum Score (Unit Score × No. of Samples) | Percentage (Total Score/Maximum Score × 100) |
|---|---|---|---|---|---|
| 1 | Building Typology of Stretch | (1) Buildings with two or more building uses | 5.72 | 34.50 | 16.58 |
| | | (2) Heritage/historic buildings | −2.49 | 34.50 | −7.23 |
| 2 | Footpath Dimension | (3) Footpath Width >2500 mm | −24.73 | 34.50 | −71.69 |
| | | (4) Unobstructed width of 1800 mm | −25.95 | 34.50 | −75.21 |
| | | (5) Unobstructed clear height of 2200 mm | 1.26 | 34.50 | 3.64 |
| 3 | Temporary Encroachment | (6) Informal Vendors/Beggar/homeless/child labor occurring during day/night | −13.00 | 34.50 | −37.68 |
| | | (7) Informal Vendors/hawkers away from the line of pedestrian flow (if Vendors are present) | 1.94 | 17.25 | 11.24 |
| | | (8) Beggar/homeless/child labor occupying a part of the footpath as their homes | 9.26 | 17.25 | 53.67 |
| 4 | Permanent Encroachment | (9) Place of religious interest (temple/churches/mosque) within or along the footpath? | 24.82 | 34.50 | 71.93 |
| | | (10) Encroachment by existing establishments on to the footpath | −18.41 | 34.50 | −53.38 |
| | | (11) 'Communal open bath' within or along the footpath | 34.38 | 34.50 | 99.64 |

| S. No. | Criterion | Indicator | Total Score | Maximum Score (Unit Score × No. of Samples) | Percentage (Total Score/Maximum Score × 100) |
|---|---|---|---|---|---|
| 5 | Bus Stop | (12) Informal stoppage for Bus | 28.09 | 34.50 | 81.43 |
| | | (13) Bus Shelter (if Bus Stops are present) | −14.57 | 17.25 | −84.44 |
| | | (14) Is 'Bus Shelter' functional (if Bus Shelter is present)? | −14.57 | 17.25 | −84.44 |
| 6 | Metro Rail Entrance | (15) Entrance connected to the footpath | 35.46 | 34.50 | 102.78 |
| | | (16) Is the Entrance functional (if Metro Rail Entrance is present) | −17.73 | 17.25 | −102.78 |
| 7 | Railings | (17) Railings (pedestrian guard rails) on the edge of the footpath | −32.34 | 34.50 | −93.74 |
| | | (18) Thorough railings with minimum 150 cm height and clear visibility (if Railings are present) | −18.25 | 17.50 | −104.29 |
| 8 | Storm Water Drains | (19) Storm Water Drains along footpath | 7.55 | 34.50 | 21.88 |
| | | (20) Functional Storm Water Drains (if Storm Water Drains are present) | −3.45 | 17.25 | −19.98 |
| 9 | Public Toilet (Restroom) | (21) Public Toilet within the footpath | −33.27 | 34.50 | −96.44 |
| | | (22) Functional Public Toilet (if Public Toilet is present) | −17.17 | 17.25 | −99.52 |
| 10 | Trash Bins | (23) Trash Bins within the footpath | −22.68 | 34.50 | −65.73 |
| | | (24) Functional Trash Bins (if Trash Bins are present) | −12.90 | 17.25 | −74.77 |
| | | (25) Trash Bins located away from the line of pedestrian flow (if Trash Bins present) | −15.59 | 17.25 | −90.35 |
| 11 | Streetlights | (26) Streetlights within the footpath | 27.75 | 34.50 | 80.44 |
| | | (27) Functional Street Lights (if Street Lights are present) | 13.32 | 17.25 | 77.22 |
| | | (28) Light Poles situated away from pedestrian flow or, if present, are demarcated with a tactile marking of a minimum of 60 cm around them (if Street Lights are present) | −10.29 | 17.25 | −59.63 |
| 12 | Flooring | (29) Satisfactory Cross Fall (i.e., <1:50) | −17.65 | 34.50 | −51.16 |
| | | (30) Tactile Marking | −27.12 | 34.50 | −78.60 |
| | | (31) Anti-skid/matte-finish tiles in footpath and Curb | 5.86 | 34.50 | 17.00 |
| 13 | Manholes | (32) Manholes within/along the footpath | 7.62 | 34.50 | 22.10 |
| | | (33) Drain-type manholes flush with the pavement surface (if Manholes are present) | 2.30 | 17.25 | 13.34 |
| | | (34) Grating-type manholes situated away from the pedestrian walkway (if Manholes are present) | −5.53 | 17.25 | −32.07 |
| 14 | Curb | (35) Curb on the edge of footpath | 30.09 | 34.50 | 87.21 |
| | | (36) Curb Height of no more than 150 mm from the road level (if Curb is present) | 8.16 | 17.25 | 47.29 |
| | | (37) Minimum 1200 mm width and tactile warning (if Curb is present) | −16.66 | 17.25 | −96.56 |
| | | (38) Cornered Curb radius more than 6 m (if Curb is present) | −14.03 | 17.25 | −81.30 |

| S. No. | Criterion | Indicator | Total Score | Maximum Score (Unit Score × No. of Samples) | Percentage (Total Score/Maximum Score × 100) |
|---|---|---|---|---|---|
| 15 | Pedestrian crossing | (39) 'At-grade' pedestrian crossing (MID-BLOCK crossing) at all intersections along the walkway | −32.32 | 34.50 | −93.67 |
| | | (40) Signalized Intersection (if Crossing is present) | −14.57 | 17.25 | −84.44 |
| | | (41) Functional Signalized Intersection (if Crossing is present) | −13.53 | 17.25 | −78.42 |
| | | (42) Audio Signal (if Crossing is present) | −17.71 | 17.25 | −102.66 |
| 16 | Street furniture | (43) Street Furniture in the footpath | −31.15 | 34.50 | −90.28 |
| | | (44) Street furniture having a knee clearance of a minimum of 70 cm and wheelchair space of 100 cm (if Street Furniture is present) | −17.73 | 17.25 | −102.78 |
| 17 | Safety and Security | (45) Fire Hydrant | −35.46 | 34.50 | −102.78 |
| | | (46) Security Camera | −10.13 | 34.50 | −29.35 |
| 18 | Additional Inclusive features | (47) Signage | −16.52 | 34.50 | −47.89 |
| | | (48) Bicycle Track | −34.42 | 34.50 | −99.77 |
| | | (49) Public Drinking Water Facility | −34.35 | 34.50 | −99.58 |
| | | (50) Street Art/Sculpture | −32.30 | 34.50 | −93.61 |
| 19 | Contextual Factors | (51) Is the surveyed location within a high-pedestrian zone? | −36.50 | 34.50 | −105.80 |
| | | (52) Is/are there any other contextual factors such as potholes, parking, etc., affecting the high-pedestrian zone? | 2.98 | 17.25 | 17.28 |

## Appendix B

Appendix B shows the tabulation of the data used in creating Figure 4.

| Footpath Number | Score of Each Stretch out of 16.5 | Percentage |
|---|---|---|
| 1 | −7.5 | −45.45 |
| 2 | −11 | −66.67 |
| 3 | −9.5 | −57.58 |
| 4 | −10 | −60.61 |
| 5 | −10 | −60.61 |
| 6 | −10.5 | −63.64 |
| 7 | −12 | −72.73 |
| 8 | −5.5 | −33.33 |
| 9 | −6.5 | −39.39 |
| 10 | −3.5 | −21.21 |
| 11 | −8 | −48.48 |
| 12 | −9 | −54.55 |
| 13 | −6 | −36.36 |
| 14 | −8 | −48.48 |
| 15 | −1.5 | −9.09 |
| 16 | −3 | −18.18 |
| 17 | −2.5 | −15.15 |
| 18 | −10.5 | −63.64 |
| 19 | −2 | −12.12 |
| 20 | −3 | −18.18 |
| 21 | −3.5 | −21.21 |
| 22 | −1.5 | −9.09 |
| 23 | −1.5 | −9.09 |
| 24 | −2.5 | −15.15 |
| 25 | −4.5 | −27.27 |
| 26 | −3 | −18.18 |
| 27 | −9 | −54.55 |
| 28 | −7.5 | −45.45 |

| Footpath Number | Score of Each Stretch out of 16.5 | Percentage |
|---|---|---|
| 29 | −6.5 | −39.39 |
| 30 | −11 | −66.67 |
| 31 | −8.5 | −51.52 |
| 32 | 2.5 | 15.15 |
| 33 | −7.5 | −45.45 |
| 34 | −7 | −42.42 |
| 35 | −10.5 | −63.64 |
| 36 | −3.5 | −21.21 |
| 37 | −15 | −90.91 |
| 38 | −15 | −90.91 |
| 39 | −14 | −84.85 |
| 40 | 0.5 | 3.03 |
| 41 | 2 | 12.12 |
| 42 | −9.5 | −57.58 |
| 43 | −1.5 | −9.09 |
| 44 | −9.5 | −57.58 |
| 45 | −4 | −24.24 |
| 46 | −2.5 | −15.15 |
| 47 | −2.5 | −15.15 |
| 48 | −4 | −24.24 |
| 49 | −3.5 | −21.21 |
| 50 | −4 | −24.24 |
| 51 | −8 | −48.48 |
| 52 | −5.5 | −33.33 |
| 53 | −5 | −30.30 |
| 54 | −6 | −36.36 |
| 55 | −6 | −36.36 |
| 56 | −6 | −36.36 |
| 57 | −5.5 | −33.33 |
| 58 | −5 | −30.30 |
| 59 | −6.5 | −39.39 |
| 60 | −5.5 | −33.33 |
| 61 | −6 | −36.36 |
| 62 | −6 | −36.36 |
| 63 | −8.5 | −51.52 |
| 64 | −8 | −48.48 |
| 65 | −7.5 | −45.45 |
| 66 | −7.5 | −45.45 |
| 67 | −7.5 | −45.45 |
| 68 | −7.5 | −45.45 |
| 69 | −7.5 | −45.45 |

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## Appendix 5: 4th Peer reviewed referred journal publication

**G. Das Mahapatra**, S. Mori, and R. Nomura, 'Interpreting Universal Mobility in the footpaths of urban India based on experts' opinion,' *Sustainability*, vol. 15, no. 4, p. 3625, Feb. 2023, doi 10.3390/su15043625. [Impact Factor = 3.9; Citations = 2 (as of July 2023)]

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Article

# Interpreting Universal Mobility in the Footpaths of Urban India Based on Experts' Opinion

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MDPI

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# Interpreting Universal Mobility in the Footpaths of Urban India Based on Experts' Opinion

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**Abstract:** In this research, expert opinions on universal mobility in the footpaths of urban India have been critically appraised. Universal mobility (as a component of universal design) is still a largely ignored urban parameter in India despite an increase of 732.20% in the specially-abled and 105.25% in the elderly between 1911 and 2011. A total of 257 experts from the field of architecture and planning hailing from 66 cities in India were interviewed for this research. It was found that despite nationally implemented universal design guidelines, footpaths in 42.8% of the cities do not have universal mobility. In total, 74.7% of the respondents identify the dimension of the footpath as the most important factor for implementing universal mobility. The results of this study indicate the importance of universal design in improving the quality of life in Indian cities, and how urban local bodies can play a significant role in the process by using Public Private Partnership (hereafter, PPP) models and a new accessibility audit checklist.

**Keywords:** universal mobility; footpath; specially-abled; elderly; expert opinion; urban India

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## 1. Introduction

The development of the universal design approach in architectural planning began as mere principles [1], which developed into a progressive idea [2], and finally transformed into an interdisciplinary medium with the advent of global initiatives such as the United Nations Convention on the Rights for Persons with Disabilities (or UNCRPD) [3]. United Nations have affirmed that from a social standpoint, inclusiveness is an essential component in achieving sustainability. Especially after the inception of the United Nations Sustainable Development Goals (hereafter, UN-SDG), the need to implement equitable design is a mandate for member nations such as India. In particular, indicators 11.2.1 and 11.7.1 within targets 11.2 and 11.7 of the UN-SDG emphasise making the public spaces and transportation system accessible to all, with additional focus on the elderly and specially-abled [4,5]. This approach is particularly substantial in the 21st century due to an estimated 15% specially-abled global population [6], and an expected rise in the global elderly population to almost 16% in the year 2050, up from 6% in 1900 [7]. Thus, ensuring accessibility in the built environment is inevitable to ensure sustainability within the global context, especially when researchers have validated that ignorance towards disability is a hindrance towards sustainable development [8].

To make public spaces and transportation systems accessible to all, mobility is the foremost concern. When universal design considerations are incorporated into the mobility sector, the term 'universal mobility' evolves. Along similar lines, Ormerod and Newton (2011) have explained the need to go beyond the service level benchmarks in universal mobility and seek a contextual approach [9] because significant theoretical and practical gaps exist even after years of research [10]. This research seeks to explore the contextuality of universal mobility in the footpaths of urban India from the opinion of experts from India.

### *1.1. Background*

Whipping, chaining, and starving to death were communal activities to which the specially-abled were subjected to until at least the 4th Century CE. Most of these cases in Aegean, Pagan, or other evolved religions were under the impression that any form of disability is a direct form of punishment by God to human beings. In other cases, specially-abled people were also forced to beg or were tactically used as court clowns (jesters) [11]. After this stage, from the 5th to 13th centuries CE, the torture towards specially-abled people also included death sentences by immersing in boiling water or oil [12]. Almost 8 million biological mothers of specially-abled children were labelled as witches before being ceremoniously killed during the period between the 14th to 17th centuries CE in Europe alone. Rather ironically, this period (14–17th century) was known as the Renaissance period, and was characterized by political, cultural, architectural, and social awakening [13]. The following period in history, from the 18th to 19th centuries CE, was known as the Industrial Revolution, which saw some relaxation in terms of torture towards the specially-abled. However, the needs and problems of the cognitively impaired were still largely ignored [14]. Even in modern-day USA, before the advent of the Americans with Disabilities Act (ADA) in 1990, there were discriminatory acts such as the Ugly Act, which advocated for the removal of ugly and disabled beggars from the streets; the last convicted specially-abled person in this case was as recent as 1974. The USA also had a judicial rule of two-year imprisonment for specially-abled people in case they have physical intimacy or engage in marriage [15]. Even in terms of etymology, specially-abled people are often addressed as handicapped, disabled, differently-abled, and even persons with a disability [16].

Indian society has seen specially-abled people from a different viewpoint from times immemorial. Being a society inspired by culture and mythology, stories that showed people losing their mobility or vision due to the act of sinning cultivated an ill feeling about disability amongst citizens [17,18]. Only after 1947 (independence from the torturous British empire), the implementation of Article 15 empowered the marginalized by removing any restriction whatsoever from using public (government-owned or supported) facilities based on disability [19].

### *1.2. Demography*

Between 1891–1991, the population of India has grown by 192% (from 287,179,715 in 1881 to 838,567,936 in 1991) [20,21]. The subsequent decadal growth from 1991 to 2001 has been 22.66%, followed by 17.22% from 2001 to 2011 (referring to 1,028,610,328 in 2001 and 1,210,854,977 in 2011) [22]. However, between 1891–1991, the disabled population of India grew by 1546.75% (from 856,252 in 1881 to 14,100,344 in 1991) [23]. The subsequent decadal growth from 1991 to 2001 has been 55.36%, followed by 22.41% from 2001 to 2011 (referring to 21,906,769 in 2001 and 26,814,99 in 2011). In addition to this, between 1891–1991, the elderly population of India has grown by 737.32% (from 6,769,435 in 1881 to 56,681,640 in 1991). The subsequent decadal growth from 1991 to 2001 has been 35.18%, followed by 35.18% from 2001 to 2011 (referring to 76,622,321 in 2001 and 103,849,040 in 2011).

Even if factors such as changing the categorization of disabilities, omission of disability in certain censuses, lack of adequate surveying, and changing land boundaries are taken into consideration, it is still evident that the growth percentages in the number of disabled and elderly people has been phenomenal in comparison to the overall population growth of India.

### *1.3. Indian Statutory Guidelines*

Thus, in the wake of the changing demographics, there have been several guidelines, policies, acts, rules, regulations, notifications, and schemes to facilitate differently-abled people and the elderly, especially in the fields of architecture, civil engineering, and planning (as mentioned in Table 1). However, these guidelines have not been able to bring about a radical change in universal mobility vis-à-vis the universal design paradigm of urban India due to multiple administrative reasons [24].

**Table 1.** Indian guidelines related to inclusiveness (Source: Author).

| S. No. | Year | Indian Guidelines | Implementing Agency (Within Government of India) |
|---|---|---|---|
| 1 | 1950 | Constitution of India, Article 15 | Ministry of Law and Justice, Government of India |
| 2 | 1968 | IS 4963; Recommendations for Buildings and Facilities for the Physically Handicapped. Bureau of Indian Standards: New Delhi, India, 1968 [25] (Revised in 1987) | Bureau of Indian Standards (Ministry of Housing and Urban Affairs) |
| 3 | 1970 | National Building Code of India (Revised in 1983, 2005, 2016) | Bureau of Indian Standards |
| 4 | 1983 | IS 7419; Requirements for stairs for physical rehabilitation. Bureau of Indian Standards: New Delhi, India, 1983 [26] (First Revision) | Bureau of Indian Standards |
| 5 | 1987 | The Mental Health Act | Legislative Department, Ministry of Law and Justice |
| 6 | 1991 | IS 8086; Rehabilitation Equipment-Wheelchairs, folding, junior size-Specification. Bureau of Indian Standards: New Delhi, India, 1991 [27] (First Revision) | Bureau of Indian Standards |
| 7 | 1992 | Rehabilitation Council of India Act (Amended in 2000) | Ministry of Law Justice and Company Affairs |
| 8 | 1995 | Persons with Disabilities (Equal Opportunities, Protection of Rights and Full Participation) Act (Replaced in 2017 after RPwD Act) | Department of Empowerment of Persons with disabilities, Ministry of Social Justice and Empowerment |
| 9 | 1997 | Rehabilitation Council of India (Standards of Professional Conduct, Etiquette and Code of Ethics for Rehabilitation Professionals) Regulations (Revised in 1998) | Department of Empowerment of Persons with disabilities, Ministry of Social Justice and Empowerment |
| 10 | 1998 | Guidelines and Space standards for Barrier Free Built Environment for Disabled and Elderly persons | Central Public Works Department, Ministry of Urban Affairs and Employment, |
| 11 | 1999 | The National Trust for Welfare of Persons with Autism, Cerebral Palsy, Mental Retardation and Multiple Disability Act | Legislative Department, Ministry of Law, Justice and Company Affairs |
| 12 | 2000 | The National Trust for Welfare of Persons with Autism, Cerebral Palsy, Mental Retardation and Multiple Disability Rules (Amended in 2010, 2015) | Ministry of Social Justice and Empowerment |
| 13 | 2001 | The National Trust for Welfare of Persons with Autism, Cerebral Palsy, Mental Retardation and Multiple Disability Regulations | Ministry of Social Justice and Empowerment |
| 14 | 2001 | Board of Trust Regulations (Amended in 2004, 2006, 2010, 2017) | Department of Empowerment of Persons with disabilities, Ministry of Social Justice and Empowerment |
| 15 | 2001 | Planning a Barrier Free Environment | Office of the Chief Commissioner, People with Disability |
| 16 | 2006 | National Policy for Persons with Disabilities | Ministry of Social Justice and Empowerment |
| 17 | 2009 | National Action Plan on Business and Human Rights | Ministry of Corporate Affairs |
| 18 | 2012 | Guidelines for Pedestrian Facilities (IRC: 103–2012) | Indian Roads Congress |
| 19 | 2012 | Manual on Disability Statistics | Central Statistics Office, Ministry of Statistics and Programme Implementation |
| 20 | 2014 | Handbook of Barrier Free and Accessibility | Central Public Works Department |
| 21 | 2014 | The Rights of Persons with Disabilities Bill | Legislative Department, Ministry of Law and Justice |
| 22 | 2015 | Accessible India Campaign | Department of Empowerment of Persons with Disabilities, Ministry of Social Justice and Empowerment |

**Table 1.** *Cont.*

| S. No. | Year | Indian Guidelines | Implementing Agency (Within Government of India) |
|---|---|---|---|
| 23 | 2015 | First Country Report on the Status of Disability in India (Submitted in pursuance of Article 35 of the UN Convention on the Rights of Persons with Disabilities) | Department of Empowerment of Persons with Disabilities, Ministry of Social Justice and Empowerment |
| 24 | 2016 | Harmonized guidelines and space standards for Barrier Free Built Environment for People with Disability and Elderly Persons | Ministry of Urban Development |
| 25 | 2016 | The Rights to Persons with Disability (RPwD) Act (enacted on 28.12.2016, came into force from 19.04.2017) | Ministry of Law and Justice |
| 26 | 2016 | Elderly in India | Social Statistics Division, Central Statistics Office, Ministry of Statistics and Programme Implementation |
| 27 | 2016 | Disabled persons in India-A Statistical Profile | Social Statistics Division, Ministry of Statistics and Programme Implementation |
| 28 | 2017 | Rights of Persons with Disabilities Rules (Amended 2020) | Department of Empowerment of Persons with disabilities, Ministry of Social Justice and Empowerment |
| 29 | 2017 | Parallel Report of India on the Convention on the Rights of Persons with Disabilities (CRPD) | National Disability Network (NDN) and National Committee on the Rights of Persons with Disabilities (NCRPD) |
| 30 | 2019 | CPWD Works Manual 2019 (including Standard Operating Procedures) | Central Public Works Department |
| 31 | 2020 | Building Accessible, Safe, and Inclusive Indian Cities (BASIIC) | National Institute of Urban Affairs (NIUA) in collaboration with Ministry of Housing and Urban Affairs (MoHUA) |
| 32 | 2021 | Harmonised Guidelines and Standards for Universal Accessibility in India 2021 (Revised in 2022) | Ministry of Housing and Urban Affairs |

### *1.4. Research Methodology*

These guidelines are published by government agencies, but often involve experts from the field of architecture, civil engineering, and urban planning, including experts such as academics, practitioners, and government officials. Thus, this research involves the following experts: academics (professor, associate professor, assistant professor, and Ph.D. scholar in architecture/planning), practitioners (practising architects, practising planners, and architects or planners working in private establishments), and government officials related to architecture/planning. The research questions for this research are:

- Which factors of universal mobility should be prioritized during a renewal/greenfield project related to footpaths in urban India?
- Which sector of administration should focus on decision-making related to statutory administration related to footpaths in urban India?
- What genre of urban development should be used in the case of implementing universal mobility in footpaths in urban India?

The survey and data collection were done digitally by explaining the intent and content of the research with the link to the questionnaire attached digitally using the following mediums:

- Sending electronic mail (e-mail) to the academics (professors, associate professors, assistant professors, and research scholars). The contacts of the respondents in this category were acquired from the websites of the universities that are recognized by the Council of Architecture or COA (available at https://www.coa.gov.in/institutionStatus.php, accessed on 7 February 2023) and Institute of Town Planners, India or

ITPI (available at https://www.itpi.org.in/uploads/pdfs/2-provisional-list-of-schools-Institutions-and-universitites-planning-courses-approved-by-itpi.pdf, accessed on 6 February 2023).

- Sharing via social media platforms, which comprises a large share of Indian architects (licenced from the COA) or Indian planners (registered with ITPI); for example, 'Conscious Urbanism', 'The Switch', 'Planning India', etc. This approach has helped to gather responses from practising architects, practising planners, and architects or planners working in private establishments.
- Contacting government officials through personal connections established by the corresponding author in India, such as the Delhi Development Authority and Public Works Department in the Government of West Bengal.

The questionnaire used in this research is available at https://forms.gle/bmDVHMcFQpxwzSUs5 (accessed on 6 February 2023) and the questions are also mentioned in Table 2. The questionnaire was shared with the respondents online using Google forms from 14th October 2021 to 17th November 2022. A sample of the filled questionnaire is available in Appendix A of this paper.

**Table 2.** Questionnaire used in this research (Source: author).

| S. No | Category | Question | Options |
|---|---|---|---|
| 1 | *Respondent details* | Name | N/A |
| 2 | | Affiliated Institute (Presently Engaged/ Last Academic Institute/ Own Company) | N/A |
| 3 | | Designation | • Professor<br>• Associate professor<br>• Assistant professor<br>• Ph.D. scholar in architecture/ planning<br>• Practicing architect<br>• Practicing planner<br>• Architects or planners working in private establishments<br>• Government official |
| 4 | | Name one Indian City (where you are born/ working/ educated) | N/A |
| 5 | | The above-mentioned City falls in which State/ Union Territory of India? | N/A |
| 6 | *Universal Design* | Are the footpaths in your above-mentioned city Universally Designed? | • No, not at all Universally Designed<br>• Partially Universally Designed<br>• Yes, Completely Universally Designed |
| 7 | | Which is the major obstacle in the implementation of Universal Design in the pedestrian areas of your city? | • Central Government<br>• State Government<br>• Urban Local Body<br>• Private enterprises/organizations<br>• Residents of your city |
| 8 | | How much would you rate the impact of Universal Design on Indian Urban Quality of Life? | Likert Scale (On a scale of 1–10; 1 being least significant and 10 being most significant) |
| 9 | | Is there a need for the involvement of Private establishments or PPP models in the field of Universal Design in Urban India? | • Yes<br>• No |

**Table 2.** *Cont.*

| S. No | Category | Question | Options |
|---|---|---|---|
| 10 | *Accessibility Audit* | Do you think that the Accessibility Audit checklists presently available in India are completely adequate for assessing accessibility in Urban India? | • Yes<br>• No |
| 11 | | Do we need separate Universal Design guidelines for Old Cities and New Cities in India | • Yes<br>• No |
| 12 | *Universal Mobility* | On a scale of 1–10, how important is universal mobility in realizing Universal Design in Urban India? | Likert Scale (On a scale of 1–10; 1 being least significant and 10 being most significant) |
| 13 | | Is the authentication of a theoretical model important for ensuring the universal mobility scenario in Urban India? | • Yes<br>• No |
| 14 | | Is prioritizing stretches in Old Indian cities (like a pilot project) important for ensuring better implementation of universal mobility? | • Yes<br>• No |
| 15 | | On a scale of 1–10, what is the importance of Cognitive Elements (like Temperature, Sound, Texture, Landmarks, etc.) in ensuring universal mobility? | Likert Scale (On a scale of 1–10; 1 being least significant and 10 being most significant) |
| 16 | | Mark any 05 (ONLY FIVE) of the MOST IMPORTANT of the factors while assessing universal mobility for pedestrians in Old Cities of India | Adjacent Building Typology (Mixed Use and Historic Buildings); Dimension of the Footpath (Clear width and height); Temporary Encroachment (Informal Vendors, Beggars, Homeless and Child Labours); Permanent Encroachment (Places of Religious Interest, Business Establishments and Open Bath); Transport Stops (Bus Stop, Metro Rail Entrance, etc.); Railings (Pedestrian Guard Rails); Storm Water Drains; Public Toilets; Trash Bins (Garbage Bin); Streetlights; Flooring (Surface Finish); Manholes (Drain-Type and Grating-Type); Kerb; Pedestrian Crossing (Signalized Crossing and Audio-assistance); Street Furniture; Safety and Security (Fire Hydrant and Security Camera); Additional Inclusive Features (Signage, Bicycle Track, Public Drinking Water Facility, and Street Art); Contextual Factors (like Topography, etc.) |

The research methodology for this paper is in three major parts: (a) research background, (b) primary survey, and (c) findings.

The research background consists of an understanding of topics such as the global need for universal mobility, the social model of disability, demographic studies, and statutory guidelines, all of which have been discussed in Section 1–Part a, b, and c. The primary survey involves the survey of 257 experts from 21 states and 1 union territory in India. The findings of the primary survey are elaborated on in Sections 2.2.1–2.2.11.

The findings of this research suggest answers to the primary questions mentioned in the methodology: (a) Which factors to prioritize? (b) Which sector of administration to focus on? (c) What genre of urban development to opt for? The findings are elaborated on in Section 3 and further discussed in Section 4 of this paper. The research methodology used in this paper is illustrated in Figure 1.

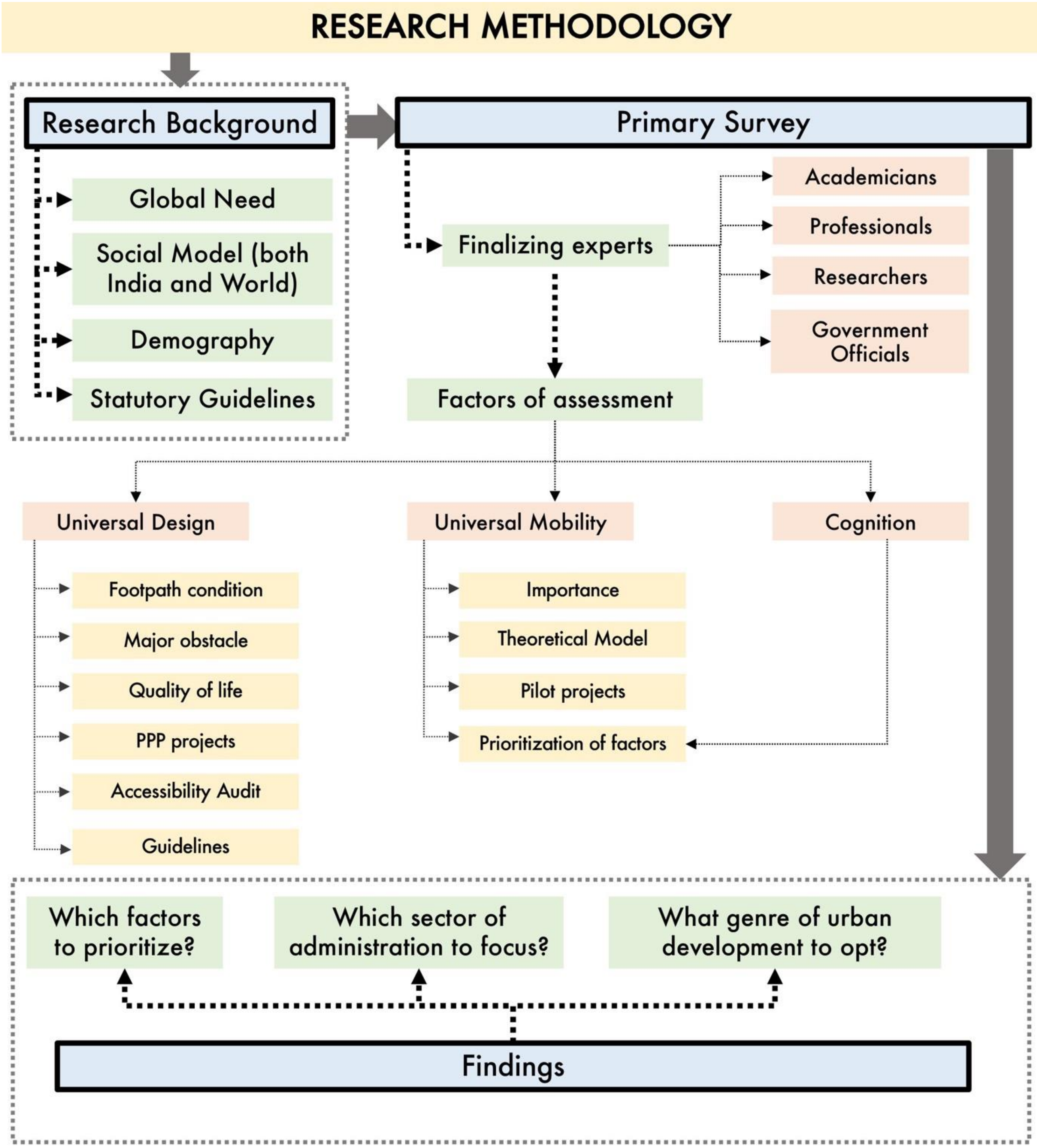


**Figure 1.** Research Methodology (Source: Author).

## 2. Materials and Method

### 2.1. Sample Description

#### 2.1.1. The Expertise of the Respondents

In this study, 257 experts were chosen from the fields of architecture and planning. The compositions of the respondents are as follows: professors (26 nos.), associate professors (22 nos.), assistant professors (57 nos.), Ph.D. scholars in architecture/ planning (21 nos.), practicing architects (58 nos.), practicing planners (27 nos.), government officials related to architecture/planning (12 nos.), and architects or planners working in private establishments (34 nos.). Figure 2 shows the percentage share of each category of respondents.

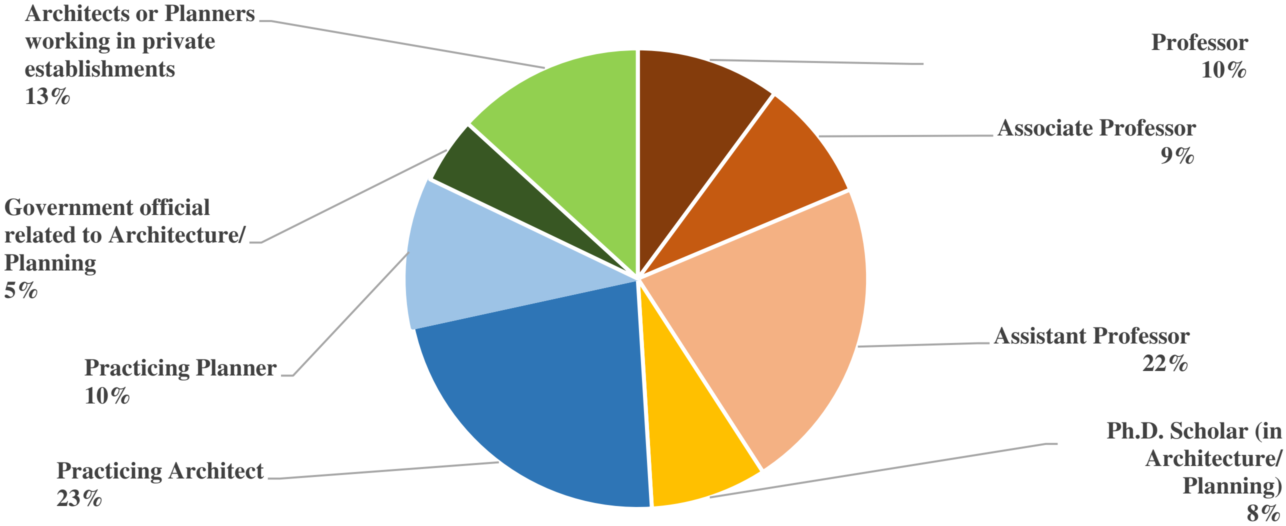


**Figure 2.** The percentage share of each category of respondents (Source: Author).

#### 2.1.2. Geographical Distribution

The respondents for the primary survey in this research were from 21 out of 28 states and 1 out of 8 union territories in India. The compositions of the respondents across the states (in alphabetical order) are as follows: Andhra Pradesh (11 nos.), Assam (6 nos.), Bihar (3 nos.), Chhattisgarh (2 nos.), Gujarat (2 nos.), Haryana (8 nos.), Jammu and Kashmir (1 no.), Jharkhand (2 nos.), Karnataka (8 nos.), Kerala (6 nos.), Madhya Pradesh (17 nos.), Maharashtra (17 nos.), Odisha (30 nos.), Punjab (5 nos.), Rajasthan (1 no.), Tamil Nadu (15 nos.), Telangana (9 nos.), Tripura (1 no.), Uttar Pradesh (17 nos.), Uttarakhand (1 no.), and West Bengal (68 nos.). In addition to this, 27 respondents were from the union territory of the National Capital Territory (or NCT) of Delhi. Figure 3 shows the distribution of the respondents across India.

### *2.2. Survey Observations*

#### 2.2.1. Universal Design in Indian Footpaths (Data Type: Ordinal Data)

The respondents were asked about the status of universal design in the footpaths of their respective cities. Only 2.72% (7 nos.) of the respondents said that the footpaths were completely universally designed and 42.80% (110 nos.) of the respondents said that the footpaths were partially universally designed; in contrast, 54.47% (140 nos.) of the respondents confirmed that the footpaths were not at all universally designed.

#### 2.2.2. The Major Obstacle in the Implementation of Universal Design (Data Type: Ordinal Data)

A total of 135 respondents felt that the major obstacle in the implementation of universal design in their city is an urban local body. Following this, 50 respondents blamed residents, 39 respondents accused the state government, 22 respondents attributed private enterprises/organizations, and 11 respondents thought the central government were the major obstacle in the implementation of universal design in their city. Figure 4 shows the percentage share of each category of respondents.

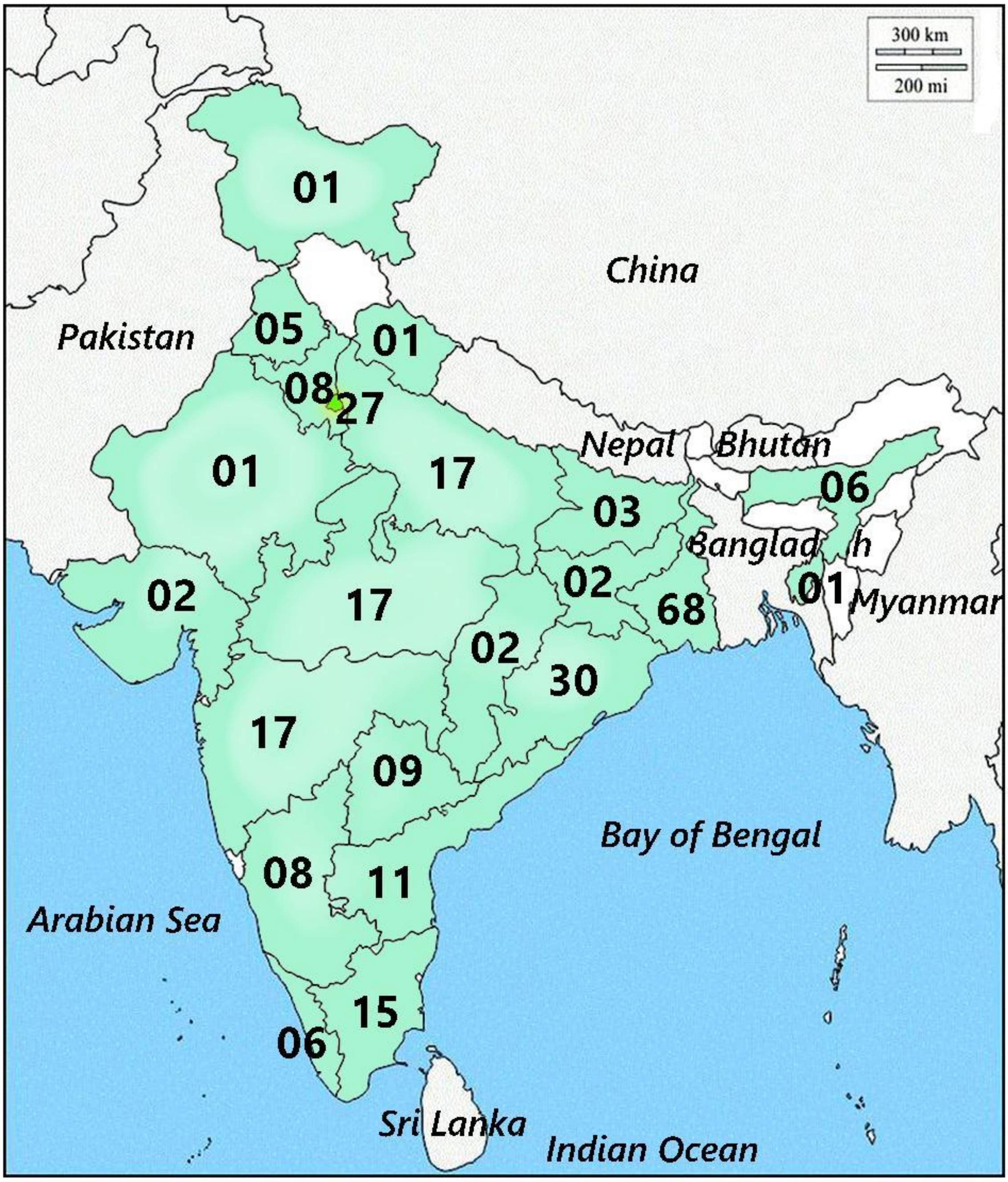


**Figure 3.** Distribution of the respondents across India. The numbers in each state mention the share of respondents from each state (Source: Author).

2.2.3. Impact of Universal Design on Urban Quality of Life (Data Type: Ordinal Data)

More than 74% of the respondents allocated a score of 7 or more when the respondents were asked to rate the impact of universal design on Indian urban quality of life on a scale of 1–10 (1 being least significant and 10 being most significant). Figure 5 shows the distribution of the respondents regarding the impact of universal design on urban quality of life.

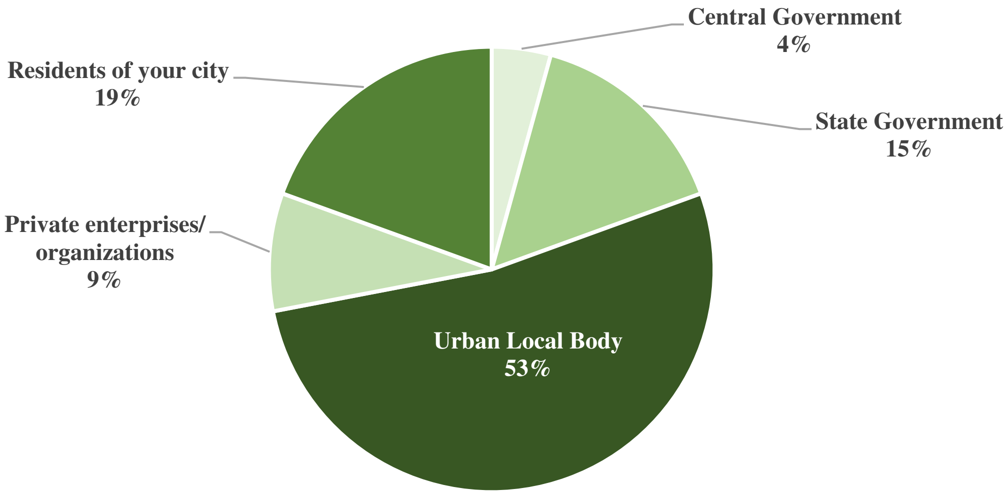


**Figure 4.** Percentage of the respondents regarding major obstacles in the implementation of Universal Design (Source: Author).

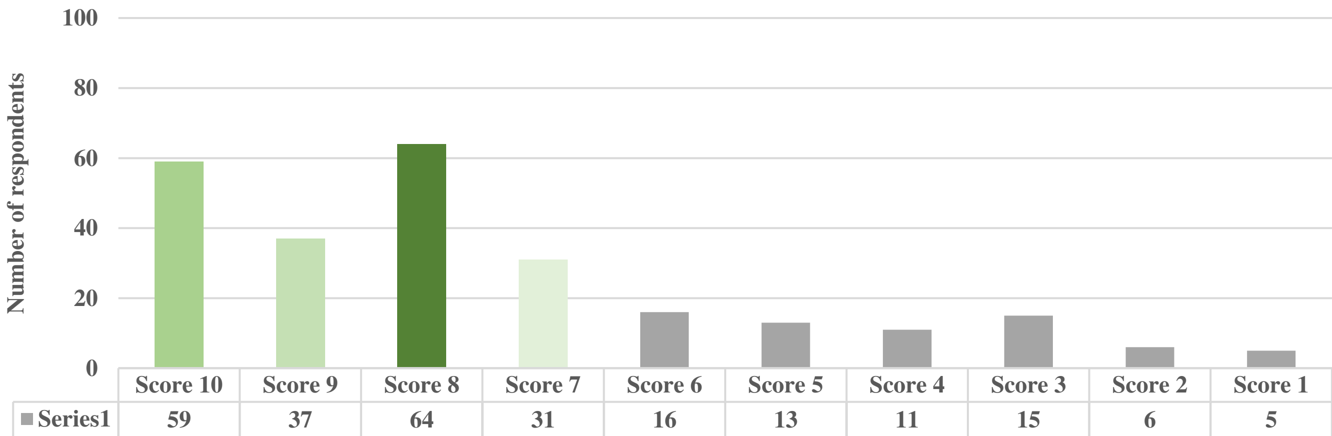


**Figure 5.** Distribution of the respondents regarding the impact of universal design on urban quality of life. The green shades emphasize the respondents who have scored 7 and above (Source: Author).

The median score for academics (professors, associate professors, assistant professors, and researchers) and practitioners (architects, planners, and private employees) is 8. However, the median score for government officials is 9.

#### 2.2.4. Need for the Involvement of Private Establishments or PPP Models in the Field of Universal Design (Data Type: Nominal Data)

A total of 91.44% of respondents (235 respondents) confirmed that there is a need for the involvement of PPP models in the field of universal design in urban India.

#### 2.2.5. Adequacy of Accessibility Audit Checklists in India (Data Type: Nominal Data)

A total of 80.93% of respondents (208 respondents) stated that the accessibility audit checklists presently available in India are not completely adequate for assessing accessibility in urban India.

#### 2.2.6. Separate Universal Design Guidelines for Old Cities and New Cities (Data Type: Nominal Data)

A total of 94.55% of respondents (243 respondents) are of the opinion that there is a need for separate universal design guidelines for old cities and new cities in India.

#### 2.2.7. Importance of Universal Mobility in Realizing Universal Design in Urban India (Data Type: Ordinal Data)

More than 91% of the respondents apportioned a score of 7 or more when the respondents were asked to rate the importance of universal mobility in realizing universal design in urban India on a scale of 1–10 (1 being least significant and 10 being most significant). Figure 6 shows the distribution of the respondents regarding the impact of universal design on urban quality of life.

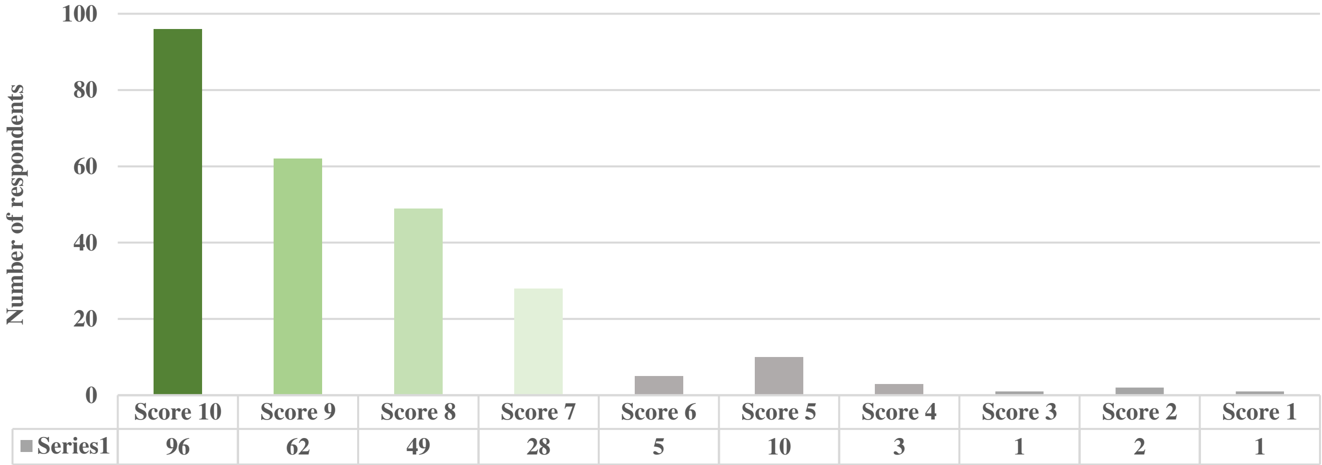


**Figure 6.** Distribution of the respondents regarding the importance of universal mobility in realizing universal design in urban India. The green shades emphasize the respondents who have scored 7 and above (Source: Author).

The median score for academics (professors, associate professors, assistant professors, and researchers) and practitioners (architects, planners, and private employees) is 9. However, the median score for government officials is 10.

#### 2.2.8. Authentication of a Theoretical Model Is Important for Ensuring the Universal Mobility Scenario (Data Type: Nominal Data)

A total of 87.16% of respondents (224 respondents) confirmed that authentication of a theoretical model is important for ensuring the universal mobility scenario in urban India.

#### 2.2.9. Prioritizing Stretches in Old Indian Cities (Pilot Project) Is Important for Ensuring Better Implementation of Universal Mobility (Data Type: Nominal Data)

A total of 96.50% of respondents (248 respondents) established that prioritizing stretches in old Indian cities (such as a pilot project) is important for ensuring better implementation of universal mobility.

#### 2.2.10. Importance of Cognitive Elements (Temperature, Sound, Texture, Landmarks, etc.) in Ensuring Universal Mobility (Data Type: Ordinal Data)

Nearly 86% of the respondents allocated a score of 7 or more when the respondents were asked to rate the importance of cognitive elements (temperature, sound, texture, landmarks, etc.) in ensuring universal mobility on a scale of 1–10 (1 being least significant and 10 being most significant). Figure 7 shows the distribution of the respondents regarding the importance of cognitive elements (temperature, sound, texture, landmarks, etc.) in ensuring universal mobility.

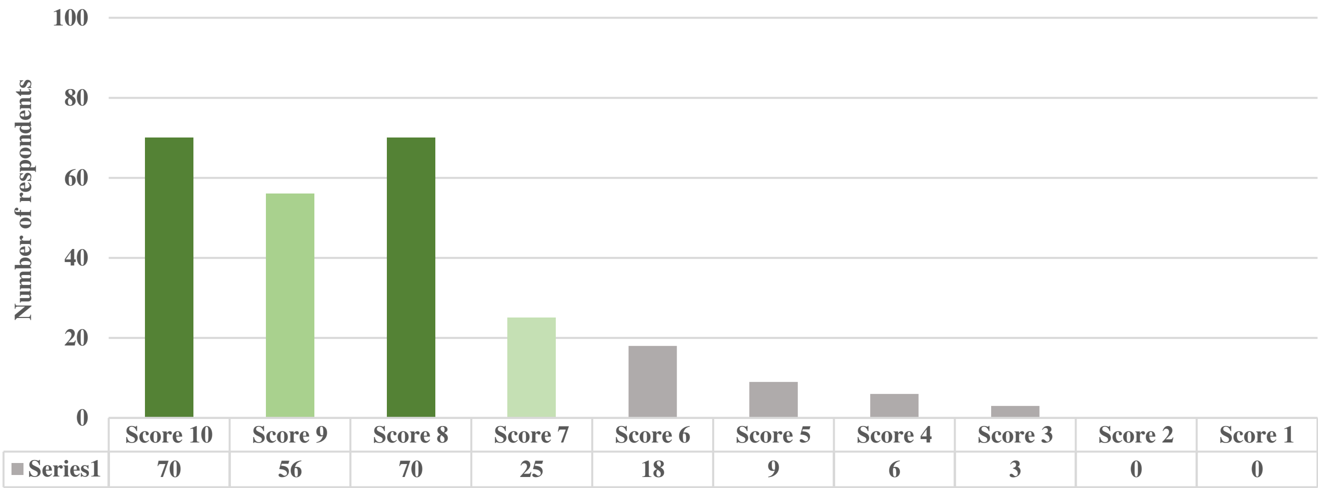


**Figure 7.** Distribution of the respondents regarding the importance of cognitive elements (temperature, sound, texture, landmarks, etc.) in ensuring universal mobility. The green shades emphasize the respondents who have scored 7 and above (Source: Author).

The median score for academics (professors, associate professors, assistant professors, and researchers) and government officials is 8. However, the median score for practitioners (architects, planners, and private employees) is 9.

#### 2.2.11. Factors of Universal Mobility (Cognitive. Prioritization, etc.)

The respondents were asked to mark any 5 (only five) of the most important of the factors while assessing universal mobility for pedestrians in old cities in India. The respondents were given a choice from eighteen factors, as mentioned in Appendix A (Question Number 5a).

A total of 50.58% (130 nos.) of the respondents ranked the 'dimension of the footpath (Clear width and height)' as the most important question of the factors while assessing universal mobility for pedestrians in old cities in India, while 35.41% (91 nos.) of the respondents ranked adjacent building typology (mixed-use and historic buildings). Other respondents preferred: temporary encroachment (informal vendors, beggars, homeless and child labours), 5.06% (13 nos.); transport stops (bus stop, metro rail twist entrance, etc.), 3.50% (9 nos.); railings (pedestrian guard rails), 2.72% (7 nos.); permanent encroachment (places of religious interest, business establishments and open baths), 1.56% (4 nos.); storm water drains, 0.78% (2 nos.) and public toilets, 0.39% (1 no.). Figure 8 shows the distribution of respondents in choosing the first and most important of the factors. None of the respondents opted for trash bins (garbage bin), street lights, flooring (surface finish), manholes (drain-type and grating-type), kerb, pedestrian crossing (signalised crossing and audio assistance), street furniture, safety and security (fire hydrant and security camera), additional inclusive features, signage, bicycle track, public drinking water facilities, street art, and contextual factors (such as Topography, etc.).

### *2.3. Data Validation*

Although there are differences in the opinion between different categories of respondents, there is a need to validate the internal consistency of the data collected so that this research can validate the opinions of the experts to be used in policymaking. Thus, Cronbach's Alpha was used for this purpose. Because the respondents are already categorized into (1) academics (professors, associate professors, assistant professors, and researchers), (2) practitioners (architects, planners, and private employees), and (3) government officials, the next steps are explained hereafter. Because there are 3 types of questions in the survey format, the first step was to categorise them into Multiple Choice

(Sections 2.2.1 and 2.2.2), Likert Scale (Sections 2.2.3, 2.2.7, 2.2.10 and 2.2.11) and Dichotomous (Sections 2.2.4–2.2.6, 2.2.8 and 2.2.9).

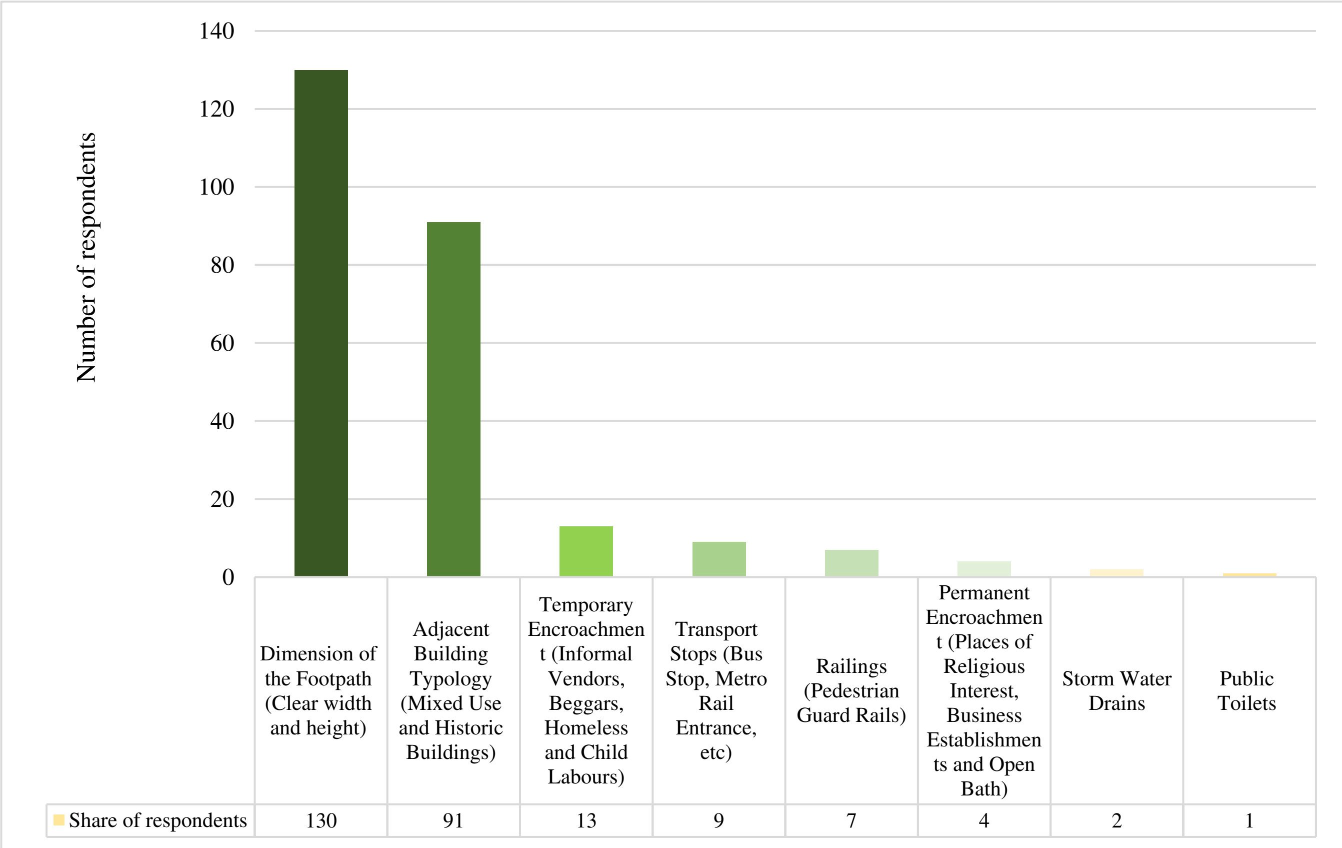


**Figure 8.** Distribution of the respondents regarding the most important of factors while assessing universal mobility for pedestrians in old cities of India (Source: Author).

To analyse the distribution of respondents: (1) the first choice of the respondents was the factor used for the multiple-choice type questions; (2) the majority choice of the responses was the factor used for the dichotomous type questions; (3) respondents who selected the score of 7 and above were the factor used for Likert Scale-type questions. As an example, for Section 2.2.1, among the 140 respondents who selected that the footpaths in their city are not at all universally designed, (1) 54.35% (69 nos.) were academics, (2) 55.46 (66 nos.) were practitioners, and (3) 41.67 (5 nos.) were government officials. Table 3 shows the type, followed by their point of analysis, and the distribution of respondents for all questions.

Hereafter, the percentage distribution of respondents against the selected point of reference was used for the Cronbach's Alpha analysis of internal consistency using IBM® SPSS® Statistics 26.0 version. The Cronbach's Alpha for the dataset is 0.981, reflecting the highest order of internal consistency. Furthermore, it can be commented that the inference of this research (i.e., cumulative opinion of the experts including academics, practitioners, and government officials) can be used as a component in the policymaking of urban guidelines related to universal mobility.

**Table 3.** Framework for assessment of internal consistency (Source: Author).

| S. No | Question No. | Type of Question | Point of Analysis | Percentage Category of Respondents | | |
|---|---|---|---|---|---|---|
| | | | | Academics | Practitioners | Government Officials |
| 1 | 2.2.1 | Multiple Choice | The first choice amongst the options (i.e., No, not at all Universally Designed) | 54.76 | 55.46 | 41.67 |
| 2 | 2.2.2 | Multiple Choice | The first choice amongst the options (i.e., Urban Local Body) | 56.35 | 49.58 | 41.67 |
| 3 | 2.2.3 | Likert Scale | Respondents who selected score of 7 and above | 76.19 | 73.11 | 66.67 |
| 4 | 2.2.4 | Dichotomous | Majority of response (i.e., Yes) | 91.27 | 92.44 | 83.33 |
| 5 | 2.2.5 | Dichotomous | Majority of response (i.e., No) | 79.37 | 82.35 | 83.33 |
| 6 | 2.2.6 | Dichotomous | Majority of response (i.e., Yes) | 93.65 | 94.96 | 100.00 |
| 7 | 2.2.7 | Likert Scale | Respondents who selected score of 7 and above | 93.65 | 89.92 | 83.33 |
| 8 | 2.2.8 | Dichotomous | Majority of response (i.e., Yes) | 84.92 | 89.92 | 83.33 |
| 9 | 2.2.9 | Dichotomous | Majority of response (i.e., Yes) | 97.62 | 95.80 | 91.67 |
| 10 | 2.2.10 | Likert Scale | Respondents who selected score of 7 and above | 88.10 | 83.19 | 91.67 |
| 11 | 2.2.11 | Likert Scale | Respondents who selected score of 7 and above | 55.56 | 46.22 | 41.67 |

## 3. Discussion

Rhoads et al. (2023) have debated the adaptability of footpaths concerning diverse mobility conditions, which is close to the concept of universal mobility that this research primarily focuses upon [28]. In continuation to this, this section primarily focuses on comparing this research with relevant, earlier published research. This section further critically examines the possibility of implementing universal mobility in urban India.

Solanki and Khare (2018) have concluded the status of building-standard-oriented accessibility guidelines in the India [29]. In addition to this, Table 1 in this paper mentions the different guidelines. However, due to socio-political reasons, the implementation of Universal Design guidelines in urban India has not been a reality. Due to the decentralised politics of India, the schemes and programmes at the central government level often get ignored at the state government level, especially if the ruling political party is not the same at both levels [30]. This research identifies the urban local body as the major obstacle in the implementation of universal design guidelines, which is understandable because the local municipal corporation or municipality is responsible for checking, authorising, legitimizing, and supervising any construction in the city limits. This research raises questions on the challenging yet essential component of urban quality of life, which is especially significant in the wake of the growing urban population [31]. Lee and Park (2023) have maintained that urban guidelines are significant in maintaining walkability standards. Sustainable urban development in the 21st century is often unimaginable without the involvement of private enterprises with public entities, thus creating Public Private Partnerships or PPP [32–34]. Along similar lines, there is a need for the involvement of PPP models in the field of universal design in urban India. The only government-recognized comprehensive accessibility audit checklist available in India was made available in 2015 vis-à-vis the Accessible India Campaign [35]. However, the checklist is a mere holistic one [36] and depending on the criticality of urban India, this research confirms that accessibility audit checklists presently available in India are not completely adequate for assessing accessibility in urban India. Duman and Asilsoy (2022) have maintained the evidence-based approach [37], and Lid (2013) has preferred a literature-based approach towards establishing universal mobility [38]. This research argues that an expert opinion-based approach is apt for the Indian context. Decision makers around the world have preferred to implement pilot projects in the case of urban-level universal design programmes [39,40]. Respondents in this research have also confirmed this fact in the urban Indian context, as elaborated in Section 2.2.9 of this paper. The cognitive component of this research confirms the impact of cognition at the pedestrian level for universal mobility [41,42]. Indian cities are unique due to their historic temporal developments [43], and researchers have published a set of contextual factors for assessing/observing the footpaths [44]. This research further investigates the various factors of assessing the footpaths in the Indian context and establishes that besides finding the factors for assessment, prioritizing them is equally important to make decisions at urban levels.

Aligned with the findings for this research, other research on universal mobility done by the author for the past decade also reflects the critical condition of footpaths in urban India, especially in old cities [30,31,41,43,44]. Figures 9 and 10 show some footpath conditions in various cities in India.

**Figure 9.** Kolkata (Source: Author).

These pictures are evidence that basic mobility is a challenge in urban India, let alone universal mobility. Thus, India needs to undertake a complete overhaul in its developmental approach towards universal mobility if it aims to come close to the deadline of SDG 11 to provide an inclusive urban environment for all users regardless of their physical and cognitive abilities by 2030.

**Figure 10.** Visakhapatnam (Source: Author).

One important point that this research highlight is the role of urban local bodies in ensuring the implementation of universal design in pedestrian areas (mentioned in Section 2.2.2). Furthermore, land is a state subject in India and owing to the decentralised political system in India, the state administration works independently from the central administration. In addition to this, India is a country with numerous urban contexts depending on the climate, language, topography, social, and political issues. Taking a cue from this, future research can focus on the location-specific analysis of universal mobility issues, where the respondents should ideally be from the same urban local body where the research is being conducted. Another possible and essential scope of future research is the addition of environmental factors along with cognitive and infrastructural factors in the fieldwork survey; open-ended questions can be added in future research.

## 4. Conclusions

Based on the survey mentioned in Section 2, the findings from the viewpoint of experts are elaborated hereafter. Despite the significant impact on the urban quality of life, the footpaths in urban India have no/minimal universal design considerations and urban local bodies are primarily responsible for the lack of implementation of universal design in their respective jurisdictions (derived from Sections 2.2.1–2.2.3). Thus, the involvement of private establishments or PPP models can positively influence universal design in urban India (derived from Section 2.2.4). Subsequently, the accessibility audit checklists presently available in India are not completely adequate for assessing accessibility in urban India (derived from Section 2.2.5). Therefore, there is a need for separate universal design guidelines for old and new cities in India (derived from Section 2.2.6). Along similar lines, universal mobility is essential in realising universal design in urban India (derived from Section 2.2.7). However, authentication of a theoretical model is important for ensuring the universal mobility scenario in urban India (derived from Section 2.2.8). Moreover, prioritizing stretches in old Indian cities (such as a pilot project) is important for ensuring better implementation of universal mobility (derived from Section 2.2.9). Additionally, cognitive elements (temperature, sound, texture, landmarks, etc.) are significant in ensuring universal mobility (derived from Section 2.2.10). Finally, the most important factors while assessing universal mobility for pedestrians in old cities of India are (1) the dimension of the footpath (clear width and height) and (2) adjacent building typology (mixed-use and historic buildings) (derived from Section 2.2.11). In addition, academics and private practitioners tend to agree more with each other in comparison to government officials. The next section answers the three research questions for this paper.

First, based on the expert opinions elaborated in Sections 2.2.10 and 2.2.11, in the case of approaching an urban area to incorporate universal mobility, the dimension of the footpath and adjacent building typology should be prioritized. In relation to this, the Indian Road Congress (2012) has mentioned 1800 mm as the clear width and 2200 mm as the clear height for an ideal walking zone in the streetscape. In addition to this, the required width of the footpath as per adjacent land use is also specified. For example, a minimum of 2500 mm clear width for footpaths is mandatory in areas with commercial/mixed-use adjacent building typology [45]. Many other guidelines, as mentioned in Table 1, also focus on the quantitative guidelines for footpaths. However, these guidelines lack the acknowledgement of cognitive factors such as sound and temperature, as well as contextual factors such as temporary encroachment, permanent encroachments, and transport stops. Thus, the authors argue that a qualitative study of footpaths in urban India is necessary, as well as a quantitative assessment during any development plans.

The second step was to identify which sector of administration to focus on. The land-related policies in India fall under the jurisdiction of state administration as per the directions of the Seventh Schedule (Article 246) [46]. If the state and central administration do not have the same political party, the guidelines (as mentioned in Table 1) are often not implemented due to political bottlenecks [47]. Thus, based on the expert opinions elaborated in Sections 2.2.2–2.2.4, reforms in the statutory functioning of the urban local body (under state government) will be beneficial for the footpaths to bear universal mobility. In addition to this, PPP models shall be beneficial where local businesses consult Corporate Social Responsibility (CSR) or any other suitable models such as Build-Operate-Transfer (BOT).

The third step was to determine what urban development genre to choose. Based on the expert opinions elaborated in Sections 2.2.5–2.2.9, the ideal development model is to create a new research-based accessibility audit checklist suitable for urban India, then verify the same on a case area, and finally prioritize stretches (such as a pilot project).

Thus, this research adds value/contributes to these major fronts:

- The researchers/academics can use the findings and even refer to the methodology used in this research to conduct more investigations for improving the research domain in universal design/mobility in Indian cities.
- The government officials can interpret how to distribute funding and resources based on the prioritization of universal mobility issues.
- Furthermore, the policymakers can now understand the viewpoint of the experts in the field of universal design and include them more in the process of framing guidelines (as explained in Section 2.3).

In addition, it is ethically imperative for an architect/planner to think rationally before approaching any design solution at an urban level to ensure that the proposed design solution should be both creative and inclusive to ensure sustainability in the domain of the built environment.

**Author Contributions:** Conceptualization, S.M. and G.D.M.; Methodology, G.D.M.; Software, G.D.M.; Validation, S.M. and R.N.; Formal analysis, G.D.M.; Investigation, G.D.M.; Resources, S.M., R.N. and G.D.M.; Data curation, G.D.M.; Writing—original draft preparation, G.D.M.; Writing—review and editing, S.M. and R.N.; Visualization, G.D.M.; Supervision, S.M. and R.N.; Project administration, S.M. and R.N.; Funding acquisition, S.M. All authors have read and agreed to the published version of the manuscript.

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**Institutional Review Board Statement:** Ethical review and approval were waived for this study because no data and information related to the ethical guidelines were at the discretion of the committee at Hokkaido University.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

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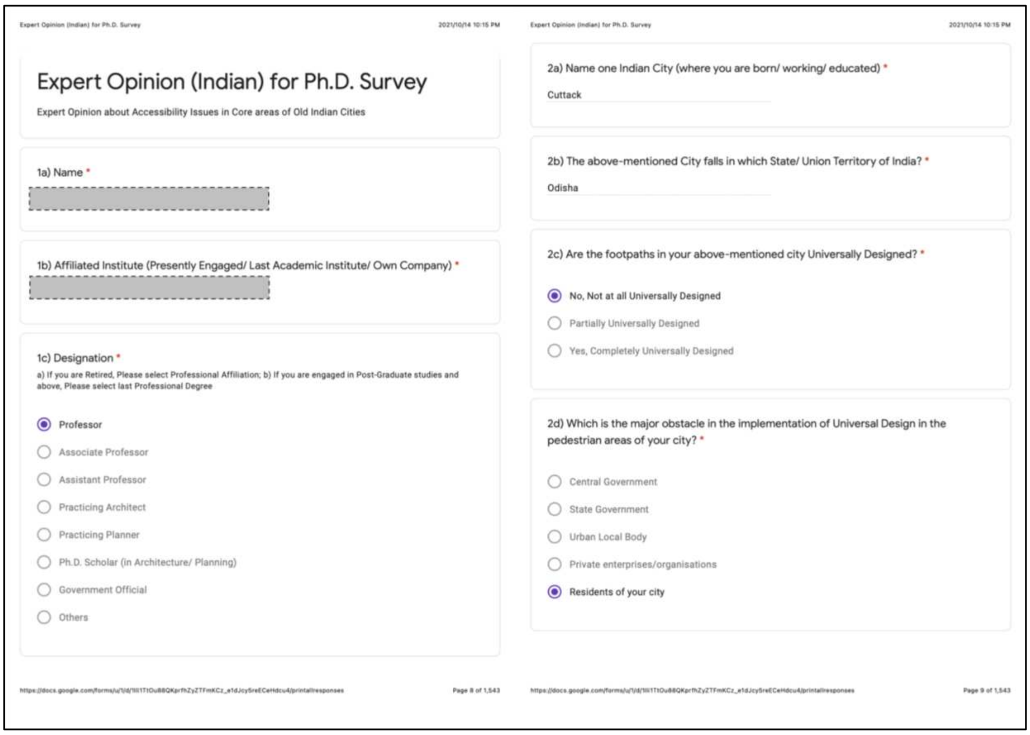
**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A

A filled Google form questionnaire used for this survey is shown. The respondents' and affiliated institutes' names are not mentioned for privacy reasons.



Expert Opinion (Indian) for Ph.D. Survey 2021/10/14 10:15 PM

# Expert Opinion (Indian) for Ph.D. Survey

Expert Opinion about Accessibility Issues in Core areas of Old Indian Cities

1a) Name *

[redacted]

1b) Affiliated Institute (Presently Engaged/ Last Academic Institute/ Own Company) *

[redacted]

1c) Designation *
a) If you are Retired, Please select Professional Affiliation; b) If you are engaged in Post-Graduate studies and above, Please select last Professional Degree

- (•) Professor
- ( ) Associate Professor
- ( ) Assistant Professor
- ( ) Practicing Architect
- ( ) Practicing Planner
- ( ) Ph.D. Scholar (in Architecture/ Planning)
- ( ) Government Official
- ( ) Others

https://docs.google.com/forms/u/1/d/1lli1TtOu88QKprfhZyZTFmKCz_e1dJcy5reECeHdcu4/printallresponses Page 8 of 1,543

Expert Opinion (Indian) for Ph.D. Survey 2021/10/14 10:15 PM

2a) Name one Indian City (where you are born/ working/ educated) *

Cuttack

2b) The above-mentioned City falls in which State/ Union Territory of India? *

Odisha

2c) Are the footpaths in your above-mentioned city Universally Designed? *

- (•) No, Not at all Universally Designed
- ( ) Partially Universally Designed
- ( ) Yes, Completely Universally Designed

2d) Which is the major obstacle in the implementation of Universal Design in the pedestrian areas of your city? *

- ( ) Central Government
- ( ) State Government
- ( ) Urban Local Body
- ( ) Private enterprises/organisations
- (•) Residents of your city

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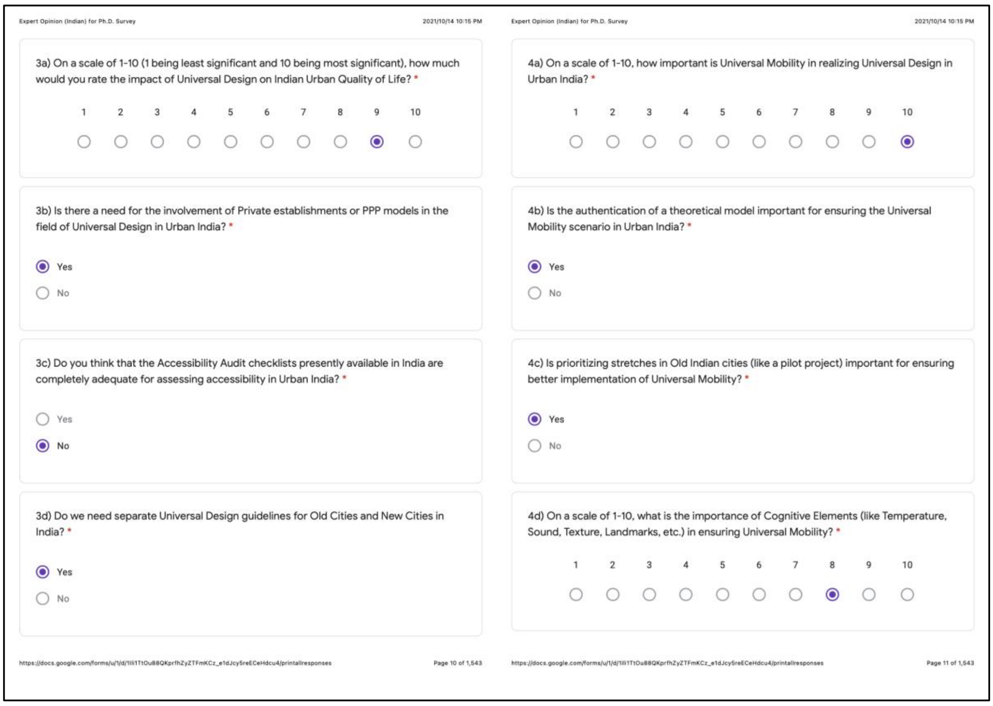

Expert Opinion (Indian) for Ph.D. Survey 2021/10/14 10:15 PM

3a) On a scale of 1-10 (1 being least significant and 10 being most significant), how much would you rate the impact of Universal Design on Indian Urban Quality of Life? *

1 2 3 4 5 6 7 8 9 10 — selected: 9

3b) Is there a need for the involvement of Private establishments or PPP models in the field of Universal Design in Urban India? *

- (•) Yes
- ( ) No

3c) Do you think that the Accessibility Audit checklists presently available in India are completely adequate for assessing accessibility in Urban India? *

- ( ) Yes
- (•) No

3d) Do we need separate Universal Design guidelines for Old Cities and New Cities in India? *

- (•) Yes
- ( ) No

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Expert Opinion (Indian) for Ph.D. Survey 2021/10/14 10:15 PM

4a) On a scale of 1-10, how important is Universal Mobility in realizing Universal Design in Urban India? *

1 2 3 4 5 6 7 8 9 10 — selected: 10

4b) Is the authentication of a theoretical model important for ensuring the Universal Mobility scenario in Urban India? *

- (•) Yes
- ( ) No

4c) Is prioritizing stretches in Old Indian cities (like a pilot project) important for ensuring better implementation of Universal Mobility? *

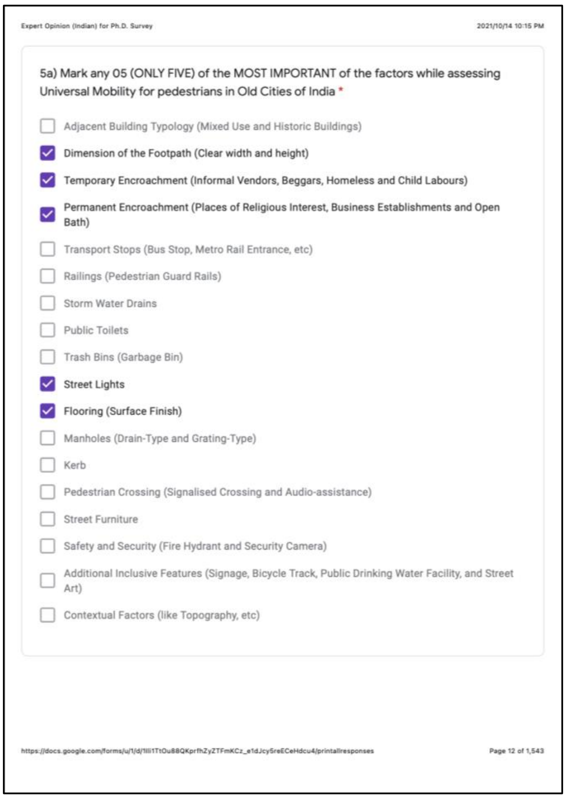
- (•) Yes
- ( ) No

4d) On a scale of 1-10, what is the importance of Cognitive Elements (like Temperature, Sound, Texture, Landmarks, etc.) in ensuring Universal Mobility? *

1 2 3 4 5 6 7 8 9 10 — selected: 8

https://docs.google.com/forms/u/1/d/1lli1TtOu88QKprfhZyZTFmKCz_e1dJcy5reECeHdcu4/printallresponses Page 11 of 1,543

**Figure A1.** *Cont.*


Expert Opinion (Indian) for Ph.D. Survey 2021/10/14 10:15 PM

5a) Mark any 05 (ONLY FIVE) of the MOST IMPORTANT of the factors while assessing Universal Mobility for pedestrians in Old Cities of India *

- [ ] Adjacent Building Typology (Mixed Use and Historic Buildings)
- [x] Dimension of the Footpath (Clear width and height)
- [x] Temporary Encroachment (Informal Vendors, Beggars, Homeless and Child Labours)
- [x] Permanent Encroachment (Places of Religious Interest, Business Establishments and Open Bath)
- [ ] Transport Stops (Bus Stop, Metro Rail Entrance, etc)
- [ ] Railings (Pedestrian Guard Rails)
- [ ] Storm Water Drains
- [ ] Public Toilets
- [ ] Trash Bins (Garbage Bin)
- [x] Street Lights
- [x] Flooring (Surface Finish)
- [ ] Manholes (Drain-Type and Grating-Type)
- [ ] Kerb
- [ ] Pedestrian Crossing (Signalised Crossing and Audio-assistance)
- [ ] Street Furniture
- [ ] Safety and Security (Fire Hydrant and Security Camera)
- [ ] Additional Inclusive Features (Signage, Bicycle Track, Public Drinking Water Facility, and Street Art)
- [ ] Contextual Factors (like Topography, etc)

https://docs.google.com/forms/u/1/d/1Ili1TtOu88QKprfhZyZTFmKCz_e1dJcy5reECeHdcu4/printallresponses Page 12 of 1,543

**Figure A1.** Filled Google Form questionnaire for this research (Source: Author).

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## Appendix 6: 5th Peer reviewed referred journal publication

**G. Das Mahapatra**, S. Mori, and R. Nomura, 'Role of Cognition in Pedestrian- Level Universal Mobility: Case of Central Kolkata, India,' *Athens Journal of Architecture*, vol. 9, no. 1, pp. 107–128, Jan. 2023, doi: 10.30958/aja.9-1-5. [Citations = 1 (as of July 2023)]

*Athens Journal of Architecture - Volume 9, Issue 1, January 2023 – Pages 107-128*

# Role of Cognition in Pedestrian-Level Universal Mobility: Case of Central Kolkata, India

*By Gaurab Das Mahapatra*, Suguru Mori± & Rie Nomura°*

*In this research, the role of cognition in Universal Mobility at the pedestrian-level has been investigated. A stretch of approximately 850 m in the core of Kolkata Municipal Corporation (in India) has been delineated as the case area for this research. The 02 data sets considered for this research are: 1) Physical data: Pedestrian Count and Vehicular Traffic Volume, and 2) Cognitive data: Light Intensity, Noise, and Thermal Comfort. The authors collected the data from the case area in the years 2020 and 2021. This paper initially involves determining the pedestrian "Level of Service" (LOS) based on the pedestrian count. Furthermore, the authors co-relate (Pearson's Correlation with a 95% confidence interval) the LOS data with the light intensity, sound intensity, and temperature data; to establish a relationship between them. The result of this research indicates that there is a gap in realizing the potential of walkability in the case area. The authors conclude that the improvement of cognition in pedestrian-level Universal Mobility can lead to a better physical environment for the specially-abled and elderly.*

## Introduction

There are 26.8 million specially-abled people in India as per the last census in 2011. Additionally, there are 103.8 million elderly people.[1] Along similar lines, the "United Nations Sustainable Development Goals" (UN-SDG) number 11 (Sustainable Cities and Communities) becomes more significant than ever in the Indian context. Universal Mobility is a fundamental component of "Sustainable Cities and Communities", which suggests equal mobility preferences for all,

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1. Social Statistics Division, Ministry of Statistics and Programme Implementation, *Disabled Persons in India - A Statistical Profile 2016* (New Delhi: Government of India, 2016).

https://doi.org/10.30958/aja.9-1-5 doi=10.30958/aja.9-1-5

devoid of the users' physical conditions.[2] Pedestrian (including wheelchair-bound users) level use of urban areas is a relatively challenging domain of Universal Mobility in India. Specifically, in the old urban areas of India, the Universal Mobility scenario is more complicated due to organic urban development, low temporal changes, and high density. Amongst the numerous factors of pedestrian-level Urban Mobility, "Cognition" is significantly important. Cognition is important for specially-abled and elderly people alike since it (Cognition) ensures legibility, orientation, and a sense of place. Despite multiple international, national, and state-level guidelines related to Universal Mobility in India, the aspect of cognition has been disregarded in these guidelines. Although there has been immense research on accessibility and Universal Design in India, the impact of cognition on Universal Mobility at the pedestrian level of old Indian cities is a relatively new research topic.

Universal Mobility incorporates the needs of varied users, including the elderly and specially-abled within a designated spatial boundary. On an urban scale, Universal Mobility serves the function of an infrastructural bridge between buildings having Universal Design/Barrier-Free features and precincts with inclusive components. In addition to the previous statement, both inclusive buildings, and the inclusive precincts, shall remain non-utilitarian if they are not connected by a "Universally-designed" mobility corridor. Thus, Universal Mobility may be categorized as one of the top priorities in the United Nation's Sustainable Development Goal Number 11 which indicates "Sustainable Cities and Communities".[3] This paper focuses on Universal Mobility at the pedestrian level of old cities.

Pedestrian-level infrastructures in old cities are often affected by poor infrastructure and pose a threat to able-bodied and users with wheelchairs or walking assistance alike. Concerning this, a stretch in Central Kolkata (in India) is considered a case example for this paper. The typology of urban patterns is complex in old-core Indian cities (like Kolkata) due to the multiplicity of building uses, thus attracting users from a diverse age groups.[4] Age diversity presents a challenge to decision-makers regarding the type of facility in the pedestrian environment; on the other hand, it promotes the need for universal mobility[5]. Mahapatra, Mori, and Nomura (2021) establish that the challenges in implementing

2. United Nations Department of Economic and Social Affairs, *Goal 11: Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable* (United Nations Department of Economic and Social Affairs, 2015).

3. M. Brussel, M. Zuidgeest, K. Pfeffer, and M. v. Maarseveen, "Access or Accessibility? A Critique of the Urban Transport SDG Indicator," *International Journal of Geo-Information* (2019): 1-23.

4. G. D. Mahapatra, and K. Puntambekar, *Reinterpreting Urban Fabric in Cities with Living Heritage: The Case of Central Kolkata* (Delhi: COPAL Publishing Group, 2020).

5. Mahapatra, and N. Mandal, *Re-inventing Urban Spaces by Accessing Accessibility in Old City Core - A Case of Kolkata (*Chisinau: Lap Lambert Academic Publishing, 2019), 11-17.

Universal Mobility in an urban Indian context can be attributed to legislative as well as population density.[6] Old Indian cities are experiencing degeneration in terms of their urban fabric.[7] Since old cities are often associated with historic value, maintaining physical revitalization is also an added challenge for architects and city officials alike.[8] Furthermore, a unique assessment format is necessary for understanding the context-specific accessibility conditions of old core Indian cities.

The holistic approach to urban development should be to create a livable city and not mere infrastructural development.[9] Cognition, especially, plays an important role in improving the spaces of public use, including pedestrian spaces.[10] The importance of cognition is well-established in walkability, especially for elderly people. Additionally, mental maps are an effective form of cognitive perception of spaces; thus, serve as an essential tool for differently-abled and elderly.[11] In this context, pedestrians needed to be prioritized in the user group segment of the urban development. There are many definitions of a pedestrian. Besides regular walking by able-bodied people, pedestrian also includes people in a non-motorized wheelchair or, driving a motorized wheelchair with a speed of less than 10km/hr on the level ground.[12] Although international and national guidelines/goals encourage pedestrianization, poor urban-level pedestrian quality discourages pedestrian activity.[13]

This research paper is apportioned into three segments hereafter: 1) Analysis, 2) Major Findings, and 3) Proposals. 02 data sets are dealt with in the "Analysis" segment, they are a) Pedestrian Volume, and b) Cognitive Data (comprising Noise, Light, and Thermal Comfort Data). In "Major Findings", the following points are highlighted: a) Importance of Light in Cognition, b) Impact of Sound on

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6. Mahapatra, S. Mori, and R. Nomura, "Universal Mobility in Old Core Cities of India: People's Perception," *Sustainability* 13, no. 8 (2021): 1-36.

7. Mahapatra, K. Puntambekar, and S. Ckakraborty, "Understanding Transformation Dynamics in Old Cities," *Conscious Urbanism* 1, no. 1 (2021): 30-41.

8. S. Tiesdell, T. Oc, and T. Heath, "Towards the Successful Revitalization of Historic Urban Quarters," in *Revitalizing Historic Urban Quarters* (eds.) S. Tiesdell, T. Oc, and T. Heath, 200-212 (Oxford: Architectural Press, 1996).

9. Mahapatra, "Neighborhood Planning: Approach in Improving Livability and Quality of the Life in the Cities," in *Understanding Built Environment. Springer Transactions in Civil and Environmental Engineering* (eds.) F. Seta, A. Biswas, and J. Sen, 47-53 (Singapore: Springer, 2017).

10. R. Chopra, and Mahapatra, "Cognitive Mapping in Spaces for Public Use," *IJRET: International Journal of Research in Engineering and Technology* 7, no. 9 (2018): 138-142.

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13. M. Taleai, and E. T. Amiri, "Spatial Multi-Criteria and Multi-Scale Evaluation of Walkability Potential at Street Segmnet Level: A Case Study of Tehran," *Sustainable Cities and Society* 31 (2017): 37-50.

Walkability, and c) Influence of Temperature on Mobility. In the last part of the paper "Proposals", the linkage between the five senses in humans and their pedestrian behavior and the roles of hormones in facilitating cognition in streetscape for specially-abled people, is mentioned. Additionally, the importance of Assistive Technology in achieving Service Level Benchmarks (hereafter, SLBs) is also discussed in the last leg of the paper. The details of the survey and the findings are mentioned hereafter.

## Materials and Methods

The data collected by the authors in the case area for this research are 1) Pedestrian Volume and 2) Cognitive Data including Noise, Light Intensity, and Thermal Comfort. The locations where the data were collected along the study area are represented in Figure 1 and elaborated in Table 1 thereafter.

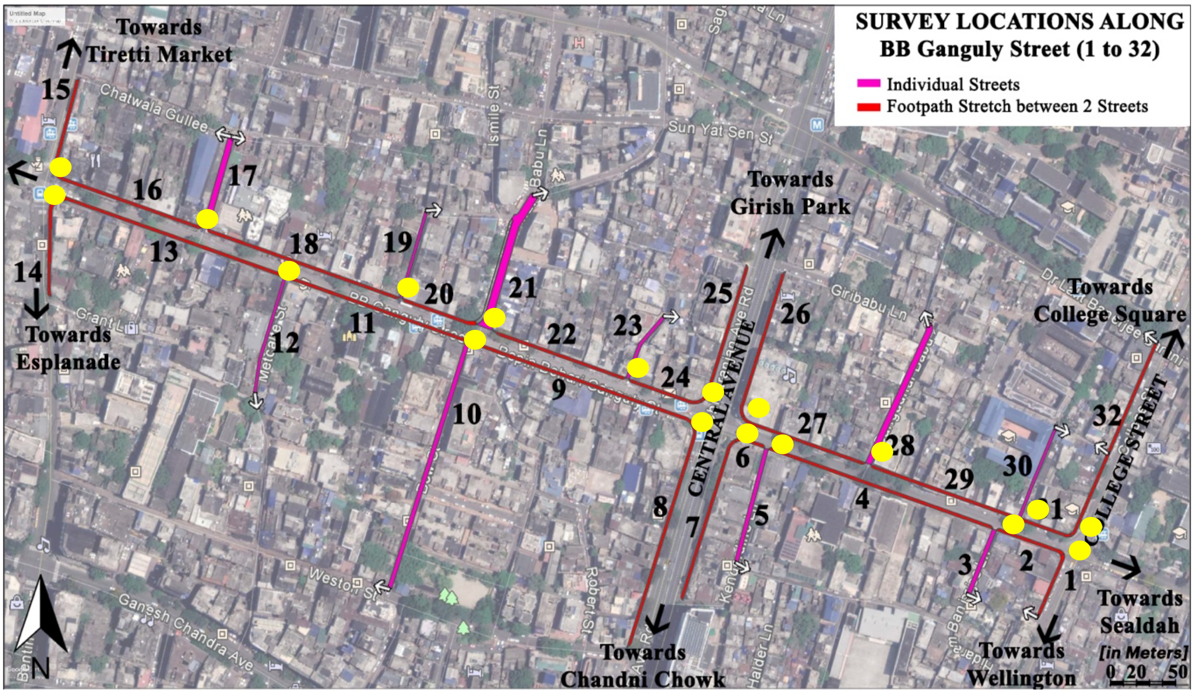



**Figure 1.** *Survey Locations*

The station points for the "Cognitive" survey were midway in some of the footpaths shown as number 1 to 32 as shown in Figure 1. The names of the footpaths selected (with corresponding footpath widths) for the survey are mentioned in Table 1. Furthermore, the station points for the "Pedestrian Volume" survey were done at the yellow points shown in Figure 1.

**Table 1.** *Name of Station Points for Survey*

| Corresponding Numbers in Figure 1 | Name of Station Points | Footpath Width |
|---|---|---|
| 1 | Nirmal Chandra Dey Street | 2.1 |
| 3 | New Bowbazar lane | 5 |
| 5 | Kenderdine Lane | 3 |
| 7 | Central Avenue (GATE 4: Yogayog Bhawan) | 2.1 |
| 8 | Central Metro (GATE 1: Indian Airlines) | 2.1 |
| 10 | Bow Street | 3.8 |
| 12 | Metcalfe Street | 3.5 |
| 14 | Bentinck Street | 2.1 |
| 15 | Rabindra Sarani Rd. | 1.9 |
| 17 | Chatawalla Gully | 3.5 |
| 19 | Phears Bye Lane | 2 |
| 21 | Phears Lane | 4.8 |
| 23 | Giri Babu lane | 2.4 |
| 25 | Central Metro (GATE 2: Lalbazar) | 1.9 |
| 26 | Central Avenue (GATE 3: RITES) | 1.8 |
| 28 | Gangadhar Babu lane | 5 |
| 30 | Bibi Rozio Lane | 1.8 |
| 32 | College Street | 1.9 |

Pedestrian Volume [Peak Hour 15-Minute Interval]

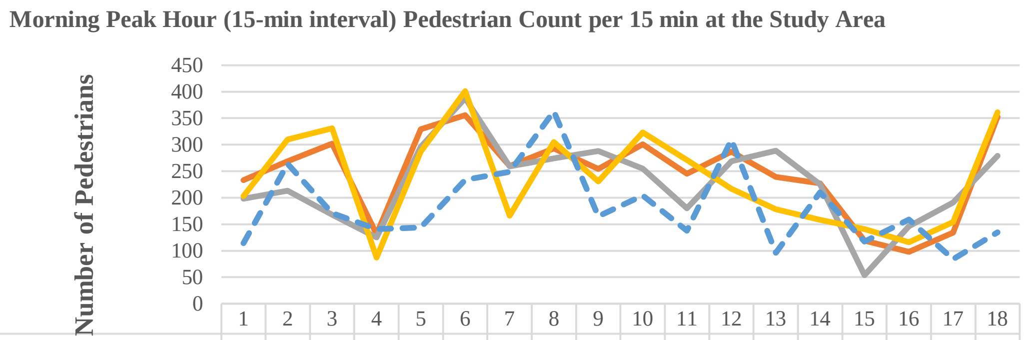
The peak-hour (15-minute interval) Pedestrian Volume Data were recorded three times in 2020 (on 25.10.2020, 14.10.2020, and 02.11.2020) and once in 2021 (on 24.09.2021). On each of the days, the data was recorded twice a day – at Morning Peak Hour (9:00 a.m. – 11:00 am) and Evening Peak Hour (6 p.m. – 7 p.m.). In the morning, the educational institutions and businesses begin functioning around 9 am. The offices start slightly later around 10 am. The educational institutions close around 2-4 pm. However, the offices and businesses start closing around 7 pm. This is also the time when a lot of informal shopping functions. Thus, depending on the mixed land use genre of the space, multiple peak hours are set for the survey. The format used for the Survey is mentioned in Table 2.

**Table 2.** *Survey format for Pedestrian Count*

| Peak Hour Pedestrian Count Survey [15-minute interval] | | |
|---|---|---|
| Date of Survey | | |
| Time | | |
| Name of the street | | |
| Latitude and Longitude | | |
| Width of the street | | |
| | Pedestrians coming towards the surveyor | Pedestrians going away from the surveyor |
| Morning Peak Hour ( - ) | | |

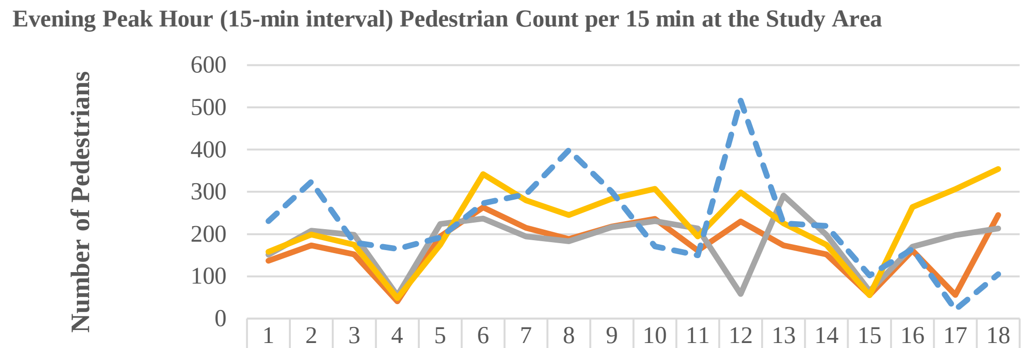
| Evening Peak Hour ( - ) | | | |
|---|---|---|---|
| How many bicycles did you see during the survey? | | | |
| Did you see any differently-abled/ elderly people? | | | |
| *Surveyed By:* | | *Checked By:* | |

Figure 2 and Figure 3 represent the pattern of pedestrian traffic in the study area at morning peak hour and evening peak hour respectively.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 01 Morning Peak Hour | 233 | 269 | 302 | 131 | 329 | 356 | 260 | 293 | 254 | 301 | 245 | 287 | 239 | 227 | 119 | 98 | 134 | 353 |
| Day 02 Morning Peak Hour | 198 | 213 | 168 | 125 | 296 | 388 | 259 | 274 | 288 | 255 | 180 | 269 | 289 | 225 | 54 | 146 | 191 | 279 |
| Day 03 Morning Peak Hour | 203 | 310 | 331 | 87 | 287 | 401 | 166 | 305 | 231 | 323 | 271 | 217 | 178 | 158 | 141 | 116 | 154 | 361 |
| Day 04 Morning Peak Hour | 114 | 264 | 171 | 141 | 144 | 234 | 249 | 363 | 165 | 204 | 138 | 309 | 96 | 210 | 117 | 159 | 84 | 135 |

**Figure 2.** *Morning Peak Hour (15-Min Interval) Pedestrian Count per 15 Minutes at the Study Area*




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 01 Evening Peak Hour | 137 | 173 | 152 | 41 | 194 | 263 | 215 | 188 | 218 | 236 | 161 | 230 | 173 | 152 | 56 | 161 | 56 | 245 |
| Day 02 Evening Peak Hour | 151 | 208 | 198 | 54 | 224 | 237 | 194 | 183 | 216 | 231 | 213 | 58 | 291 | 198 | 65 | 170 | 197 | 213 |
| Day 03 Evening Peak Hour | 158 | 199 | 175 | 48 | 175 | 342 | 280 | 245 | 284 | 307 | 194 | 299 | 225 | 175 | 55 | 264 | 306 | 354 |
| Day 04 Evening Peak Hour | 231 | 324 | 180 | 165 | 192 | 273 | 294 | 399 | 300 | 171 | 150 | 516 | 225 | 219 | 102 | 165 | 21 | 105 |

**Figure 3.** *Evening Peak Hour (15-Min Interval) Pedestrian Count per Minute at the Study Area*

On average (mean value), the recorded Peak Hour (15-min interval) Pedestrian Count at the Study Area was 223 people in the morning and 201 people in the evening respectively. The average pedestrian flow in morning peak hours can be attributed to the presence of morning schools, offices, churches, and related informal vending during those hours. However, the flow is consistent during the evening due to the crowd returning from offices, shops, and informal vending too. Thus, nearly 800 pedestrians (derived by multiplying the “Peak Hours 15-minute interval Pedestrian Count” by four) commute through the study area during peak hours.

### Cognitive Data

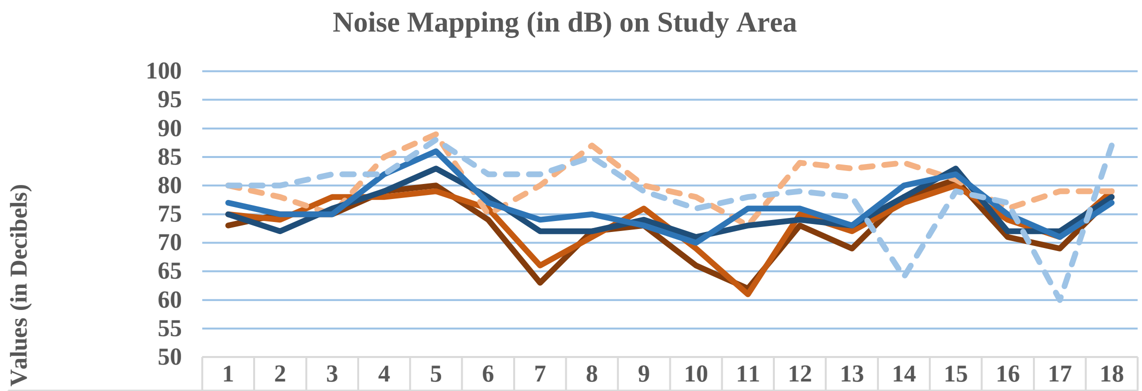
The next set of data for cognitive data involving noise, light intensity, and thermal comfort were recorded at the same time (peak hour) and date as the pedestrian volume survey. The data was recorded by the author using mobile-based applications.

**Table 3.** *Survey Format for Cognitive Data*

| Cognitive Survey [Sound, Light and Temperature Data at Peak Hour] | | |
|---|---|---|
| | Morning | Evening |
| Name of Surveyor | | |
| Name of the street | | |
| Date of Survey | | |
| Time | | |
| Sound Intensity (in Decibel) | | |
| Light Intensity (in Lux) | | |
| Temperature (in Degree Centigrade) | | |
| | *Checked By:* | |

#### Noise

Figure 4 illustrates the Noise (Sound Intensity in Decibel) in the Study Area. The data were recorded using “Sound Meter”, a mobile-based application.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 1 | 73 | 75 | 75 | 79 | 80 | 74 | 63 | 72 | 73 | 66 | 62 | 73 | 69 | 78 | 81 | 71 | 69 | 78 |
| Day 2 | 75 | 74 | 78 | 78 | 79 | 76 | 66 | 71 | 76 | 69 | 61 | 75 | 72 | 77 | 80 | 74 | 71 | 79 |
| Day 3 | 80 | 78 | 75 | 85 | 89 | 75 | 80 | 87 | 80 | 78 | 73 | 84 | 83 | 84 | 81 | 76 | 79 | 79 |
| Evening 1 | 75 | 72 | 76 | 79 | 83 | 78 | 72 | 72 | 74 | 71 | 73 | 74 | 73 | 78 | 83 | 72 | 72 | 78 |
| Evening 2 | 77 | 75 | 75 | 82 | 86 | 77 | 74 | 75 | 73 | 70 | 76 | 76 | 73 | 80 | 82 | 75 | 71 | 77 |
| Evening 3 | 80 | 80 | 82 | 82 | 88 | 82 | 82 | 85 | 79 | 76 | 78 | 79 | 78 | 64 | 79 | 77 | 60 | 87 |

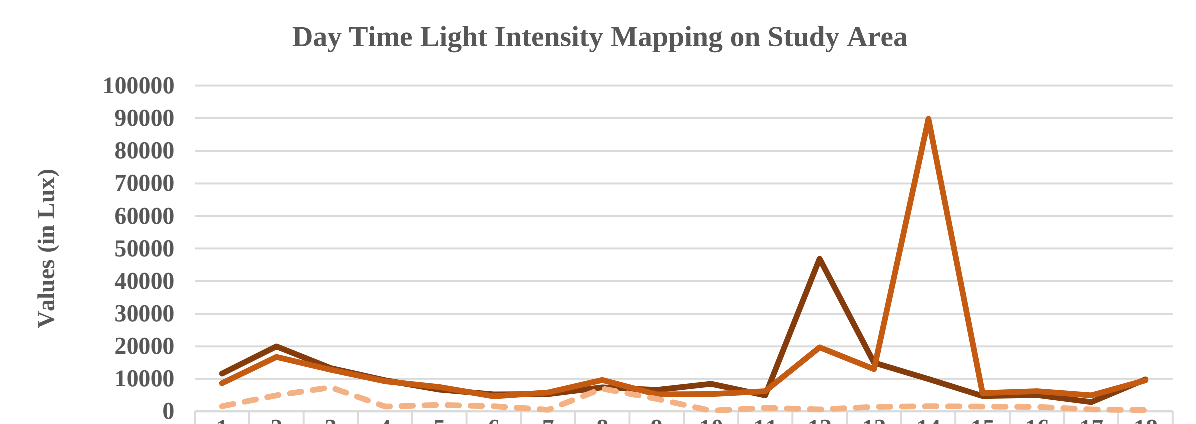
**Figure 4.** *Noise Mapping on Study Area*

Exposure over 85dB might lead to damage to hearing over prolonged exposure,[14] which has been observed in 04 out of 18 surveyed locations. The infrastructure and pedestrian environment need a more sensitive approach.

Light Intensity

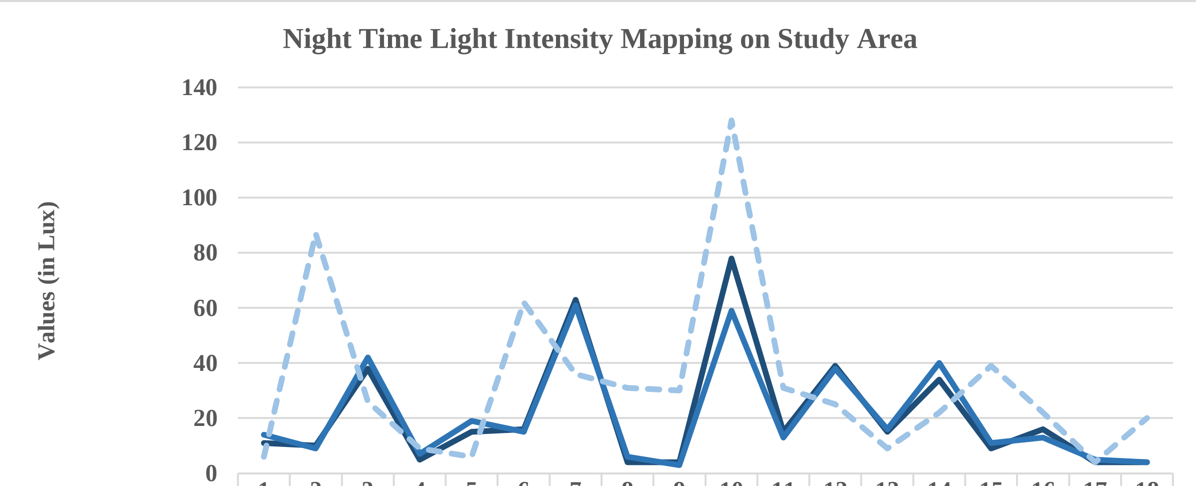
The Light Intensity (in Lux) in the Study Area during Day and Evening respectively are illustrated in Figure 5 and Figure 6. The data were recorded using a mobile-based application "Light Meter". The focus of this study was to understand whether the light intensity is satisfactory for people, especially during the evening/night.

14. National Center for Environmental Health. *What Noises Cause Hearing Loss?* (Centers for Disease Control and Prevention, 2019).




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 1 | 1157 | 1994 | 1328 | 9595 | 6720 | 5208 | 5310 | 7389 | 6585 | 8476 | 4900 | 4684 | 1496 | 9980 | 4769 | 5048 | 2880 | 9800 |
| Day 2 | 8682 | 1675 | 1279 | 9211 | 7493 | 4687 | 5841 | 9606 | 5268 | 5340 | 6223 | 1967 | 1301 | 8982 | 5580 | 6209 | 4896 | 9506 |
| Day 3 | 1636 | 4984 | 7414 | 1530 | 1986 | 1600 | 469 | 7016 | 3810 | 181 | 1073 | 636 | 1377 | 1565 | 1481 | 1394 | 589 | 463 |

**Figure 5.** *Day Time Light Intensity Mapping on Study Area*



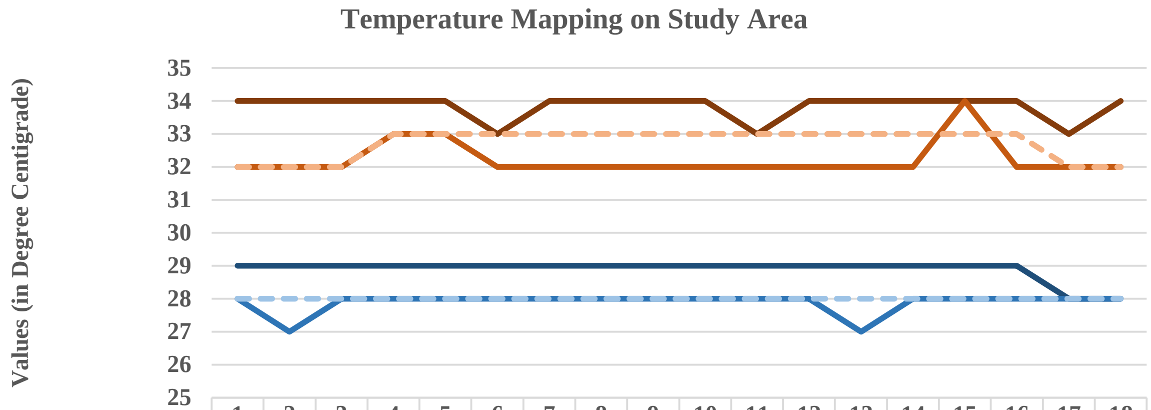

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Evening 1 | 11 | 10 | 38 | 5 | 15 | 16 | 63 | 4 | 4 | 78 | 15 | 39 | 15 | 34 | 9 | 16 | 4 | 4 |
| Evening 2 | 14 | 9 | 42 | 7 | 19 | 15 | 61 | 6 | 3 | 59 | 13 | 38 | 16 | 40 | 11 | 13 | 5 | 4 |
| Evening 3 | 6 | 87 | 26 | 9 | 6 | 62 | 36 | 31 | 30 | 128 | 31 | 25 | 9 | 22 | 39 | 22 | 4 | 20 |

**Figure 6.** *Evening Time Light Intensity Mapping on Study Area*

Despite having 93.75% of the streetlights in working condition (observed during the primary survey), instances show that there was >10lux illumination in certain pedestrian areas; thus, hinting towards a need for improved 'urban evening lighting'. The drastic differences in day and evening lighting create cognitive difficulties, especially for the elderly and differently-abled.

Thermal Comfort

The Temperature (in Degree Centigrade) in Study Area during Day and Evening respectively are illustrated in Figure 7. The data (in degrees Centigrade) were recorded using “Outside Temperature”, a mobile-based application. This study was conducted mainly to access the real-time situation of pedestrians.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 1 | 34 | 34 | 34 | 34 | 34 | 33 | 34 | 34 | 34 | 34 | 33 | 34 | 34 | 34 | 34 | 34 | 33 | 34 |
| Day 2 | 32 | 32 | 32 | 33 | 33 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 34 | 32 | 32 | 32 |
| Day 3 | 32 | 32 | 32 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 32 | 32 |
| Evening 1 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 28 | 28 |
| Evening 2 | 28 | 27 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 27 | 28 | 28 | 28 | 28 | 28 |
| Evening 3 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |

**Figure 7.** *Temperature Mapping on Study Area*

Although there is a minimal difference in day and evening temperatures during the surveyed dates, the actual scenario might be different. In summer, the temperature in Kolkata rises to 44 °C, complemented by 83% humidity: making the non-shadowed areas extremely uncomfortable. Besides, there are considerations like Apparent Temperature, Sensation and Perception, Time Required to feel the temperature change, Cardinal Direction, and “Felt” Temperature.

The aspects of light, sound, and temperature are related to the senses of vision, hearing, and touch, which need to be complemented with smell (landscape maybe) to create an enhanced cognitive experience.

## Results

This section discusses two major things- 1) Criticism of the level of service based on the pedestrian data, and 2) Correlating various attributes of the field survey.

Criticism on the Level of Service

As per the Indian Road Congress (hereafter, IRC) guidelines, pedestrian areas in India must abide by certain ideal guidelines. IRC defines Level of Service (hereafter, LOS) using the “Pedestrian Space” method, which follows the formula: Pedestrian Space = Area / Peak Hour Volume. As per IRC, there is another way of calculating LOS using the “Flow Rate” method, which involves the formula: Pedestrian Unit Flow Rate = Peak 15-min Flow Rate/ (15 x Effective Walkway Width). However, for this paper, the “Pedestrian Space” method is being used, where:

**Pedestrian Space = Area of Footpath/ Peak Hour Volume**

Besides, the LOS thus determined is designated as LOS A, LOS B, LOS C, LOS D, LOS E, and LOS F, with LOS A being the best. The detail of the LOS is mentioned in Table 4.

**Table 4.** *Level of Service (Source: Guidelines for Pedestrian Facilities-IRC 103-2012, Indian Road Congress)*

| S. No | Level of Service (LOA) | Pedestrian Space (area/peak hour volume) | Flow Rate (peak pedestrian flow rate/ effective walkway width) | Pedestrian Condition |
|---|---|---|---|---|
| 1 | LOS A | > 4.9 | < 12 | Ideal Pedestrian Condition |
| 2 | LOS B | > 3.3 - 4.9 | < 12 – 15 | Acceptable |
| 3 | LOS C | > 1.9 - 3.3 | < 15 – 21 | Just Satisfactory |
| 4 | LOS D | > 1.3 - 1.9 | < 21 - 27 | Poor |
| 5 | LOS E | > 0.6 - 1.3 | < 27 – 45 | Unsuitable |
| 6 | LOS F | < 0.6 | Varying | Severely Restricted |

[N.B.: The ‘width’ is footpath width and is calculated in meters; and the ‘area’ signifies footpath area (width x length) and is calculated in square meters.]

After interpreting the data collected during the survey in the case area, only seventeen out of the eighteen footpath stretches have LOS F or severely restricted pedestrian conditions. The one remaining footpath stretch is bearing the tag of LOS E or unsuitable pedestrian conditions. Thus, none of the footpath stretches have ideal/acceptable/satisfactory pedestrian conditions as per the guidelines laid by IRC. Tables 3 and 4 represents the LOS for each of the eighteen surveyed footpath stretches during the morning and evening peak hours. The following abbreviations are used in Tables 3 and 4:

| | | | |
|---|---|---|---|
| $W_E$ | = | Effective Walkway Width | (in m) |
| $L_E$ | = | Effective Walkway Length | (in m) |
| $A_E$ | = | Effective Walkway Area | (in m) |
| $V_{15}$ | = | Peak 15-min Flow Rate | (in p) |
| $V_{60}$ | = | Peak Hour Flow Rate | (in p) |
| $PS_D$ | = | Daytime Pedestrian Space Value | (in sqm/ p) |
| $PS_N$ | = | Daytime Pedestrian Space Value | (in sqm/ p) |

The $W_E$ and $L_E$ data were collected during the primary survey. $A_E$ was calculated thereafter. $V_{15}$ has been derived by taking the average of the Peak Hour (15-min interval) Pedestrian Count for the morning peak hour and evening peak hour respectively. $V_{60}$ was determined by multiplying $V_{15}$ by 4. $PS_D$ and $PS_N$ have been calculated by dividing the $A_E$ by $V_{60}$. The data has been elaborated in Table 5, and Table 6 respectively.

**Table 5.** *Level of Service at Morning Peak Hour*

| MORNING TIME: Determining Quantitative Level of Service (LOS) through PEDESTRIAN SPACE METHOD | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Street Name** | **$W_E$** | **$L_E$** | **$A_E$** | **$V_{15}$** | **$V_{60}$** | **$PS_D$** | **Corresponding LOS** |
| Nirmal Chandra Dey Street | 2.1 | 51.49 | 108.13 | 187 | 748 | 0.14 | **LOS F** |
| New Bowbazar lane | 5.0 | 51.68 | 258.40 | 264 | 1056 | 0.24 | **LOS F** |
| Kenderdine Lane | 3.0 | 87.62 | 262.86 | 243 | 972 | 0.27 | **LOS F** |
| Central Avenue (GATE 4_Yogayog Bhawan) | 2.1 | 126.43 | 265.50 | 121 | 484 | 0.55 | **LOS F** |
| Central Metro(GATE 1_Indian Airlines) | 2.1 | 176.77 | 371.22 | 264 | 1056 | 0.35 | **LOS F** |
| Bow Street | 3.8 | 26.84 | 101.99 | 345 | 1379 | 0.07 | **LOS F** |
| Metcalfe Street | 3.5 | 89 | 311.50 | 234 | 934 | 0.33 | **LOS F** |
| Bentick Street | 2.1 | 72.04 | 151.28 | 309 | 1235 | 0.12 | **LOS F** |
| Rabindra Sarani Rd. | 1.9 | 72.37 | 137.50 | 235 | 938 | 0.15 | **LOS F** |
| Chatawalla Gully | 3.5 | 70.94 | 248.29 | 271 | 1083 | 0.23 | **LOS F** |
| Phears Bye Lane | 2.0 | 66.03 | 132.06 | 209 | 834 | 0.16 | **LOS F** |
| Phears Lane | 4.8 | 57.85 | 277.68 | 271 | 1082 | 0.26 | **LOS F** |
| Giri Babu lane | 2.4 | 54.62 | 131.09 | 201 | 802 | 0.16 | **LOS F** |
| Central Metro (GATE 2_Lalbazar) | 1.9 | 110.67 | 210.27 | 205 | 820 | 0.26 | **LOS F** |
| Central Avenue (GATE 3_RITES) | 1.8 | 115.52 | 207.94 | 108 | 431 | 0.48 | **LOS F** |
| Gangadhar Babu lane | 5.0 | 109.26 | 546.30 | 130 | 519 | 1.05 | LOS E |
| Bibi Rozio Lane | 1.8 | 72.5 | 130.50 | 141 | 563 | 0.23 | **LOS F** |
| College Street | 1.9 | 163.12 | 309.93 | 282 | 1128 | 0.27 | **LOS F** |

**Table 6.** *Level of Service at Evening Peak Hour*

| EVENING TIME: Determining Quantitative Level of Service (LOS) through PEDESTRIAN SPACE METHOD | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Street Name** | **$W_E$** | **$L_E$** | **$A_E$** | **$V_{15}$** | **$V_{60}$** | **$PS_N$** | **Corresponding LOS** |
| Nirmal Chandra Dey Street | 2.1 | 51.49 | 108.13 | 169 | 677 | 0.16 | **LOS F** |
| New Bowbazar lane | 5.0 | 51.68 | 258.40 | 226 | 904 | 0.29 | **LOS F** |
| Kenderdine Lane | 3.0 | 87.62 | 262.86 | 176 | 705 | 0.37 | **LOS F** |
| Central Avenue (GATE 4_Yogayog Bhawan) | 2.1 | 126.43 | 265.50 | 77 | 308 | 0.86 | **LOS F** |
| Central Metro(GATE 1_Indian Airlines) | 2.1 | 176.77 | 371.22 | 196 | 785 | 0.47 | **LOS F** |
| Bow Street | 3.8 | 26.84 | 101.99 | 279 | 1115 | 0.09 | **LOS F** |
| Metcalfe Street | 3.5 | 89 | 311.50 | 246 | 983 | 0.32 | **LOS F** |
| Bentick Street | 2.1 | 72.04 | 151.28 | 254 | 1015 | 0.15 | **LOS F** |
| Rabindra Sarani Rd. | 1.9 | 72.37 | 137.50 | 255 | 1018 | 0.14 | **LOS F** |
| Chatawalla Gully | 3.5 | 70.94 | 248.29 | 236 | 945 | 0.26 | **LOS F** |
| Phears Bye Lane | 2.0 | 66.03 | 132.06 | 180 | 718 | 0.18 | **LOS F** |
| Phears Lane | 4.8 | 57.85 | 277.68 | 276 | 1103 | 0.25 | **LOS F** |
| Giri Babu lane | 2.4 | 54.62 | 131.09 | 229 | 914 | 0.14 | **LOS F** |
| Central Metro (GATE 2_Lalbazar) | 1.9 | 110.67 | 210.27 | 186 | 744 | 0.28 | **LOS F** |
| Central Avenue (GATE 3_RITES) | 1.8 | 115.52 | 207.94 | 70 | 278 | 0.75 | **LOS F** |
| Gangadhar Babu lane | 5.0 | 109.26 | 546.30 | 190 | 760 | 0.72 | LOS E |
| Bibi Rozio Lane | 1.8 | 72.5 | 130.50 | 145 | 580 | 0.23 | **LOS F** |
| College Street | 1.9 | 163.12 | 309.93 | 229 | 917 | 0.34 | **LOS F** |

For a day as well as evening in the eighteen surveyed stretches in the case area, none of them have Level of Service A or B or C or even D. Only one (5.6%) of the surveyed stretches have a LOS E which represents unsuitable pedestrian conditions. The remaining case area has LOS F which represents severely restricted pedestrian conditions.

### Correlating Various Attributes of Field Survey

In this section of the paper, the pedestrian data is correlated with the other factors in this research- 1) Footpath width, 2) Noise, 3) Light intensity, and 4) Thermal comfort. Pearson's Correlation with a 95% confidence interval has been used in this research. Tables 5 and 6 elaborate on the correlation between Peak Hour Volume (15 min) and Variables in daytime and evening time, respectively.

**Table 7.** *Level of Service at Evening Peak Hour*

| DAY TIME: Correlation between Peak Hour Volume (15 min) and Variables: | | | |
|---|---|---|---|
| **S.No.** | **Variable** | **Correlation Coefficient** | **Relationship** |
| 1 | Footpath Width (in Metres) | 0.25 | Weak +ve |
| 2 | Avg. Sound Intensity (in Decibel) | -0.07 | Weak -ve |
| 3 | Avg. Light Intensity (in Lux) | 0.11 | Weak +ve |
| 4 | Avg. Temperature (in deg Centigrade) | -0.30 | Weak -ve |

**Table 8.** *Level of Service at Evening Peak Hour*

| EVENING TIME: Correlation between Peak Hour Volume (15 min) and Variables: | | | |
|---|---|---|---|
| **S.No.** | **Variable** | **Correlation Coefficient** | **Relationship** |
| 1 | Footpath Width (in Metres) | 0.44 | Moderate +ve |
| 2 | Avg. Sound Intensity (in decibels) | -0.17 | Weak -ve |
| 3 | Avg. Light Intensity (Average Day Time) | 0.35 | Moderate +ve |
| 4 | Avg. Temperature (in deg Centigrade) | -0.06 | Weak -ve |

In most urban areas with planned layouts and systematic transportation schemes, there exists a strong correlation between the pedestrian count and other related factors. However, in this research, there is an absence of a strong correlation between the pedestrian count and the other factors of the field survey.

### Further Linking the LOS with Previous Research

However, research in the same case area involving 125 individuals (74 able-bodied people under the age of sixty and 51 people from the senior citizen and differently-abled people category) from the case area shows that the users are not comfortable with the pedestrian environment.[15] Only 74.51% of the respondents from the senior citizens and differently-abled categories can use the pedestrian facility, in comparison to 93.24% of the able-bodied people under the age of sixty. Furthermore, on inquiring the respondents (who use the pedestrian facility) about pedestrian comfortability using a Likert Scale approach (1 being the worst and 10

15. N. Ricci, *The Psychological Impact of Architectural Design* (Claremont, California: Claremont McKenna College, 2018).

being the best) the weighted mean score of their (senior citizen and differently-abled category) response was 4.92 out of 10, which is a poor score in terms of walkability standards. The response from able-bodied people under the age of sixty was also below satisfactory standards. The aforementioned research also reflects the lack of Universal Mobility standards in terms of infrastructure in the case area.

Thus, it can be inferred that although there is no correlation between the LOS and the pedestrian count; the full potential of the walkable population is not explored due to the lack of proper pedestrian facilities.

## Discussion

At the urban level, design elements (like buildings, road patterns, or sculptures) can have both positive and negative effects on human psychology.[16] Pritzker Award (1980 edition) winning architects like Luis Barragan have emphasized the emotional aspect of design. Similarly, Indian architect Pramod Beri has put forward the theory of 'Form follows Feelings'. Additionally, the role of four out of five fundamental human senses: vision, touch, smell, and hearing influences pedestrian movement. Thus, in the wake of the 21$^{st}$ -century's global focus on Universal Mobility, Architectural Planning should take into consideration the parameters of design that could positively influence pedestrians by targeting specific hormonal secretions. The role of Assistive Technology can be crucial in this process.

The way human beings behave in a particular socio-environmental setting is based on the type and rate of hormones that they secrete.[17] The hormone plays an important role in the aging process too.[18] Even for differently-abled people, the hormonal aspects are comparatively more important since they are having compromised physical and/or mental states.[19] Hormones impact human behavior.[20] It can also influence the cognition of humans in different physical environments.[21]

16. C. S. Carter, "Hormonal Influences on Human Behaviour," in *New Aspects of Human Ethology* (ed.) A. K. Schmitt, 141-162 (Boston, MA: Springer, 1996).

17. V. Zjačić-Rotkvić, L. Kavur, and M. Cigrovski-Berković, "Hormones and Aging," *Acta Clinica Croatica* 49 (2010): 549-554.

18. A. K. P. Kumar, "Hormones and Behaviour," in *Encyclopedia of Animal Cognition and Behavior* (ed.) S. T. J. Vonk, 1-22 (Cham: Springer, 2018).

19. Carter, "Hormonal Influences on Human Behavior," 1996.

20. A. Kumar, P. Kumar, M. Faiq, V. Sharma, K. Sesham, and M. Kulandhasamy, "Hormones and Behaviour," in *Encyclopedia of Animal Cognition and Behavior* (eds.) J. Vonk, and T. Shackelford (Cham: Springer, 2018).

21. R. R. Kearns, and R. Spencer. "An Unexpected Increase in Restraint Duration Alters the Expression of Stress Response Habituation," *Physiology & Behavior* 122 (2013): 193-200.

Stimulus is received by the brain when a person walks in an environment and accordingly the body responds, thus creating an associated memory leading to habituation. In contrast to the above, when a person walks in an environment that has a certain level of difficulty walking (like potholes, high sound of traffic, or poor visibility) a sense of fear is generated which leads to a sense of diminished security. The sense of fear is neurologically caused due to over-secretion of Epinephrine (Adrenalin and Cortisol) leading to an increased heart and breath rate.[22] In addition to this, the over-secretion of Epinephrine dilates the blood vessels in the lungs and muscles. Thus, specially-abled and elderly people often get disoriented and gets panicked when subjected to critical pedestrian conditions.[23] Architectural Planning Research can help human behavior by identifying and later influencing hormone secretion through architectural planning interventions.[24] Furthermore, the authors suggest that Assistive Technologies might prove beneficial for improving the behavior of the specially-abled and elderly in pedestrian environments.

Assistive Technology is essentially any technology or method to improve the daily life of specially-abled people.[25] The primary focus of assistive technology is to remove obstacles and foster the functional ability of a diverse user group.[26] Assistive Technology should be affordable and mandatory since it is considered a human right rather than a mere additional facility in the context of 21st-century urbanization [27] Although various assistive/ interactive technologies like HADRIAN, VERITAS, Inclusive CAD, SEE-IT, and the University of Cambridge fostered Inclusive Design Toolkit exist, their usage is highly dubious in the pedestrian context of developing nations.[28] Additionally, street-level assistive

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22. University of Rochester Medical Center Rochester, *Neuroscience* (University of Rochester Medical Centre, 2022).

23. L. B. Fich, M. Wallergård, A. M. Hansen, and P. Jönsson, "Stress Hormones Mediated by the Built Environment. A Possibility to Influence the Progress of Alzheimer's Disease?" in *ARCH 17: 3RD International Conference on Architecture, Research, Care and Helath* (eds.) N. Mathiasen, and A. Kathrine Frandsen, 150-162 (Kongens Lyngby: Polyteknisk Boghandel og Forlag, 2017).

24. World Health Organization and The World Bank, *World Report on Disability* (Malta: World Health Organization, 2011).

25. J. Mueller, M. Jones, and L. Broderick, "Assessment of User Needs in Wireless Technologies," *Assistive Technology* 17, no. 1 (2005).

26. L. d. Witte, E. Steel, S. Gupta, V. D. Ramos, and U. Roentgen, "Assistive Technology Provision: Towards an International Framework for Assuring Availability and Accessibility of Affordable High-Quality Assistive Technology," *Disability and Rehabilitation: Assistive Technology* 13, no. 5 (2018): 467-472.

27. E. Zitkus, "A Review of Interactive Technologies Supporting Universal Design Practice," in *Universal Access in Human–Computer Interaction. Design and Development Approaches and Methods*, 132-141 (Springer, Cham, 2017).

28. C.-Y. Huang, C.-K. Wu, and P.-Y. Liu, "Assistive Technology in Smart Cities: A Case of Street Crossing for the Visually-Impaired," *Technology in Society*, 68, no. 101805 (2022): 1-8.

technology focused on specific disabilities like the visually impaired or auditory impaired.

To foster the use of assistive technology at the street level, the authors have proposed further investigation in the same domain, which is mentioned hereafter.

## Conclusions

For understanding the pedestrian behavior of the elderly alongside others, a simulation study is being conducted by the authors. In the first phase, the study involves 25 individuals from 16 different nationalities.

A survey format (shown in Table 9) was used to record the participants' data.

**Table 9.** *Survey Format for Understanding Pedestrian Behavior*

<table>
<tr><td colspan="11">Survey Format for understanding pedestrian behavior</td></tr>
<tr><td colspan="3">Date of Survey</td><td colspan="8"></td></tr>
<tr><td colspan="3">Time</td><td colspan="8"></td></tr>
<tr><td colspan="3">Temperature (in degrees Centigrade)</td><td colspan="8"></td></tr>
<tr><td colspan="3">Wind Speed (in meter/second)</td><td colspan="8"></td></tr>
<tr><td colspan="3">Humidity (in %)</td><td colspan="8"></td></tr>
<tr><td colspan="3">Precipitation</td><td>YES</td><td></td><td colspan="3">NO</td><td colspan="3"></td></tr>
<tr><td colspan="3">Snowfall</td><td>YES</td><td></td><td colspan="3">NO</td><td colspan="3"></td></tr>
<tr><td colspan="11">Participant</td></tr>
<tr><td>Name</td><td colspan="2"></td><td>Country</td><td colspan="4"></td><td colspan="2">Age</td><td></td></tr>
<tr><td>Gender</td><td>MALE</td><td></td><td>FEMALE</td><td></td><td colspan="3">TRANSGENDER</td><td colspan="3"></td></tr>
<tr><td colspan="11">Travel Reading</td></tr>
<tr><td colspan="2">With a prosthetic suit</td><td>While going</td><td></td><td colspan="2">seconds</td><td>While coming</td><td colspan="2"></td><td colspan="2">seconds</td></tr>
<tr><td colspan="2">Without a prosthetic suit</td><td>While going</td><td></td><td colspan="2">seconds</td><td>While coming</td><td colspan="2"></td><td colspan="2">seconds</td></tr>
<tr><td colspan="3">Surveyed By:</td><td></td><td colspan="3">Checked By:</td><td colspan="4"></td></tr>
</table>

A footpath stretches of approximately 150 meters within the Hokkaido University campus between Seicomart and the Graduate School of Engineering (shown in Figure 8) was selected, and the participants were asked to casually walk up and down in that stretch. This stretch has a relatively higher pedestrian footprint in comparison to the other parts of the university. The participants were further made to walk the same stretch (up and down) wearing a geriatric simulator, which made them behave like elderly people.

Apart from other deductions, on average, the time taken by an individual in a simulated elderly condition is 2.11 times more than the time taken under an able-bodied condition.

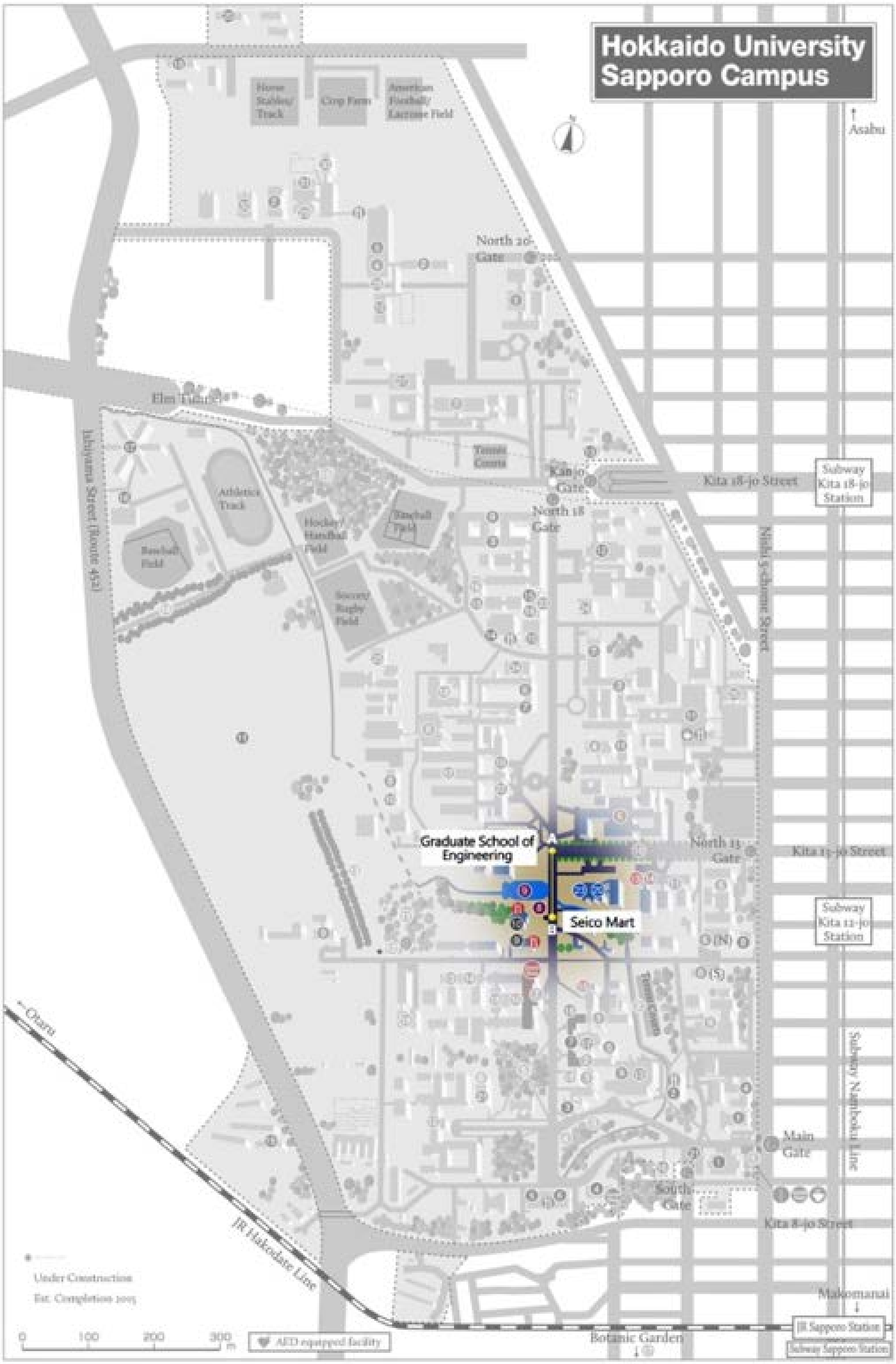
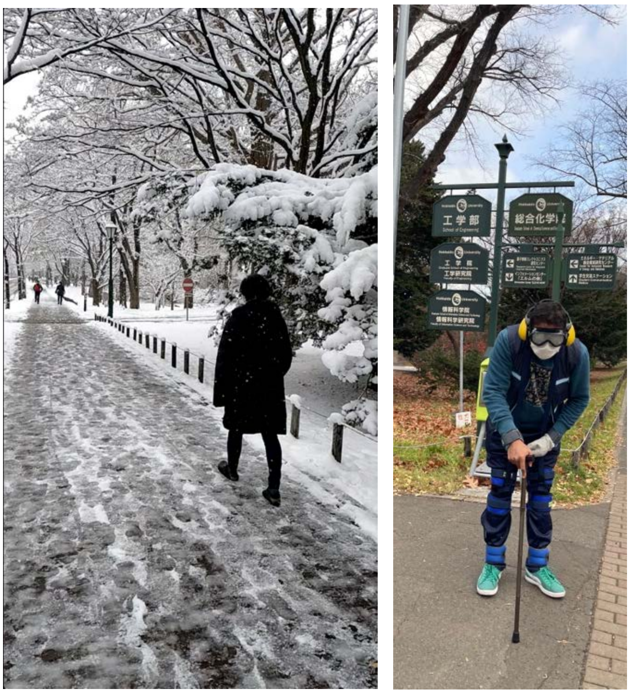



**Figure 8.** *Survey Location in Hokkaido University*
*Source:* Hokkaido University Official Website. https://www.global.hokudai.ac.jp/about/publications/campus-map/. [Accessed 28 April 2022.]

Figure 9 shows the different components that the geriatric simulator is composed of. Figures 10 and 11 show some pictures from the survey wearing the simulation suit and general conditions respectively.


**Figure 9.** *Simulation Suit*



**Figures 10 and 11.** *Pictures from Survey*

Apart from this, the authors are exploring the application of the Impairment Simulator Software developed by the researchers at the Engineering Design Centre in the Department of Engineering, University of Cambridge.[29] The software is used to generate alternate scenarios (like for differently-abled and elderly) and thereby open paths for strategic intervention.

Finally, the authors state that the methodological framework from this paper (results furnished in this paper and methodology for future research) shall be beneficial for researchers while designing/ planning for improving cognition in pedestrian-level Universal Mobility in other old cities of India.

## Acknowledgments

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29. Engineering Design Centre Department of Engineering, University of Cambridge, *Impairment Simulator Software*. (Inclusive Design Toolkit, 2017).

Gould, P., and R. White. *Mental Maps.* 2nd Edition. London: Allen and Unwin, 1986.

Huang, C.-Y., C.-K. Wu, and P.-Y. Liu. "Assistive Technology in Smart Cities: A Case of Street Crossing for the Visually-Impaired." *Technology in Society,* 68, no. 101805 (2022): 1-8.

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