

Research on the Spatial Renovation of Bus Stops Based on Universal Design Principles

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ABSTRACT

As China enters the stage of an aging society, issues related to the accessibility and usability of bus stops have become increasingly prominent. This paper, based on universal design principles, explores the optimization and renovation of bus stop spaces to enhance their fairness and convenience. First, the study reviews relevant theories on universal design and analyzes its applications in urban public spaces by referencing domestic and international research findings. Subsequently, through field investigations and questionnaire surveys, the current state of bus stops in Beijing is evaluated, revealing issues such as aging facilities, lack of accessibility facilities, unclear information transmission, and poor waiting environments. Based on user satisfaction analysis, this research proposes optimization strategies for bus stops, including improving accessibility facilities, optimizing seating design, enhancing information readability, improving waiting environments, and increasing spatial utilization efficiency. The research's findings can serve as a reference for the practical implementation of bus stop space design and offer insights for optimizing public bus facilities in other cities.

Key Words: Aging Population; Universal Design; Bus Stops; Accessibility Facilities; Questionnaire Survey

Currently, China is entering a rapidly aging society. According to the latest data from the National Bureau of Statistics, by the end of 2023, the population aged 60 and above reached 296.97 million, accounting for 21.1% of the total population of 1.4 billion. Among them, those aged 65 and above account for 15.4%. Meanwhile, China has over 85 million people with disabilities, accounting for 6.20% of the total population. This has made the issues of accessibility and usability in public spaces increasingly prominent. In the public bus system, bus stops serve as crucial hubs for urban travel; their spatial design not only affects travel efficiency but also directly impacts the convenience of travel for the elderly, people with disabilities, and those with limited mobility. However, many current design of bus stops remains inadequate, resulting in numerous barriers for certain groups when using the bus system.

In response to this issue, universal design (UD) has emerged in recent years as a key approach to improving inclusivity in public spaces. Universal design emphasizes fairness and usability, aiming to create facilities that are accessible and convenient for all people, including elderly individuals, people with disabilities, children, and general passengers. Currently, the specific implementation of universal design in bus stop design in China remains limited, and relevant design standards need further refinement to better meet the diverse needs of society.

Based on this context, this research examines selected bus stops in Beijing, employing field investigations and questionnaire surveys to analyze the existing facilities and user experiences. It explores the application strategies of universal design in optimizing bus stop spaces, aiming to provide theoretical support and practical references for bus stop renovations. The research

seeks to improve accessibility, comfort, and fairness in bus stop design while offering insights for optimizing bus stops in other cities.

1. Theoretical Background and Literature Review

1.1 Overview of Universal Design Principles

Universal Design (UD) refers to the design of products and environments that aim to meet user needs as much as possible. By designing in this way, products or environments become convenient for everyone to use, ensuring a comfortable life for all. The 7 principles of Universal Design are presented in the table below.

2.2 Application of Universal Design in Bus Stop Spaces

The concept of universal design emphasizes inclusive environments that cater to all users. Applying universal design principles in the planning and design of bus stops can improve accessibility and usability, ensuring that all individuals—including the elderly, people with disabilities, children, and general passengers—can fairly, safely and conveniently use public bus service. Based on the seven universal design principles, bus stop optimization can be approached as follows:

1)Equitable Use

Bus stop facilities should accommodate all users

without compromising usability due to differences in ability. For example, platforms should include accessible ramps and low-floor bus docking areas to facilitate wheelchair users. Seating should be designed with appropriate height and armrests to enhance comfort and safety for elderly individuals and those with mobility impairments.

2)Flexibility in Use

Designs should cater to preferences and abilities of different users. For example, bus stop information displays can integrate digital screens with traditional printed signage to ensure accessibility for diverse user groups.

3)Simple and Intuitive Use

Bus stop wayfinding signage should be clear and easy to understand, reducing the cognitive load for users. Maps, route information, and transfer guides should employ high-contrast colors, legible fonts, and universal icons to facilitate quick comprehension for all passengers, including tourists and those with lower literacy levels.

4)Perceptible Information

Key information at bus stops should be conveyed through multiple sensory channels to accommodate various users’ needs. For instance, auditory announcement systems can assist visually impaired individuals to obtain

Principle	Description
Equitable Use	The design should be useful and marketable to people with diverse abilities.
Flexibility in Use	The design should accommodate a wide range of individual preferences and abilities.
Simple and Intuitive Use	The design should be easy to understand and operate.
Perceptible Information	The design should provide a variety of sensory channels for information transmission.
Tolerance for Error	The design should minimize risks and accidents in use.
Low Physical Effort	Physical effort should be minimized during use.
Size and Space for Approach and Use	Bus stop spaces should be sufficiently spacious to accommodate users of varying sizes, postures, and mobility needs.

stop information, electronic screens can display real-time bus arrival information, and tactile paving can provide directional guidance for visually impaired individuals.

5)Tolerance for Error

Design elements should minimize risks and prevent errors. For instance, high-contrast safety lines on platform edges can alert passengers to maintain a safe distance while waiting. The slope of accessible ramps should be gentle enough to prevent wheelchair users from slipping.

6)Low Physical Effort

Bus stop facilities should minimize physical strain on users to improve the convenience of use. For example, seating should be designed for comfort, avoiding metal surfaces that become excessively cold in winter or hot in summer. Ramps and pathways should be smooth and barrier-free, eliminating unnecessary steps and obstacles to ensure smooth passage for individuals with mobility impairments.

7)Size and Space for Approach and Use

Bus stop spaces should be sufficiently spacious to accommodate users of varying sizes, postures, and mobility needs. Waiting areas should be wide enough to allow easy movement for wheelchair users and passengers with strollers. The width of accessible pathways and the height of handrails should adhere to ergonomic standards to accommodate users of different heights and abilities.

By incorporating the seven universal design principles, the optimization of bus stop space can not only enhance travel convenience but also promote social equity, ensuring that all individuals can enjoy safe, comfortable, and convenient public bus services. The application of this design approach is of great significance for improving the inclusivity of urban public facilities and provides valuable references for future bus stop planning.

3. Research Methods

This research employs a combination of quantitative and qualitative methods, focusing on selected bus stops in Beijing. A literature review is conducted to gather domestic and overseas research data on universal design and barrier-free bus stop design, and the relevant theoretical framework is sort out. Mealwhile,

field investigations are carried out to document the conditions of various bus stops, and a questionnaire survey is designed to collect user feedback on potential improvements. The collected data is analyzed using SPSS software to identify key issues in bus stop design and propose optimization strategies.

4. Case Analysis and Evaluation

In this research, 24 bus stops were randomly selected in Beijing for field investigation, as shown in the figure below.

Through research, it was found that the existing bus stops are mainly designed with an integrated stainless steel with a "7"-shaped structure, and the overall design is relatively uniform. However, there are still many shortcomings in meeting the diverse needs of passengers, which are reflected in the following aspects.

4.1 Deficiencies in Facility Design

Currently, most bus stops in Beijing are equipped with basic facilities, including a windscreen, sunshade roof, and stainless steel seats. Most stops are equipped with trash bins, and a few have safety guardrails. However, during actual use, these facilities reveal many problems. Firstly, the comfort of the bus stop seating is poor. Due to the use of stainless steel material, the seats become too cold in winter and too hot in summer due to exposure to the sun, affecting the passenger experience. In addition, the limited number of seats makes it difficult to meet the demand during peak hours, with many passengers having to stand. Secondly, the wind and rain protection at the bus stops is weak. The current bus stops typically only have a single windscreen, and passengers cannot be effectively shielded in bad weather conditions. Especially in winter, when the wind is strong, the waiting environment becomes harsh, greatly reducing passenger comfort.

4.2 Inadequate Accessibility Facilities

Although most bus stops have tactile paving, the accessibility facilities still have significant room for improvement and do not fully meet the needs of special groups. For wheelchair users, some bus stops do not have accessible ramps or have ramps with unreasonable

slopes, affecting the convenience for wheelchair users and people with mobility impairments. Additionally, the accessible pathways at the platforms are often obstructed by terrain or other facilities, further increasing travel difficulties. In terms of the guide system, some bus stops have discontinuous tactile paving, and some have no guide paths at all, making it difficult for visually impaired people to access the platform. Due to the lack of voice prompts or other auxiliary facilities, they face significant challenges when finding the bus stop, affecting both travel safety and convenience.

4.3 Inadequate Information Accessibility

Currently, the readability of the information at bus stops is low. The bus stop signs often use ordinary fonts with small sizes and lack high-contrast designs, making it difficult for the elderly and visually impaired people to read. The location and lighting conditions of the signs may also affect the recognition of information, making it hard for passengers to obtain timely information about bus routes and schedules. Moreover, the methods of information delivery are relatively singular. Most bus stops are not equipped with voice broadcasting devices and rely solely on the signboards to display information, which does not meet the needs of the visually impaired people. In a complex travel environment, the lack of multi-sensory information access channels may increase travel difficulties for special groups, reducing the convenience and safety of the waiting experience.

4.4 Low Utilization of Waiting Space

Some bus stops experience space shortages and overcrowding during peak hours, which affects the waiting experience and traffic efficiency. The platform space is relatively narrow, and the design does not fully consider the activity needs of different groups, leading to inefficient passenger flow, especially during morning and evening rush hours when congestion is common. The platform layout lacks flexibility, making it difficult for passengers to maintain smooth movement when queuing, further exacerbating the space shortage. The waiting environment also needs to be improved. Some bus stops lack greenery and humane design, resulting in a lack of comfort in the waiting area. Moreover, large

trees or other obstructions around the platform may block passengers' line of sight, making it difficult to clearly see bus information, further reducing the overall waiting experience.

In conclusion, there is still significant room for improvement in terms of facility design, accessibility device, information accessibility method, and utilization of waiting space at bus stops in Beijing. There is an urgent need to optimize these aspects based on the universal design concept to improve the accessibility and convenience of bus stops.

5 Survey Questionnaire Analysis

In order to gain a deeper understanding of the usage of bus stop facilities and improvement needs, in this research, different feedbacks were collected from different groups through a questionnaire survey through statistical analysis. Suggestions related to universal design were extracted, and based on the five core elements of universal design (comfort, acceptability, accessibility, safety, and information accessibility), the collected suggestions were summarized to identify optimization directions.

5.1 Comfort

1) Optimization of the waiting environment.

Suggestions include adding shading, rain, and wind protection, such as installing windshields, cooling fans, or outdoor air conditioning units, and optimizing the spatial design for winter warmth and summer cooling.

2) Optimization of seats.

Suggestions include improving seat comfort by increasing the number of seats, optimizing materials (avoiding cold in winter and hot in summer), enhancing aesthetics, and adding heating functions.

3) Improvement of the spatial environment.

Suggestions include enhancing the waiting area environment by planting greenery, strengthening humane design, and improving lighting facilities for night-time use.

5.2 Acceptability

1) Enhancement of the waiting experience.

Suggestions include optimizing bus stop management, such as adding convenience facilities,

improving orderliness, and strengthening bus service facilities.

2)Capacity and station planning.

Suggestions include adjusting bus frequencies, optimizing bus numbers, and planning more reasonable route layouts to alleviate overcrowding during peak hours.

5.3 Accessibility

1) Improvement of accessibility facilities.

Suggestions include adding accessible pathways, dedicated wheelchair areas, tactile paving, and other facilities to meet the needs of people with disabilities.

2)Optimization of accessible information.

Suggestions include providing electronic information screens, voice broadcasting systems, and high-definition bus stop signs to make information more accessible.

5.4 Safety

1) Improvement of traffic safety.

Suggestions include improving platform guardrails and setting up designated waiting areas to reduce the impact of electric vehicles and bicycles on waiting passengers.

2)Management of boarding order.

Suggestions include optimizing boarding order by clearly demarcating boarding areas and enhancing order guidance to improve safety management.

3)Improvement of safety facilities.

Suggestions include installing monitoring equipment, lighting systems, warning signs, etc., to enhance safety at night and in special circumstances.

5.5 Information Accessibility

1) Improvement of information readability.

Suggestions include optimizing the bus stop design by using larger fonts, clearer contrast, and adding lighting for better readability.

2)Introduction of intelligent information systems.

Suggestions include incorporating real-time vehicle arrival reminders, electronic signboards, BIS systems, etc., to improve the convenience of obtaining information.

3)Optimization of the guidance system.

Suggestions include optimizing the station information layout by adding more intuitive signs,

electronic guiding screens, and separating different routes at bus stops.

6 Design Strategies of Bus Stops Renovation

Based on the problems found in Beijing's bus stops, in this research, the following optimization strategies are proposed based on the universal design concept to improve the inclusivity, convenience, and comfort of bus stops.

6.1 Facility Optimization and Update

1) Improve seat design.

Use ergonomically designed seats with materials that provide insulation, such as seats with automatic heating or cooling to adapt to seasonal changes.

2)Add accessible facilities.

Improve accessible ramps, guide systems, and set up dedicated waiting areas for wheelchairs to increase accessibility.

3)Improve rain protection facilities.

Add three-sided windshields to enhance rain protection and ensure passenger comfort while waiting.

6.2 Optimization of Information Delivery

1) Improve the readability of bus stop signs.

Use high-contrast, large-font designs and include Braille information for better accessibility by different groups. Add voice broadcasting systems. Install voice prompt devices at bus stops to provide real-time bus information for the visually impaired people and elderly, improving information accessibility.

2)Add electronic screens.

Install electronic display screens to provide real-time bus information, improving passengers' travel efficiency.

6.3 Optimization of Waiting Space

1) Optimize platform layout.

Properly plan functional zones on the platform to ensure smooth flow for wheelchair users, pedestrians, and waiting passengers to reduce congestion.

2) Add greenery and lighting.

Increase greenery to enhance environmental quality and optimize lighting to improve safety when waiting at night.

7 Conclusion

Based on the universal design concept, in this research, the current situation of bus stops in Beijing is analyzed and many problems in facilities, information delivery, and waiting spaces that affect the passenger experience are identified. Through questionnaires and field research, the core demands of users for bus stops are identified and a series of optimization strategies are proposed, such as improving seat materials, adding accessible facilities, optimizing information delivery methods, enhancing waiting space utilization, and introducing intelligent design. These strategies will effectively enhance the inclusivity of bus stops, better serve different groups, and improve the accessibility and convenience of urban public bus systems. The conclusions of this research can provide theoretical support and practical guidance for the universal design of future bus stops.

References

- [1] Wang Ping. The Total Population Has Declined, and High-quality Population Development Has Achieved Results. https://www.stats.gov.cn/sj/sjjd/202401/t20240118_1946701.html.
- [2] The State Council's Notice on Issuing the Plan for the Protection and Development of the People with Disabilities during the 14th Five-year Plan. https://www.gov.cn/zhengce/content/2021-07/21/content_5626391.htm.
- [3] People's Daily Online (2016). Didi Releases Report on Elderly Travel Habits: Nearly 20% of Elderly People Give Up Going Out When Facing Travel Difficulties. Retrieved from <http://it.people.com.cn/n1/2016/0310/c243510-28189227.html>.
- [4] Wang Qiuxia. Analysis of the Number of Persons with Disabilities Receiving Rehabilitation, Institutions, Education Scale, Practitioners, and Social Security in 2024: Significant Improvement in the Quality of Rehabilitation Services for Persons with Disabilities in China, with Over 9 Million Urban and Rural Disabled People Successfully Employed. Retrieved from <https://www.chyxx.com/industry/1196611.html>.
- [5] Health Newspaper Net (2017.2.17). Why Are More Than 85 Million People with Disabilities Rarely Seen in Public Places in China? Retrieved from <http://www.jksb.com.cn/html/news/headlines/2017/0217/108670.html>.
- [6] Beijing Traffic Radio. Elderly Passengers Account for Nearly 32%! How Beijing Buses Show "Respect and Care for the Elderly". Retrieved from https://m.gmw.cn/2023-10/24/content_1303548278.htm.
- [7] Lee, J. A Review of the Diversity of Design Approaches Considering the Socially Disadvantaged: Exploration of the Emergence and Evolution of Universal Design-Related Concepts. *Journal of the Korea Society of Spatial Design*, Vol.18, No.1 (Issue 86), 2021, pp.459–460.
- [8] Naver Dictionary. Definition of Xiaokang Society: A Society Where People's Living Standards Reach a Moderately Well-off Level. Retrieved from <https://zh.dict.naver.com>.
- [9] Xing, C., & Chae, M. Guidelines for Improving Universal Design in China's Public Environment. *Exhibition Design Research*, Vol.19, No.2, 2022, p.39.
- [10] Xinhua News Agency. Law of the People's Republic of China on the Construction of Barrier-Free Environments. Retrieved from https://www.gov.cn/yaowen/liebiao/202306/content_6888910.htm.
- [11] Park Ji-Eun, Kim Young-Won, Suh Soo-Kyung. Evaluation Study on the Applicability of Universal Design for Bus Platforms: Focusing on Domestic and International Bus Stop Cases [J]. *Proceedings of the Korean Institute of Interior Design Conference*, 2023, 15(1):107-111.
- [12] Yao Qingfeng. Research on the Transformation of Barrier-free Public Facilities in Rural Streets Based on Universal Design Concepts [J]. *City Planning Review*, 2024:31-34.
- [13] Xi Congqing. Discussion on the Value System and Practical Significance of the Concept of Disabled People in Modern Civilized Society [J]. *Disability Research*. No.3, 2013.
- [14] Piao Jianhui. Application Design Analysis of Bus Station in Urban Planning and Design [J]. *WENCUN YUEKAN*. No.4, 2024.
- [15] Huang Geng. Strive to Explore the Effective Path of Urban Organic Renewal [J]. *Chongqing Architecture*. No.2, 2021.