



Application Research on Inclusive Design: Take the Hang-Hai Intercity Railway for Example

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Abstract: Under the situation of integrated development of the Yangtze River Delta, the city of Haining has put forward the strategic goal of "integrating itself into Hangzhou and Shanghai". Therefore, Hang-Hai Intercity Railway has been planned and built as a positive response and specific implementation to this goal. This paper studies the inclusive design in the Hang-Hai Intercity Railway. Through this small practical case, this paper attempts to reflect the current situation of inclusive design in China, especially in public transport. At the same time, it gives high light on the potential advantages of inclusive design in public transport, and provides suggestions for inclusive public transport design, inclusive city construction and inclusive urban agglomeration planning and construction. The research, based on the classification of the railway leading users, analyzes the questionnaires to the railway potential users, together with the design empathy experience of the student teams, further demonstrates the necessity and the possibility of inclusive design applying in Hang-Hai Intercity Railway. Through the practice of the inclusive icon design of each station of the Hang-Hai Intercity Railway, this paper also demonstrates the feasibility of inclusive design in Intercity Rail Transit, and provides inspiration and innovation to optimize and utilize the inclusive design in public transport.

Keywords: Hang-Hai Intercity Railway, Leading Users, Design Empathy, Inclusiveness, Design Practice

1. Introduction

1.1. Research Background

In the context of the integrated development of the Yangtze River Delta, the city of Haining put forward the urban development strategic goal of "integrating Hangzhou, and connecting Shanghai" and the planning and construction of the Hang-Hai Railway is an active response and concrete implementation of this goal. The planning of intercity railway transportation is also the development demand of an inclusive city. It not only shortens the distance between Haining and Hangzhou, but also provides convenience for citizens to commute and travel.

Meanwhile, according to the statistics of the Haining Health and Family Planning Bureau, in 2016, 171,800 people aged over 60 in the city, accounted for 25.2% of the city's population. According to figures, Haining's population, as

well as the age structure, is aging. There are 21,000 disabled people in the city, accounting for 2.5% of the city's population, which is also a large proportion.

Changes in the social demographic structure, increased awareness of human rights, and the need for the construction of intercity railway facilities have led to the transformation of design concepts and design methods. Inclusive Design has therefore become a design theory method that is concerned by society and industry [1]. Its main purpose is to explore the needs of elderly users, disabled people and other disadvantaged groups and help them integrate into the mainstream society. Inclusive design is of certain importance and urgency in the planning and design of the Hang-Hai Railway. It is an important manifestation of inclusive city construction. It is also the prerequisite for Haining to achieve barrier-free tourism as well as the specific implementation of the Hangzhou-Jiaxing integrated pilot area and an indication that reflects the living standards and human care of Haining people.

1.2. Research Significance

Any design decision has some exclusiveness [2], and inclusive design is to reduce the exclusiveness of the design as much as possible, and to include all kinds of people in the category of users. Countries around the world have entered the aging society, and changes in the social demographic structure have spurred changes in design methods. Inclusive design has therefore become a design theory and method of concern to society and industry [3].

Relevant research of inclusive design in the public environment is mainly discussed through Interdisciplinary approach [4] using "elderly-oriented design" as the entry point; inclusive design research in the construction of intercity railways mainly stays at the stage of design principles and evaluation systems. However, the domestic research has deficiencies in the following aspects and needs to be expanded: First, the research on inclusive design in China, especially the applied research in urban subways, currently has few results. Secondly, inclusive design has cultural sensitivity [5], how to localize the inclusive design is seldom discussed. The development of inclusive products and facility designs that are suitable for Chinese basic national conditions, bearing the cultural symbols of the country, and fitting the ideology of Chinese residents is currently vacant. Thirdly, so far as the current domestic public lacks a correct understanding of inclusive design, how to use new methods to popularize inclusive design requires in-depth discussion.

Thus the significance of this article lies in the following points.

First, from the perspective of urban construction, reflecting social care [6] and improving the quality of the city. The investigation of intercity rail transit can objectively evaluate the use effect of urban inclusive facility design, analyze potential problems and propose solutions, optimize the design, make the urban subway more inclusive, improve citizen travel satisfaction, and improve the quality of urban life.

Second, from the perspective of design practice, concretizing inclusive design. Through the inclusive design optimization scheme, the application of inclusive design in the intercity railway is specified, and the inclusive design theory is further enriched.

Third, from the perspective of cultural publicity, localizing inclusive design. The localization of inclusive design can solve the outstanding contradictions in Haining's urban development at this stage and further promote the improvement of urban quality; use new methods to promote and popularize inclusive design, thereby evoking public awareness of inclusive design and accelerating the popularization of inclusive design concepts.

1.3. Theoretical and Practical Value

The research direction is in line with the pace of urban public transportation construction, and it is highly consistent with national conditions, market conditions and international

design trends. With the rapid growth of the permanent population in Haining, the intensification of the aging population, along with the strategic deployment of the city, the intercity rail lines have also been further expanded. The functional layout is complex; the passenger flow is large; the characteristics of various groups of people are obvious; the movement lines are complex; public transport can demonstrate the quality of a city. To make Haining an inclusive city, barrier-free public transport travel plays an important role, and thus inclusive design has important research value. This article starts with the analysis of the leading users, then conducts an in-depth analysis of the behavior of taking the intercity railway, and draws a design concept of systematic design of inclusive design, "point mode" layout, and details to drive the overall situation. It proposes the overall implementation of inclusive design while taking into account of the local conditions. Combining inclusive design with cultural symbols is an attempt to localize inclusive design, which is in line with Haining's conditions and has Chinese characteristics.

2. Leading User Research

2.1. User Pyramid

To study the application of inclusive design in the Hang-Hai Railway, first of all, the leading users should be clearly identified [7]. They belong to marginalized people who are overlooked by products and facilities, but they often have greater, deeper and more urgent needs for products, facilities, services and environments.

The user pyramid [8] was proposed by the Swedish Ergonomics Group. At the bottom of the pyramid are the healthy people, that is, the mainstream people mentioned in this article; those with poor middle-level capabilities are users with reduced physical strength and mobility due to disease or organ senescence; At the top of the pyramid are users with severe disabilities and people who need care. As can be seen from the model, the needs and limitations of users with disabilities in public travel are shown in Figure 1.



Figure 1. User pyramid, capability level.

2.2. Questionnaire

In July 2019, the author made a questionnaire for the inclusive design of the Hang-Hai Railway and distributed it through WeChat. The users are mainly concentrated in Hangzhou and Haining, including residents along the way and migrants. In two weeks, 259 copies were received.

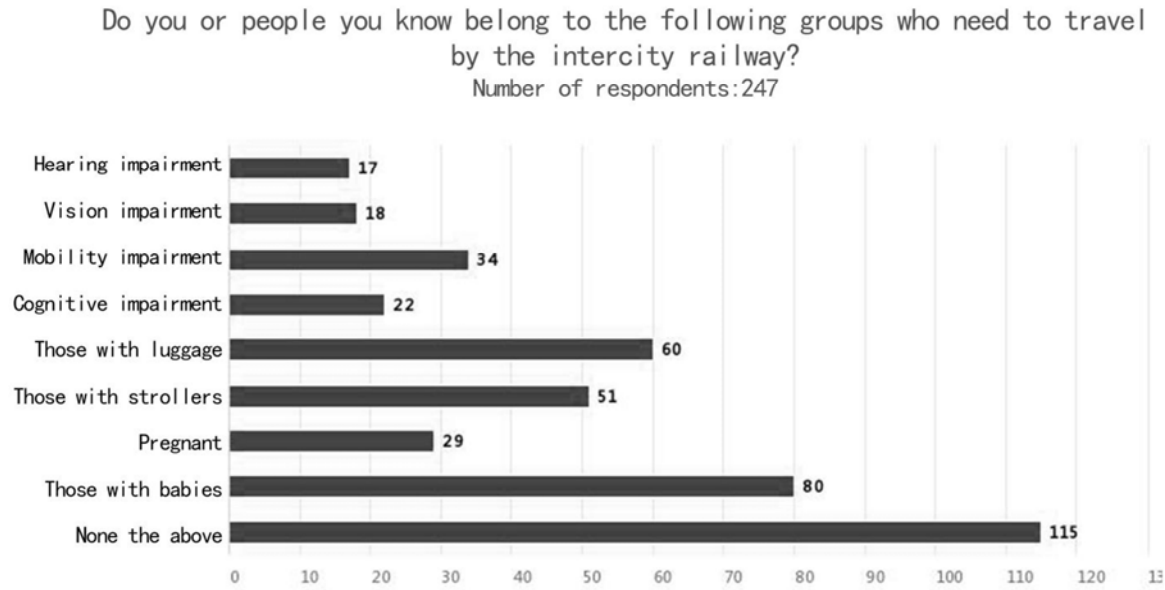


Figure 2. Questionnaire data results.

2.2.1. Percentage of the Leading Users

According to the questionnaire, the passengers of the Hang-Hai Railway are mainly residents of Hangzhou and Haining. The purposes of travel are short-distance tourism, not mentioned, Hangzhou East Railway Station, commuting, Haining West Railway Station, airport and school, long-term tourism. The diverse characteristics of the crowd can also be interpreted from the questionnaire. According to the classification of capacity, it can be divided into normal people, elderly people, the physical disordered (including internal and external causes), the cognitive impaired, children, foreigners, etc [9]. Apart from normal people, the other types of people have advantages and disadvantages in terms of cognitive

capability, sensory capability and motion capability [2]. Although their numbers are distributed in the form of a pyramid, from the analysis of the survey data, the proportion of the upper-level population (severely disabled and poorly abled) in the respondents is still very high, as can be seen from Figure 2. Among 247 respondents there are 132 people with various obstacles around them, more than half of the total number.

2.2.2. Feedback of Users

After the classification of the interviewed people, the investigation of the targeted problems found that all kinds of non-mainstream people have different perspectives. The first four items are listed in Table 1.

Table 1. Concerns of inclusive design for different groups.

Groups and total number (person)	Focus points	Numbers (person)
Hearing impairment 17	A readable announcement display in the carriage	11
	A complete and readable guidance system	10
	An electronic route guide in the carriage	9
	A staff member who know sign language at the information desk	6
	Voice prompts for entrance and exit, getting on and off	17
Vision impairment 18	A voice announcement in each carriage and the volume is suitable	14
	A manual ticket office	12
	The font size of the guidance system is appropriate and clear (for nearsighted and hyperopic groups)	11
	Braille should be available at the station and route map, ticket gate, and ticket office	6
	The gap and height difference between the carriage and the platform should allow wheelchairs to pass	24
Mobility impairment 34	A smooth road along the ride	22
	Adequate rest seats	21
	A barrier-free elevator in the station	20
	The graphic system is general graphic language	16
Cognitive impairment 22	The graphic system has voice prompts	15
	The route map should have graphic prompts in the carriage	14
	Chinese and English voice announcement in each carriage	12
	A place for luggage in each carriage	45
Those with luggage 60	No large height difference during the ride	39
	Convenient for people carrying luggage at the security check machine	39

Groups and total number (person)	Focus points	Numbers (person)
Those with strollers 51	The ticket gate should allow people with luggage to pass through	32
	Convenient for people carrying stroller at the security check machine	41
	The ticket gate should allow people to pass through with a stroller	40
	Space in the carriage for a stroller and sit	38
	A maternity room in the station	33
Pregnant 29	No large height difference during the ride	33
	Caring seats	26
	Caring first aid sites	21
	Others	1
	Caring seats	51
Those with babies 80	A child missing Prevention Center	44
	Special ticket gate allowing two people to pass through	41
	A gender-less toilet/accessible	39

At the same time, it is also found through the questionnaire that in most cases, the function of the intercity railway is a means of transfer to the subway. 95 people choose to take the subway as their next step, so in the transfer experience, people take walk distance, transfer barriers and the integration of ticket purchase into consideration. The users also made valuable suggestions: the first and last train time should be in line with the subway as well as the high-speed rail time shift; transfer can be achieved without re-buying tickets or going outside the station and so on.

2.2.3. Analysis and Conclusion

There is a great demand for barrier-free travel. The main reason for this is that the non-mainstream population accounts for a relatively large amount and the requirements for quality life are increased. First of all, the definition of non-mainstream people no longer only stays at the level of people with disabilities. People with normal mobility can also enter the non-mainstream people at different stages of life, such as increasing age, pregnancy, taking children or even daily travel with a large luggage. As the aging of the Hangjia area intensifies, a large number of elderly people also enter this ranks. Secondly, with the positioning of Haining to build a quality city, citizens' expectations for a quality life are becoming stronger. Intercity travel is no longer like going to the market but from the desire to pursue comfort and humanity.

The appeals of the different groups lie in accessibility, safety, applicability and humanism. Although the focuses of various non-mainstream groups are different due to various obstacles, the appeals are directed to the five principles of inclusive design [10], that is, safety, usability, accessibility, readability [6]. There are some dimensions that even designers and implementers cannot find, which can provide new ideas for the public transportation improvement, such as the inclusive design of security inspection facility and of ticket gates. This reveals the necessity, urgency and sustainability of the application of inclusive design in Hang-Hai intercity railway.

2.3. Design Empathy Practice

2.3.1. The Significance and Purpose of Empathy

For designers, empathy means being able to feel and discover people's actual needs (both explicit and implicit) [11], which is the basis for helping users solve problems. Design empathy is a pre-stage design method in the user-centered design, and may cover the entire design stage. It requires active observation, listening, participation and even experiment by the designer. In addition to serving the normal population, the concepts and products of inclusive design also serve the disadvantaged groups. It is worth mentioning that most of the successors and designers of these concepts are normal people, and they cannot fully understand the user's mentality and pain points. Therefore, empathy can inspire designers and learners to experience and inspire inclusive design.

With the help of the summer social survey project, the writer conducted a survey on the status quo of inclusive design in the intercity bus space, and ask the survey students experience to simulate a series of situations and problems that occur during the use of transportation through role-playing (design empathy). Various types of problems and data have been collected by reading and consulting documents, analyzing the causes of problems, proposing countermeasures or optimizing design schemes (through graphics, hand-painting, and Video logs shooting). Through this survey, the writer considers the nature of barrier-free environment design: good design is of course aesthetic, but it also needs to perform the function; good design meets the needs of the mainstream groups, but should also include disadvantaged and marginalized groups.

2.3.2. Specific Implementation

i. Grouping and responsibilities

The team members are divided into two types: role actors and recorders. The role actors are responsible for playing various roles as required. The recorder is responsible for observing and recording the situations and problems encountered by the role actors, as well as the safety of the group. The team record the whole process in the forms of video logs. (See Figures 3 to 5).



Figure 3. Pulling the stroller on the sidewalk.



Figure 4. Passers-by help us entering the carriage.



Figure 5. Stimulated role with wheelchair entering the barrier-free elevator.

ii. Roles categorization

Through the preliminary questionnaire survey and literature reading, according to the characteristics of intercity public transportation, especially rail transit, I divided the users' roles into 6 different groups. Each group is typical and has its own characteristics, and should behave according to its own different conditions. The roles are shown in Table 2.

Table 2. Concerns of inclusive design for different groups.

Number	Roles	Requirements
1	Those with hearing impairment	Using earplugs or headphones with no sound to be heard
2	Those with luggage	Having 1-2 pieces of heavy luggage
3	Those with vision impairment	Eyes closed throughout the process with sunglasses, blind guide sticks. Recorder can provide appropriate help
4	Those with strollers	Different from an ordinary luggage a stroller requires a baby with preliminary parenting experience. The stroller should be handled gently and kept within sight.
5	Seniors	To move forward with weights, you need to wear a weight-bearing vest and leggings and sandbags. Fit boys are excluded here.
6	Disabled	Borrowing a wheelchair to complete the transfer at the transportation hub

iii. Research plan and procedure

After selecting the role, specific research plan is conducted according to the tasks, such as determining intercity public transportation hubs, subway and car interchange stations, Hangzhou east railway station and subway interchange stations, bus interchange points, and bus and subway interchanges. At the same time, the team determines the route (such as the starting point from the Hangzhou east railway station, the end point to the Zhanongkou subway station), takes the specific time (accurate to a few minutes, because it will involve the flow of people), and lists the actors to be prepared for the props, recording tools, etc.

The first step is to list the research plan. The second step is

for each group to compare the trip and return to the city twice according to the planned destination, once as normal people and once as vulnerable group for the design of the empathy experience. The third step is data sorting and extraction: extract effective data, draw tables and analyze. The fourth step is to write a design empathy report.

2.3.3. Practice Conclusion

Conclusion 1: The gap of speed of action is wide. The groups of people, whether in the horizontal movement speed or the vertical movement speed, are half times to twice slower than the normal crowd. The reason for this conclusion is very apparent, due to the limitations of physical function, time and space.

Table 3. Behavior time statistics.

Groups	Standard test	Normal walking time	Walking time of the roles
Those with luggage	Horizontal distance 100m	18.23s	28.53s
	Getting on the carriage	8.5s	15.0s
Those with wheelchairs	Horizontal distance 100m	35s	61.5s
	Getting on the carriage	11s	25s
Seniors	Horizontal distance 15m	20.73s	25.56s
	Getting on the carriage	8.75s	12.21s
Those with strollers	Transfer for different subway lines	4.33s	8.31s
	Getting on the carriage	5s	26s

Note: The test conclusion depends on the specific situation. There is no comparability between different groups, and the crowding degree in each group is different during the test, which will cause errors.

Conclusion 2: The degree of dependence on barrier-free facilities varies with all types of people. Each type of non-mainstream people depends on different inclusive facilities due to their own characteristics. For example, strollers can only choose barrier-free elevators and those who carry large luggage can still choose escalators. Moreover, different people have various degree of dependence of different barrier. For example, the hearing-impaired can use visual information and give up the communication of sign language, while the visually impaired can only carry out activities through broadcast and Braille touch, and the efficiency of information transmission between the two is far apart.

Conclusion 3: The inclusive needs of non-mainstream

people are not throughout the whole journey. In the process of travel for all people with disabilities, there will be time for a critical need for inclusive design, a moderate need and no special need; through qualitative analysis, taking the behavior of taking the subway as an example, there are multiple peaks of critical need, and there are also troughs (no special need). The peak indicates that the crowd is in urgent need of inclusive facilities, and the trough indicates that this group of people can use normal facilities like normal people, see Figure 6 below. This phenomenon shows that inclusive facilities and designs do not need to cover the entire journey of users, but appear at peak times.

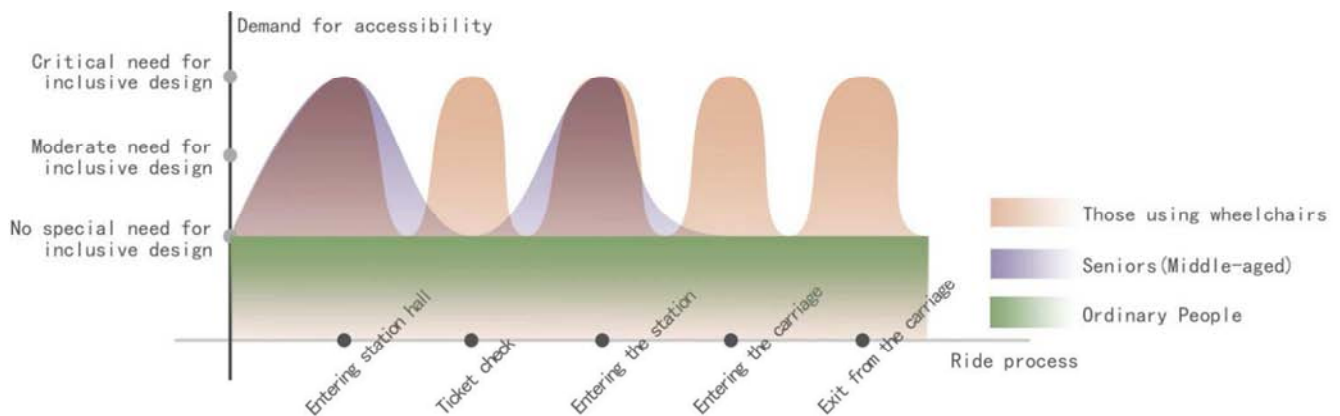


Figure 6. Qualitative analysis of inclusive design needs of two kinds of vulnerable groups in the ride process.

3. Design Practice

3.1. Introduction of the Design

Based on the above objectives and conclusions, the author decided to start from the aspect of information communication and experimentally design a set of station icons for Hang-Hai Railway. The purpose is to demonstrate the possibility of inclusive design through design practice, and at the same time facilitate language cognitive disabled, preschool children and foreigners to perform information identification and capture. These icons are only used as a demonstration and experiment, and its rigor, systematic and design language professionalism still have a long way to go before practical application.

3.2. Design Contents

3.2.1. Hue Extraction

The Hang-Hai Intercity Railway starts from Yuhang High-speed Railway Station in the west (transferred to Line 9) and ends at Biyun Station, passing through Xucun Town Station, Haining High-speed Railway Station, Chang'an Town Station, Zhouwangmiao Town Station, Yanguan Town Station, Tongjiu Highway Station, Xieqiao Town Station, Leather City Station, Haichang Road Station, Zhejiang University International College Station. Among them, there are 8 elevated stations and 5 underground stations. Its

function is to connect the two cities of Hangzhou and Haining. Based on this function, the author extracted the colors of the city flower of Hangzhou, osmanthus, and the city flower of Haining, crape myrtle, and adjusted the hue and brightness, as shown in Figure 7. Among them, pink and mid-yellow are the main colors extracted directly, while purple and gray-green are hue changes. Based on this, a set of higher lightness pink, yellow, purple and gray-green are generated. Each site is distinguished from neighboring sites with different colors.



Figure 7. Basic color card for osmanthus and crape myrtle.

3.2.2. Graphic Language Design

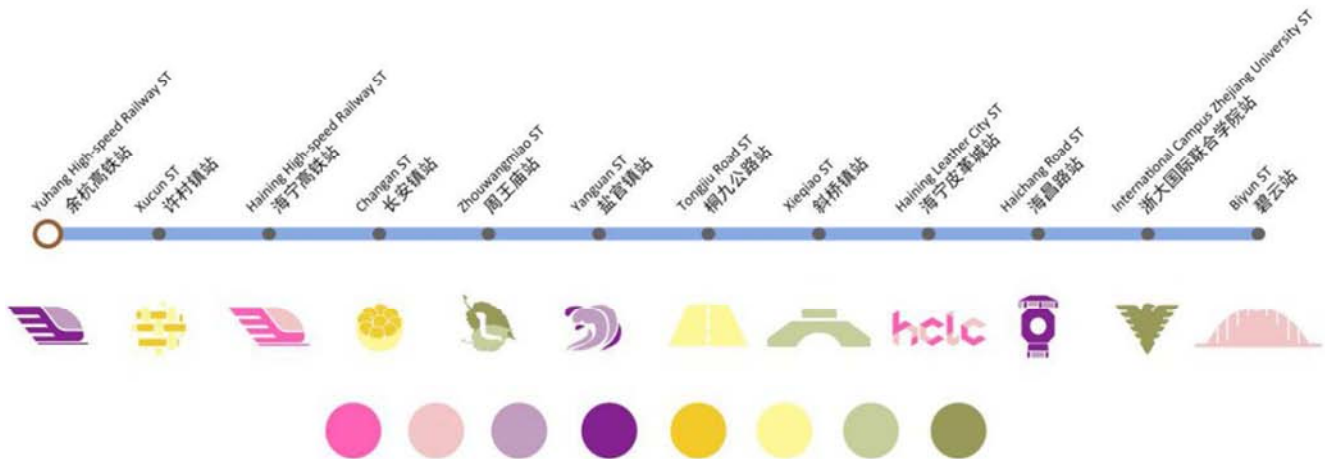


Figure 8. Station icon in the carriage.

Icons, because of its pictogram and universality, can help readers have a sense of connection and identification, and are more inclusive and informative than Chinese characters. According to the name of the station and the cultural characteristics of local folk culture, each station has a unique graphic icon to simplify the visual cognitive need and provide users with identification and recognition. The specific icons of each station are shown in Figure 8. Here several icons are explained as examples.



Figure 9. Icon at Xucun Station.

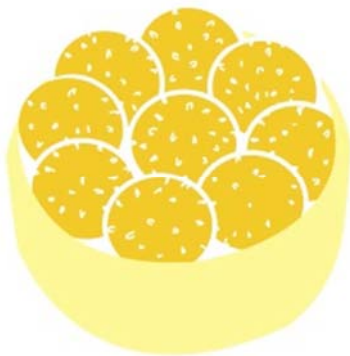


Figure 10. Icon at Chang'an Station.



Figure 11. Icon at Haichang Road Station.



Figure 12. Icon at Biyun Station.

For Xucun Town Station, home textiles are a major feature of the town. The site graphics are derived from the extraction of home textile fabric fibers. The final reference is to the work of Xu Yongpeng, the winner of the 2014 China Home Textile Expo Image Logo Design Excellence Award. It imitates the weaving elements through fiber precision and the dimensional weaving forms the cloth, see Figure 9. For Chang'an Town Station, the visual language selected for the site is Banquet Ball, and the cooking utensil "Steamer" is added. Chang'an Banquet Ball is a well-known Haining dish, which was once written in "Chang'an Town History", see Figure 10. Haichang Road Station chose the spherical palace lantern as the graphic language. The reason is that after the liberation, the Haining

people's custom of admiring lanterns during the Mid-Autumn Festival and National Day first began on Haichang Road. Nanguan Xiang, a place where a Haining lantern museum locates, is a characteristic attraction of Haining, as shown in Figure 11. Biyun Station chooses Biyun Bridge as the visual prototype. The three red half-arcs on the bridge have a strong visual impact. The figure retains the seven supporting columns in the half-arc, while displacing the two arcs to form the visual effect of the double shadow, as is shown in Figure 12.

3.3. Design Results and Demonstration

3.3.1. Readability Test

After the graphic design of the site was completed, the author selected two local preschool children (3 and 6 years old) in Haining for tracking experiments. Through the station name explanation and cognitive association, in the station name memorization exercise of 12 graphic icons, 6-year-old children remembered 9 and 3-year-old children remembered 5. Among them, the high-speed rail icon and the Yanguan icon can be recognized without explanation; the Chang'an icon, the leather city icon, and the Haichang Road icon are deeply impressed (the children tested have the life experience of visiting and eating); the Biyun station icon and diagonal The bridge icon can also be distinguished and remembered through further experience (observing the packaging logo of the mustard mustard on the slanting bridge, going to Biyun Bridge to observe). The experiment received valuable feedback on the practicality, readability, and legibility of graphic design.

3.3.2. SWOT Analysis

From the results, the inclusive design of the site icon is worth exploring. The significance of this inclusive site icon design is analyzed from the following four aspects. In terms of strength, the design of the graphic language makes the platform guidance system more inclusive. By recognizing the graphic, it can make preschool children, people with reading disabilities, and foreigners who speaks neither Chinese nor English, have a better comprehension and ride experience; the extraction and condensing of the graphic language also reflects the local cultural characteristics and the style of the folk customs. It is the product of the organic combination of inclusive design and local culture, which plays a role in summarizing, publicizing and promoting to a certain extent. As for the weakness, people who have not been exposed to graphic recognition or who have no cultural and folklore recognition are prone to ambiguity; the details of application and implementation may further increase the cost. In terms of opportunities, it has enlightened the use of inclusive design in the Hang-Hai intercity railway; at the same time, it also meets the needs of international and inclusive urban construction in Hangzhou and Haining. In terms of challenges, how to apply this graphic language system to all transportation systems more widely so that it has a conventional meaning and can further reduce the difficulty and cost of inclusive design; mass design is still the mainstream. The promotion and implementation also require the full support of the government, designers and planners, operators and audiences.

4. Conclusion

Based on leading user research and design practices, and comparing foreign inclusive design cases, it is not difficult to find that the Hang-Hai Intercity Railway has a great demand for inclusive design. At the same time, for inclusive design and application in public intercity transportation, there is still much room for development in the design and planning of inclusive facilities. During the research on the inclusive design of the Hang-Hai Intercity Railway, the author intends to arouse more urban decision-makers, designers, and the general public to understand and value inclusive design, and contribute to the continuous improvement of the inclusive construction of the city.

Here I call on, first, to incorporate barrier-free design norms into the legal system, and to further improve barrier-free design laws and regulations [12]; at the same time, increase local incentives and punishments, using subsidies, tax reductions [13], and low-profit financing to encourage the government, enterprises and real estate developers to carry out inclusive design and construction. Second, the design industry should re-examine the scope of leading users, include these disadvantaged groups mentioned in the article as design objects, encouraged them to participate in the design [14], attach importance to inclusive design research during design education [15], and encourage more designers to participate in inclusive design. Third, take cities, public transportation and public buildings as the radiation center, gradually increase the implementation of inclusive design; at the same time, carry out effective publicity and science popularization for residents and the public.

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