PLANNING METHOD OF CORRIDOR NETWORK IN MULTI-RESIDENTIAL PUBLIC SPACE (1059)

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Abstract. In recent years, the planning concept of creating a pleasant environment for residential areas has been applied to improve the quality of new residential areas, but it has not improved the living environment of old residential areas, nor the fragmentation of public space in urban residential areas. Under this background, the research first analyzes characteristics of several public space of residential area, connected corridor network, build a distinctive and identification, is advantageous for the promotion of public space connected corridor network planning method, and probes into the public space connected corridor network application in the actual program. The planning method improves the continuity of the public space system in urban residential areas and provides a feasible method for design practitioners to practice in multiple fields.

Keywords: Connecting corridor; Network planning; Public space; Planning method

China's urbanisation is at a critical stage of changing from speed to quality. People's requirements for urban and rural living environment and community living quality are increasing day by day. In accordance with the Opinions of the CPC Central Committee and The State Council on Promoting Ecological Civilisation Construction issued in 2015 and Several Opinions of the CPC Central Committee and The State Council on Further Strengthening the Administration of Urban Planning and Construction issued in 2016, the CPC Central Committee and The State Council issued the Opinions on Strengthening Ecological restoration and urban repair on 6 March, 2017. "Strengthen urban design in key areas for urban repair, organise public space and coordinate landscape features," the guideline said (Ministry of Housing and Urban-Rural Development, 2017). Thus, it can be seen that improving the overall quality of life and vitality of urban settlements and communities has become an important issue. As the most dynamic place in the residential community and neighborhood, public space not only accepts the daily activities of residents, but also serves as an important medium and bond for the communication and interaction between the residential community, neighborhood and the city. Only by constructing a continuous and orderly public space system can we create a benign and dynamic urban living environment.

In recent years, under the background of "urban repair and ecological restoration", the

planning concept of "small neighborhood and dense road network" has been widely applied to the planning and construction of residential areas, which has effectively improved the living quality of some newly built residential areas, but the living environment of the vast majority of old residential areas has not been improved. In the development of urban residential areas, real estate enterprises pay more attention to the construction of inner space of residential areas and neighborhoods, and pay less attention to the connection between multiple residential areas and public space of neighborhoods. The internalisation of public space of multiple residential districts and neighborhoods leads to discontinuous walking paths in urban residential areas, low density of walking paths, and incomplete structure of urban slow walking space. At present, China has not yet formed a set of perfect planning methods to connect residential quarters and neighborhood public Spaces to deal with the above problems. Therefore, this study explores a characteristic, recognizable and easy to promote public space connecting corridor network planning method, in order to improve the continuity of urban residential public space system.

1. Characteristics Of Public Space Of Residential District And Neighborhood

Urban public space refers to the urban space that is open and accessible to the public. Roads, squares, parks and beaches are typical urban public Spaces (Li, 2014). The residential public space is different from the concept of urban public space. As an important part of urban public space, it is the main place for residents' daily life. This paper studies the public space within multiple residential districts and neighborhoods, namely the public space of residential areas, and defines the public space of residential areas as community parks, neighborhood parks, residential parks, linear parks along the riverfront green belt and civic squares that carry residents' leisure, fitness, sports and communication activities.

1.1. Functions And Levels Of Public Space

From the perspective of function, the main body of public space in residential areas can be divided into rest type public space, traffic type public space and service type public space (Li, 2014). Rest type public space refers to the space that meets the activity functions of residents of different ages such as communication, rest and recreation. This kind of rest space includes green space, square, walking path, playing field, rest seat and other elements. It usually takes green space as the main body and lays out soft and natural space environment. The transportation public space usually takes the street space as the carrier. It is composed of the form skeleton of the residential area, such as the vehicle lane, walking path, traffic square and bus station, etc., and undertakes the functions of the residential area, such as the traffic, viewing, leisure walking and

neighborhood communication. Service-oriented public space refers to the public service facilities in residential areas, such as commercial centre, community cultural centre, etc. The place is mainly a hard square space, combined with seats, plants and other activity facilities, carrying commercial shopping, cultural entertainment and social activities and other functions, such places have strong public attributes, can accommodate a large number of people gathering public activities. From the perspective of spatial hierarchy, public space can be divided into semi-public and semi-private residential areas. Semi-public residential areas have a large radiation range, strong openness, shallow communication level, and can organise large-scale and group activities, accommodating a variety of activity types. Semi-private residential areas have small radiation range, strong sense of privacy and belonging, and close neighborhood interaction activities. The residents' communication activities are usually based on fitness and chatting, and the groups involved are relatively fixed (Hu, 2007).

1.2. Scale And Service Radius Of Public Space

The literature review found that there is currently no quantitative index control of public space in China, and some developed countries in Europe and the United States have formed a relatively mature index control system tested by practice in the field of public space. Draw lessons from European and American case experiences of public space index control（Table1）(Yang, Si and Hong, 2008), Corresponding to China's current residential green space design standards(Table2), Determine quantitative indicators of public space in residential areas(Code for design of residential green space, 2003). The scale of community level public space is greater than 1 hectare, and the service radius is controlled within 300-500 meters. The scale of district-level public space is greater than 4 hectares, and the service radius is controlled within 800-1000 meters. The scale of municipal public space is greater than 40 hectares, and the service radius is controlled within 2000-3000 meters.

Table 1. Indicators of public space in Europe and America

Standard	Landscape and Public Space Planning in London (2000)		San Francisco Public Space Plan (1997)		Vancouver Public Space Plan (2002)	
Level	Spatial scale（ha）	Service radius（m）	Spatial scale（ha）	Service radius（m）	Spatial scale（ha）	Service radius（m）
City	60	3200	400	800	-	-

District	20	1200	4	600	40	1600-4800
Community	2	400	4	400	1.2-2	500-800

Table 2. Design standards of residential green space in China

Standard	Design standard of residential green space in China	
Level	Spatial scale （ha）	Service radius （m）
Residential district	1	800-1000
community	0.4	300-500

2. Construction Of Connected Network In Public Space

At present, the development scale of urban residential areas is increasing day by day, and multi-level and large-scale people gather inside residential areas. In terms of openness and publicity, the public space of residential districts and neighborhoods shoulder more and more responsibilities of sharing urban resources. Planning and design can no longer simply talk about the community, we should control and guide the planning, construction and development of residential areas from the regional level. With the improvement of the quality and demand for public space, residents pay more attention to the accessibility and connection of public space. In the future, the construction of public space corridor network will become one of the important means to improve the public space environment in residential areas. To construct an overall public space corridor network suitable for multiple residential districts and neighborhoods, firstly, we should add complete dotted public Spaces of different levels in multiple residential districts and neighborhoods, connect urban attraction resources, connect various types of corridor networks, optimise the environment connecting potential public Spaces on the corridors, and refine the connecting nodes between the connected corridors and public Spaces. Form a region-oriented public space connectivity network.

2.1. Add Public Space

Add public space inside each residential district and neighborhood to improve the utilisation rate of public space. Two levels of community level public space and internal small public space are arranged. The scale of community level public space is larger than 1 hectare, with a spacing of 900-1500 meters, and the scale of internal small public space is larger than 0.4 hectare, with a spacing of 450-750 meters. The types of public

space include central green space, pocket park and micro square (Figure 1).

Corner space renovation. In view of the increasing demand of residents for fitness, culture, communication and other activities, and the shortage of public space in existing residential areas, extensive public opinion surveys and scientific traffic flow analysis are adopted according to the actual needs to add public space with appropriate size and function, and the added public space should maintain integrity (Peng, 2018).

Entrance space renovation. The entrance space of most of the built residential areas is mixed with people and vehicles, and the flow of people is interwoven with the flow of vehicles, and there is a lack of identifying landscape facilities. In the process of urban renewal, the entrance space should be appropriately transformed and divided into motor vehicle area, pedestrian area and entrance landscape identification area. It can not only effectively increase the safety of the entrance space, but also highlight the community culture (Figure 2).

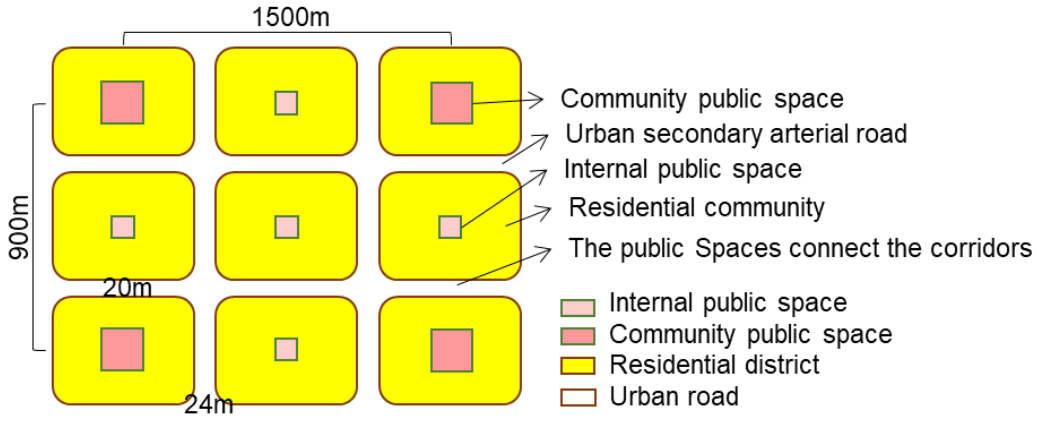


Figure 1. Public space of residential district and neighborhood
source: author.

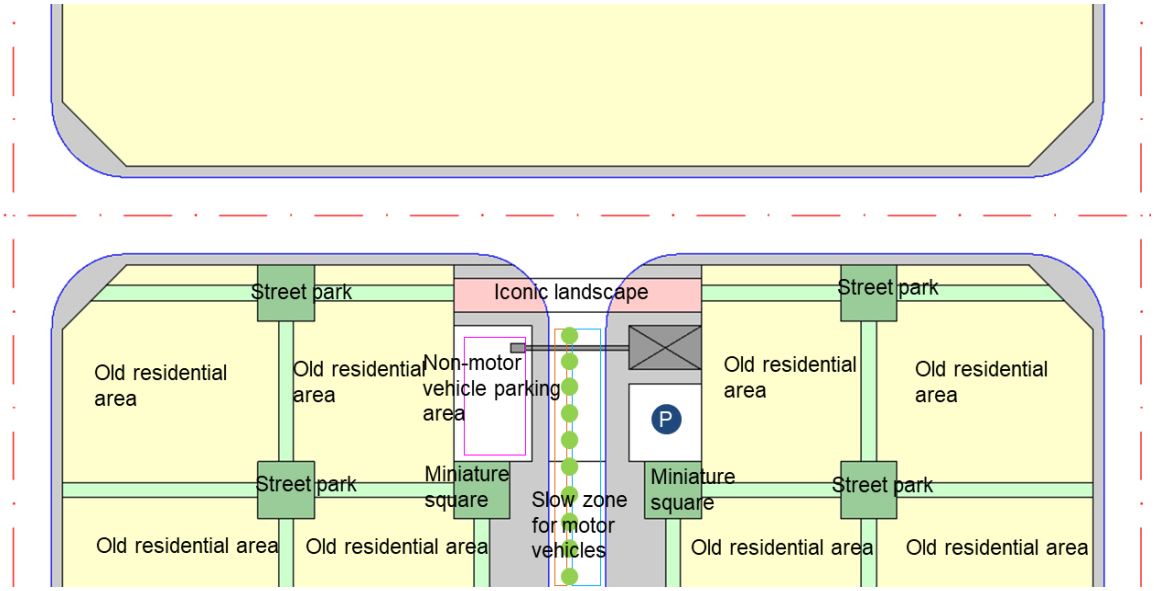


Figure 2. Space division of entrance
Source: author.

Microspace re-embedding. Open the original barrier walls and fences, innovative liberation of street green space. The optimisation and improvement of green open space at street corners will provide more places for residents to communicate and help improve the quality of ecological environment in residential areas.

2.2 Connecting The Corridor Network

2.2.1 Connection Corridor Type

According to their spatial positions, connecting corridors can be divided into three types: aerial connecting corridors, ground connecting corridors and underground connecting corridors. Among them, the air connecting corridor includes slow landscape bridge and building platform connecting corridor; The ground connecting corridor includes the pedestrian system on both sides of the slow street and the motorway. The underground connecting corridor includes the building underground walkway and the continuous walkway through the bridge.

The air connecting corridor is divided into two types: independent flyover and building connecting corridor. The freestanded bridge can carry a large number of people and has strong recreational and landscape functions. This mode mainly crosses intersections, rivers and urban roads. Under the bridge, vehicles can be used for parking, afforestation, square and commercial market space, etc. It is suitable for crossing the lot with large flow of people, which affects the original function in the vertical direction (Figure 3)

(Chen, 2018). The building corridor is connected by the second floor of shops and buildings, and its connection mode has no impact on the ground road traffic and pedestrian traffic, ensuring the continuity of walking space. Combined with the layout of the street buildings, it is necessary to deal with the public management problems between the street landscape and buildings. This model is suitable for areas with dense commercial facilities in residential areas and areas around subway stations in the TOD development model (Peng, 2011).

Figure 3. Aerial building corridor
Source: author.

Figure 4. Ground connection gallery
Source: author.

Ground connecting corridor is residential greenway. The residential area provides a green open space with good natural landscape and leisure functions for pedestrians and cyclists to enter, providing residents with a continuous field suitable for jogging, walking, cycling and other outdoor activities. The corridor integrates sidewalk, slow track and bicycle path, pays attention to the creation of a green environment, and is a channel network for people to exercise, relax, get close to nature and travel easily (Figure 4). The

public space of green space and public square in residential blocks added above is seamlessly connected with the ground connecting corridor, providing places and opportunities for residential residents to integrate and communicate, providing safe and exclusive sports space for jogging and cycling enthusiasts, and enabling residents to realise their dream of running anywhere and anytime. The residential greenway is connected to the slow track of the community park, and the ground connecting corridor is combined with the urban walking system, which not only satisfies the functions of recreation and sports, but also shares part of the functions of the slow traffic system, which helps to realise the separation of people and vehicles and reduce the pressure of urban traffic.

Underground connecting corridors are less used because of their high cost. The connection form of the corridor is only applicable to the underpass node of the vehicle-traffic arterial road bridge and the surrounding area of the subway station (Zhang, 2016).

2.2.2 Connect Urban Attraction Resources

Urban attraction resources are divided into three categories: basic attraction resources, supporting attraction resources and image attraction resources. Basic attraction resources include urban landmark buildings, urban recreation areas, exhibition and event venues, etc. Supporting attraction resources include exhibition facilities, sports venues, entertainment venues, shopping centres and various forms of transportation, etc. Image attraction resource is the diversified city characteristic landscape image. Urban attraction resource points are easy to exist in the intersection space of urban road and public space corridor in residential neighborhood (He and Yang, 2020).

In the process of community planning and construction, when connecting the public space inside the community and the public space outside the community, the existing attraction resources of the city should be incorporated into the network system of connecting corridors of the public space as far as possible (Figure 5). When there is no established urban attraction resource in the residential neighborhood, the subjective initiative of the neighborhood should be given proper play to create "unique" urban attraction resources. For example, organizing community cultural festival activities, expanding community activity venues, increasing leisure landscape facilities such as seats, plants, flower beds, promenades, sculptures and children's amusement facilities, etc., improving the node vitality of corridor crossing zones, helping to enhance the charm of residential districts and neighborhoods.

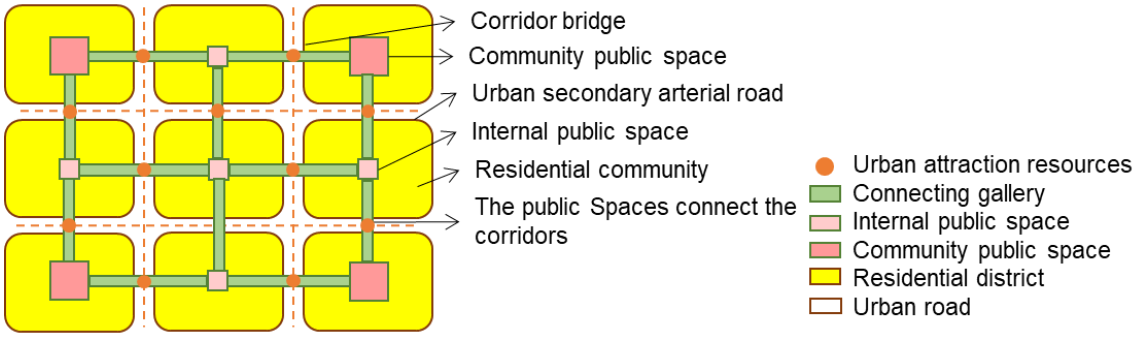


Figure 5. The corridor network between the inner space of residential neighborhood and urban attraction resources is shown
Source: author.

2.3. Improve The Connecting Nodes Of The Corridor

The ground connecting corridor is a continuous network system, and no special connecting nodes are needed. When the air connecting gallery and the underground connecting gallery connect with the ground, it is necessary to improve the vertical traffic elements to guide the people evacuation and ensure the smoothness of the connection. Interesting urban furniture is designed to enhance the vitality of the joint space.

2.3.1. Facilitation Of Node Traffic

Vertical means of transportation is the most basic element of the connection node connecting the corridor. The commonly used vertical means of transportation include stairs, ramps, escalators and elevators. The main vertical traffic nodes should be arranged on the broad nodes of the main stream line, which is a necessary tool for traffic evacuation to facilitate the flow of people to the upper and lower levels (Zhang, 2016). At present, the main functions of traffic evacuation are mostly undertaken by escalators or elevators, and stairs, as an auxiliary vertical connection element, are mainly used for fire evacuation. The stairs are rich in forms, mainly using straight or folded lines. The design of the stairs combines with the natural landscape to form different walking landscape experience, which not only satisfies the traffic function, but also increases the spatial attraction of connecting nodes. Vertical elevator is a kind of tool with the fastest transportation speed and the smallest floor area among various vertical transportation tools. It is convenient to cross multi-layer vertical space and can be used to solve barrier-free transportation. However, the carrying capacity of elevator is small, and it is not suitable for the spatial connection area with large human flow. Escalators are usually set in the vertical space transformation area, landmark node space or square area with large flow of people. In the space area of the two floors connected by escalators, locally open space is required for people to gather and disperse. Escalators are usually no longer built

when there are elevators for accessible traffic. The ramp is a continuous barrier-free channel with a certain incline Angle, and the gradient is mostly controlled at 1:12. The ramps that can gently connect the upper and lower Spaces usually occupy a large area of outdoor space, which can effectively reduce the fatigue of people crossing the vertical distance. The unconscious ascending experience brings surprises and freshness to people, enriching the fun of space transformation.

2.3.2. Interesting Node Facilities

A conventional connection node connecting the air corridor and the ground corridor is designed. The node is composed of a slow air corridor, a barrier-free elevator, a walking staircase, a cylindrical children's slide and a circular spiral ramp. The slow air corridor is 4.14m high and 6.5m wide, and its sections are divided into 1.5m slow runway, 2m slow corridor and 3m recreational lawn. The size of barrier-free elevator is 2.6m*3m; The walking stairs are divided into three sections with a width of 4m and a total of 28 steps. The cylindrical children's slide, with a diameter of 1m, slides from the slow-moving aerial corridor to the children's play sand pit on the ground floor; The circular spiral staircase has a radius of 7.5m and a circumference of 50m. The ramp is 2.8 meters wide and has a gradient of 1:12, providing continuity for cyclists and pedestrians jogging(Figure 6).

The cylindrical children's slide, children's play sand pit, slow track and recreational lawn are set up to increase the interest of connecting nodes. The construction of children's facilities and recreation space has increased the opportunities and frequency of children's contact with nature, and created a colorful and good environment for children with outdoor activities, so that children can exercise in activities and get happy communication with other children. With the arrival of children, parents can also gather in the node facility space, making the bridge deck a small communication space between communities.

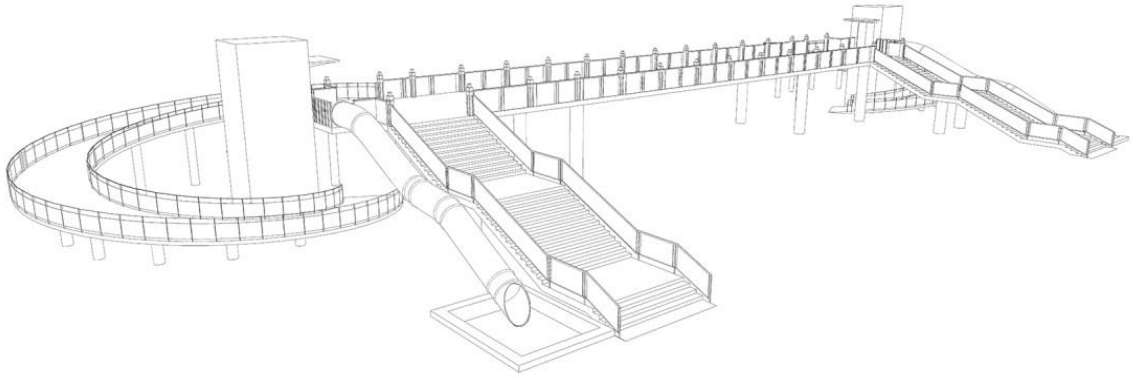


Figure 6. Stereogram of node facilities
Source: author.

2.3.3. Vitality Of Node Space

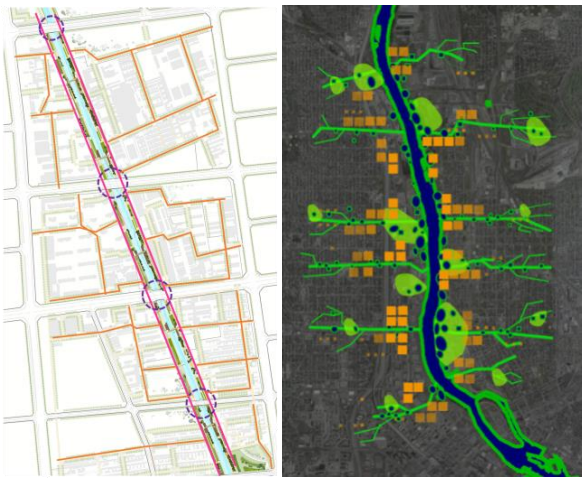
Combined with the cultural characteristics of adjacent communities, integrate community public resources, make full use of the bridge floor seats, square under the bridge and other leisure Spaces, hold community cultural exchange activities, hold festival activities on the Children's Day, Labor Day, National Day, Mid-Autumn Festival, Spring Festival and other holidays, create a "big community" cultural brand. If conditions permit, the neighborhood can start the night view lighting project of the corridor bridge, design different lighting effects on the bridge, perfect integration of lighting technology and the bridge, the bridge at night flowing brightly, giving people a dreamlike feeling, not only brings a sense of belonging to the residents, but also provides residents with leisure and communication space.

3. Application Of Connected Corridor Network In Public Space

3.1 Communication Between Public Space And Urban Attraction Resources

In 2017, the Ministry of Housing and Urban-Rural Development issued the "Guidance on Strengthening Urban repair Work of Ecological Restoration" (hereinafter referred to as the "Guideline"), which proposed to restore urban ecology and improve ecological functions; Repair urban function, improve environmental quality; Fill the debt of urban facilities, increase public space, improve travel conditions, renovate old residential areas and other requirements(Ministry of Housing and Urban-Rural Development, 2017).

In this context, Langfang organised a special plan of "urban repair" to optimise the space of multiple residential communities and neighborhoods on both sides of the Bagan Canal, an important river system in the city, actively add waterfront public space and continuous slow space, and ensure the continuity of the connecting gallery through the main road under the pedestrian path. Urban attraction resources such as green veins on the riverfront permeate into the neighborhoods on both sides. Form the public space connecting corridor network system of the whole waterfront residential area(Figure 7).



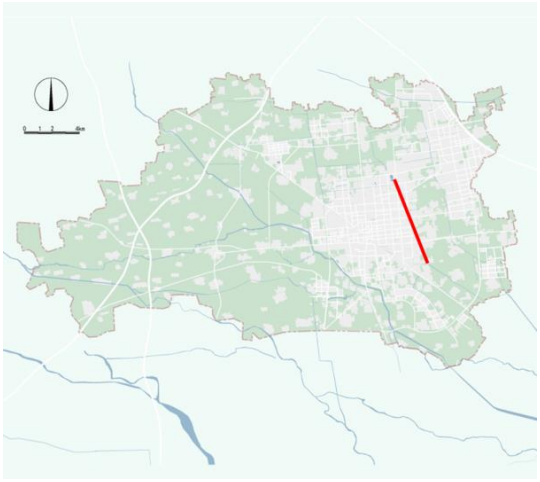


Figure 7. The location of Eight canals in Langfang city space and the network of connecting corridors
Source: author.

3.2 Design Of Connecting Node Of Connecting Gallery

In the planning and design of the Three Rivers and Six Banks project in Lanxi City, Zhejiang Province, the strategy of "green heart ring" was put forward to construct the connecting slow greenway and reshape the open waterfront space, so as to solve the problems of fracture and obstruction of the three rivers and six banks. The components of "green heart ring" include: green island, green bridge, green bank, green core and green veins. Among them, three green Bridges, namely Lanjiang Bridge, Nanmen Bridge and Hengshan Bridge, straddle the water surface of the three rivers and become the key elements of building a "green heart ring" and shaping urban attraction resources. Take Lanjiang Bridge as an example. Built in 1975, Lanjiang Bridge was the largest highway bridge in China in the mid-1970s. It was awarded as one of the top Ten Buildings in China that year by the National Science Congress and was inscribed by Guo Moruo, president of the Chinese Academy of Sciences. In September, 2000, the widening project was implemented. After the widening, the total length of the bridge is 1,080 meters. The main bridge is 820 meters long and 24 meters wide. The vehicle traffic is four lanes in two directions, including three lanes in the new bridge and one lane in the old bridge, which can fully meet the traffic demand, but the current situation of the bridge deck carries a limited amount of pedestrian traffic. There is a height difference of about 5 meters between the east and west ends of Lanjiang Bridge and the bank. At present, there is a double-run staircase with a width of about 1.5 meters connecting the new bridge and the bank, and there is a lack of barrier-free access facilities. It is planned to transform the old part of Lanjiang Bridge into a slow passage, set up bicycle lanes and pedestrian recreation gardens, and set ramps on the east and west sides to connect the urban greenway. The bridge deck and ground connection zone becomes one of the important nodes of the green ring of Three rivers and six banks.

Reconstruction of the west end bridge: the bridge deck elevation is 37.90m, the north sidewalk width is 2.2m, and the south greenway width is 7.8m. The ground level of the north side of the bridge is 31.11m, and there are 2-4 storey concrete buildings. The pedestrian greenway on the north side of the bridge is partially widened to form a wooden viewing platform, which is connected with the second floor of the building on the north side by a bridge and a pavilion. The ground part is used as a recreation garden.

The ground elevation of the south side is 30.36m. The existing building with poor quality is demolished, and the original site is transformed into a street green park. The red light steel is used as a ring bridge to connect the bridge deck with the ground(Figure 8). The width of the ring bridge is 2.5m, the total length is 75.6m, and the average slope is about 10%. The other curved bridge is connected to the top of the dike, the top elevation is 34.29m, the length of the bridge is 28.5m, and the average slope is about 12%.

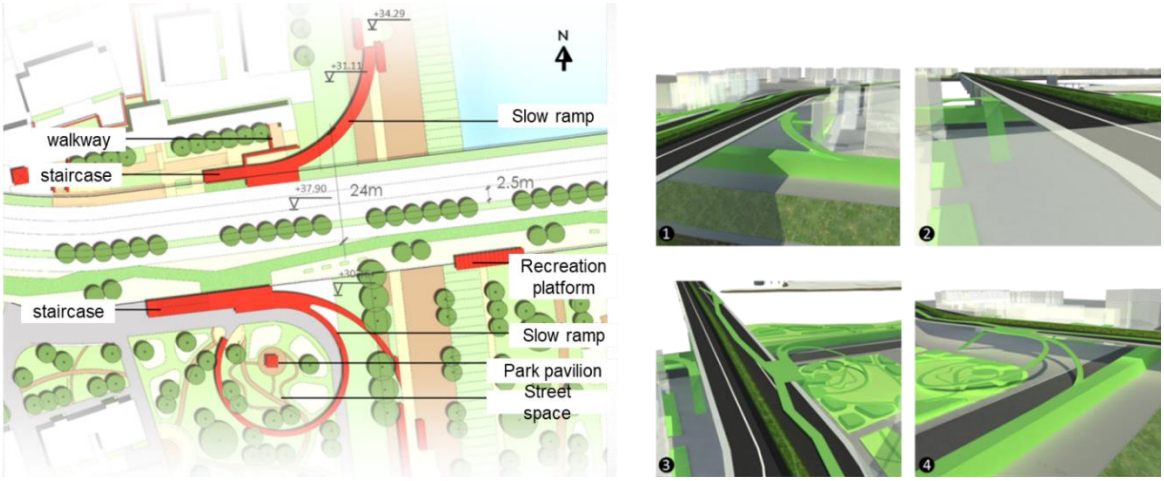


Figure 8. Reconstruction of the west end of Lanjiang Bridge

Source: author.

4. Conclusion

This paper innovatively proposes a "three-dimensional" public space connected corridor network system which is easy to popularise, easy to implement, identifiable and suitable for residential quarters and neighborhoods. The establishment of a series of "chain" corridors including various water systems, streets and landscape roads helps the public space environment of residential areas move from closed to urban integration, introduces urban life into residential areas, and realise a multi-level open public space system, which provides a theoretical basis for the upgrading of the renewal level of urban residential areas in China and the improvement of livable living environment. In view of the different environments of various public Spaces in residential areas, multiple "three-dimensional" public space connecting corridor network is organised. Public Spaces of different levels connect corridor and connect public Spaces of different levels in residential areas. The research on the connected corridor network of public space has a wide range of application, and it involves the guidance of control regulations in the planning and design(Zheng, Liu and Jiang, 2013), In urban design, the opening and corridor reservation of newly built residential areas, and the renovation of old residential areas in the reconstruction of old cities are an innovation of the current urban planning and design methods. Can also be directly applied to the field of architectural design, reconstruction, expansion of buildings have a certain guiding role,

with a wide range of practical value. It provides feasible methods for planning and design practitioners in the fields of controlling detailed planning, urban renewal, urban design, old district reconstruction and so on.

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