Study on the Optimized Strategies of Resilient Spatial Pattern from the Perspective of Sponge City -Taking Garden Street Historic Block in Harbin City as an example

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Abstract
Sponge city is a type of strategies to cope with stormwater management under the rapid urbanization in China. It intends to naturally improve water quality with infiltration while drawing lessons of Low Impact Development (LID) and Green Infrastructure (GI) from European and American Countries. Old districts in China now are faced with more obvious and urgent issues including excessively large of construction intensity, much population, insufficient area for implementation and old infrastructures, which call for the targeted approaches and methods to coordinate and conserve the original historic buildings and features. This paper will select Garden Street historic block , a representative historic block in Harbin, to determine its control goal of total annual runoff adapting to its problems and status quo. The space will be hierarchically managed and controlled and buffer zone is applied to avoid the foundation of historic buildings. Meanwhile, the green LID facilities are combined with Gray Infrastructure to design the invisible LID infrastructures, which are coordinated with the features of traditional blocks. The space of old district is optimized in a resilient manner to establish spatial system of stormwater management, which contributes to the theoretical exploration for sustainable and resilient development of old districts in China.
Keyword
Sponge city; old districts; hierarchy management and control; Garden Street Historic Block; Harbin

1. Introduction

As urbanization speeds up in China, social economy booms rapidly with significant achievement of city construction. Although city numbers increases and city scales expand and development, the extremely strong development density also leads to the excessive hardening of the original natural underlying surface and alters the original city natural ecology background and hydrological characteristics and other issues (Zhang, 2015). City is challenged with frequent water logging, runoff pollution, heavy loss of rainwater resources, deterioration of ecological environment, loss of water culture and other issues. The traditional drainage model of city rainwater is hardly to follow and to cope with the more severe stormwater problems, China has drawn lessons from foreign counties worldwide and, in sight of our national conditions, further propose the rainwater solutions and strategies: sponge city.
The core of sponge city is to realize the comprehensive objectives of pollution control, disaster prevention, utilization of rainwater resource and city ecological remediation. The coordination and control are applied during the entire process by multidisciplinary from mechanism construction, planning regulation and control, design and practice to construction operation and management. It aims to conserve and utilize city Greenland, waters and other spaces as well as prioritize to combine green infrastructure with Gray Infrastructure to jointly establish the resilient rainwater infrastructures and realize five aspects of rainfall runoff: infiltration, blocking, reservoir, purification, utilization and drainage.
The construction of sponge cities is in full swing in China. Its construction and research

mostly focus on outskirts areas and new cities with less serious issues, not even mentioning the old districts with frequent water logging. As old districts afford much of the city population and more important functions, their stormwater problems are more server. The sponge city is therefore imperative in old districts. In sight of the excessive hardening of the original natural underlying surface, insufficient space for implementation of sponge city and more strict of features' management and control, this paper will attempt to put forward the targeted and resilient controlled indices and implementation strategies in space with the aim to improve the stormwater issues in old districts. At the same time, the author also has discussed the coordination between the construction of sponge city and the historic features of old districts as well as the heritage and continuation methods of local culture in China.

2. Difficulties for implementation and construction of Sponge City in old districts

2.1 Large construction density and insufficient implementation space

One of the main difficulties for implementation and construction of Sponge City in old districts in China lies in the insufficient space of implementation, resulting from high construction intensity, crowded environment and excessively hardening of underlying surface. Old districts are always located at the core area of the city and the area with the largest construction intensity. Therefore the commercial atmosphere from the excellent geographical location and history accelerates the population agglomeration and the growth of construction intensity, which thus hardens the underlying surface with infiltration and permeability.

As indicated from the research, the hardening ratio of underlying surface in old districts nationally could peak at 65% and the public green land area per capita is less than 5 m^2 and the common green rate usually is between 7%-12% (Li, et al., 2017). Compared with the regulated green land ratio for newly constructed communities, 30%, the area of green land is seriously in sufficient with unevenly distribution, leaving less public space for the construction of Sponge City. And all these are contrary to the connotation of Sponge City to reconstruct the stormwater facilities through the extensively and largely demolish the harden pavement or rigidly occupy the limited space resource. Ultimately, the spatial layout and features are destroyed in old districts, challenging the construction of Sponge City in old districts.

2.2 Old and obsolete drainage system and low bearing capacity of pipes' network

Urban drainage system of Harbin, initiated in 1904, witnessed the preliminary construction during tsarist Russia, Japan and pseudo-ruling periods, sped up in the later period of the founding of the People's Republic of China and was generally improved nationally after the reform and opening up. It has been over a century of history from the establishment of drainage system. Old districts are mostly dominated by the drainage of confluence of rainwater and sewage. However, the drainage facilities for these old districts are already overwhelmed with seriously insufficient drainage capacity of flooding due to their long construction periods and increasing construction and population density.

The initial drainage system, in old districts, basically set the runoff coefficient, ϕ, at 0.5, comparing with the actual runoff coefficient, 0.7. Part of the construction standard of pipes' network set the recurrence period at 0.5 years (Xue et al., 2011). The drainage efficient is much far from the national standards. The area with drainage system is 216.05 km^2, accounting up 66.36% of the planned area. According to national standard, the coverage of drainage pipes' network should be over 80% for the cities , equal to the same scale of Harbin. As regulated, the density of pipes' network for the system of confluence of rainwater and sewage should be 8 km/ km2. The density for Harbin City is only 5.68 km/km2. The service coverage of network is only 69%, hardly satisfying the standard, 95%, enforced by Ministry of Housing and Urban-Rural Development. In 2016,the total length of drainage pipes was 1,242 km in old district in Harbin and among about 49.6 km was constructed in 1940s or 1950s. 5.3% was constructed in 1960s. It's 217 km in 1970s, also the peaking point. appropriate one in third length of pipes has already far exceeded the 40-year lifespan, an national standard. The over-aged service is also one reason for urban rainwater issues and also endangers the stormwater safety. If the drainage system are reconstructed to satisfy the current flood control in old districts, it will not only be time-consuming and laborious, but also badly have influence on daily lives.

2.3 Management and control of historic features and huge reconstruction difficulties

Old district, formed during certain periods, has already developed and evolved for hundred of years to represent the original of a city. With abundant historic culture, old districts have generated their unique city features based on their characteristic material environment and civilization. They can't be regenerated and replaced. City features and buildings'culture in Harbin is extremely valuable in their conservation. Firstly, as a colonial city, Harbin is both the experiment site of modern construction for European sovereign countries and the platform for integration of Chinese and Western architectural styles. The unique buildings' features in old district were the results of collision between local building design and international trends, such as Art Nouveau, Russian style, Baroque, and eclecticism. Meanwhile, as rising from railway, the earlier buildings were basically constructed to service railway system and the architectural styles also have been strongly marked during the aided period by the former Soviet Union. In 1994, Harbin was approved as one of the third list of National Historic and Culturally-Significantly Cities by the State Council of China and its historic conservation blocks also was increased into 23 from 19 in old districts.

The reconstruction and renovation in old districts all should prioritize the conservation of historic features ahead of the development and construction. The Sponge City also should obeys the requirements of traditional features' management and control in old districts. The existing construction of Sponge City calls for large-scale reconstruction and design in its control methods. The construction of sunken lawn, permeable pavement, grass ditch, wet pong and rainwater detention tank will inevitably affect the features of old districts. How to coordinate the construction of Sponge City and traditional features is a huge challenge faced by Sponge City in old districts, especially under the strict features' control and management of historic blocks.

2.4 Low construction quality and limited construction conditions

The buildings are newly constructed, renovated and improved during each period historically. The temporal construction is divided into four ages: Qing Dynasty to the early Republic of China, the middle and late period of the Republic of China, 1950-1970 and 1980-now. The buildings from Qing Dynasty to the early Republic of China are the main bodies for most of old districts in our country with the oldest construction time. In the current designated buildings in old districts, the number or area of the buildings before early Republic of China accounts for about 50% of the total buildings. Within the old districts, the buildings are damaged naturally and artificial to some extent due to the long time after construction. Their quality are also weak because of the limited construction technology and technique and insufficient construction material when they were built. Most of the buildings in old districts in Harbin were built at the beginning of last century and therefore are faced with issues including roof leakage, structural aging and foundation damage due to frozen in winter.

The buildings and their surroundings are the important space for the implementation of Sponge City, which calls for the high quality of buildings or is greatly challenged otherwise. For instance, the structure and roof waterproof , for some less qualified buildings, hardly satisfy the construction of green roof and infiltration, blocking and technology might lead to the foundation erosion by rainwater.

3. Optimized implementation strategies of resilient space for Sponge City in old districts

3.1 Layout of three-dimensional sponge facilities

Different from the goals-oriented pattern of new districts for the construction of Sponge City, the old districts should integrate the controlled objectives and indicator system into the design requirements at the very begging of the planning and design. The built-up area is high in old districts, leaving less space for Sponge City. Therefore the construction of Sponge City should better orient in problems and the controlled rate of annual total runoff and storage capacity and other objectives are decomposed into the facility type and number for each plot, realizing three-dimensional layout with maximized utilization of each space *(Xue, et al., 2017; Xue, et al., 2015; Xue, et al., 2014)* (see Figure 1).

From the earlier field research, it's concluded that the green land space is less with fragmented distribution, depending on which some large sponges are decomposed into sponge cells to rationally use green land space system with landscape design. The roof greening is feasible for flat roof with good roof loads and waterproof conditions or the sloping roof with the angel less than 15%. The roof greenery should be carefully selected in historic blocks. Historic buildings and the less-qualified buildings could apply rainwater tank to collect the roof rainwater. The total underlying area of the roof in old districts possibly accounts up to 30%. if the rainwater runoff is well blocked and utilized on the roof, annual runoff could be reduced by one third. The permeable pavement is applied in squares and road space as much as possible with permeable design for ground parking in old districts. The less-qualified buildings should be avoided rationally for implementation. By utilizing the cracking space in old districts, we intends to carry out the controlled objectives, construct resilient and three-dimensional spatial system of Sponge City to further achieve the development requirements of Sponge City: natural reservoir, natural infiltration and natural purification.

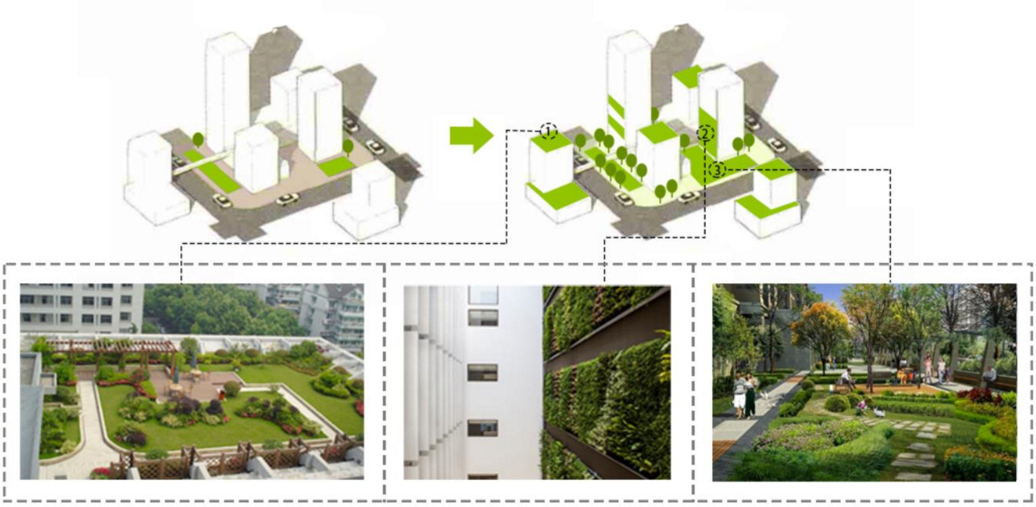


Figure 1: Layout of three-dimensional sponge facilities in old districts
Figure sources: drawn by author.

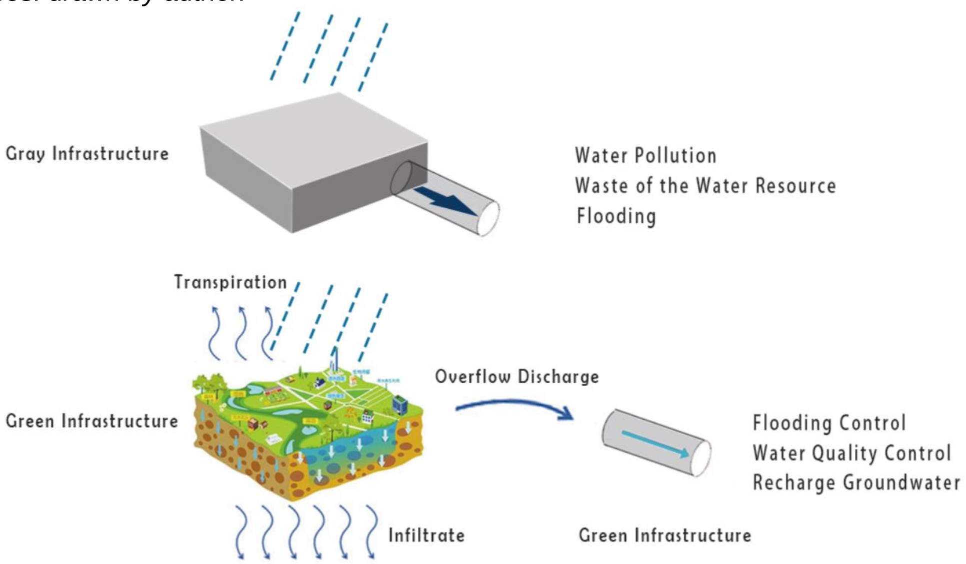


Figure 2: Combination of Gray and Green rainwater drainage pattern
Figure sources: drawn by author

3.2 Combination of Gray Infrastructures and green infrastructures

The flooding is more serious in old districts with obsolete Gray Infrastructures and less bearing capacity, leading to the definite flooding when it rains. Gray Infrastructure, as a way of fast drainage, will waste water seriously , in particular when the underground water level decreases year by year. Additionally, the bearing capacity of drainage, set at the early period of construction, only cope with low intensity rainwater (Yan et al., 2013). Meanwhile, the green land is less in old districts and the construction space for green infrastructures is also less. It’s hardly to solve the stormwater issues just depending on green infrastructure. The difficulties also lie in the reconstruction the old district whose original permeable area is not large. In conclusion, the stormwater in old districts must apply the combination of Gray and green, underground and ground and origin and ending point with rational economy (Zhang, et al., 2012). When the rainfall intensity is high and the green infrastructures are already saturated or there is no time for absorption, the Gray Infrastructures will discharge the extra rainwater .The combination of green and Gray and rapid and slow have realized the effective drainage of sponge in old districts(see Figure 2).

	No.	**Area （ha）**
Old districts	322	298.68
Harbin City	923	2312.84
Percentage	34.89	10.62

Table 1: Urban water environment layer during the period of city siting
Table sources: drawn by author.

Green Infrastructures layout of Sponge City almost depends on public area, especially that the green land space network serves as its implementation carrier. Based on green land pattern, city green land space can be divided into spot green land, parcel green land, belt green land and wedge-shaped green land. ArcGIS is applied to analyze the green land in old districts and the areas are selected within the fourth ring of Harbin, namely the wide-recognized Harbin City, as the comparative research area. From data comparison through NDVI (see Table 1), it’s clear to compare the characteristics of green land space for old districts. Two in thirds of single green land area is less than 0.5h with fragmented layout (see Figure 3). Spot green land , as the most one in old districts, should serve as the source controlling facilities to absorb rainwater, which can be used as the support space for sunken green land , simple bioretention ponds and rainwater wetland and others. Belt green land can be used as transport space on halfway and transport rainwater connecting with spot green land, which can be used as the support space for transporting grass ditches, dry/wet grass ditches and plant buffer zone and others. Parcel and wedge-shaped green land, as the less large green land space in old districts, function as ending treatment and rainwater management and control, which can be used as the support space for infiltration ponds, wet ponds and large rainwater wetlands with concentrated disposal.

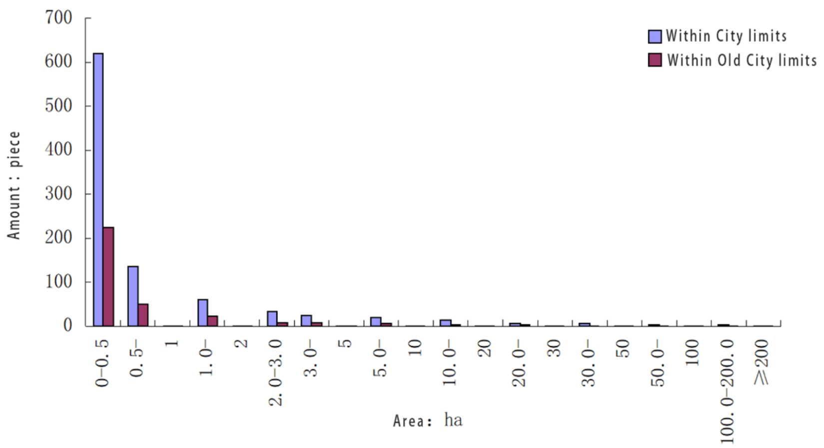


Figure 3: Area statistics of each type of green land
Figure sources: drawn by author

3.3 Quantitative design and hierarchy management and control of space

In old districts, the runoff pollution and controlled total runoff is relatively higher than that in new districts. The construction of Sponge City in old districts sets the total runoff and runoff pollution as the controlled objectives. The design of facilities within should be quantitative according to the volumetric method.

The construction number of sponge facilities is quantitative based on the above results. Meanwhile, limited under Sponge City in old districts, it's particular important to quantitatively and hierarchically plan and design the space. Different rainfalls are designed to generate varied rainwater absorbing and reservoir space with hierarchical management and control. The spaces are divided into rainfall density every 0.5 year, 3 years and 5 years. Difference space is launched under different rainfall intensities (see Figure 4). without the threat of rainfall, the sponge space functions as landscape and urban use.

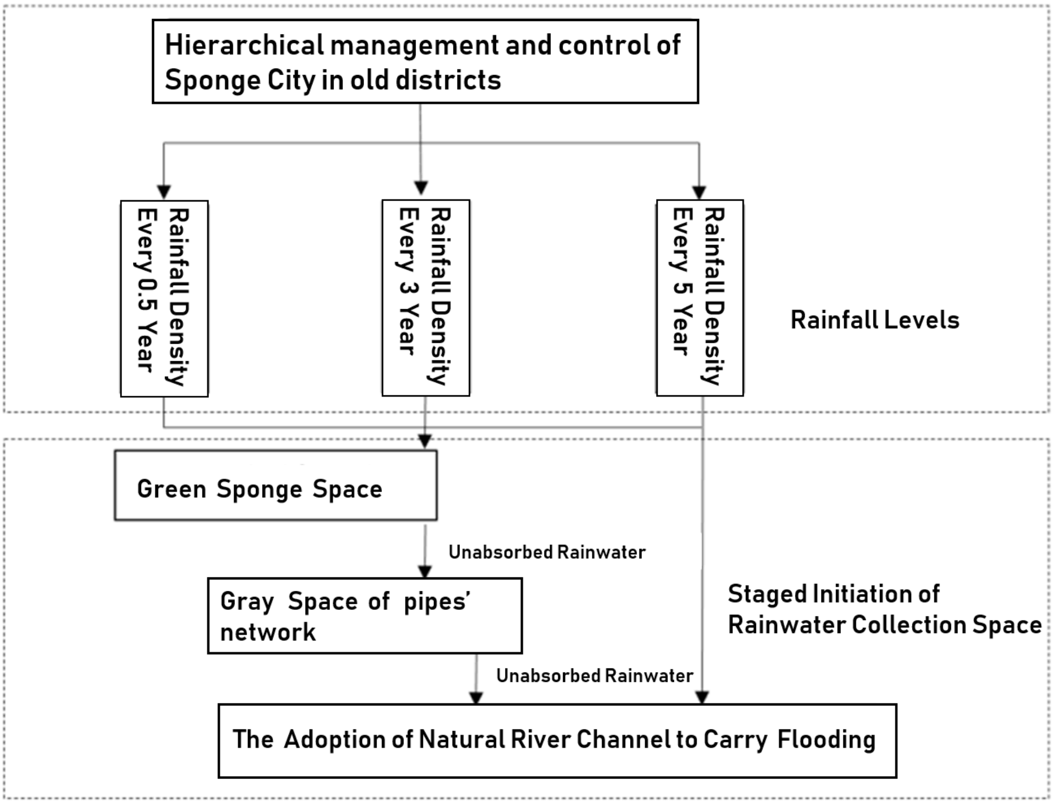


Figure 4 : Illustration of hierarchical management and control of Sponge City
Figure sources: drawn by author.

3.4 City features' coordination based on status quo

Old districts have witnessed city development and mitigation and its features should be planned and designed as coordinated elements whenever in any plannings and designs. The construction of old districts should not affect city landscape features, especially the construction of Sponge City in historic conservation areas should also be based on the features of historic blocks. The construction of Sponge City in old districts should be resilient according to the status quo. The sponge measures are selected with minimized influence as well as technology facilities. The appropriate local reconstruction of Sponge City facilities is possible combined with the features of old districts.

The features conservation coordinated areas are divided hierarchically. The purple line range for historic blocks and historic buildings serves as the 1st level feature conservation area, where the construction of Sponge City should strictly adheres to the conservation of historic features. The single sponge facility is strictly constrained with large influence on city features with coordination and conservation of the landscape elements within the range of purple line; the historic block or one block scale surrounding the single building serves as the 2nd level feature conservation area, where the sponge facilities with less influence are selected. If the selected facilities has large influence on features for rainwater construction, the appropriate resilient landscaping reconstruction could be conducted with the guarantee of implementation function of single facility; the view range of historic blocks serves as the 3rd level feature conservation area, where the requirement for the selection of sponge facilities is low and the historic landscape feature can be coordinated with certain ornamental value.

4. Practice of Sponge City in Garden Street Historic Blocks in Harbin

4.1 Status quo

Garden Street Historic Block was initiated in 1899 in Harbin new city planning. new city plan considered railway administration as the main body during the construction period of Chinese Eastern Railway by Tsarist Russia. The most advanced Howard Garden City was introduced at that time. Garden Street Historic Block , as the residential community for Russian senior railway staffs, represents high-level Russian style of architectural blocks in early times and also the only existing area in Harbin which maintains the basic appearance during the period of business with foreign countries. The spatial layout of Garden Street Historic Street was was originally organized in groups. Single residence was set up in surrounding style with wide internal public space within the blocks, integrating with the greenery including elms in the blocks. Buildings' layout was relatively loose and every residence had its own independent courtyard with high greenery rate and completed landscape, becoming the representative of garden residential blocks at that time. However, since 1950s, due to the lack of management and maintenance , unified planning of large-scale construction, free construction, house and warehouses expansion inside the block, the blocks' texture has been badly damaged and the green area is constantly encroached with the increasingly serious of underlying surface (see Figure 5). This also has led to the emergence of stormwater in Garden Street as well as the severe water logging issues. The construction of Sponge City is imperative.

Figure 5: Texture changes of Garden Street Historic Block

Figure sources: drawn by author.

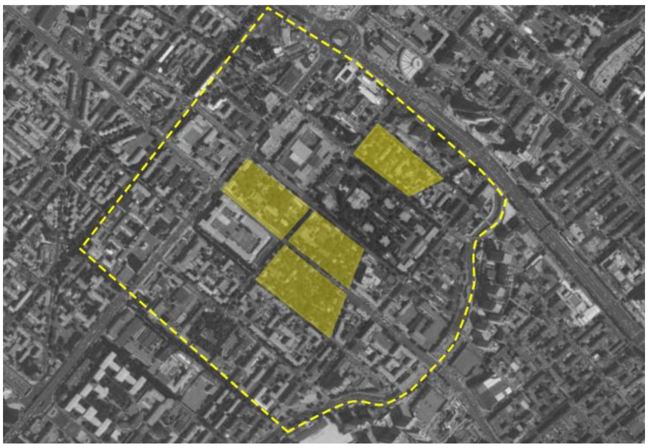


Figure 6 : The selected research range and the range of Garden Street Historic Block

Figure sources: drawn by author.

According to the zoning of water collection area, the practice of Sponge City usually set the area of 1-2 km^2 as a zoning of water collection area. In this practice, to better control the features of historic blocks and sponge construction, Garden Street Historic Block is set as the center to expand one block outward. As shown in Figure 6, the yellow area is the historic conservation blocks. The selected research range is yellow dotted area with the area of 1.13 km^2.

4.2 Construction principles

4.2.1 Conservation principles of elms

A large number of elms were planted in four blocks in the early stage of the construction. According to the survey, there are 258 elms, including 13 with a breast diameter of l00cm, over 100 with a breast diameter of 66cm and 188 with the breast diameter over 50cm. The conservation of elms with hundred years of history should be prioritized over the construction of Sponge City. The conservation hierarchy is determined to further divide the conservation range and clarify the prohibited area of construction for facilities of Sponge City. The elms with the breast diameter over 100 cm are designated as the 1st level of conservation, which should be strictly avoided by the construction of Sponge City. Within the vertical projection of the canopy and its 5.0 m outward, the construction sponge should not damage the topsoil and change the surface elevation; the elms with the breast diameter of 66 cm are designated as the 2nd level of conservation. Within the the vertical projection of the canopy and its 2.0 m outward, the sponge facilities are strictly forbidden which could soak the elms' root such as bioretention ponds and rainwater garden. The elms with the breast diameter over 50 cm are designated as the 3rd level of conservation. Within the vertical projection of the canopy and its 1.0 m outward, the construction demands are relatively flexible and the construction of the sponge facility requires the anti-soak design of the root.

4.2.2 Principles of features' coordination

The coordination between the construction of Sponge City and historic features is the first principle to abide by the construction of historic blocks in old districts. The historic features are well conserved in Garden Street Block. The sponge facilities with the minimized influence will be selected in sight of the coordination and conservation. The source control facilities should be coupled with the traditional green land in Garden Street. The spot green land is depended on to take the scattered layout with damage to its spot historic distribution pattern. Meanwhile, the sponge facilities are reconstructed according to the status quo to adapt the scale and layout of LID space to that of historic blocks. Additionally, the material, texture and color of rainwater collection facilities also should be coordinated with the surrounding historic buildings. The plants should obey the context and landscape styles of the edge of traditional architectural style to continue the historic atmosphere. The concealed principle is adopted to reduce the influence on historic features and optimize the reservoir and purification of rainwater.

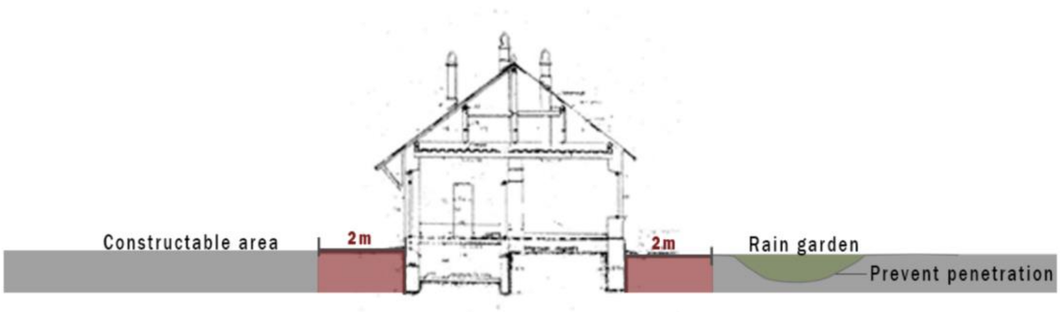


Figure 7 : Illustration of avoiding Historic architectural foundation in Garden Street Historic Block
Figure sources: drawn by author.

4.2.3 Principles of avoiding buildings' foundation

The quality of each building should be surveyed as well as the foundation situation for the construction of Sponge City in Garden Street Historic Block. The foundation, structure and roof condition are determined. And then during the construction of Sponge City, the architectural foundation should be avoided by 2 m , according to the conservation regulations of historic buildings. The sponge facilities, involving the rainwater penetration, such as rainwater garden and sunken green land, require the water-proof on part of their foundations nearby the architectural foundation(see Figure 7).

4.2.4 Resilient design principles

A lot of factors need to be coordinated for the design of Sponge City in Garden Street Historic Blocks, which has more difficulties comparing with the construction of new city. Being at the preliminary stage of development, the construction of some sponge facilities still simply draws the lessons from the United States for implementation. And many facilities and methods still lack local absorption and utilization, causing the difficult implementation of Sponge City in old districts, especially the historic blocks with more difficulties, such as Garden Street Historic Block (Xue, et al., 2012). The design of Sponge City here must uphold the resilient principle and make resilient exploration into sponge facilities and construction methods according to the status quo with the aim to successfully solve the contradictions between increasingly serious stormwater issues and blocks' features.

Single facility	**Influence on features**	**Landscape value**	**disposal**	**involved landscape elements**
permeable pavement	weak	weak	scattered	Pavement
green roof	Strong	Strong	scattered	Plants, vegetation and garden structures
sunken green land	Strong	Strong	scattered	topography, plants
bioretention pond	weak	Medium	scattered	topography, plants
infiltration pond	weak	Medium	Relatively concentrated	topography, plants and water
infiltration well	weak	weak	Relatively concentrated	—
wet pond	Medium	Medium	Relatively concentrated	topography, plants and water
rainwater wetland	Medium	Strong	scattered/Relatively concentrated	topography, plants, water and structures
Reservoir tank	Medium	Medium	Relatively concentrated	—
Adjusting tank	Medium	weak	Relatively concentrated	topography, plants and garden structures
grass ditch	weak	Medium	scattered	plants
filtration pipes/ditches	Medium	weak	scattered	—
vegetation buffer zone	weak	Medium	scattered	topography, plants
rainwater flow facilities	weak	—	Relatively concentrated	—

Table 2: Comparison and selection of sponge facilities in historic blocks

Table sources: drawn by author.

4.3 Facilities' comparison, selection and quantification

4.3.1 Facilities' comparison and selection

Sponge facilities usually function as the supply of underground water, reservoir and utilization, peaking runoff reduction and rainwater purification with multiple-objectives of total runoff amount, runoff peak and pollution. When selecting the sponge facilities in historic blocks, the economics and applicability of water collection area and facilities' function should be combined along with their influence on features, landscape and space disposal, generating flexible selection ways of sponge facilities and their combination system.

Within the 1st feature conservation areas, the combination of sponge facilities is implemented, which include permeable pavement, bioretention pond, infiltration pond, grass ditch, vegetation buffer zone and rainwater flow facilities. Within the 2nd feature conservation area, the added facilities cover filtration well, wet pond, adjusting tank, filtration ditch and rainwater wetland. Within the 3rd feature conservation area, green roof is added surrounding the well-qualified buildings and the sunken green land is also available.

4.3.2 Quantitative facilities

The quantitative facilities adopt the volume method. ArcGIS is used to supervise the classification of underlying surface, which is divided into green land, roof and road. The proportion for each type is concluded (see Table 3).

Types of underlying surface	Runoff coefficient	Mean value of runoff coefficient	Proportion
Buildings' roof	0.85~0.95	0.90	0.565
Roads' pavement	0.55~0.65	0.60	0.168
Green land	0.10~0.20	0.15	0.267

Table3: Comparison and selection of sponge facilities in historic blocks

Table sources: drawn by author.

The specific calculations can be referred to that in Technical Guidelines for the Construction of Sponge City issued by the Ministry of Housing and Urban-Rural Development. Calculated as follows. The calculation formula is shown as follows.

$V=10H\varphi F$

Where: V - design pondage volume, m^3;

H - design rainfall, mm;

Φ——runoff coefficient of integrated rainfall , calculated according to the weighted average of the runoff coefficient of the underlying surface of the study area;

F——the collection area, hm^2;

The pondage volume, V, is concluded at 19,639.65m^3 according to the rainfall density every 0.5 years in Garden Street Historic Blocks; it's 28,990.12 m^3 according to the rainfall density every 3 years and 31,652.25m^3 every 5 years. Then the implementation space is hierarchically designed based on the above results.

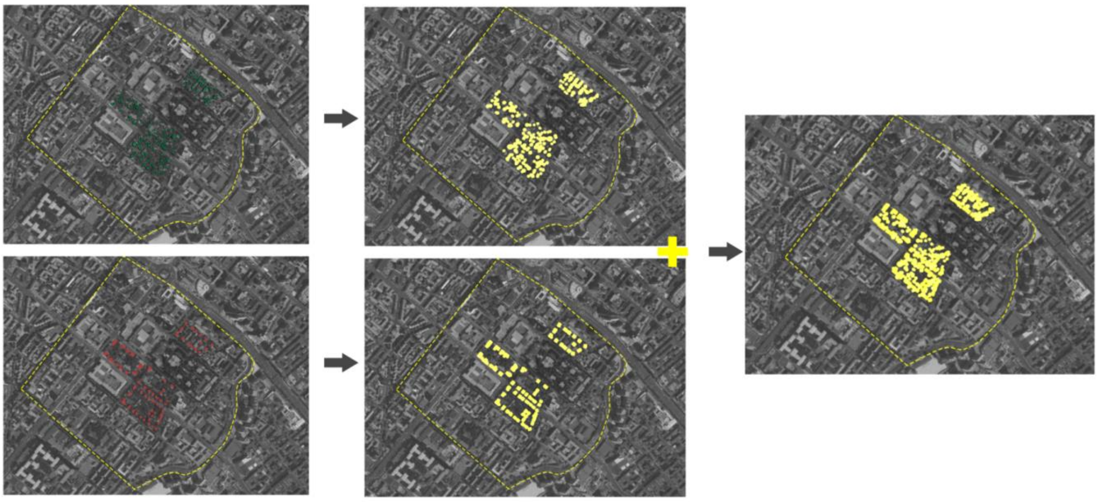


Figure 8 : illustration of non-construction area in Garden Street Historic Blocks

Figure sources: drawn by author.

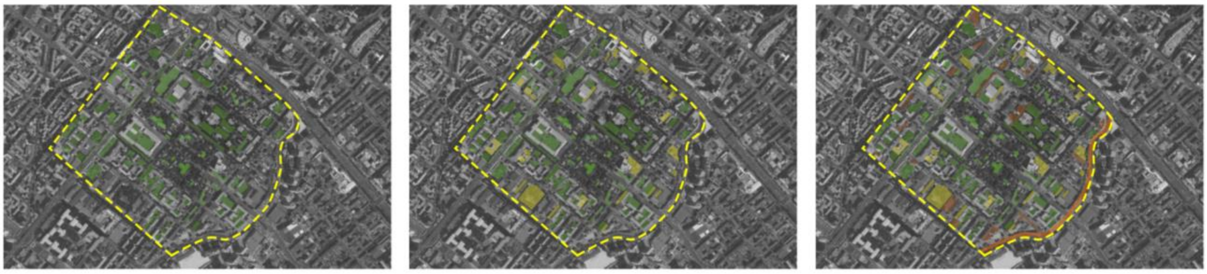
4.4 Design strategies of implementation space

4.4.1 Determine the construction range

According to the construction principles of Sponge City and the field research, the location of historic buildings and conserved elms are determined with the conservation range of buildings and elms within historic blocks. The Sponge City is strictly forbidden within 2 m away from the historical buildings' foundation. Elms are avoided according to their conservation levels. The avoiding space of historic buildings and the non-construction space of elms are overlapped and matched to determine the ultimate construction management and controlled range of historic blocks. As shown in Figure 8, the yellow area is the non-construction range , which should be strictly avoided in the construction of Sponge City in historic blocks.

4.4.2 Resilient hierarchical management and control

Volume method is used to quantitative the construction of sponge facilities with the resilient layout in space. In sight of different rainfall density every 0.5 years, 3 years and 5 years, the three-dimensional sponge facilities are set up in scattered manner in the construction-available range (see Figure 9). The hierarchical management and control of sponge space depends on the rainfall density. For 0.5 year, the green sponge space with the pondage volume of 19,639.65m^3 is turned on to collect and reserve the rainwater; for 3 years, the yellow sponge facilities' space is additionally used besides the green space with the sponge facilities' pondage volume of 28,990.12m^3 collect and transfer the rainwater. Meanwhile, the grey rainwater pipes' network is used to rapidly discharge the rainwater which can't be collected timely to prevent city water logging. For 5 years, the orange sponge space is added with the sponge facilities' pondage volume of 31,652.25m^3 collect the rainwater, mitigating the speed of flowing into low-lying areas. The gray rainwater pipes' network dominates with its rapid drainage. The flooding space of river channel is used to discharge the rainwater which can't be absorbed by the design plot along with the gray pipes' network space.



a Space for rainfall every 0.5 years b Space for rainfall every 3 years c Space for rainfall every 5 years

Figure 9 : illustration of hierarchical management and control for historic space of Garden Street

Figure sources: drawn by author.

5. Conclusion

Oriented in problems, this paper has deeply analyzed the implementation difficulties of Sponge City in old districts and put forward the targeted and resilient optimized strategies for the construction of Sponge City with the quantitative design of the implementation of Sponge City; Garden Street Historic Block in Harbin is taken to explore the old districts with insufficient implementation space and more serious stormwater issues with the possible three-dimensional space design in each small space. To coordinate with the historic features in old districts, the hierarchical management and control ways are put forward in sight of different rainfall densities; ultimately this paper aims to offer the reliable foundation for the future research and construction of Sponge City in old districts.

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