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Present Status & Realistic Demand of China's Low Impact Development Rainwater Control & Utilization Standardization

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Abstract: With the progress of urbanization, the traditional rainwater flooding management is not applicable to the demand of new-type urban development, which causes the urban local flooding, water environmental pollution, water ecological non-recyclable and other issues. In recent years, with the pilot construction of the sponge city, the low impact development technology has been widely applied everywhere nationwide, while the state and local governments have actively developed and modified the relevant standards and specifications. Through teasing out the standards in the rainwater control & utilization and other relevant fields, this paper summarizes and analyzes the present status and realistic demand, so as to provide the reference for the next standardization construction of the sponge city.

1. Introduction

The urbanization is the strong engine to maintain the continuous healthy economic development, the powerful support to promote the regional coordinated development, and also the necessary requirements to promote the all-round social progress [1]. However, the urbanization has brought about the change of urban surface structure, changed the site permeability, and also destroyed the original ecological cycle. If the water cannot be timely drained out, it will not only cause the road water-logging, but also pollute the water environment, and cause the urban rainwater flooding issue. At present, China's urban rainwater flooding management is heavily dependent on the drainage pipeline. The large-scale drainage pipelines are set in cities, which are used to collect the rainwater and directly drain it out when the rain comes. Although a great number of such rainwater is drained into the urban rivers and lakes, and the cities are also provided with the large-scale water storage facilities, the actual functions and effects are still not obvious. Meanwhile, China's cities still lack the effective measures to cope with the rainwater runoff pollution, while the rainwater that is directly drained into the rivers is neither subject to the adequate precipitation, nor subject to the treatment of removing the impurity. In the flowing course, it has carried and produced a lot of pollutants, and finally flowed into the original water body, which causes the water source pollution. Due to the retention of a great number of untreated urban pollutants and impurities, the infiltrated rainwater in the city not only pollutes the surface vegetation and water, but also causes the enormous hazards to the safety of groundwater, when it flows through the surface.

The idea of low impact development is a sort of stormwater management technology that was offered by the United States at the end of 1990s. The basic principle of such technology is to minimize the impact upon and damage to the natural ecosystem during the development and construction activities of the artificial system. For the sensitive and fragile water ecosystem of the mankind, the idea of low impact development requires realizing the control over the stormwater runoff and pollution, through the decentralized, small-scale source control facilities, so as to try to maintain the similar natural hydrological conditions after the regional development and construction [2]. Featured in the innovative idea, ecological technical measures and good operation effect, the low impact development mode has been widely applied to the urban development and construction

activities in the United States, and also widely referred to in other countries and regions. In recent years, China has also introduced the idea of low impact development. In 1998, Beijing Construction Engineering College (now known as "Beijing University of Civil Engineering and Architecture"), began to carry out the systematic study on the urban rainwater utilization technology. In 2003, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences started to carry out the urban diffuse pollution control research of the National Water Pollution Control and Treatment Science and Technology Major Project. In 2005, China Architecture Design & Research Group commenced to carry out the systematic research on the rainwater utilization engineering in building and sub-district. With regard to all sorts of severe water issues occurring to the city, China has already orderly carried out the urban water environmental treatment and rainwater management, control and utilization, and other works, since 2013. As a significant part of the sponge city construction, the practical application of the low impact development mode has already been widely conducted in relevant cities in China. However, less standardization works have been implemented.

2. Present Status for China's Rainwater Control & Utilization Standardization

China's first rainwater standard was prepared in 2006, while there were only 6 standards before 2010. Afterwards, due to the rapid development in the relevant fields and the urgent demand of solving the realistic issues, the preparation of a series of rainwater standards has started since 2013[3]. As of now, in order to coordinate with the construction of sponge city, the preparation and modification works of the specifications and standards directly related to the drainage and local flooding prevention and sponge city construction involved in the rainwater system composition, control targets and indexes & technology, planning & construction means and methods and other core issues of the sponge city, have already been partially completed. Generally, the urban rainwater flooding management-related standards are still under the continuous supplement and improvement.

According to incomplete statistics, at present, there are 47 nos. of domestic standards with regard to the rainwater control and utilization (as shown in Table 1), including 41 nos. of active standards, 5 nos. of standards under development and 1 no. of substituted standard. Among the active standards, there are 20 nos. of national standards and 21 nos. of local standards. At present, there are mainly 8 nos. of low impact development rainwater control & utilization standards that are either released or under development.

Among the active national standards, there are 10 nos. of mandatory standards, 10 nos. of voluntary standards, 6 nos. of standards related to the drainage and local flooding, and 3 nos. of basic standards. The released low impact development rainwater control and utilization-related national standards are almost not available, while there are 3 nos. of major low impact development rainwater control and utilization-related national standards that are under development. Among them, *LID stormwater management and harvest-Classification of facilities* (Proposed serial number: 20171355-T-424), *LID stormwater management and harvest-Code for operation & maintenance of facilities* (Proposed serial number: 20171354-T-424) and *LID stormwater management and harvest-Basic terminology* (Proposed serial number: 20184559-T-424) are separately drafted under the leadership of China National Institute of Standardization, Beijing University of Civil Engineering and Architecture and Qingdao Institute of Standardization, and put under the centralized management by China National Institute of Standardization. At present, these standards are under the urgent development.

Table 1 Summary of Urban Stormwater Control & Utilization Standards

S.N.	Name of Standards	Status of Preparation	Type of Standards
1	*Technical code for data acquisition and maintenance of urban drainage and local flooding prevention and control facilities* (GB/T51187-2016)	Released	National standard
2	*Code for design of urban flood control project* (GB/T 50805-2012)	Released	National standard
3	*Technical code for rainwater collection,storage and utilization* (GB/T 50596-2010)	Released	National standard
4	*Evaluation standard for urban landscaping and greening* (GB/T 50563-2010)	Released	National standard
5	*Standard for basic terms of water and wastewater engineering* (GB/T 50125-2010)	Released	National standard
6	*Standard for building water supply and drainage drawings* (GB/T 50106-2010)	Released	National standard
7	*Assessment standard for green building* (GB-T 50378-2014)	Released	National standard
8	*The reuse of urban recycling water-Water quality standard for scenic environment use* (GB/T 18921-2002)	Released	National standard
9	*Terms of equipment and materials for building water supply and drainage* (GB/T 16662-2008)	Released	National standard
10	*Technical code for urban flooding prevention and control* (GB51222-2017)	Released	National standard
11	*Technical code for urban stormwater detention and retention engineering* (GB51174-2017)	Released	National standard
12	*Technical code for water supply and sewerage of urban* (GB 50788-2012)	Released	National standard
13	*Code for design of flood detention and retarding basin* (GB 50773-2012)	Released	National standard
14	*Technical code for rainwater management and utilization of building and sub-district* (GB 50400-2016)	Released	National standard
15	*Technical code for roof engineering* (GB 50345-2012)	Released	National standard
16	*Code for design of municipal wastewater reclamation and reuse* (GB 50335-2016)	Released	National standard
17	*Code for urban wastewater and stormwater engineering planning* (GB 50318-2017)	Released	National standard
18	*Code for design of building water supply and drainage* (GB 50015-2003)	Released	National standard
19	*Code for design of outdoor wastewater engineering* (GB 50014-2006, 2014 version)	Released	National standard
20	*Code for Urban flooding prevention and control planning* (JBGZ [2017] No. 110)	Under development	National standard
21	*Terminology of water-saving products for buildings* (GB/T 35577-2017)	Released	National standard
22	*Standard for sponge city construction assessment* (JBBH 〔2018〕No. 346)	Under development	National standard
23	*LID stormwater management and harvest-Code for operation & maintenance of facilities* (Proposed serial number: 20171354-T-424)	Under development	National standard
24	*LID stormwater management and harvest-Classification of facilities* (Proposed serial number: 20171355-T-424)	Under development	National standard
25	*LID stormwater management and harvest-Basic terminology* (Proposed serial number: 20184559-T-424)	Under development	National standard
26	*Water quality specifications for reclaimed water & stormwater utilization in Shenzhen* (SZJG 32-2010)	Released	Local standard
27	*Engineering technical code for rainwater utilization in Shenzhen* (SZDB/Z 49-2011)	Released	Local standard
28	*Technical code for LID stormwater comprehensive utilization in Shenzhen* (SZDB/Z 145-2015)	Released	Local standard
29	*Technical code for engineering of rain utilization in Jiangsu Province* (DGJ 32/TJ 113-2011)	Released	Local standard
30	*Engineering technical code for rain utilization in building and sub-district in Shaanxi Province* (DBJ61/T 84-2014)	Released	Local standard
31	*Standard for urban road drainage of Fujian Province* (DBJ/T 13-167-2013)	Released	Local standard
32	*Code for planning and design of sponge city in Shandong Province* (DB37/T 5060-2016)	Released	Local standard
33	*Standard of rainstorm runoff calculation for urban storm drainage system planning and design in Beijing* (DB11/T969-2016)	Released	Local standard
34	*Code for design of stormwater management and harvest engineering in Beijing* (DB11/ 685-2013)	Released	Local standard
35	*Technical code on rainwater harvesting engineering in urban area of Henan Province* (DB 41/T 818-2013)	Released	Local standard
36	*Technical code on rainwater harvesting system in urban area of Liaoning Province* (DB 21/T 2241-2014)	Released	Local standard
37	*Engineering technical code on stormwater control and harvesting in Hebei Province* (DB 13 (J) 175-2015)	Released	Local standard
38	*Code for design of rainwater harvesting engineering in urban areas of Beijing* (DB 11/T 685-2009)	Substituted	Local standard
39	*Design code for stormwater storing and discharging for underpass road in Beijing* (DB 11/T 1068-2014)	Released	Local standard
40	*Standard for planning & design of water drainage and flooding prevention system in Wuhan*	Released	Local standard
41	*Standards for local flooding prevention and control system planning in Zhejiang Province*	Released	Local standard
42	*Technical code for the sponge city construction in Xiamen*	Released	Local standard
43	*Code for design of LID stormwater management and harvest engineering in Guangxi Province*	Released	Local standard
44	*Guidelines for the planning and design of urban rainwater drainage facilities in Shanghai*	Released	Local standard
45	*Design standard for rainwater management and utilization of low impact development projects in Sichuan Province* (DBJ51/T084-2017)	Released	Local standard
46	*Technical standards for operation & maintenance of low impact development facilities in Chongqing* (DBJ50/T-276-2017)	Released	Local standard
47	*Technical code for LID urban stormwater collection and harvest engineering in Liaoning Province* (DB21/T 2977-2018)	Released	Local standard

Generally, most of the active local standards are dominated by the rainwater collection and utilization standards. There are 5 major released low impact development rainwater control and utilization-related standards. As per the known local standardization details nationwide, Beijing, Shanghai, Shenzhen, Chongqing, Zhejiang, Jiangsu, Henan, Hebei and other 10 plus provinces and cities have prepared the local rainwater standards. Relatively speaking, Beijing and Shenzhen start to prepare the rainwater-related standards much earlier and their quantities are much larger, while their impacts in the industry are also much larger. The basic standard *Standard of storm water runoff calculation for urban storm drainage system planning and design* (DB 11/T 969-2013) mainly prepared by the Beijing Municipal Institute of City Planning & Design was released in 2013, which was modified into the *Standard of rainstorm runoff calculation for urban storm drainage system planning and design in Beijing* (DB11/T969-2016). The *Code for design of stormwater management and harvest engineering in Beijing* (DB11/ 685-2013) mainly prepared by the Beijing Institute of Architectural Design, replaces the *Code for design of rainwater harvesting engineering in urban areas of Beijing* (DB 11/T 685-2009), and becomes the national first mandatory rainwater control and utilization local standard [4,5]. With regard to the sunken bridge district drainage and local flooding control upgrading and reconstruction project of the key waterlogging points in the urban area, Beijing city also prepares the *Design code for stormwater storing and discharging for underpass road in Beijing*, providing the design basis for the construction of the rainwater storing and discharging in such representative district. At present, due to the promotion of the sponge city construction and the increase of pilot areas, while more provinces and cities are speeding up the preparation of their own specifications and standards or design guideline type technical documents.

3. Realistic Demand for China's Low Impact Development Rainwater Control & Utilization Standardization

Combined with the present development status and future development trend of China's low impact development rainwater control & utilization standardization, this paper intends to find the realistic standardization demand existing in the actual works of the low impact development rainwater control and utilization that urgently needs to be addressed, and analyze the classification and positioning of the low impact development rainwater control & utilization standards, which is of great significance in the development of preparation and modification works of the future low impact development rainwater control & utilization-related standards, and of the vital practical significance in the development of China's low impact development rainwater control and utilization standardization, and even the development of the sponge city construction standardization.

(1) It is urgent to establish the low impact development rainwater control & utilization standard system

The standard system is the foundation stone of standardization construction works. The establishment of the scientific and reasonable standard system is the significant basis to effectively carry out the standardization construction works. With regard to the low impact development technical research & application, China mainly refers to the overseas advanced idea and experience, but still forms its own perfect theoretical and technical system. Meanwhile, its application and practice is still at the initial stage, while the industry related to the low impact development is still not formed, and its popularity rate is still much lower. The low impact development standardization construction is also greatly lagged behind, while not a few problems still exist. At present, China's low impact development rainwater control and utilization standard system is still not established, while the development of low impact development rainwater control and utilization nationwide is not balanced, and the low impact development rainwater control and utilization standards formulation is a weak link of low impact development rainwater control and utilization. The industrial standardization lacks the top-level design and still does not establish the unified and coordinated scientific standard system, which makes it difficult to guide the orderly implementation of the low impact development rainwater control and utilization standardization works.

Besides, in the existing *Water supply & drainage engineering construction standard system*

table [6], it is neither possible to properly incorporate the low impact development technical standards, nor possible to highlight the significance of low impact development technical standards in the sponge city construction and application. The establishment of China's urban drainage system standard system framework also needs to incorporate the "source control system", "drainage pipe network system" and "local flooding prevention and control system" [7], while the low impact development is the basic framework to realize the high efficient sponge city construction. Through the application of the multi-type, small-scale, scattered green ecological facilities, it intends to follow the six-word guideline "osmosis, retention, harvesting, purification, recycling and drainage" [8], namely, the source runoff control system will be utilized to recover the good urban hydrological cycle [9]. Therefore, the gradual establishment of the low impact development rainwater control and utilization standard system is also of great significance in the establishment of China's urban drainage system standard system framework.

(2) It is urgent to prepare the important basic & general standards of low impact development rainwater control and utilization

It lacks the state-level relevant basic & general standards to guide the actual construction and operation of low impact development. At present, it lacks the overall low impact development construction technical guiding principles, design specifications and assessment standards that conform to China's reality, while the professionals in the design & construction, operation, maintenance and assessment and other fields cannot find the basic and general national standards or relevant policy basis, which causes the great practical operation difficulty. Meanwhile, many researches on the low impact development technical measures are only limited to some concrete measures, but lack the overall, systematic and in-depth monitoring, simulation and assessment researches on the low impact development. Therefore, as per the actual construction demand, it is urgent to carry out the development of significant basic standards of low impact development rainwater control and utilization, for instance: the development of basic terminology of the low impact development rainwater control & utilization, planning guide rules, facility classification, facility operation, maintenance and management, assessment index system and other national standards.

Besides, the great regional differences may also cause the weak applicability of the existing specification. Many simulation works in the rainwater laboratory are the abstract situations, which is disconnected from the local actual planning conditions and lacks the verification of the local actual monitoring data. As a result, it is inadequate for the simulation results to guide the design, construction, operation, maintenance and assessment of the local actual low impact development facilities. Under the condition that the relevant policies and specifications are inadequate, the professionals at the front line of design, construction, development and others, cannot precisely grasp how to accurately apply them into the low impact development construction works. For example, the impact of permeability coefficient of permeable pavement upon the rainfall will cause the huge difference between the Northern and Southern China. If it is impossible to learn from each other during the construction process, it is only necessary to adjust measures to local conditions and reacquire the relevant data. Therefore, each region shall carry out the development of significant basic local standards of low impact development rainwater control and utilization with the strong applicability, as per the actual local monitoring data.

4. Conclusion

Based on China's present status and realistic demand of low impact development rainwater control & utilization standardization, and in combination with China's development experiences of low impact development rainwater control and utilization, and aiming at the development and implementation works of China's low impact development rainwater control & utilization system, this paper makes the following proposals:

(1) It is required to establish and perfect the low impact development rainwater control & utilization standard system

At present, the low impact development rainwater control and utilization still has not established

the unified and coordinated scientific standard system. Therefore, it is required to establish the unified standard system at the state level and from the top-level design perspective. Meanwhile, it is also required to construct the scientific standard system from the basic terminology, facility classification, assessment indexes and other aspects by utilizing the standardized means, so as to promote the perfection and development of the low impact development rainwater control and utilization standard system.

(2) It is required to accelerate the formulation of significant standards of low impact development rainwater control and utilization

The final task of the construction of low impact development rainwater control & utilization system is to implement the development of significant standards. Although China has already released many water and wastewater drainage technical specification type standards, the standards related to the low impact development rainwater control and utilization are still too scare to conform to the demands of the low impact development rainwater control and utilization standardization works. Especially with the gradual construction and development of the sponge city, the inadequate basic standards of low impact development rainwater control and utilization are far away from the need of sponge city construction. Therefore, it is necessary to accelerate the formulation and modification of the low impact development rainwater control and utilization standards, and further perfect the low impact development rainwater control and utilization standard system, so as to provide the technical support and assurance for the low impact development rainwater control and utilization standardization works.

(3) It is required to strengthen the promotion and implementation of the low impact development rainwater control and utilization standards

It is required to properly make the promotion and training works of the standards and incorporate all sorts of standards into the sponge city construction by centering around the key links of low impact development rainwater control and utilization. It is required to train the standardized thinking pattern of low impact development rainwater control and utilization, and enable the relevant staffs of sponge city construction to know and understand the importance and necessity of standardized system construction.

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