

Operation and Maintenance Challenges in China "Sponge City" Program

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Abstract: China started a Sponge City program to offset the adverse impacts of urban developments and to tackle many water-related problems. By emphasizing stormwater management practices with "natural solutions", many positive results have been achieved. The operation and maintenance (O&M) of Sponge City to support long-term success gained considerable focus. China is facing challenges many developed countries have encountered, as well as unique ones due to specific social, economic, and environmental conditions. This study identified and discussed Sponge City O&M challenges: (1) scheduling challenges, (2) technical challenges, (3) in short of local regulation/ordnance, (4) inadequate O&M assessment standard, (5) underprovided training, (6) PPP related concerns, (7) inter-agency coordination needs, (8) ownership and responsible party issues, (9) substandard documentation, and (10) funding and financial concerns. Selected cases and progress in pilot cities are introduced in the discussions.

Key words: Sponge city, O&M, urban stormwater management, green infrastructure.

1. Introduction

On July 21, 2012, a flash flood hit the city of Beijing. In total 56,933 people evacuated and 79 people died; a wake-up call before reforms in urban stormwater and drainage management [1]. To offset the adverse impacts of rapid urban developments, the Chinese central government introduced the Sponge City concept in December 2013 as an approach to tackle many water-related problems in the cities [2].

The definition of Sponge City is that "during the upgrade of urban drainage infrastructure they should make it a priority to retain valuable water resources and to utilize the natural system to achieve drainage, to establish natural retention, natural infiltration, and natural purification—like a sponge" [2]. The goal is to manage approximately 70% of the runoff in 20% of

urban lands by 2020, and 80% of urban lands by 2030, emphasizing stormwater management practices with natural solutions [3].

The concept of Sponge City is in line with many modern urban stormwater management concepts in developed countries, such as best management practices (BMPs) and low impact development (LID) in North America, sustainable urban drainage systems (SUDS) in the UK, and water sensitive urban design (WSUD) in Australia [4].

Based on reports from various sources, the estimated Sponge City construction cost per square km is approximal 14 to 26 million USD, with an estimated investment of 0.2 to 1.6 trillion USD in total [5, 6].

Since 2015, pilot cities, as well as many cities in China, started the implementation of Sponge City practices (see Fig. 1). More than 600 cities in China are required to meet the Sponge City goals in the next decade, and the scale is massive with a challenging schedule.

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Fig. 1 Sponge City phased approach—from pilot cities to most cities in China.

As a result, an enormous amount of urban stormwater management practices have been built, from site-level LID practices to regional flood control facilities. Just within the first three years, more than 4,900 projects have been completed in the 30 pilot cities with total investments of 23 billion USD [7].

2. Challenges in O&M

The success of an urban stormwater management program largely depends on the sustainability of the O&M. China is facing challenges many developed countries have encountered (see Fig. 2).

There are also specific challenges due to its unique social, economic, and environmental conditions (see Fig. 3).

2.1 Scheduling Challenges

The tight compliance schedule and a large number of stormwater infrastructures constructed in a relatively short period time create challenges in Sponge City's O&M. Cities have to react fast to embrace the increased assets.

Chizhou City is one of the pilot Sponge cities selected by the central government since 2015. A total of 710 km of pipelines and more than 10 sq. km of areas are included in the pilot project area. Additional funds and staff have been added to the city's O&M team, as well as local O&M contractors. Prioritization studies have also been conducted to



Fig. 2 Missing vegetation and erosion after construction.



Fig. 3 Vegetation replaced by Taro in biorientation by local residents (credits: Mr. Minhua Zhao).

identify critical sites/practices and to optimize the O&M program cost-effectively (see Fig. 4).

2.2 Technical Challenges

There is limited experience in Sponge City O&M for many involved parties. Creating O&M technical guidance documents is not easy since specific social, economic, and environmental factors need to be considered to meet local needs. Most cities do not have comprehensive technical guidance in place yet [8]. Also, consideration of integrated strategies in various spatial scales, from single practices to city-wide O&M program management is greatly needed.



Fig. 4 Prioritizing O&M in Chizhou City based on risk and likelihood analysis.

2.3 In Short of Local Regulation/Ordnance

Though some national regulations exist, China desperately needs a system of O&M regulations at state and city levels to be enforced through local social or governmental institutions to clarify and regulate activities during Sponge City O&M.

In 2020, Chizhou became the first city in China with Municipal-level Sponge City regulations/ordnance, O&M management rules are specified in Chapter 4 of the regulation/ordnance [9] and more cities will follow.

2.4 Inadequate O&M Assessment Standard

So far, O&M assessment standards and local O&M manuals are sporadic; O&M implementation varies between sites and cities.

Assessment Standard for Sponge City Construction Effect has been published as a national standard since 2019 [10]. It is believed that similar standards for Sponge City O&M will be in place as well.

2.5 Underprovided Training

Sponge City is a relatively new concept for most people. The O&M of Sponge City practices is also

different from traditional ones. It will be a steeper learning curve for maintenance staff and local residences. Education and training for different groups related to Sponge City O&M are needed to expand skills and knowledge of inspecting and maintaining Sponge City practices. National or local certification programs are also to be considered to offer employers a way to identify individuals with credentials.

2.6 PPP Related Concerns

There are also challenges related to the Public-Private Partnership (PPP) involvement during the Sponge City implementation. Many PPPs include O&M after building the practices. The O&M regulatory environment and evaluation standards are inadequate [11]. Since PPPs are performance-based, numeric provisions are preferred as well as clear, enforceable, and measurable narrative standards, which may not be well-considered with these agreements signed; causing potential delays and disputes in delivery.

2.7 Inter-agency Coordination Needs

The O&M of some Sponge City practices overlaps with regular maintenance. Coordination between these parties/departments (such as landscape architecture, parks and recreation, environmental and urban development departments) needs to be enhanced.

2.8 Ownership and Responsible Party Issues

Unlike many other countries, land in China is owned by collectivities or by the state. Property owner and operator's responsibilities in the O&M are blurry, creating additional difficulties in public awareness and adoption of the Sponge City practices. O&M agreements are not in place or not strictly enforced in many places. Moreover, since the construction of many Sponge City practices was led by the government, passing the O&M tasks of these to local owners and operators may be more challenging, and public involvements need to be improved.



Fig. 5 Stormwater management partnership in Lingang District, Shanghai [12].

To overcome these issues, in March 2019, Lingang District in Shanghai City initiated a Sponge City O&M pilot project study (see Fig. 5). O&M partnership agreements were established by the property management association, design firm, local residence, and landscaping contractors. A proper training program was also identified as a key to success and was well provided to different parties to support the O&M implementation [12].

2.9 Substandard Documentation

From design to construction, in general, many drawings and construction as-built documents are poorly recorded and filed during Sponge City construction due to deficiency in permit requirements and tight construction schedule. This creates additional difficulties in performing O&M and causes potential disagreements between parties. The reporting and filing process shall be regulated in the permitting requirements to resolve the issue.

2.10 Funding and Financial Concerns

The long-term funding stream for Sponge City is also very important. Central and some local governments provided financial supports to stimulate the construction of Sponge City, but funding for the long-term O&M is more challenging. Many investors are not interested in Sponge City; stormwater fees may be an important source to financially support the on-going large-scale constructions as well as intensive O&M needs.

Mr. Chen Zhenggao, the former vice director of China Ministry of Housing and Urban-Rural Development, inquired for studies on stormwater discharge fees by learning from foreign countries [13]. No Chinese city so far is collecting stormwater fees yet. However, experts say that Shanghai and Shenzhen are engaged in exploratory research [14]. Considering the massive scale of investments, it is reasonable to believe that the stormwater fee in China will not be the sole source of funding to cover the cost of Sponge City construction and O&M. Other financial sources are still needed [7].

3. International Collaboration Needs

A wide array of challenges also means significant needs in international collaboration. The experience in developed countries has played a constructive role in initiating Sponge City in China (i.e. the Technical Guidance on Sponge City Construction is based on LID concepts [3]). so will be in promoting the sustainable of the O&M.

4. Conclusions

China is implementing a trillion-US dollar "Sponge City" Initiative to offset many urban stormwater issues using natural solutions, in line with many sustainable stormwater management concepts in developed countries. There are challenges during Sponge City constructions, so is the O&M as an emerging subject. Many difficulties are similar to developed countries while there are also unique challenges due to social, economic, and environmental conditions. Many studies and practices have been implemented to resolve issues. In the meantime, international collaborations are strongly needed.

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References

- CNN. 2012. "Floods Kill 37 in Beijing." CNN Asia News, July 23, 2012. Accessed October 1, 2020. https://www.cnn.com/2012/07/22/world/asia/china-floodi ng/index.html.
- [2] Leach, Anna with the Guardian News & Media. 2016.
 "Soak It Up: China's Ambitious Plan to Solve Urban Flooding with 'Sponge Cities'." Guardian News October 3, 2016. Accessed October 1, 2020. https://www.theguardian.com/public-leaders-network/201 6/oct/03/china-government-solve-urban-planning-floodin g-sponge-cities.
- [3] Ministry of Housing and Urban-Rural Development of the People's Republic of China. 2014. *Technical Guidance on Sponge City Construction—Establishing Low Impact Development Stormwater System*. Beijing, China. (in Chinese)
- [4] Fletcher, T. D., Shuster, W., Hunt, W., et al. 2015. "SUDS, LID, BMPs, WSUD, and More—The Evolution and Application of Terminology Surrounding Urban Drainage." *Urban Water Journal* 12 (7): 525-42.
- [5] Sohu News. 2016. "Sponge City with Trillion Yuan Market Is to Be Released." Sohu News. Accessed October 1, 2020. https://www.sohu.com/a/61971431_119556. (in Chinese)
- [6] Guotai Junan Securities. 2016. "Sponge City Stimulates Trillion Markets." Tencent Finance. Accessed October 1, 2020. https://finance.qq.com/a/20160218/031000.htm. (in Chinese)

- [7] Su, Y., Wang, W., and Qin, S. 2020. "An Introduction to Stormwater Fees in the USA and Its Significance to Sponge City Development." *Water and Waste Water* 46 (8).
- [8] Jia, H., Wang, Z., Zhen, X., et al. 2017. "China's Sponge City Construction: A Discussion on Technical Approaches." *Front. Environ. Sci. Eng.* 11 (4).
- [9] Committee of the 13th National People's Congress of Anhui Province. 2019. Chizhou City Sponge City Construction and Management Regulations (2019-11/19). (in Chinese)
- [10] Ministry of Housing and Urban-Rural Development of the People's Republic of China. 2018. GB/T51345-2018 Assessment Standard for Sponge City Construction Effect. Beijing, China. (in Chinese)
- [11] Li, H., Ding, L., and Ren, M., et al. 2017. "Sponge City Construction in China: A Survey of the Challenges and Opportunities." *Water* 9 (9): 594.
- [12] China Urban Planning Association. 2019. Research on the Planning Control System of Sponge City Construction. Accessed October 1, 2020. https://dy.163.com/article /EN4H 5UMU05366JV6.html.
- [13] Chinanews.com. 2015. "The Ministry of Housing and Urban-Rural Development Promotes the Construction of Sponge Cities and Strives to Retain 70% of the Rain." Domestic News 05/29/2015. Accessed October 1, 2020. http://www.chinanews.com/gn/2015/05-29/7310369.shtm l. (in Chinese)
- [14] Pan, Q. 2017. "Should China Introduce a Stormwater Fee?" China Dialogue 8/30/2017. Accessed October 1, 2020. https://chinadialogue.net/en/cities/10018-shouldchina-introduce-a-stormwater-fee/.