Greenway: The Backbone of Sponge City in China

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The Background and Literal Review of Sponge City

In recent decades, many Chinese cities are facing serious inner flood issues, especially big cities. Large built-up area, high ratio of impervious surface, and deficient infrastructures are the main reasons. The conventional drainage infrastructure can hardly deal with frequent inner floods companied with fast urbanization. Ironically, most Chinese cities are suffering from water shortage meanwhile (Fan & Zhao, 2010).

Under such a situation, the idea of constructing "Sponge City of natural retention, natural infiltration and natural purification" was proposed on the 2013 Central Authority Congress of Urbanization. In 2014, the Ministry of Housing and Urban-Rural Development (MOHURD) released *Technical Guide of Sponge City: Construction of Low Impact Development Stormwater System*. MOHURD, Ministry of Finance, and Ministry of Water Resources started the First Pilot Sponge Cities program supported by central finance in 2015.

The concept of Sponge City referenced to LID and BMPs of United States and other related strategies. Different from the conventional stormwater controls, LID emphasizes using green infrastructure to manage non-point source stormwater runoff, and the constructed practices have proved the efficiency, and economic and environmental benefits of LID (EPA, 2000).

In China, researches and practices on LID began in the late 2000s (Yang & Lin, 2015). Before that, using green spaces to manage stormwater had been discussed (Zhang & Yan, 1996; Li et al., 2001; Wang & Zhang, 2006). The concept of LID evolved to Sponge City in 2011, when researchers and officials proposed Sponge City to manage stormwater (Yang & Lin, 2015). At present, the researches on Sponge City are increasing rapidly, including interpretation of the concept (Yu et al., 2015; Qiu, 2015), planning models (Peng et al., 2015; Tong et al., 2015), technical measures (Wang et al., 2016) and project practices (Wang et al., 2014).

Urban Green Space System and Sponge City

Green spaces are important components of Sponge City. The LID measures applied in Sponge City, such as rain garden, rain wetland, bioretention, grass swales and vegetated filter strips, need to be applied in green spaces.

It is mentioned in the *Guide* that urban green space system, urban stormwater pipeline system and first flush drainage system work together to manage stormwater runoff. However, the existing situation in China decides that green space system is the major part of Sponge City. Firstly, the low efficiency of drainage pipeline system is a main reason of city inner floods, so Sponge City was proposed as alternative. And the *Guide* doesn't mention the improvement of the design standards of drainage pipeline system. Secondly, the *Guide* shows that first flush drainage system is actually a part of the drainage pipeline system, instead of an independent system. Moreover, many constructed LID practices didn't apply it.

Urban Heat Island effect caused by urbanization could increase the rainfall in Heat Island area, especially extreme rainfall. Green spaces with rational distribution can mitigate UHI effect, consequently, indirectly reduce rainfall in city centers, where inner floods occur more frequently.

Thus, urban green space system must be a major component of Sponge City. Spatial pattern of urban green space system decides whether the goal of Sponge City can be achieved. The goal of this article is to find out a suitable model of urban green space system for Sponge City.

After a wide literal review of the documents on Sponge City, the authors propose a hypothesis that green spaces as not been consider as a whole system in Sponge City construction. The hypothesis is verified through practice cases. Then, the authors propose that the role of greenways in Sponge City, and verifies this idea by the case of Guangming New District, Shenzhen.

The Issues Needs to Be Concerned in Sponge City Green Space System

The main objective of Sponge City is to manage non-point source stormwater, just like LID, whose measures are small scaled and scattered on the site to control runoff from the dispersive sources. Thus, most Sponge City projects emphasize distributed LID practices across the city (Yu & Zhang, 2007; Wang et al., 2014). It must be pointed out that, though Sponge City is from the concept of LID, they are implemented on different levels. LID is applied on community level, and manages stormwater by separate measures, so it is suitable to build small-scale Sponge Communities. Sponge City needs to

manage stormwater on city level, so to plan and build a Sponge City is more complicated than a Sponge Community. Therefore, scattered and isolated LID practices are insufficient to achieve a Sponge City, and a city-scale Sponge green space system with broad and balanced distribution is needed.

The *Guide* points out, the scattered measures at sources are hard to achieve the objective of runoff volume control alone, so measures at midways and the ends are needed. That means part of the runoff volume will be conveyed from the sources to the measures in other green spaces (Fig. 1). Thus, connectivity is required by the Sponge green space system.

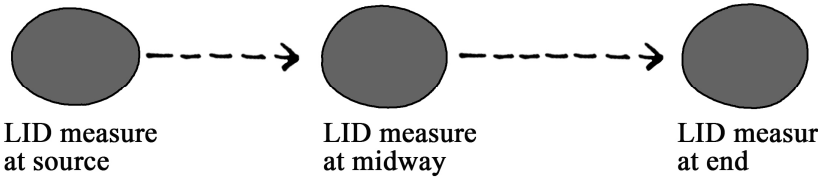

Figure 1. Runoff Conveyance for Volume Control

The measures at sources are hard to reduce enough pollutants. Infiltration and reuse of over-polluted stormwater will cause serious ecological issues. There are no specific pollutant removal measures used in LID practices but first flush control and biological (plants and microbes) treatment, because of water quality of rain and runoff in American cities. However, pollutants in rainwater and runoff in Chinese cities are times higher than that in American cities (Che et al., 2003). If the same biological measures are used in Chinese Sponge City, they will not remove enough pollutants to meet the related criteria of water quality. Thus, more fist flush volumes, where are most pollutants, need to be controlled, and more efficient removal measures are required. However, the *Guide* doesn't have a specific requirement except first flush abandon, but pollutants in remaining runoff is still times higher than that in America. A possible solution is to allocate some offsite concentrated and high efficient pollutant removal measures in Sponge City, such as large constructed wetlands. If so, connectivity is a requirement to convey runoff (Fig. 2).

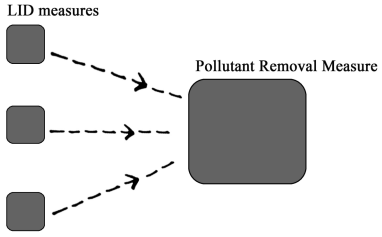

Figure 2. Runoff Conveyance for Pollutant Control

In summary, Sponge City needs a macro-level green space system, in order to efficiently integrate all sorts of LID measures in green spaces together, so that the goal of stormwater management of Sponge City can be achieved.

Sponge City Green Space System Based on Greenways

As an important green infrastructure, greenways is a linear green land or green network, providing ecological, recreational and cultural functions in macro (national), medium (regional) and micro (city) level (Fábos, 2004). An ideal model of Sponge City green space system is to use greenways as a framework.

First, greenways can enhance runoff volume control and pollutant removal in Sponge City. Distributed LID measures at sources are hard to meet the goal of Sponge City, so management at midways and ends is needed. In greenways, LID measures can be allocated to control more runoff volume, as well as high efficient treatment measures, like large constructed wetlands or linear bioretention, to remove more pollutants.

Secondly, connectivity of greenways makes the linkages among all LID measures, and creates a spatially connected system in the city, to manage stormwater on macro level. Urban green space system emphasizes the coordination of its all components, that is, distributed green spaces are not isolated, but functionally or spatially linked. To achieve the goal of a Sponge City, rational proportion of the total controlling goal needs to be allocated to each district or borough, and runoff can be conveyed among green spaces. Conveying through greenways is the only choice, because drainage system has insufficient capacity in storms and combined drainage and sewage is common.

Thirdly, Sponge City green space system needs to be implemented in a hierarchical structure to manage stormwater on macro, medium and micro levels (Yu & Zhang, 2007; Che et al., 2015). Distributed LID measures with direct connection are of flat structure with low efficiency, while a hierarchical structure with layers can enhance efficiency of stormwater management (Fig.

3). A hierarchical greenway network linking distributed LID measures on different levels by well arrangement, will achieve the goal of Sponge City.

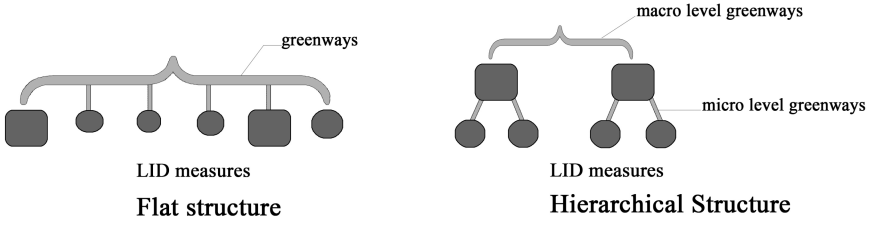

Figure 3. Flat Structure V.S. Hierarchical structure

Some planning projects considered the systematicness of stormwater management (Yu & Zhang, 2007; Yang & Liu, 2014; Yu et al., 2015), but focused on the linkage by waterways. However, waterways don't exist in every city, and it costs much to construct waterways, even much more than pipelines; furthermore, most Chinese cities face water shortage, and have no enough water to maintain the waterways in common days (Fu & Zhao, 2010). Greenways can include waterways, ditches and pipelines, and waterways combined with greenways provide better visual aesthetics and more efficient pollutant removal than waterways alone. Some projects considered greenways, but just emphasized to distribute of LID measures within greenways to control more runoff volume (Wang et al., 2014), instead of the systematicness and connectivity of greenways to create a whole Sponge City system.

Case Study: Guangming New District, Shenzhen

Guangming New District, Shenzhen started LID pracitces in 2008, and was granted the only National LID Stormwater Utilization Pilot Zone. The New District had started 26 LID projects with total 370.57 ha.

However, these LID projects were not implemented under a planned framework, but separately, without a systematic arrangement. Provincial and city greenways were planned and built in Guangming, but these greenways hadn't been considered to apply LID strategy and work for Sponge City.

Fortunately, Phoenix City of 1,489 ha in Guangming, proposed a Boston's Emerald Necklace styled green ring of total 381 ha and 12 km long (Fig 4) in the *Research on Guangming Phoenix City Development Guiding Plan* in 2014, and the Ring was the basic green infrastructure to apply Sponge City strategy (Administration of Guangming, 2015). Moreover, the administration considered to extend the Ring into Phoenix City at the next step to link LID

measures inside, and to form a two-leveled greenway system with Sponge function. The only defect of the plan is that the Ring hadn't been considered to link to the provincial greenways nearby because of the administrative territory.

Conclusion

Urban green space system of balanced distribution, connectivity, and integration is necessary to achieve the goal of Sponge City. Therefore, greenways are required to create the backbones of Sponge City system.

Figure 4. Green Ring of Phoenix City

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References

Administration of Guangming. (2015). Document for Guangming Green Ring Design Competition.

Che, W., Liu, Y., Li, J. (2003). Urban Rainwater and its Pollution Control. *Water & Wastewater Engineering,* 29(10), 38-42.

EPA. (2000). *Low Impact Development (LID): A Literature Review.*

Fábos, J.G. (2004). Greenway Planning in the United States: Its Origins and Recent Case Studies, *Landscape and Urban Planning,* (68), 321–342.

Fu, F. & Zhao, C. (2010). The Drying Betting and Rethinking of Fengshui. *Chinese Landscape Architecture*, 26(5):80-82.

Li, J., Che, W., Meng, G., et al. (2001). Design and Techno-Economical Analysis on Urban Rain Water Utilization. *Water & Wastewater Engineering*, (12), 25-28.

MOHURD. (2014). *Technical Guide of Sponge City: Construction of Low Impact Development Stormwater System*.

Peng, C., Zhang, C., Gu, C. (2015). Response to Megalopolis' Comprehensive City Planning for a " Sponge City". *South Architecture*, (3), 48-53.

Qiu,B. (2015). Connotation, Approaches and Prospect of LID. *Modern City*, (4), 11-18.

Tong, H., Wang, J., Che,W., et al. (2015). The Methodological Discussion on Urban Planning on the Concept of Sponge City. *South Architecture*, (4), 108-114.

Wang, P. & Zhang,Y. (2006). Utilization of Rainfall Resources in Urban Green Space. *Chinese Landscape Architecture*, (2),75-81.

Wang, S., Cheng, H., Wang, J., et al. (2014). Summary of Technical Guideline for Decentralized Stormwater Management System in Jiaxing City. *China Water & Wastewater*, 30(21), 139-142.

Wang, E., Li, J., Wang, W. (2016). The Analysis of Sponge City Construction Technology Facilities And Products Selection. Construction Science and Technology, (1), 19-21.

Yang, D.& Liu, H.(2014). Research on Spatial Planning Strategy for Flood Control System in Fuzhou. *City Planning Review*, 38(8): 85-90.

Yang,Y.& Lin,G. (2015). A Review on Sponge City. *South Architecture*, (3), 59-64.

Yu, K. & Zhang, L. (2007). Ecological Infrastructure as Unbuildable Zone and Urban Green Space System: A Case Study of Heze. *City Planning Review*, 31(12): 89-92.

Yu, K., Li, D., Yuan, H., et al. (2015). "Sponge City": Theory and Practice. *City Planning Review*, 39(6), 26-36.

Zhang, J. & Yan,Y. (1996). Several Measures of City Flood Control. *Economic Vision*, (12), 46-46.

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