Section 4

Notable Technical Cases

Chapter 13

The success story of multi-purpose rainwater management system at Star City, Korea: Design, climate change adaptation potential and philosophy

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13.1 INTRODUCTION

Rainfall extremes such as floods and droughts are becoming more frequent or severe in many parts of the world due to climate change. As an adaptation strategy for coping with climate change, an ancient concept of rainwater harvesting and management is being revisited.

Star City, located in the north-eastern part of Seoul, near the Han River, South Korea is a major commercial/residential complex with four tall buildings, each having between 35 and 57 stories with more than 1300 apartments (Figure 13.1). The catchment area comprises 6200 m^2 of four rooftop areas and 45,000 m^2 of terraces and gardens throughout the complex. The Star City rainwater management system (RWMS) has been operating since 2007 until now (2019) and is receiving worldwide attention as a model water management system that supplements the existing centralized water infrastructure as a Climate Change Adaptation (CCA) strategy for floods and droughts (International Water Association [IWA], 2008) and as a model for water management regulation enforcement.

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Figure 13.1 Location of star city in Korea. (*Source*: Author's own).

Han and Nguyen (2018) emphasized that the special features of Star City RWMS are: (1) the concept of multi-purpose systém; (2) the proactive management of flooding; and (3) the city government incentive program.

In this chapter, the design and operational details are briefly reported. The potential for climate change adaptation for flood mitigation is presented quantitatively. The philosophical meaning in water management will be addressed. And lessons learned from this project will be discussed for further promotion of RWHM.

13.2 DESIGN AND OPERATION OF STAR CITY RWHM

The design and operation data of Star City RWHM has been reported in many publications (Han & Mun, 2011; Han & Nguyen, 2018).

13.2.1 Design

Figure 13.2 is a schematic diagram of the Star City RWHS. A total of 3000 m^3 of water is stored in three separate tanks. The capacity of each tank is 1000 m^3 with the mission of flood mitigation, water saving and emergency supply.

The rainwater collected from these areas is piped to two separate water tanks located in one of the basement floors under Building B which is 35-storey apartment, which has a floor area of 1500 m^2. By making 2 m water depth, a total water storage of 3000 m^3 can be made. The rainfall runoff from the ground is routed to the first tank and the rainwater collected from the rooftops goes into the second tank. A course screen is used for pre-treatment, while within the tanks a J shaped calm inlet prevents resuspension of bottom sludge. Each tank is designed

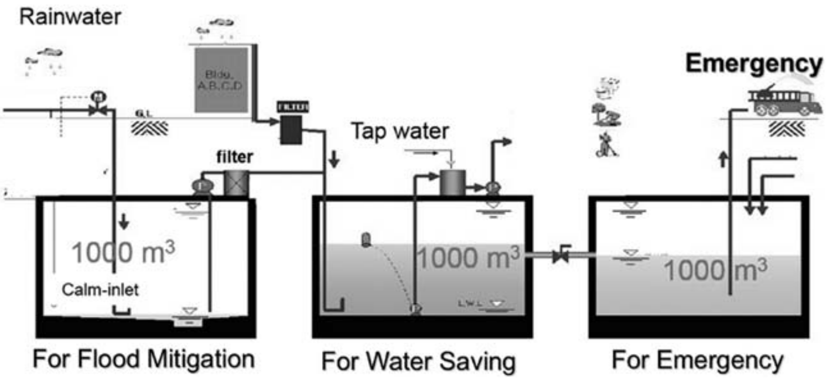

Figure 13.2 Schematic diagram of star city RWHM. (*Source*: Author's own).

to work as a plug flow reactor by installing baffles along the direction of flow, which can enhance the capacity of sedimentation. The water stored in the second tank (for water conservation, 1000 m^3) is used for irrigating the greened areas, flushing public toilets in the complex, and cleaning of roads and facilities. Garden irrigation is achieved efficiently by letting the overflow to the gutters connected to the second tank. When extreme rainfall is expected such as typhoon, the first tank (for flooding mitigation) will be emptied in advance before one day of arrival of typhoon to avoid the flooding. At this time, the sewer nearby can handle such a flow, because it is before the heavy rain arrives. It is designed to store the first 100 mm rainfall onto this site. The third tank (for emergency, 1000 m^3) is designed to store water for emergency at all times. It can be used as fire-fighting water or for emergency drinking and non-drinking water when the water supply is interrupted by any reason. Fresh tap water is maintained by regular replenishment of tap water after decanting half of the old water to the rainwater tank.

13.2.2 Operation data (Han & Nguyen, 2018)

13.2.2.1 Water quality

The pH of rainwater stored in the tanks is in the range of 6.2–8.5. The turbidity at the point of use is below 1.5 NTU due to the enhanced sedimentation in the plug flow type tank design and long detention time. There are no chemical parameters of concern because of the short mileage feature of rainwater. The water quality is good for irrigation and for toilet flush and cleaning without further treatment. During an emergency, it can be used for drinking by simple treatment facilities.

13.2.2.2 Water quantity

Water quantity can be normalized by using RUR (Rainwater Utilization Ratio) which is the ratio of the amount of rainwater utilized to the total annual rainfall fallen at the site. In most of the traditional design of land development, because the rainwater is designed to be drained, the RUR is near zero. However, based on the operating data for the first year, the volume of water that is saved is 26,000 m^3/year which is equivalent to RUR of 47%. By careful design and operation, higher RUR could have been achieved.

13.3 CLIMATE CHANGE ADAPTATION POTENTIAL

The flooding mitigation potential of Star City RWHM can be simulated by R-S-D model, by inputting the design rainfall and catchment area and the tank volume. In this case, the Tank volume/Catchment area is 5.8 m^2/100 m^3. The flooding mitigation potential is easily simulated by the method described in Han and Nguyen (2018) as in Figure 13.3. A 100-year frequency peak runoff when there is no storage tank of 26 m^3/h (point A) can be reduced to 18 m^3/h thanks to this rainwater tank (Point B). The peak runoff of 18 m^3/h indicates a 10-year frequency peak runoff (Point C). This means the downstream sewer which is designed for 10-year return period can be safe for a heavier rainfall of 100-year return period without increasing the sewer capacity. As such, the nearby area of Star City which was notorious as a flood prone area has not experienced flooding for last 15 years since the rainwater system was installed.

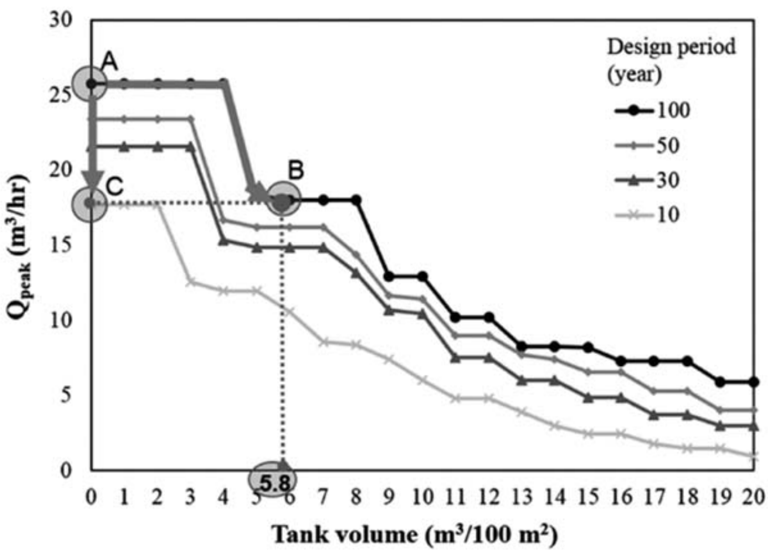

Figure 13.3 TP (Tank volume – Peak runoff) curves for R-S-D system using different design return period (using Seoul rainfall data and Huff method, normalized for 100 m^2 catchment area). (*Source*: Author's own).

13.4 PHILOSOPICAL CONSIDERATION OF STAR CITY

13.4.1 Win-Win process

The initial motivation of the Star City Rainwater System was for flood mitigation. Because the Star City site used to be a flood-prone area, the local government was afraid of further flooding risk after the development. They agreed with the construction company to build a rainwater system by giving financial incentive to allow building of 3% more floor area. After this successful demonstration project, Seoul city passed a regulation that can provide financial incentives when a developer makea a well-designed rainwater system. This Win-Win process made both public officials and developers happy. The tank design is also based on a proces to keep everybody happy. Among the three tanks of 1000 m^3 each, the first flood mitigation tank is for the benefit of downstream people, the second water conservation tank is for the benefit of residents, and the third emergency tank is made for the safety of all the nearby neighbors, which made everybody happy. This idea of everybody happy is based on the Korean 'Hong-ik-in-gan' Philosophy, which means 'make every party beneficial'.

13.4.2 Philosophy of 'Dong' (Village)

In Korea, each small village name ends up with Dong, such as Myoung-Dong and Insa-Dong, which has a special meaning for rainwater management. Star City RWHM adapted the concept of Korean 'Dong' philosophy. It means that water status should be the same before and after development using decentralized rainwater management (Figure 13.4). This is similar to the current rainwater regulations of advanced countries. For example, in Germany, they have a law to charge the sewer fee by the amount of increased runoff (2~3 Euro/m^2) after development. Or they are exempt the sewer fee when the owner makes a

Figure 13.4 'Dong' philosophy for rainwater.

rainwater harvesting facility to cover the increased runoff. This is exactly the same as the Dong concept.

13.4.3 Five Commandments for water management

Han and Nguyen (2018) suggested the five commandments of water management which should be consider in urban water management. The star city can be a model for exactly following the rule.

Rain is money – Because the resident use rainwater to maintain their nice landscaping, the residents are enjoying a very cheap maintenance cost for the water usage in common area. According to the yearly bill for apartment, the water fee for the common use such as irrigation, cleaning and public toilet is only 20~50 cents per month for an apartment since the start of the Star City Complex in 2007. Therefore all the residents believes that the rainwater is money.

Distribute and manage rainwater – Star City site was formerly a baseball play ground of Konkuk University and used to be a flood-prone area. However, after the Star city rainwater management was constructed, there have been no flooding event for more than 15 years. Most of the rainwater that falls at the Star City site is not discharged to nearby sewer until the first 100 mm rainfall. So the rainwater at Star City can be managed easily.

Collect rainwater upstream on a small scale – The rainwater once it has fallen flows downstream by gravity. Because Star City collects rainwater at the point it falls, it is collecting rainwater at the furthest upstream point of the sewer systém and because it is not combined with other flow, the scale can be small.

Make it multi-purpose – Star City RWHM divided the rainwater tank into three tanks, with the missions of flood mitigation, water conservation and emergency. Sometimes, RWH system is thought not to be economically feasible because the water fee saved by rainwater is not very much. However, if it is designed for multiple benefits, the RWH system can be made economically viable and can make the society more resilient to climate change and social and natural accidents.

Social responsibility of rainwater management – It is logical for the developer to take responsibility for extra runoff created due to land development. In the Star City design, any rainwater up to 100 mm from a rainfall event that fell inside the site was collected and used as the responsibility of the building developer. The local government compensated the extra money for construction by providing some financial incentives. This is similar to the case in German law regarding charging a sewer fee based on increased runoff by development.

13.5 CONCLUSION

The Star City RWMS, even after 12 years operation, is working perfectly according to the design objective without any problem. The water fee for the common area usage is less than half a dollar per month per family. In the downstream neighbourhood which used to be a flood-prone area, there have been no flooding events reported. The emergency tank has never been used since the start of operations because there have been no accidental events to use it, however, it can still reduce the risk of accidents such as fire or sudden failure of water supply. The philosophy embedded in the design and operation of Star City RWMS stems from the Korean Philosophy of 'Hong-iK-in-gan', which is to make everybody happy. Based on this Win-Win system of offering financial incentives, more than 70 local governments in Korea have already made city ordinances to give financial incentives for RWHM systems. A new national ordinance is proposed to enforce the RWHM in Korea.

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