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ANALYSIS ON RUNOFF CHARACTERISTICS OF DECENTRALIZED RAINWATER MANAGEMENT SYSTEM USING XP-SWMM SIMULATION

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In recent years, impervious areas are increasing in residential zone as well as unsettled area with rapid urbanization and land use. Consequently, this phenomenon influences weak urban environmental compositions about climate change including urban flooding accidents. Therefore, a new paradigm on rainwater management is needed for sound and sustainable restoration of hydrological circulation. Recently, a novel rainwater management system has been developed and recommended for irrigation and flood control in Korea. Especially, P city is now planning a new rainwater management system adopting LID (Low Impact Development) techniques on a small scale development area. In this study, XP-SWMM was used to simulate effects on runoff characteristics by installation of 8 kinds of rainwater management facilities on small scale development area (4.2 ha) of P city in Korea. Also, flood control safety analysis under the condition of localized torrential downpour event was carried out and effects of rainwater recycling facility was evaluated to measure annual water resource amount and water cost reduction. Peak rate runoff was reduced 11.8% and 36.4% in restrict A and B, respectively. Total amount of annual water source substitution was estimated 3,000 ㎥/yr with LID adoption in land use planning.

Introduction

Artificial development without considering rainwater management distorts the water cycle and causes water-related problems such as flood, drought, and water shortage. Even though people suffer from repeated natural disasters every year, they have stuck to existing water management methods and have taken passive actions such as locking the stable door after the horse is stolen. As a result, damages caused by the change in ecosystems due to water cycle distortions have come back to haunt people. People need to take responsibility for such destructions of nature and have a duty to pass on a better-preserved environment to the next generation. Accordingly, in order to restore the natural state of the water cycle, multipurpose dispersal rainwater management must be conducted at all locations, which are or will be under development. With this responsibility in mind, POSCO E&C planned and designed a WTP (Water Treatment Plant) to which the LID (Low Impact Development) concept was applied for the first time in Korea. It applied a DRM (Decentralized Rainwater Management) method based on the concept "encounter of rainwater, which is the most clean water source, and WTP," and has made efforts to pass on a better preserved natural environment to the next generation with the aim of maintaining the state of water in developed areas at the same condition as that before development began.

In this study, development area in P city as a research area to study using a XP-SWMM 1) the impact on the peak runoff reduction for the decentralized rainwater management, and 2) the effect on reduction of service water cost and energy costs for installing eight types rainwater facility.

Materials and Methods

The site where the 90,000-ton water treatment plant will be built is an undeveloped small mountainous area of 10 ha. Accordingly, it was expected that discharge would increase because of development, and thus certain solutions were needed to reduce the possibility of floods which could damage houses in the downstream region of the mountainous area. Therefore, the LID techniques which applied DRM method were performed with the aim of restoring the water cycle system and to obtain zero discharge in all regions under development. By installing eight types of rainwater facilities including rainwater ponds, rainwater detention facilities, and green roof systems at this water treatment plant site, decentralized rainwater management was installed to fit regional characteristics (fig. 1.).

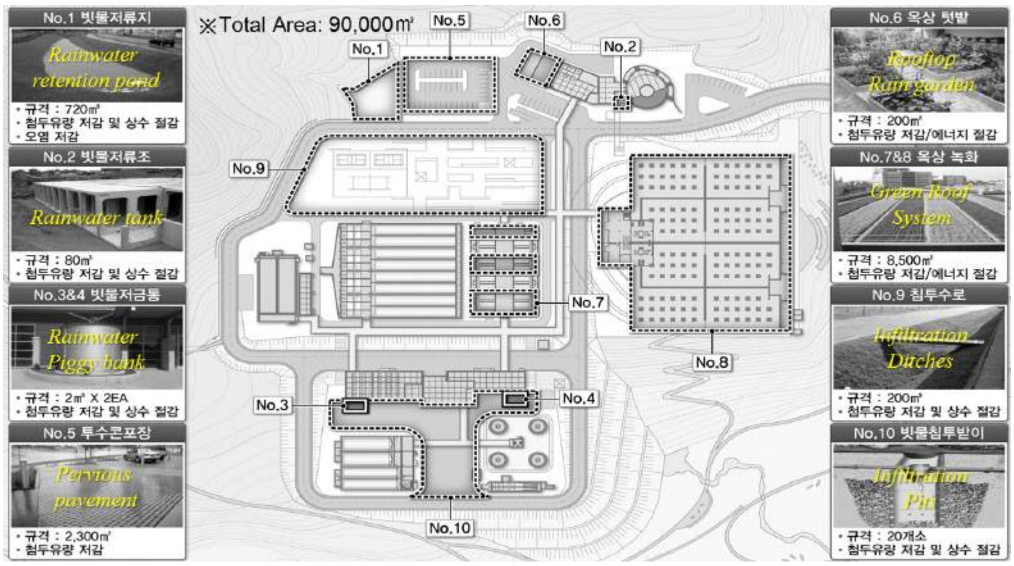


Figure 1. Installation map of 8 types rainwater facilities

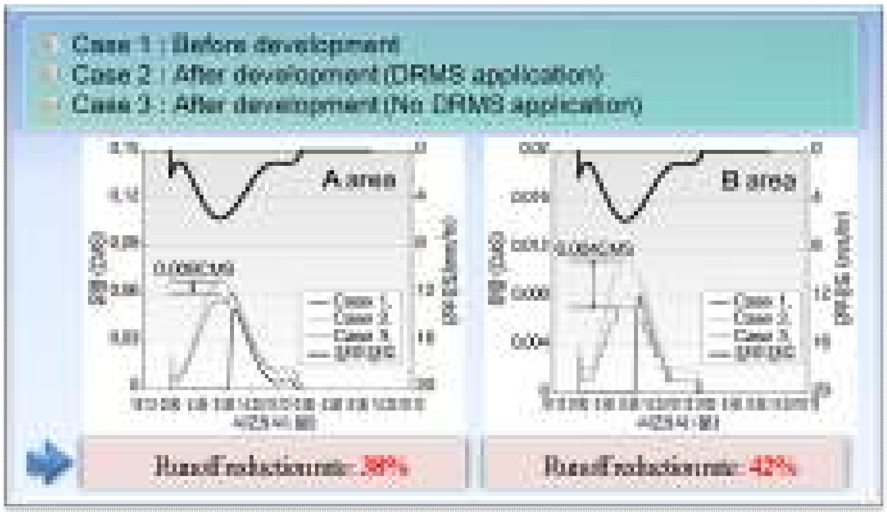
The initial discharge was controlled by placing a 720 m^2 rainwater detention area in the upper region of a mountainous area. One rainwater detention facility of 80 tons and two rainwater piggy banks of two tons were installed in order for it to be possible to use the rainwater for various purposes, and also to be able to replace the service water with the rainwater. In addition, a 200 m^2 roof garden was built at a management building to conserve energy through the cooling effect. Furthermore, across all the available sites, pervious pavements of 2,300 m^2, green roof systems of 8,500 m^2, rainwater collectors of 200 tons, and

20 rainwater penetration receivers were installed at many locations, in order to achieve the target reduction of discharge. Above all, by using a large detention area of 1,000 tons in the downstream region of the mountainous area, the discharge remained after the retention, penetration and evaporation were controlled, and thus we were able to achieve zero discharge.

Results and discussion

By applying the NID, the cleanest rainwater in the world was encountered with WTP for the first time in Korea, and through about a 40% discharge reduction, the possibility of a flood in the downstream region decreased (fig.2).

Figure 2. The effect on runoff reduction for DRMS application



In addition, the economic effects, such as the reduction of 2,700 USD/year in the service water cost and the reduction in energy costs through the cooling effect of the green roof system, were calculated.

Figure 3. The effect on cost saving of water and energy

Conclusions

As a result, flood control safety analysis under the condition of localized torrential downpour event was carried out and effects of rainwater recycling facility was evaluated to measure annual water resource amount and water cost reduction. Peak rate runoff was reduced 11.8% and 36.4% in restrict A and B, respectively. Total amount of annual water source substitution was estimated 3,000 ㎥/yr with LID adoption in land use planning.

In this project, we proposed detailed design methods using the LID technique in order to enable the DRM method to work, and demonstrated various effects caused by this. We also lowered the risk of flood damage at the downstream area of the developed region through the reduction of discharge, as well as reduced service water costs by utilizing rainwater for various purposes, and drew great appreciation from residents for economic effects such as energy efficiency improvements through the cooling effect of the green roof system. This project is a model design case for disposal rainwater management with great value, and customized applications are available for the design of smaller areas under development.

Acknowledgments

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