Advanced Science and Technology Letters
Vol.136 (ITCS 2016), pp.14-17
http://dx.doi.org/10.14257/astl.2016.136.04

The Analysis of Stormwater Runoff Quality and Quantity of Water Cycle Sidewalk using Low Impact Development Technologies

Daehee Lee[1], Jung-hun Lee[2] and Reeho Kim[1,2,*]

[1]Construction Environmental Engineering,
Korea Institute of Civil Engineering and Building Technology Campus,
University of Science and Technology,
283, Goyangdae-ro, Ilsanseo-gu, Goyang-si, Gyeonggi-do, Republic of Korea
[2]Environmental & Plant Engineering Research Institute,
Korea Institute of Civil Engineering and Building Technology,
283, Goyangdae-ro, Ilsanseo-gu, Goyang-si, Gyeonggi-do, Republic of Korea
daehee1212@ust.ac.kr, junghun3@kict.re.kr, rhkim@kict.re.kr
* Corresponding author

Abstract. The purpose of this study is to analyze effects of stormwater runoff and water quality management in connection with various Low Impact Development (LID) facilities within urban area. For this study, the Water Cycle Sidewalk (WCS) was applied to overcome the limitations of LID facilities and manage stormwater runoff and water quality in the area near green area-sidewalk-road. As a part of WCS, a permeable block pavement (BPB) was installed on the sidewalk, and a vertical infiltration pipe (VIP) and an infiltration-storage tank were located underneath the surface. Runoff on the sidewalk was pre-treated through a first flash treatment facility and then stored in a storage tank to be used or landscape management on the green area. The overall efficiency rate of runoff reduction was between 50% and 70%. In addition, the treatment efficient of the first flash treatment facility found to be 25%-59%.

Keywords: Water Cycle Sidewalk (WCS), permeable block pavement (BPB), vertical infiltration pipe (VIP), Infiltration Storage Tank, Stormwater Runoff

1 Introduction

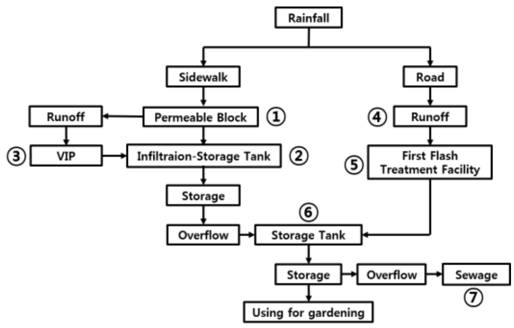
There are various types of Low Impact Development (LID) element technology that can be applied to urban area according to land use characteristics. However, LID facilities can have its limitations and problems depending on the land use types and the purpose of use. Permeable pavements are sometimes difficult to maintain due to a durability issue while general roads cause a large amount of polluted runoff [1][2]. In an area with plenty of artificial or clayish grounds, infiltration by using permeable paving can be ineffective. And, since the soil erosion of a green area which can cause the clogging of a permeable block, it is needed to come up with a measure to maintain the infiltration efficiency of permeable blocks connected to a green area [3][4]. As previously explained above, the different spatial characteristics can cause different problems in applying the LID technology. Therefore, in order to resolve the problems

ISSN: 2287-1233 ASTL

that can occur depending on the space form of the green area-sidewalk-road, a design that can connect LID facilities with different functions is required. In this regard, this study adopted the WCS that can manage stormwater runoff and water quality in a space where a green area, a sidewalk and a road are interconnected, by designing a sidewalk with multiple LID element technologies applied. Besides, this study intends to evaluate stormwater runoff and water quality management capacities on the sidewalk and the road by using a complicated scenario where several elements are considered such as preventing mudslides on the green area, managing runoff after the clogging of permeable blocks, securing space for a storage tank in a hard-to-infiltrating artificial ground, managing the road surface runoff and nonpoint pollution sources and utilizing water resources.

2 Materials & Method

The concept and the design of the WCS are indicated in Figure 1. The technology consists of a BPB, an infiltration-storage tank, a VIP, a soil erosion protector, a first flash treatment facility, a storage tank, and a rainwater use device. Rainwater on the sidewalk is infiltrated into soil through the BPB. As soon as the soil layer is saturated, the rainwater is stored in the infiltration-storage tank installed under the sidewalk. When the amount of the rainwater stored in the infiltration-storage tank and exceeded a certain level, it will overflow to the rainwater storage tank. The VIP accelerates the infiltration of surface runoff that is generated during rainfall above the level of the infiltration capacity of the permeable block. The soil erosion protector is capable of preventing the soil of the green area from being spilt. Stormwater runoff generated from the road surface is collected through the drain and then goes into the storage tank via the first flash treatment facility. The stored water in the tank can be used as water for landscape of the green area after the rainfall stops. When the level of the stored water reaches a certain level, the stored water overflows to the storm sewer.



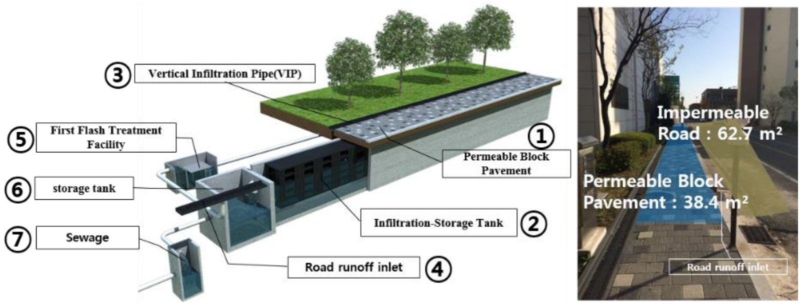


Fig. 1. Overview of Water Cycle Sidewalk (WCS)

This study analyzed elements such as the capacity to infiltrate into permeable blocks and VIPs and road runoff pick-up in order to evaluate the management of stormwater runoff and water quality for the mentioned facilities. The infilration capacity testing for permeable blocks, in particular, was conducted in a section with a storage tank installed underground and a section without the facility in a separate manner. Based on these, the stormwater runoff management ability in a comprehensive scenario was appraised. Also, rainwater quality before and after an initial rainwater treatment facility was analyzed to evaluate treatment efficiency.

3 Results

While the average infiltration capacity of a general BPB without a storage tank under the BPB was recorded at 0.23 mm/s, that of a BPB with a storage tank under the BPB was registered at 0.34 mm/s. The infiltration capacity of a single VIP was approximately 0.36 mm/s. In rainfall events, the overall runoff reduction efficiency on the sidewalk and the road ranged from 50% to 70%. The quality of runoffs and the stored water before they were treated in the first flash treatment facility was also analyzed. The analysis showed that the first flash treatment facility had 25-59% of treatment efficiency rate for water quality management ability indicators such as turbidity, color, total colonies general bacteria and total coliform.

4 Conclusion

In the complicated scenario for the WCS, the stormwater management function of the system is deemed to be effective with 50-70% of runoff reduction efficiency. In addition, the infiltration capacity of a section with a storage tank under the BPB was 1.5 times higher than that of a general BPB. Based on these results, it was found out that the active utilization of space under a road on a hard-to-infiltrating ground can contribute to the increase of the infiltration capacity of permeable blocks. Moreover, a proper combination between a VIP and a BPB will likely allow the space-efficient management of stormwater runoff in a road section. It was also verified that the quality of the stored water in the tank has no problem with being used for landscaping or road-cleaning. A further study leveraging the achievements of this study will be required in order to resolve problems such as urban drought and flooding through the stormwater runoff management of the WCS.

Acknowledgements. This research was supported by a grant (12technology innovationC04) from Advanced Water Management Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government.

References

1. Chen, Y., Wang, K., Wang, X., Zhou, W.: Strength, fracture and fatigue of pervious concrete. J. Construction and Building Materials. 42, 97--104 (2013)
2. Gilbert, J. K., Clausen, J. C.: Stormwater runoff quality and quantity from asphalt, paver, and crushed stone driveways in Connecticut. J. Water Research. 40, 826--832 (2006)
3. Nichols, P.W.B., White, R., Lucke, T.: Do sediment type and test durations affect results of laboratory-based, accelerated testing studies of permeable pavement clogging?. J. Science of the Total Environment. 511, 786--791 (2015)
4. Winton, R.J., Al-Rubaei, A.M., Blecken, G.T., Viklander, M., Hunt, W.F.: Maintenance measures for preservation and recovery of permeable pavement surface infiltration rate – The effects of street sweeping, Vacuum cleaning, high pressure washing, and milling. J. Journal of Environment Management. 169, 132--144 (2016)

