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A Novel Buffer Tank to Attenuate the Peak Flow of Runoff

Yinghong Qin [a, b*], Zhengce Huang [c], Zebin Yu [b, c], Zhikui Liu [a], Lei Wang [a]

[a] College of Civil and Architecture Engineering, Guilin University of Technology, 541004, Guilin, China.

[b] College of Civil Engineering and Architecture, Guangxi University, 100 University Road, Nanning, Guangxi 530004, China.

[c] Hualan Design & Consulting Group, Nanning, Guangxi Province, 530004, China.

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Abstract

Impermeable pavements and roofs in urban areas convert most rainfall to runoff, which is commonly discharged to local sewers pipes and finally to the nearby streams and rivers. In case of heavy rain, the peak flow of runoff usually exceeds the carrying capacity of the local sewer pipes, leading to urban flooding. Traditional facilities, such as green roofs, permeable pavements, soakaways, rainwater tanks, rain barrels, and others reduce the runoff volume in case of a small rain but fail in case of a heavy rain. Here we propose a novel rainwater buffer tank to detain runoff from the nearby sealed surfaces in case of heavy rain and then to discharge rainwater from an orifice at the tank's bottom. We found that considering a 100 m^2 rooftop with 0.80 runoff coefficient and a 10cm rainfall depth for an hour, a cubic tank with internal edge side of a square of 2 m attenuates the peak flow about 45%. To reduce a desirable peak flow, the outlet orifice of the buffer tank must be optimized according to site-specific conditions. The orifice can be set at an elevation from the tank's bottom to create a dead storage for harvesting rainwater.

Keywords: Urban Flooding; Runoff; Rainwater Tank; Rainwater Management; Peak Flow.

1. Introduction

Urbanization has sealed natural permeable surfaces with pavements, roofs, and other impermeable surfaces. Rainwater falling on these surfaces generates runoff, which is diverted to local sewer pipes and finally ends up at nearby streams or rivers. In the case of a heavy rain, the runoff-discharging rate commonly exceeds the carrying capacity of the sewer pipes, resulting in urban flooding. Urban flooding subsequently causes a series of serious negative consequences such as traffic jams, loss of human life, damage to property, loss of livestock, and deterioration of health conditions owing to waterborne diseases, and others [1]. Across the globe, rainwater management techniques have widely employed to mitigate urban flooding. Mainstream techniques include Low Impact Development [2], Best Management Practices [3], Water Sensitive Urban Design [4], Sponge Cities [5], and other similar projects [6-8]. While their names of these projects are different, the purposes of these techniques are similar. That is, on-source techniques are developed to retain, detain, infiltrate, harvest, evaporate, transpire, and/or re-use rainwater for reducing the runoff volume and the peak flow.

The specific rainwater management techniques include green roofs, permeable pavements, bio-retentions, soakaways, rainwater tanks, rainwater barrels, and others. A green roof consists of a vegetated layer and a growing medium layer above a roof deck, over which both layers cannot further retain rainwater after they get saturated [9]. Green roofs therefore effectively reduce the runoff volume and the peak flow in case of a small rain but fail in case of a

* Corresponding author: yqin1@mtu.edu

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