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Research paper

Performance of cylindrical detention pond (CDP) as depression storage under fully saturated condition

H. Maseri [1] *, O. S. Selaman [1], M. A. Mannan [1], SNL. Taib [1]

[1] Department of Civil Engineering, Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS), 94300 Kota Samarahan Sarawak
**Corresponding author E-mail: mhisyam@hotmail.com*

Abstract

Permeable pavements are a key Storm water management measure employed both to attenuate surface runoff in urban areas and to filter urban storm water pollutants. Existing permeable pavements (PP) are design with the specific percentage porosity whereby enabling excess rainwater to infiltrate through the system and acting as a depression storage at the same time. Depression storage basically refers to the volume of water trapped in the depression when the precipitation of a storm reaches the ground and filled up all the depression before it can flow over the surface. Cylindrical Detention Pond (CDP) is an alternative paving material that may alleviate many of the hydrological problems caused by urban runoff from developed areas. CDP consist of three basic component; top cover, bottom cover and hollow cylindrical at centre (300mm thickness). The hollow cylindrical has approximate 50 percent porosity from the total solid of component, which is every 1 inch (25 mm) of pavement depth can hold 0.5 inches (12.5 mm) of rain in theoretical. In this study, the depression storage rate of CDP was investigated under three different rainfall intensity scenarios which are 77mm/hr (low), 153mm/hr (medium), and 230mm/hr (heavy) respectively whereby it function to monitoring the analytical trend line. The experiment was conducted in model box in the laboratory under fully saturated condition. It found that the CDP can perform to detent the water until 180 min of excess rainfall for all 2 year ARI, 5 year ARI, 10 year ARI, 20 year ARI, 50 year ARI and 100 year ARI with different rates. The result was proved the hollow cylindrical at centre of CDP very effective in runoff volume reduction according to the different ARI trend line projection.

Keywords: *Depression Storage; Cylindrical Detention Pond; Permeable Pavement; Storm Water Management; Fully Saturated.*

1. Introduction

In recent years, rapid urbanization changes the land use by removes vegetation, green cover and replaces pervious area with increases in impervious surface with proximity to premix roads and concrete [1]. Since 1970's, the total population were urban dwellers increases to 30 percent and even more surprisingly in a year 1991, the urbanization had increase the population up to 50 percent and even keep on increasingly from year to year until now. Urban developments will also increase to meet the need of these increasing urban populations. Therefore, the impact of development has become one of the major causes that lead to flooding and the natural hydrologic cycle is disturbed where infiltration rate and ground water recharges decreases, changes imposing high peak flows pattern of surface and river runoff volume increases [1 - 3].
Moreover, not surprisingly rate of flash flood in urban area in Malaysia in generally is expansion severe from year to year. Many urban cities have also increased the speed of overland flow and the amount of runoff because gray infrastructure has been designed to move water off streets as quickly as possible through gutters, storm drains, sewer pipes and other engineered collection systems and is discharged into nearby water bodies. Previously in Sarawak, a conventional drainage system has been designed to provide the fastest possible transport of storm water runoff out of the catchment into the receiving water as an effective mitigation flash flood [4]. Unfortunately, due to rapid development and high rainfall intensities, conventional drainage system, has led to high potential occurrence of flash flood at the downstream of the catchments.
Therefore, permeable pavement (PP) is another alternative approach in stormwater management to replace the conventional impervious concrete and asphalt paver and purposely to prevent physical damage to persons and assets from flooding and to maintain the natural hydrologic cycle, reduce runoff volume, and to decrease peak flow pattern of surface [5]. Therefore, the Environmental Protection Agency (EPA) focuses in studies more specifically to determine the efficiencies of numerous types of PP's for urban runoff control in the early 1970s. Many researchers have reported that PP's performances show the decrease peaks flow rate and reduce runoff volume. According to the National Asphalt Pavement Association (NAPA), the concept of PP was suggested to allow percolation, reduce storm sewer loads, reduce floods, raise water tables, and replenish aquifers since the 20th century.
Permeable Pavement are widely suitable for a variety of residential, commercial and industrial applications [6], although it confine to light duty and infrequent usage, but the capabilities of these systems allocate for a large extent range of usage and one of the best alternatives used in stormwater management. Researcher was start to develop the new idea to produce the portable permeable pavement with the futuristic design, color, easy to install and user friendly. There are many variants for each of PP depending on the design goals such as permeable concrete (PC), permeable asphalt (PA), permeable interlocking concrete pavers (PICP), concrete grid pavers (CGP), and plastic grid pavers [4]. However, all the existing of PP is only to help rainfall water infiltrate into the subgrade but not design to store the rainfall water for temporary at the