Water Practice & Technology Vol 11 No 4
doi: 10.2166/wpt.2016.091

# Improving drowned drainage outlets with submerged orifices

Evon E. W. Tang*, Darrien Y. S. Mah and Onni Suhaiza Selaman

Department of Civil Engineering, Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS), Kota Samarahan, Sarawak 94300, Malaysia

*Corresponding author. E-mail: evontangeewen@gmail.com

## Abstract

Drowned outlets are common in riverine areas and sometimes unavoidable. Due to site restrictions, drainage discharge outlets are often submerged as the water level fluctuates during high tides or during the monsoon. As the runoff cannot be discharged through the outlet the drainage system fills up faster, leading to flash floods caused by overspill from the drains. This study is focused on the application of an on-site detention system with submerged orifice to improve the runoff delay from a drowned outlet. The application was investigated through a reduced-scale laboratory set up and then visualized with computational fluid dynamics simulations. The model was tested under different perpendicular flow velocities to analyze the workability and flow characteristics of the submerged orifice. The study showed that, with different headwater and tailwater levels, the energy level can be restored upstream of the orifice and ensure full flow of water from the submerged orifice even when hindered by perpendicular tailwater flow. Besides, the orifice jet's pattern changes with high velocity tailwater flow, although it does not slow down the discharge rate.

**Key words:** computational fluid dynamics (CFD), headwater, on-site detention (OSD), orifice jet, tailwater flow

## INTRODUCTION

When a drainage outlet is submerged (drowned), it reduces or can even overwhelm the energy of the run-off discharge. This results in reduced rate or zero discharge from the outlet. As the effective headwater/hydraulic grade line is reduced, the surface drainage system fills quickly (UPRCT 1999). If an overflow occurs, flash flooding will follow and could cause inconvenience or damage to property. Drowned outlets have thus been tagged as unfavorable and their avoidance in design is strongly advised. Unfortunately, drowned outlets are at times unavoidable, especially on restricted sites, e.g., beside a river, so outlet drowning requires a solution.

An orifice is an opening that enables a fluid to flow out. Its sizing is designed to limit flow discharge. According to Buchanan *et al.* (2013), an orifice is also a specific type of outlet that can transform potential (elevation head) to kinetic energy (velocity) by accelerating flow. Hence, orifice flow has low volume but produces high-velocity discharge. A submerged orifice discharges under water (Figure 1). Bos (1989) showed that the discharge flow from a submerged orifice can be expressed using Bernoulli's theorem – Equations (1) and (2). Assuming there is no energy loss over the submerged orifice, so the streamlines are straight and the velocity of flow in eddies above the jet is relatively low.

$$H_1 = \left(\frac{P}{\rho g} + z\right)_1 + \frac{v_1^2}{2g} = \left(\frac{P}{\rho g} + z\right)_c + \frac{v_c^2}{2g} \quad (1)$$