Simulation on Water Behavior in a Retention Pond at UNITEN

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Abstract. Retention pond have been used widely to manage stormwater runoff to avoid flooding and downstream erosion and even improve water quality. It is an artificial pond that have vegetation around the perimeter and a permanent pool of water. This paper presents the study on water flow behaviours in UNITEN’s retention pond by using ANSYS Fluent. Findings shows that the velocity of water in wet condition is higher than the dry condition because of an additional inlet in wet condition to imitate the heavy rainfall phenomenon. It is also found that the water pressure in wet condition is higher compare to dry condition. Therefore, the conditions that have a higher movement of water can be determined through this simulation. Based on the findings, it can be concluded that the wet condition have a high movement of water behaviour compare to dry condition.

1. Introduction

Detention pond is water runoff from streets and parking areas carry all pollutants such as dirt and oil from roadways and neighbourhood areas. Two situations would be involved in this pond which is wet and dry. Wet detention pond act to treat storm water runoff to prevent flash flood and protect streams and creeks while dry detention pond generally only hold water during a rainstorm and their main purpose is to prevent a flood. The primary function designation of detention pond is to estimate the pond’s normal detention volume and it is important to know the inflow hydrograph for the detention pond that may cause worst damage under the design standard [1]. The variables or parameters that need to be considered in designing detention pond are several pipes for the service outlet, the pond storage and the diameters of pipe [2]. However, the population equivalent or population capacity also becomes a main concern on constructing a detention pond in order to estimate the size and depth will be use.

Detention pond has become widely used around the world because it provides flow control through decreasing of stormwater runoff. Any wide range of rainfall events can be stored to avoid the neighbourhood or landscaped area from a flash flood, and it is simple to construct and design and easy to maintain. Involved pollutants by settling and elimination of suspended solids are needed to improve the stormwater quality for stormwater ponds to use expansively. However, this study is to know the water behaviour and sediments or particle flow of detention pond because there is no fluid particle movement investigation on that area which is in UNITEN. The methods presently used to determine sediments flow settling in stormwater ponds are not reasonable and are based on two methods which are the computational fluid dynamics (CFD) models and ideal settling tank concept [3, 4]. Water flow of sediments or particle modelling and water flow modelling that shows the simulations of the effects of...
solid particles on the sparkling behaviour in a liquid-solid flow system by applying this CFD method [5-10].

2. Methodology

Figure 1 show the flow chart of methodology:

![Flow chart of methodology](image)

**Figure 1.** Flow chart of methodology.

2.1. Data Collection

The water level of the pond is measured with two different conditions which are wet and dry. The wet condition occurs during heavy rain while the dry condition is during the normal day. The depth of the pond during wet and dry is 0.7m and 1.0m respectively. The area is measured using google earth to estimate the area or manually measured at site personally. The length of the pond is 548m while the total area is 0.836 m² or 8360 m². The diameter of the inlet and outlet also measured at site or detention pond.

2.2. Modelling Setup

From the top view, the calculated and measured detention pond length was 548 m by using Google Earth. There were 5 other minor inlets adding from wet condition pond. This was due when raining heavily the water flow through the drainage system entering detention pond. The flow stops during dry condition because heavy water raining will flow to drain that causing another inlet to put out their functions.
2.3. **Meshing**

Meshing generated for both models are shown as below:

3. **Results and discussion**

3.1. **Velocity contour**

Theoretically, the water behaviour can be affected by velocity of water. Whenever the water flows at high speed, turbulence will occur and there would be a high movement of water behaviour can be observed. Figure 4 shown a velocity contour for dry and wet conditions. Based on the figure, during dry condition it shown that the velocity of water is lower than the wet condition. The maximum velocity for dry condition can reach until 1.631e-2 m/s while wet condition can reach until 8.21e-2 m/s but both conditions still in steady state and in laminar flow range. The major different in maximum velocity for both conditions is because of an additional minor and major inlet in wet condition due to heavy rainfall. Based on the findings, the maximum velocity of minor and major inlet is 1.5m/s and 2.5m/s respectively and the minimum velocity for each inlet is 0.2m/s and 2m/s respectively.
3.2. **Velocity vector**

Figure 5 shows the velocity vector of dry and wet conditions. Based on the figure below, the lowest water flow for dry condition was 4.077e-2 m/s which was located at the middle of the pond heading towards the outlet while the maximum reading was 1.631e-1 m/s located at the border of the pond which heading to Inlet 2. There was 2 result that was ranged between (1.223e-1 to 1.631e-1) m/s and arrow for both direction orange in colour. One was lighter and opposite for the other arrow which was darker. As per calculated the velocity for both arrow 1.427e-1 m/s. While for wet conditions it shows that the direction of water velocity vector wet condition which very different from dry condition. The maximum value for velocity vector was 8.210e-1 m/s which was in front minor inlet 2 and the direction for the flow was heading towards major inlet 2 while for the minimum value was 6.158e-1 m/s. The result for minimum value like that due arrow which yellow in colour and located between minor inlet 1 and minor inlet 2 while the direction of the arrow heading towards minor inlet 1. There were 2 arrows facing in the same direction, one with orange in colour and the other one lighter orange. The velocity vector for both arrows was 7.184e-1 m/s.

**Figure 4.** Velocity contour: (a) dry condition and (b) wet condition.

**Figure 5.** Velocity vector: (a) dry condition and (b) wet condition.
3.3. Pressure contour

Figure below shows the pressure contour for dry and wet conditions. The pressure in dry conditions shows that at both inlet and some spot showed a light blue zone which could be referred from the graph at the side between (-1.212e+001 – 3.568e+001) Pa. But there was a spot where dark blue zone which the pressure between (-1.077e+002 to -5.992e+001) Pa very low. The result indicates that there was very low water pressure in that area because the water keeps the flow to the outlet. But the green zone area pressure in between (8.348e+001 – 1.791e+002) Pa, showed a little bit higher. This area was approaching the outlet so the colour contour was accepted because the water would flow in that part to reach the outlet. However, there were a small spot of the yellow zone and red zone ranged between (2.269e+002 – 3.703e+002) Pa at the end of the detention pond before reaching the outlet but there was no such situation happened around inlet 2. This could be proven the water flow from inlet 1 approaching wall at inlet 2 but there was also water flow at the water inlet 2 which avoiding the water from hitting the wall hard. Then all the water flows right into the outlet and before reaching it the water may be accumulated at that spot.

Figure 5. Pressure contour: (a) dry condition and (b) wet condition.

Figure 6(b) shows the pressure contour for wet condition. Wet condition has 5 minor inlets, 2 major outlets and an outlet. From the result above, the highest pressure was located at minor inlet 4 valued 6.762e3 Pa. This was due to water that flow in that area came from higher ground with high velocity down to the detention pond, which is only that spot was in the red zone. The lowest pressure for this condition was ranged between (-6.005e2 – 1.358e2) Pa which was located at the corner of the outlet. It is normal to have negative static pressure since the pressure energy gets converted into kinetic energy. After some distance, the pressure would be recovered and increased pressure but still, the result remains negative. The negative value was the difference between actual pressure and operating pressure. For light blue zone, the area was only spotted at 2 different location, one at the outlet and the other one was between minor inlet 1 and minor inlet 2. Blue zone only appears at the outlet which was (8.721e2 – 1.608e3) Pa, majorly blue area only seems to appear at the outlet. This happens because the water flow velocity decreasing from time to time as well as kinetic energy. Yellow spot only appears on minor inlet 1, 4 and 5 only. These were due to high water velocity coming from drainage area to the detention pond, while the other 2 water only flows from lower ground level from the other 3 minor inlet that was why the water flow from both inlets slow. The yellow zone pressure was ranged between (4.553e3 – 5.290e3) Pa. However, majorly water pressure contour for pond oscillated between (2.345e3 – 3.817e3) Pa which appears on the green zone as shown in the Figure 6(b).
4. **Conclusions**

Understanding the water behaviour of retention pond during dry and wet condition is necessary in order to come out with a better design for the pond in worst case. Therefore, a simulation on water behaviour in a retention pond is needed to visualize the water behaviour of the pond. The water behaviour has been simulated using ANSYS Fluent. Accordingly, the water velocity, velocity vector and water pressure can be obtained through this simulation. These three variables able to explain and elaborate more the behaviour of water in UNITEN’s retention pond. Based on the findings, it shows that wet condition has high movement of water behaviour compare to the dry condition. This phenomenon occurs because of an additional inlet for the wet condition during heavy rainfall. Water movement is a bit different due to everyday forecast. The water flow is affected by weather condition such as windy, sunny or even rainy day. These data will be helpful in improving the scheme of designing detention pond that can produce the optimum result.

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