C06

Analysis of Breach Characteristics and Equilibrium Scour Pattern for Overtopping Induced River Dyke Breach

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1. Introduction

Dykes are among the most ancient and widely used defense structures against river flooding in the world (Bhattarai et. al. 2014). In the context of this work, we refer to dykes as to man-made earthen embankments built along a river parallel to the river flow and flow strikes the dike length in an angle but not perpendicularly.

However, the construction of embankments has two main consequences on the flood risk: first, it increases the flooding hazard reducing the lateral flood storage area and hence the flow capacity of peak discharges attenuation; second, being the surrounding areas often urbanized, the amount of potential damages induced by flooding is dramatically increased. Therefore, although the probability of flooding may be lower because a dyke exists, the consequences to personal safety and property are much higher should a dyke overtop or fail. Flooding from embanked rivers may occur when the structural defense fails in containing the water flow inside the river banks.

(a) Asuwa River 2004 (b) Yabe River 2012

Photo 1 Embankment Breaches in Japan

In the context of breach modeling, flood embankment failure is considered to be the situation where erosion or structural failure of the earthen embankment cause flood water to pass over or through the embankment in an increasingly uncontrolled manner (Morris et. al. 2009), leading to a hole or breach in the dyke. Scouring may be defined as the removal of material around embankments caused by flow acceleration and turbulence near embankments. Scour has been the major concern for safety of marine and hydraulic structures. A large number of hydraulic structures failed as the local scour progresses which gradually undermines the foundations. It is important to control the local scour depth at downstream of hydraulic structures to ensure safety of these structures But, the study of scour pattern and depth is poorly understood if it comes in the case of dyke foundation and downstream. Considering these facts, an extensive experimental study were done in Ujigawa Open Laboratory to compare the breach characteristics (Lateral widening, flow and sediment hydrograph) and scour pattern for dyke with systematic variation of sediment sizes forming dyke materials.

2. Approach

The study is fully based on the Experiment and the setup is as shown in fig 1 as plan and section.

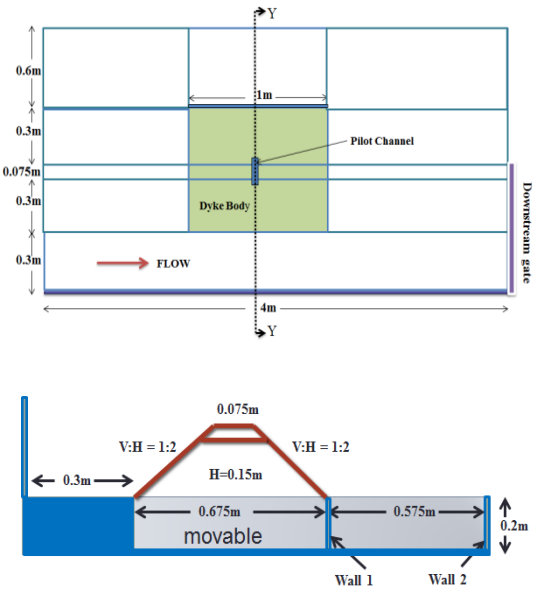

Fig. 1 Experimental Setup (Plan and Section along YY)

Nine experiments for the breach characteristic case and six experiments for the scour pattern case are performed. Currently only one scenario (considering dyke, foundation and downstream part movable) is considered for the scour case.

The wall 1 is placed and wall 2 is removed for the first case and vice versa for the scour case experiment. The sediments sizes used for variations are No. 6(mean diameter = 0.3144 mm), No.7(mean diameter = 0.1666 mm) and No.8 (mean diameter = 0.0891 mm).

3. Results and Analysis

The results obtained in this research are in two parts: First in terms of lateral widening speed and discharge and sediment hydrographs; second in terms of equilibrium scour pattern and discharge hydrograph. The sample results are shown in fig 2 below:

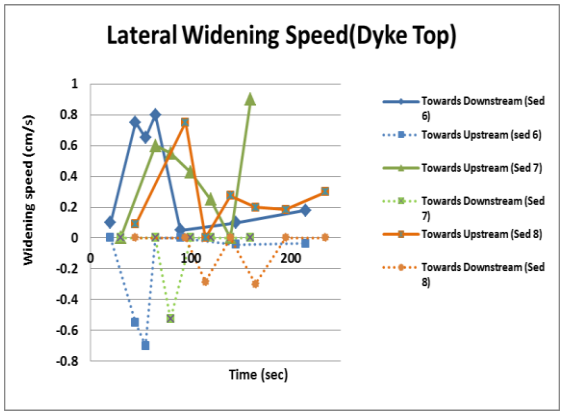

Fig. 2 Widening Speeds at Dyke Top for all sediments

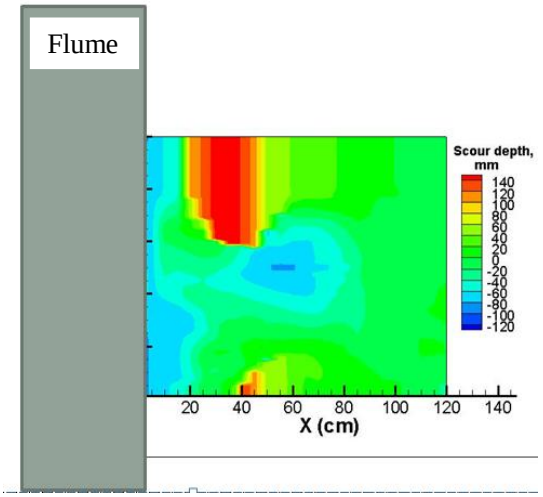

Fig. 3 Equilibrium Scour Pattern for Sed. 7 (scenario 1)

The results from the lateral widening speed curve show the asymmetrical widening of the dyke in comparison to dam bream analysis where flow direction is perpendicular to the embankment. For each sediment sizes i.e. sed 6, sed 7 and sed 8, the pattern is quite different and follows some trend. For the hydrograph case also, the peak discharge follows according to sediment sizes. High no. of sediment size (having smaller mean diameter) shows late peak attenuation and long time in comparison to sed 6 and sed 7. The sediment graphs have more than one peak which reveals that the vertical stable wall at the side of the channel collapses into the center of breach at different times.

The equilibrium scour pattern is developed for different scenarios: scenario1- considering dyke, foundation and downstream movable; scenario2- considering dyke and foundation movable but downstream fixed and scenario 3- considering dyke and foundation fixed but the downstream movable. The result shows higher scour depth for smaller size sediments than coarser one with changing locations.

4. Conclusion

The present experimental work investigated the lateral widening breach characteristics and Equilibrium scour pattern with different particle sizes due to overtopping. Each individual experiment result has its unique results in terms of lateral widening, hydrographs and equilibrium scour pattern. The scour pattern is also different for different particle sizes. The lower the mean diameter of the particles higher the scour depth. The location of the scour depth is also varied according to sediment sizes.

References

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