THEORITICAL AND EXPERIMENTAL STUDY OF THE DAM-BREAK WAVE TIP REGION

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INTRODUCTION

Dam-break flow has direct relationship with many coastal engineering problems, such as swash movement and tsunami event. Plenty of studies have been conducted on this topic. In terms of theoretical analysis, initiating from the classic Ritter's solution, various approaches have been applied, e.g., the method of characteristics, the perturbation method, and the parametric substitution. As for the physical test, significant improvement has been achieved with the development of measuring instruments. Nevertheless, clear understanding on the hydrodynamic features of the wave tip region, where the bottom resistance and flow viscosity play important roles, is still far beyond enough.

METHODOLOGY

In this study, flow features in the dam-break wave tip region were targeted. Wu et al. (1999) theoretically derived the shoreline moving velocity, the temporal water depth of dam-break wave over an initial wet downstream bed. Deng et al. (2018) theoretically presented the flow velocity and water depth variation in the wave tip region, together with other relevant factors, for an initially dry and frictional downstream bed condition. In addition, Liu and Liu (2017) performed detailed laboratory measurements using a horizontal PVC dam-break flume under both initially dry and wet bed conditions to measure the spatiotemporal characteristics of the dam-break flow. Here, comparison between these results was conducted to demonstrate the applicability of the theoretical models, and to reveal the physical insights of the flow characteristics in the dam-break wave tip region.

RESULTS AND DISCUSSIONS

Figure 1(a) shows the comparison of the temporal shoreline position over the dry and wet beds. The same initial water head of 16 cm is considered here. Ritter's result of shoreline position over frictionless dry bed is also included as a reference. Non-dimensional parameters are applied here, i.e., the shoreline position $x_s = x_s^*/H_0^*$ (x_s^* and H_0^* are the dimensional shoreline position and the initial upstream reservoir water depth) and the dimensionless time after gate releasing, $t = t^*\sqrt{(g/H_0^*)}$ (t^* is the dimensional time and g is the acceleration due to gravity).

In general, theoretical results are in good agreement with experimental measurements. Shoreline moving velocity decreases due to the effects of bottom friction or the existence of downstream water level; whereas Ritter's dry frictionless shoreline moving velocity keeps a constant value of 2. For the considered wet bed experiment setting, the non-dimensional shoreline moving velocity based on the theoretical analysis is 0.95, which is smaller than the velocity of the frictional dry bed case under the same initial water head setting. This is in consistent with the experimental measurements. Slightly over-/under-estimations are found for the frictional dry/ initially wet bed conditions.

Figure 1(b) shows comparison of the instantaneous water surface elevation over dry and wet bed conditions. The non-dimensional water depth $h = h^*/H_0^*$ and the flow velocity $u = x^*/(H_0^* t)$ are considered here. In general, the agreement between theory and experiment is good although significant bore breaking occurs in experiment which is not considered in the analytical derivation. For the frictional dry bed, the temporal wave front profile is retarded forming an upward convex shape, which however is tangent to the bottom bed in frictionless Ritter's solution. As for the wet bed condition, a progressing shock wave with a certain length is obtained in the analytical solution, which has a discontinuous front connecting with the downstream wet bed, and a continuous contact with the upstream water level. This is also observed in experiment.

REFERENCES

Deng, X., Liu, H., Lu, S. (2018). Analytical study of dam-break wave tip region. J. Hydraulic Eng., 144(5), 04018015.
Liu, H., Liu, H. (2017). Experimental study on the dam-break hydrodynamic characteristics under different conditions. J. Disaster Res., 12(1), 198-207.
Wu, C., et al. (1999). Theoretical solution of dam-break shock wave. J. Hydraulic Eng., 125(11), 1210-1215.

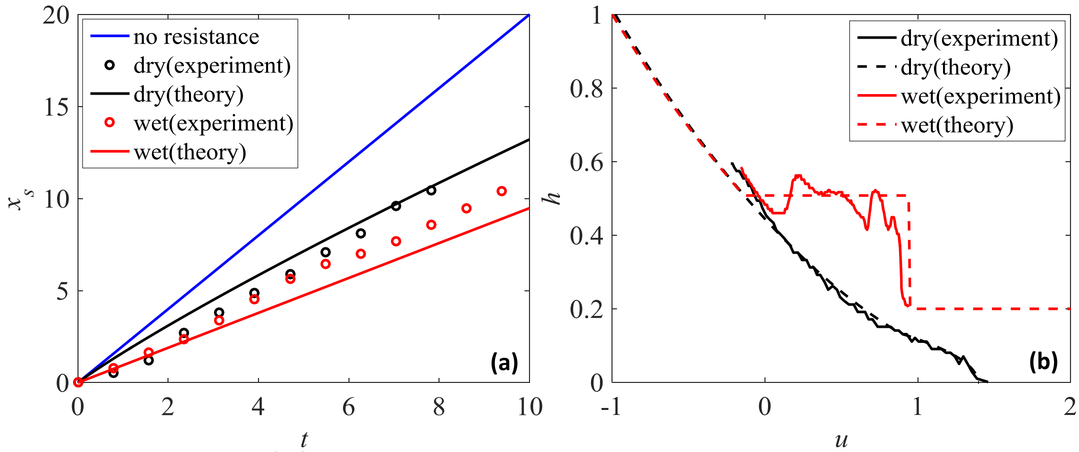

Figure 1. Comparison between experimental and theoretical results.