Erosion characteristics of bed composed of cohesive and non-cohesive material

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1. Introduction

In the bank of the natural river, some layers of the bank material are composed of both non-cohesive and cohesive material. The cohesive properties arise from electrochemical forces in the clay-water medium. These forces usually dominate and larger than the weight force of individual particles. Therefore, this will have a certain effect to erosion on river bed. Hence, in order to understand the channel and bed deformation phenomena, erosion rate of cohesive sediment has been investigated by many researchers.

Bed material in river is non-uniform sediment. And non-cohesive material and cohesive material coexist in rivers. For example, the coarse non-cohesive material in the Mekong River flows on the fine cohesive material in the Tonle Sap River during the flood season around Phnom Penh in Cambodia. This fact indicates that the cohesive material can be eroded by both non-cohesive material and water.

Laboratory and in situ experimental have been conducted by many researchers. However, suggested erosion rate equations of cohesive material in these studies are the erosion rate by water only.

In this study, the erosion characteristics of mixture material (non-cohesive and cohesive sediment) by both non-cohesive sediment and clear water are discussed. 14 flume tests are performed with bed composed by non-cohesive sediment only and the mixture of non-cohesive and cohesive sediment. Those data will be used to compare to find out the erosion characteristics of mixture material bed.

2. Erosion characteristics of mixture material bed caused by non-cohesive sediment transport

a. Experimental Apparatus

The flume with 800 cm long, 15 cm wide and 25 cm deep. Mean diameter of sediment feeding and sand material on bed is 0.324mm. Three types of bed material are used in the experiment: non-cohesive sediment only and the mixture of non-cohesive and cohesive sediment. There are 60% sand and 40% kaolin in the mixture bed. The bed material was laid on the bed with 700 cm long, 15 cm width and 5 cm thickness. The water content is 50%.

b. Measurement Method

In order to evaluate the bed elevation change on the surface of cohesive sediment, bed elevations before and after each experiment were measured at 105 points. An average value for each 100 measurement points is used to find down bed level changing and then will be used to compare with other cases. Measurement area is 400 cm^2. Water velocity were measured by manual at downstream of the flume.

c. Hydraulics Condition

The hydraulic conditions of the experiments are: slope is 0.004; Water discharge is around 1,031 l/s, Flow-depth is 0.0237 m; Water temperature is 30 degree of heat; For each type of bed material, sediment feeding discharge is widely distributed from 0 to 2.63 times as equilibrium sediment transport rate (q_{be}) (0%q_{be}:0; 30%q_{be}:15.96g; 50%q_{be}:26.59g; 70%q_{be}:37.23g; 100%q_{be}:53.19g; 200%q_{be}:106.37g; 263%q_{be}:139.56g). Equilibrium sediment transport rate is calculated by using Ashida-Michiue equation. Experiment time for each cases is six minutes.

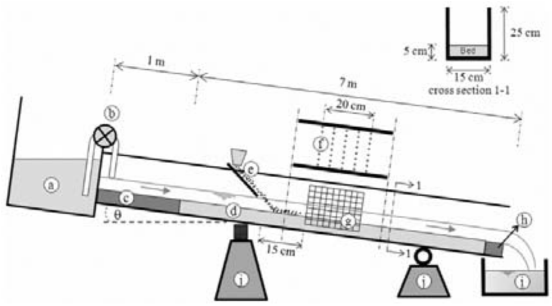

Fig. 1 Experimental setup (a. water tank, b. Pump, c. Rigid bed, d. Cohesive sediment, e. Sediment feeding location, f. Horizontal view of cross sections, g. Screen grid, h. Downstream weir, i. Downstream tank, j. Tilting machine)

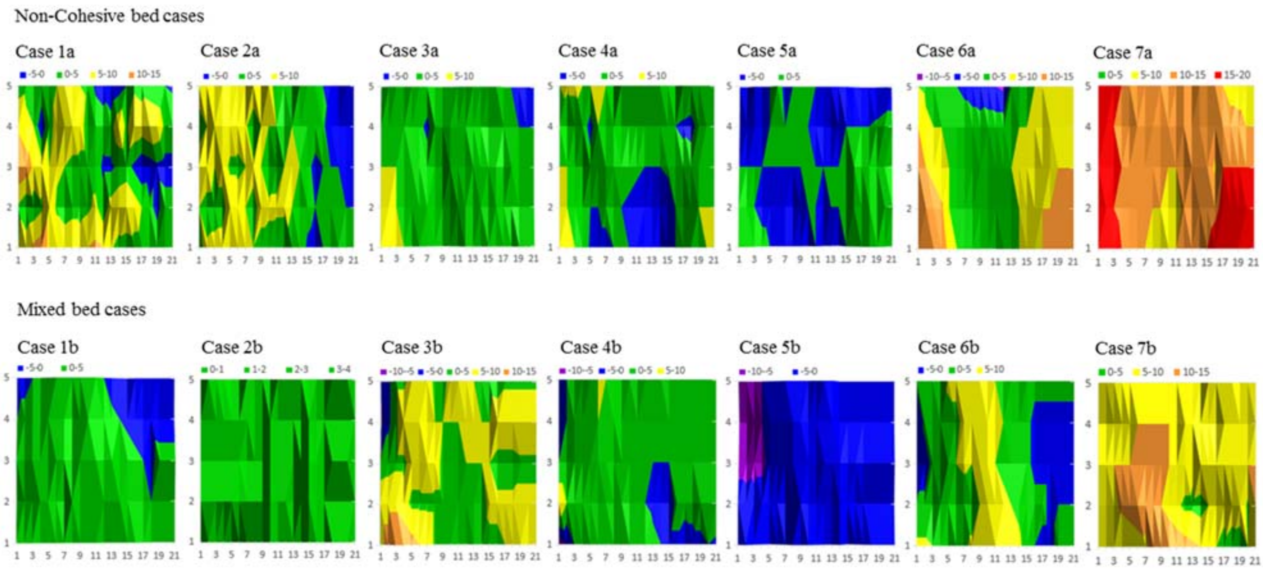

Fig. 2 3D display of bed level changing data in cases different bed material
Vertical axis is measurement cross sections (1-5), Horizontal axis is measurement points (1-21). Case 1 to 7 are correlative with different sediment feedings which are equal with 0, 30, 50, 100, 200, 263%qbe, separately. Color index (with value range) on the top of each picture is bed level changing (mm). Smaller than 0 is erosion. Larger than 0 is deposition.

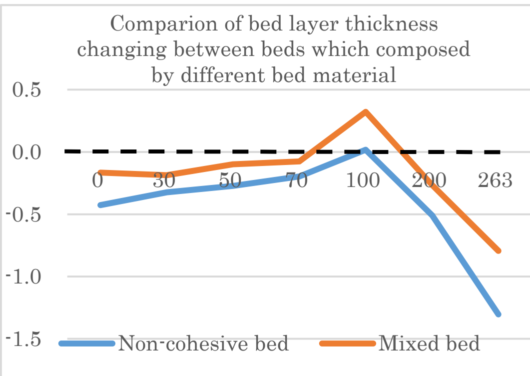

Fig. 3 Comparison of bed level changing in cases beds are composed by non-cohesive sediment only and mixture of non-cohesive and cohesive sediment. Vertical axis is bed level changing (mm). Smaller than 0 is deposition and higher than 0 is erosion. Horizontal axis is percent of sediment feeding discharge (%qb_e).

3. Discussion and conclusions

Fig. 3 showed that there are a small amount of sediment which deposited in both cases with the sediment feeding is 0%qb_e, 30%qb_e, 50%qb_e and 70%qb_e.

Small water discharge and other sediment in upstream of flume move to observation area caused deposition in cases which bed is non-cohesive only. However, the increasing of sediment feeding make the bed deposition slightly reduce until 100%qb_e where erosion and deposition are balance. After that, the deposition is increase in cases sediment feeding are 200%qb_e and 263%qb_e.

In cases which bed content sediment mixture, deposition in the first four case cause by the cohesion of bed and small water discharge. However bed level changings are higher than non-cohesive bed cases. That caused by the mixture bed start to be eroded cause by the effect of bed load. Maximum erosion happen with 100%qb_e while non-cohesive bed case get the equilibrium state. Deposition increase when sediment feeding are 200%qb_e and 263%qb_e but deposition in those is still smaller than non-cohesive bed case. This happen because mixture bed is eroded first, then deposition sand cover those place.

Fig. 2 show that case 5b is completely eroded while case 5a got the balance state. It also show the completely difference of deposition level between case 7a and 7b. Increasing of deposition can be seen clearly in case 3b and those deposition sediment is removed all in case 4b. The increasing of deposition in cases sediment feeding larger than 100%qb_e also can be seen in fig. 2

4. References

Harsanto, P., Toan, N.M.M., Takebayashi, H., Fujita, M. (2011): Erosion Characteristics of Cohesive Sediment by Non-Cohesive Sediment, Disaster Prevention Research Institute Annuals, B. 54(B), pp. 611-618.