Evaluation of bed shear stress for cohesive sediments erosion- comparison between the Reach-averaged method and the "Law of the wall" method

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Introduction

The erodibility of cohesive sediments has been recognized to be significantly different from that of non-cohesive beds. The existence of clay particles in the soil often leads to a much greater resistance to erosion.

Method

- *Specimen preparation*

We collected the soil specimens from the Agongdian Reservoir in southern Taiwan, then mixed them with tap water and reconsolidated by natural settlements for 24, 48, and 72 hours, to create specimens with different bulk densities and moisture contents.

- *Flume experiments*

We set five different bed shear stress conditions by control the discharge and water depth. During the experiment, we keep the top of the sample in line with the bottom of the flume and record total length we push into the flume.

- *Bed shear stress analysis*

To analyze the bed shear stress caused by the flow in the flume, two methods were applied to calculate it: (1) Reach-averaged method; (2) "Law of the wall" method.

Fig . 1. Photo of the flume, specimens placement area, and the ADV.

Results & Discussion

We measured the bulk density to each type of the specimen, and the averaged values are 2.02, 2.08, and 2.15g/cm^3, correspond to 24, 48, and 72 hours of settlements, respectively.

- *Flume experiments*

Erosion rates in different bed shear stress and settling time are compared in Fig. 4. We calculate the bed shear stress in "Law of the wall" method here. In the same bed shear stress, erosion rate is decreasing with the settling time; but for the trails with same settling time, erosion rates do not show an obvious trends with the increase of bed shear stress, which may be attributed to the low values of bed shear stress closing to the critical value of erosion initiation.

- *Bed shear stress analysis*

In the experiment, the bed shear stress calculated by the "Law of the wall" method is highly correlated with the values obtained from the Reach-averaged method.

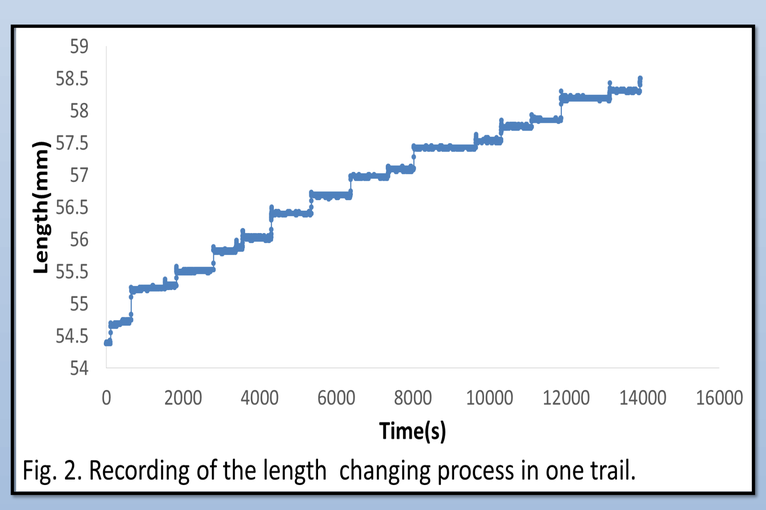

Fig. 2. Recording of the length changing process in one trail.

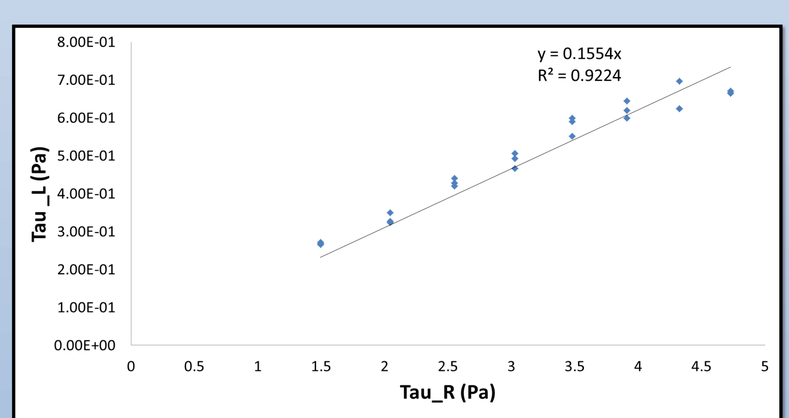

Fig. 3. Bed shear stress calculated by the "Law of the wall" method v.s. the Reach-averaged method

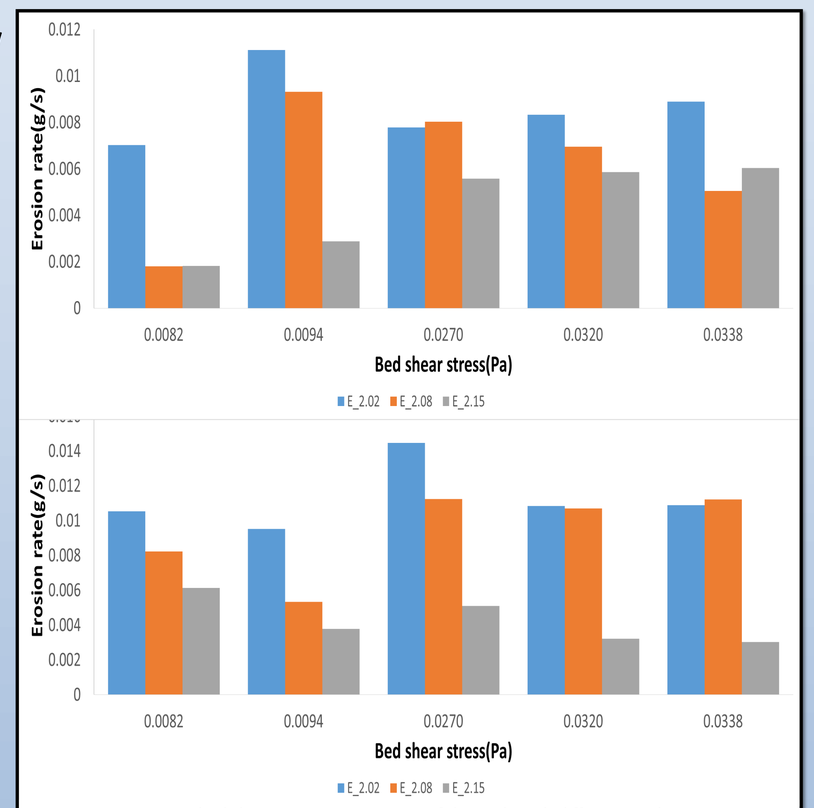

Fig. 4. Erosion rate v.s. bed shear stress: comparison of the trails with different settling time represented in density

Conclusion

In this study, we analyzed the erosion resistance of sludge collected from the Agongdian Reservoir in southern Taiwan with the flume experiments. In the same bed shear stress conditions, erosion resistance is increasing with longer settling time. In addition, the bed shear stresses are highly correlated obtained by the reach-averaged method and the "Law of the wall" method. In the filed, ADV measurements and the near-bed shear stress obtained from the "Law of the wall" method may be translated to the bed shear stress caused by the bulk flow using the proposed correlation, where the reach-averaged method is not applicable, i.e. the unit flow condition is hard to obtain.