Alternate bars on bed composed of cohesive and non-cohesive material layers

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Alternate bars have been researched with non-cohesive sediment on bed, but it has not been observed in channels considering the effect of cohesive characteristic which appear at some rivers like Tonlesap River, Cambodia. The mechanism and the process of development of the alternate bar under effect of cohesive sediment are investigated in this paper. Four type bed materials, (1) Mixture of coarse sand and cohesive sediment, (2) Only coarse sand, (3) Coarse sediment laid on cohesive sediment layer, (4) Cohesive sediment only, are used in this study.

Hydraulic conditions

A flume with 0.2 m wide and 10.55 m long with steep slope (0.011) was used. Mean diameter of coarse sediment (Sand number 4) and cohesive sediment (Kaolin) are 0.88 mm and 4.61 μm, separately. Water discharge is 1 l/s. The layer thickness of the bed material height is 7.8 cm in all three cases. Mixture sediment in case 1 has 83% of coarse sediment and 17% of cohesive sediment. Cohesive sediment layer (6 cm thickness) in case 3 is the mixture of 52% of cohesive sediment and 48% of water. The sediment was set up on flume bed and wait for three days for cohesive sediment settlement before put on coarse sand layer (1.8 cm thickness). Development of bars, wave length and bar migration velocity were record by a time-lapse camera which was hang on the top of the flume.

Sediment discharge at downstream

Sediment was measured every 15 minutes at downstream end by a bucket. Effect of cohesive characteristic can be seen very clearly. Figure 1 showed that sediment compose on the very first observed bar did not come to downstream end after 15 minute from starting point. The data which can be used to compare cases is the measured data from 30 to 120 minute. At 15 minute, sediment discharge is high because downstream bed was eroded (eroded length is around 20cm), so this data should be neglected.

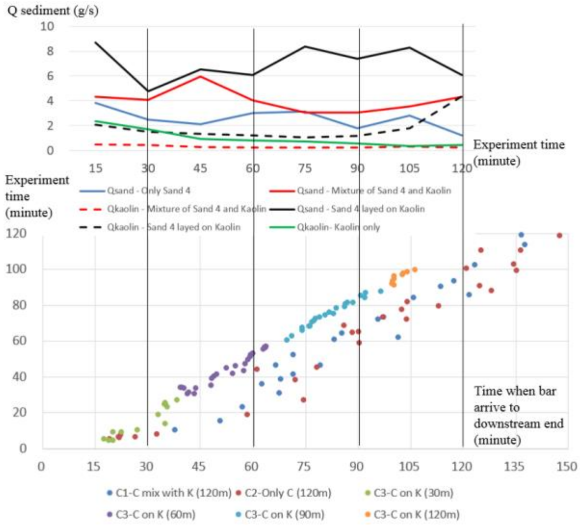

Figure 1: Changes of sediment discharge measured at downstream end

Characteristic features of development process

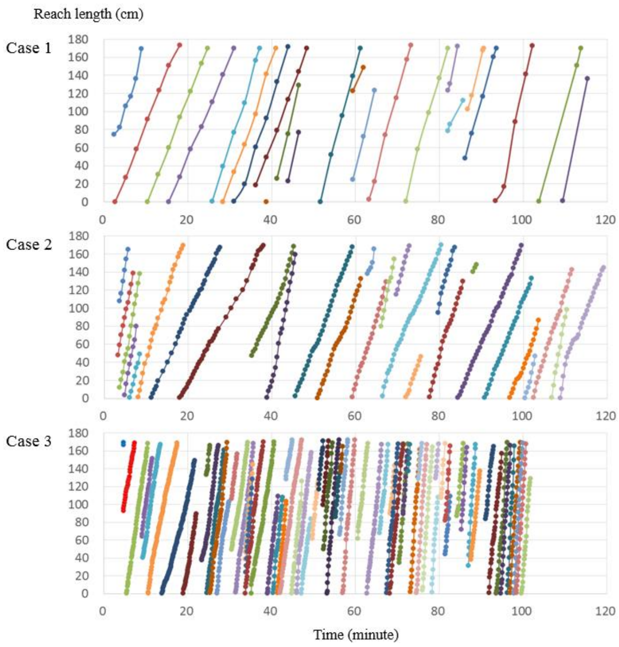

Figure 2: Bars development

The migration diagram above show that a rapidly developed bar occurred in case 3 in compare with case 1 and 2. Number of bar in case 1, 2, 3 is 22, 29 and 69, separately. After around 100 minutes, coarse sediment on case 3 was almost flown away so that there is no more bar in case 3. There is no bar was formed in case 4. Bar developed quite uniformly along the whole measured reach in early stage (until 40 minutes) then complicated bar behavior happened later, especially in upstream reach of case 3.

Bed profile and erosion rate variations

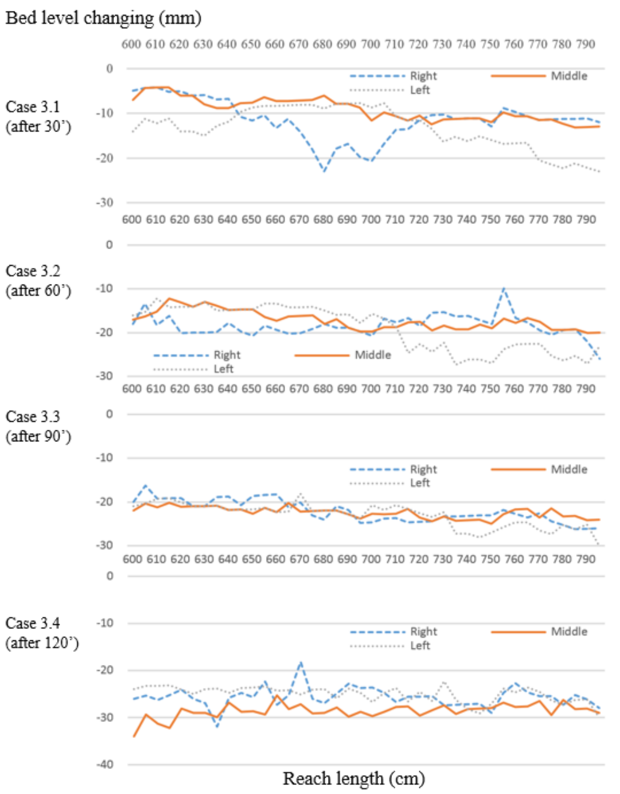

Figure 3: Bed changing profiles in case 3

Figure 3 shows the longitudinal bed profiles along the centerlines and the both side-walls.

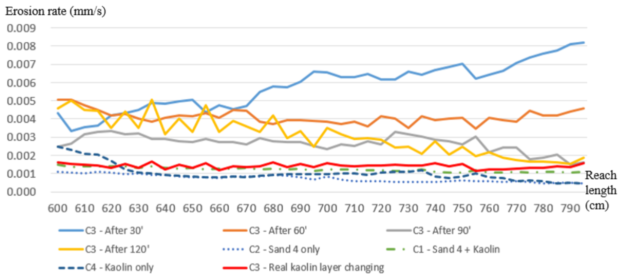

Figure 4: Erosion rate

Variations of migration velocity and wave length

Figure 5 showed that migration velocity in all stage of case 3 is higher than case 1 and 2 and tend to be increasing. While the trend are the same from experiment starting point to 60 minute, velocity increase more after 60 minute and even more after that. Wave length in case 1 tends to be longer in compare with case 2, while it tends to be shorter in case 3 at the final.

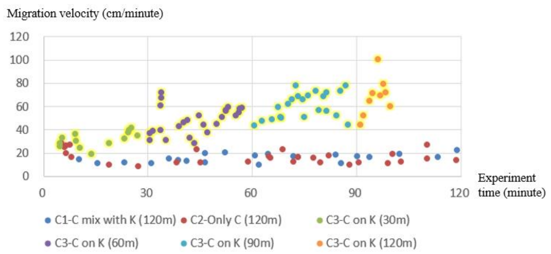

Figure 5: Mean migration velocity of alternate bars

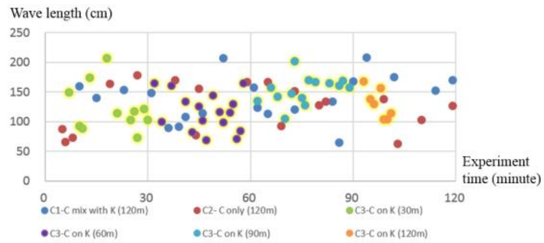

Figure 6: Wave length

[C: Coarse sediment, K: Cohesive sediment (Kaolin)]

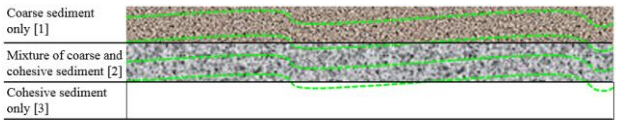

Figure 7: Different layers in case 3 and illustration of alternate bars

Coarse sediment lay on cohesive sediment in case 3 divided bed material to three layers: coarse sediment only, mixture of coarse and cohesive sediment and cohesive sediment only. This caused the bar development became complex. This can be seen in figure 5 where migration velocity fluctuation is higher than case 1 and 2 and in figure 6 where developing trend of wave length is different on each 30 minutes.

Conclusion

The data show that these appearance of bar developments are dependent on the conditions of the initial bed material. Cohesive sediment cause more erosion of both coarse and cohesive sediment. Under cohesive characteristic effect, alternate bar's migration speed and sediment discharge is higher.