Study on bank erosion processes with cohesive and non-cohesive material

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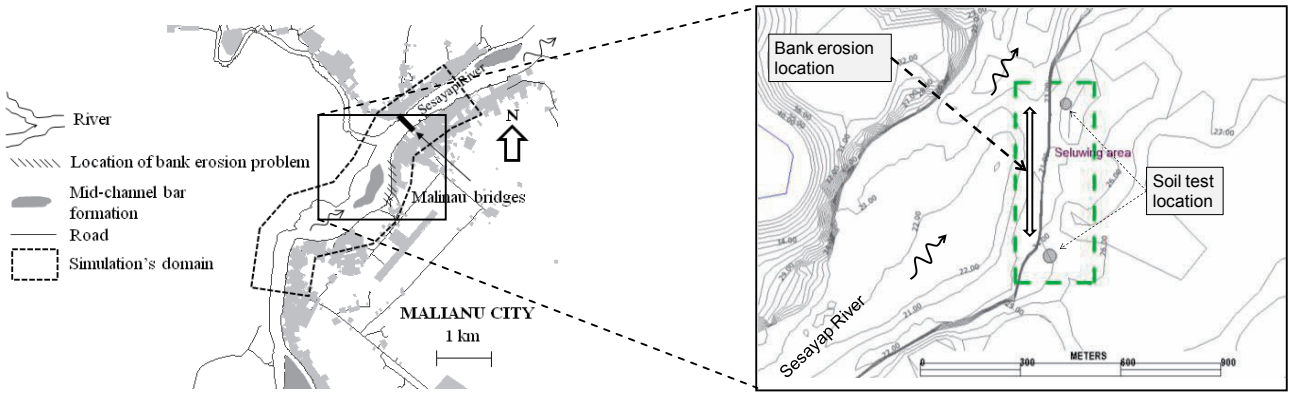
1. INTRODUCTION

Bank erosion is the processes, which dominated by the complicated interactions among of flow, sediment transport, and bank material (Duan, 2001). The physical interaction between channel geometry, water flow, sediment transport and deposition is poorly understood for riverbank erosion process. However, to counteract on the riverbank erosion problems, most of the scientist and engineering are only focused on bank characteristics. A reach of the Sesayap River, Indonesia, was studied in order to examine the interaction of channel geometry, water flow, sediment transport and deposition associated with a single mid-channel bar.
The Sesayap River is 279 km long, and the catchment has an area of about 18158 km2. Sesayap River is a navigation channel which conducts between Malinau and Tarakan city. At Seluwing area (see in Fig. 1a), riverbank was collapsed on April and September 2008. Those collapses gave damages on the road structure. The water depth on flood plains was 30 cm during the November 2008 flood (Fig. 2b). This study aims to apply a horizontal two-dimensional flow and bed morphology model at the Sesayap River in order to understand the flow pattern, estimate the bank failure processes, and propose a suitable countermeasure of the bank erosion.

2. RIVER BANK CONDITION

The processes of bank erosion are closely related to soil composition and mechanical properties of the riverbanks. So, field investigations for bank properties were conducted. The location of soil investigation on Sesayap River is shown in Figure 1b. Soil mechanic's test included hand bore, and cone penetration tests were carried out by Engineering Faculty of Gadjah Mada University.

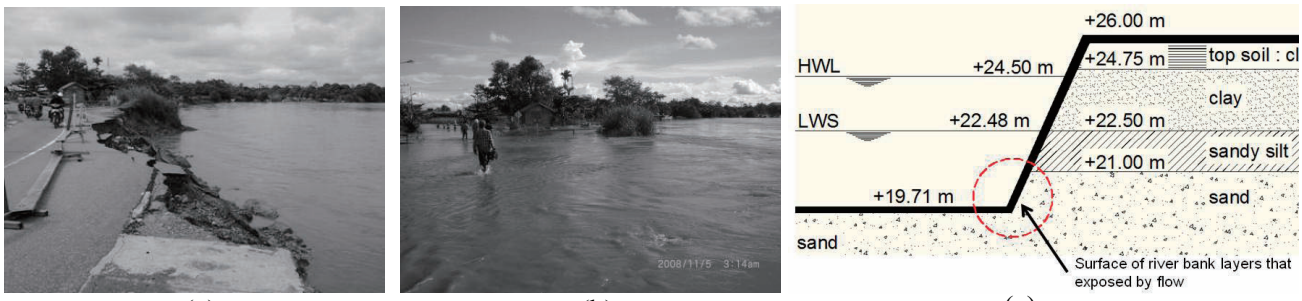


(a) (b)

Fig. 1. Sesayap River reach at Malinau and topography at Seluwing area

2. NUMERICAL SIMULATION

A numerical simulation was developed to investigate the characteristics of flow pattern and bank toe deformation. To get the more accurate results on bed deformation, the grain size distribution of river bed is considered and will be evaluated using the sediment transport multilayer model. The boundary condition at the downstream end is the water level elevations, which have the elevation at +22.50 m for LWS and +24.50 m for HWS. The discharge input at the upstream end is 436 m^3/s.



(a) (b) (c)

Fig. 2 Bank failure (a), flooding at Seluwing (b), and stratification of river bank (c)

3. RESULTS AND DISCUSION

Fig. 2c shows the stratification layer of river bank. The results from the soil test show that cohesive soil layer (clay) is above of +23.25 m, between elevations +21.00 m to +23.25 m is a transition of soil layer from cohesive soil to non-cohesive (sandy-silt). Below the elevation of +21.00 m is non-cohesive soil presence by sand. The elevation of river bed is +19.71 m and presence by non-cohesive materials. These conditions give high potential of flow to expose the non-cohesive layer of the bank. According to the water level, velocity (numerical simulations) and bank stratifications (field survey) indicate that the processes of bank failure at Seluwing area are as follows:

- Erosion process: The water flow with high velocity causes erosion at the bank toe on the part of non-cohesive soil layer (sand).
- Overhang process: The erosion at the bank toe steepen the bank height that decrease the bank stability and also the erosion of non-cohesive layer develops cantilever of cohesive layers on riverbanks.
- Bank failure process: The susceptibility of the bank to mass failure depends on their geometry, structure, and material properties.
- Temporarily protect, during bank failure and collapse, block of bank material slide or fall toward the toe of the bank, where they remain until they are broken down or entrained by the flow. Failed block may become a temporarily protection at the toe of the bank from erosion.

4. CONCLUSIONS

The results from numerical simulation and soil investigation can describe the processes of river bank. The bank erosion in the Sesayap River causes by the concentration flow velocity due to the presence of the mid-channel bar. That is led to excessive degradation at the bank toe and erosion of the non-cohesive surface bank. The composition of the stratification layers of the bank at Sesayap River has a high potential of bank failure. The basic treatment to prevent the bank erosion can be done by controlling the flow velocity along the bank and or preventing actions to the flow to expose the non-cohesive layer of the bank.

Keywords : Bank eroison, cohesive, non-cohesive, numerical analysis, bank protection

5. References

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Duan, J.G., Wang, S.S.Y., and Jia, Y., "The Applications of the Enhanced CCHE2D Model to Study the Alluvial Channel Migration Processes", 2001, Journal of Hydraulic Research, Volume 39, Issue 5, pp. 469-480.