Identifying Framework for Analysis River Bank Stability

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1. Introduction

Stream bank erosion is one of common disasters occurring on surface earth crust that relate to multiple element and their interactions. The results on assessment of erosion stream banks was analyzed in widely aspects as slope stability in type of shallow slide, rotational slip, slab, cantilever, popout, piping, undercutting, seepage, and so on. Recently, climate change has caused more extreme weather condition, huge storm and extended droughts bring greatly impactions to river bank system in tropical area. It is recognized that all above failure mechanism appear plentifully, hydraulic dynamic play the most important factors effect to the shape of meander river. Moreover, the seepage force side bank material during time of changing water river level, or changes the moister of soil normally occurs. Among of conceptual knowledge of assessment bank slope stability, the theory demonstration of transient seepage into soil bank is still not well understood.

This study has objectives is to investigate and build database including geo-engineering condition in Red River bank, and to indentify a frame work for assessment river bank stability in corresponding to seepage and undercutting failure bank mechanism. Study area is Red river bank through into Hanoi, the northern of Vietnam. Bank failure in this area has greatly impaction as losing land use and destroys constructions near river bank site because Hanoi area is the most crowded citizen in Vietnam.

2. Case study: The geotechnical condition of Red River Bank in Hanoi, Vietnam

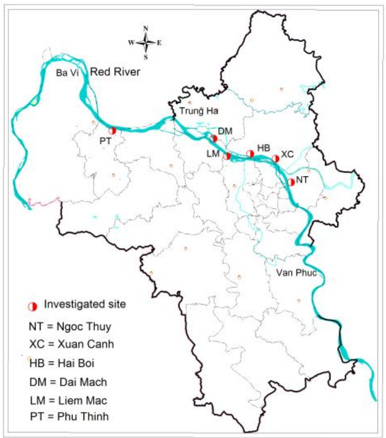

Figure 1. The study area map

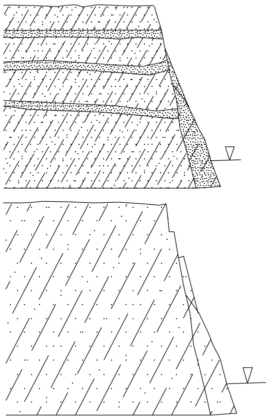

Figure 2. Bank soil layer stratigraph Type 1 and Type 2

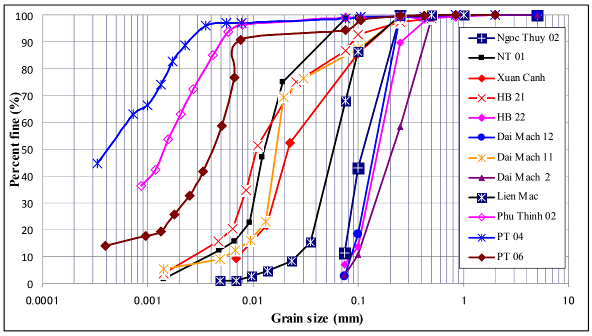

Figure 3. Grain size distribution of soil in Red river bank

Figure 4. Failure river bank (pictures took in Ngoc Thuy, Xuan Canh, Hai Boi)

Table 1. Geometry characteristics of Red River bank

Site	Longitude (m)	Latitude (m)	Height of bank	Soil bank
NT	589300	2329200	11m	Type 1
XC	586000	2333700	7 m	Type 2
HB	582000	2334500	8 m	Type 1
DM	573100	2339100	13 m	Type 1
LM	579700	2333300	8 m	Type 2
PT	511000	2342000	8m	Type 2

Table 2. Some geotechnical properties

Site	Mean grain size	Hydraulic conductivity	Cohesion force	Friction angle
	D_{50} (mm)	Ks (cm/s)	C (kPa)	ϕ(degree)
NT 01	0.014	3.4×10^{-3}	51.132	14.53
XC	0.040	7.8×10^{-3}	9.913	31.52
HB 21	0.011	2.5×10^{-3}	2.2435	18.12
DM 11	0.017	3.8×10^{-3}	66.784	12.96
PT 06	0.004	4.2×10^{-4}	49.566	20.67

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Red River through into Hanoi area has a length of about 90km, while 40 km is located in site developing urban area (figure 1). Field investigation along this area has been carried in January 2012 to select soil sample and measure geometry of river bank at site occurring erosion (figure 1and table 1). River bank here is natural alluvial which deposited intersection of sand, silt layer. It can be seen two main of soil stratigraphy: homogeneous silt soil or do silt and sand in shift (figure 2 and table 1). Based on graphs of grain size distribution (figure 2), there are three main group of soil type: fine sand, sitl soil, clay soil has mean grain size of $D_{50}>0.1$mm, $D_{50}=0.1$-0.005mm and $D_{50}<0.005$mm, respectively, white silt layer appears dominant. These soils are unconsolidation, high porosity, low cohesive and easy collapse by increasing saturated degree by increasing gravity loading via change pore water or confining pressure (figure 4). Table 2 show some result of direct shear test of undisturbed sample and hydraulic conductivity test. In further study, data base will be built with changing of mechanics soil properties and unsaturated soil corresponding variation density of Red river bank soil.

3. Identifying the factors affecting and building the framework for analysis river bank stability

The advantage and success as well as limitation in multiple previous researches has been reviewed and presented here to discus and get conceptual for building framework of assessment of river bank stability. The functions for determine factor of safe (FOS) and rate of erosion, critical shear strength, are effective and useful stability functions. Their impaction and effected factors also have been studied in wide aspects:

Firstly, soil bank material is recognized as most important factor in aspect of geo-engineering. Based on 15 years of erosion testing experience using EFA, Briaud (2008) proposed erosion categories indicating that the most erodible soils are fine sands with a mean grain size in the range of 0.1 to 0.5 mm. In these grain size has mean grain size (D_{50}) 0.01 to 0.05mm had little data and it can be seen that soil with D_{50} from 0.1 to 0.01 has critical shear strength and erosion rate change rapidly. Since it is need to addition more results in this inclusion. Another physical property as density, that has impaction to large functions, must be considered. Its value range should determine based on compaction curves. Soil water retention, hydraulic conductivity, and shear parameters with multiple of variation grain size and density, play directly and effectively role to change of stability function. In further research, it is expected to analysis these soil properties focus on soil of $D_{50}=0.005$ to 0.05mm in Red river bank. Secondly, change of hydraulic dynamic including river stage (draw down and rising), rail fall, evaporation cause greatly change of pore water pressure combining with seepage processing lead to undercutting and slab failure. S. Dapporto (2001) shown peaks river stage up to 1.7m above low-water stage, the FOS associated to the alcove failure is less than the FOS computed for the slab failure. The slab failure becomes decrease when peak river stages above 1.9m. M. L. Chu-Agor et al. (2008b) show that (1) tension or popout failure when the force of the seepage was greater than the resistance of the soil, and (2) particle mobilization and bank undercutting when the seepage force gradient was less than the initial resisting force of the soil block. Third but not final, geometry and thickness of soil layer in river bank are need to running failure modeling.

Modeling simulation is necessary to predict soil erosion in large scale and multiple factors. Finite Element Method (FEM) is one of optimal option with simulation of combining interaction hydraulic dynamic and change soil properties to bank stability. By literature and field condition, a fame work following be suggested with its expecting to obtain effective results for evaluating Red river bank as well other area:

Field Investigation
- Soil colleting
- Geometry measuring
- Collect hydraulic data

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Soil properties analysis
- Grain size
- Soil classification
- Compaction test
- Soil water retention
- Hydraulic conductivity
- Shear strength
- Erosion rate

← FEM →

Analysis change of pore pressure in relationship of input factors

← FEM →

Analysis of FOS with predetermined or real condition

4. Conclusion

As the first of step in progress of research on bank stability, this study expresses some important data in area of Red river: there are three main group of soil type as fine sand, silt soil, clay soil has mean grain size of $D_{50}>0.1$mm, $D_{50}=0.1$-0.005mm and $D_{50}<0.005$mm, respectively, white silt layer appears dominant. These soils are unconsolidation, high porosity, low cohesive and easy collapse by increasing saturated degree by increasing gravity loading via change pore water or confining pressure. And the present study makes indentify of effected factor to bank stability as soil grain size, density change in many case lead to change of bank stability function should be considered and accounted in suggestion full modeling.

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References:

(1) Briaud, J.-L. (2008). "Case Histories in Soil and Rock Erosion: Woodrow Wilson Bridge, Brazos River Meander, Normandy Cliffs, and New Orleans Levees." J. Geotech. Geoinviron. Eng., ASCE, 134(10), 1424 - 1447. (2) M. L. Chu-Agor, G. A. Fox, R.M. Cancience, G.V. Wilson, 2008b. Seepage causes tension failure and erosion undercutting of hillslopes. Journal of Hydrology 359 (2008) 247-259. (3)S. Dapporto, M. Rinaldi, N. Casagli, 2001. Failure Mechanisms and pore pressure condition analysis of Riverbank along the Arno River (Central Italy). Engineering Geology (2001) 221-242.