ANALYSIS OF LIQUEFACTION POTENTIAL OF RIGHT RED RIVER DYKE, K73+500-K74+100

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1. INTRODUCTION

The right Red river dyke has a crucial role to protect Hanoi capital from flooding. In some dyke locations, however, the foundation consists of shallow fine sandy layers which can easily be liquefied during strong earthquakes.

Hanoi city is situated in the region of Red river-Chay river fault where some strong earthquakes with maximum magnitudes of 5.5 degree have occurred in the past. Although Hanoi is now in the silent period, but the seismic activities may increase in the future (Xuyen, 2004).

Liquefaction caused by strong earthquakes has seriously damaged river dykes in the world in some typical failures such as excess settlement and instability.

Soil liquefaction describes the behavior of saturated sandy soils that, when undrained loaded, suddenly suffer a transition from a solid state to a liquefied state. The excess porewater pressure builds up causing soil strength decreased, and finally the soil becomes liquefied.

To investigate the liquefaction potential of soil, the simplified procedure (Seed and Idriss, 1971; Youd el al., 2001) using the insitu soil tests such as SPT, CPT has been applied extensively.

This study aims at evaluating the liquefaction potential of dyke foundation of right Red river dyke, from K73+500 to K74+100 based on the geotechnical investigation data (WRU, 2015).

2. EVALUATION OF DYKE LIQUEFACTION POTENTIAL

The simplified procedure (Seed and Idriss, 1971) suggests the factor of safety against liquefaction determined as below:

$$FS = (CRR_{7.5}/CSR)MSF \qquad (1)$$

where CSR = calculated cyclic stress ratio generated by the earthquake shaking; $CRR_{7.5}$ = Cyclic resistance ratio for magnitude 7.5 earthquakes; MSF = magnitude of scaling factor.

Fig.1. *Layout of boreholes*

For clean-sand (Youd et al., 2001):

$$CRR_{7.5} = \frac{1}{34-(N_1)_{60}} + \frac{(N_1)_{60}}{135} + \frac{50}{[10(N_1)_{60}+45]^2} - \frac{1}{200} \qquad (2)$$

where $(N_1)_{60}$ is the SPT blow count normalized to an overburden pressure of approximately 100 kPa and a hammer energy ratio or hammer efficiency of 60%.

$$MSF = 10^{2.24} / M_w^{2.56} \qquad (3)$$

where M_w is earthquake magnitude.

The critical stress ratio, induced by the design earthquake, CSR was calculated as:

$$CSR = \frac{\tau_{cyc}}{\sigma'_{vo}} = 0.65\left(\frac{a_{max}}{g}\right)\left(\frac{\sigma_{vo}}{\sigma'_{vo}}\right) r_d \qquad (4)$$

where a_{max} = peak horizontal ground acceleration (PGA); g = gravitational acceleration; σ_{vo} and σ'_{vo} = total and effective vertical overburden stresses, respectively, at depth z (m) from ground surface. r_d=stress reduction coefficient.

$$r_d = \frac{(1.000 - 0.4113z^{0.5} + 0.04052z + 0.001753z^{1.5})}{(1.000 - 0.4177z^{0.5} + 0.05729z - 0.006205z^{1.5} + 0.001210z^2)} \qquad (5)$$

The soil investigation was implemented at the right Red river dyke, segment: K73+500 - K74+100 (WRU, 2015). Nine boreholes (HK1 to HK9) were drilled into the dense sand with the depth of maximum 50m (Fig.1).

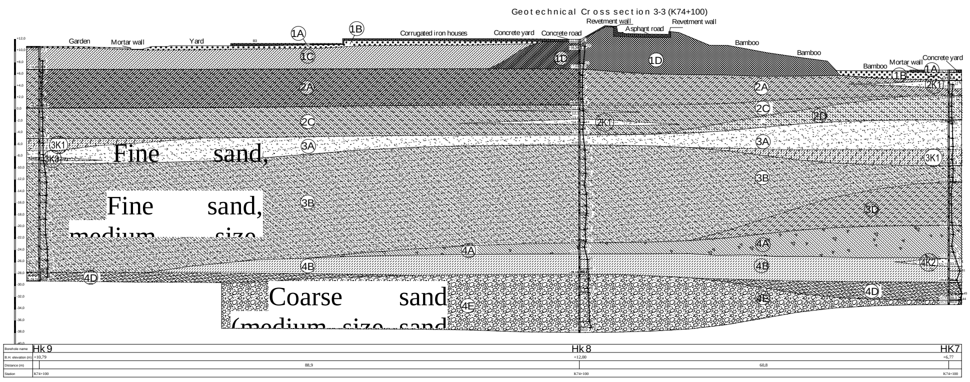

Fig.2: *Geotechnical cross section 3-3 (K74+100).*

The soil strata from the ground surface consists of the following layers (Fig.2): 1A (concrete, asphalt); 1B (made soil); 1C (clayey soil);1D (made soil); 2A (clay, sandy clay);2C (sandy clay); 2D (clayey sand, silty sand);3A; 3B ; 3C (medium size sand with some gravel, medium dense–dense); 3D (clay, sandy clay, somewhere with sand); 4A (Clay, sandy clay, with some gravel); 4B (clayey sand); 4C (medium size sand, small size particle, somewhere with gravel, medium dense); 4D (medium size sand, somewhere with fine sand, medium dense-dense); 4E. The SPT work was conducted in all boreholes following TCVN 9351:2012 standard. Results of SPT-N distribution with borehole depth are shown in Fig.3.

The evaluation of liquefaction potential for each borehole was implemented using simplified procedure (Seed and Idriss, 1971).

The elevation of water table in nine boreholes varied between 0.01m to 1.99m. Note that the water level at the river side was smaller than that in the field side. The calculation was implemented with two proposals of return periods of 475 years (a_{max}=0.13g) and 2475 years (a_{max}=0.21g) at the project area. The PGA values were deduced from the seismic analysis applied to the project area (Son, 2014). In addition, the a_{max} =0.1047g at the site with a return period of 475 years by TCXDVN 375- 2006 was also employed to the analysis.

3. RESULTS AND DISCUSSION

Figure 3 shows the factors of safety against liquefaction by eq. (1) with the depth below ground surface for nine boreholes with three PGA values as above mentioned.

It can be seen from most boreholes that, the factors of safety fall below unity within the depth of less than 15m from the ground surface, except borehole HK7. The possible reason could be due to the limits of simplified procedures. The sandy soils of 2C, 2D, and 3A could be liquefied.

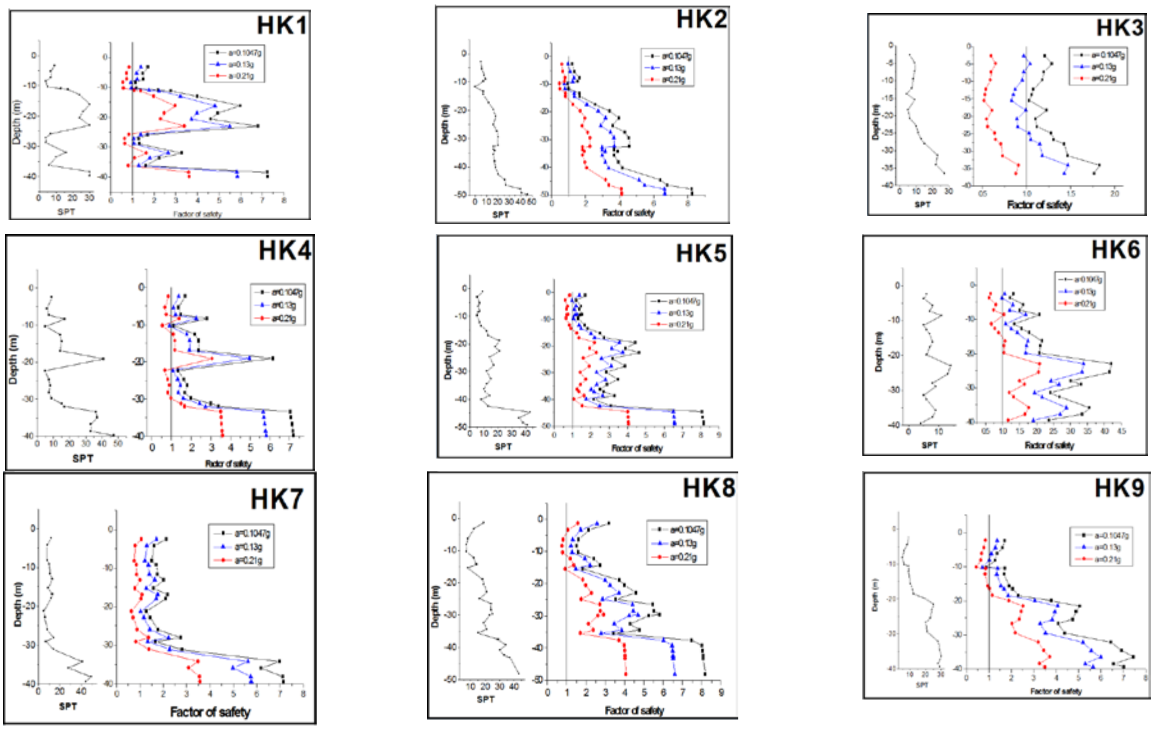

Fig.3: *Factors of safety against liquefaction at boreholes HK1 to HK9.*

When the PGA increased, the factor of safety against liquefaction decreased.

Note that the water level measured during the surveying time was not the dangerous case when the water level rises up to the ground surface during flood season. In addition, the effect of fine content was neglected due to its small percentage.

4. CONCLUSION

The right Red river dyke, K73+500-K74+100 is a weak segment where its foundation consists of shallow fine sand layers 3A, 3B.

The evaluation of liquefaction potential of foundation soils by simplified method (Seed and Idriss, 1971) with SPT data revealed that the segment K73+500-K74+100 could be liquefied when subjected to strong earthquakes (a_{max}=0.13g and 0.21g).

The analysis of liquefaction potential and the mapping the liquefaction zone of Red river dike foundation should be properly considered in the design, planning and maintenance of the river dykes.

5. REFERENCES

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