ANALYSIS OF LIQUEFACTION POTENTIAL OF RIGHT RED RIVER DYKE

Nguyen Thi Khanh Hoa [1]・Nguyen Hong Nam [2]・
・Tadashi YAMADA [3]

[1]Chuo University (1-13-27 Kasuga , Bunkyo-ku ,Tokyo 112-8551)
E-mail: hoantk1nk@*wru.vn*
[2] Center for International education, Thuy Loi University. (175 Tay Son, Dong Da, Hanoi, Vietnam)
E-mail: nghongnam@gmail.com
[3] Professor , Department of Civil and Environmental Engineering Department ,
Faculty of Science and Enginering , Chuo University
(1-13-27 Kasuga , Bunkyo-ku ,Tokyo 112-8551)
E-mail: yamada@civil.chuo-u.ac.jp

Liquefaction is one of very common phenomenal which cause many serious problems of destruction in the structures placed in many where in the world. However, study about liquefaction has not concerned in Vietnam, where is quite sensitive and easy to be liquefied if earthquake has occurred in the North Wes, especially in the Red river where is placed many structure through its long. In this study, by using the empirical formula of Seed people are probably identify the location of liquefied highly preliminary assessment of soil survey in the Standard penetration test.

Key Words : *Liquefaction, earthquake, SPT test, Red river dyke, peak horizontal ground acceleration*

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 manitudes 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 pore water 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 insitude soil tests such as Standart penetration test (SPT), Cone penetration test (CPT has been applied extensively. Besides, failure of embankment under seismic loading may occur due to liquefaction of embankment and/or foundation material is familar with the condition of this researched places. That also the reason why the simplified procedure was utilitied

This study aims at evaluating the liquefaction potential of dyke foundation of of right Red river dyke based on the geotechnical investigation data (base on survey of Water Resource University Vietnam, 2015).

The analysised position is placed in Vietnam, so the Vietnamese standard should be applied, therefore the standard TCVN 9351:2012 was used during the calculating process

2. LITERATURE REVIEW

(1) Liquefaction of soil: overview

Red river system is placed in the Fault Zone system which could be affected by earthquake of 6.0 or 7.0 Richter. Earthquake cause many serious problems to structure, one of them is liquefaction

Behavior of soils is soil liquefaction, when loaded, suddenly suffer a transition from a solid state to a liquefied state, or having the consistency of a heavy liquid. A more precise definition of soil liquefaction is given by Sladen et al. (1985):

"Liquefaction is a phenomenon wherein a mass of soil loses a large percentage of its shear resistance, when subjected to monotonic, cyclic, or shock loading, and flows in a manner resembling a liquid until the shear stresses acting on the mass are as low as the reduced shear resistance"

(2) Standard Penetration Test (SPT)

Standard Penetration Test (SPT)is a test base on the comparison of shear resistance standard (SPT-N) and the ratio shear stress through time period of earthquake (M=7.5 Richter) of sand and silt in where is observed that liquefied and non-liquefied occur to determine smallest shear stress ratio to cause liquefaction

Standard Penetration Test (SPT) method consists of repeatedly dropping a 63.5-kg mass from a height of 760 mm to drive a split-spoon sampler into the ground (ASTM D-1586).

3. METHODOLOGY

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

$$FS = (CRR7.5/CSR)MSF \tag{1}$$

Where CSR = calculated cyclic stress ratio generated by the earthquake shaking; CRR7.5 = Cyclic resistance ratio for magnitude 7.5 earthquakes; MSF = magnitude of scaling factor.

(1) Calculate cyclic resistance ratio for magnitude 7.5 earthquakes

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

CRR7.5=

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

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%.

(2) Calculate magnitude of scaling factor

$$MSF = 10^{2.24}/M_w^{2.56} \tag{3}$$

Where Mw is earthquake magnitude. The critical stress ratio, induced by the design earthquake.

(3) Calculate cyclic stress ratio generated by the earthquake sharking

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

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

$$r_d = \frac{(1.000-0.4113z^{0.5}+0.04052z+0.001753z^{1.5})}{(1.000-0.4177z^{0.5}+0.05729z-0.006205z^{1.5}+0.0012z^2)} \tag{5}$$

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

The soil investigation was implemented at the right Red river dyke, segment nearly 600m. Nine boreholes named from HK1 to HK9, respectively were drilled into the dense sand with the depth of

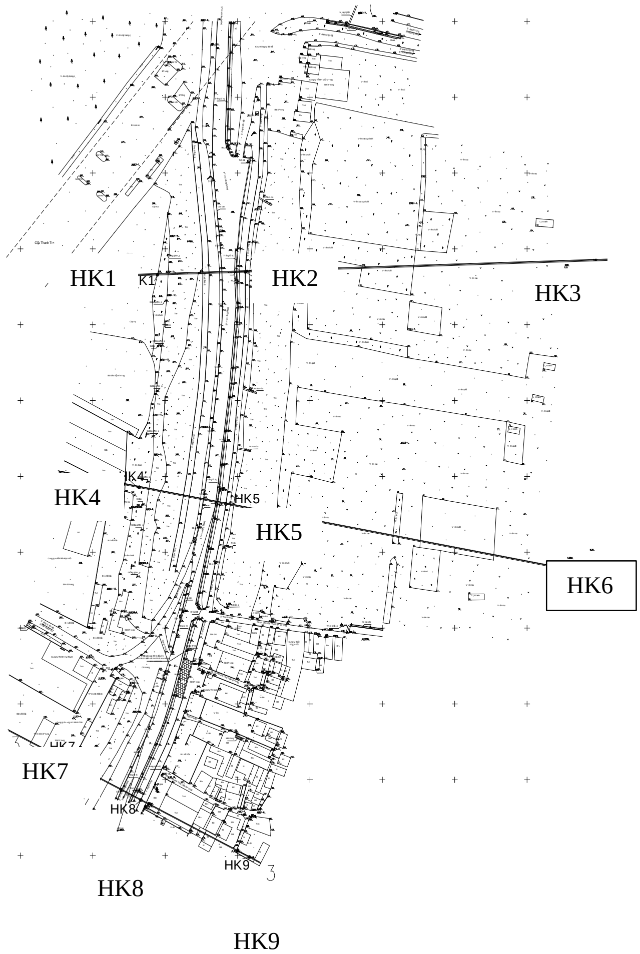

Fig.1. Layout of boreholes

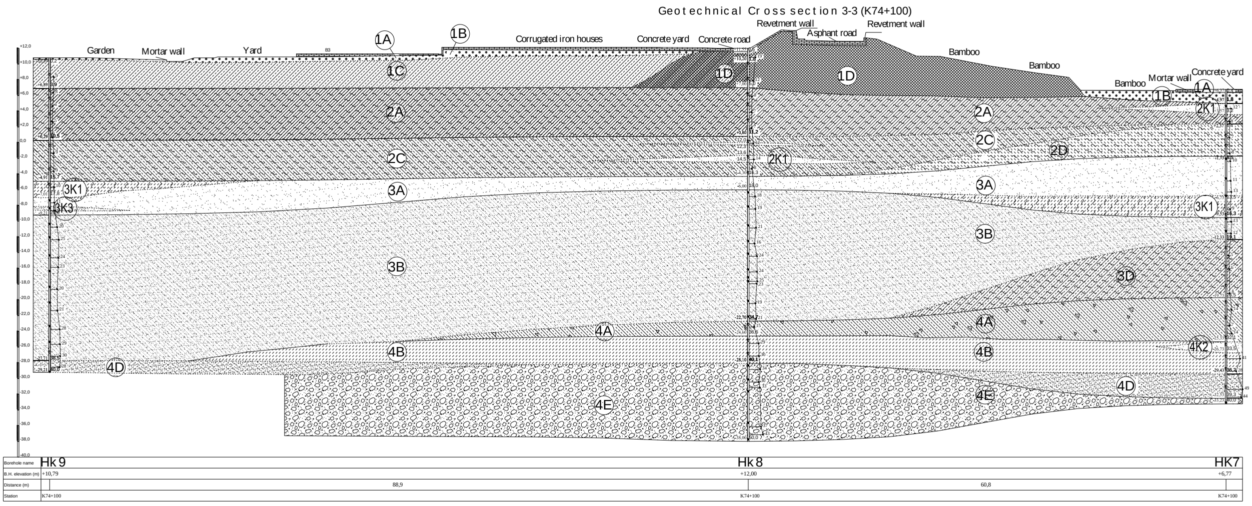

Fig.2 Geotechnical cross section 3-3 (K74+100).

Table 1 The layer in the soil strata

1A	Concrete, asphalt	3A	Sand, gravel, medium dense–dense, A-type particle-size distribution
1B	Made soil	3B	Sand, gravel, medium dense–dense, B-type particle -size distribution
1C	Clayey soil	3C	Sand, gravel, medium dense–dense, C-type particle -size distribution
1D	Made soil	3D	clay, sandy clay, somewhere with sand
2A	Clay, sandy clay	4A	Clay, sandy clay, with some gravel
2C	Sandy clay	4B	clayer sand
2D	Clayey sand, silty 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	medium size sand, somewhere with fine sand, medium dense-dense

maximum 50m (Fig.1)

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.2.

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 (amax=0.13g) and 2475 years (amax=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 amax =0.1047g at the site with a return period of 475 years by TCXDVN 375- 2006 was also employed to the analysis.

4. APPLICATION OF SIMPLIFIED METHOD IN LIQUEFATION OF RIGHT RED RIVER DYKE

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.

(1) Non-submerged case

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.

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

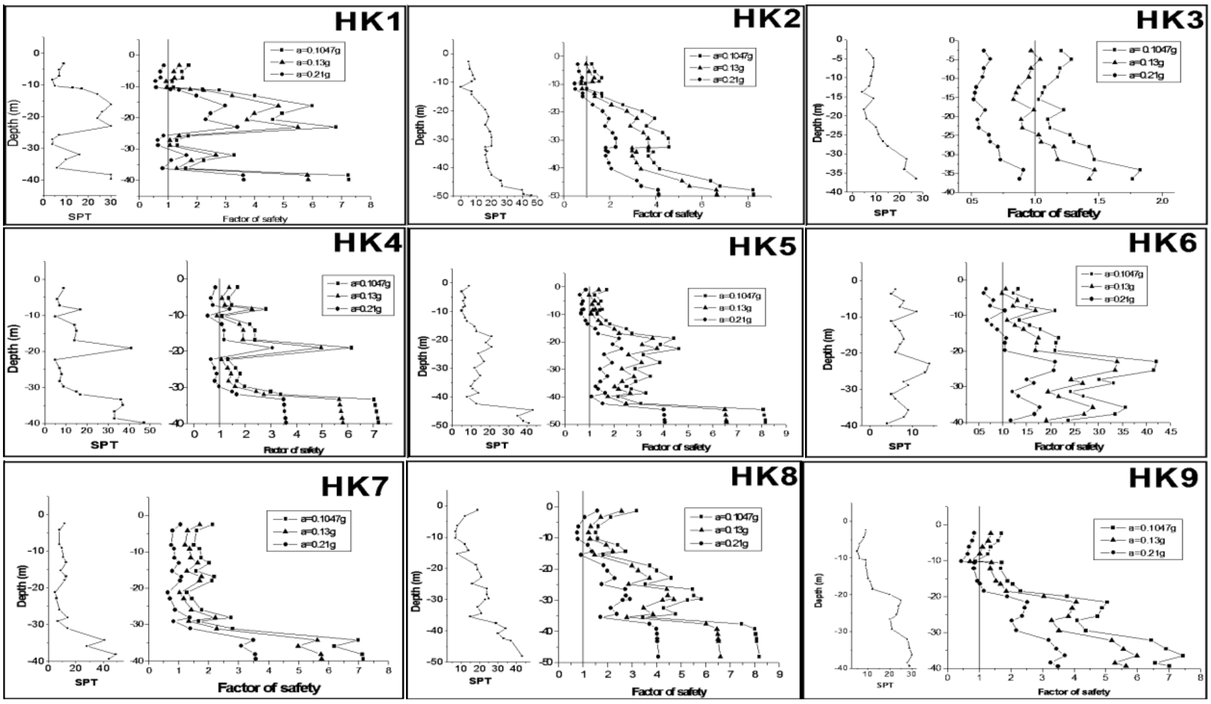

Fig.3 Factors of safety against liquefaction at boreholes HK1 to HK9.

Table 2 Size particle of layer 3A

CSH, Dried			
Diameter (mm)	Mass retained (g)	Percent retained (%)	Percent passing (%)
4.75	0.4	0.13%	99.87%
2	1.4	0.47%	99.40%
0.425	5.74	1.91%	97.49%
0.25	78.52	26.15%	71.34%
0.106	191.31	63.72%	7.62%
0.075	14.339	4.78%	2.84%
Pan	8.54	2.84%	0.00%
Sum	300.249	100.00%	

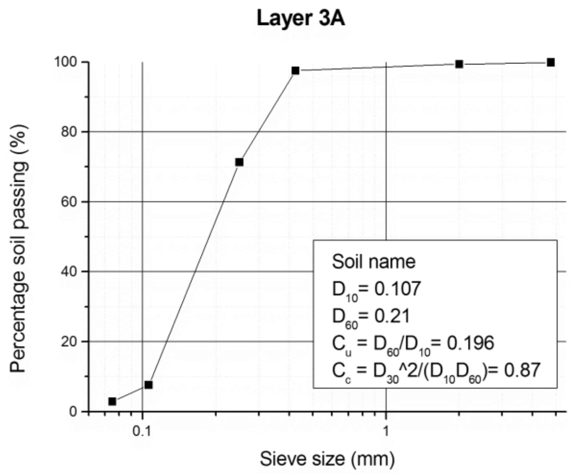

Fig.4 Size particle of layer 3A

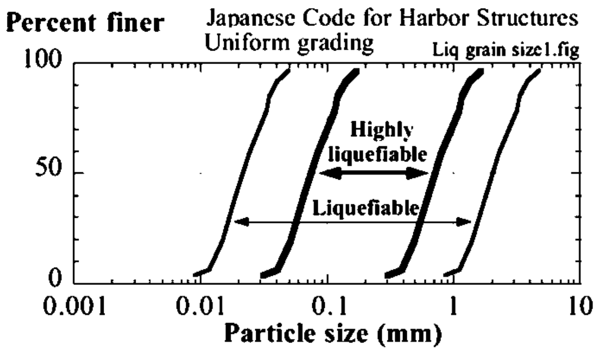

Fig.4 Uniform grading.

effect of fine content was neglected due to its small percentage.

(2) Size particle analysis of soil in layer

In the result of analyzing liquefaction of 9 holes, the layer 3A can be observed as the most sensitive with liquefaction with factor of safety are lowest compare with other layer. Table below is the result of size particle analysis of soil in layer 3A by using sieve analysis method

The layer 3A is medium size sand with some gravel, medium dense–dense. Base on the figure of analysis soil partical for layer 3A, more than 90% of soil is sand, so it is available to liquefaction

5. CONCLUSION

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

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 (amax=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.

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