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GEOLOGICAL AND GEOTECHNICAL ENGINEERING IN RESPONSE TO CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT OF INFRASTRUCTURE

Quang Binh, 21&22 September 2018

INTERNATIONAL CONFERENCE

VIETGEO 2018

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VIETGEO 2018

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PREFACE

Infrastructure development towards the sustainability in Vietnam as well as in the world is facing with many challenges, especially in the context of global climate change. Smart responses to climate change for harmonious and sustainable development are a legitimate desire. This is also the responsibility in the hands of scientists in general and geological - geotechnical engineers in particular.

Following the development and the success of the first conference in Hue 2012 (HueGeo 2012), the second in Hanoi in 2015 (HanoiGeo 2015), the third in Halong in 2016 (VietGeo 2016), the fourth international conference will be officially named VietGeo 2018. VietGeo 2018 is co-organized by the Vietnam Association of Engineering Geology and the Environment (VAEGE); Hanoi University of Mining and Geology (HUMG); Quang Binh Department of Science and Technology; Yamaguchi University, Japan; Suranaree University of Technology, Thailand; Tongji University, China; Ho Chi Minh University of Technology (HCMUT); VNU University of Science, Vietnam National University Hanoi (VNU-HUS); Hue University of Sciences - Hue University (HUSC); Hydraulic Construction Institute (HCI) and Technical World Co. Ltd (TW) on 21st and 22nd September 2018 in Dong Hoi city, Quang Binh province, Vietnam.

VietGeo 2018 will focus on the following themes:

- Slope stability and prediction,
- Coastal geotechnical engineering in response to climate change,
- Deep foundation and underground construction,
- Ground improvement method for infrastructure construction,
- Geotechnical instrumentation and materials.

VietGeo 2018 has received many kind supports from Quang Binh Department of Science and Technology, Technical World Co. Ltd (TW), FECON Corporation, GMC Investment and Development Co.Ltd. (GMC), Research Center for Technology and Industrial Equipment (RECTIE), Union of Survey and Construction J.S.C (USCO), Geotechnical Research Cenre - HUMG, Nam Mien Trung Co. Ltd, Hanoi Construction Design Investigation Consultants J.S.C, Power Engineering Consulting J.S.C 1 (PECC1), Hydraulic Construction Institute (HyCI).

The organizing committee would like to express our sincere thanks and appreciations to all of participants and supporting institutions. Special thanks to members of the advisory board, local volunteers and especially those of the secretariats who handle the daily hard work to make the conference successful.

We hope you will find this conference not only a chance to discuss, to share experience but also to explore cooperative opportunities.

Organizing Committee of VIETGEO 2018

EFFECTS OF CYCLE NUMBER OF TRIAXIAL CYCLIC TEST AND SAND DENSITY ON DYNAMIC PROPERTIES OF SAND OF THE THAI BINH FORMATION IN HANOI AREA

Nguyen Van Hung, Nguyen Thanh Duong,

Bui Van Binh, Phung Huu Hai, Pham Thi Ngoc Ha

Hanoi University of Mining and Geology, Vietnam

Corresponding author' Email: nguyenvanhung.dcct@humg.edu.vn

Abstract: Hanoi area is home that has many constructions with different loads. There are many building, which has foundation on sand layer of Thai Binh formation. However, this soil is very sensitive to liquefy. Based on the sand density, it is possible to assess the liquefaction ability of this layer, from that assessing the stability of these buildings. In general, sand of Thai Binh formation is at risk of liquefaction when subjected to dynamic loading. However, depending on the density and depth of ground water table in the area, as well as the dynamic loading conditions, liquefaction ability is different. From this, it is possible to set the foundation solutions and appropriate treatment to ensure stable and long-term works. The article used a cyclic triaxial equipment to investigate the effect of sand density on Thai Binh formation sand's ability to liquefy. The research result shows that with density of sand is over63 %, it is not liquefied (the liquefaction cyclic number is 48 with cyclic loading amplitude is 40kPa and effective consolidation pressure is 110kP).

Keywords: density, liquefaction, sand, Thai Binh formation, Hanoi area

1. Introduction

Liquefaction is a geological phenomenon caused by cyclical dynamic loadings such as earthquakes, foundation of dynamical engine, pile driving, train, etc. This phenomenon greatly affects the constructions, which have foundation distributed on the saturated sand. In the world, many buildings are destroyed by the phenomenon. These earthquakes caused the liquefaction that makes thousands of people died or injured, thousands of houses were destroyed. For example, the earthquake had occurred on Christchurch (New Zealand, on 22 February 2011) - a magnitude 6.3 earthquake caused severe damage, killing 185 people and injuring several thousand, Kashiwarashi, Niigata (Japan, July 16, 2007) - caused minor tsunamis and buckled roads and bridges in the region.

Hanoi capital is a cultural and political center of Viet Nam, where important works are concentrated. It also means ensuring the safety of constructions in the city. Therefore, study on the liquefaction phenomenon of sand of Thai Binh formation allows to predict the impact of earthquakes on the stability of construction works with foundation related to sand layer of Thai Binh formation in Hanoi area. On the other hand, it also allows for earthquake safety assessments for newly constructions. At present, the impact of sand density of Thai Binh formation sand's ability to liquefy has not been researched. On the other hand, this effect is one of the major causes of liquefaction. Thus, the study of sand density of Thai Binh formation sand has the potential to minimize the incidents occurring with buildings

2.Characteristics of sand in the Thai Binh formation (aQ_2^3tb)

Characteristics of sand in the Thai Binh formation (aQ_2^3tb) in Ha Noi area:

According to the study of dynamic consolidation phenomenon and change the durability of soil foundation in Ha Noi area under dynamic loading to improve the geotechnical information system for sustainable development and prevention of hazard, Nguyen Huy Phuong, the physico-mechanical of Thai Binh formation sand is the fine sand, greenish gray, yellowish gray, medium density

In general, the thickness of this layer changes sharply from 0.6m to 32.5m, average 14.2m. The particle size and some physico-mechanical properties of this layer are presented in Table 1.

***The characteristics of sand in this study*:** In this study, 11 sand samples were taken at Electronic triangles Works, To Huu Road, Trung Van Ward, Nam Tu Liem District and FLC complex twin tower, Cau Giay District, Hanoi. Results of particle size and physico - mechanical properties of this soil are shown in Table 2.

Tab. 1. The particle size and physico-mechanical properties of Thai Binh formation sand

5-2 (mm), %	2-0.5 (mm), %	0.5-0.25 (mm), %	0.25-0.1 (mm), %	0.1-0.05 (mm), %	<0.05	Angle of Repose for sand		SPT
						Dry	Saturation	(N)
0.3	5.3	25.8	43.3	15.2	10	$31^0 08'$	$24^0 59'$	12
Number of specimens n=685					R_0=150 kPa		E_0=10800 kPa	

Tab. 2. Particle size and physico – mechanical properties of sand used in testing

No.	Content	Symbol	Units	Value

		1-0,5			4.9
		0,5-0,25			51.4
1	Particle size (mm)	0,25-0,1	P	%	26.4
		0,1 -0.05			9.1
		< 0.05			8.2
2	Bulk density		γ_c	g/cm^3	2.66
3	Void ratio	Max.	e_{max}	-	1.200
		Min.	e_{min}		0.592
4	Size diameter		D_{60}	mm	0.121
			D_{30}		0.107
			D_{10}		0.06

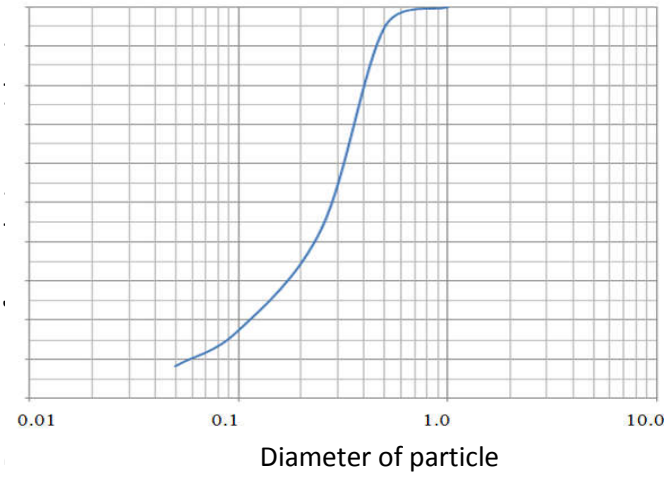


Fig. 1. Percentage of cumulative particle size

Testing procedure: According to ASTM D5311-92, cyclic triaxial test to determine the liquefaction characteristics of sand are carried out in the following steps: Specimen saturation, consolidation and cyclic loading.

Specimen saturation: To fill water in the voids of the sand. This step is carried out by increasing the cell pressure and back pressure at each level, until the saturation rises above or equal to 95%. The difference between the cell pressure and the back pressure is 10kPa in all pressure levels.

Specimen consolidation: Specimen is consolidated by increasing the cell pressure to the desired effective coherent pressure value. Meanwhile, back pressure is kept constant. The effective consolidation pressure is the difference between the cell pressure and the back pressure. This process ends when the consolidation reaches over 90%. According to the study's research, for the tests to determine the effect of sand density (Dr) on the liquefaction cycle, the effective consolidation pressure σ'_{3c} was obtained in the range of 50 kPa to 110 kPa for all samples.

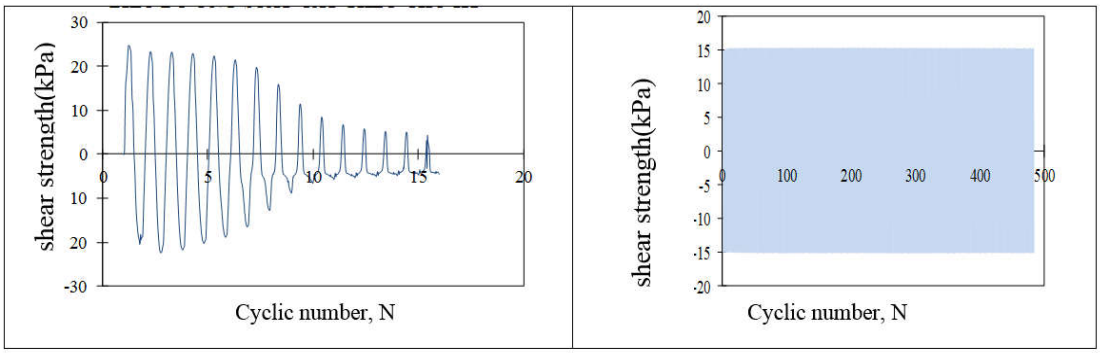
Cyclic loading: At this stage, the cyclic loading diagram and parameters: frequency, amplitude and number of cyclic are set for each specimen. This stage ends when the liquefaction occurs or after a certain period of time and number of cycles, the specimen is not liquefied. Figure 3 shows the result of two specimens corresponds to the case specimen is liquefied and not liquefied.

Based on historical earthquake characteristics in Hanoi, the largest earthquake in Hanoi corresponds to level 8 (6-6.8 Richter scale), the experiment parameters are as follows:

Frequency (f): The data show that in the Hanoi area, earthquakes usually occur with a common cycle of 0.2 - 2s equivalent to the frequency f = 5 - 0.5Hz. Within the scope of the study, for the purposes of the study and laboratory equipment, the frequency of f = 2Hz was chosen and applied to all experiments.

Amplitude (σ_d): To determine the effect of density on sand liquefaction ability, the amplitude σ_d = 40kPa (corresponding to the level 8 earthquake, from 5 to 7m depth) was selected for all experiments.

The initial mean effective stress(σ'_{3c}): In this experiment, the initial mean effective stress was used to tighten the sample for each purpose. The greater the cohesive force, the stronger the sample. Within the scope of the topic, the initial mean effective stress σ'3c is taken from 70 - 110kPa.



a) b)

Fig. 2. Specimen is liquefied (a) and not liquefied (b)

Tab. 3. The result of cyclic triaxial test to determine the effect of sand density on liquefaction cycle

No.	Specimen	Density of sand	Frequency	Cyclic loading amplitude	Effective consolidation pressure	Porewater pressure	Liquefaction cycle
		Dr(%)	f (Hz)	σ_d (kPa)	σ'_{3c} (kPa)	r_u	N
1	C9	53.9	2	40	70	1	11
2	C10	51.7	2	40	70	1	5
3	C11	56.1	2	40	70	1	13
4	C12	58.6	2	40	90	1	14
5	C13	55.9	2	40	90	1	12
6	C14	80.1	2	40	90	0.3	>150
7	C15	65.9	2	40	100	1	43
8	C16	72.6	2	40	110	1	78
9	C17	77.3	2	40	110	1	107
10	C19	63.1	2	40	110	1	48
11	C20	60.1	2	40	100	1	21

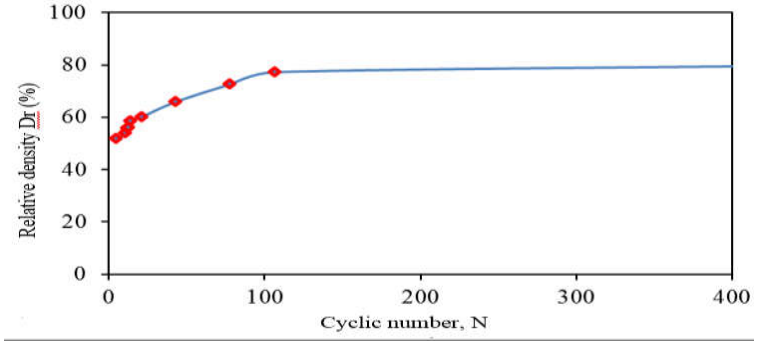


Fig. 3. Relation between sand density and liquefaction cycle of Thai Binh formation sand

3. Results and discussions

Eleven specimens of sand were tested to determine the effect of sand density (Dr) on the liquefaction cycle of sand in the Thai Binh formation in Hanoi. Specimens were reconducted and consolidated under different effective consolidation pressure levels to achieve the desired density. In the study, the samples with a density were in the range of 54.9% to 80.1%, the frequency f = 2Hz, the cyclic loading amplitude σ_d = 40 kPa, effective consolidation pressure σ'_{3c} is between 70 kPa and 110 kPa. The experimental results are shown in Table 3.

From the test result, it was found that, as sand density increased, the number of liquefaction cycles increased. For specimen with a density, Dr = 51.7%, the number of liquefaction cycles is 5, with density of Dr = 80.1%, the specimen is not liquefied. The results are shown in Figure 4.

This is explained as follows: when the density of sand, Dr is increased, the density of solid particles in the soil increases. When subjected to dynamic loading on the specimen, the particles tend to realign. The higher the relative density of sand, the realignment is faster. And it will be to achieve stability. As sand density increases, excess pore water pressure increases slowly, making sand hard to liquefy. On the other hand, the greater the density of the sand, the friction between the particles increases, resulting in increased liquefaction resistance.

Discussions

- Sandy soil of Thai Binh Formation is a type of soil that is prone to occur when liquefied by the dynamic loading. However, depending on the location of the site, the depth of the water table, the particle size, as well as the dynamic loading conditions, their liquefaction capacity may vary.

- The density of sand influences the liquefaction cycle. As the density increases, the number of liquefaction cycles increases. With fine sand and very tight, liquefaction does not occur. For sand in the Thai Binh Formation, under undrained conditions, with frequency f = 2Hz, Cyclic loading amplitude σ_d = 40kPa (corresponding to earthquake

level 8, at depth 5-7m), when sand density more than 80%, liquefaction is not likely to occur.

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