第十七屆東南亞大地工程研討會

17 SEAGC

The Seventeenth Southeast Asian Geotechnical Conference

May 10~13, 2010, Taipei, Taiwan

Geo-engineering for Natural Hazard
Mitigation and Sustainable Development

PROCEEDINGS Vol. I

Theme Sessions

Organized by

Southeast Asian Geotechnical Society (SEAGS)

Taiwan Geotechnical Society (TGS)

Co-Organized by

National Taiwan University (NTU)

Association of Geotechnical Societies in Southeast Asia (AGSSEA)

Foreword

The Southeast Asian Geotechnical Society (SEAGS) mainly consists of the members from SEA countries. When SEA country societies became the members of the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE), the SEAGS retains its role in providing the platform for exchange and sharing of the knowledge among its members and the allay with other SEA societies. Since 1967, sixteen SEAGC conference have been held in the major cities in Southeast Asia, i.e., Bangkok (1967, 1977, 1987, 2004), Singapore (1970, 1993), Hong Kong (1972, 1982, 2001), Kuala Lumpur (1975, 1985, 1996, 2007) and Taipei (1980, 1990, 1998). After the 16th SEAGC, the Association for Geotechnical Societies of Southeast Asia (AGSSEA) was founded to enhance the connections between the SEAGS and other SEA societies. This is the forth time Taipei hosts the SEAGS conference. The Conf. is organized by SEAGS with the major help from Taiwan Geotechnical Society (TGS).

The main theme of 17SEAGC is Geo-engineering for Natural Hazard Mitigation and Sustainable Development. Nine theme topics are covered as follows,

1. Site characterization and laboratory testing
2. Ground improvement and reinforcement
3. Design, construction and performance of foundations
4. Ground excavations and tunneling
5. Landslide and debris flow hazard mitigation and rehabilitation
6. Geotechnical earthquake engineering
7. Geo-environmental engineering
8. New generation design code developments
9. Geo-information and land reclamation technologies

As a result, two keynote lectures, two guest lectures, one special guest lecture and a Forum as well as the theme sessions are scheduled. The special sessions are organized by TGS, ATC3, ATC10, JWG-DMR/TC39 and GEOSNet/TC304, respectively. More than 130 papers are contributed by more than 200 delegates from 21 countries in the 17SEAGC program. The Conf. Proceedings have two volumes. The Vol. I collects the papers presented in the Theme Sessions; Vol. II presents the articles collected for plenary sessions and special sessions. The minutes of the discussions, Q&A, Forum and GC/Member Meeting of SEAGS and Council Meeting of AGSSEA as well as other activities during the Conf. shall be prepared as e-copies and retained by CD ROM after the Conf.

Special thanks are due at this stage to all the delegates, the members and referees of the technical committee. The supports given by the members of the Organizing Committee and Conference Committee are gratefully acknowledged. Thanks are also due to those individuals and organizations who have supported and assisted either financially or in other manner. Without all these supports, a successful 17SEAGC cannot be reached.

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Theme Session 5B - Geotechnical earthquake engineering (I)

Liquefaction Potential Post-Earthquake in Yogyakarta

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ABSTRACT: A 6.3 Mw earthquake on May 27, 2006 shook the provinces of Yogyakarta, number of seismic damages were reported. The damages were identified because of liquefaction phenomena during the ground vibration. The Universitas Muhammadiyah Yogyakarta (UMY) campus was constructed on 28 hectare which mostly rested on a sand deposit layer and the ground water table was shallow relatively. Theoretically, the site was susceptible to liquefaction during ground-shaking. Reconnaissance study after the earthquake was found some sand boiling sites near at the UMY area. This paper addresses two major objectives that is to evaluate the possible ground acceleration and liquefaction probability at UMY campus after the earthquake. Liquefaction potential was analyzed based on the SPT-N data from six bore-holes. The probability of liquefaction was also investigated with the depth from ground surface. Three different peak ground accelerations, i.e. 0.14g, 0.25g, and 0.49g, were evaluated in this study. The results show that liquefaction triggered at very shallow depth in area near BH1, BH2, and BH4. Area surround BH3, BH5, and BH6 were susceptible to liquefaction at a depth below 20 m from ground surface. In general, liquefaction occurred with probability ranging from 5% to 90%.

1. INTRODUCTION

The tectonic setting of Java is dominated by the subduction of the Indo-Australian plate under the Eurasian plate, which causes large deep earthquakes mainly north of Java. It is then one of the seismic sources in this area. High frictional stresses also cause medium earthquakes on the over-riding plate that are observed often within and to the south of the Island. The megathrust region to the west-north west of Java has also caused colossal earthquakes. Therefore, the study region is subjected to three potential earthquakes, medium, large and massive. Geology of the Yogyakarta area are mostly covered by quaternary young volcanic deposit of Merapi Volcano. These young volcanic deposits are composed of tuff, ash, breccia agglomerate and lava flows [1]. The weathered breccia and loose tuff were the main deposits exposed at most areas. This may have caused some areas in Yogyakarta and its vicinity to geotechnical hazards. Bantul region is precisely situated in a quake's vulnerable path of Opak Fault. This fault is one of the very important geological structures of Java Island, due to which the earthquake relative displacement occurred and from which the seismic waves emanated. Some fault plane solutions point towards a left-lateral strike-slip mechanism. The estimated fault rupture dimensions are 20 km long by 10 km wide. The earthquake of M_w 6.3 shaking on May 27, 2006 was captured by a number of seismographs.

Extensive damage to houses concentrated in lowland areas. Sand boiling evidences was reported by some witnesses indicating liquefaction. The Universitas Muhammadiyah Yogyakarta (UMY) is located in 28 hectare loose sand deposit and very shallow ground water table. Theoretically, the area was susceptible to liquefaction hazard. However, the effect was minimal so there was no severe damage for building. Lateral spreading and differential settlement was observed at Main Library building during the seismic vibration. It is significant to study liquefaction potential in the hazard area to have an understanding about hazard risk and reduction. This paper presents the analysis of liquefaction potential based on standard penetration test (SPT) data. The analysis was aimed to evaluate the liquefaction probability at various depth of the area.

2. CHARACTERISTICS OF THE STUDY AREA

Site investigation has been conducted a month after the earthquake to assess sub-surface characteristics. The location of the building and bore holes are presented in Fig. 1. Based on the boring investigation (Fig. 2), the campus of UMY is majorily covered by 8 m to 10 m thick sandy soil layers. Loose sand layer generally appears at the depth from 3 m to 10 m. The ground water table is at the depth of 0.5 m to 1.0 m. The unit weight of the soil above water table was 16.4 kN/m^3 in average, while the unit weight of soil below water table was about 20.4 kN/m^3 in average. The particle size distribution curves of sites are presented in Fig. 3. The fine content of the soil was 10.5% in average. The average particle diameter D_{50} of the soil at Masjid building range from 0.07 mm to 0.57 mm (the mean and variance was 0.26 mm and 0.025 mm, respectively), and at Library building, the range of D_{50} was between 0.057 mm – 0.841 mm (the mean and variance value was 0.57 mm and 0.054 mm, respectively). Comparing with curves from other researches [2], it is obvious that the sandy soils in UMY area fall in the range of sands with high liquefaction potential.

3. ASSESSMENT METHOD FOR LIQUEFACTION POTENTIAL

Calculation, or estimation, of two variables is required for evaluation of liquefaction resistance of soils: (1) the seismic demand on a soil layer, expressed in terms of cyclic stress ratio (CSR) to generate liquefaction; and (2) the capacity of the soil to resist liquefaction, expressed in terms of cyclic resistance ratio (CRR). A simplified method to estimate CSR was also developed by Seed and Idriss [2] based on the peak ground surface acceleration (a_{max}) at the site. This simplified approach can be summarized as follows:

$$CSR_{eq} = \frac{\tau_{av}}{\sigma'_{vo}} = 0,65\left(\frac{a_{\max}}{g}\right)\cdot\left(\frac{\sigma_{vo}}{\sigma'_{vo}}\right)\cdot r_d \qquad (1)$$

where τ_{av} is the average cyclic shear stress; a_{max} is the maximum horizontal acceleration at the ground surface; g = 9.81 m/s^2 is the acceleration due to gravity; σ_{vo} and σ'_{vo} are the total and effective vertical overburden stresses, respectively; and r_d is a stress-reduction factor which is dependent on depth. The factor r_d can be estimated using the following bi-linear function, which is originally proposed by Seed and Idriss [2].

$$r_d = \begin{cases} 1-0,00765z & ;\text{ if } z < 9,15 \text{ m} \\ 1,174-0,0267z & ;\text{ if } 9,15 \le z \le 23 \text{ m} \end{cases} \qquad (2)$$

Youd and Idriss [3] suggested that the insitu equivalent uniform cyclic stress ratio must be evaluated as:

$$CSR^*_{eq} = \frac{CSR_{eq}}{MSF}\cdot K_\sigma \qquad (3)$$

where MSF = magnitude scaling factor = $(10^{2.24}/M_w^{2.56})$, M_w = magnitude of earthquake, and K_σ = correction factor = $(\sigma_{vo}')^{f-1}$, f = 0.6 – 0.8.

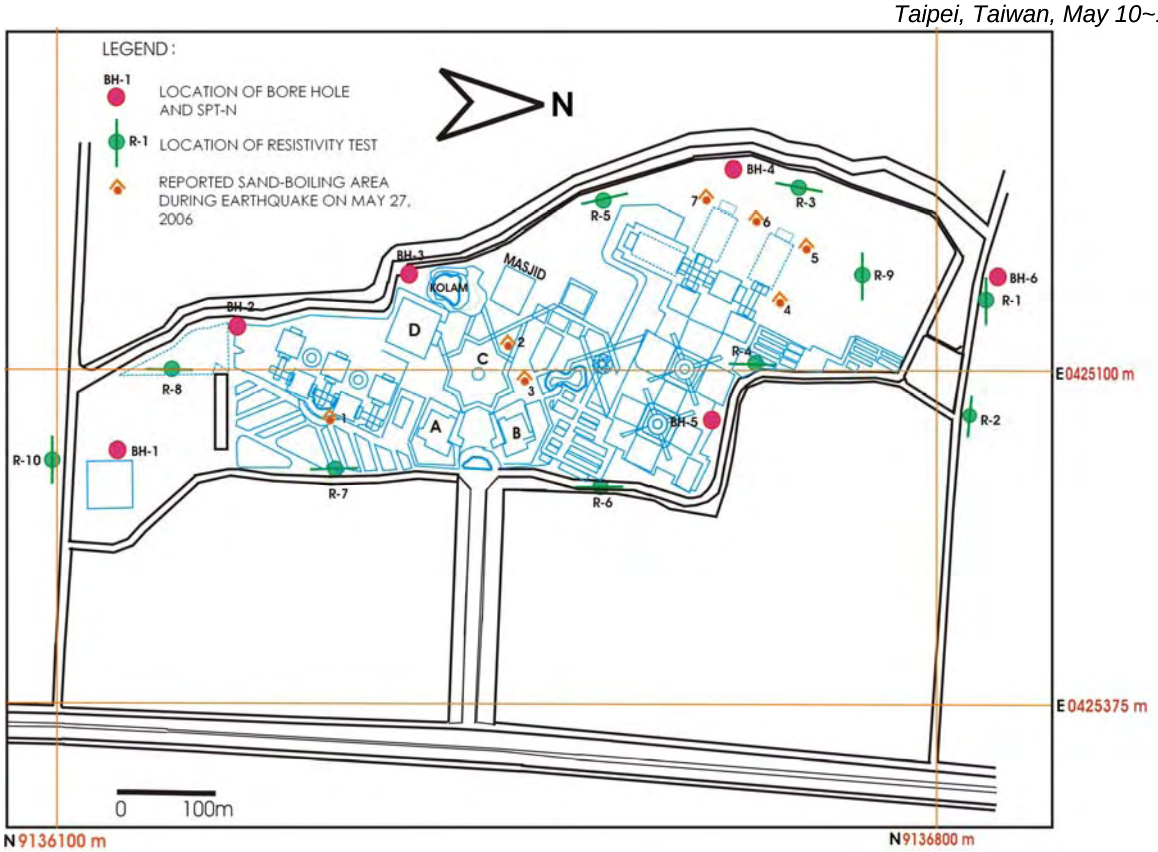

Figure 2 Location of the bore holes and SPT investigation

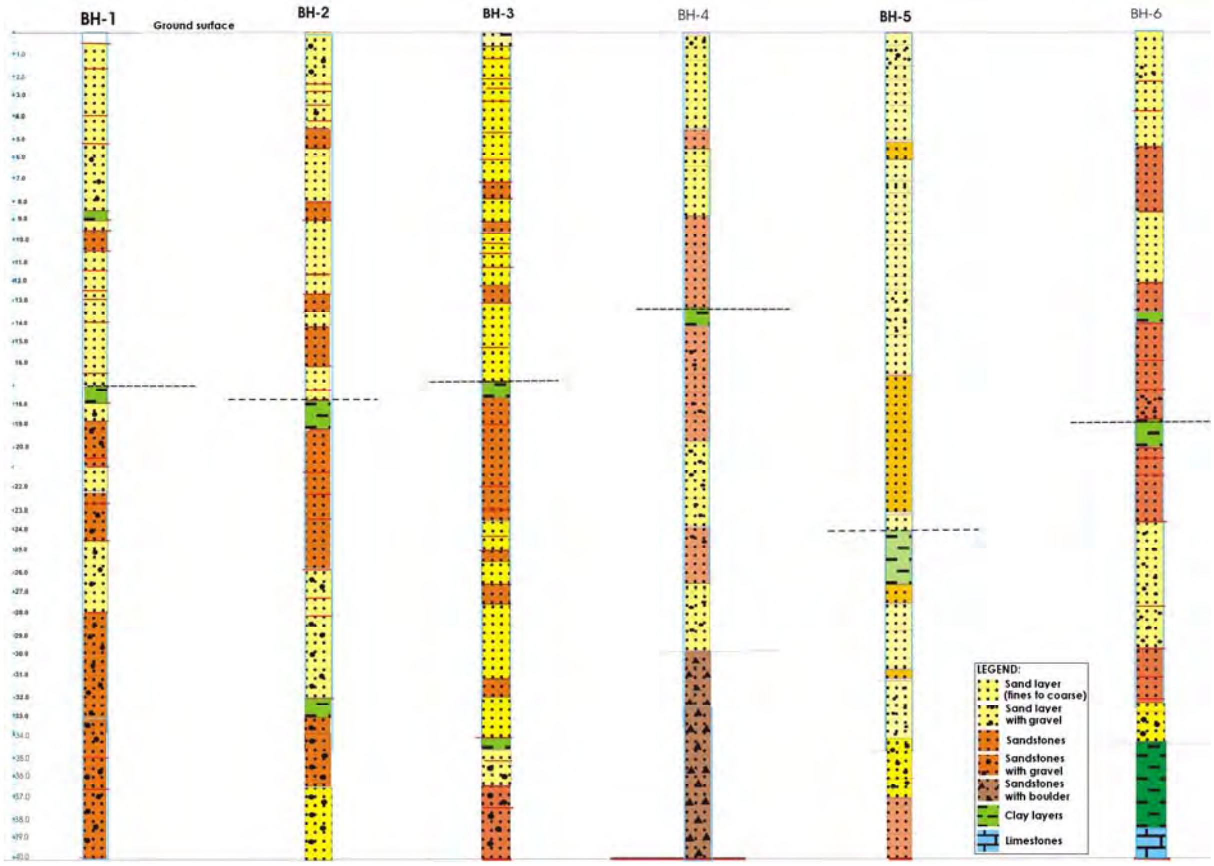

Figure 1 Sub-surface profile at UMY campus

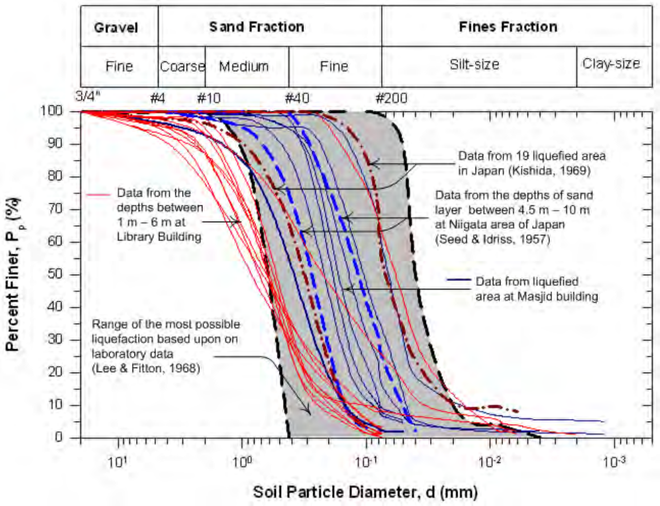

Figure 3 Particle size distribution of the soil at hazard area.

In this study, the magnitude M_w is 6.3 and f is taken 0.7. The ground accelerations of about 0.10g to 0.14 g were proposed most possible for the hazard area [4].

Criteria for evaluation liquefaction resistance based on the SPT was determined from the value of the corrected $(N_1)_{60}$. The value was suggested by Youd and Idriss[3] as :

$$(N_1)_{60} = N_m C_N C_E C_B C_R C_S \tag{4}$$

where N_m = measured standard penetration resistance; C_N = factor related to effective overburden stress; C_E = correction for hammer energy ratio; C_B = correction factor for borehole diameter; C_R = correction factor fro rod length; and C_S = correction for samplers with or without liners. For this study, the corrected factor for overburden stress are determined as C_N = $(100/\sigma_{vo}')^{0.5}$. The maximum value of C_N is 1.7. The values of C_E, C_B, and C_S are 0.9, 1.15, and 1 respectively. The value of C_R ranges from 0.75 to 1 depending on the rod length.

The corrected $(N_1)_{60}$ is further corrected for adjustment of fines content.

$$(N_1)_{60,CS} = C_F\,(N_1)_{60} \tag{5}$$

The corrected factor for fines content (C_F) is defined using the following relationship:

$$C_F = 1 + 0.004FC + 0.05\left(\frac{FC}{(N_1)_{60}}\right), \text{ for } 5\% \geq \text{FC} \leq 35\% \tag{6}$$

where, FC = percent fines content, $(N_1)_{60}$ = units of blows.

4. RESULTS AND DISCUSSION

Assessment of liquefaction needs the data of ground acceleration. However, the accelerometer data from the sites were not available. Some studies recommended various possible maximum horizontal ground acceleration of the hazard area i.e. 0.14g [4], 0.49g [5], and 0.25g [6]. Lee et al. [4] estimated the a_{max} from back-calculation based on the CPT, CPTu and SPT data. Elnashai et al. [5] estimated the a_{max} from the seismograph measured at YOGI station. Lastly, Soebowo et al. [6] back-calculated the a_{max} from CPT, CPTu, and SPT data. Using those different a_{max}, the liquefaction potential is presented in the form of relationship between insitu equivalent cyclic stress ratio (Eq. 3) and corrected of SPT blows (Eq. 5) as shown in Fig. 4. Based on this figure, the liquefaction was not likely to occur for a_{max} = 0.14g as suggested by Lee et al., [4]. The liquefaction is initially occurred if the a_{max} = 0.25g as proposed by Seobowo et al. [6].

Using equation proposed by Cetin et al. [7] to assess probability of liquefaction (P_L), variation of the P_L with depth can be evaluated. The results show that liquefaction triggered at shallow depth up to 5 m below ground surface in area near BH-1 (Fig. 5), BH2, and BH4. Area surround BH-3, BH-5, and BH-6 (Fig. 56) were susceptible to liquefaction at a depth below 20 m from ground surface. In general, liquefaction occurred with probability ranging from 5% to 90%. Area near BH1 was occupied by sportorium building. Library building, Faculy of Engineering building, and student dormitory are rested on the area near BH3, BH5, and BH6 respectively.

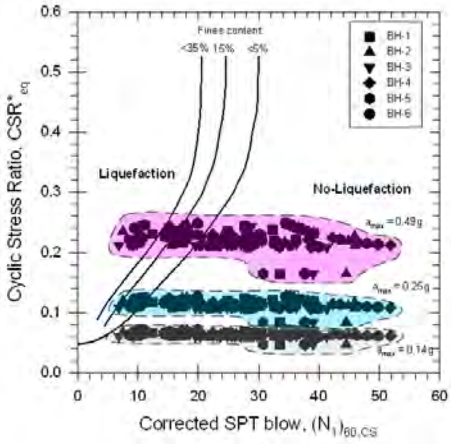

Figure 4 Liquefaction potential based on the SPT with a_{max} = 0.14g, 0.25g, and 0.49g..

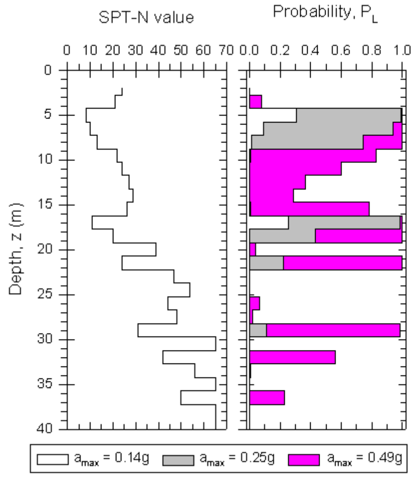

Figure 5 Variation of SPT-N and probability of liquefaction with depth at BH1.

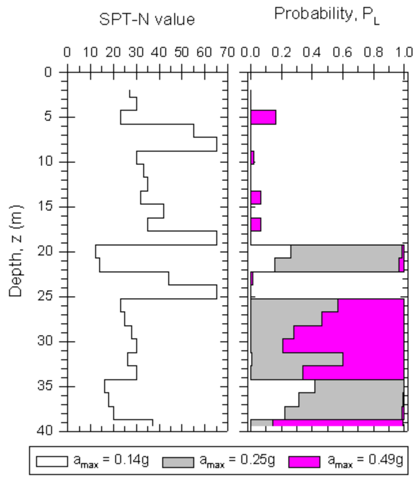

Figure 6 Variation of SPT-N and probability of liquefaction with depth at BH6.

5. CONCLUSIONS

The paper has presented an evaluation for liquefaction potential based on SPT data. Three different peak ground accelerations have been used for analysis. Thus far, liquefaction was likely to occur initially if the a_{max} reached 0.25g. he results show that liquefaction triggered at shallow depth up to 5 m below ground surface in area near BH-1, BH2, and BH4. Area surround BH-3, BH-5, and BH-6 were susceptible to liquefaction at a depth below 20 m from ground surface. In general, liquefaction occurred with probability ranging from 5% to 90%.

6. REFERENCES

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