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 (SEAeS)
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 ally 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.

Dr. John Chien-Chung Li

Prof. Meel-Ling Lin
Conference Committee

Chairperson
Prof. Meei-Ling Lin (NTU)

Vice Chairperson
Prof. Cheng-Hsing Chen (NTU)
Prof. Hung-Jiun Liao (NTUST)
Prof. Horn-Da Lin (NTUST)

Secretary General
Prof. Der-Wen Chang (TKU)

Deputy Secretary General
Prof. Jie-Ru Chen (NCNU)

Secretary
Mr. Ting-Chiu Su (MAA)

Members
Mr. Chiang-Huai Chen (PGEA)
Prof. Tien-Chien Chen (NPUST)
Mr. Yu-Tong Chung (SGRDF)
Prof. Yung-Shan Hong (TKU)
Dr. Lee-Ping Hsu (TCRI)
Prof. Ming-Lang Lin (NTU)
Dr. Chwen-Huan Wang (Geopier Fdt.)
Prof. Tai-Tien Wang (NTUT)

Dr. Chien-Chang Chen (PGEA)
Dr. Nelson Chou (SEC)
Mr. Tai-Yuan Ho (CECI)
Prof. Yo-Ming Hsieh (NTUST)
Prof. Wei Feng Lee (NTUST)
Prof. Tzou-Shin Ueng (NTU)
Dr. Kuo-Lung Wang (NTU)

Session coordinators and paper reviewer

Dr. Kuang-Tzung Chang (NCHU)
Dr. Wilson Chang (BHSR, MOTC)
Mr. Ta-Cheng Chen (MAA)
Mr. Chung Ren Chou (MAA)
Ir. Chee-Meng Chow (IEM, Malaysia)
Prof. Tao-Wei Feng (CYU)
Dr. Hsii-Sheng Hsieh (TFEC)
Mr. I-Chou Hu (MAA)
Prof. Chung-Jung Lee (NCU)
Prof. Min-Lang Lin (NTU)
Prof. Trevor L. L. Orr (Trinity U, Ireland)
Mr. Ting-Chiun Su, (MAA)
Prof. Tzou-Shin Ueng (NTU)
Prof. Tai-Tien Wang (NTUST)
Dr. Meng-Chia Wenz (NUK)

Prof. Wen-Jong Chang (NCKU)
Prof. Jie-Ru Chen (NCNU)
Mr. Teh Chin (UGI)
Mr. Kelvin K.S. Chou (CECI)
Mr. Shaw-Wei Duann (MAA)
Mr. Tai-Yuan Ho (CECI)
Prof. Y. M. Hsieh (NTUST)
Prof. Jin-Hung Hwang (NCU)
Prof. Horn-Da Lin (NTUST)
Mr. Pen-Chi Lin (MAA)
Prof. Hsin-Yu Shan (NCTU)
Mr Ek-Khai Tan (SEAGS)
Mr. Ching-Ping Wang (CECI)
Prof. Yu Wang (CUHK, Hong Kong)
Mr. Tung-Lih Yen (MAA)
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seepage and Slope Stability Analysis on the Occurrence of Debris Flow at Jinhu, Korea</td>
<td>318</td>
</tr>
<tr>
<td>Chan-Young Yune, Kyoung-Hea Jun, Gangnyung-Wonju National University (Korea, Republic Of), Heung-Seok Seo, Gangneung Yeongdong College (Korea, Republic Of)</td>
<td>322</td>
</tr>
<tr>
<td>Regional Scale Natural Terrain Landslide Risk Assessment: An Example from West Lantau, Hong Kong</td>
<td>326</td>
</tr>
<tr>
<td>S.W. Millis, Ove Arup &amp; Partners Hong Kong Limited (Hong Kong), K.B. Clahan, Fugro (Hong Kong) Limited / William Lettis &amp; Associates (Hong Kong), S. Parry, Georisk Solutions (Hong Kong)</td>
<td>331</td>
</tr>
<tr>
<td>Engineering Geology of Rock Slopes - Some Recent Case Studies in Malaysia</td>
<td>336</td>
</tr>
<tr>
<td>Boon-Kong Tan, Petaling Jaya (Malaysia)</td>
<td>343</td>
</tr>
<tr>
<td>The Relationship of Displacement Rate and Factor of Safety for Lu-Shan Landslide during Torrential Rainfall</td>
<td>347</td>
</tr>
<tr>
<td>Der-Guey Lin, Jian-Ting Lu, National Chung-Hsing University (Taiwan), Huang Jen-Kai, Liming Engineering Consultant Company, Ltd (Taiwan)</td>
<td>351</td>
</tr>
<tr>
<td>A Case study of debris flow mitigation of No.3 valley at Sitou Nature Education Area</td>
<td>355</td>
</tr>
<tr>
<td>Kelvin K. S. Chou, Wen-Long Wu, Kung-Tai Chou, CECI Engineering Consultants, Inc., Taiwan (Taiwan), Cheng-Sheng Chang, 1Experimental Forest of Bio-Resources and Agriculture Colledge NTU (Taiwan)</td>
<td>359</td>
</tr>
</tbody>
</table>

**Theme Session 5B - Geotechnical earthquake engineering (I)**

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artificial Neural Network in CPT Base Liquefaction Prediction</td>
<td>343</td>
</tr>
<tr>
<td>Sik-Cheung Robert Lo, University of New South Wales at Australian Defence Force Academy (Australia), Mizanur Rahman, University of Canterbury (New Zealand), Sayed Abdul Mofiz, Rajshahi University of Engineering &amp; Technology (Bangladesh)</td>
<td>347</td>
</tr>
<tr>
<td>Ali Derakhshani, University of Tokyo (Iran (Islamic Republic Of)), Mohammad Sajjad Fayyazi, Khosrow Bargi, University of Tehran (Iran (Islamic Republic Of))</td>
<td>355</td>
</tr>
<tr>
<td>Degradation of Shear Modulus During Liquefaction Modeled in 1-D Centrifuge Shaker</td>
<td>359</td>
</tr>
<tr>
<td>Chung-Jung Lee, Yu-Chen Wei, Wen-Yi Hung, Huei-Tsyi Chen, National Central University (Taiwan), K.T. Chou, CECI Engineering Consultants, Inc. (Taiwan)</td>
<td>359</td>
</tr>
<tr>
<td>Analyses of Embankment Failures Associated with 2007 Noto Peninsula Earthquake</td>
<td>359</td>
</tr>
<tr>
<td>Tatsunori Matsumoto, Yusuke Nishiki, Shun-ichi Kobayashi, Takashi Shimominami, Kanazawa University (Japan)</td>
<td>359</td>
</tr>
<tr>
<td>Development and Verification of New Site Classification System and Site Coefficients for the Regions of Shallow Bedrock in Korea</td>
<td>359</td>
</tr>
<tr>
<td>Dong-Soo Kim, Sei-Hyun Lee, KAIST (Korea, Republic Of)</td>
<td>359</td>
</tr>
</tbody>
</table>
Liquefaction Potential Post-Earthquake in Yogyakarta

AGUS SETYO MUNTOHAR1 and S.P.R. WARDANI2
1 Department of Civil Engineering, Universitas Muhammadiyah Yogyakarta, Yogyakarta, Indonesia.
2 Department of Civil Engineering, Diponegoro University, Semarang, Indonesia
E-mail: muntohar@umy.ac.id

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 Mw 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 majorly 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/m² in average, while the unit weight of soil below water table was about 20.4 kN/m² 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 D₅₀ 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 D₅₀ 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 [1], and Youd and Idriss [3] based on the peak ground surface acceleration (a_max) at the site. This simplified approach can be summarized as follows:

\[ \text{CSR}_{eq} = \frac{\tau_{vo}}{\sigma_{vo}} = 0.65 \left( \frac{a_{max}}{g} \right) \left( \frac{\sigma_{vo}}{\sigma_{vo}} \right) \cdot r_d \]  

where \( \tau_{vo} \) is the average cyclic shear stress; \( a_{max} \) is the maximum horizontal acceleration at the ground surface; \( g = 9.81 \text{ m/s}^2 \) is the acceleration due to gravity; \( \sigma_{vo} \) and \( \sigma_{vo} \) are the total and effective vertical 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].

\[ r_d = \begin{cases} 1 - 0.0076z & \text{if } z < 9.15 \, \text{m} \\ 1.174 - 0.0267z & \text{if } 9.15 \leq z \leq 23 \, \text{m} \end{cases} \]  

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

\[ CSR^*_{eq} = \frac{\text{CSR}_{eq}}{\text{MSF}} \cdot K_p \]  

where \( \text{MSF} = \text{magnitude scaling factor} = (10^{24} M_w^{5.24}) \), \( M_w \) is magnitude of earthquake, and \( K_p = \text{correction factor} = (\sigma_{vo})^{0.1} \cdot f = 0.6 - 0.8 \).
Figure 1 Sub-surface profile at UMY campus

Figure 2 Location of the bore holes and SPT investigation
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 $(N_{60})_{b0}$. The value was suggested by Youd and Idriss[3] as :

\[
(N_{60})_{b0} = N_m C_F C_g C_R
\]

where $N_m$ = measured standard penetration resistance; $C_F$ = factor related to effective overburden stress; $C_g$ = correction factor for hammer energy ratio; $C_R$ = correction factor for rod length; and $C_g$ = correction factor for samplers with or without liners. For this study, the corrected factor for overburden stress are determined as $C_F = (100/\sigma_{vo})^{0.5}$. The maximum value of $C_F$ is 1.7. The values of $C_F$, $C_R$, 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 $(N_{60})_{b0}$ is further corrected for adjustment of fines content.

\[
(N_{60})_{b0} = C_F (N_{60})_{b0}
\]

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

\[
C_F = 1 + 0.004FC + 0.05 \left( \frac{FC}{(N_{60})_{b0}} \right), \text{ for } 5\% \leq FC \leq 35\%
\]

where, $FC$ = percent fines content, $(N_{60})_{b0}$ = 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 Soebowo 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. 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%. Area near BH1 was occupied by sportarium building. Library building, Faculty of Engineering building, and student dormitory are rested on the area near BH3, BH5, and BH6 respectively.
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. The results show that liquefaction triggered at shallow depth up to 5 m below ground surface in area near BH-1, BH2, and BH4. Area around 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


第十七届東南亞大地工程研討會
17SEAGC
The Seventeenth Southeast Asian Geotechnical Conference