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An Efficient and Evaluating Liquefaction Occurrence Against Huge Ocean Trench Earthquake

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ABSTRACT:*Accuracy of thepresent simplified approach is evaluated by evaluating the onset of liquefaction by using both methods. It is determined thatpresent method is applicable to a close to field or inland earthquake however now not to an ocean trench earthquake and thatit overestimates liquefaction capability ensuing in risky layout even though PGA is smaller in ocean trenchearthquake. It comes from the difference of effective variety of loading cycles; that for ocean trench earthquakeis set 10 instances larger than that taken into consideration within the existing technique. Then a correction thing is proposed forliquefaction strength; liquefaction electricity is ready approximately a half of-of that used inside the current approach. This methodworks so that both risky ratio (ratio of the cases in which onset of liquefaction is recognized through powerful stressevaluation but is not by way of present simplified manner) and accuracy ratio (ratio wherein each powerful stress andsimplified approach display identical result) keep almost similar to for the case of the inland earthquake.*

KEYWORDS-liquefaction, ocean trench earthquake, simplified method, duration

I. INTRODUCTION

Liquefaction prediction and assessment is a vital a part of the earthquake-resistant layout of structures on liquefiable soils. Liquefaction prediction and assessment charts, in the beginning, advanced via Seedand Idriss (1971), were widely used for such design in practice, as well as for catastrophe prevention and mitigation. The liquefaction charts are characterized by means of the relationships between themseverity or level of earthquake loading, represented by means of the cyclicpressure ratio, versus the soil liquefaction resistance, represented viafield measured values such as the SPT (widespread penetration test)N-values, i.E., blow counts (Seed et al. 1983, 1985; Tokimatsuand Yoshimi 1983; Iai et al. 1989; Youd et al. 2001; Cetin et al.2004; Boulanger et al. 2012), CPT (cone penetration test) q-values,i.E., tip resistances (Robertson and Wride 1998; Moss et al. 2006;Robertson 2015; Boulanger and Idriss 2015), and shear-wavevelocities (Andrus and Stokoe 2000; Andrus et al. 2004; Kayenet al. 2013). These charts were calibrated in opposition to instances inwhich liquefaction happened or did no longer arise at given sites.Earthquake motions at given websites usually have differentwaveforms and intervals that fluctuate substantially in area and timedepending on the traits of the websites, routes alongside whichseismic waves propagate, and source rupture procedure of earthquakes (e.G., Aki and Richards 2009). However, modern engineering designs do not competently remember such earthquake loading characteristics in mild to liquefaction, that is to mention, the influenceof variable waveforms and their intervals for given earthquakes, inevaluation of soil resistance traits, which have been substantially studied and evolved, such as the getting old effect with fines(e.g., Kokusho et al. 2012; Dobry et al. 2015). Indeed, underneath givenmost floor accelerations and maximum cyclic stressratios at given depths, the effects of the corresponding liquefactionprediction and assessment will be the same, for the given soilcharacteristics, although there were giant differences in thewaveforms and duration of the seismic motions involved.

In this study, a newly simplified liquefaction prediction and assessment approach that is capable of considering the impact ofthe waveforms and intervals of earthquakes is advanced. The concept of the powerful number of waves is added and demonstratedthe usage of the results of a comprehensive set of laboratory tests and thecase histories of five predominant earthquakes, which include 2011 Off thePacific Coast of Tohoku Earthquake. A precise feature of the proposed approach is its universality, allowing it to be carried out to allkinds of liquefaction charts cited above.

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II. RELATED WORKS

A series of dynamic centrifugal model tests wasconducted in order to investigate the effects ofseveral factors on the stability of the structuresagainst uplift. The tests were conducted by usingthe dynamic geotechnical centrifuge in thePublic Works Research Institute, Japan with athe radius of 6.6 m and a maximum payload of 40 ton-G [5].A cross-section of the typical model used in thecentrifuge tests is shown in Fig.1 and the testconditions are summarized in Table 1. Themodels were prepared in a rigid steel containerwith inner dimensions of 80 cm long, 20 cmwide, and 30 cm high. The model of basic casesconsists of the sand layer with a thickness of 20 cmand acrylic box assuming underground structure.In the tests, density of sand layer, amplitude andthe waveform of input acceleration, the thickness ofliquefiable layer, an apparent unit weight of theunderground structures and shapes ofunderground structures were varied.

III. THE PROPOSED APPROACH

Totally 275 sites that have been used in the past researches are collected (PWRI, 1996). Among them, 236 sitesare investigated because 39 sites do not have liquefiable layer. Natural period of these grounds is summarized inFigure 1; natural periods scatter widely between 0.084 and 0.609 seconds. In order to make the analysis simple,the ground is modeled based on the following procedure.

1) Soil is classified into sand, silt, gravel, or clay. Sand is treated as liquefiable material, but layers withliquefaction strength ratio greater than 0.6 or layers with SPT–N value greater than or equal to 25 are treatedas non-liquefiable material. The term "liquefiable layer" will be used to indicate sand layers that does notcomposed of non-liquefiable material defined here. Total number of liquefiable layers is 1345.

2) SPT-N value is averaged in the same layer. Then, shear wave velocity Vs is evaluated as Vs=100N1/3 for clayand Vs=80N1/3 for other soil (JRA, 2002). Internal friction angle φ of sand is evaluated based on Hatanaka and Uchida (1996).This equation is also applied to silt and gravel. Shear strength c of clay is calculatedby c=25N (kPa).

3) Liquefaction strength is evaluated as a function with respect to mainly SPT–N value (JRA, 2002), which willbe explained later. Since it gives shear stress ratio when liquefaction occurs under 20 cycles of loading, R20,liquefaction strength curve is extrapolated based on Seed et al. (1981), by which shear stress whenliquefaction occurs under 5 cycles of loading, R5, is obtained by R5 = 1.429 R20

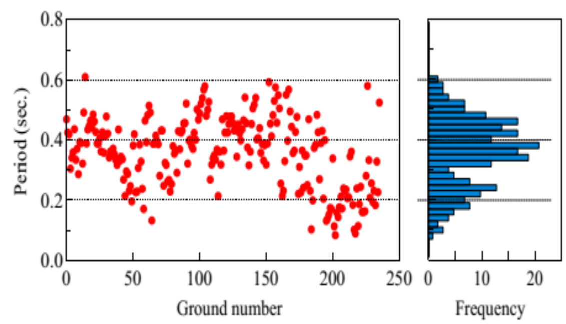
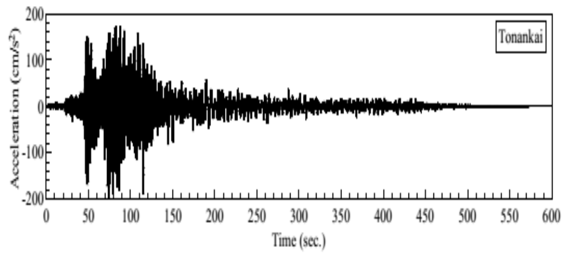


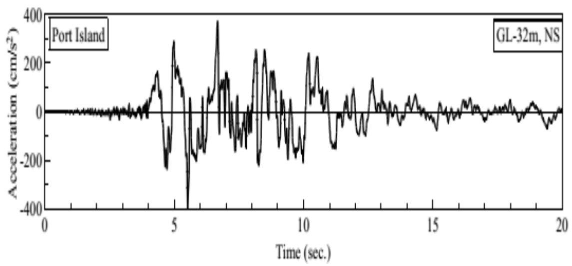
Figure 1 Distribution of natural period of investigated sites

Earthquake motions:

Two earthquake motions, shown in Figure 2, are used. The one is a synthesized earthquake motion for thecoming Tonankai earthquake (Sawada et al., 2005), which is a huge ocean trench earthquake motion that isexpected to hit Japan in future. The other is a recorded earthquake motion at Port Island, GL-33 m, during the1995 Kobe earthquake, which is an inland or near field earthquake and is used to compare effectiveness of thesimplified method. These earthquake motions are used as base motion of each site. It is noted that duration ofthe ocean trench earthquake is about 600 seconds, whereas that of the Kobe earthquake is several tens secondsat maximum, and that PGA in the inland earthquake is about two times as large as that of the ocean trenchearthquake.



(a) Tonankai earthquake



(b) Port Island, Kobe earthquake

Figure 2 Waveforms of the earthquake motions

Consideration of irregular nature of earthquake

Since shear stress ratio during earthquake and liquefaction strength defined at 20 cycles of loading are definedunder different backgrounds, one and/or both must be modified to compare under the same conditions.According to Iwasaki et al. (1978), origin of the JRA method, only liquefaction strength is modified in order tocompare liquefaction strength with maximum shear stress ratio.

$F_L = R/L$ …………………………. (1)

$R_{max} = c_1 c_2\, c_3\, c_4\, c_5 R_{L.}$........................ (2)

Here, R_{max} is liquefaction strength to be compared with L. Coefficient c1 considers effect of coefficient of earthpressure at rest, K_0, and is $(1+2K_0)/3$, c2 considers effect of irregular nature of earthquake motion and isdiscussed later, c3 and c4 consider loosening at sampling and/or handling, and densification during traveling, andc5 corrects effect of multi-directional loading and is 0.9. They found that multiplication of all 5 factors is nearlyunity, yielding $R_{max}= R_L$.

The irregular nature of the earthquake motion is considered as effective cycles of loading. The earthquakemotions are classified into shock and cyclic types. Shock type earthquake motions is defined when number ofeffective cycles is less than or equal to 2, whereas cyclic type when it is greater than or equal to 3. Thecorrection factors are 1/0.55 and 1/0.7, respectively, and the average value 1/0.65 is applied in Eq. (2).

Earthquake response analysis

YUSAYUSA (Yoshida and Towhata, 1991), an earthquake response analysis computer program for horizontallydeposited ground based on effective stress, is used. This program is the most frequently used program in theengineering practice in Japan. It employs hyperbolic model with Masing's rule for shear stress-shear strainrelationships. The shear strength defined in the preceding is sufficient to define the stress-strain model. Thestress paths are defined in an effective overburden stress–shear stress plane in order to consider excessporewater pressure generation, which is schematically shown in Figure 3, where τ denotes shear stress and pdenotes effective stress. Parameters Bp and Bu that define the stress paths are determined so that R20 and R5 agreewith that evaluated in the preceding section. The value of κ, a parameter to define shear stress ratio under whichexcess porewater pressure does not generate, is set 0.06, a suggested value in the program. Maximum excessporewater pressure ratio is set 0.97 for the stability purpose of the program, which is equivalent with theminimum effective stress of 0.03.

YUSAYUSA uses two definitions on onset of liquefaction. The first one is initial liquefaction which is definedwhen stress path cross the phase transform line. The second one is complete liquefaction which is defined to bethe state that effective stress becomes minimum value. These usages, however, are not commonly used terms. Inthe engineering practice, initial liquefaction is defined when excess porewater pressure becomes equal to initialeffective confining stress (Japanese Geotechnical Society, 2000), which state is nearly identical with thecomplete liquefaction in

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YUSAYUSA. Therefore, complete liquefaction by YUSAYUSA is used to identify theonset of liquefaction.

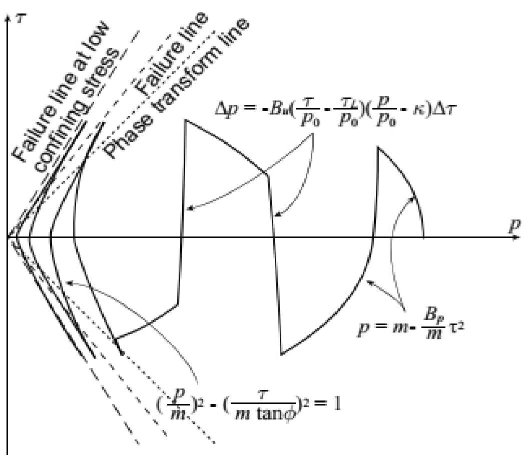

Figure 3 Stress paths used in YUSAYUSA

V. CONCLUSION

It is discovered through many powerful pressure analyses that existing simplified method works properly against inland typeearthquake, but no longer towards ocean trench huge earthquake along with coming Tonankai earthquake. The reason isthat impact of abnormal nature of earthquake motion isn't considered properly; variety of effective cycles issubstantially underestimated.

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BIODATA

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