"Geotechnical Problems in Earthquakes"

A. Ghahramani Prof. of Shiraz University,Shiraz,Iran

Key not Lecture

Abstract

Geotechnical problems related to Earthquakes are dealt with and the new developments based on the state of the art reports of the proceedings of the second International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, March 11-15, 1991, St. Louis, Missouri is summerized. The Field and Laboratory Testing, Earth Retaining Structures, Liquefaction potential and Post Liquefaction Behaviour and Land Slides are the topics chosen. The research at Shiraz University on Dynamic Earthpressure and Slope Stability is also presented.

1. Introduction

The subject of geotechnical problems related to Earthquakes has been the theme of several international conferences. The most recent one was held in last March at Missouri under the title of "Second International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics" (GEE2). State of the art papers were presented in related fields. In this paper the state of the art papers relating to Field and Laboratory Tests, Earth Retaining Structures, Liquefaction Potential and Post Liquefaction Behaviour is summerized and the important findings and grophs are presented. The research at Shiraz University on Land Slides and amic Earth pressure is also presented.

Field and Laboratory Tests

The state of the art paper by Woods (1991) presents several in-esting developments on field and laboratory testing. The important ld tests are cross-hole (Fig 1) in which the shear wave velocity is sured between holes. The new electronics devices permits rapid eva-tion of shear wave velocity which can be used for earthquake analysis h as the differentation of soils with liquefaction potential (L) and se with-out liquefaction pontential (NL) such as Fig. 2. The seismic e shown in Fig 3 is also a new development. Fig 4 shows the most quent test method of surface wave measurements. The new portable di-al equipment allows use of spectral analysis of surface wave which be used for predicting shear wave velocity with respect to depth. s technique is very useful in areas where samplings are difficult. The t widely used laboratory tests seems to be Resonant column tests and lic triaxial, shear and torsional equipment. These devices have been roved recently and computer software and dataloggers and electronic ipment have been the major improving factors.

Earth Retaining Structures

The state of the art paper by Whitman (1991) summerizes the new deve-ments in this area. It is concluded that the retaining structures built aterfront are potentially weak during earthquake due to poor soil con-on and poor backfill, however such structures away from waterfront have performed fairly well. The static formulae for earth pressure are as follows

$$P = K\gamma H$$

$$F = \frac{1}{2} K\gamma H^2$$

where P is pressure on the wall, K is earthpressure coefficient and γ is unit weight of the soil and H is the depth (Fig 5). The coefficients are.

$K_o = 1 - \sin\phi$ at rest

$K_a = \tan^2(45 - \phi/2)$ active

$K_p = \tan^2(45 + \phi/2)$ passive

The dynamic formulas presented by Mononob-Okabe are still widely used and have been simpified by Whitman.

$\Delta P_{AE} = \frac{3}{8}\gamma H^2 A$ (increase)

$\Delta P_{PE} = 2.135\gamma H^2 A$ (decrease)

point of application 0.6 H above base

$\Delta P_w = 0.5\ \gamma H^2 A$ (increase)

In these formulas A_g is the predicted accelleration due to earthquakes, ΔP_{AE} is the increment of active force added to static active force due to earthquake. ΔP_{PE} is the Decrement of passive force and ΔP_w is excess pore pressure. The point of application of earthquake force is recommended to be at 0.6H above base. It is recommended to use A between .05 to 0.15 according to severity of earthquakes.

4. Liquefaction Potential and Post Liquefaction Behaviour of Earth Structures

The state of the art paper by Finn (1991) presents new developments in this field. Seed's chart (85) shoun in Fig (6) is still the most widely used chart for predicting liquefaction potential. It relates the standard penetration number of 60% energy to average shear stress during cyclic test. For soils for which CPT cone penetration test result is available Seed's chart in Fig 7 can be used. The use of shear wave velocity for predecting cyclic shear strength is shown in Fig (8). In this figure V_{S1} is the normalized shear wave velocity at 1 Kg/cm^2 which is derived from measured shear wave velocity by the following formula.

$$V_{S1} = \frac{V_s}{(\sigma'_0)^{0.25}}$$

σ'_0 is the intergrannular vertial pressure in Kg/cm^2. The criteria for fine grained soil liquefaction under the title of Chinese criteria Wang (1979) has been modified by Finn (1991). If all 3 of the following criteria are existing, there is real danger of liquefaction of the fine grained silty clayplastic soil

1. Fines (less than .005 mm) < 15%
2. LL (Liquid limit) < 36%
3. W_n(natural water content) < 0.9 LL + 2

It should be noted that plastic soils having standard penetration resistance of less than 5 (SPT) are succeptible to Liquefaction. The post Liquefaction Behaviour is of major concern because most of the contractive soils exhibit reduced shear (steady state shear) at large strain after going to the peak shear strength due to liquefaction. This phenomena is shown in Fig 9. the slope sujected to earthquake if liquefied goes through reduced factor of safety which may produce large displacements. Seed (1988) gives a chart Fig 10 for predicting such residual strengths S_{us} from standard penetration test. The computer program developed by several investigators are capable of prediction displacement after liquefaction.

5. Land Slides

The land slides produced by earthquakes are either due to liquefaction which was dealth in paragraph 4 or is basically due to earthquake accelleration. A convenient approach to the problem seems to be the use of Ishihar Charts (1990). These curves shown in Fig. 11 relate the pre earthquake factor of safety to the required accelleration necessary for failure during earthquakes. These curves are bassically function of the average slope angle and it is interesting to note that the steeper slope angles of the same factor of safety require higher accelleration for sliding during earthquake.

6. Research at Shiraz University

The research at Shiraz University is concerned with predicting dynamic earth pressure and studying the land slides during earthquake. The earth pressure coefficients both static and dynamic are given as function of not only the angle of internal friction ϕ, but also the angle of dilation of ν .Charts developed are shown in Fig 12 from Ghahramani (1980). The Rood-bar landslide of recent Manjil-Roodbar Earthquake is also under investigation Behpoor (1992). The results indicate that Ishihara curves are applicable.

References

- STATE OF THE ART PAPERS , (cited references are) Woods, R.D. (1991), Field and Laboratory Determination of Soil Properties at Low and High Strains" GEE2 pp 1727-1740.

- Whitman, R.V. (1991), "Seismic Design of Earth Retaining Structures", GEE2 , pp 1767-1778.

- Finn, W.D. Liam. (1991), "Assesment of Liquefaction and Post Liquefaction Behaviour of Earth Structures: Developments 1981-1991", GEE2 , pp 1833-1849.

OTHER PAPERS

- Ishihara, K. and Hsu, H.L. (1986) "Considerations for Landslides in Natural Slopes Triggered by Earthquakes, Proceedings JSCE, No 376/(III-6), pp 1-16
- Ghahramani, A. and Clemence, S.P. (1980), "Zero Extention Line Theory of Dynamic Passive Pressure," Proceedings of ASCE, Vol. 106, No. GT6, pp 631-643.

- Behpoor, L. and Ghahramani, A. (1992), "Mountain Slide During Recent Earthquake of Manjil-Roodbar in Iran", 5th International Conference Landslides, 1992 New Zealand (to be published).

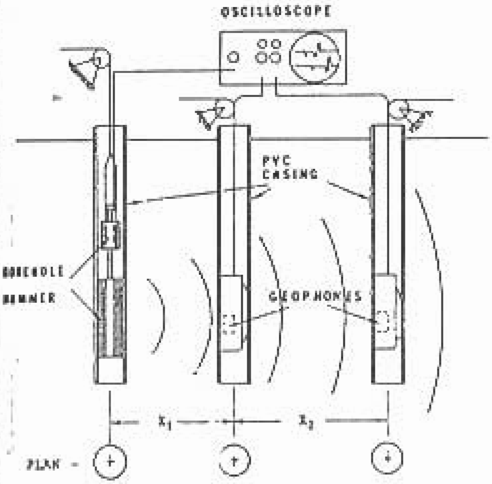

Fig. 1- Cross-Hole

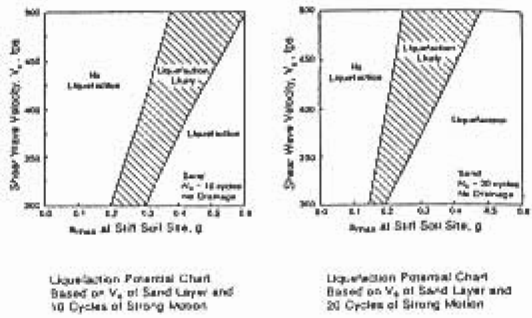

Fig. 2- (Stokoe 88)

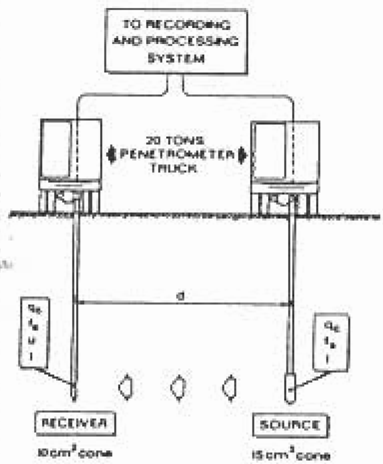

Fig. 3- Seismic Cone
(Baldi 88)

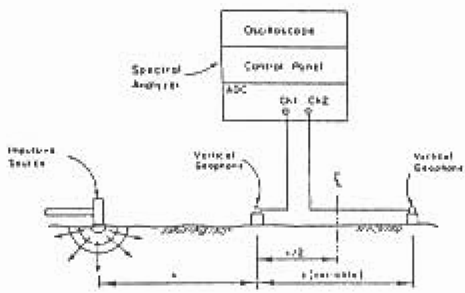

Fig. 4- Spectral Analysis of
Surface Waves
(SASW)(Nazarian 85)

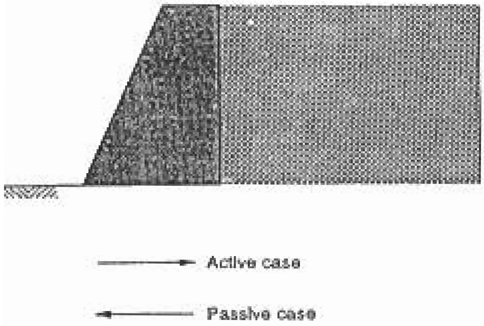

Fig. 5- Dynamic Earth Pressure

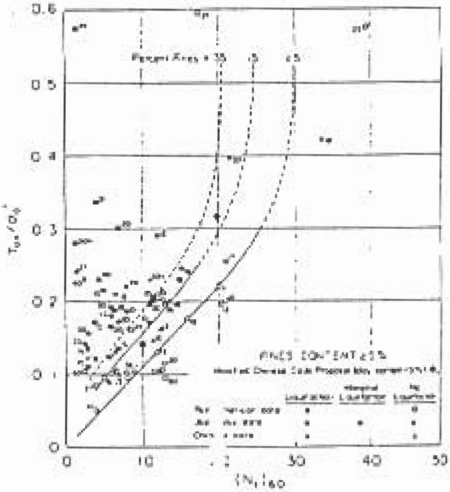

Fig. 6- SPT Seed's Charts 85

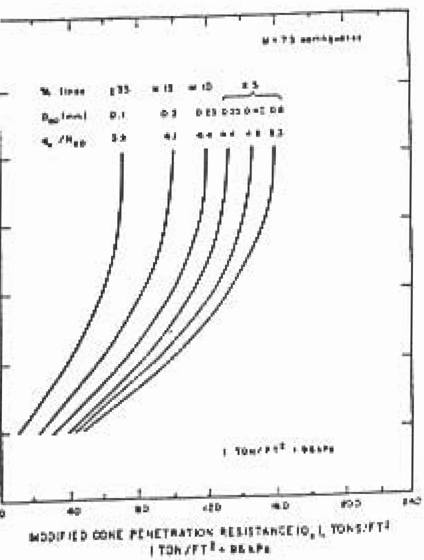

Fig. 7- CPT Seed's Chart 86

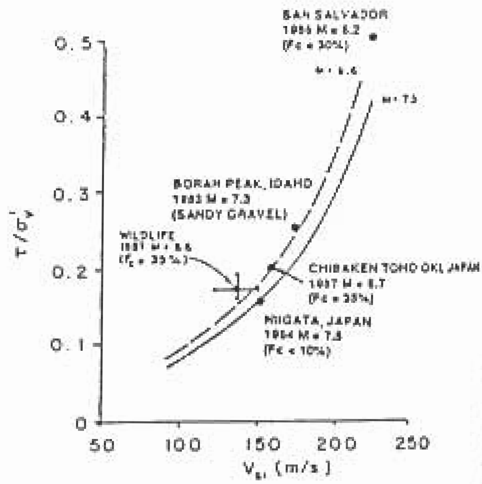

Fig. 8- Shear Wave (Finn 1990)