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An Overview of the Liquefaction of Fine Grained Soils

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Abstract: *This paper reviews the current status of knowledge regarding liquefaction of soils containing fines based on the theoretical and experiments studies conducted so far. It is well established that the criteria for assessment of liquefaction potential of coarse grained soil is entirely different than that of fine grained soils. However, fine grained soil viz. silt and clays also behave differently which is attributed to their individual plasticity index or the plasticity index of the mixture. It has been found that the liquefaction susceptibility of silts shows a noticeable change in its liquefaction with change in plasticity index. For a PI range of 2-4%, the liquefaction resistance of silt was found to decrease with an increase in plasticity.*

Keywords: *Cyclic Stress ratio, Standard Penetration Test, Cone Penetration Test, Plasticity index,*

I. Introduction

During the past several years a number of studies have been conducted on the liquefaction behavior of the cohesionless soil. A number of methods have also been developed relating the liquefaction potential of the cohesionless soil to some of its physical properties based on its structure and texture. The general methods developed for the assessment of liquefaction potential of the cohesionless soil are based on their penetration resistance. These are such as Standard Penetration Test (SPT) or the Cone Penetration Test (CPT). The fine grained soils with plastic characteristics were considered as the non-liquefiable such as silts, clayey silts and sands with fines and silty soils. However in the recent past, several researches conducted have clearly established that the clayey soils also have liquefaction potential, and hence susceptible to liquefaction, (Youd and Idriss 2001 and Youd et. al, 2001)[1]

The studies conducted on some of the recent earthquakes have also supported that many cohesive soils liquefied during the earthquake. In these studies the cohesive soils was found to contain clay fraction limited to less than 20%, liquid limit varied from 21% to 35%, plasticity index varied from 4% and 14% and water content more than 90% of their liquid limit. Earlier Kishida (1969)[2] reported liquefaction of soils with up to 70% fines and 10% clay fraction during Mino-Owar, Tohankai and Fukui earthquakes. Observations during several other earthquakes show evidence of liquefaction in silty and clayey soils (Turkey earthquakes, etc.). As of now it is well established that not only the cohesionless soil but all the soils such as sands, silts, clays, and gravels and their mixtures can liquefy provided the seismic and corresponding environmental factors favour it. The susceptibility of fine grained soil is related to its composition and physical condition such that it contains soil fraction as 15% finer then 5 micron, with liquid limit limited to 35% and the water content is more 90% of its liquid limit, (Seed and idriss, 1983)[3].

However, Seed et al. (1985)[4] suggested that for the sand with fine contents limited to 5%, the influence of fine is negligible and as such could be neglected and suggested the use of charts suggested by him for the sands and the soil containing fines. The chart is graphic representation in terms of the Cyclic stress Ratio and the Standard Penetration Test Blow. According to Wang (1979)[5], silty soils with 15 % to 20% clay particles (smaller than 5 μm size) and plasticity index more than 3, can liquefy during a strong seismic motion provided its water content is above 90 % of its liquid limit. Thus not only the percentage but percentage together with the size of clay particle is important in respect of liquefaction potential assessment of fine grained soil with the critical values of liquid limit and the water content.

II. Anomalies About Effect Of Fines On Liqefaction

In spite of several researches completed ad many more on-going in the area of effect of the fines on liquefaction potential of soils, still large scale anomalies are surfacing which needs proper clarification before reaching to some concrete conclusion. Some of the anomalies are; (i). Seed et al (1985)[5] have recommended that for sands containing less than 5% fines, the effect of fines on the liquefaction may be neglected. On the contrary for the sands containing more than 5% fines, it is clear that the liquefaction potential decreases as is from the data furnished by chart proposed by him relating Cyclic Stress ratio to standard penetration test blows. It is because of this reason that if the effect of fines for the suggested percentage is neglected it would lead to serious error in the assessment of liquefaction potential of the soil. Thus, lot of scope is available for conducting experimental studies to remove this anomaly. (ii) Ishihara and Koseki (1989)[6] had suggested that liquefaction potential is not affected by the low plasticity fines (PI < 4). This suggestion is independent of the void ration of the investigated soil. We do know that the void ratio plays an important role in the liquefaction potential of the soil. Thus there is clear need to take studies to explain the effect of void ratio for the soil with PI < 4 and to find out whether the liquefaction potential remains unaffected or varies in case of low plasticity fines with PI < 4.

III. Conclusions

It may be concluded that:

(1) The not only the cohesionless soils but cohesive soils also have the tendency to liquefy but the assessment of cohesive soil should be different compared to that cohesionless soil. The liquefaction potential of the silts and the mixture of silt-clay also have the potential to liquefy but they behave differently.

(2) There are large scale gap that needs to be filled by taking up more researches before coming to concrete conclusion. The research work is required to be carried out in the area as what would be the impact on the fall of the liquefaction in case the 5% criterion neglecting the fines is set aside.

(3) The effect on liquefaction potential by the low plasticity fines (PI< 4) based on the variable void ratio needs to be clarified. Experimental research work is needed to be conducted for clearing the confusion once for all.

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