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Strengthening of weak soil against soil liquefaction

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ABSTRACT

Liquefaction is one of the main concerns to the geotechnical network just as those associated with the building and advancement of basic establishment. Liquefaction is a phenomenon in which the quality and stiffness of a soil is diminished by earthquake shaking or other quick loading. Liquefaction and related phenomenon have in a charge of colossal measures of damage in historical earthquakes tremors the world over.

Keywords— *Liquefaction, Geotechnical, Soil, Earthquake, Soil stabilizer, Seismic, Bearing capacity, Building, Foundation*

1. INTRODUCTION

The term liquefaction is defined as loss of strength of soil, mainly occurs in saturated soil, when there is excess of water present in the soil the space between the particles gets completely filled with water which causes the less interaction of soil particles and get loosely packed. Thus, soil will have very little strength, and will behave more like a liquid than a solid - hence, the named as "liquefaction". Soil liquefaction is a major problem in geotechnical as it reduces the strength bearing capacity of soil, the voids are filled with water this water exerts some pressure on the soil particles. This water pressure is however relatively low before the occurrence of earthquake. But when earthquake occurs shaking can cause the water pressure to increase due which the soil particles started readily move with respect to one another. It one of the major causes of damage to buildings and infrastructure during an earthquake and when there is sudden load is applied cause breakdown of particle interaction. To know liquefaction potential at a particular soil site we must know the ground properties, topography of the site, magnitude of earthquake affecting the site and the position of the ground water table. We study the seismic data analysis, macroscopic phenomena of soil liquefaction (e.g., sand boiling, ground cracking, and lateral spread) are summarized, and some new phenomena related to earthquakes from the twenty-first century are interview, including liquefaction in areas with moderate seismic intensity, liquefaction of gravelly soils, liquefaction of deep-level sandy soils, re-liquefaction in aftershocks, liquid-like behaviour of unsaturated sandy soils.

The damage during an earthquake are affected by the response of the soil mass, existing at the particular site, to cyclic loading. This cyclic properties of the soils in turn depend upon the stress in the soil before an earthquake and the stress imposed during seismic loading. The load imposed during an earthquake is governed by three significant characteristics of the ground motion which are the amplitude of motion, frequency content and duration of the motion. When earthquake occurs soil deformation caused by transient, monotonic or cyclic loading and starts the generation of excess pore water pressure in saturated loose cohesion less soil under undrained loading conditions. Liquefaction can also be predicting by flow liquefaction and cyclic mobility, and the deformations occurs due to cyclic mobility failures develop incrementally during earthquake shaking and driven by both static and cyclic shear stress.

Liquefaction potential at a particular soil site are influenced by the ground properties, topography of the site, magnitude of earthquake affecting the site and the position of the ground water table. However, in recent years probabilistic assessment of liquefaction potential has been performed by various researchers where liquefaction potential is assessed in terms of probability of liquefaction, leading to better engineering decisions. The results is obtained from seismic liquefaction analysis in accordance with deterministic and probabilistic hazard analysis can be used for determining the seismic hazard existing at a particular region. These results are also used for earthquake resistant design of various geotechnical structures like retaining wall, pile, foundation etc. as applied by various researchers.

After several studies and various researches, we found that occurrence of liquefaction is the result of rapid load application and break down of the loose and saturated sand and the loosely-packed individual soil particles tries to move into a denser configuration. However, there is not enough time for the pore-water of the soil to be squeezed out in case of earthquake. Instead, the water is trapped and prevents the soil particles from moving closer together. Thus, there is an increase in water pressure which reduces the contact forces between the individual soil particles causing softening and weakening of soil deposit. In extreme conditions, the soil particles may lose contact with each other due to the increased pore water pressure. In such cases, the soil will have very little strength, and will behave more like a liquid than a solid - hence, the name “liquefaction”.

2. SUSCEPTIBILITY OF SOILS TO LIQUEFACTION IN EARTHQUAKES

Liquefaction is most commonly observed in shallow, loose, saturated cohesion less soils subjected to strong ground motions in earthquakes. Unsaturated soils are not subject to liquefaction because its volume compression does not generate excess pore water pressure. Liquefaction and large deformations are more associated with contractive soils while cyclic softening and limited deformations are likely with expansive soils. In practice, liquefaction potential in a given soil deposit during an earthquake is often evaluated using in-situ penetration tests and empirical procedures. Since liquefaction phenomena arises because of the tendency of the soil grains to rearrange when sheared, any factor that prevents the movement of soil grains will increase the liquefaction resistance of a soil deposit. Particle cementation, soil fabric, and again are some of important factors that can hinder soil particle movement. The National Research Council lists eight types of ground failure commonly associated with the soil liquefaction in earthquakes:

- Sand boils resulting in land subsidence accompanied by relatively minor change.
- Failure of retaining walls due to increased lateral loads from liquefied backfill or loss of support from the liquefied foundation soils.
- Ground settlement, generally linked with some other failure mechanism.
- Flow failures of slopes resulting in large down slope movements of a soil mass.
- Buoyant rise of buried structures such as tanks.
- Lateral spreads resulting from the lateral movements of gently sloping ground
- Loss of bearing capacity resulting in foundation failures.
- Ground oscillation involving back and forth displacements of intact blocks of surface soil.

3. PREVENTION OF SOIL LIQUEFACTION

1. Providing deep foundation (pile).
2. Replacing the soil.
3. Compaction of soil for increase the soil density.
4. Grouting of soil.
5. Ground water pumping.
6. Application of surcharge.
7. Drainage of soil.

4. OBJECTIVE OF OUR PROJECT

We study the chemical, physical or mechanical process with the purpose of adjusting the properties of the soil in order to meet certain requirements. There are five most important properties which define a good soil. These are strength, volume stability, permeability, resistance and variability. We mainly focus about how to prevent liquefaction of soil by using different admixtures to improve soil quality and reduce its liquefy property. Soil improvement techniques are commonly used at sites to eliminate or reduce the hazard to an acceptable level. A variety of improvement techniques have been evolved over the years, mostly through trial and error, aimed at improving inadequate strength, low stiffness, or insufficient drainage properties of soil. The main objective is to reduce pore water pressures, to increase the shear strength of the soils. This helps in gaining the strength bearing capacity of soil and to make it reliable for any construction and prevent form failure of soil mass and foundations of buildings.

5. STRENGTHING TECHNIQUES OF WEAK SOIL

Strengthening of soil are depends on the properties of soil particles by densification, compaction, drainage, replacement and rearrange the particle size. Following are the various method to strengthen of weak soil.

5.1 Vibratory Method

It is mainly based on the densification of soil mass due to induced of vibration by an electrical and mechanical vibration. There are mainly three vibratory methods.

(a) Sand compaction method: For constructing sand compaction piles, a 40 kN to 53kN hydraulic or electric vibrator is attached to the top of 400 to 600 mm diameter steel pipe. It is economical for depth up to 15m. Construction of the sand column is extremely fast.

(b) Stone column method: Vibro stone column or aggregate piers are a crushed stone pillar placed with a vibrating tool into the soil. It improves the ground by a compaction of soil. But it also suffers with the same drawback as that of sand compaction method. There are currently three basic method for constructing stone column in cohesive soil.

- Wet top feed
- Dry top feed
- Dry bottom feed

(c) Vibro concrete method: Concrete are used, instead of sand and stone .and also it is more effective compare to sand and stone column. Supporting road and rail embankment when other vibro or soil mixing techniques cannot use. It is a versatile technique that can be adjusted to a wide variety of soil conditions and foundation requirements.

5.2 Grouting

It is mainly divided into three part.

(a) Compaction grouting: Compaction grouting is the injection of a thick (cement paste), low mobility grout that remains in a homogenous mass without entering soil pores .as the grout max expands, the surrounding soil is displaced and densified. The technique is not effective in thick, saturated clay soils, and may be marginally effective in silt deposits. Treatment under existing structure and treatment in narrow area.

(b) Permeation grouting: Permeation grouting is the injection of low viscosity particulate or chemical fluids into soil pores space with little change the physical structure of the soil. The objective of permeation grouting is either to strengthen ground by cementing soil particles together or to reduce water flow by plugging soil pores.

(c) Jet grouting: In the jet grouting, high pressure fluid jet is used to erode and mix/replace soil with grout. It falls into three broad categories, underpinning or excavation support, stabilization of soft or liquefiable soils, groundwater. In general method begins by drilling small diameter holes (90-150mm) up to the final injection depth. Cement mixture is injected into the soil with a metal rod that runs a rotational and withdrawal motion. The liquefiable strata extended to depth up to 26m.

5.3 Soil stabilization with admixture

Calcium chloride being hygroscopic and deliquescent is used as a water retentive additive in mechanically stabilized soil bases and surfacing. Now a days Nano chemical are widely used for improving the properties of soil, some Nano chemicals are terrasil, zycobond etc.

(a) Terrasil: Terrasil is nanotechnology-based product produced by Zydex industries Ltd, Gujarat. Mainly ingredients used in terrasil are hydroxyalkyl–alkoxy (65% - 70%), benzyl alcohol (25% -27%), and ethylene glycol (3%-5%). It is based 100% organosilance, water solvent, bright and warmth steady, respective soil modifier to waterproof soil subgrade . soil can be compacted and also give a better interlocking in the soil particles. And it offers a permanent water repellent Nano layer on the soil surface, aggregates etc. It prevents the damage of capillary rise of water, cracking of soil and resist to ultraviolet rays. The holding procedure starts inside of 3 hours of the starting and procedure is finished 72 hours.

(b) Silica fume: Silica fume is a ultrafine powder collected by a silicon metal and ferrosilicon alloy. Its average particle shape is a spherical and size is 0.1-0.15 micro meter. It is available in grey to off white colors. Silica fume is waste of industrial materials, it is most valuable by product pozzolanic material due to its very active and high pozzolanic property. So it's beneficial use for concrete. In a grout, silica fume is added to the cement were 0%, 5%, 10%, and 20% by total weight of solid material used for the model tests.

(c) Fly ash: Fly ash is a byproduct of coal fired electric power generation facilities; it has little cementitious properties compared to lime and cement. Fine particles rise with flue gasses and are collected with filter bags or electrostatic precipitators. However, in the presence of small amount of activator, it can react chemically to form cementitious compound that contributes to improved strength of soft soil. Fly ashes are readily available, cheaper and environment friendly. We use fly ash to prevent liquefaction. Fly ash is added in different percentages of total soil 30 % of fly ash in soil is economy for prevent liquefaction effect. With increase the fly ash more than 30 % increase the rate of fly ash. The reduction of swell potential achieved in fly ashes treated soil relates to mechanical bonding rather than ionic exchange with clay minerals.

These are various prevention methods which are suitable for the two types of failure occurs during soil liquefaction.

- Flow failures: It is observed when the liquefaction of loose, contractive soils (i.e. the soils where there is no increase in strength at larger shear strains) results in very large deformations.
- Deformation failures: It is observed when there is a gain in shear resistance of the liquefied soil at larger strain, resulting in limited deformations but no loss of stability.

The liquefaction potential is an important issue which should be considered in soil site investigation. The study deals with the investigations and results on the evaluation of the potential of liquefiable soil layers at location where new industrial complex is planned to be built.

6. CONCLUSION

In cohesion less soil liquefaction is occur during the heavy earth quake. The effect of liquefaction is creating major problem. To mitigate the effect of liquefaction many methods are available. We use admixture to prevent liquefaction. Thus, we consider these above methods as a useful solution to treat the weak soil to achieve the required engineering properties and specification so that structures can be placed safely without undergoing large settlement and any failure.

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