Strengthening of Weak Soil against Liquefaction

Rajneesh Yadav [1]
Babu Banarasi Das National Institute of Technology and Management Lucknow (U.P.)

Ranjan Gupta [2]
Babu Banarasi Das National Institute of Technology and Management Lucknow (U.P.)

Ravi Gautam [3]
Babu Banarasi Das National Institute of Technology and Management Lucknow (U.P.)

Prashant Rawat [4]
Babu Banarasi Das National Institute of Technology and Management Lucknow (U.P.)

Purusharth Yadav [5]
Babu Banarasi Das National Institute of Technology and Management Lucknow (U.P.)

Abstract- *Liquefaction is a aspects in which the strength and stability of soil is decline by earthquake shaking or rapid loading. Seismic events cause disturbance in the ground which are damage the building and structural stability. In this study we use biological process and admixture to develop the strength and stability of soil. In this review we focused on micro piles which change the properties of liquefied soil, and soil gain their strength. This paper review present the biological process by using microorganism and some suitable method to improve the strength of liquefied soil.*

Key Words- *Liquefaction, Geotechnical soil, admixture, microorganism, Earthquake, micro pile.*

INTRODUCTION

Liquefaction occurs by seismic and rapid loading and decrease the soil strength. Undrain saturated soil with a high risk of earthquake are inquest to liquefaction. During liquefaction the pore water pressure become high and effective stress of the soil is rapidly reduce to zero. These aspects change the properties of soil and its cause of the collapse building structures and loss of lives. As more recent example of Indonesia, liquefaction was major cause of damages in 2018 central Sulawesi Indonesia earthquake. When liquefaction occurs, soil stabilization techniques are commonly used at the site to eliminate the chances of site failure. These methods may include following action- [1]. Avoidance the liquefied site and relocation is provided to safer site. [2]. Improve the ground stability of liquefied soil by using some admixture. [3]. Strengthening of weak soil by using some physical methods or providing extra strength of structure against liquefaction by using Micro piles. [4]. Improve the stability of the ground by biological process using microorganism. All the above procedure have been used effectively to eliminate the risk or damages from liquefaction. When selecting one of the best and suitable method to reduce the hazard it is necessary to select the effectiveness of the improvement approach for the particular situation. Liquefied soil layers mostly includes in inner bed layer of gravel and sand with excess percentage of fines contents. Many researchers have investigate the strength of liquefaction following the result of Standard Penetration Test (SPT) and Cone Penetration Test (CPT). These study were conducted on the basis of case history of earthquake allover the world. The present state of art in liquefaction evaluation involves in-situ testing rather than the other laboratory testing because it is impossible to find these property in laboratory: degree of consolidation, age of soil profile, degree of cementation, which affect the strength of soil to liquefy under seismic or rapid loading. The study shows the approach to reduce the risk of soil liquefaction using jet grouted micro piles. Stabilization of soil after using jet grouted micro pile and compared with existing soil. In recent activity to improve soil stability to use of bio-mediated system. Bio-improvement technique is environment friendly and sustainable method to improve the bearing capacity of soil using microorganism. The main aim of this review to use of grouted micro piles and microbial process to improve the property of liquefied soil.

ASSESSMENT OF LIQUEFACTION

[1]. Cone penetration test (CPT)

This test is used for soil liquefaction characterization. In this test the Cyclic Resistance Ratio (CRR) is compared to the Cyclic Stress Ratio (CSR). And the ratio of cyclic resistance ratio and cyclic stress ratio is called factor of safety for predicting the risk of liquefaction. If the factor of safety value greater than one (1) then liquefaction triggered.

The expression for cyclic stress ratio (CSR) is following:

$$CSR_{7.5} = \tau_{cyc}/\sigma_{0v0} = 0.65(a_{max}/g)*(\sigma_{v0}/\sigma_{0v0})*(rd/MSF) \quad ……\quad …….. (1)$$

Where the variable τ_{cyc} is the maximum shear stress, σ_{v0} and σ_{0v0} are vertical effective and total stress, a_{max} is the horizontal ground acceleration, **rd** is the shear reduction coefficient and **MSF** is the moment magnitude.

By the use of above expression find cyclic stress ratio. And cyclic resistance ratio expression is following:

$$CRR_{7.5} = 0.833[(q_{C1N})_{CS} / 1000] + 0.05$$

If $(q_{C1N})_{CS} < 50$

$$CRR_{7.5} = 93[(q_{C1N})_{CS} /1000]^3 + 0.08$$

If $50 < (q_{C11N})_{CS} < 160$

Where the variable $(q_{C11N})_{CS}$ is penetration resistance.

The available data compared to cone penetration resistance. Resulting graph and empirical curves to define the bearing capacity of soil against liquefaction and noting that liquefaction triggered or not.

[2]. Standard penetration test (SPT)

This test is the one of the most tools in assessment of soil liquefaction. In this test the cyclic stress ratio (CSR) equation is same as cone penetration test.

$$CSR_{7.5} = \tau_{cyc}/\sigma_{0v0} = 0.65(a_{max}/g)*(\sigma_{v0}/\sigma_{0v0})*(rd/MSF)$$

In standard penetration test (SPT) the factor of safety one (1) was considered in calculation. Empirical curves to define the liquefaction were developed based on standard penetration test (SPT) data base in the site. On the basis of previous database compared to the equivalent corrected SPT blows count value $(N_1)_{60CS}$ for the soil and the finalized curved for the SPT based liquefaction triggering analysis is presented: **$(N_1)_{60CS}$ versus $CSR_{7.5}$.**

Soil profile and liquefaction risk is evaluated by BOULANGER and IDRIS method and soil liquefaction assessment by using $(N_1)_{60cs}$ values.

STRENGTHENING OF LIQUEFIED SOIL

[1]. By grouted micro piles

Micro piles are used effectively in different applications of ground improvement to develop the load carrying capacity of soil and reduce the settlement of foundation. Micro piles implementation is done on the guideline of Federal Highway Administration (FHWA-NHI). Micro piles have tendency to high load carrying capacity and self sustained. Micro pile is define as a pile 300 mm or less in diameter and length up to 4m with surrounded by cement grout. Their review focused on the use of micro piles as foundation and reduce the motion of structures. The micro piles are reinforcing members to reduce the risk of liquefaction by stiffening the soil. The effect of micro pile on ground to reduce the shear strain and due to this, the displacement are reduce.

CHARTON'S method used a cone penetrometer to push the micro pile in ground and use pressure grout pumping, this is called as jet grouting. According to the CHARTON'S two micro piles installed at 30^0 from vertical. Micro piles are in small diameter and grouted friction piles. Each piles are made of steel elements that are bounded in the bearing soil with grout material. In installation of micro piles the grout was injected into soil at high pressure (300 psi) to provide bonding at nearest soil around micro piles. The resulting grout was 100mm to 115mm in diameter. These reinforced micro piles reduce the shear strain and prevent the soil from liquefaction. The basic advantages of grouted micro piles in improving strength of weak soil is following:

- The micro piles are installed for every type of ground and this is installed very quickly.
- It offers high skin friction, it means soils have tendency to take extra loading and easily wear it.
- It makes the ground dense.
- This method is economical and easily installable.

[2]. By bio-mediated technique

The improving of soil by the concept of biological process is called bio-mediated soil improvement technique. Microbial persuade calcite precipitation is the important discovery in the field of geotechnical engineering. The bio-mediated technique is ecofriendly technique to improve the property of soil through microbial convince calcite precipitation. In bio-mediated process "SPOROSARCINA PASTUERII" microorganism is use to complete calcite precipitation which is called as microbial bacteria. Microbial persuade calcite precipitation utilizes bacteria to introduce calcite and impart the strength of liquefied soil due to formation of coating and bonds between soil particles. Microbial induced calcite precipitation (MICP) are also use to reduce permeability, compressibility and increase shear strength and stiffness of soil. In this process the calcium carbonate (calcite) is formed into the soil by biological process. The produced calcite bind the liquefied soil particles together by cementing and clogging. Due to this the soil increase shear strength and reduce void ratio, compressibility and hydraulic conductivity. This calcite achieved by persuading a greater amount of calcite forming microorganism and cementation reagent into the liquefied soil. They forming a cement compound that help to develop the engineering properties of soil. The procedure to formation of calcium carbonate (calcite) in three parts: (a) Bacteria growth, (b) Bacteria metabolism, (c) Calcium carbonate precipitation. Calcite ($CaCO3$) is a product of microbial induced calcite precipitation that can be produced by many pathway. The alternatives includes urea hydrolysis. Urea hydrolysis is the most desire precipitation method because this method is very easily controlled and strength forward. In 24 hours the process can produced almost 90% chemical conversion.

The mechanism is done into two stages: (1) urea hydrolysis, (2) $CaCO3$ precipitation.

$CO(NH_2)_2 + 2H_2O$-----CO_3^{--} + $2NH^+_4$………(1)

$Ca^{++} + CO_2^{--}$ ------- $CaCO_3$ …………(2)

During hydrolysis stage urea is hydrolyzed and produced carbonates and ammonia ions. Ammonia ions increase the pH. In calcite precipitation stage cementation solution react with carbonates ions and forms calcium carbonates crystals.

Calcite precipitation generally affected by four major factors: pH, temperature, bacteria cell concentration, concentration of cement agent. Formation of calcite is alkaline in nature, so the pH range under alkaline condition from 7.5 to 9.5. calcite precipitation is temperature dependent also. The peak temperature of 50^0 give the highest strength with respect to other low temperature. Bacteria are the most microorganism found in soil with size range from 0.5 to 3.0 micro meter. High concentration of bacteria cell increase the amount of calcite precipitation. This indicates that higher concentration of calcite precipitation for binding and clogging the soil particles that leads to increase the strength of liquefied soil.

CONCLUSION

Liquefaction is occurs during the heavy loading or earthquake or some construction process. We have to prevent liquefaction from above methods are adopted. This paper review define the load carrying capacity of the foundation soil is developed by using micro piles. This method is quick and easily controlled. This paper also review on bio-mediated soil improvement technique using MICP in alleviation of liquefiable soil. Several researchers have been carried out on the use of MICP to reduce the liquefaction, none of the study about the effect of bacterial concentration and cementation concentration. This method is ecofriendly and superior to sandy soils. After both methods are adopted then again apply cone penetration test (CPT) and standard penetration test (SPT) to check liquefaction and compare with initial data. And verifying that these two methods are superior to mitigate liquefaction from soils.

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