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Review on Microbial Induced Calcite Precipitation

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ABSTRACT—*Soil improvement by using microbial induced carbonate precipitation is new and innovative technique for granular soils. It utilizes bacteria to hydrolyse urea to give to give carbonate ions which react with a calcium rich solution to produce calcium carbonate bacteria are injected to soil. It increases strength and stiffness which is measured by unconfined compression tests and permeability changes from falling head method. MICP reduces permeability and liquefaction. An important factor in achieving uniform precipitation is proper injection of reagents of ureolytic bacteria, urea, calcium, staged injection including retention periods and with a pressure head applied during injection of the bacterial cell solution, proved most effective.Greater improvements in stiffness and strength were achieved for lower bacterial cell and higher cementation solution concentrations with a higher molarity of urea (non-equimolar solutions) proving even more effective. This review discusses on findings which are confirmed by scanning electron microscope observations.*

Keywords— MICP, urea hydrolysis, scanning electron microscope, $CaCO_3$

1, INTRODUCTION

To make land suitable for construction purpose, improvement of soil is needed to reduce settlement , to prevent liquefaction and damage in seismic cones . Microbial induced calcite precipitation increases shear strength and bearing capacity of soil . Chemical methods to improve soil conditions are toxic and harmful but microbiological process can change soil behaviour without causing damage. Urea hydrolysis increases alkalinity of pore fluid and induce calcite to precipitate. Traditional grouting methods are expensive but MICP can be done with low cost. Bacteria such as sporosarcina pasteuri hydrolyse urea in presence of calcium ions, resulting in precipitation of calcium crystals. Investigation of MICP gives suitable method of injecting different concentration of bacterial cell and cementation solutions on stiffness, strength, hydraulic properties of treated sand.

2, MECHANISM OF MICROBIAL INDUCED CALCITE PRECIPITATION

It is biogeochemical process. Calcium carbonate precipitation happens within the soul matrix to improve soil with help of bacteria. This process binds soil particles and soil strength and stiffness is increased. Transformation of loose sand into sandstone occurs. Those microorganisms are photosynthetic microorganism, for example sulphate reducing

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bacteria. Bacteria changes urea to ammonia, tricarbonate and carbonate precipitation, urea hydrolysis, denitrification, sulphate production and iron reduction.

3, MATERIALS

First step is select and analysis of soil sample. Soil must contain minimum pore size. Second step is selection of bacteria with its culture medium. Third step is selection of cementation reagent for treatment. Fourth step is soil specimen preparation. Finally suitable injection method is chosen and applied.

3.1,Type Of Soil

Soil type should allow transportation of bacteria i.e 0.5 - 3.0µm in length. Ideal particle size is 50 - 400µm.

3.2,Microorganisms

Bacteria should be urease positive bacteria. Example: Bacillus, sporosarcina, spoloactobacillus, clostridium and desulfotomaculum , Ph should be 8.5 . Culture medium is sterilized by autoclaving at 121ºC for 15minutes.

3.3,Cement Reagent

Urea – calcium is used for influence on ureolytic driven calcium carbonate precipitation.

3.4, Specimen Preparation

Test specimen are formed using PVC split moulds with two valves held together. Filter paper is placed at bottom . 385g of dry sand is filled in 5 layers. Compaction is carried out. 140mm along sand specimen are prepared. 30mm deep gravel is used as filter

3.5, Injection Method:

a) Mixing bacterial cell and cementation solution together before injection into the sand.
b) Two phase injection in which bacterial cell solution is injected first, followed by cementation solution.
c) Staged injection, retention period between the injection phases may or may not be used

4, EXPERIMENTS FOR DETERMINATION OF IMPROVED SOIL PROPERTIES:

4.1, SEM: SEM images are obtained by scanning with high energy beam of electrons. SEM analysis shows precipitation of calcite by bacteria. Greater precipitation is formed at top and bottom portion.

4.2, PH: ph varies from 8.5 to 9.3

4.3, Shear Wave Velocity: It helps to find density and stiffness. Loose sand shear velocity is between 100-200m/s. Liquefaction soil has 500m/s. MICP raises above 500m/s and maintains between 500 – 1000m/s

4.4, Strength and Stiffness In Unconfined Compression: After curing for 21days at lab temperature of 20º ± 28ºC, specimen is tested. UCS and stiffness values increases with increase in the cementation solution concentration upto a certain limit.

4.5, Coefficient Of Permeability: Higher cementation is measured using falling head method, concentration over range 0.1 – 1.0m has greater permeability coefficient. Experimentally reduction in permeability from 15 – 20% by Ferris Etal (1996) and

22 – 75% of initial permeability by Whiffinet.al (2007 is observed).

VIII. CONCULSION

To improve properties of potentially liquefiable sand, an alternate cementation technique called microbiologically induced calcium carbonate is reviewed. The calcite precipitation by microbial activity increases shear strength, confined compressive, stiffness and reduces liquefaction. Contacts of calcium carbonate crystal and adjacent sand grains increases mechanical strength with factor of 2.4 USC is increased. Permeability is reduced 0.26times. To get successful hydrolysis of urea, ph is increased and change in concentration of urea, ammonium, calcium, calcium carbonate should be made. There exists a positive relationship between shear wave velocity and amount of precipitated calcite. Recent works reveals surface percolation and irrigation is also feasible. Higher concentration, stiffness and strength. Another factor was grading (particle size), with the finer of the two treated sands investigated mobilizing higher UCS and stiffness values.

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