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A Review on Biological Consideration in Geo-Technical Engineering

[1]J. Sree Naga Chaitanya, [2]Dr. K. Chandramouli, [3]G. Varun

[1]Assistant Professor, Department of Civil Engineering, NRI Institute of Technology, Visadala (V), Medikonduru (M), Guntur, Andhra Pradesh, INDIA.

[2]Professor & HOD, Department of Civil Engineering, NRI Institute of Technology, Visadala (V), Medikonduru (M), Guntur, Andhra Pradesh, INDIA.

[3]B. Tech Scholar Department of Civil Engineering, NRI Institute of Technology, Visadala (V), Medikonduru (M), Guntur, Andhra Pradesh, INDIA.

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ABSTRACT

In terms of performance and environmental sustainability, the idea of using biological processes in soil improvement, also known as bio-mediated soil improvement technique, has demonstrated significant potential in geotechnical engineering applications. The soil microorganisms in charge of this process are reviewed in this research, along with the variables influencing their metabolic processes and geometric compatibility with soil particle sizes. Moreover, two biomineralization mechanisms, biologically induced mineralization, and biologically regulated mineralization, were addressed. Environmental and other potential in-situ influences on the process of microbially induced calcite precipitation (MICP) were found and presented. Improvements in the permeability and strength/stiffness of soil, as measured in several research, were investigated.

Keywords: Geotechnical Engineering, Permeability, Bio-Mineralization, Soil Improvement and Calcite Precipitation.

I. INTRODUCTION

Recent investigations on applications of the bio-mediated soil enhancement technology have shown the viability of the method for effective performance and environmental sustainability. The likelihood of examining a wider application of the approach in geotechnical engineering has improved as a result of the favourable research findings. The bio-mediated approach of soil improvement has been hailed in geotechnical engineering as an inventive and cutting-edge tactic that can be employed to reduce liquefaction and landslides in loose sand, which often result in foundation deformation and/or collapse. Due to the expansion in global population, there is a growing need for housing and agricultural land in the modern day. Also, most of the ground soil needs to have its properties upgraded because it cannot withstand the weight. Presently, there are different methods to improve the soil properties. They are:

1. Current soil improvement techniques:

More than 40,000 soil improvement projects are carried out annually at a total cost of more than US$6 billion, demonstrating the growing desire for innovative, sustainable approaches to improve soil.

Most of these soil development methods rely on mechanical power and/or man-made materials, both of which required a lot of energy to produce and/or install. Injecting synthetic man-made materials, such as micro-fine cement, epoxy, and acrylamide, is a typical strategy; the most widely used method uses phenoplasts, silicates, and polyurethane. Although it used numerous kinds of chemical approaches for soil enhancement as well as into the pore space to link soil particles to one another.

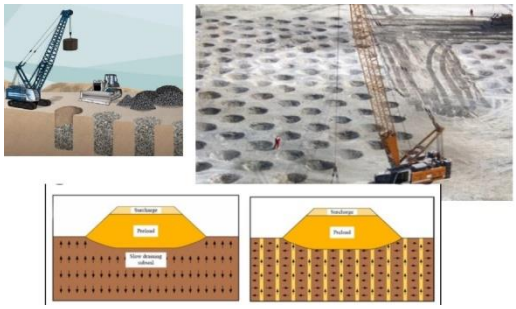

Fig-1: Different types of grouting techniques for soil improvement

2. Soil micro-organism:

Because soil has a lot of nutrients and mainly holds some liquid in its pore holes, it supports a greater diversity of microorganisms than other microbial habitats. While some microbe kinds are absent from soil properties, others are found there in large numbers. But it is impossible for microorganisms to spontaneously disperse their survival and development factors to the depths of the lithosphere. The adaptation of the microorganism's genetic and physiological makeup over the course of more than 3.5 billion years is described by Xanthakos et al. in 1994. The ground surface soils contain around microorganisms per kilogram.

The two most common bacterial groups in soil are eukarya and archaea, each of which have distinctive characteristics, such as archaea's involvement in multichromosomal cells and distinct chemical combinations. but without the nucleus that is surrounded in a membrane. Furthermore, cell wall, shape, food types, biochemical transformation type, DNA, and RNA can all be used to classify microbes.

Many soil microorganisms are found to be bacteria, according to Mitchell and Santa marina (2005). These bacteria have the potential to endure harsh conditions by producing. The bacteria have round, rod-shaped, or spiral cells with a diameter that ranges from 0.5 mm to 3 mm. They can endure various temperatures. Many bacteria produce the urease enzyme, and bio-mediated soil improvement is the approach used. The Desulfotomaculum, Bacillus, Clostridium Sporo sarcina, and Spolo-actobacilus genera make up this group of bacteria.

3. Biomineralization:

The method used most frequently in bio mineralization today is MICP. Urea is hydrolysed by bio-triggers to create inorganic minerals.

Calcium carbonate (CaCO3) precipitates as carbonating ions and calcium replace the product solution, and urease enzyme makes up many of the microorganisms. Even though the precipitation of carbonates can be aided by hydrolysis, this process "products alkalinity (by raising the localised pH value) and acts as nucleation sites in supersaturated fluids." The explanations for bacterium-initiated calcite precipitation and how mineral was produced under ecological conditions are shown in Figure 1 for Sporosarcina pasteurii (strain assignment: ATCC, 11859). These tiny creatures are cleaned in a sterile environment before being introduced to the soil in a combination of urea and calcium chloride.

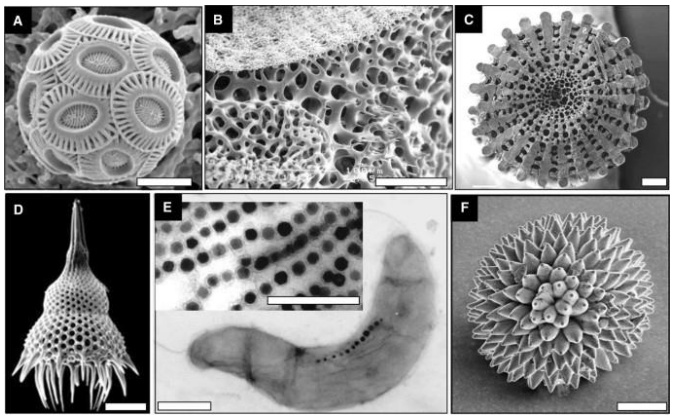

Fig-2: Bio-organisms in soil

4. Microbiology mechanism:

The two primary kinds of microbiological mechanisms used in geotechnical engineering are bio-cementation and bio-clogging. A process known as "bio-clogging" fills the space in the soil caused by a microbially-induced biochemical reaction. By introducing bacteria and cementation reagents into the soil, bio-cementation aims to improve the strength and stiffness characteristics of soil and rocks.

5. Factors affecting MICP process:

Many natural conditions are represented by microbially produced calcium carbonate precipitation, which is a distinctive process that involves the microorganisms' metabolic activities as well as some chemical reactions.

Using the bacterium Sporosarcina pasteurii, Mortensen and DeJong (2011) assessed the effects of a few conditions that might be encountered in the field during MICP treatment that are anticipated to alter bacterial growth, metabolism, and the precipitation caused by the bacteria.

6. Application of microbial in soil properties:

The microorganism can be employed in many ways to improve soil.

The majority of processes allow for the introduction of bacteria, while some also allow for soil mixing prior to placement. There is room for improvement in the following areas:

- Stabilizing or strengthening soil to aid in the stability of tunnels or other underground structures.
- Enhancing the foundations' carrying capacity, whether they are piled or not.
- lowering the soil's potential for liquefaction; and treating the pavement's surface.
- Reinforcing tailings dams to stop slope failure and erosion.
- Binding dust particles to exposed surfaces to lower dust concentrations.
- Improving offshore constructions' resistance to sediment erosion within or below gravity foundations and pipes.

II. CONCLUSION

Another useful technique in geotechnical engineering is microbial-induced calcite precipitation. It might improve both existing and new soil structures. It is used in a variety of geotechnical engineering applications, including subgrade reinforcement and slope stabilisation. This process offers great potential for engineering applications, but it will take a lot of work to achieve the desired results. In order to compare the possibility of MICP attainability with that of traditional grouting, one type of research configuration was connected for this work with comparable investigations, especially regarding environmental variables and economic aspects.

The precise mechanism of precipitation and the role of this activity within the microbial ecology of the precipitating organism remain unclear despite substantial research on MCP both in natural environments and under controlled laboratory circumstances.

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