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Soil Stabilization using Microbially Induced Calcite Precipitation

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Abstract - Microbial-Induced calcite Precipitation (MICP) has recently emerged as an effective technique for soil improvement. This paper aims to study and learn the effectiveness of MICP in rising the shear strength and reducing the hydraulic conductivity of black cotton soil. A laboratory study was conducted to analyze the engineering properties of MICP-treated soil by microorganism. The microorganism utilized in the study was Bacillus Megaterium. The soil samples were prepared in a mould having diameter just like the diameter of vane shear equipment and permeameter mould and test were taken. The results of vane shear test and permeability test show that there's a major increment within the shear strength and decrement in hydraulic conductivity of black cotton soil compared to black cotton soil without microorganism.

Key Words*: *microbial-induced calcite precipitation, soil improvement, shear strength, vane shear test, permeability test, permeameter mould, Bacillus megaterium

1. INTRODUCTION

In India due to the rise in population and industrialization there's a far want for the soil to be used for variety of activities. There's a necessity to boost the properties of soil if it is unsuited for the construction. With increasing awareness of environmental problems there has been an interesting shift towards "green" and sustainable technologies. In the past few years before soil stabilization using MICP was introduced, chemical grouting technique was applied to stabilize soil. The method of chemical grouting technique is achieved by adding additives that are extremely toxic like cement, lime, asphalt, glass, acrylate, lignin, urethane, and resins. Several researchers had concluded that these additives can modify the pH of soil and contaminate the groundwater and soil and chemical grouting is turning into very hip thanks to its economic edges however these days with the increasing awareness of environmental problems, it's necessary to introduce effective technique like MICP for stabilization of soil. Many issues of tropical residual clay condition like low strength, high porosity, softening due to infiltration had caused several geotechnical issues like settlement of hill or foundation. Landslides has inflated and become the foremost considerations of engineering geologists and geotechnical engineers. Microbially Induced Calcite Precipitation could be comparatively effective and sustainable soil stabilization technique that utilizes the organic chemistry method that exists naturally in soil to enhance the properties of soil. Hence, there's a necessity of study on new environment friendly technologies within the field of geo-technology. Different strains of bacillus produce different amount of calcite precipitates. Bacillus Megaterium ATCC 14581 is an eco-friendly bacteria that has no harmful effects on animals, human beings or environment. Bacillus Megaterium is easily available in National Chemical Lab.

This paper focuses on increasing the shear strength and decreasing the hydraulic conduction of black cotton soil and thus increase the bonding between soil particles. Also to study the feasibility of Bacillus Megaterium ATCC 14581 in improvement of soil properties.

1.1 Objective

1. To study the feasibility of Bacillus Megaterium ATCC 14581 in improvement of soil properties.
2. To improve the shear strength of black cotton soil.
3. To reduce the permeability of black cotton soil.

1.2 Future Scope of MICP

1. For the improvement of behavior of soil, various ground improvement methods are available example chemical stabilization, cement stabilization etc. The inherent drawbacks of these method are not new to the industry.

2. MICP promises to provide a solution for the existing problem like repair work of roads, tunnels, canals, etc.
3. This method is eco-friendly and economical technique compared to other soil stabilization technique.
4. The availability of bacteria as well as its cultivation can be done in huge amount

2. TESTING MATERIALS

2.1 Specimen preparation and soil material:

The test was carried on the PVC pipes containing the soil material having black cotton soil, for Vane Shear Test. The pipes of L/D ratio for Vane Shear Test is required between 2 to 3, therefore pipe of diameter 2.67 cm and length 8 cm was used. Shear strength was calculated using Vane shear test. Sample containing 70% soil, 8% sand and 22% silt was prepared in specimens and results were taken on 0 day, 1rd day, 2nd day up till 6th day for Vane Shear Test. For permeability test six samples were prepared and the tests were taken on 0 day, 7th day and 14th day.

Fig -1: vane shear test

Fig -2: Soil Specimen (Permeability test)

2.2 Microbial Induced Calcite Precipitates in soil:

Calcite Precipitates was induced in soil with help of aerobic Urease producing bacteria, i.e. Bacillus Megaterium. The culture was directly added in the specimen with the help of sterilized dropper (2.5 ml in each specimen).

Fig -3: lyophilized strain

Fig -4: Cultural Medium

Table -1: Physical Properties of the black cotton soil

Soil characteristics (Black cotton soil)	Description
Liquid Limit	49%
Plastic Limit	36.57%
Plasticity Index	12.43%
Maximum Dry Density	1.75 gm/cc
Optimum Moisture Content	9.1%
Vane Shear strength	0.012kg/cm^2

Table -2: Composition of specimen

Black cotton soil	70%
Sand	8%
Silt	22%

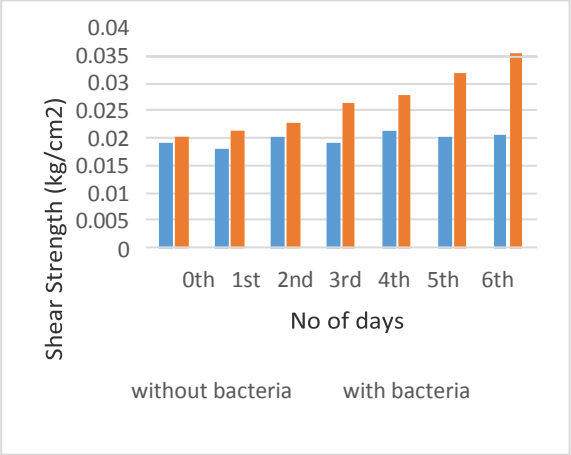

Chart -1: Vane Shear Test Result

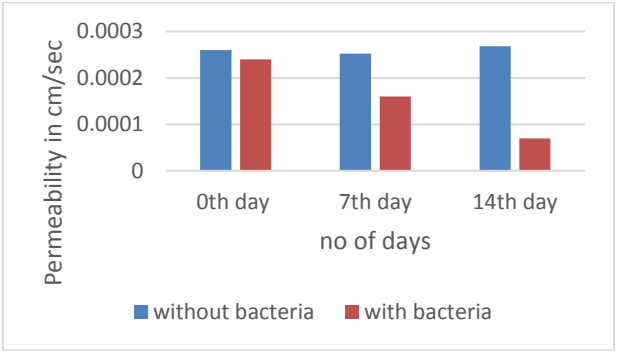

Chart -2: Permeability Test Result

3. CONCLUSIONS

1. From the study it can be concluded that by injecting the bacteria in the soil, on the 6th day the shear strength of black cotton soil was significantly increased by 42.8% as compared to 0th day which was increased by 6.4%. Hence the shear strength increases with increase in duration as the bacteria multiplies.

2. In the permeability test there was decrease in permeability by 70.83% on 14th day as compared to the 0th day which was decreased by 7.6%.

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