International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 5 ǁ May 2023 ǁ PP. 815-819

Analyzing the effect of Algae on the strength of subgrade soil

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Abstract- *The soil stabilization is the process which improves the physical properties of soil such as shear strength, bearing capacity, etc. which can be done by use of gypsum, bituminous lime, etc. have already proven to be a key factor in soil stabilization. This study reviews the fundamental mechanisms of biological soil improvement*

methods—microbially induced calcium carbonate precipitation and biopolymer treatment (BPT).Extensive experimental data on various geotechnical properties of sands treated by MICP and BPT are compiled, including the unconfined compressive strength, and permeability. Furthermore, the variations in these engineering parameters are correlated to calcium carbonate content for MICP which provides insights into the extent of biological modification in engineering properties of sands, potential applications, and limitations. Several mechanical, chemical methods have been developed to improve the expansive soil engineering property with varying success rates. Various industrial waste and traditional materials such as lime, bottom ash, fly ash, pond ash, silica fume cement are majorly used to stabilize the expansive soil. Although these techniques have shown a high improvement in the expansive soil, these chemical stabilizers also adversely affect the environment. In addition to that addition, these chemical stabilization techniques alter the chemical properties of the soil; as a result the contamination, toxic and hazardous characteristics, and high pH values have been observed in surrounding soil and water bodies due to leaching of these materials. Therefore, the alternative for ground improvement techniques with environment-friendly, less invasive, and durable materials are in need of time, which can control the plasticity nature of expansive soil.

Keywords*— Algae, Bacteria, Subgrade soil*

Date of Submission: 16-05-2023 Date of acceptance: 30-05-2023

I. Introduction

Road transport has been a driving factor in India's growth after Independence. India is a country with a very large area and various different types of soils. Connecting each and every part of the country with all weather roads is essential for its overall development. But while doing so, we often come across soil which is not sufficiently strong to bear the load of traffic on the road. Such soils require stabilization through artificial methods. Most widely used of these methods is the stabilization with cement or lime. But not only is this method expensive but puts a heavy toll on the environment in the form of pollution caused by cement production. Thus, there is a need to identify a method for stabilization of subgrade soil which is eco-friendly as

well as economically feasible. Biomineralization phenomenon of microorganisms can be a sustainable and eco-friendly method to produce lime.

Biomineralization & MICP:

Biomineralization is a commonly observed phenomenon in miro-biological world. Biomineralization is a phenomenon in which some microorganisms precipitate a layer of water insoluble salts like CaCO3 on their surface as a result of their biological processes. It is most commonly observed in coral reefs in oceans, which are formed due to microbial decomposition of dead aquatic organisms. Scientists and researchers have been studying this phenomenon to identify feasible ways of exploiting it for a large number of problems in civil engineering. Microbially Induced Calcite Precipitation (MICP) is a heavily researched method of using biomineralization for preparation of self-healing cement and for stabilization of sand. In MICP, the microbes are put in a controlled environment where they precipitate Calcium Carbonate, which has binding properties. MICP is successfully tested for filling cracks in concrete.

II. Properties of soil:

Image.1: Black cotton soil

Sr. No.	Test	Result	Std. values	IS Code
1	Natural moisture content	34.5%	-	IS: 2720 (Part 2): 1973
2	Specific gravity	2.12	2.0 - 2.65	IS 2720 (Part 3, Section 1): 1985
3	Liquid Limit	56%	55-60%	IS: 2720 (Part 5): 1985
4	Optimum moisture content	16.25%	16- 35.38%	IS-2720 (Part 7): 1980
5	Max. dry density	1.76 gm/cc	1.51-1.81 gm/cc	IS-2720 (Part 7): 1980
6	CBR (2.5mm)	13.25%	>10%	IS: 2720 (Part 16): 1987

III. Selection of Algae:

As they are frequently placed in difficult conditions with high alkalinity, a lack of nutrients, and significant compressive force, algae must have high cell availability and high enzyme activity. As they are frequently placed in difficult settings with high alkalinity, a lack of nutrients, and high compressive force, the bacteria must have high cell availability and high enzyme activity. The scientists claimed that chicken dung effluent was 88.2% less expensive and allowed for more than two times as much urease synthesis than regularly used nutrient broth. to decrease the weight-based water adsorption of various types of concrete particles. They discovered that Sporosarcina pasteurii reduces water absorption of aggregates by up to 20% better than Bacillus subtilis.

Image 2: Cyanobacteria (aqueous algae)

IV. Addition of Algae into soil:

The algae was procured from stagnant water under Sant Tukaram Maharaj Bridge, Sector 32 A, Nigdi, Pimpri-Chinchwad. It was stored at room temperature (25℃ to 30℃), along with groundwater, in a plastic jar with sufficient openings for passage of air. Since green algae performs photosynthesis, it was ensured that it received adequate sunlight (approx. 5-6 hours per day). Prior to the addition of algae, the soil was prepared by breaking the lumps and removing stones, grass, roots and other impurities. The soil was crushed till all of it passed through a 4 mm sieve. For each sample, 5 Kg soil was taken since the approximate quantity of soil required for CBR mold was found to be 5 Kg. The proportions of algae and soil in sample mixes were determined from the literature study and the amount of algae solution added in each subsequent sample was increased by 20 ml. The required amount of algae solution was mixed with 500 ml of tap water thoroughly and the resulting mixture was added to soil by sprinkling it evenly over the soil and mixing by hand.

Image 2: Sprinkling of Algae on soil

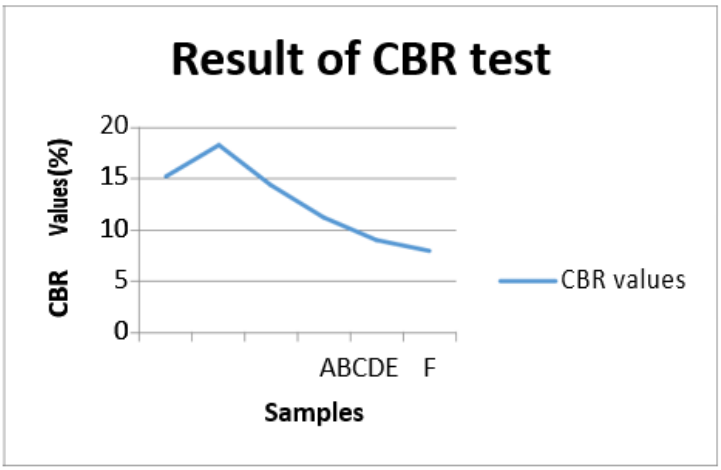
V.CBR test performed on modified soil

The samples were cured with 1 liter of tap water daily for 7 days. The water was just sprinkled on the soil kept in trays without mixing it or disturbing soil. The period of 7 days was chosen based on the similar studies found in the literature review. In most cases, the significant increase in soil was found in the initial 7 days as compared to the subsequent stages. After 7 days, the samples were tested first for checking the change in CBR value of the modified soil. The CBR test was carried out according to the IS: 2720 (Part 16): 1987. Table no.1 shows the results of CBR tests conducted on various samples.

Image 3: Performing CBR on modified soil

Name	Algae solution+Water	CBR value	Std. value
Sample A	20 ml+500 ml	15.3%	10%
Sample B	40 ml+500 ml	18.26%	10%
Sample C	60 ml+500 ml	14.37%	10%
Sample D	80 ml+500 ml	11.27%	10%
Sample E	100 ml+500 ml	9.06%	10%
Sample G	120 ml+500 ml	8.016%	10%

Table 1: results of CBR tests conducted on various samples.



VI. Conclusion:

1. Cyanobacteria or blue green algae was selected for the experimentation as it uses the atmospheric CO2 for Calcite precipitation and is readily available as well as easy to grow.
2. The Black cotton soil was chosen for this study as it has not been studied adequately for MICP using Cyanobacteria.
3. Algae was added to the soil by sprinkling method followed by curing for seven days.
4. CBR test was conducted on 6 samples, each containing a different proportion of algae, after 7 days and the sample B (40 ml algae) was found to have maximum CBR value.
5. The tests were conducted on modified soil having maximum CBR value to compare its index properties with that of original soil.
6. Following table is showing detail readings of experiment performed on soil.

Table 2: Comparison between original soil and modified soil.

Sr. No.	Test	Result		Std. values	IS Code
		Original Soil	Modified Soil		
1	Natural moisture content	34.5%	-	-	IS: 2720 (Part 2): 1973
2	Specific gravity	2.12	1.99	2.0 - 2.65	IS 2720 (Part 3, Section 1): 1985
3	Liquid Limit	56%	65%	55-60%	IS: 2720 (Part 5): 1985
4	Optimum moisture content	16.25%	16.47%	16- 35.38%	IS-2720 (Part 7): 1980
5	Max. dry density	1.76 gm/cc	2.01 gm/cc	1.51-1.81 gm/cc	IS-2720 (Part 7): 1980
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