An Experimental study on the Improvement of strength properties of soil by using biopolymer microbes

Mohsin Hassan[1], Er Tripti Goyal[2]

[1]M.tech Student, Modern Institute of Engineering & Technology, Mohri (Haryana)

[2]Head of Department, Civil Engineering, Modern Institute of Engineering &Technology, Mohri (Haryana)

Abstract: Over the last century, ground improvement techniques, which are rising rapidly as worldwide development for the utilization of unstable or soft soils, have been developed and nowadays many of them are widely used in geotechnical engineering projects. Considerable developments have occurred since the twentieth century. Ground improvement techniques continue to make considerable progress, both quantitatively and qualitatively, as a result of not only technology developments but also of an increasing awareness of the environmental and economic advantages of modern soil improvement methods. Various ground improvement techniques can be characterized as the modification of existing soils or earth structures to provide better performance under design and/or operational conditions. The main goal of most soil treatment methods whose basic principles has been not changed since the past of mankind is to improve the soil characteristics. The ground improvement techniques utilize either mechanical energy or man-made materials. Guar gum is formed from cymposis tetragonoloba and Xanthan gum is formed by xanthomonus campestris during the process of fermentation. For the sample preparation, two different mixing methods can be adopted: dry mixing in which the biopolymer was directly mixed with the soil before adding water and wet mixing in which biopolymer was mixed with water to form hydrosolution before mixing in the soil. Dry mixing method was used. Soil sample mixed with various percentage of biopolymer (0.6%, 1.2 %, 1.8 % and 2.4 %).

Keywords: Soil Stabilization, Guar Gum, CBR value, Atterberg's Limits.

1.1 INTRODUCTION

Stabilization is one of the soil modification technique is for modifying the properties of a soil to improve its engineering performance. Dramatically increased construction activities demands more area, and final outcome was scarcity of land with proper strength characteristics. In all the geotechnical works, it is impossible to locate a construction site that with proper design requirements. Mostly, the sites with unsuitable soil are modifying by the various ground modification methods to change its engineering properties to meet the design necessities. Stabilization is being used for a variety of geotechnical works and its main objective is to increase the soil stability of to reduce the construction cost by making best use of locally available materials. This study was to perform a feasibility study concerning the use of Microbial Induced Calcite Precipitation to strengthen the problematic soil by Bio-cementation. As the scale of geotechnical construction such as land reclamation is usually large, a microbial treatment could be one of the most cost effective methods. The major factors that affect the

applications of microorganisms to geotechnical engineering include the screening and identification of suitable microorganisms for different applications and different environments, the optimization of microbial activity in situ, biosafety of the application, cost effectiveness, and stability of soil properties after bio modification. Among all the factors, cost effectiveness is the most important factor for large-scale application. The microbial induced cementation method is the use of bacteria with nutrients as an energy source. Bacteria are round, rod-like, or spiral-shaped without a membranes closed nucleus with a simple cell structure. Sizes vary between 0.5 and 3 mm. Cell growth and reproduction of bacteria need carbon to form the molecule in the cells and energy to sustain life. Bacteria live in aerobic and anaerobic environments, and are heterotrophic. Aerobic bacteria live in an environment with free or dissolved oxygen, in contrast to anaerobic bacteria. The semi-permeable cell membrane controls the transport of chemicals and electrical charges in and out. Precipitation of carbon dioxide on the bacteria surface varies from clay to gravel.

1.2 APPLICATIONS OF MICROBES

Following are the various applications of microbes:

1. Exopolysaccharide producing bacteria may be used to :
   - Reduce permeability of soil
   - Selective zonal bioremediation
   - Harbour and dam control
   - Earthquake liquefaction mitigation
2. Cost of soil clogging can be reduced by using organic wastes for producing exopolysaccharide
   - To reduce drain channel erosion
   - To form grout curtains to diminish migration of heavy metals and organic pollutants
   - To prevent piping of dams and dikes
3. Bioclogging can be used to:
   - Enhance recovery of oil from reservoirs
   - Repair cracks in concrete
   - Seal unforeseen leaks in the sheet piling screens around construction wells

1.3 GUAR GUM

The Guar or bunch bean (Cyamopsis Tetragonoloba) is a yearly vegetable and the wellspring of Guar gum. It is likewise known as Gavar, Guwar or Guvar bean. Scarcely any agriculturists in semiarid districts use guar as a source to recharge the dirt with fundamental composts and nitrogen obsession, before the following crop. Guar as a plant has a large number of various capacities for human and creature nourishment however its gelling operator containing seeds (Guar gum) are today the most significant use.

Figure 1.1: Guar Gum

1.4 LITERATURE REVIEW ON GUAR GUM AS A MICROBES

Liang Cheng et al studied on the Bacteria induced cementation for soil stabilization. In the present study, the performance of MICP treated soil samples under different environmental conditions were investigated, including the degree of temperature and marine environment. In addition, the mechanical properties of MICP treated soil were compared with those obtained from soil treated using ordinary Portland cement (OPC) in terms of unconfined compressive strength and permeability. The microstructure of precipitated crystals of MICP treated soil was also examined using scanning electron microscope. This study has demonstrated the feasibility of using MICP treatment for marine environment using the calcium ions directly from seawater as the sole calcium source instead of commercially available calcium chloride. The strength of sand columns in such a case can be significantly increased by repeated treatment of seawater. The application of using natural calcium source of seawater can possibly offer a cost effective and sustainable way to strengthen the ground in marine and coastal environments.

N. Kamaraj et al studied on Improvement of Soil Behaviour by Bio-Stabilsation Method. This study was to perform a feasibility study concerning the use of Microbial Induced Calcite Precipitation to strengthen the problematic soil by Bio-cementation. The problematic soil used is expansive soil, which has high swelling, high compressibility properties and low bearing capacity. The laboratory tests were conducted to know the study the influence of Microbial Induced Calcite Precipitate Bacteria on Swelling, Strength properties and Micro structural Analysis with effect of aging in bacteria and with different curing periods. The XRD was conducted on

powdered treated samples to examine the orientation of minerals. The X- ray diffraction diagrams for the untreated soil and treated samples with two different bacteria at one curing period. From this study the results are observed for the strength characteristics, swell characteristics and micro structural analysis of the soil.

Pawar Shahaji P. et al studied on the Assessments of Soil Properties by Using Bacterial Culture. In this study, an attempt has been made to use of microorganisms, nutrients, and biological processes naturally present in subsurface soils to improve the engineering properties of soil in sustainable way. The calcite precipitation was achieved using the microorganism Bacillus Pasteurii(NCIB8841 or NCIM2477), an aerobic bacterium pervasive in natural soil deposits. The permeability and shear strength were conducted in this project these experiments demonstrate that indigenous bacteria can induce significant quantities of calcite precipitation that calcite precipitation can result in measurable changes to geotechnical soil properties. The variable percentage amount of bacteria was flushed through from top to bottom on selected soils and observes for different durations. The shear strengths of microbial soils is increases while permeability is reduces. The primary purpose of microbial soils is to improve its stability, increasing its bearing capacity and reduce settlements and lateral deformations. Bio-clogging &bio-cementation of soils could be used in geotechnical engineering to improve the mechanical properties of soil; these methods can replace the more energy demanding mechanical compaction methods or the expensive and environmentally unfriendly chemical grouting methods.

Volodymyr Ivanov et al studied on the Applications of microorganisms to geotechnical engineering for Bioclogging and biocementation of soil in situ. The aims are to summarize the existing or potential applications in these two areas, to compare advantages and disadvantages of different methods, and to identify some of the physiological groups of prokaryotes that could be potentially used effectively for biocogging and biocementation. This paper is organized in such a way that the applications related to bioclogging and biocementation are summarized first before a method for the screening of the suitable physiological groups of prokaryotes is suggested.

1.5 MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE CONTENT

Standard Proctor's compaction tests are carried out on black cotton soil admixed with guar gum at various percentages ranging from 0 % to 2.4 % by weight of the soil in increment of 0.6 %. The Maximum Dry Density and optimum Moisture Content are given in table 1.

Table 1: Maximum Dry Density of soil

Sr. No	Mix Sample	Maximum Dry Density	Optimum Moisture Content
1.	Soil	28.52	1.56
2.	Soil + 0.6 % Guar Gum	27.51	1.61
3.	Soil + 1.2 % Guar Gum	23.94	1.65
4.	Soil + 1.8 % Guar Gum	25.42	1.78
5.	Soil + 2.4 % Guar Gum	21.52	1.53

1.6 UNCONFINED COMPRESSIVE STRENGTH

The unconfined compressive strength value of soil samples admixed with GG increase with increase in percentages of GG up to 1.8 % and It is found that the excess of GG more than 1.8 % causes decrease in strength value. Because of reactions and basic nature of Biopolymer it transformed into a lumps when it is mixed with corresponding water content. So that, excess percent of guar gum results in decrease in unconfined compressive strength value.

Table 2: Unconfined Compressive strength of soil

Sr. No	Mix Sample	Unconfined Compressive Strength		
		0 Days	3 Days	7 Days
1.	Soil	1.074	1.137	1.265
2.	Soil + 0.6 % Guar Gum	1.443	1.558	1.874
3.	Soil + 1.2 % Guar Gum	1.590	1.832	2.011
4.	Soil + 1.8 % Guar Gum	2.001	2.138	2.317
5.	Soil + 2.4 % Guar Gum	1.743	1.954	2.012

1.7 CALIFORNIA BEARING RATIO

The CBR value of soil samples admixed with GG increase with increase in percentages of GG up to 1.8 % and it is found that the excess of GG more than 1.8 % causes decrease in CBR value. Because of reactions and basic nature of Biopolymer it transformed into a lumps when it is mixed with corresponding water content. So that, excess percent of guar gum results in decrease in CBR value.

Table 3: California Bearing Ratio of soil

Sr. No	Mix Sample	California Bearing Ratio	
		Un- Soaked	Soaked
1.	Soil	2.526	2.072
2.	Soil + 0.6 % Guar Gum	3.699	2.917
3.	Soil + 1.2 % Guar Gum	5.052	3.974
4.	Soil + 1.8 % Guar Gum	5.771	4.693
5.	Soil + 2.4 % Guar Gum	5.137	4.175

CONCLUSION

After doing various literature survey and experimental studies, following conclusions are drawn:

1. Liquid Limit of the soil decrease by increasing the percentage of guar Gum in the soil.
2. Plastic limit of the soil decreases by increasing the percentage of guar Gum.
3. The specific Gravity of the soil increases by increasing the percentage of guar Gum.
4. The maximum specific gravity is achieved at the percentage of 2.4 % Guar Gum.
5. The California Bearing Ratio value of the soil is influenced by the addition of guar gum. The Maximum CBR Ratio is achieved equal to 5.771 at the percentage of 1.8 % of Guar Gum.
6. The maximum Unconfined Compressive strength is achieved equal to 2.317 at the percentage of 1.8 % of Guar Gum.
7. The optimum content of the guar gum in the soil is 1.8 %.
8. The Dry Density of the soil decreases by increasing the percentage of guar Gum.
9. The optimum moisture content of the soil increases by increasing the percentage of guar Gum.
10. The un-soaked CBR value of soil with 0.6 to 2.4 % of guar gum admixed soil showed an increment of 2.526 to 5.771.

11. The soaked CBR value of soil with 0.6 to 2.4 % of guar gum admixed soil showed an increment of 2072 to 4.693.

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