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# Role of Microbially Enticed Calcite Precipitation in Stabilization of Cohesive Soils

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## Abstract.

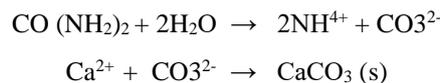
A novel soil-improving technique called "bio grouting" is based on microbiologically calcium carbonate precipitation that was induced. A solution containing urea is added to the soil before bacteria that can turn urea into ammonium and carbonate, tailed by solution of urea & calcium chloride. The calcium then precipitates with the carbonate that is formed, the Clay particles are connected by bridges made of carbonate crystals, increasing the strength within the soil mass. The objective of this endeavour is to identify the ideal bacillus composition solution containing subtilis bacteria to stabilise soil and assess the mechanical properties changes of the soil's stabilising bacillus subtilis bacteria solution and combination of cure times and a cementation solution. Bacillus subtilis bacteria are inserted into the soil in amounts ranging from 10 mL to 30 mL, and the curing duration is between 7 and 28 days. According to the results of a laboratory test measuring unconfined compressive strength, samples injected with bacteria tested at 1.70 kg/cm<sup>2</sup> and samples tested without bacteria tested at 1.20 kg/cm<sup>2</sup>. Using the bio-grouting approach to stabilise clay soil with bacteria results in an increase in the soil's bearing capacity.

**Keywords.** Bio-Grouting, Bacillus Subtilis, Ground-Improvement, Cohesive soil, UCS.

## 1. INTRODUCTION

The most crucial component in any work involving building foundation and structure is the soil [1]. Ground settlement, especially in areas that are very susceptible to settlement, such clay soil, can cause structural failure. Many different approaches of improving soil that exhibits swelling-shrinkage characteristics have been used, including soil stabilisation. In order to enhance one or more of the features of a natural soil material, a particular soil may be apportioned, added, or withdrawn, or another chemical substance may be introduced. This process is known as soil stabilisation. Mixing natural coarse- and fine-grained soil to create a mixture that produces sufficient internal friction and cohesiveness is one of the most popular stabilising techniques. Some examples include stabilisation, which uses a grouting technique with various materials as suspension (cement, clay-cement, bentonite, pozzolana etc.) or emulsions (asphalt, etc.) that are not environmentally friendly [2]. Therefore, it is

strongly advised to identify ecologically friendly alternatives for grouting methods. One of such alternatives is the use of microorganisms (called as bacteria) that may create calcite and can turn sand into sandstone. This process called as "bio-grouting". There have been a number of initiatives completed earlier, such as the Microbiologically enticed Cementation for Checking Sand Response to Undrained Shear [3]. *Bacillus pasteurii* was the microbe used in this experiment. Another effort is ground improvement using microbially enticed carbonate precipitation, which is used as a material for soil improvement [4]. The work uses bacteria *Sporosarcina pasteurii*, a species of bacterium with a high concentration of the urease enzyme, were used in the method. Last but not least, Bacterial carbonate precipitation for bio grouting looked for alternative materials that might be used to improve soil strength by exploiting microorganisms demands without considering the data volume. The majority of bio grouting research involve bacteria, particularly *B. subtilis*, which produces the urease enzyme [3]. A nutritional thesaurus containing yeast extract (20 g/L), a trace amount of nickel chloride (10 M) and ammonium chloride (10 g/L), is used to cultivate these microorganisms aerobically in the lab, and the cultures are harvested after roughly 24 hours. Solution of urea & calcium chloride is added to the soil along with the suspension containing the bacteria. The hydrolysis of urea into carbonate and ammonium is catalysed by the microbial urease. When calcium ions are present, the carbonate ions that are formed precipitate as calcite crystals, which cement the gaps within the sand grains.



The idea of biologically treated soil enhancement technology put out by [5] and many other researchers have already tried it [3], [4], [6], [7] etc. Although there are many other types of bacteria in soil, *Bacillus subtilis* is frequently utilised to produce microbial cementation of soil particles. This is due to the fact that *Bacillus subtilis* converts urea into ammonia, which raises the pH of the surrounding environment and causes  $\text{CO}_3^{2-}$  and  $\text{Ca}^{2+}$  to precipitate as  $\text{CaCO}_3$ .

## 2. MATERIALS AND METHODS

### 2.1. Microorganisms

The catalase-positive bacteria *Bacillus subtilis* (gram –positive), also referred as the grass bacillus or hay bacillus, is found within soil and the ruminant & human gastrointestinal tracts. *Bacillus subtilis*, a rod-shaped member of the genus that can create a hard, protective endospore that allows it to withstand against harsh environmental circumstances. Though there is evidence to suggest that *B. subtilis* is facultative aerobe, it has already previously been categorised as compel aerobe. *B. subtilis* is most well-studied gram-positive bacterium, which is also used as a model to research bacterial cell development and chromosome replication. *B. subtilis* is one among the bacterial leaders in the synthesis of secreted enzymes which is utilised on a large scale in biotechnology businesses.

### 2.2. Cohesive Soil

Locally accessible clay soil was utilised for this research. If a particle's size is less than 0.002 mm, it is considered to be clay. The properties of cohesive soil involve its tiny grain size, that is below than 0.002 mm, low permeability, cohesiveness, high increase in water