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Case ID:M18-260P^
Published: 3/20/2024

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Enhancing Strength of EICP-Treated Sand Using a Protein-Based Additive

Background

Effective ground improvement methods are essential for optimal utilization of land, whether they be roads, embankments, dunes, or slopes. Conventional methods using compaction, pile insertion, and cement-soil mixing provide adequate stability but have several major drawbacks. They are often expensive, time-consuming, require specialized machinery, and may present significant negative environmental impacts.

The use of calcium carbonate precipitation as a sustainable binder for granular soils has been an active field of research. This technique relies on urease enzyme to catalyze the hydrolysis of urea in an aqueous solution, creating carbonate ions and alkalinity that lead to calcium carbonate precipitation in the presence of calcium ions. Assimilating this process into soil improves strength, stiffness, and dilatancy by way of pore filling, particle roughening, and inter-particle binding. For this process, ureolytic microbes are commonly used as the source of urea, in what is referred to as microbially induced carbonate precipitation (MICP). More recently, the use of agriculturally derived free urase enzyme for soil improvement, known as enzyme induced carbonate precipitation (EICP), has been investigated by researchers.

The typical measure of soil improvement via carbonate precipitation is unconfined compressive strength. In studies described in the literature, both EICP- and MICP-treated soil resulted in a carbonate content in excess of 3% (w/w) with an unconfined compression strength in excess of 0.5 MPa after multiple treatments.

Invention Description

Researchers at Arizona State University have developed a new process for EICP wherein an inexpensive protein-based stabilizer is added to the treatment solution. Enhanced soil strength at a relatively low carbonate content was observed: With only a single treatment cycle, unconfined compressive strengths of up to 2 MPa were achieved at <1.4% carbonate content. By comparison, a single-cycle treatment of the same soil without the added stabilizer saw strength reach less than 0.2 MPa even with similar levels of precipitated carbonate. Additionally, to achieve an unconfined compressive strength near 2 MPa, 8x to 10x carbonate

content was required from multiple treatment cycles.

Potential Applications

- Soil improvement
- Sustainable construction
- Infrastructure maintenance

Benefits and Advantages

- Innovative – Yields unprecedented soil strength for single-cycle EICP treatments with sub-3% carbonate content
- Sustainable – Decreases generation of ammonium chloride, an undesirable EICP byproduct
- Time-saving – Achieves significant soil strength after only one treatment
- Economical – Widely available additive reduces cost of treatment
- Efficient – Boosts carbonate precipitation levels toward theoretical limits

Homepage of Professor Edward Kavazanjian