Effect of Magnesium as Substitute Material in Enzyme-Mediated Calcite Precipitation for Soil-Improvement Technique

The optimization of enzyme-mediated calcite precipitation was evaluated as a soil-improvement technique. In our previous works, purified urease was utilized to bio-catalyze the hydrolysis of urea, which causes the supplied Ca$^{2+}$ to precipitate as calcium carbonate. In the present work, magnesium chloride was newly added to the injecting solutions to delay the reaction rate and to enhance the amount of carbonate precipitation. Soil specimens were prepared in PVC cylinders and treated with concentration-controlled solutions composed of urea, urease, calcium, and magnesium chloride. The mechanical properties of the treated soil specimens were examined through unconfined compressive strength (UCS) tests.

A precipitation ratio of the carbonate up to 90% of the maximum theoretical precipitation was achieved by adding a small amount of magnesium chloride. Adding magnesium chloride as a delaying agent was indeed found to reduce the reaction rate of the precipitation, which may increase the volume of the treated soil if used in real fields because of the slower precipitation rate and the resulting higher injectivity. A mineralogical analysis revealed that magnesium chloride decreases the crystal size of the precipitated materials and that another carbonate of aragonite is newly formed. Mechanical test results indicated that carbonate
precipitates within the soils and brings about a significant improvement in strength. A maximum UCS of 0.6 MPa was obtained from the treated samples.

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