Used Paper Fibers for Sustainably Enhancing the MICP Stabilization of Sand

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Abstract. The increasing awareness of the energy crisis and environmental protection has led to a proliferation of studies on novel ground improvement techniques. One of these techniques is microbially induced carbonate precipitation (MICP), which sustainably applies the microorganisms for soil stabilization purposes. During the process, calcium carbonate is achieved bio-chemically within the embedded soil, enhancing the strength and stiffness. For several decades, fiber materials have been a prime part of soil improvement on account of its desirable mechanical characteristics. Therefore, this work aims to introduce the fiber onto the MICP, demonstrating how the fiber material could enhance the MICP process in the sand. Used paper fibers, one type of recycled material, were chosen herein as an environmental-friendly option, and a series of experiments were conducted on the sand with different ratios (1–8%) of fiber. The findings suggest that the fiber addition enhanced the immobilization of the bacteria cells and provided favourable conditions for bacterial performance and survival. The calcium carbonate measurements revealed that the fiber addition could significantly yield the precipitation content, increasing the unconfined compressive strength (UCS). However, the optimum fiber content corresponding to the highest UCS was found to be 1%, and further addition appeared to suppress the UCS of sand. Overall, the study has demonstrated that the used paper fiber could be effectively reused in the MICP technique, enabling the pathway with several desirable merits.

1 Introduction

Recent trends in sustainable development have heightened the need for the introduction of new technologies into ground improvement techniques (DeJong et al., 2010). Microbially induced carbonate precipitation (MICP) is relatively a new environmentally friendly method, which has rapidly gained greater attention as a green technology for the future (DeJong et al., 2010). The process of MICP highly relies on metabolic activity and a series of biochemical reactions, persuading the calcium carbonate cement within the embedded soil matrix. Urease produced by soil bacteria (referred to as ureolytic bacteria) catalyzes the hydrolysis of urea (Eq. (1)), hence favorably increase the pH of the reaction medium. In the presence of calcium ions, calcium carbonate precipitates in nucleation sites provided by the bacterial cells (Eq. (2)), which binds the soil particles and acts in a

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