学 位 論 文 内 容 の 要 旨

博士の専攻分野の名称　博士（工学）　氏名　YAN ZHEN

学 位 論 文 題 名

Exploring the Solidification of Sand Using Biocement Technology with Kitchen Waste
(生ごみを利用したバイオセメント技術による砂の固化に関する研究)

This dissertation presents a comprehensive investigation into a novel biocementation approach that utilizes kitchen waste to solidify sand, aiming to provide a cost-effective and environmentally friendly alternative to traditional cement-based soil stabilization methods. By structuring the study around biocement's economic and environmental advantages, this work offers valuable insights into reducing production costs and maximizing sustainable applications of biocement methods. The need for sustainable soil stabilization is becoming increasingly critical as the construction industry seeks to reduce carbon emissions and transition toward greener practices. Despite the well recognized potential of biocement techniques, traditional methods involve high costs and environmental challenges, such as ammonia emissions and the use of costly reagents. To address these issues, this study explores the use of kictchen waste materials in biocement processes, introducing an innovative, lower-cost pathway to achieving biocementation.

Chapter 1 details the organization and novel contributions of this study in the context of sustainable construction and soil improvement.

Chapter 2 reviews current measures for lowering biocement production costs, discussing alternative cultivation media for MICP, plant-based sources for EICP, and various urea and calcium sources. This chapter provides a comprehensive overview of recent advancements in cost-effective biocementation strategies.

Chapter 3 introduces a novel method of improving biocement strength by altering precipitation patterns. Using eggshell waste and soybean crude enzymes, it demonstrates how the nucleation sites from eggshells can shift calcium carbonate precipitation from a coating to a bridging mode, thereby significantly enhancing strength within the same treatment period.

Chapter 4 presents techniques to reduce biocement permeability through modifications in precipitation patterns. Shellfish waste and soybean crude enzymes are used to provide nucleation sites, allowing calcium carbonate precipitates to effectively fill pore spaces, which decreases permeability within the same processing duration.

Chapter 5 investigates how altering the crystal phase of precipitates enhances biocement strength. This approach shows that adjusting crystal phases of calcium phosphate compounds can significantly increase material strength without increasing the precipitation amount, demonstrating a sustainable method for durable biocementation.

Chapter 6 shows the exploration of biocementation under microgravity conditions, marking the first use of crude enzyme-induced calcium phosphate precipitation for biocement production in microgravity environments. This pioneering investigation provides valuable insights for future space construction applications.

Chapter 7 summarizes the study's findings and conclusions for future research directions. Together, the findings of this thesis highlight the potential of biocement technology, leveraging waste resources to achieve sustainable soil stabilization. This approach holds promise for a wide range of applications, including terrestrial and extraterrestrial infrastructure, thereby advancing sustainable development in diverse construction contexts.