

Article

Experimental Study on the Permeability of Microbial-Solidified Calcareous Sand Based on MICP

Yanjun Li and Jianwen Chen *

Faculty of Engineering, China University of Geosciences (Wuhan), Wuhan 430074, China

* Correspondence: jwchen@zgwg.com

Abstract: In the construction of artificial islands in distant seas, calcareous sand has been widely used as a foundation filler due to its excellent mechanical properties and extensive availability in the marine environment. How to store more fresh water on the artificial islands by reducing its permeability is currently a great challenge. Microbial-induced carbonate precipitation (MICP) has always been considered as a great potential method to improve the cemented properties of calcareous sand, but the effect of grain gradation on the permeability of MICP-improved calcareous sand remains unclear. In this research, a self-made device was developed to conduct MICP grouting and permeability tests, where the permeability coefficient (k) under different grain gradations (curvature coefficient (C_c) and uniformity coefficient (C_u)) was measured. A CT scan was conducted to investigate the variation in the porosity (π) of sand samples before and after MICP treatment. The weighting method was adopted to measure the content of induced calcium carbonate (M). A scanning electron microscopy (SEM) technique was used to further study the micromechanism of the MICP treatment. Finally, the correlations between the k of MICP-treated sand and C_c , as well as C_u , were semiquantitatively analyzed. The results show that the magnitude of M , k and π changes are closely related to C_c and C_u . The reduction amount of k and π increased with the rise in C_c and C_u , and the increased amount of M increased with the rise in C_c and C_u . The SEM results show that the particle surface became rough due to the coating effect of CaCO_3 crystals, and the pore spaces were reduced because of the partially filling effect of the crystals, which was responsible for the decrease in permeability and porosity. Furthermore, k fitted well with C_c and C_u , respectively, and the fitting curve reveals that larger C_c ($C_c \geq 6.09$) and smaller C_u ($2.0 > C_u > 0.5$) were more suitable for MICP treatments and lead to a large reduction in permeability. The above results indicate that the grain gradation of calcareous sand had a significant influence on its permeability improved by MICP.



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Keywords: MICP; calcareous sand; grain gradation; permeability coefficient; porosity

1. Introduction

The construction of artificial islands is in full swing all over the world due to space limitation in coastal areas [1,2] and transfer transportation requirements in distant seas (e.g., Fiery Cross Island in the South China Sea). On the artificial islands, the storage and access of fresh water are important fundamental conditions for human living [3,4]. In China, it has been reported that the cost of transporting high-quality tap water from the mainland to one island reaches USD 370 thousand per year [5]. How to store more fresh water on the artificial islands is of great significance to cost savings. Previous efforts have found that the permeability of island-building materials dominates the water storage on the island. General consensus has been achieved that the application of less permeable island-building materials can increase freshwater storage [6,7].

Regarding island-building materials, calcareous sand, formed by the accumulation of coral debris and other biological debris, has been widely used as a foundation filler [8–10] due to its excellent mechanical properties and extensive availability in marine environments [11,12]. However, the reclamation in distant seas using sand is often carried out via

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Theory and Practice in Microbial Enhanced Oil Recovery Kun Sang Lee, Tae-Hyuk Kwon, Taehyung Park, Moon Sik Jeong, 2020-07-18 Selection of the optimal recovery method is significantly influenced by economic issues in today's oil and gas markets. Consequently, the development of cost effective technologies which bring maximum oil recovery is the main interest in today's petroleum research communities. *Theory and Practice in Microbial Enhanced Oil Recovery* provides the fundamentals, latest research and creditable field applications. Microbial Enhanced Oil Recovery (MEOR) is potentially a low priced and eco friendly technique in which different microorganisms and their metabolic products are implemented to recover the remaining oil in the reservoir. Despite drastic advantages of MEOR technology, it is still not fully supported in the industry due to lack of knowledge on microbial activities and their complexity of the process. While some selected strategies have demonstrated the feasibility to be used on a mass scale through both lab and field trials, more research remains to implement MEOR into more oil industry practices. This reference delivers comprehensive descriptions on the fundamentals, including basic theories on geomicrobiology, experiments and modeling, as well as current tested field applications. *Theory and Practice in Microbial Enhanced Oil Recovery* gives engineers and researchers the tool needed to stay up to date on this evolving and more sustainable technology. Covers fundamental screening criteria and theories, selective plugging and mobility control mechanisms. Describes the basic effects on environmental parameters and the mechanics of simulation, including microbial growth kinetics. Applies up to date practical applications proven in both the lab and the field.

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Abstracts of Bacteriology Society of American Bacteriologists,1923 Includes Scientific proceedings of the Society of American Bacteriologists *Computational Methods in Water Resources IX* T. F. Russell,1992 **Proceedings ... SPE Annual Technical Conference and Exhibition** Society of Petroleum Engineers (U.S.). Technical Conference and Exhibition,1996

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