MarTREC
Maritime Transportation Research & Education Center

MarTREC UTC Project Information Form
USDOT Tier 1 University Transportation Center
Agency ID or Contract Number 69A3551747130

Project Title: Evaluation of Hydrogel–stabilized Expansive Soils in Mississippi for Sustainable Maritime Infrastructure Design
Project Abstract (Brief Description): The expansive soil causes a variety maritime transportation infrastructure problem, such as cracks, damage of pipeline, and the differential settlement of foundation. In Mississippi, Yahoo clay, one type of expansive soil, causes significant concern during the maritime design and maintain. To address the need of MarTREC for the sustainable and resilient transportation infrastructure preservation and building upon its experience and expertise in the area, this project is being proposed the feasibility of using innovative hydrogel treatment as alternative expansive soil stabilization. Hydrogel is a network of polymer chains that are hydrophilic, which has physical entanglement and chemical bonding to integrate solid and liquid properties. Meanwhile, the superior toughness and mechanical strength of hydrogel can provide additional bonding force between soil particles and may reduce the swelling behavior of expansive soil. The hydrogel treatment may provide great and previously unexplored opportunities as cost-effective and sustainable preserving alternative approach for expansive soil stabilization in maritime infrastructure.
Describe Implementation of Research Outcomes: The optimum reaction time and curing temperature of hydrogel-impregnated sand were found to be 3 days and 50°C, respectively. The UCS tended to increase with the increase of sodium alginate 32 content, but hydraulic conductivity decreased with the increase of sodium alginate content. The UCS of hydrogel-impregnated sand at 0.4% sodium alginate content can reach 430 kPa. Meanwhile, the hydrogel-impregnated sand showed a significant improvement in cohesion. The results showed that the cohesion and friction angle of hydrogel-impregnated sand is 150 kPa and 16º respectively. These would help bond the sand particles as a whole and improve their strength performance. In addition, the stress-strain curves of hydrogel-impregnated sand indicated that the ductility of hydrogel-impregnated sand was significantly improved compared with the traditional cementitious method. Moreover, the results of durability tests indicated that approximately 60% of the original UCS of hydrogel-impregnated sand remained after 12 wet-dry and freeze-thaw cycles. There are some challenges when the hydrogel is applied to clayey soil. The strength of clay samples without sodium alginate (3200 kPa) was the highest, which was about 4.3 times of clay samples with 0.4% sodium alginate content (750 kPa). But the strain of hydrogel-impregnated clay samples increased along with higher sodium alginate content, and the hydrogel-impregnated clay with 0.4% sodium alginate content had a residual strength of 750 kPa. And higher sodium alginate content gave more help to reduce the swelling deformation of clay soil. The expansive behavior was mitigated through the addition of sodium alginate. With the addition of 0.4% sodium alginate, the swelling deformation decreased from 0.8 mm to 0.5mm, giving a reduction of the swelling deformation of 38.7%. From the triaxial tests, it has been found that higher sodium alginate content resulted in higher friction angles. However, the cohesion decreased along with higher sodium alginate content. After 12 wet-dry and freeze-thaw cycles, 60% and 80% of the original UCS of hydrogel-impregnated clay remained. The results indicated that the Ca-alginate hydrogel has a good durability performance against wet-dry and freeze-thaw cycles.
Impacts/Benefits of Implementation: Based on these conclusions above, sodium alginate was highly recommended for the application of reinforcement of cohesionless soil in maritime transportation infrastructure projects. It can significantly improve the strength and ductility performance of cohesionless soil. It can also create a relatively high cohesion strength for sandy or silty soil which could significantly enhance the subgrade of maritime transportation infrastructure against coastal erosion. The sodium alginate does not show any improvement in the strength behavior of treated clay soil. However, it helps to mitigate the swelling behavior of the expansive clay which may benefit to mitigate the cracks damage on the maritime transport infrastructure. Further study on erosion resistance of hydrogeltreated sandy soil

and cracks mitigation observation tests were highly recommended to better understand the feasibility of applying the hydrogel in the subbase of maritime transportation infrastructure.
Web Links: martrec.uark.edu
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Principal Investigator(s) and Contact Information: Dr. Yadong Li, ORCID: 0000-0001-6477-9074, Email: yadong.li@jsums.edu, phone: 601-979-1093.
Principal Investigator Institution (University): Jackson State University

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