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EXTENDED ABSTRACT

Impact of Biologic Single and Mixed Medium on Mechanical-Hydraulic properties of Dune Sand

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Biological improvement, Single and mixed culture, Unconfined compression, Permeability.

1. Introduction

Today, new improvement methods to improve the geotechnical properties of soils are considered. Although a lot of improvement techniques are in use around the world, they have their own advantages and disadvantages. Chemical, physical, mechanical, biological and electrical techniques may be named as the common methods of soil improvement (Karol, 2003). Some of the methods, particularly those using cement and other toxic chemical grout, may cause environmental problems which limit their usage. In this regard biological improvement is an innovative method that uses microorganisms in the soil and biochemical reaction networks, the soil physical and mechanical properties are improved. In this research, mixed culture performance was studied against single culture of bacteria on physical strength properties of sandy soil, as the stabilization efficiency was evaluated in terms of the soil compressive strength, secant stiffness, and permeability with unconfined compression and falling head tests, respectively.

2. Methodology

Bacillus Pasteurii bacteria was used as single culture and Bacillus Pasteurii+Bacillus subtilis were used as mixed culture. Both of them were cultured in LB medium. After the required bacterial growth had occurred, the cells in the culture medium were harvested by centrifugation for 15 min at 4500g. The harvested cells were then washed twice in sodium phosphate buffer 0.1 M (pH 7) to remove metabolic waste and any metabolism produced during the bacterial growth phase. The cells were transferred to in nutrient broth (NB)–urea solution comprising 3 g of NB, 20 g of urea, 10 g of ammonium chloride and 2.12 g of sodium bicarbonate per litre of deionized water with OD_{600}= 1.1 (Shahrokhi-Shahraki et al., 2014).

Cementation solution by dissolving 1 mole of urea and 2 moles calcium chloride per liter of distilled water were prepared. Bacteria solution mixtured with sand and then was poured into moulds made of PVCwith dimensions of 47 mm diameter and 100 mm in height (height to diameter ratio 2.1), after that, cementation solution was injected into samples and after a period of 12 hours the cementation solution was injected again and the curing time was considered 7 days.

3. Results and discussion

To examine the mechanical and physical properties, the unconfined, triaxial compression and permeability (failling head method) tests were carried out on the cured specimens. These tests were conducted in accordance with the ASTM standard. The compression tests speed was 1 mm/min.

3. 1. Unconfined compression strength and stiffness

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Fig. 1 shows the axial stress-strain of the soil samples derived from unconfined compression tests. As observed, the unconfined strength of the treated soil with *B. pasteurii+ B. subtilis* is obtained 1690.3 kPa which is significantly greater than the treated soil strength with *B. pasteurii* that obtained 1391. The unconfined strength of the treated soil with *B. pasteurii+ B. subtilis* and *B. pasteurii* mediums are significantly greater than the untreated soil strength. The untreated soil strength at a confining stress of 50kPa to be about 256kpa through triaxial conditions at w=16% and $\gamma_d = 1.74\ \mathrm{gr/cm^3}$ (proctor compaction conditions). The high unconfined strength of *B. pasteurii+ B. subtilis* medium in comparison with that of the treated soil with *B.* pasteurii is due to the higher calcite precipitation made of biochemical reactions. The cementation process is caused the soil particles sticking to each other and creating a firm mass. Fig. 2 shows amount of elasticity modulus of untreated and treated sandy soil. Elasticity modulus is calculated with Secant method.

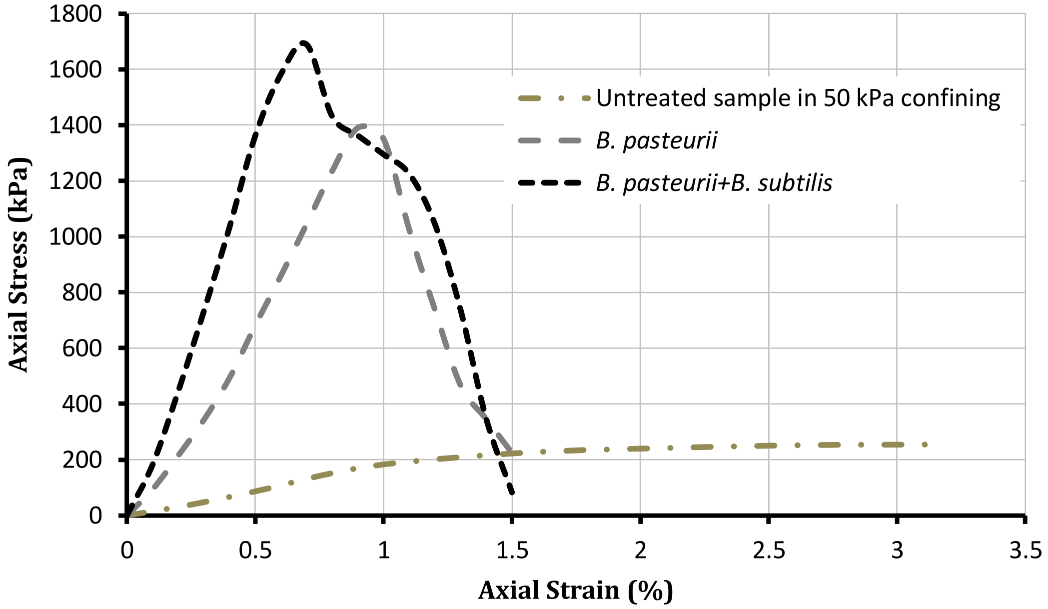

Fig. 1. Stress-strain diagram of untreated and treated sand

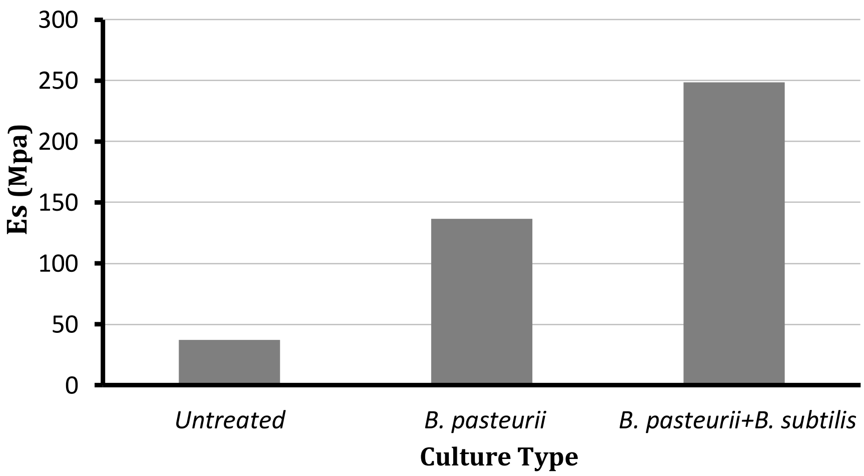

Fig. 2. Amount of elasticity modulus

3. 2. Coefficient of permeability

Fig. 3 shows permeability of untreated sand and treated with *B.pasteurii* and *B. pasteurii+ B. subtilis* mediums. According to Fig. 3 permeability coefficient of *B. pasteurii+ B. subtilis* medium is less than *B. pasteurii* mediun and untreated sand, it is for this reason that the calcite precipitation made of biochemical reactions reduce void ratio of sandy soil.

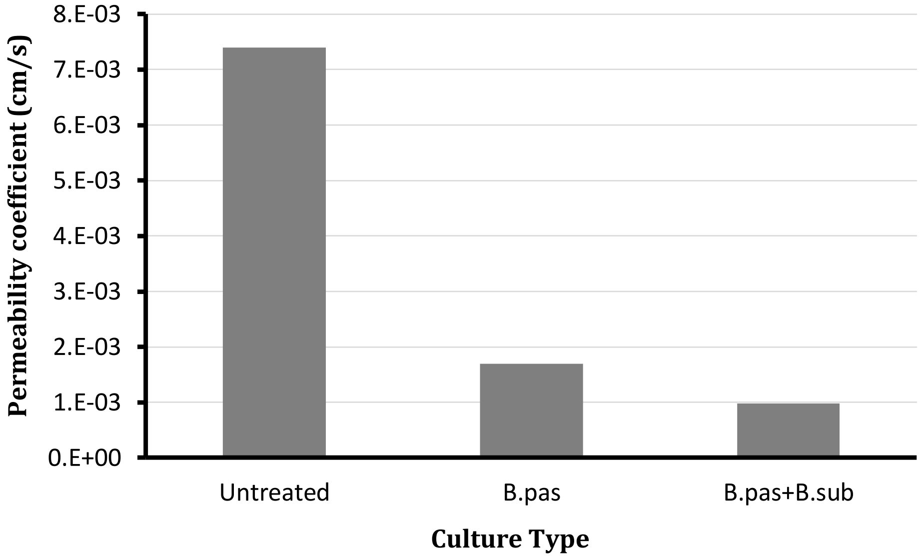

Fig. 3. Coefficient of permeability

4. Conclusions

After curing time (7 days), the results showed that the unconfined compression of improvement soil by single and mixed cultures are 1391kPa and 1690.3 kPa, respectively, which increased 44% and 53% compared to the sandy soil, respectively. Also the results showed that the unconfined compression of improvement soil in mixed culture to single culture has increased 38%. Permeability test results also show mixed culture better performance than single culture in reducing the permeability, as permeability in mixed culture state is 34% less than single culture state. Increasing unconfied strength and decreasing permeability factor of improved samples by mixed culture to single culture is for this reason that *Bacillus subtilis* increases urea hydrolysis rate and the rate of precipitation of calcite. Finally precipitated calcium carbonate has been shown by SEM.

5. References

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