THE EFFECT OF ALPHASOIL ON THE ENGINEERING PROPERTIES OF SOIL AT KHULNA REGION OF BANGLADESH

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Background

The presence of clayey soils with an excessive number of exchangeable ions almost everywhere is a major challenge in Bangladesh. This can be depleted rapidly when it interacts with moving water by separating individual particles. Such soils are not suitable for constructing hydraulic earth structures. Most road embankments in areas susceptible to flooding suffer soil erosion, making roads unusable in Bangladesh. Landslides have caused a rise in the number of casualties and infrastructure damage in Bangladesh's Chittagong Hilly Areas (CHA). A series of landslides occurred in 145 locations in CHA in June 2017, resulting in 168 deaths and the destruction of 40 thousand homes. A total of USD 223 million was lost in economic terms. More than 3500 people have died in Bangladesh due to landslides in the last 30 years. In addition, flood plains are vulnerable to riverbank erosion. Poor soil structure, and devegetation are recognized as the main causes of landslides. The conventional soil stabilization techniques in Bangladesh do not have the capability to improve soil structure. That's why, a new and innovative soil stabilization technique is highly required to improve the stability of hilly slopes and make the soil structure internally stronger. The goal of soil stabilization is to increase the strength and durability of the soil in the required conditions for the design life of the earthen infrastructure.

What is soil stabilization?

Chemical soil stabilization technique is indeed more effective than mechanical due to the inconsistency in soil stabilization. The chemical techniques focus on chemical additives reactions to soil particles, which lead to a wide network of soil grains. Conventional methods such as cement, bitumen or industrial by products for chemical stabilization strategies have the drawbacks of being inefficient, expensive, and not environment friendly. That's why, we introduced an innovative a liquid chemical soil stabilizer, alphasoil to make the soil internally stronger.

Alphasoil

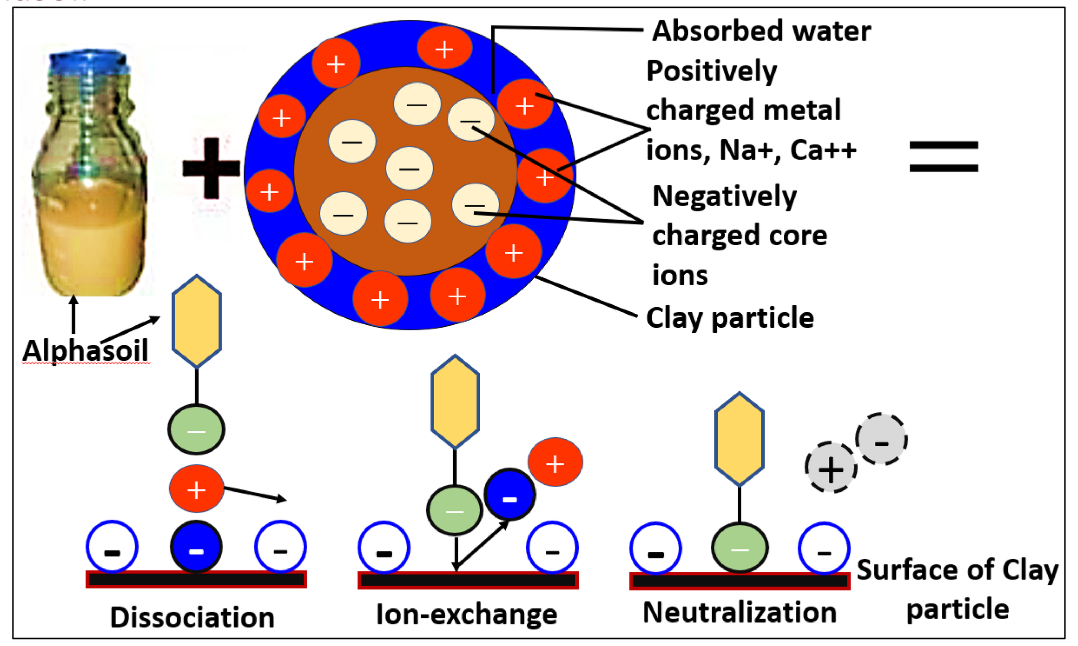

Figure 1. Principles of alphasoil, it works in three stages – dissociation, ion-exchange and neutralization on the clay surface. That's how, it removed the water from the surface of clay particle which is the main reason of swelling and shrinkage properties

Purpose

To investigate its influence on the engineering properties of different types of soil samples at Khulna region, Bangladesh.

To compare the treated and untreated soil sample by conducting unconfined compressive strength (UCS), plasticity index (PI)

To know the impact of treated soil structure internally by scanning electron microscope (SEM) test.

Research question

- Is it possible to improve soil properties by using alphasoil in laboratory scale in Bangladesh?
- If yes, then how much improvement can be possible?
- What is the impact of internal soil structure after using alphasoil?

Methods

Site selection and sample collection

Five soil samples designated as S1, S2, S3, S4 and S5 were collected from five different places in KUET campus - Khan Jahan Ali Hall (S1), Lalon Shah Hall (S2), Rokeya Hall (S3), Civil Building (S4), and Dormitory (S5).

Figure 2. Five soil samples; All the samples were collected from 2-4 feet depth below the existing ground surface. The geotechnical engineering properties of each soil sample were measured by using ASTM methods. Soil samples were collected from different locations due to find the effect of alphasoil at different types of soil. 50 ml alphasoil bottle was provided by Alphasoil® technical solutions GmbH, Germany.

Laboratory Investigation

Table 1: Geotechnical properties of samples used in this study

Soil Properties	S1	S2	S3	S4	S5
Natural moisture content, %	20.30	21.48	26.13	22.40	24.79
Specific gravity, G_s	2.52	2.59	2.67	2.37	2.64
Sand, %	50.7	54.4	41.1	56.03	57.4
Clay, %	39.5	34.35	38.9	30.6	30.6
Silt, %	9.8	11.2	13	22.6	20
Description of soil	Brown Clay, little sand	Sandy clayey silt,dark gray	Clayey silt, little sand, dark gray	Sandy clay, little clay, gray	Brown, silty clay

Soil stabilization by Alphasoil

Figure 3. Treated soil sample by using alphasoil dilution. A ball was formed by hand with the material and dropped from 1m to the floor. As there were no cracks and fissures in this ball shaped sample, it was determined that the ball shaped sample was hardly formed, and the water content and material composition were in order. After stabilizing soil by alphasoil, different types of experiments such as standard proctor compaction test, liquid limit and plastic limit test and water storage test were conducted to determine the performance of treated samples in comparison with untreated samples.

First, several pieces of boulder sized soil sample were broken by hammer and made into a small sized soil sample. This was performed for each type of soil sample. After that, all small sized sample was passed through #4 sieve and this passing sample was used for further processing. Sand was added depending on its clay content for example in normal clayey soil, 200gm clay was mixed with 100gm sand.

Unconfined Compressive Strength (UCS) test

Figure 4. Compression testing machine. Treated soil sample before UCS testing and after testing. Treated soil sample was molded into a cylinder-shaped mold (2"diameter and 5" height). Deformation dial reading – 0.01mm, Load dial division – 0.00147 kN/div. Deformation dial gauge reading was recorded after every 60s.

Liquid limit (LL) and Plastic limit (PL) test

Figure 5. Grooving tool with spatula for LL and PL test. This test was performed for treated and untreated soil sample. For 25 blows, water content value was recorded and considered as liquid limit of the soil sample. This test was performed to know the plasticity index (PI) of treated and untreated soil.

Water Storage test

Figure 6. California Bearing ration testing machine. The mold with treated soil sample was pressed by load until no more water escaped out from the drainage holes. By opening the press-core, it was pumped out from the mold and dried in an oven for 3 hours at 70°C. Samples were provided with 3 marks (1cm-2cm-3cm) and weight of each sample was taken. It was filled with water in a water bath up to 1st mark.

This test was done to know what would happen to the treated and untreated sample if both came to contact with water.

Findings

Impact of alphasoil on UCS

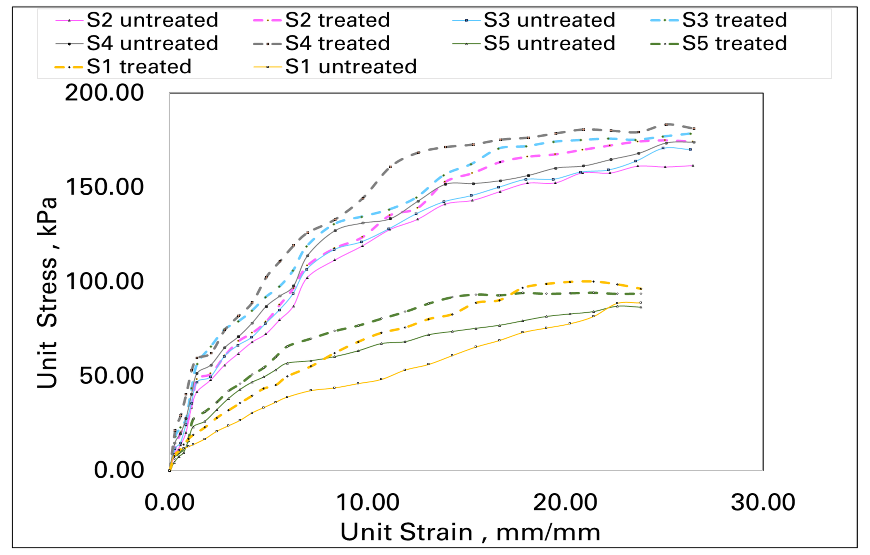

Figure 7. Stress v/s strain curves for each treated and untreated samples are shown. After 3 days, soil strength was measured. It is observed that, improvement of soil strength is different for different types soil, but strength improvement is possible for different soil types by using alphasoil. The reason can be explained by the formation of more adhesive alphasoil particles that entangle with soil particles and enhance soil cohesion.

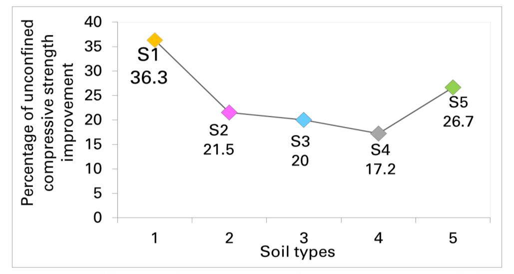

Figure 8. Comparison between treated and untreated soil based on UCS. We found the best soil strength improvement (55%) for S1 among this 5 types of soil. The explanation may be due to the bond of alphasoil to the surface of clay particles, ionic interactions and the appropriate soil texture.

Overall, soil strength increased for each types of soil after treating with alphasoil and 28.1% soil strength improvement is possible.

Impact of alphasoil on plasticity index

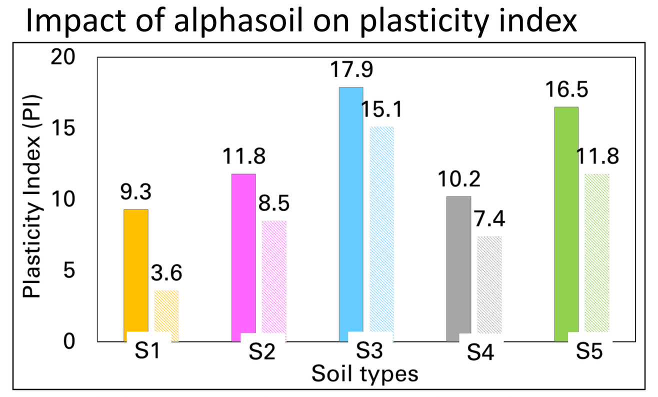

Figure 9. Comparison between treated and untreated soil based on plasticity index. Solid bar indicates untreated soil and dashed bar indicates treated soil sample. In general, reduction in the liquid limit is the confirmation of reduction in the compressibility and swelling characteristics. From this bar chart, it is observed that the PI decreases for each type of soil. It indicates the improvement of soil properties. The reduction in plasticity index may be due to the filling of the voids of the flocculated soil while reducing the capacity to retain water.

We did not get the same reduced percentage of PI. It may be happened due to the difference in soil properties and soil textures such as sand, clay, and silt. Overall, 33.9% of reduction of PI was observed.

Results of water storage test

Figure 10. Comparison between treated and untreated soil based on water storage test. After 3 days, treated soil sample remains same as before with the increasing amount of weight and moisture content. That means, it just changed the soil structure internally and made it stronger. That's how, treated soil structure could survive even if there is water. The treated soil was not washed away like the untreated soil. It can be assumed that the absorbed water for treated sample may be chemically combined with the particle of clay surface and cannot swell because of alphasoil particle, that's why weight increases but no damage in each treated soil sample.

The collected water from water bath was tested to check if there was any chemical component or not. But fortunately, no chemical was found. That indicated no leaching condition.

Scanning Electron Microscopic (SEM) test

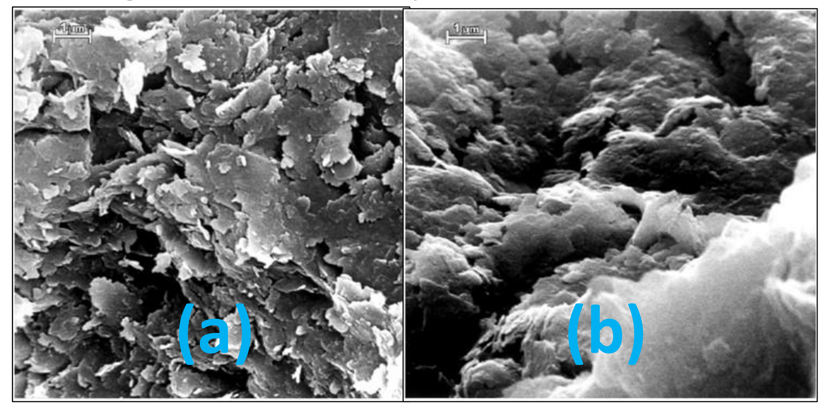

Figure 11. (a) Scanning electron image of untreated S1. Porous, heterogenous structure with center pores (0.2-10 μm). (b) Scanning electron image of treated S1. Appearance of a compact structure with few pores. 10,000 times magnification. We observed that treated soil structure changed internally with less void spaces and more compact condition. This test was conducted only for S1 due to the improvement of maximum strength than other soil samples.

Above all, alphasoil has the capacity for improving the clayey soil by changing the soil structure internally. All credit of this SEM test goes to Mr. Werner Bernhard.

Conclusions

This study investigates the potential alphasoil utilization as an alternative to conventional soil stabilization methods and the effects of alphasoil on unconfined compressive strength and plasticity index were determined and analyzed. The grain size analysis, specific gravity test and water storage test were carried out as soil properties characterization and for physical evaluation. The results showed that incorporation alphasoil to clayey soil could enhance the interparticle cohesion and therefore increase the mechanical properties of expensive soil. However, this stabilization mechanism is affected by major factors of properties of soil, proper mixing, and proper compaction of alphasoil. In a wet conditioned soil sample, it works as a cohesive agent to improve the bond of soil particles. In summary, alphasoil offers a potential for soil stabilization in perspective of Bangladesh. Furthermore, the findings of this research affirm the potential for using alphasoil to stabilize tropical residual soils, in particular the construction of landslides, earthen dam and pavement base or subbase layers in Bangladesh, or other construction projects in tropical regions with extensive earthworks requiring a large volume of clay soils. Further studies on soil stabilization with alphasoil with CBR tests, permeability test, and large-scale application are of interest.

Practical/social implications

Alphasoil can be utilized in constructing earthen dam structures for flood mitigation in Bangladesh. To prevent landslide, soil structure can be made stronger by implementing alphasoil. With the pilot scale application of alphasoil, people's life can be saved and economical loss due to landslide can be stopped. We also published a flyer about alphasoil. After seeing the flyer, the Design Engineer of World Food Programme (WFP), Mr. Biniam Michael has shown his interests for pilot scale study of alphasoil for implanting at Rohingya refugee camps in Cox's Bazar in Bangladesh.

Value of the project

The Forcibly Displaced Myanmar Nationals (FDMN), also known as "Rohingya," sought refuge in Bangladesh's Cox's Bazar District after fleeing ethnic atrocities and genocide in Myanmar's Northern Rakhine State in 2017. Kutupalong Rohingya Camp (KRC) is a network of camps located in tectonically active tertiary hilly terrain. The KRC has been exposed to hydrometeorological hazards, including landslides. WFP in collaboration with other UN agencies, has been engaged in infrastructure development such as road and settlement areas, within the refugee camps in Cox's Bazar following to the Rohingya refugee crises. However, the recurrent failure of slopes, road surfaces and the like has restrained the activities of the Engineering Unit of the Agency in a continuous maintenance works. Alphasoil was first introduced in Bangladesh through our research work. That's how, Mr. Biniam Michael has been keen, to pilot new soil stabilization techniques with the help of alphasoil-06 catalyst after seeing the promising improvement of soil strength by alpahsoil. This phenomenon reflects the value of this project.

Acknowledgement

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