Performance Evaluation Of Snail Shell Powder As Partial Replacement For Unsuitable Soils

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Abstract: The research work analyzed the performance evaluation of snail shell powder as partial replacement for unsuitable soil collected from ABUAD sport field. The particle size analysis shows that the percentage passing number 200BS sieve is 61.88% for the soil sample. When 40% snail shell powder was added to the sample, the percentage passing number 200BS sieve was reduced to 31.25% for the stabilized soil sample. Atterberg limit results show that the soil sample has a liquid limit of 42.9%, plastic limit of 31.0%, a plasticity index of 11.9% and shrinkage limit of 23.6% which make the soil sample to have potential to swell or shrink. The stabilize sample gives a liquid limit of 22.8%, plastic limit of 15.2% plasticity index of 7.6% and shrinkage limit of 11.0%. The natural moisture content for the soil sample is 17.3% then reduces to 5.4% when snail powder was added to the soil sample. The specific gravity of the soil is 2.83% which is reduced to 2.60% after the snail shell powdered was added to it. The soaked CBR value for the soil sample is 24% while the stabilized sample is 45%. The maximum dry density (MDD) for the soil sample is 1.53Mg/m^3 while the optimum moisture content (OMC) is 20.76%. The stabilized soil sample gives a MDD of 1.97Mg/m^3 and OMC of 17.5%. The unconfined compressive strength q_u for the soil sample is 31.27Kpa which shows that the soil is weak. When 40% of snail shell powder was added q_u increases to 89.18Kpa. Hence, the soil sample can be classified as A-7 material (clayey soil) while the stabilized soil can be classified as A-2 material (silty or clayey gravel and sand) which is suitable for sub-grade material.

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Introduction

Soil stabilization is a way of improving the weight bearing capabilities and performance of in-situ sub-soils, sands, and other waste materials in order to strengthen road surfaces. The prime objective of soil stabilization is to improve the California Bearing Ratio of in-situ soils by 4 to 6 times. In highway projects, the strength of a soil determines the suitability of the soil for foundation course. If the strength of the soil is below required standard, then there will be the need to improve the properties of the soil (Owolabi and Aderinola, 2014). The other prime objective of soil stabilization is to improve on-site materials to create a solid and strong sub-base and base courses. In certain regions of the world, typically developing countries and now more frequently in developed countries, soil stabilization is being used to construct the entire road. However, recent technology has increased the number of traditional additives used for soil stabilization purposes. Such non-traditional stabilizers include: Polymers Based Products (cross-linking water-based styrene acrylic polymers that significantly improves the load-bearing capacity and tensile strength of treated soils), Copolymer Based Products, fiber reinforcement, calcium chloride, and Sodium Chloride.

Snails belong to the phylum molluscs and to the class gastropods; this class includes the gastropods, slugs and snails. Most gastropods have a single usually spirally coiled shell into which the body can withdraw. Gastropods are characterized by 'torsion' a process that results in the rotation of the visceral mass and mantle on the foot (Brunt *et al.,* 1999). The shell has a brownish color with a characteristic stripe pattern. The main constituent of the shell is calcium carbonates which are either of two crystalline forms calcite and aragonite. The remainder is organic matrixes which constitute a protein known as conchiolin that usually make up to 5% of the shell. The fine structure of mollusks shells has been studied by using various techniques including scanning electron microscope of broken surfaces. In each of them, blocks or stripe of calcium carbonate are separated by a thin layer of conchiolin. The shell consists of long stripes of aragonite laid down in groups. The shell protects the snail from physical damage and from predators; they are also use in the manufacture of buttons, jewels and art collections. The typical gastropod shell is a cone, coiled round a central axis as a spiral geometrically. The simple reason for this coiled shell is because an uncoiled shell would be impossible to carry its massive body because of its high centre of gravity.

As a result of the chemical composition of the shell, it can be used as a partial replacement for unsuitable soil and waste water treatment either as a coagulant or adsorbent. As a coagulant, it helps to neutralize fine particles of suspended and dissolve matter in a water supply or sample to form flocs that settles and can be filtered out. Calcium the main composition of snail shell when in solution dissociates into Ca^{2+} and various calcium complexes such as calcium hydroxide ion $Ca[OH]^{2+,}$ the various positive species which are formed may combine with negative charges and form the colloidal particles (Jatto *et al.,* 2010).

Unsuitable soils are soils that expand when water is added and shrink when they dry out. This continuous change in soil volume can cause homes built on this soil to move unevenly and crack. Soils can prove problematic in geotechnical engineering because they expand collapse, disperse, and undergo excessive settlement with a distinct lack of strength (Owolabi and Ola, 2014). Expansive clay is a clay soil that is prone to large volume changes that are directly related to changes in water content. Soils with a high content of expansive clay can form deep cracks in drier seasons or years; such soils are called vertisols. Soils with smectite clay minerals, including montmorillonite and bentonite have the most dramatic shrink-swell capacity (Kandhal, 1997). Road failure has become a major problem in Nigeria as well as most other tropical and subtropical countries. The most disturbing aspect is that even new roads constructed experience failures at different points in less than six months or about a year (Aderinola and Owolabi, 2014). Black cotton soils are problematic for Civil Engineers because of their unconventional behaviour. These soils show large volume changes with respect to variation of seasonal moisture content. These soils when subjected vehicular traffic, road pavement gets heaved and cracked due to swelling and shrinkage. Hence, these soils are to be stabilized before constructing the roads in order to have efficient and long lasting roads. Considerable research has been taken place using different stabilizing materials such as lime, flyash, cement, rice, husk ash, industrial wastes etc. and proved to be useful in stabilization of black cotton soils.

Materials And Methods

The study involved the collection of soil sample at Afe Bababalola University. Soil sample was collected at ABUAD sport field. Snail shells were collected from various locations at Ado-Ekiti. The shells collected were washed, dried and ground to fine powder to achieve a large surface area.

Table 1. Location of the soil sample

Longitude	7^0 38'N
Latitude	5^0 15'E
Elevation	455m

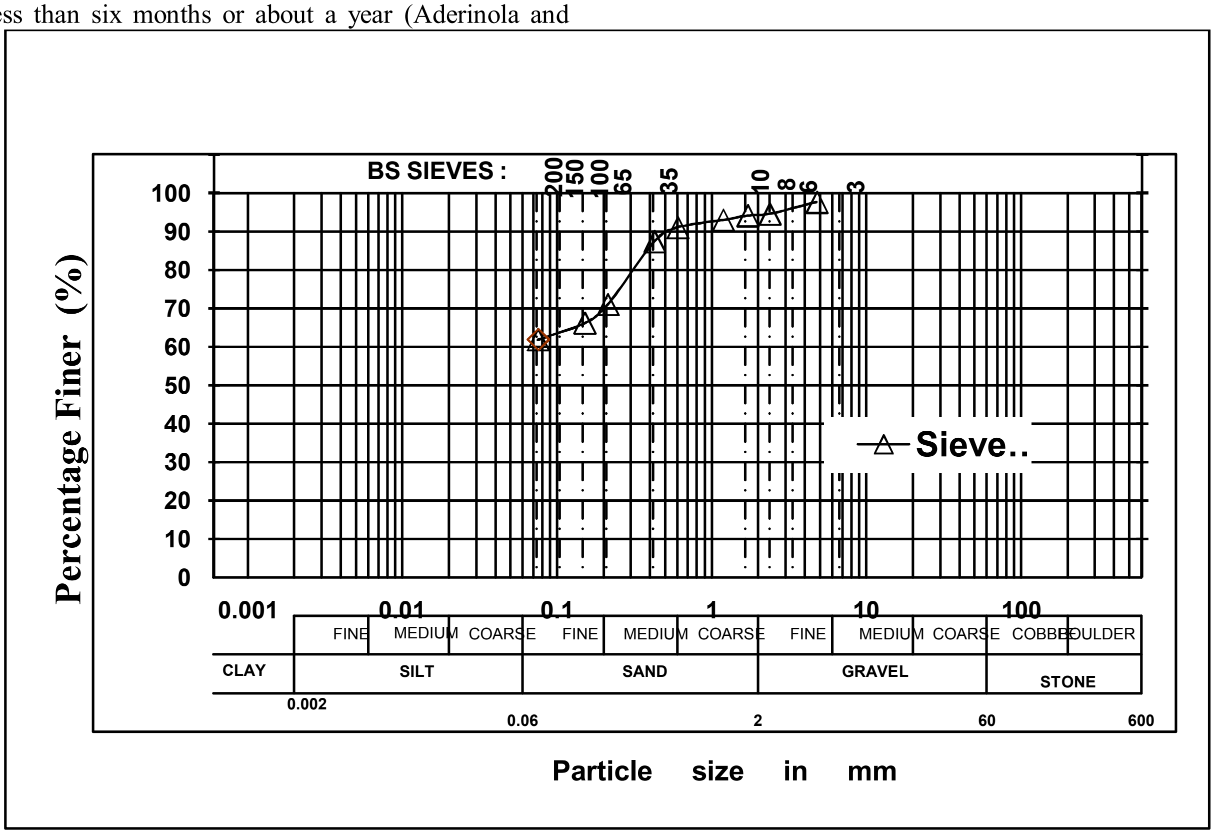

Figure 1: Particle size distribution for the sample

The soil sample collected was taken to soil mechanics laboratory for soil test to identify the index properties of the soil. Then 40% snail shell powder was added to the soil sample to stabilize it (i.e. 40% snail shell powder and 60% of soil sample). Then soil test were carried out on the stabilized sample. The following laboratory tests was conducted on the samples: Atterberg limits test, specific gravity test, sieve analysis test, moisture content test, compaction test and California bearing ratio test (CBR) and unconfined compressive strength.

All the tests were carried out in accordance with British standard code of practice (BS1377:1990). Methods of test for soils for civil engineering purposes.

Result And Discussion

For the purpose of assessing the suitability of using snail shell powder as soil stabilizer, soil laboratory tests were performed on the collected sample and stabilized sample. Results of the experiment are discussed below.

Sieve Analysis

The particle size analysis shows that the percentages passing number 200BS sieve is 61.88 % which shows that the soil cannot be used as sub-grade, sub-base and base materials as the percentage by weight finer than N0 200BS test sieve is greater than 35% (FMWH, 1997). When 40% snail shell powder was added to the sample, the percentages passing number 200BS sieve reduced to 31.25%. The graphs are shown in figure 1 and 2.

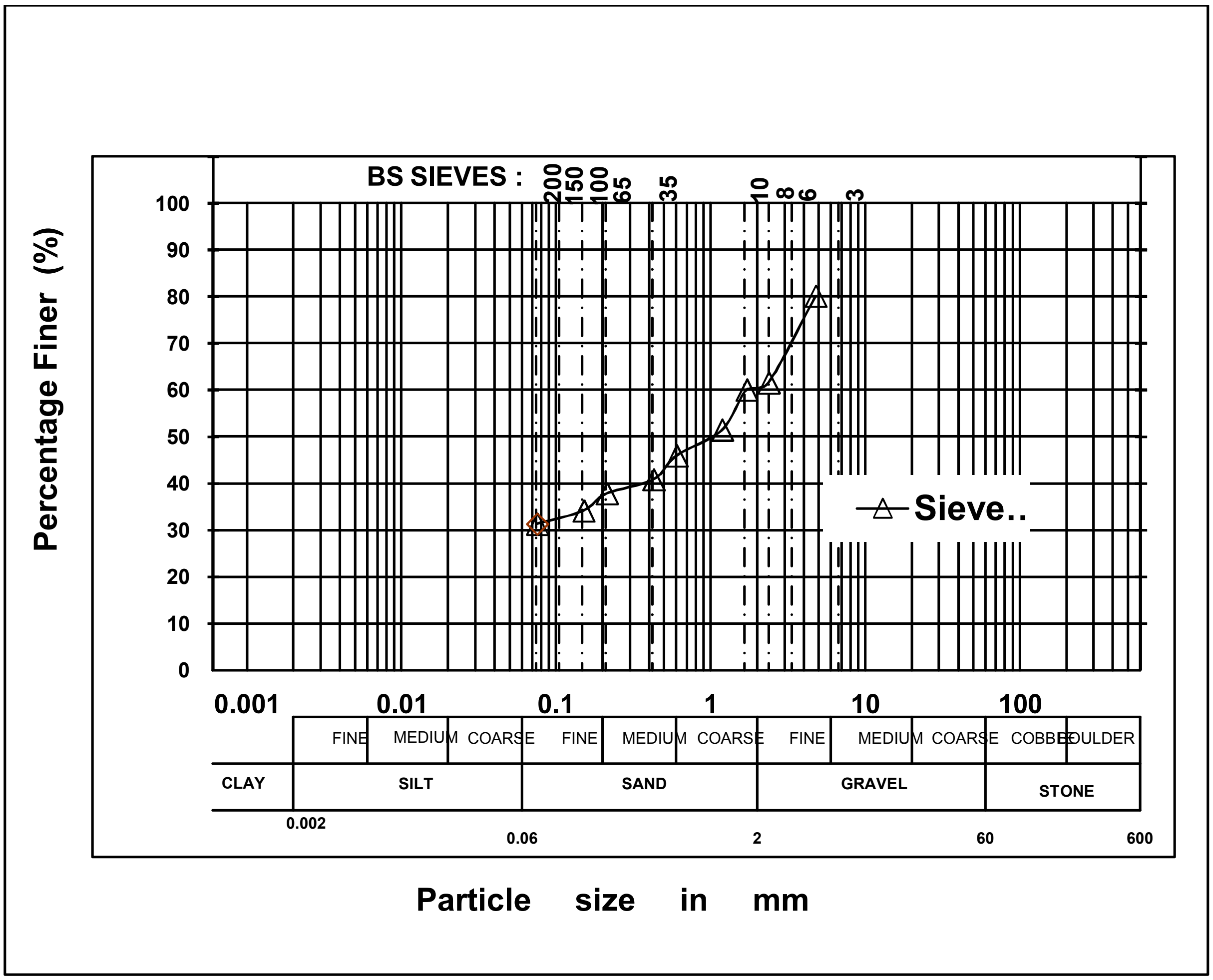

Figure 2: Particle size distribution for the stabilized sample

The Atterberg Limit

The soil sample has a liquid limit of 42.9%, plastic limit of 31%, plasticity index of 11.9% and shrinkage limit of 23.6%. This shows that the soil is a poor soil which cannot be used as construction materials. The stabilized sample gives a liquid limit of 22.8%, plastic limit of 15.2%, plasticity index of 7.6% and shrinkage limit of 11%. The result shows that there was an improvement in properties of the soil when the snail shell powder was added. The graphs are shown in figure 3 and 4.

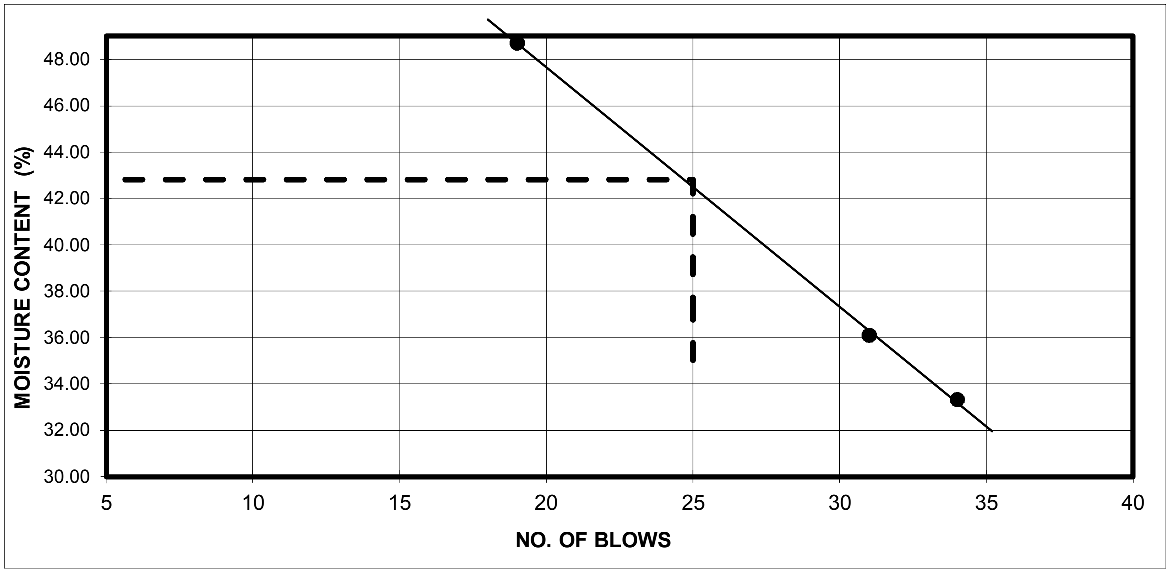

Figure 3: Liquid limit for the soil sample
Liquid limit =42.9%
Plasticity index = 42.9-31=11.9%

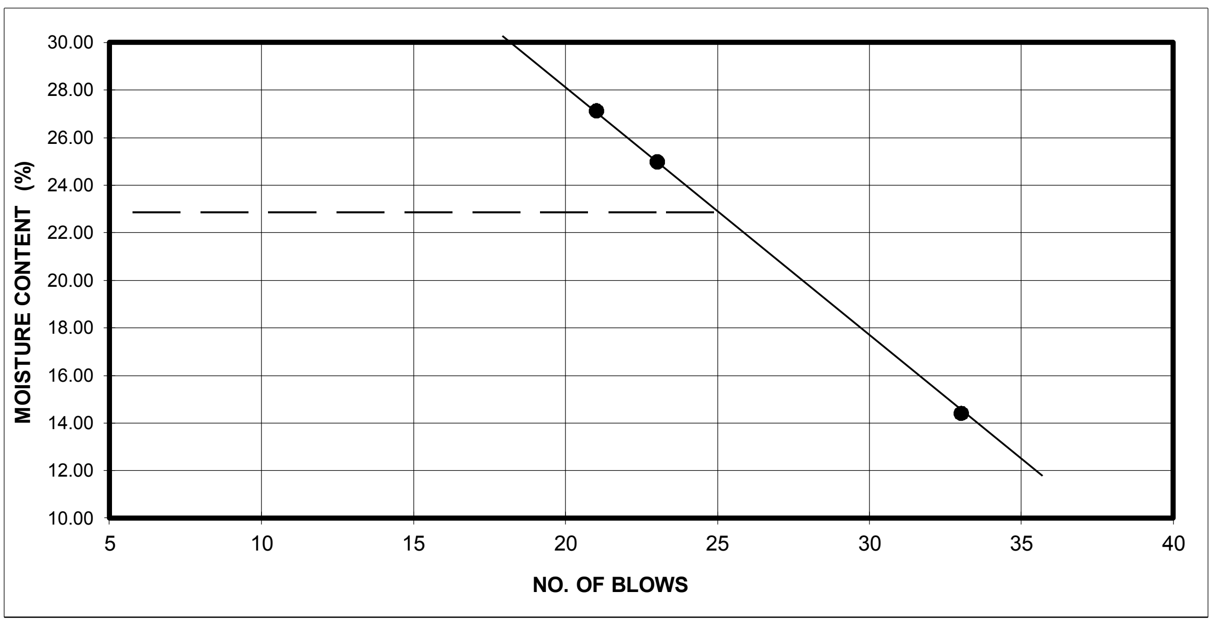

Figure 4: Liquid limit for the stabilized soil sample
Liquid limit =22.8%
Plasticity index = 22.8-15.2=7.6%

Natural Moisture Content

The natural moisture content for the soil samples is 17.3%. The moisture content reduces to 5.4% when the snail sell powder was added to the soil.

Specific Gravity

The Specific gravity of the sample is 2.83. It reduces to 2.60 when the snail shell powder was added to the sample.

California Bearing Ratio

The soaked CBR value for the soil samples is 24%. Federal ministry (1994) recommended soaked CBR for sub-grade and sub-base soils not less than 5% and 30% respectively. For the base (unsoaked and soaked CBR) not less than 80%. The result for soil sample shows that the soil is not suitable for construction material. The soaked CBR value increases to 45% when it was stabilized which can be used as sub-grade and sub-base materials. The graphs are shown in Figure 5 and 6.

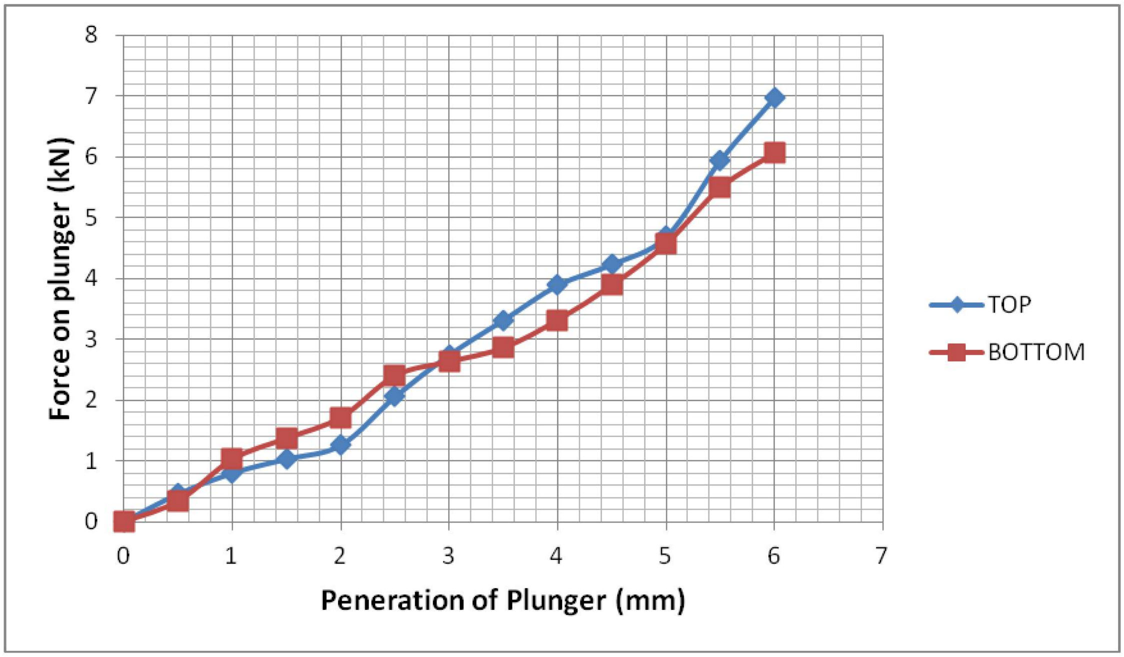

Figure 5: CBR graph for the soil sample

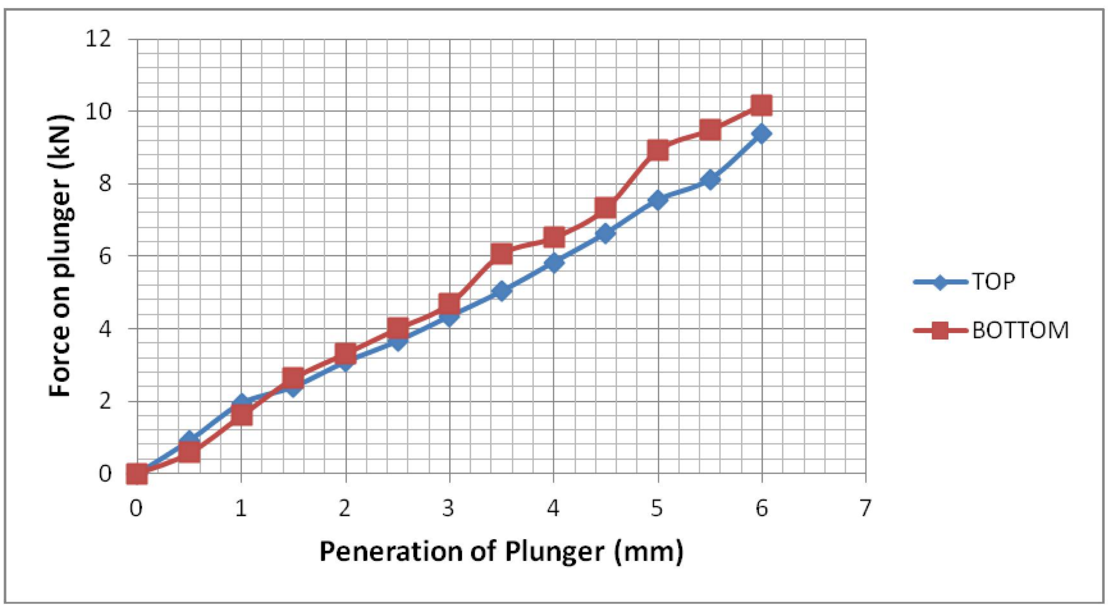

Figure 6: CBR graph for the stabilized sample

Compaction

The maximum dry density for the soil sample is 1.53Mg/m^3 while the optimum moisture content is 20.76%. The stabilized soil sample gives a maximum dry density of 1.97Mg/m^3 and optimum moisture content of 17.5%. Figure 7 to 8 shows the behavior of the soil for compaction. According to O'flaherty (1988) which gives the ranges of maximum dry density and optimum moisture content, from the results of the soil samples, it could be deduced that the soil sample is a clay soil and the stabilized sample shows improvement of the soil which gives sandy clay.

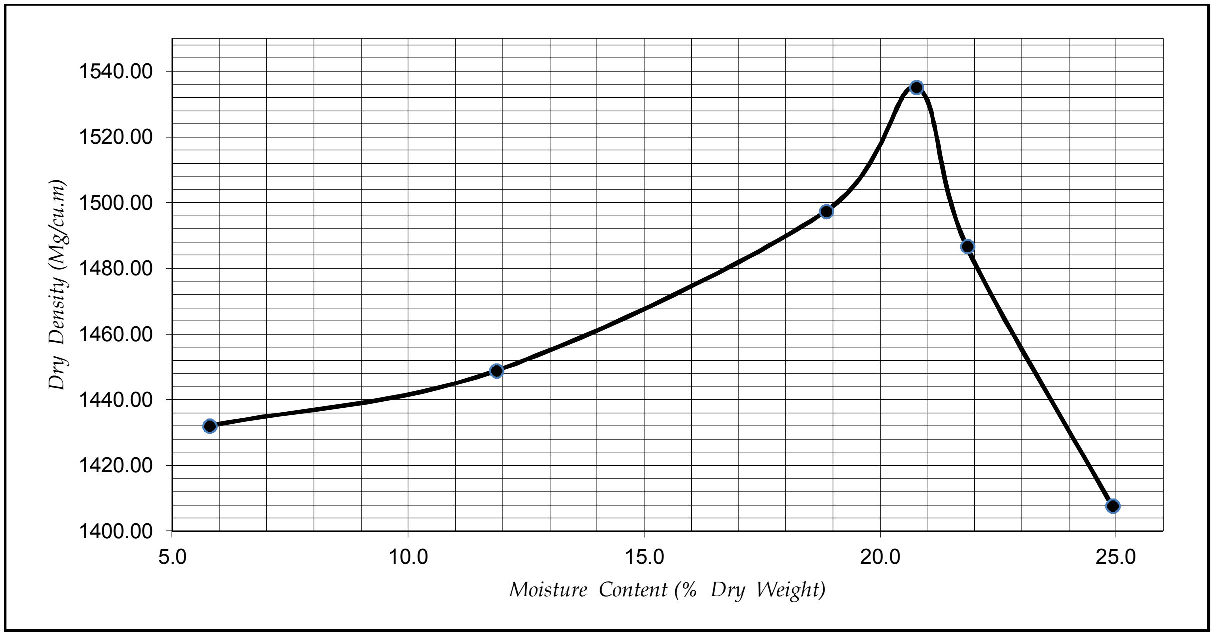

Figure 7: Compaction graph for the soil sample

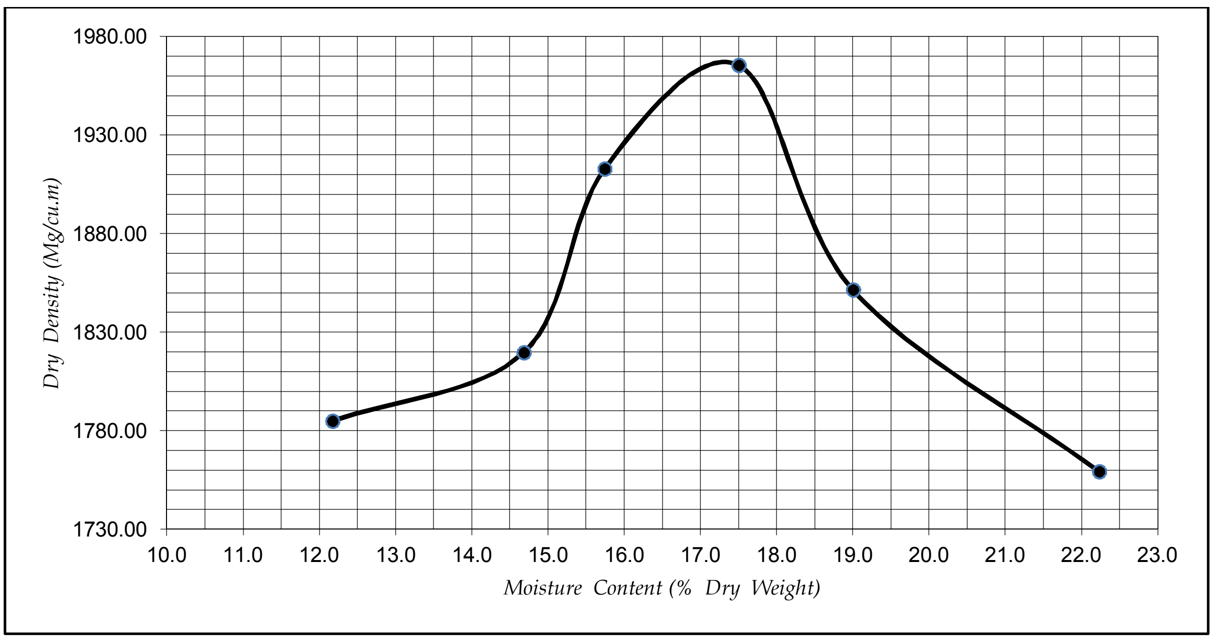

Figure 8: Compaction graph for the stabilized sample

Unconfined Compressive Strength Test

Figure 9 and 10 shows the behavior of the soil samples for the test. The unconfined compressive strength q_u for the soil sample is 31.27kpa which shows that the soil is weak. When 40% snail shell powder was added the unconfined compressive strength q_u increases to 89.18kpa. This shows a significant improvement in the soil sample.

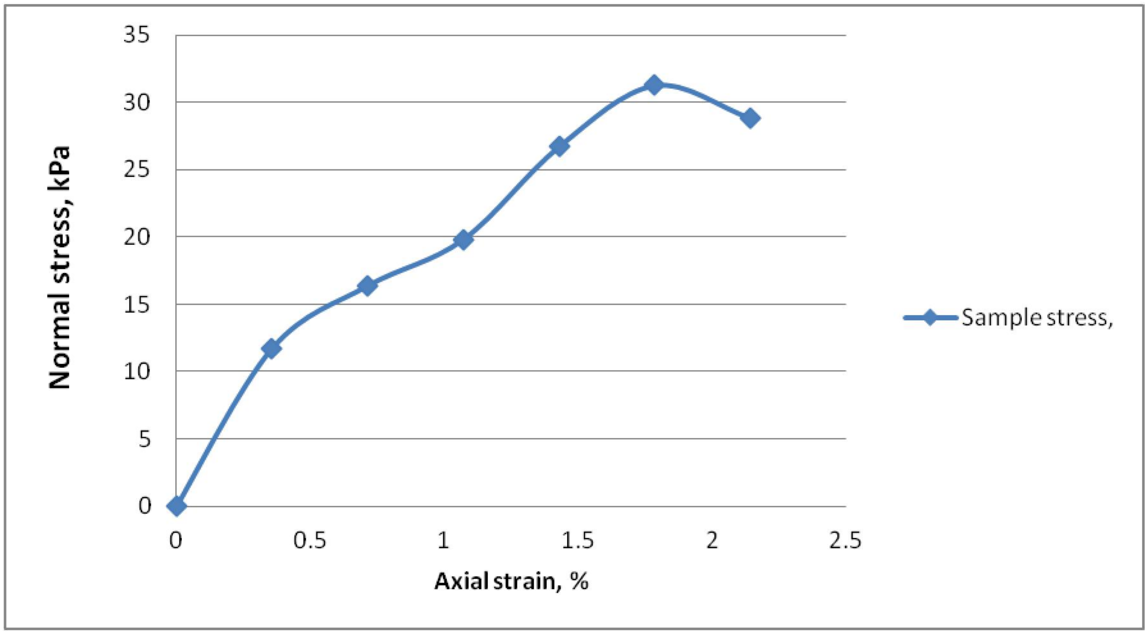

Figure 9: Unconfined compressive strength graph for the soil sample

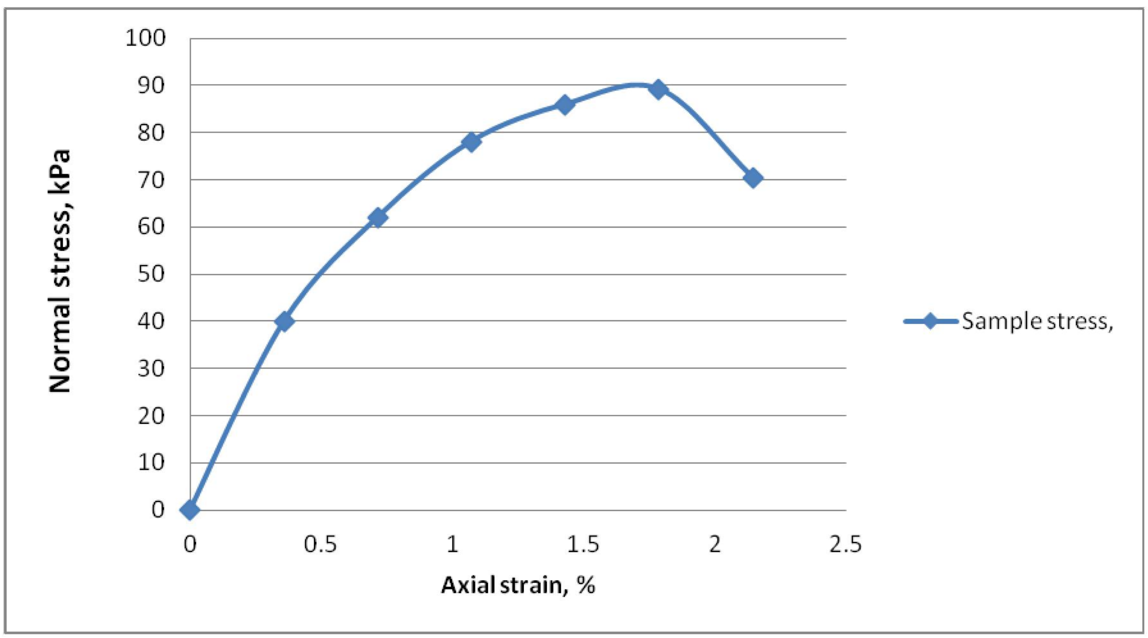

Figure 10: Unconfined compressive strength graph for the stabilized sample

Classification Of The Soil Samples

According to AASHTO classification, the soil sample can be classified as A-7 material (clayey soil). They are rated as fair to poor soil for sub-grade material. The stabilized soil can be classified as A-2 material (silty or clayey gravel and sand). They are rated as excellent to good material for sub-grade.

Conclusion

From the tests carried out on the soil sample and stabilized sample. It shows that the soil improves significantly on addition of snail shell powder. The soil sample which is a clayey material improves to a clayey gravel and sand material which is good for construction material. The snail shell powder also makes the soil to have low potential to swell or shrink.

Recommendation

Engineers and contractors should ensure that all weak soils should be removed or stabilized on site before the commencement of construction. Further research can also be done for other stabilizer to know if they are suitable for improving the index properties of weak soils.

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