THE SUITABILITY OF TARSAND AS A STABILIZING AGENT FOR LATERITIC SOILS

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Abstract

The suitability of tarsand as a stabilizing agent for lateritic soils was investigated in this study. This is to find a rather cheaper means of stabilizing lateritic soils that has become very important for the construction industry. The soil samples were subjected to the general classification and strength tests. The strength tests are: the compaction, unconfined compression and California Bearing Ratio (CBR). Tarsand was introduced as stabilizer in 0, 2, 4, 6, 8 and 10 percentages.

The CBR, Maximum Dry Density (MDD) and unconfined compression values all decreased with increasing tarsand contents. For example, MDD reduced gradually from 1919 kgm^{-3} at 0% tarsand content to 1765 kgm^{-3} at 10% tarsand content, while CBR also reduced gradually from 21.0% at 0% tarsand content to 3.40% at 10% tarsand content. These results showed that tarsand is not a suitable stabilizing agent for lateritic soils, especially in the strength assessments.

Key words: Suitability, tarsand, stabilizing agent, lateritic soil.

1. Introduction

The usefulness of lateritic soil to construction works cannot be over-emphasized. Soil has been in use for ages (Davey, 1981) and is still being used today especially in developing nations. The usefulness of soil generally borders on their strength properties, especially their load bearing capacities. An unsuitable soil may be made suitable for construction purpose by the process of soil stabilization. According to Krebs and Walker (1987) the use of stabilized soils in road construction had been in practice since the Roman times.

Stabilization is therefore the process of making a poor soil suitable for engineering/construction purposes by improving its properties. Such properties include its swelling potential, permeability, shearing and compressive strengths. There are many methods of soil stabilization of which the commonest is the mechanical compaction. Other methods entail the addition of certain compounds which tend to increase the strength properties of soil in varying proportions. Such compounds are called stabilizing agents.

Tarsands:

This is also known as oil-sands or bituminous sands, contain oil impregnated rocks composing of highly viscous hydrocarbons called bitumen and significant quantities of oxygen (O_2), nitrogen (N) and sulphur (S) bearing compounds. The Nigerian tarsand reserve is rated as the fourth largest in the world, occurring along the eastern margin of Dahormey basin, stretching across Ogun, Ondo and parts of Delta States. Tarsands will not flow at ambient temperatures, and so cannot be recovered by normal oil well production. The dense nature of tarsand makes the conventional methods of extraction impossible, thereby making it compulsory for the oil-impregnated rocks to be mined and processed especially so that bitumen or heavy oil could be recovered.

Researchers have not been able to proffer a specific explanation for the origin of tarsands. Suggestions had been made that some heavy crude oil and tarsands are formed as a result of the oxidative process that occurs when oxygen-bearing ground water invades a petroleum bearing reservoir. It was also said to be formed due to the existence of geologically originated young oil, which being formed in the source rock did not have the opportunity of migrating into a reservoir rock. Studies have shown that all tarsand deposits are a mixture of sand grains (quartz and fine sand), water and bitumen (Ola, 1978). These components are arranged such that oil sand aggregate has sand particles fairly and uniformly embedded into the bitumen film. Tarsands have been discovered to exist in various reserve bases in over 88 countries of the world. The major known deposits are those of

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Venezuela, United States, Canada, Trinidad and Tobago, Nigeria and Malaysia. One of the largest tarsand deposits in the world is that of Alberta in Canada with an estimate of over 700 billion barrels.

Laterites:

These are among the most abundant soils that are developed in the tropics; they form thick blankets near the topsoil horizons in the area. Available data on geotechnical characteristics of lateritic soils show that these soils range in performance from excellent to poor for engineering purpose (Nixon and Skip, 1987).

The term 'laterite' was first used to describe a ferruginous vesicular unstratified and porous material with yellow ochre due to high iron content occurring in Malabar, India. The freshly dug material was soft enough to be readily cut into brick blocks with an iron instrument but it rapidly hardened on exposure to air and was remarkably resistant to the weathering effect of climate. According to Gidigasu (1976), laterite was recognized as a tropical and sub-tropical weathering product of various crystalline igneous rocks mostly granites sediment deposits and volcanic ash.

Campbell (1987) analysed some Nigerian soils and the oxides of aluminium, iron and silicon and their relative percentages were found as given in Table 1. A ratio of (SiO_2/Al_2O_3) of less than 1.33 was found thus indicating that Nigerian soils are mostly laterites. The physical, chemical and morphological definitions of laterites were summarized as a highly weathered material, rich in secondary oxides of iron, aluminium or both. It is nearly void of bases and primary silicates, but it may contain large amounts of quartz and kaolinite. It is either hard or capable of hardening on exposure to wetting or drying. Ola (1978) defined laterite soils as products of tropical weathering with red, reddish brown or dark brown colour with or without modules or concretions and generally (but no exclusively) found below ferruginous crusts.

Soil Stabilization:

Lambe (1981) defined soil stabilization as the alteration of any property of a soil to improve its engineering performance. Castel (1970) and Gidigasu (1980) proffered that through soil stabilization, an unsuitable material may be made suitable for a particular purpose.

The technique of stabilizing a soil by increasing its strength and stability through the introduction of admixtures is called chemical stabilization. The materials, which are commonly used as admixtures, are cement, lime, bitumen and resin. Hydrated lime is mostly used for stabilization. Unless lime was to be used mainly to improve the plasticity and workability of the soil, only A-2 class could be adequately stabilized as a base material while class A-1 soils with some clayey material might be considered (Ola, 1978).

In soil stabilization, certain physical characteristics of clay bearing soils are altered in order to transform such soils into more stable materials for improved road durability. These physical changes may include decrease in plasticity index (which is a result of an increase in plastic limit), an increase in the unconfined compressive strength and also an increase in California Bearing Ratio (CBR).

Bituminous materials have been used for modern stabilization purposes as dust palliatives on natural soil roads in Southern California in 1998. Since then, most research work has been carried out on bituminous soil stabilization. The use of bitumen as stabilizing agent is hinged on the cementation process, which increases the soil strength. Another reason for the use of bitumen for stabilization is its waterproofing property, which preserves the natural stability of soils in dry and well compacted conditions.

Bitumen has been used as a stabilizing agent by various researchers and it has been found suitable most of the time. It is therefore pleasant to investigate the stabilization characteristics of tarsand, bearing in mind that it is much cheaper and much more readily available than bitumen.

2. Materials and Methods

This study was conducted between February 1999 and March 2000 in the Transportation Laboratory of Civil Engineering Department, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria. The materials used are (i) Tarsand, which was obtained from a tarsand reserve at Ijebu-Ife in Ogun state of Nigeria, (ii) Lateritic soil sample, which is an A-2-6 (AASHTO) obtained from a burrow pit in Odogbo, Ibadan, Oyo State of Nigeria, (iii) Water fit for drinking and (iv) Distilled Water.

The soil samples were subjected to the following classification tests:

- Natural moisture content determination which was determined in the laboratory by measuring the loss in weight of soil samples after drying to a constant weight at 110 °C.
- The Specific gravity was determined in the laboratory by using a density bottle.
- Consistency limits involved the determination of the liquid limit, plastic limit and the plasticity index from the Atterberg limit test, and
- Particle size analysis involved the sieve and hydrometer analyses.

The following strength tests were also performed on the sample:

Compaction Test:

A known weight of soil sample was obtained; tarsand was added in 0, 2, 4, 6, 8, and 10 percentages by weight. The soil sample was taken from the part of the sample which passed through sieve No 4. The mixture of the soil and tarsand was compacted into the standard compaction mould in three layers, with

Table 1: Types and the relative percentages of oxides in Nigerian soil (Campbell, 1987)

Oxide	%
Quartz SiO_2	21.20
Q combined SiO_2	5.30
TiO_2	1.10
Al_2O_3	19.90
Fe_2O_3	36.70

Table 2: Variation of Atterberg limits with tarsand content

Tarsand (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
0	54.00	29.07	24.93
2	56.12	30.04	26.09
4	57.31	28.27	29.04
6	58.94	30.55	28.39
8	59.91	30.90	29.01
10	61.50	31.17	30.34

Table 3: Effects of tarsand on Maximum Dry Density (MDD)

Tarsand (%)	Maximum Dry Density (kgm^{-3})	Optimum Moisture Content (%)
0	1919	13.00
2	1918	14.00
4	1910	14.00
6	1822	14.00
8	1788	13.00
10	1765	13.00

Table 4: Variation of unconfined compressive strength with tarsand content

Tarsand (%)	Strength for 1 day curing period (kNm^{-2})	Strength for 3 days curing period (kNm^{-2})
0	241.11	249.33
2	242.63	250.12
4	243.88	252.12
6	241.88	250.43
8	241.84	249.38
10	241.80	249.03

Table 5: Variation of California Bearing Ratio with tarsand content

Tarsand (%)	1 day (%)	3 days (%)	7 days (%)
0	21.00	22.13	23.98
2	13.60	14.40	15.40
4	10.00	11.20	12.80
6	6.50	8.00	10.60
8	5.00	7.80	10.30
10	3.40	5.20	9.60

25 blows per layer, using a 24.5 N compaction hammer.

Unconfined Compression Test:

This test was carried out to determine the suitability of the lateritic soil for treatment with tarsand and to possibly specify tarsand contents for construction works. The specimens were cured for 1 day, 3 days and 7 days, respectively before testing. Testing was done on the unconfined compression machine with strain rate of 0.5 mm/m. The load rate was calibrated to give 0.2132 kg/Division.

California Bearing Ratio (CBR) Test:

The CBR machine was used to measure the shearing resistance of a soil under controlled moisture and density conditions. This test gives a bearing ratio number. For this test, 3 kg soil sample was taken from the portion of soil that passed through sieve No 4 and prepared at the optimum water contents of soil as determined from the compaction test. This ratio measures the bearing resistance of the soil under controlled moisture and density.

3. Results and Discussion

The laboratory experiment gave the natural moisture content of the soil as 11.60% and the specific gravity was found to be 2.82. This specific gravity suggests that the soil contains some heavy minerals. General observations on the soil showed that the soil is prone to changes in moisture content and could become a little soft and slippery during the wet season, though hard and gritty during the dry season.

The plasticity index (P.I.) of the soil was determined by the Atterberg limit (Liquid limit – Plastic limit). The P.I. increased, although not regularly, from 24.93% at 0% tarsand to 30.34% at 10% tarsand (Table 2). Liquid limit increased consistently from 54.00% to 61.50% at 0% and 10% tarsand contents, respectively, while the plastic limit increased sparingly from 29.07% at 0% tarsand to 30.04% at 2% tarsand, then decreased to 28.27% at 4% tarsand, from where it increased consistently to 31.17% at 10% tarsand content.

The Maximum Dry Density (MDD) was determined by the compaction test (standard proctor). The MDD reduced with increasing tarsand content. The MDD value of 1919 kgm^{-3} at 0% tarsand reduced gradually to 1765 kgm^{-3} at 10% tarsand content (Table 3). The factors responsible for this behaviour could be the grain size distribution of the soil, its specific gravity and that of tarsand. The decrease in maximum dry density of 1919 kgm^{-3} at 0% tarsand to 1910 kgm^{-3} at 4% tarsand content is quite negligible. Considerable reduction was observed between 4% to 10% tarsand contents, indicating that the optimum level had been reached at 4%.

The unconfined compressive strength increased negligibly from 241.11 kNm^{-2} at 0% to 243.04 kNm^{-2} at 4% tarsand content for 1 day curing and started dropping from this point to a value of 241.80 kNm^{-2} at 10% tarsand. The trend was the same for 3 days curing period (Table 4). In a nutshell, tarsand has no remarkable influence on the compressive strength of the soil.

The unsoaked CBR decreased with increasing tarsand content from 21.00% at 0% tarsand to 3.40% at 10% tarsand content (Table 5). This was the trend for both the 3 and 7 days soaked samples.

However, since between 2-4% content of tarsand, the maximum dry density of the soil was practically unaffected, tarsand could therefore be recommended for dust reduction in earth roads and as water proofing material in unpaved earth road constructions on the basis that all the strength parameters indicated that tarsand is not an effective stabilizing agent for lateritic soils.

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