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Soil-Cement Stabilization For Road Pavement Using Soils Obtained From Agu-Awka In Anambra State

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***Abstract*—This work was carried out to determine the effectiveness of soil-cement stabilization for road pavement construction using soils gotten from Agu-Awka, Awka, Anambra State. Tests were carried out on the soil sample which includes the Atterberg limit tests, particle size distribution analysis; compaction test using the West African Standard mould compaction test and the California Bearing Ratio (CBR) test. Based on the tests carried out on the soil, the sample was found to belong to the A-2-6 subgroup of A-2 group of the AASHTO soil classification system. It is required that a minimum California bearing ratio which should not be below 80%, 30% and 10% be met for base, sub-base and subgrade materials respectively. From the California bearing ratio (CBR) test carried out on the soil sample, the CBR value for the soil sample was found to be 15%, which was adequate for subgrade materials but not adequate for sub-base materials and thus, the soil sample had to be stabilized. After stabilizing the soil sample by the addition of cement, CBR values of 27%, 33%, 50%, 86%, 111%, and 122% were obtained for percentages of cement added at 5.0%, 5.5%, 6.0%, 6.5%, 7.0% and 7.5% respectively.**

The minimum percentage of cement added to the non-stabilized soil in order to attain the minimum CBR value requirement for sub-base materials and base course materials were 5.36% and 6.48%. The result met AASHTO standard specifications and set a minimum benchmark that applies to the soil tested.

Keywords—CBR, soil cement stabilization, Agu-Awka, Soil Classification

I. INTRODUCTION

The long term performance of a road pavement requires the construction of a structure that is capable of carrying the imposed traffic loads. Some soils do not always meet this requirement as they have low bearing capacity and thus requires an improvement in its engineering property. This is often accomplished by stabilization [1]. Stabilization can be achieved by mechanical stabilization or compaction [2]. This method is particularly effective for cohesionless soils, where compaction can cause particle rearrangement and particle interlocking. But the technique may not be effective if these soils are subjected to significant moisture fluctuations [3]. The efficacy of compaction may also diminish with an increase of the fine content fraction smaller than about 75μm, of the soil. This is because cohesion and inter-particle bonding interferes with particle rearrangement during compaction [4].

An alternative to the mechanical stabilization or compaction option is to stabilize the soil by the addition of additives (like cement) to the soil [5]. Commonly used additives include Portland cement, lime and fly ash [6]. For this project, the additive to be used is cement. Lime and fly ash are scarce and very costly unlike cement which has the advantage of being produced and found locally [7]. Soil-cement has been defined as a mixture of soil and a measured amount of cement and water mixed to a high density with the aim of improving the engineering properties of the host soil [8]. Portland cement has been used to stabilize soils for pavement applications on thousands of miles of roadway all over the world [9]. Soil-cement stabilization is best required for soils which are subject to fluctuations in strength due to fluctuation in moisture content [10]. The lateritic soils at Agu-Awka is is enormous and is largely used for civil engineering works (including road construction). Its use has majorly been as an earth fill or in some instances as a sub-base material after much mechanical compaction. The work explores the option of a cement-stabilization and seeks to determine its effectiveness.

METHODS

Soil samples were collected at uniform depths from the borrow pit at Agu-Awka in Awka, Anambra state, along the old Awka-Enugu road. A particle size distribution analysis and an atterberg limit test were carried out on the sample. 4kg of dry soil sample was selected for an African standard compaction test. The optimum moisture content OMC of the soil was determined. This value was used in determining the CBR value of the soil at OMC.

The Soil sample was stabilized by the addition of various percentages of cement. 5.0%, 5.5%, 6.0%, 6.5%, 7.0%, and 7.5% of cement (by weight) was added to the non-stabilized soil sample.

After stabilizing the soil by addition of cement, the CBR test procedure was carried out on the stabilized soil and their new CBR values obtained.

RESULTS AND DISCUSSION

From the results of the particle size analysis (see Figure 1), the percentage of sand and fines was determined and thus the soil sample was observed to have a percentage of fines of 28.960% (percentage at < 0.075mm) with 71.04% of sand (percentage range of 0.075mm< x <4.76mm). It was observed that D_{60} (grain diameter at 60% passing) was 0.43 and that D_{30} (grain diameter at 30% passing) was 0.08; it was not possible to obtain the value of D_{10} (grain diameter at 10% passing), because the minimum percentage passing is 28.96% and thus, the soil can be said to be well graded. The liquid limit and plastic limit of the soil was found to be 38.6 and 20.1% respectively. This gives a plasticity index (P.I) of 18.5

In classifying the soil sample on the basis of both the particle size distribution as well as the plasticity characteristics of the soil using the AASHTO soil classification system, the aforementioned results were used to classify the soil as belonging to the A-2-6 soil group. In classifying the soil sample on the basis of plasticity using the unified soil classification system (USCS), it was observed from the plasticity chart that the PI (18.5%) is greater than 7, and the Atterberg limits are above the A line and thus, the soil sample was classified to be sandy clay (SC).

From the compaction test graph (see Figure 2), the maximum dry density (MDD) was obtained as 2169 kg/m^3 and the optimum moisture content (OMC) was obtained as 10.4%. This value was used as percentage of water (by weight of soil sample) for mixing the soil sample for the California Bearing Ratio (CBR) tests subsequently carried out on the soil sample (both the non-stabilized soil sample and the stabilized soil samples).

After carrying out the CBR test on the stabilized soil samples at various percentages of the cement added to the soil sample, the CBR values obtained and the details of the soil-cement stabilization are presented in the Table 1 and plotted in Figure 3. From the CBR results it was observed that the CBR value of the sample increased progressively by the addition of greater percentages of cement and thus we obtained a soil-cement sample which met the CBR requirement for sub-base materials (i.e. CBR value of 30%) and base-course materials (i.e. CBR value of 80%). Hence, we obtained a material which has an improved bearing capacity.

From the soil-cement stabilization graph, the minimum percentage of cement added to the soil in order to meet the minimum CBR value requirement for sub-base materials i.e. CBR value of 30% was 5.36%. The CBR requirement for base coarse material (i.e. 80%) was met at 6.48%.

CONCLUSION AND RECOMMENDATION

Based on the tests carried out on the soil, AASHTO soil classification system indicates that the soil belongs to A-2-6 subgroup of A-2 group (generally consisting of silty or clayey sand) and the unified soil classification system (USCS) indicates that the soil is sandy clay (SC). The aforementioned classifications indicates a soil material which does not allow easy drainage of water, it rather retains some water. The CBR value for the soil sample was obtained as 15% which implies that the soil sample meets regulatory minimum CBR requirement for subgrade materials, but it did not meet regulatory minimum CBR requirement for sub-base or base course materials. The addition of 5.36% and 6.48% of cement help the soil meet the CBR requirement for sub-base and base course respectively. The values apart from being precise also agree with the predicted 5%-9% (D.N. Little et al. 2009) of cement for soils in the A2 group.

The obtained minimum percentages of cement for the stabilization of the soil at Agu-Awka will help contractors in evaluating the likelihood of cement stabilization as against hauling better soil from more distant borrow pits. This will be based on a cost analysis of the cement stabilization against the cost of hauling better materials from a borrow pit of a known distance.

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.APPENDIX

Table 1: CBR Values for different percentage of cement stabilization

% of cement added (%)	0	5.0	5.5	6.0	6.5	7.0	7.5
Quantity of Soil (g)	6000	6000	6000	6000	6000	6000	6000
Quantity of Cement (g)	0	300	330	360	390	420	450
Amount of Water (cc)	624	655	658	661	665	668	671
CBR Values (%)	15	27	33	50	86	111	122

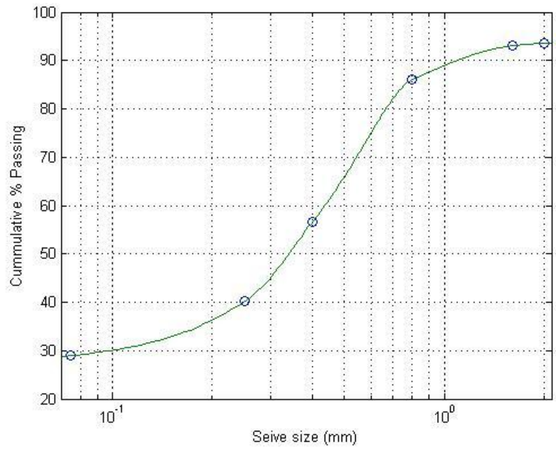

Figure 1: Result of a Particle size distribution analysis on soil sample

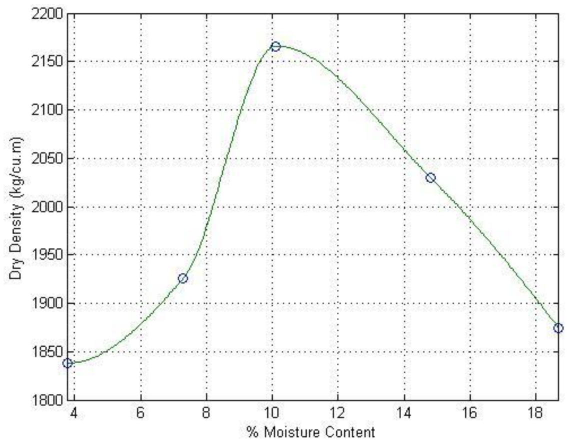

Figure 2: Graph of Soil Dry Density against Moisture content

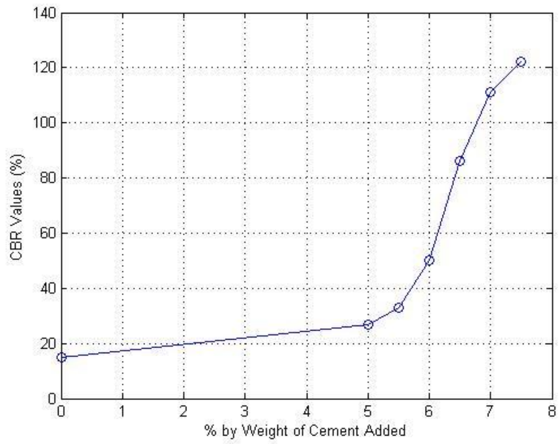

Figure 3: Graph of CBR Values against Percentage of Cement Stabilization