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Cement Stabilized Granular Soil for Sub-Base/Bases of Road Construction

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Abstract**—***Granular soil such as gravelly and sandy soil is an important commercial product, with a number of applications. Many roadways are surfaced with granular soil, especially in rural areas where there is little traffic. As majority of the local soils, in their natural form lack the desired strength and durability required for intended constructions, they are to be improved through the process of stabilization to make them suitable as construction material. Among the available stabilization techniques, Cement stabilization is one of the best options as it suits to granular soil. Cement stabilized granular soils are widely used as construction material in sub base and base courses of pavements due to high strength and durability. The objective of this experimental study is to improve the properties of granular soil (sandy soil/gravelly soil) by adding cement as stabilizing agent in different proportions, For this comprehensive laboratory work is carried out to study the geotechnical properties of cement stabilized granular soil i.e. compaction and strength characteristics of granular soil(sandy/ gravelly soil) with cement proportions of 2%, 4%, 6%, 8%, by dry weight of the soil. The strength of cement stabilized granular soil has been assessed after 7 days of curing. Based on the study, cement stabilized granular soil (sandy/gravelly soil) is used to assess its strength and make it possible as an alternate material for construction or road sub-base/ base.*

Keywords:**—***Granular soil, Cement Stabilization, Sub base layer, Base layer, Sieve analysis, Unconfined compression test.*

1. INTRODUCTION

The purpose of a stabilized base or sub-base layer is to provide a transitional load-bearing stratum between the pavement layer, which directly receives the wheel loadings of vehicular traffic, and the underlying sub-grade soil. Stabilized base or sub-base materials may be used to provide support for either flexible or rigid pavements, but are more frequently used with flexible pavements. The key to strength development in stabilized base or sub-base mixtures is in the matrix that binds the aggregate particles together. The strength of the matrix is affected by the cementations material used in the mixture. The amount of cementations material in a stabilized base or sub-base mix usually ranges from 5 to 10 percent by weight of the mix. The main concentration of the research is to determine various sand grain analyses and which of them is perfect for stabilization with cement to use instead of bricks or stone chips. This research also indicates the stability of the road with perfect sand cement mixing proportions.

2. EXPERIMENTAL INVESTIGATION:

Methodology

In pavement design, to reduce the cost of material cement stabilized sand can be used instead of other material such as brick, stone etc. In this study sands were collected from different part of Jabalpur (M.P). Those were collected from Narmada river sand, Gour river sand, Hiran river sand. Further these sand were designated by SAMPLE I (Containing predominantly gravelly soil), SAMPLE II (containing predominantly medium sand), and SAMPLE III (containing predominantly fine sand) was taken and OPC 43 grade cement was used to mix thoroughly at 2%,4%,6%,8%, by dry weight of the soil. The experiment that were done in this experiments are Sieve analysis test and Unconfined compressive strength test. The test results revealed that there is significant variation in the unconfined compressive strength of soil samples. It was found that the 7 days unconfined compressive strength of SAMPLE I stabilized with 8% and 6% cement was found 2.81 MPa, and 1.84 MPa which is used as base and sub-base of road similarly SAMPLE II stabilized with 8% cement was found 1.75 MPa which is used as sub-bases of road and SAMPLE III is not fulfill the requirement for base and sub-base layer hence it is suitable for subgrade construction.

2.2 Sieve analysis

Sieve analysis is a procedure used to find the particle size distribution of a granular material. Sieve analysis is for coarse grained soils which can easily pass through a set of sieves. In this study, sieve analysis is done for gravelly sand and sandy sand. The sand is sieved through a set of sieve. It is sieved through a set of sieve of the size (12.50mm), (6.30mm), (4.75 mm), (2.00mm), (1.00 mm), (0.6 mm), (0.425 mm), (0.3 mm), (0.212 mm), (0.150 mm), (0.075) and pan. The material retained on the each sieve was collected and weighed. The material that would have been retained on the pan is equal to the total mass of the soil minus the sum of the masses of material retained on all sieve.

Figure 1. Set of Sieve in Lab.

2.3 Cement

Cement can be defined as the bonding material having cohesive & adhesive properties which make it capable to unite the different construction material and from the compacted assembly. Ordinary / normal Portland cement is one of the most widely used type of Portland cement.

Types of cement used here is OPC (Ordinary Portland Cement) grade 43. OPC 43 grades based on the 28 days compressive strength of cement. Different types of ordinary Portland cement available in India like grade 33, grade 43 and grade 53. That all based on their 28 days characteristics strength. Type of cement used in this research is 43 grades OPC.

2.4 Unconfined compression strength test

UCS is also known as uniaxial compression tests, is special case of a triaxial test, where confining pressure is zero. UC test does not require the sophisticated triaxial setup and is simpler and quicker test to perform as compared to triaxial test. In this test, a cylinder of soil without lateral support is tested to failure in simple compression, at a constant rate of strain. The compressive load per unit

area required to fail the specimen as called unconfined compressive strength of the soil As per I.S. 2720-part-10.

Figure 2. Preparation of a sample

3. DATA ANALYSIS

3.1 Sieve analysis of different type of sands

In this study sands were collected from different part of Jabalpur (M.P). Those were collected from Narmada river sand, Gour river sand, Hiran river sand. Sieve analysis was conducted for sand gradation. The fractions of fine, coarse and medium sand in the specimen was found out, which furnished us the idea of the fraction of different river sand.

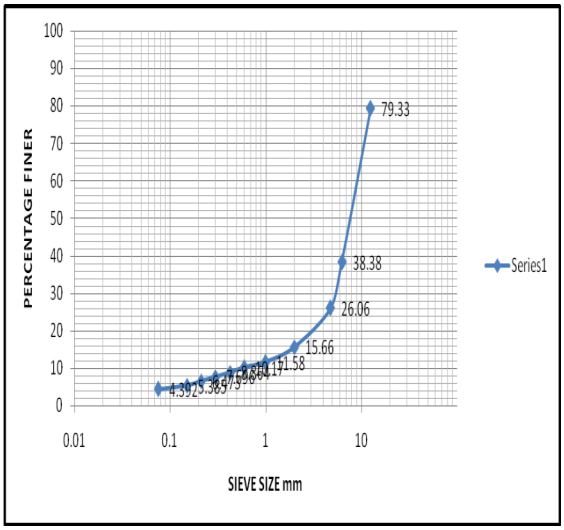

Figure 3. Gradation curve of SAMPLE 1

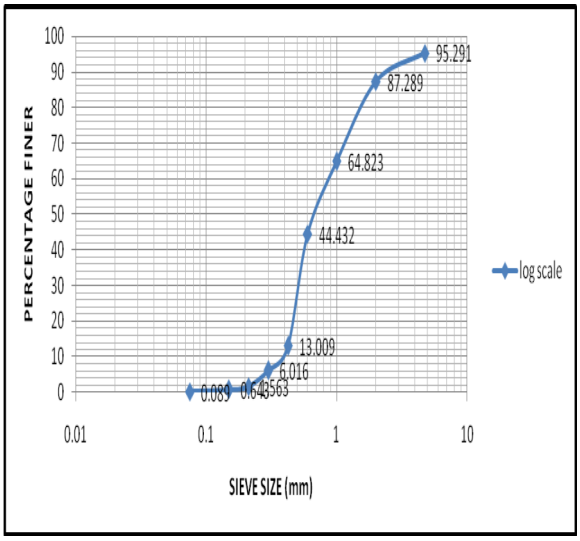

Figure 4. Gradation curve of SAMPLE 2

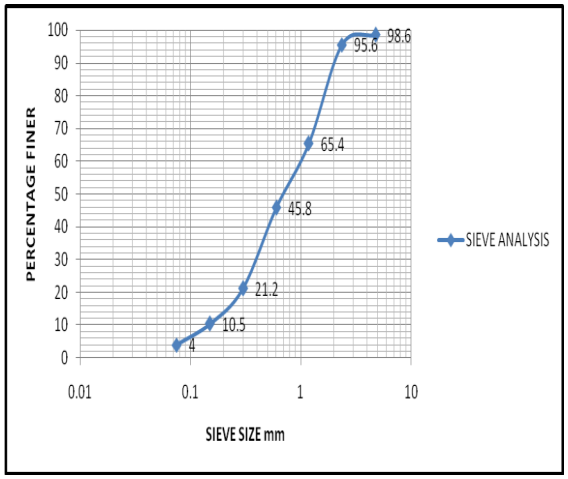

Figure 5. Gradation curve of SAMPLE 3

From the above Gradation Curve of different type of sand, in which the gradation of SAMPLE 1 containing predominantly well graded gravel, SAMPLE 2 containing medium sand, and SAMPLE 3 containing fine sand.

3.2 Unconfined compressive strength analysis

Unconfined compression test were carried out on the soil samples that were collected from different river of Jabalpur. These soil samples mix with different proportion of cement i.e. of 2%, 4%, 6%,8% by dry weight of soil samples and samples were cured for 7 days curing. The test result of different soil sample is given below.

Table 3.2.1 UCS Value of Different Types of Soil Sample

	UNCONFINED COMPRESSIVE STRENGTH (Mpa)		
DESCRIPTION OF MIX	SAMPLE I	SAMPLE II	SAMPLE III
SOIL + 2% CEMENT	0.462	0.441	0.29
SOIL + 4% CEMENT	0.6	0.598	0.571
SOIL + 6% CEMENT	1.84	0.926	0.871
SOIL + 8% CEMENT	2.81	1.755	1.343

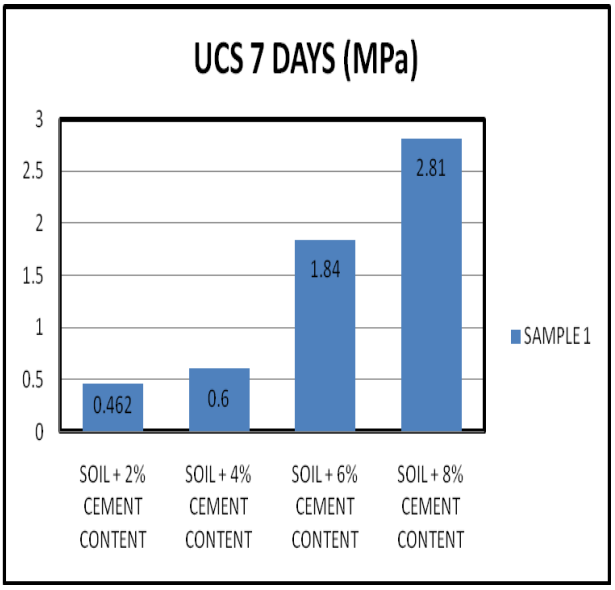

Figure 6. Unconfined compressive test of SAMPLE 1

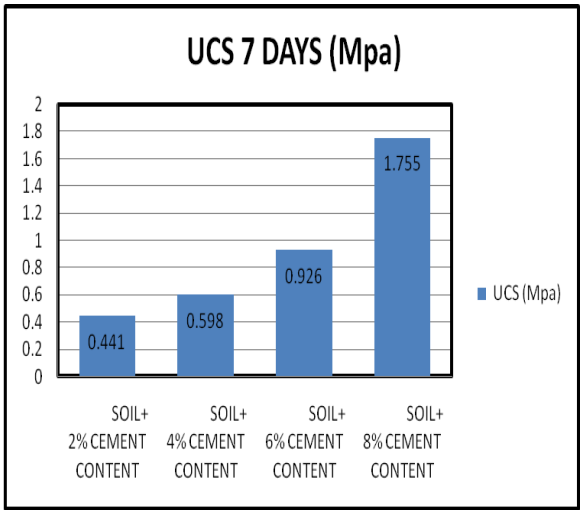

Figure 7. Unconfined compressive test of SAMPLE 2

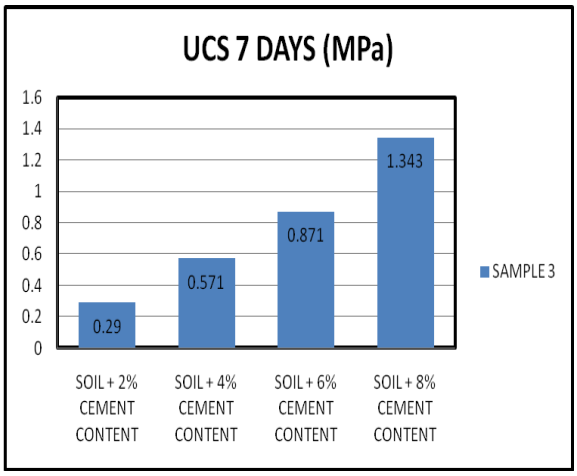

Figure 8. Unconfined compressive test of SAMPLE 3

The test results revealed that the unconfined compressive strength of three type of granular soil samples (gravelly, medium sand, fine sand) increases significantly with the addition of cement into it. It was found that the 7 days unconfined compressive strength SAMPLE I stabilized with 8% and 6% cement was found 2.81 MPa and 1.84 MPa which is used for base and sub-base of road and sample II stabilized with 8% cement was found 1.75 which is used as sub-bases of road.

3.3 Comparison of Strength with Different Type of Sand

Unconfined compressive strength of soil samples are improved with the addition of cement with different proportion as 2%, 4%, 6%, 8%. The UCS results were observed after the 7days of curing. The table shows the

variation of unconfined compressive strength with different percent of cement content on all three types of soil samples. Comparisons of results are tabulated below in graph.

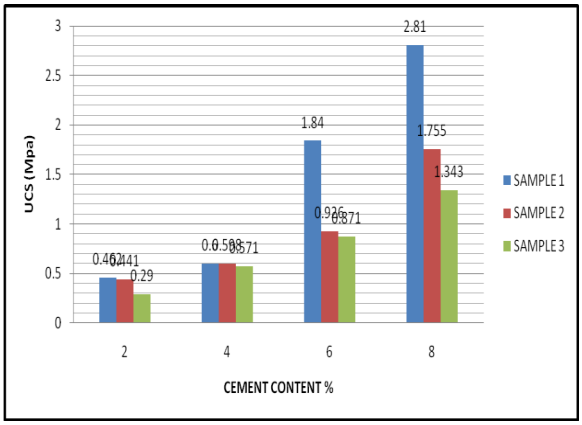

Figure 9. Comparison of UCS in 7 Days

These bar graphs illustrate the comparison of strength with three types of sand for 7 days. From the diagram, Blue color presents the SAMPLE I, Red color presents the SAMPLE II, and Green color presents the SAMPLE III. In general, the value of 7 days fluctuate very little among the three type of sand. SAMPLE I meets the compressive strength requirement of base and sub-base pavement layer on 7 days similarly SAMPLE II meets the UCS requirement of sub-base layer. On the other hand, SAMPLE III could not satisfy the UCS requirement on 7 days however it is suitable for subgrade construction.

4. CONCLUSION

Based on the results of tests conducted on granular soil with different proportion of cement 2%, 4%, 6%, 8%, by dry weight of the soil. Under the study, the following conclusions are drawn.

The UCS of gravelly soil SAMPLE I increases from 0.49MPa to 2.81MPa if we added 2% to 8% of cement into the soil similarly for SAMPLE II and SAMPLE III the UCS increases from 0.44MPa to 1.75MPa and 0.29MPa to 1.34MPa respectively.

It can be seen that, SAMPLE I which is predominantly well graded gravelly soil is suitable for sub-base at 6% cement content and it is suitable for base at 8% cement content and SAMPLE II which is well graded medium sand is suitable for sub-base at 8% cement content. While SAMPLE III which is well graded fine sand is not suitable for sub-base and base of pavement layer hence, it is suitable for subgrade construction.

Hence, cement stabilized granular soil (sandy soil/gravelly soil) may be used for sub-base/bases of road construction.

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