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Soil Stabilization by Industrial Waste (GGBS and Stone Dust)

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Abstract:- In the last century, there has been a considerable increase in population and rapid industrialization. The industries emit a large amount of industrial waste. Industrial waste occupied a large area of land. It creates a land problem and also pollutes the environment. To utilize the industrial waste, an attempt is made to stabilize the expansive soil by adding ground granulated blast furnace slag and stone dust. This project work aims to evaluate the effect of addition of 0%, 5%, 10%, 15%, 20%,25%,30% GGBS and Stone dust to stabilize the expansive soil and to verify its appropriacy to be used as a construction material for road, embankment and structural fills. In this project, the effects of the addition of GGBS and stone dust are investigated and are compared with that of the virgin expansive soil. The testing of expansive soil was conducted in three phases. In the first phase, the physical properties of the expansive soil samples were studied by conducting Sieve analysis, Specific gravity, Atterberg limit, Light compaction test, CBR test, and UCS test. In the second phase of the test program, expansive soil was mixed with 5%,10%,15%,20%,25%,30% of GGBS, and stone dust as a percentage of the dry weight of expansive soil. Granulated shaped blast furnace slag and stone dust were most suitable for increasing the strength of the soil and for this the following property of soil was checked. GGBS and stone dust were added from 0% to 30% by dry weight of soil. The experimental investigations indicated that generally, the engineering properties improved with the addition of GGBS and stone dust. In the standard proctor test, the maximum dry density increased and the optimum moisture content decreased with increase in GGBS and stone dust content and at maximum increase in mechanical properties was obtained at 30% of GGBS and Stone dust.

Keywords: GGBS, Stone dust, Light compaction test, UCS test, CBR test

1. INTRODUCTION

Stabilization of soil was the process of change the properties of soil by improved its engineering properties. Expansive soils exhibit major volume changed due to change in moisture content. This causes the foremost damage to the structure constructed on them. The swelling and shrinkage behavior of expansive soil was attributed to presence of montmorillonite minerals. Once they absorbed water their volume increased. A land-based structure of any type was simply as strong as its foundation. For that reason, the soil was even be a critical element influenced the success of a construction project. Soil stabilization was maximizing the suitability of soil for a given construction purpose. Soil was stabilized by chemical, mechanical, thermal, and electrical methods. Since expansive soils have changed their volume to an extent, they caused damage to engineering constructions. Although mechanical compaction, dewatering, and earth reinforcement are found to strengthen the strength of the soils, other methods like stabilization using admixtures were more efficient. The numerous admixtures available are lime, cement, fly ash, furnace slag, etc. this stabilization, nowadays, was gained importance because of its abundant availability and environmental concerns associated with its production.

1.1 SIGNIFICANCE OF THE PROJECT

Soil properties was varied a great deal and the construction of structures depended upon the bearing capacity of the soil, hence, we have to stabilized the soil, which made easier to divine the load-bearing capacity and even improve it. The gradation of the soil was additionally a really important property to stay in mind while working with soils. The soils could also be well-graded which is desirable because it has less number of voids or uniformly graded which though sounds stable but has more voids. Thus, it's better to combined different types of soils to enhance the soil strength properties. It was very expensive to replace the entire inferior soil entirely and hence, soil stabilization was that the thing to seem for in these cases. It was more economical in terms of both cost and energy to extend the bearing Capacity of the soil instead of going for a deep foundation or foundation. It was also wont to provide more stability to the soil in slopes or other such places. Sometimes soil stabilization was additionally done to prevent erosion or formation of dust, which was extremely useful especially in dry weather. Stabilization was additionally finished soil waterproofing. This prevented water from get into the soil and hence helps the soil from losing its strength. It helped in reduce the soil volume change thanks to changes in temperature or moisture content. Stabilization improved the workability and therefore the durability of the soil.

1.2 SCOPE AND IMPORTANCE OF THE STUDY

The experimental study carried with the choice of an approximate sort of soil to realize a high degree of compaction and to show the compaction properties of expansive soil. The expansive soils are difficult to compact within the initial stage of compaction, but because the moisture content increased the compaction becomes quite easy. The study involved the usage of Ground granulated furnace Slag (GGBS) and Stone dust for the stabilization of clay soil, which is well mixed in several proportions as 5%, 10%, 15%, 20%,25%, and 30%. From the mixture, the effectiveness of the stabilizer is going to be determined by

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conducting CBR, Unconfined Compression, and Standard Proctor Test. Soils that will be found a day in the construction area have different characteristics and provides major effects on the development. The soils that was not safe for construction should be treated to realize the specification. An appropriate treatment method for the soil should be selected by considering the sort, cost, and duration of the development. The usage of GGBS and stone dust as stabilizers is an increasingly significant approach to treat problematic soils.

2. MATERIALS USED

2.1 EXPANSIVE SOIL

The soil which tends to expand its volume within the presence of water and reduce the volume in the absence of water is called expansive soil. Expansive soil is extremely plastic soil that normally contains montmorillonite and other active clay minerals. The more clay exists within the soil, the higher the soil swells and therefore the more water the soil can absorbed. The soil sample for this study was collected at the depth of 1.5 to 2 meters from the nearby locality of Sardhapur of Angul. The soil was dried and pulverized to perform the varied experimental studies.

Figure 1: Expansive soil

The photograph of soil collected from the above location was presented in Figure 1. The index properties and mechanical properties of the soil like (CBR value and UCS) were experimentally evaluated as per the procedure of the relevant Indian Standard codes. The results of these properties are presented in table 1 below.

Table 1: Properties of Expansive soil

SL. NO.	PROPERTIES	VALUE
1	Specific gravity (Gs)	2.6
2	Grain size Distribution Coefficient of Uniformity (Cu) Coefficient of Curvature (Cc)	 6.27 1
	Atterberg limits Liquid limit (%) Plastic limit (%) Plasticity index (%)	 52.33 22.45 29.88
4	Compaction properties Optimum moisture content (OMC) (%) Maximum Dry Density (MDD) (kg/m^3)	 17.47 1610
5	Free swell index (%)	20
6	C.B.R (%)	12.32
7	U.C.S (KN/m^2)	142.25
8	FINENESS MODULOUS	3.12

2.2 GROUND GRANULATED BLAST FURANCE

GGBS was obtained by quenching Melton iron slag (a by-product of iron and steel-making) from a furnace in water or steam, to provide a glassy, granulated product that's then dried and ground into powder. GGBS has a glassy, disorderly, crystalline structure which can be seen by microscopic examination. GGBS has cementations properties, which makes it a suitable partial replacement additive to Portland cement. GGBS is primarily made from silica, alumina, quicklime, magnesia, and other elements like manganese, iron, sculpture, and a trace amount of other elements of slag. GGBS was collected from Kanika square, Cuttack**.** The properties and composition of GGBS are presented in Table:2. A photo of GGBS used in this research work was presented in figure 2 below.

Table 2: Properties of GGBS

Sl. NO.	PROPERTIES	VALUE
1	Specific gravity	2.85
2	State	Fine Powder
3	Natural moisture content	Maximum 1%
4	Colour	Whitish

Figure 2: Ground granulated blast furnace slag

2.3 <u>STONE DUST</u>

Stone dust was finely pulverized stone that has been used as a base material for leveling. Stone dust was easy to grade and once it is compacted, it can be walked directly on while laying stone, pavers, or bricks Stone dust was by-product of crushed stone. It was a mechanical stabilizer and high strength and enhances geotechnical properties of soil when mixed with it in suitable proportion. It stabilizes the problematic soil by improving its compaction characteristics and reducing plasticity. The stone dust was collected from Kanika square, Cuttack.

Table 4: Properties of Stone Dust

Sr.NO.	PROPERTIES	VALUE
1	Specific gravity	2.5
2	Grain size Distribution Coefficient of Uniformity (Cu) Coefficient of Curvature (Cc)	7.56 2.67

Figure 3:Stone dust

3. RESULT AND DISCUSION

3.1 SIEVE ANALYSIS OF SOIL

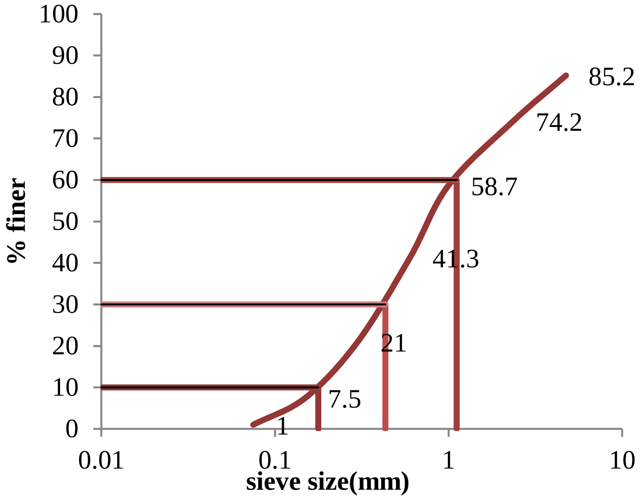

Figure 3: Sieve analysis of soil

3.2 SIEVE ANALYSIS OF STONE DUST

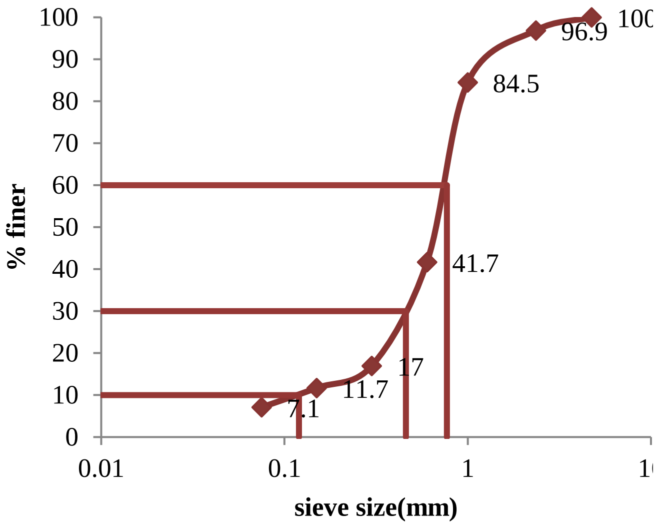

Figure 4: Sieve analysis of Stone dust graph

3.1 STANDARD PROCTOR TEST

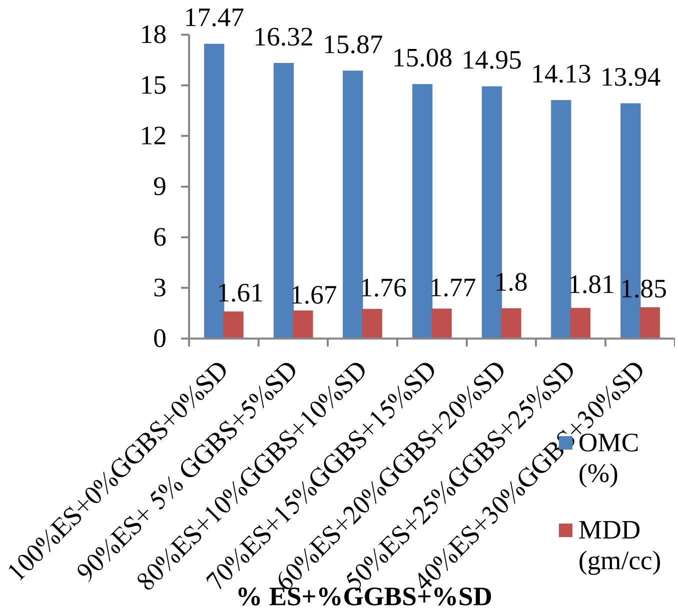

Figure 5: Composition Specification for ES Treated with different % of GGBS and %SD

All Samples were tested as per IS: 2720 (Part VIII) for Standard proctor test. Graphs drawn between water content and dry density for every percentage, from these results Optimum Moisture Content and Maximum Dry Density values are arrived. The results and graphs from these tests are presented within the Fig 4. From the compaction test result the utmost dry density value increases 1.61gm/cc ,1.67gm/cc ,1.76gm/cc,1.77gm/cc,1.80gm/cc,1.81gm/cc,1.85gm/cc and the optimum moisture content values are decreasing from 17.47%, 16.32%, 15.87%, 15.08 %, 14.95 %, 14.13%, 13.94% respectively when the soil is mixed with 0 %, 5 %, 10%, 15%, 20%, 25%, 30% of GGBS and stone dust.

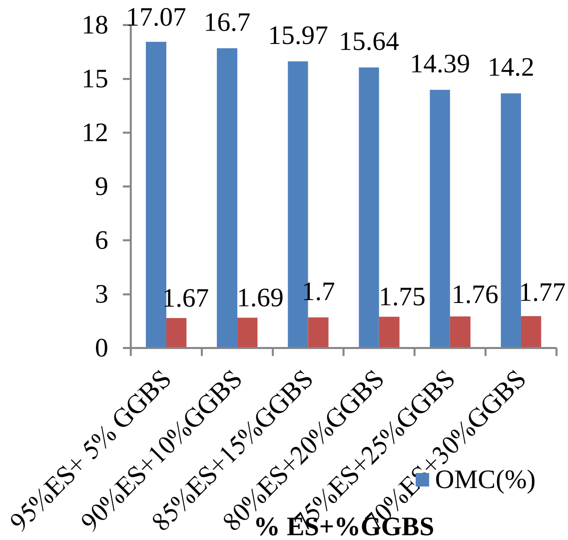

Figure 6: Composition Specification for ES Treated with different % of GGBS

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All Samples were tested as per IS: 2720 (Part VIII) for Standard proctor test. Graphs drawn between water content and dry density for every percentage, from these results Optimum Moisture Content and Maximum Dry Density values are arrived. The results and graphs from these tests are presented within the Fig 5. From the compaction test result the utmost dry density value increases 1.67gm/cc ,1.69gm/cc ,1.70gm/cc, 1.75gm/cc,1.76gm/cc,1.77gm/cc and the optimum moisture content values are decreasing from 17.07%, 16.7%, 15.97%, 15.64%, 14.39%, 14.20% respectively when the soil is mixed with 0 %, 5 %, 10%, 15%, 20%, 25%, 30% of GGBS.

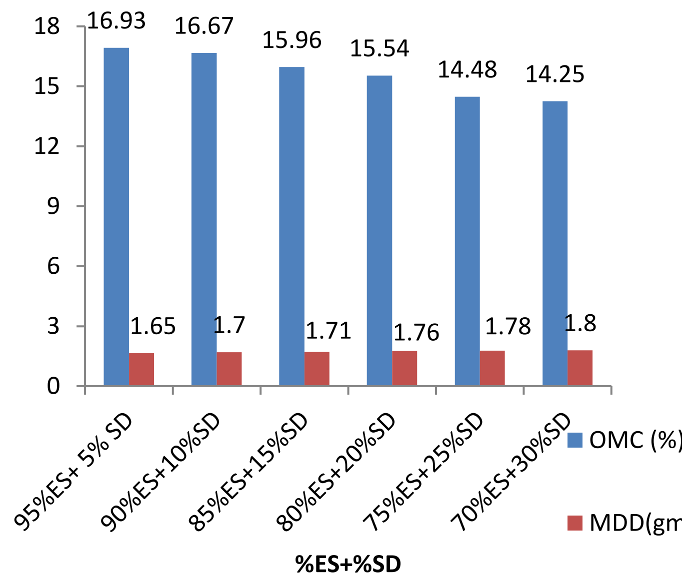

Figure 7: Composition Specification for ES Treated with different % of SD

All Samples were tested as per IS: 2720 (Part VIII) for Standard proctor test. Graphs drawn between water content and dry density for every percentage, from these results Optimum Moisture Content and Maximum Dry Density values are arrived. The results and graphs from these tests are presented within the Fig 6. From the compaction test result the utmost dry density value increases 1.65gm/cc ,1.70gm/cc ,1.71gm/cc, 1.76gm/cc,1.78gm/cc,1.80gm/cc and the optimum moisture content values are decreasing from 16.93%, 16.67%, 15.96%, 15.54%, 14.48%, 14.25% respectively when the soil is mixed with 0 %, 5 %, 10%, 15%, 20%, 25%, 30% of stone dust.

3.2 CALIFORNIA BEARING RATIO TEST

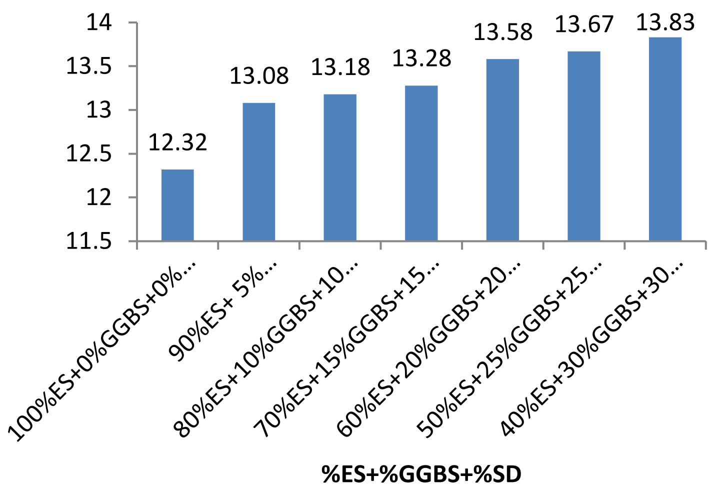

Figure 8: CBR value for ES Treated with % GGBS and %SD

All Samples were tested as per IS: 2720 (Part XVI) for California bearing ratio. Graphs drawn between penetration and load for every percentage. It was observed from that the expansive soil mixed with different percentage of GGBS and stone dust unsoaked CBR values are 12.32%, 13.08%, 13.18%, 13.28%, 13.58%, 13.67%, 13.83% for 0%, 5%, 15%, 20%, 25%, 30% of GGBS and stone dust respectively.

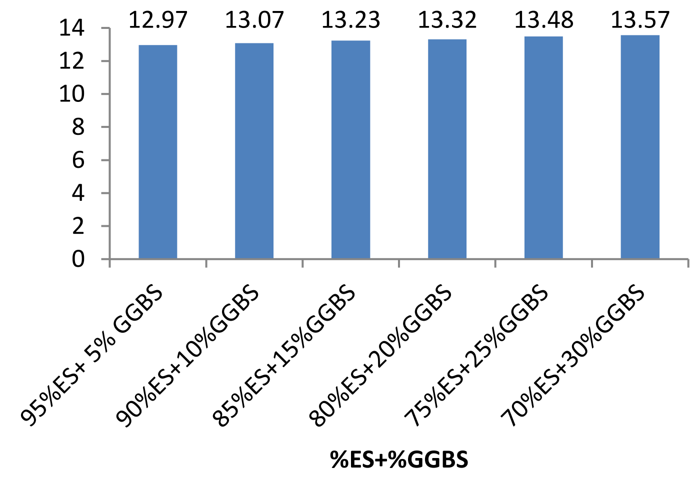

Figure 9: CBR value for ES Treated with % GGBS and %SD

All Samples were tested as per IS: 2720 (Part XVI) for California bearing ratio. Graphs drawn between penetration and load for every percentage. It was observed from that the expansive soil mixed with different percentage of GGBS unsoaked CBR values are 12.97%, 13.07%, 13.23%, 13.32%, 13.48%, 13.57% for 5%, 15%, 20%, 25%, 30% of GGBS respectively.

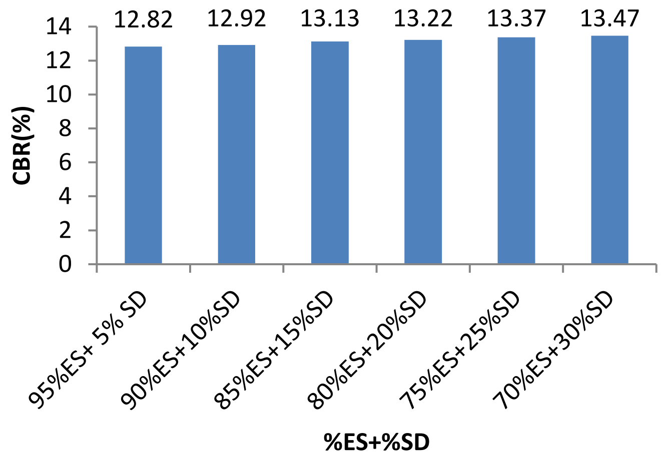

Figure 10: CBR value for ES Treated with %SD

All Samples were tested as per IS: 2720 (Part XVI) for California bearing ratio. Graphs drawn between penetration and load for every percentage. It was observed from that the expansive soil mixed with different percentage of Stone dust unsoaked CBR values are 12.82%, 12.92%, 13.13%, 13.22%, 13.37%, 13.47% for 5%, 15%, 20%, 25%, 30%o of Stone dust respectively.

3.3UNCONFINED COMPRESSIVE STRENGTH

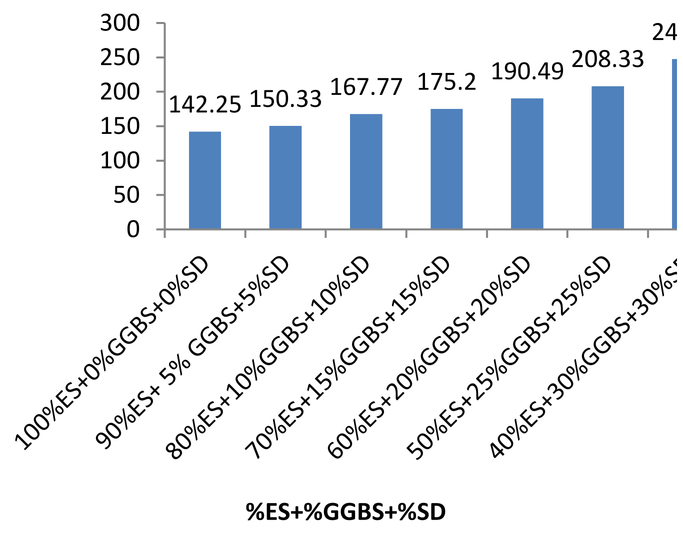

Figure 11: UCS value for ES Treated with %GGBS and %SD

All Samples were tested as per IS: 2720 (Part X) for Unconfined compressive strength. Graphs drawn between axial strain and compressive strength for every percentage. It was observed from that the expansive soil mixed with different percentage of GGBS and stone dust the UCS values are 142.25Kpa, 150.33Kpa, 167.77Kpa, 175.20Kpa, and 190.49Kpa, 208.33Kpa,247.49Kpa for 0%, 5%, 15%, 20%, 25%, and 30%. Of GGBS and stone dust respectively.

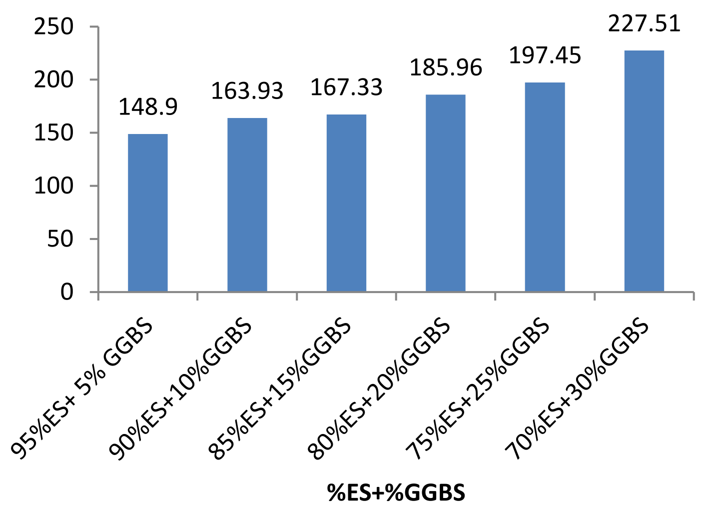

Figure 12: UCS value for ES Treated with %GGBS

All Samples were tested as per IS: 2720 (Part X) for Unconfined compressive strength. Graphs drawn between axial strain and compressive strength for every percentage. It was observed from that the expansive soil mixed with different percentage of GGBS the UCS values are 148.90Kpa, 163.93Kpa, 167.33Kpa, 185.96Kpa, 197.45Kpa, 227.51Kpa for 5%, 15%, 20%, 25%, and 30% of GGBS respectively.

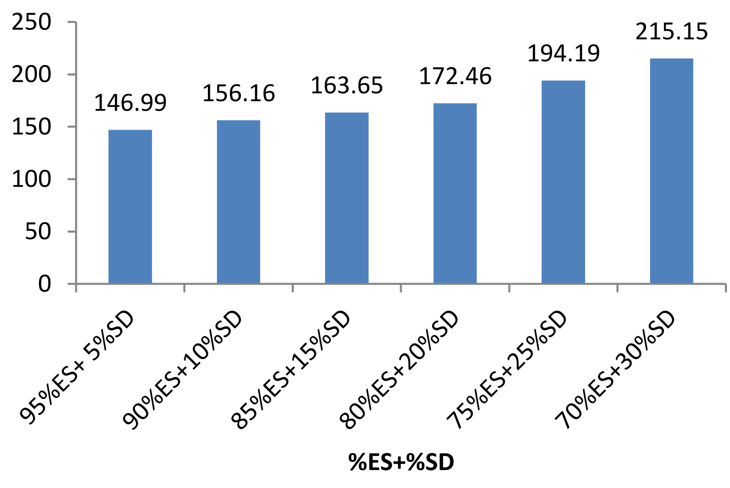

Figure 12: UCS value for ES Treated with %SD

All Samples were tested as per IS: 2720 (Part X) for Unconfined compressive strength. Graph drawn between axial strain and compressive strength for every percentage. It was observed from that the expansive soil mixed with different percentage of stone dust the UCS values are 146.99Kpa, 156.16Kpa, 163.65Kpa, 172.46Kpa,194.19Kpa, 215.15Kpa for 5%, 15%, 20%, 25%, and 30% of stone dust respectively

Figure 13: UCS test

When we added GGBS and Stone dust with expansive soil the UCS value about 74% increased and when added GGBS only the UCS value about 60% increased and when added stone dust only the UCS value increased about 51.24%.

4. CONCLUSION

The following conclusions were drawn based on the laboratory studies carried out on this study. Liquid limit of the expansive soil was 52.33%, the plastic limit was 22.45% and specific gravity was 2.6. It was observed that the OMC deceased and MDD increased by adding different percentage of GGBS and stone dust. It was observed from the laboratory investigations that the unsoaked CBR value increased up by adding GGBS and stone in different proportion. The UCS value also increased by adding GGBS and stone in different proportion. Hence, from the laboratory results, the optimum percentages of GGBS and stone dust were 30%. The GGBS and stone dust were easily available across the country from nearby by industries. With increases of GGBS and stone dust percentage compressive strength increases that means arrangement of soil particles were very closely, which reduced the voids.

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