

Study the Behaviour of Soil for Sub Grade by using Marble Dust and Ground Granulated Blast Furnace Slag

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ABSTRACT: The Rapid growth of industries of marble produce and the production of steel creates hazardous waste materials by a large extent which cause a big problem to the humans surrounding them as well as acts as a pollutant affecting the ecological system of the environment. Keeping this objective in mind, the Marble Dust and GGBS can be used as soil stabilization materials in different proportion. In this paper, sandy clayey soil was stabilised using the combination of Marble Dust and GGBS in different proportion (i.e.0%+0%, 5%+5%, 10%+10%, 15%+15% & 20%+20%) and the Characteristic behaviour (i.e. OMC, MDD, UCS, CBR & Permeability) of modified soil in the laboratory was studied. The series of test has been conducted in laboratory and it is found that Marble Dust and GGBS (15%+15%) is sufficient to increases the California bearing ratio in unsoaked and soaked condition value up to 195% and 100% approximately.

KEYWORDS: Compaction, California bearing ratio, UCS, Permeability, Sandy Clayey soil, Marble dust, GGBS.

I. INTRODUCTION

Sandy Clayey soils, which becomes unattainable to avoid them for highway construction and airways. Economic development of any country is controlled to a great extent by highway and airway networks. Therefore, the development and use of methods to decrease the cost of pavements is very necessary. For this work it is essential to know the condition of the sub-grade soil before designing the type and the thickness of pavement, as the sub-grade carries the traffic loads as well as the pavement loads. The major function of pavement is to distribute stresses to the sub-grade (K.Uppaiah et.al.-2013). The process of improving the behaviours of soil is known as Soil Stabilization. It is done by various methods and one of them is mixing the Stabilizing Additives. In this study, it has been planned to mix the Marble dust and GGBS (Ground Granulated Blast furnace Slag) with different proportions in Sandy Clayey soil.

The marble dust is a type of a solid waste which is generated from cutting and polishing of marble stone. The number of research has been done in the direction of utilizing of marble dust waste into the soil stabilization technique. Swami (2002), Baser (2009) and Palaniappan (2009), Agrawal et al (2011), Sabat et al (2011), Viswakarma et al (June 2013), had investigated that marble dust is effective waste material in soil stabilizing technique which improves the compaction characteristics, subgrade characteristics, swelling characteristics, compressive strength characteristics as well as index properties of soil like liquid limit, plastic limit, shrinkage limit.

GGBS is a non-metallic by-product produced in the process of iron production by chemical reduction in a blast furnace. Numerous researchers have worked on the stabilization of soil using GGBS. Dr. D. D. Higgins(2005) had found, a slower early-rate of strength development gives considerably more time for construction operations. In the long-term, there is an increased strength that will improve the structural performance. Cokca et al. (2009) had found that the stabilizers decreased the total amount of swell where as the rate of swell were found to be increased. Sharma and Sivapullaiah (2012) had found that the strength developments though depends on percentage of ground granulated blast furnace slag, the effect of curing was less pronounced. There was also increase in initial tangent modulus values with

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increase in ground granulated blast furnace slag percentage. Osinubi et al. (2012) had found that compaction delay reduces the strength of the stabilized soil. Celik et al. (2013) had found that the growth of ettringite mineral was prevented by the addition of ground granulated blast furnace slag, to lime stabilized clayey soil which resulted decrease in IP, LS, and Sp of lime stabilized clayey soil. Oormila.T.R et al. had found that optimum GGBS (20%) gives the maximum increment in the CBR value compared with all the other combinations.

II. EXPERIMENTAL INVESTIGATION

MATERIALS

The Sandy Clayey soil is obtained from BIT campus, Sindri, Dhanbad (INDIA). GGBS is obtained from blast furnaces of cement (ACC plant, Sindri). Marble dust is obtained from marble stone shop locally. According to Unified Soil Classification system, the soil was classified as clayey sand with low plasticity (CL) and the properties of soil are given in Table 1. The physical and chemical properties of GGBS and marble dust are presented in Tabular form.

Table 1: PROPERTIES OF SOIL SAMPLE

Sl. No.	Parameters	Values
1.	Specific Gravity	2.47
2.	Optimum Moisture Content	13.04
3.	Maximum Dry Density	1.75
4.	Liquid Limit	41.77
5.	Plastic Limit	24.710
6.	Plasticity Index	17.06
7.	Category of Soil	$C_u = 8.771$ $C_c = 0.740$
	As per USC System (fines fraction)	Poorly graded sands
	As per USC System (A-line chart)	Clayey Sand (SC) Low Plasticity (CL)

Table 2: Typical chemical composition of Marble Dust

Oxide compound	Mass percentage
CaO	40.45 %
Al ₂ O ₃	3.42 %
SiO ₂	28.35 %
Fe ₂ O ₃	9.70 %
MgO	16.25 %

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Table 3: Physical Properties of Marble Dust

Sl. No.	Properties	Test Result
1.	Specific Gravity	2.63
2.	Particle size	<90 μ
3.	Colour	White
4.	Odour	Odourless
5.	Moisture Content (%)	0.60
6.	Bulk density (without compaction) gm./cm ³	1.370
7.	Bulk density (with compaction) gm./cm ³	1.837

Table 4: Typical chemical composition of GGBS

Oxide compound	Mass percentage
Calcium oxide (CaO)	34% – 43 %
Silicon dioxide (SiO ₂)	27% – 38%
Aluminium oxide (Al ₂ O ₃)	7% – 12%
Magnesium oxide (MgO)	7% – 15 %
Iron (FeO or Fe ₂ O ₃)	0.2% – 1.6%
Sulphur (S)	1.0% – 1.9%
Manganese oxide (MnO)	0.15% – 0.76%

Physical Properties of GGBS-The physical characteristics of GGBS such as density, porosity and particle size are affected by the cooling rate (i.e. cooling method) of the slag and its chemical composition. Air-cooled GGBS is angular, roughly cubical and has textures ranging from rough, vesicular (porous) surfaces to glassy surfaces with conchoidal fractures. It has a rough surface texture giving good frictional properties and good adhesion to bituminous and cements binders, a low coefficient of thermal expansion and a high fire resistance.

GRAIN SIZE DISTRIBUTION OF SOIL

The wet sieve analysis tests were conducted as per IS-2720 (part IV) 1985(Reaffirmed 1995). The particle size distribution of soil is tested are given in “Fig.” 1.

Analysis of Gradation Curve of Soil

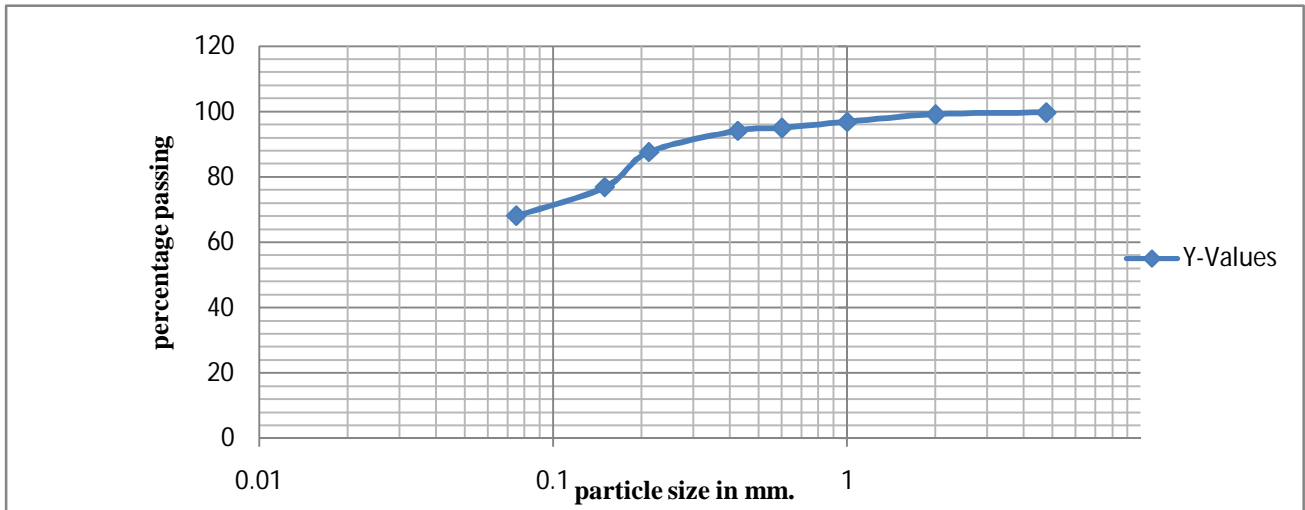
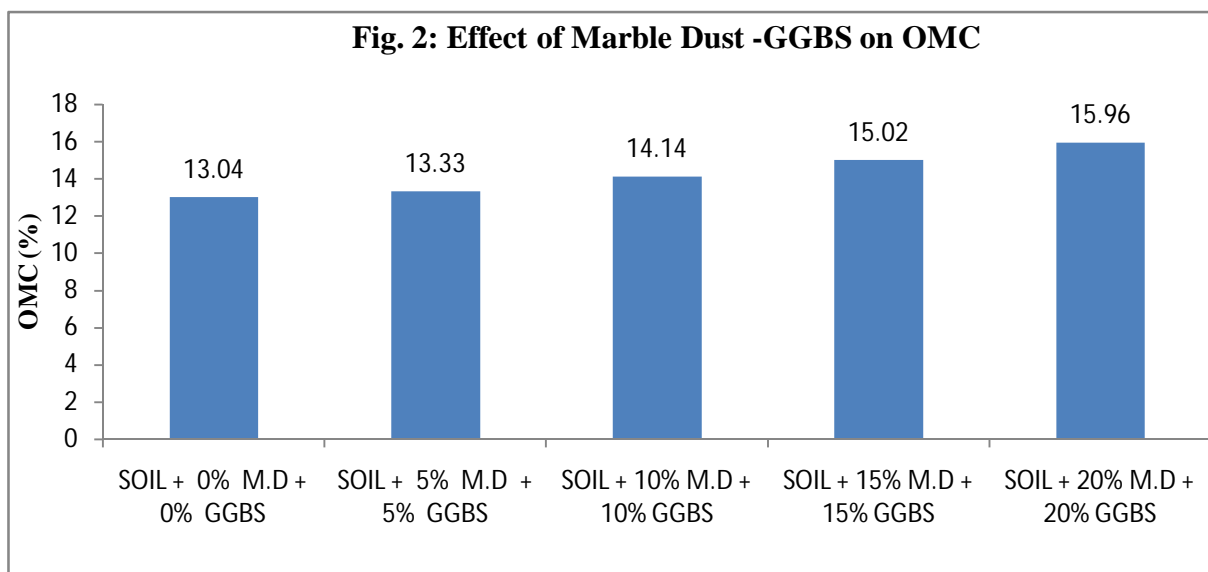
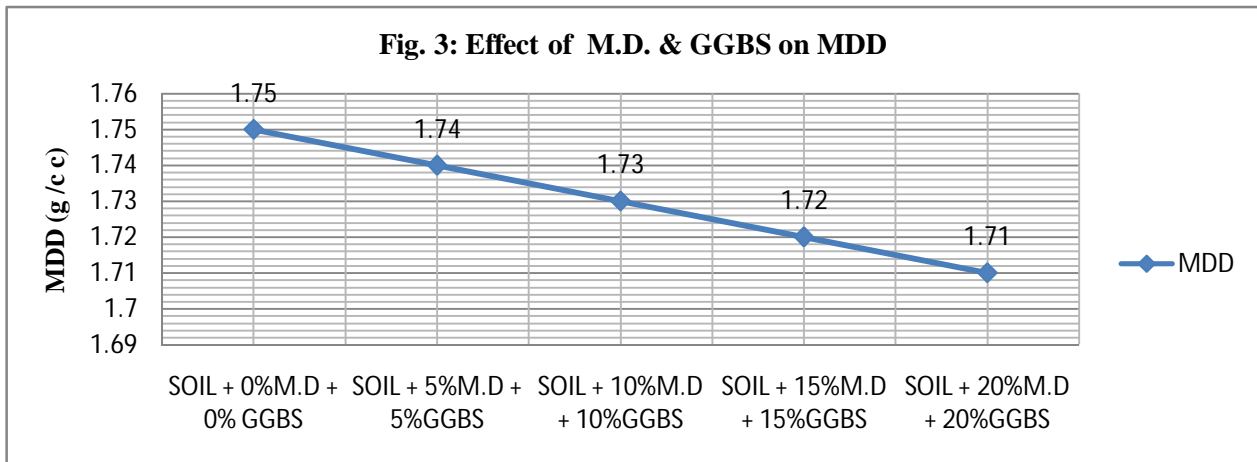


Fig. 1: Gradation curve of natural Soil

III. RESULT AND DISCUSSION

OMC & MDD Test Result- Light Compaction tests were used to establish the dry density-moisture content relationship and carried out the test of soil with various amount of Marble dust and GGBS added. To consider the effect of Marble dust and GGBS on OMC and MDD the test of soil is conducted with 0% to 20% Marble dust and GGBS and 5%-5% to 20%-20% Marble Dust- GGBS by dry weight of soil.

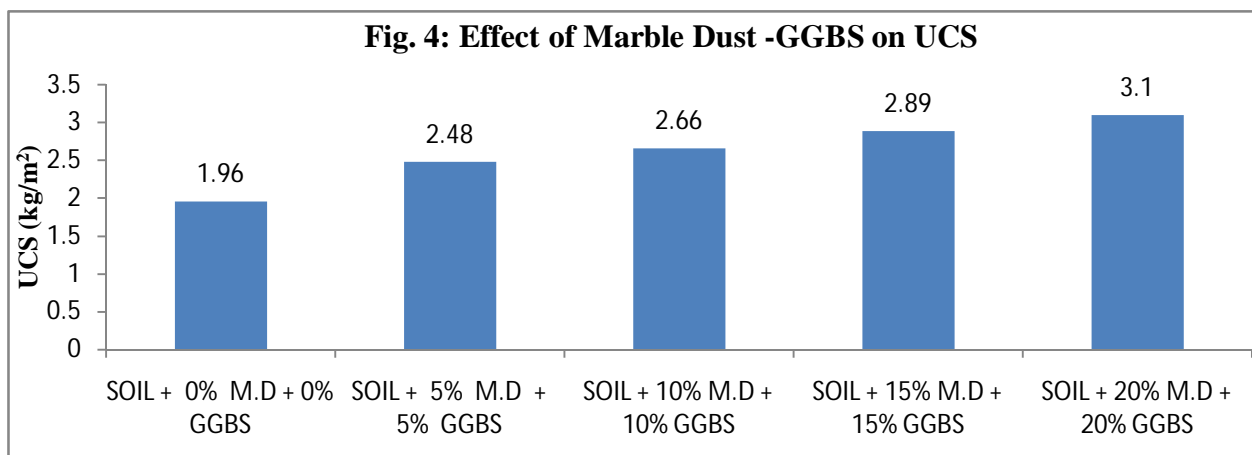




In the test result, OMC is increasing but MDD is decreasing gradually as finer particles of Marble dust and the percentage of GGBS added with Marble dust in same proportion (5% + 5% to 20% + 20%), then OMC is decreasing and MDD is increasing relatively as granular particles of GGBS. When Marble dust and GGBS is used as soil stabilizing additive, Soil particles become large-sized clusters, resulting in texture change. This flocculation-agglomeration process results in flock formation. The enlarged particle size causes the void ratio to increase. This increase in void ratio reflects the decrease in MDD and increase of moisture content for the Soil-Marble dust, Soil-GGBS and Soil-Marble dust-GGBS mixture.

UNCONFINED COMPRESSION TEST

Soil with various amount of Marble dust and GGBS added to determine the effect on compressive strength of soil with 0% to 20% Marble dust and GGBS by dry weight of soil.



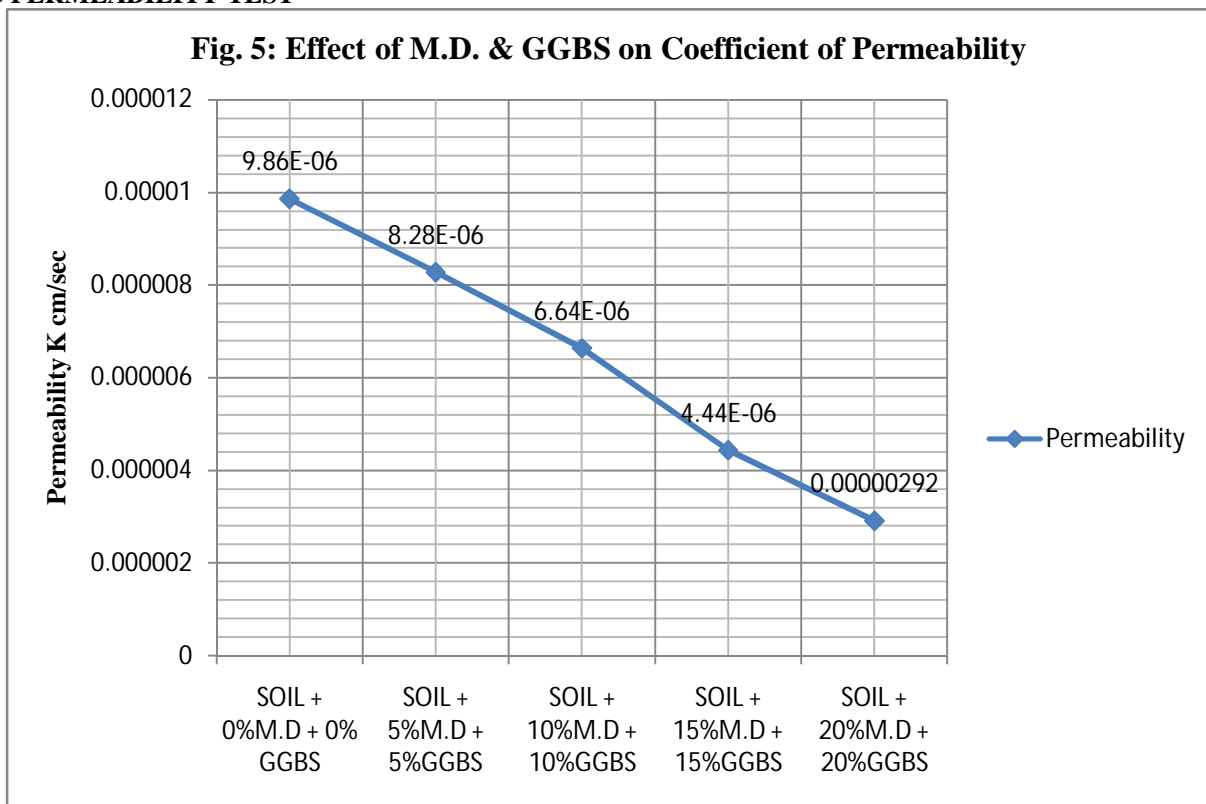
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From above figure (4), it can be seen that the Unconfined Compressive Strength of the Soil sample have increased as the percentage of Marble dust, GGBS and Marble dust-GGBS increases. The Unconfined Compressive Strength at 20%-20% addition of Marble dust- GGBS to the soil are 3.10 kg/cm². As compared to the untreated soil (at 0% Marble dust and GGBS), the percentage increase at 20%-20% addition of Marble dust- GGBS to the soil is about 58.16%. This is due to the fact that addition of Marble dust and GGBS provide additional amount of Silica than that present in natural soil only.

3.3 PERMEABILITY TEST



Soil with various amount of Marble dust and GGBS added to determine the effect on Permeability of soil with 0 % to 20 % by dry weight of soil

From above figure (5), it can be seen that the Permeability of the Soil Sample have decreased as the percentage Marble dust + GGBS increased. The Coefficient of Permeability at 20 % - 20 % addition of Marble dust - GGBS to the soil is 0.292×10^{-6} cm/sec . As compared to the Untreated Soil (at 0 % Marble dust and GGBS), the percentage decrease 20 % - 20 % addition of Marble dust - GGBS and 60.04% increased. This is due to the increase in finer material as percentages of Marble dust, Permeability value decrease in the Soil - Marble dust - GGBS mixture and due to increase in finer particles - granular particles simultaneously as same percentage of Marble Dust – GGBS. Permeability value decreases in the Soil - GGBS mixture through decreasing in capillary passage of sample.

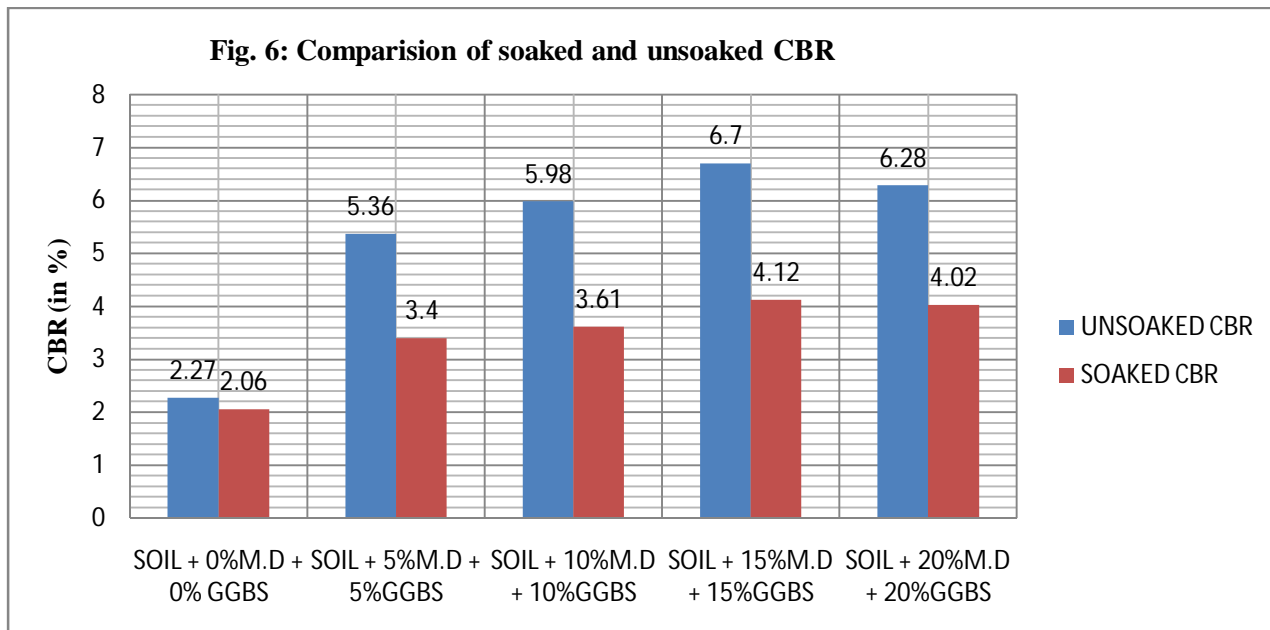
3.4 CBR Test

Soil with various amount of Marble dust- GGBS added to determine the effect on CBR value (Soaked & Unsoaked condition) of soil with 0% -0% and 5%-5% to 20%-20% by dry weight of soil.

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From above figures (6), it can be seen that the CBR of the soil samples has been increasing as the percentages of Marble dust and GGBS increased in both condition (Soaked & Unsoaked condition). In unsoaked condition, CBR is 2.27 % for untreated soil (at 0 % Marble dust and GGBS) and 15% - 15 % Marble Dust - GGBS addition it becomes 6.70 % . In soaked condition, CBR is 2.06 % for untreated soil whereas CBR is 4.12 % at addition of 15% - 15% Marble dust - GGBS to the soil. In unsoaked condition there is increase in CBR 195.15 % , while in soaked condition CBR value increases about 100 %.

Here, Unsoaked CBR values are greater than Soaked CBR values after the addition of 5% - 5% Marble dust - GGBS. This increment may be attributed to the chemical and cementation effect (the Oxides amount in the Marble dust and GGBS is about 2/3rd of Oxide amounts found as cement) on structural composition of the soil. Presence of Ca²⁺, Si²⁺, and Al³⁺ cations in Marble dust and GGBS, it react with water and resulting in the formation of Calcium-Silicate-hydrates (CSH) and Calcium-Aluminate- hydrates (CAH). CSH and CAH are cementation products similar to those formed in Cement. Time duration and sufficient water favours these reactions.

IV. CONCLUSIONS

- ◆ The characteristics of soils vary significantly with Marble dust-GGBS content. The Optimum Moisture Content (OMC) increases and Maximum Dry Density (MDD) decreases with increase in percentage of Marble dust-GGBS.
- ◆ As compared to untreated soil, the percentage increase in OMC at 20%-20% addition of Marble dust- GGBS is 22.39%.
- ◆ As compared to untreated soil, the percentage decrease in MDD at 20%-20% addition of Marble dust- GGBS is 2.29%.
- ◆ With increases 20%-20% of Marble dust and GGBS percentage compressive strength of soil increases. Percentage increase in compressive strength of soil is 58.16 % .
- ◆ CBR value for soaked and unsoaked condition increases with increases in percentage of Marble dust and GGBS. Percentage increase in CBR value for soaked and unsoaked is 195.15% and 100% respectively. The

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CBR value of Marble dust and GGBS treated soil is 6.70% which can be used for the designing of flexible pavement for light and medium traffic.

- ◆ Coefficient of permeability i.e., Hydraulic conductivity of soil reduces with increase in Marble dust and GGBS percentages. Percentage decrease in Permeability of soil is 70.39%; hence stabilized soil may be used for the impervious core in embankment.
- ◆ For the best stabilisation effect was found the optimum proportion of M.D –GGBS as 15 % - 15 % about strength.

This project work concluded that Marble dust and GGBS is potentially useful in stabilizing of soil. However, the stabilizing effect is primary a function of the chemical composition, fineness, and addition level of the Marble dust and GGBS as well as the type of parent soil. Marble dust and GGBS is an effective soil stabilization agent, based on the results observed and described in this thesis. It is recommended that it can be considered for use in the stabilization of soil for sub-grade up gradation, which capable to reduce thickness of sub-grade .

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