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Enhancement of Various Properties of Soil and Stabilization of Soil Using Copper Slag and GGBS

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Abstract: The primary objective of this work is to study the interaction of black cotton soils with Copper Slag and GGBS. To improve the Geo-Technical and Engineering Properties of the Black- Cotton soil. To study the behaviour of strength gain in black cotton soil using Copper Slag and GGBS Stabilization.
Keywords: Copper Slag, GGBS, Cement Matrix, MORTH.

I. INTRODUCTION

Soil is a non-slip deposit or a mixture of minerals, organic matter and fragments that cover most of the earth's crust. So there are different types of soil that exist and vary around the world so soil structures also vary equally. About 20% of the land in India consists of vast soils. We know that soil loses shear strength in wet conditions. So building any soil for an engineering structure should be of sufficient strength. Therefore, when it is necessary to improve soil engineering structures and the suitability of soil stabilization methods is used. Soil consolidation is the process of changing one or more areas of soil using a soil stabilizer to improve soil performance. Sustainability is therefore used for a variety of engineering activities. The most common application in the construction of roads and air field pavements, where the main purpose is to increase the strength or suitability of the soil in this use of soil consolidation. We all know that landslides occur due to heavy rainfall, earthquakes, melting snow and human activities etc. as a result the ground structures are disturbed. In many lands soil erosion occurs in such cases as soil compaction is used to prevent landslides. Mechanical stabilization and chemical stabilization are two important methods used to stabilize the soil. In chemical compounds Chemical compounds are used to improve soil stability and to achieve this stability a certain chemical compound is added to the expanded soil. Sometimes, Mechanical stabilization is neither economical nor feasible and it is not appropriate to replace undesirable soil with desirable soil. This method alters soil properties such as ground strength, compression, Hydraulic conductivity and soil volume changes. Mechanical reinforcement is a process in which mechanical power is applied with the help of rollers, plate compactors, tampers, etc. to improve soil structures by bonding. It is widely used in the construction of road fences, trains and more. Mechanical stabilization is an easy way to stabilize. Mechanical stability depends on the degree of compression which is usually the compression produced by the high humidity. it is used to improve the lower levels of low load capacity and the construction of foundations, lower foundations, and over roads.

A. Coper Slag

Copper slag is produced during the manufacture of pyro metallurgical copper from its ores. Of all the steel production, about 2.2 tons of slag is produced. Currently, worldwide producing 33 tons of slag and in India three producers of copper Sterlite copper, Birla Copper and Hindustan Copper produce 6-6.5 tons of slag at various locations. Production of copper slag is 120-130 tons per lakh per year. India's copper-producing units leave thousands of tons of copper slag as a daily waste. Disposal of slag piles is a natural challenge.

However, the fine physio mechanical properties of copper slag make it useful such as concrete inserts, building filters, ballast, abrasives, aggregates, roofing granules, glass, and tiles. (sand, crushed on natural rocks) .It receives wide acceptance from ready-mixed concrete manufacturers and government roads for concrete application roads as prescribed by BIS IS 383: 2016 (Bureau of Indian Standards) in many previous areas. Recently many corridor projects have used these alternatives, thus avoiding the depletion of valuable natural resources that contribute to environmental conservation and sustainability.

India is expected to become the sixth largest copper market by 2020 with Electrical, Transport and Telecommunications as the most widely used sectors. The use of copper slag as an alternative to other industries and industries has been widely considered over the past decade. Research on the use of copper slag instead of rough or fine aggregate shows its suitability as a building material.

B. The Benefits Of Using The Copper Slag

The benefits of copper slag are as follows,

1) The use of copper slag in road construction helps to reduce environmental impacts due to excavation.
2) Using copper slag in construction reduces waste volume, reduces environmental concerns such as metallurgy, groundwater pollution and solves the waste disposal problem for disposal.
3) Copper slag used as an alternative material can meet the growing demand for natural building blocks. Using such Industrial waste leads to sustainability and economy in construction.
4) In areas such as Kerala, Maharashtra and Gujarat, sand mining in rivers has been banned due to environmental impact. Therefore, slag has great potential for development as another suitable material for these resources.
5) Its new use in stabilization is found to increase soil strength.
6) Copper slag is also suitable as a filler for land reclamation.

C. GGBS

It is a product from recycled blast-furnaces to create metal. Explosive furnaces are fed with an accurate mixture of iron-ore, coke and limestone, and processed at a temperature of 1,500 ° C. When iron, coke, and limestone were to melt in a furnace, two crops were produced — molten iron, and molten slag. The melted slag is light and floats on top of the liquid metal. The molten slag usually contains silicates and alumina from a unique metal, which is composed of other oxides from limestone. The slag purification process involves the cooling of melted slag through compressed water jets. This quickly extinguishes slag and custom granular particles usually no more than 5 mm. Rapid cooling prevents the formation of large crystals, as well as granules comprises around 95% non- crystalline calcium-alumino silicates. The granulated slag is further processed by drying and then grinding in a vertical roller mill or rotating ball mill to a very fine powder, which is GGBS

II. LITERATURE REVIEW

Ashish kumar phatak et al (2014) studied the effect of ground granulated blast furnance (GGBS) and compared land engineering structures where 0% of slag was added to soil and soil where GGBS percentages increased from 0% to -25%. he then realized that engineering structures were being improved when GGBS was added to the ground. He also concluded that high dry density is increasing and high humidity contains a decrease with the addition of GGBS content. And high dry density is found in 25% of GGBS groundwater.

Oormila T. R. et al. (2014) studied the effect of fly ash and ground granulated blast furnace slag on the ground. The tested sample was collected from palur, Tamil nadu and various percentages of fly ash (5%, 10%, 15% and 20%) and GGBS (5%, 10%, 15% and 20%) were added to compare results of its original strength and power. He concluded that 20% of GGBS provides a higher increase in CBR value compared to all other compounds.

Ortega-Lopez et al (2014) studied the effect of five different types of ladle furnance slag on soil with a 5% component as recommended by Manso et al. (2013). You got good results.

Kayal Rajakumaran (2015) studied the effect of steel slag and fly ash on broad ground. He adds different percentages of steel slag and flying ash to wide ground. Then the performance of the converted soil is tested by various tests such as water infiltration test, density test and unlimited pressure test. Based on these tests the percentage of steel slag and fly ash is calculated.

Kavak et al (2016) studied the effect of granulated blast furnace slag and lime on Ankara clay soils. When he evaluated the test result he based on these results and concluded that the uncensored compression force (UCS) and the California carrier rate (CBR) are increasing. A 46-fold increase in the CBR values of Ankara clay compared to a natural case within 28 days of sampling treatment.

Tarkeshwar pramanik et al (2016) studied the effect of marble dust and granulated blast furnace slag on soil using foe sub-grade. He used sandy loam soils that were prepared using a combination of marble dust and GGBS in different proportions (0% + 0%, 5% + 5%, 10% + 10%, 15% + 15% and 20% + 20%). . According to various studies conducted using this component you conclude that estimates (15% + 15%) of marble dust and GGBS are sufficient to increase the amount of CBR in immersed and immersed state to 195% and almost 100%.

Dayalan J (2016) studied the effect of ground granulated blast furnace slag and ash on the ground. You have added different dimensions of GGBS and fly ashes separately as 5%, 10%, 15% and 20% of the dry soil weight you have to stabilize. He concluded by testing that the highest percentage of fly ash is 15% and that of GGBS 20% for best results.

Kavisri et al., (2018) conducted experiments to study the effect of clay soil stability with copper Slag and granulated blast furnace slag. Soil samples mixed with 10%, 20%, and 30% of each stability were tested for cohesive characteristics, unbalanced compression strength and California bearing capacity. It was concluded that 70% of clay soil and 30% copper slag or 30% of granulated blast furnace slag were the stabilizing value to meet the minimum distance requirements.
Rajendra Kumar et al., (2017) studied the effect of copper slag and flying ash on dark cotton soils with a liquid content of 86%. Soils treated with various percentages of additives were tested for Modified proctor compaction and California bearing ratio. Copper slag is added in percentages ranging from 5% to 35%. A good percentage was found to be 30% copper slag with 70% expanded soil with approximately 6.3% CBR immersed. Further research was conducted on the increase in flyash by a percentage variing from 2% to 10% and an increase of 8% available flyash showing a higher CBR of 45.5%. It has been found that high humidity has decreased and high density of dry matter increases when copper slag or ashes fly into the ground. There was a significant increase in CBR in the cleaned soil when flyash was applied.
Jaber Shahiri et al., (2016) investigated the effect of adding cement and copper slag to clay soils with a liquid content of 37%. The cement mortar was prepared by adding 2% cement, 4%, 6% cement to the soil and tested for cohesive properties. The density of the dry matter is reduced and the moisture content is sufficient to increase. The non-closed pressure after treatment is found to increase from 2.4 Mpa to 11.9 Mpa after 90 days of cement treatment of 6%. The clay soil was mixed with copper slag varying from 5% to 20%. MDD increased and OMC decreased with the addition of copper slag to the soil. Percentage of copper slag is identified as 20% for further experiments with cement, copper slag and soil mixtures. The compacted unstable strength of 6% cement soil and 20% copper slag after 90 days of healing was found to be 13.4 Mpa. In addition the Artificial Neural Network model was developed with 8 input components such as copper slag, cement content, water content, dry matter, liquid limit, plastic limit, pH and curing years. ANN was used for analysis. A network of 10 neurons is thought to be located in a hidden layer. The proposed model has been successfully implemented predict elastic modulus of stable soils and installation parameters. The results proved that the model was effective in predicting..

III.MATERIALS AND METHODOLOGY

Copper slag is an abrasive blasting grit made of granulated slag from metal smelting processes (also called iron silicate). Copper slag is a by-product created during the copper smelting and refining process.

Table Physical properties of Copper Slag

S.No.	Physical Properties	Value	Chemical Property	(% wt)
1	Particle shape	Irregular	Iron oxide (Fe2O3)	42-48
2	Appearance	Black & glassy	Silica (SiO2)	26-30
3	Specific gravity	2.9-3.9	Aluminium oxide	1-3
4	% of voids	43.20%	Calcium oxide	1-2
5	Bulk density	2.08 g/cc	Manganese oxide	0.8-1.5
6	Fineness Modulus	3.47		
7	Hardness, Mohr's scale	7		
8	Moisture Content	0.10%		
9	IS Classification	SP		

A. GGBS

The blast furnace slag is produced as a by-product during the manufacture of iron in a blast furnace. Molten blast furnace slag has a temperature of 1300-1600C and is chilled very rapidly to prevent crystallization. Ground-granulated impact furnace slag is gotten by extinguishing liquid iron slag from a shoot furnace in water or steam, to create a polished, granular item that is then dried and ground into a fine powder. The granulated material thus produced is known as granulated blast furnace slag. Blast furnace slag has a glassy, disordered, crystalline structure which can be seen by microscopic examination which is responsible for producing a cementing effect. Ground Granulated Blast Furnace Slag was gotten from Bhilai Steel Plant, situated at Durg district of Chhattisgarh. It is accessible at a pace of ₹200/- per ton.

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Soil used in experimental investigation was a locally available black cotton soil. The soil was classified as CH. Black cotton soil possesses great threat for the construction of the buildings due its less characteristics shear strength and high swelling characteristics. The structures on Black cotton soil (BC soil) bases develop undulations at the road surface due to loss of strength of the sub-grade through softening during monsoon. Due to its characteristics, it forms a very poor foundation material for road construction.

B. Coarse Aggregates

The coarse aggregate used were a mixture of two locally available crushed stone of 20 mm and 10 mm size in 70:30 proportion. Coarse aggregate of maximum size 20mm and minimum 10 mm is used throughout the concrete. The specific gravity of coarse aggregate is 3.09.

C. Fine Aggregates

Fine aggregate is used in this experimental study for concrete is river sand conforming to zone- II. The specific gravity of fine aggregates 2.65.

D. Water

Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalis, salts and sugar, organic substances that may be deleterious to concrete. As per IS 456- 2000 Potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly, potable tap water was used for the preparation of all concrete specimens.

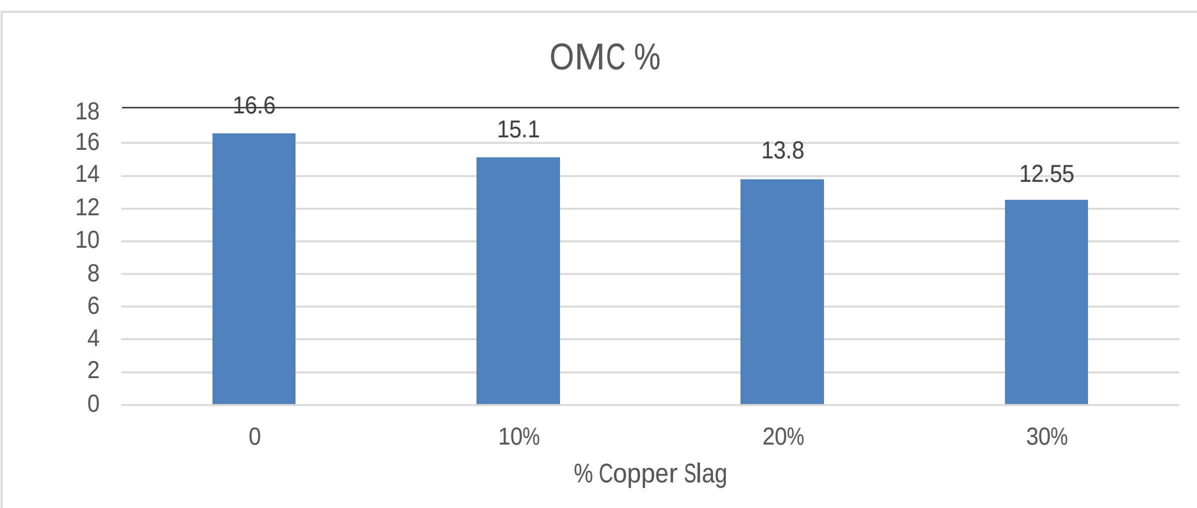
This study aims to make use of the waste material for replacing the cement and using in construction of roads. Therefore, mix design of M40 grade concrete was done by following the guidelines of IS: 465-2000 and IS 10262. With help of these codes the quantity of concrete required for 1 cubic meter can be estimated and at which water cement ratio concrete going to be mixed is also selected from these codes as shown in Fig.

Table: Quantities of materials for mix proportion

S.No.	Materials	Quantities
1.	Cement	350 kg/m^3
2.	Water	1140 kg/m^3
3.	Fine Aggregate	896 kg/m^3
4.	Coarse Aggregate	1140 kg/m^3
5.	Admixture	7 kg/m^3

IV. RESULTS

A. Optimum Moisture Content



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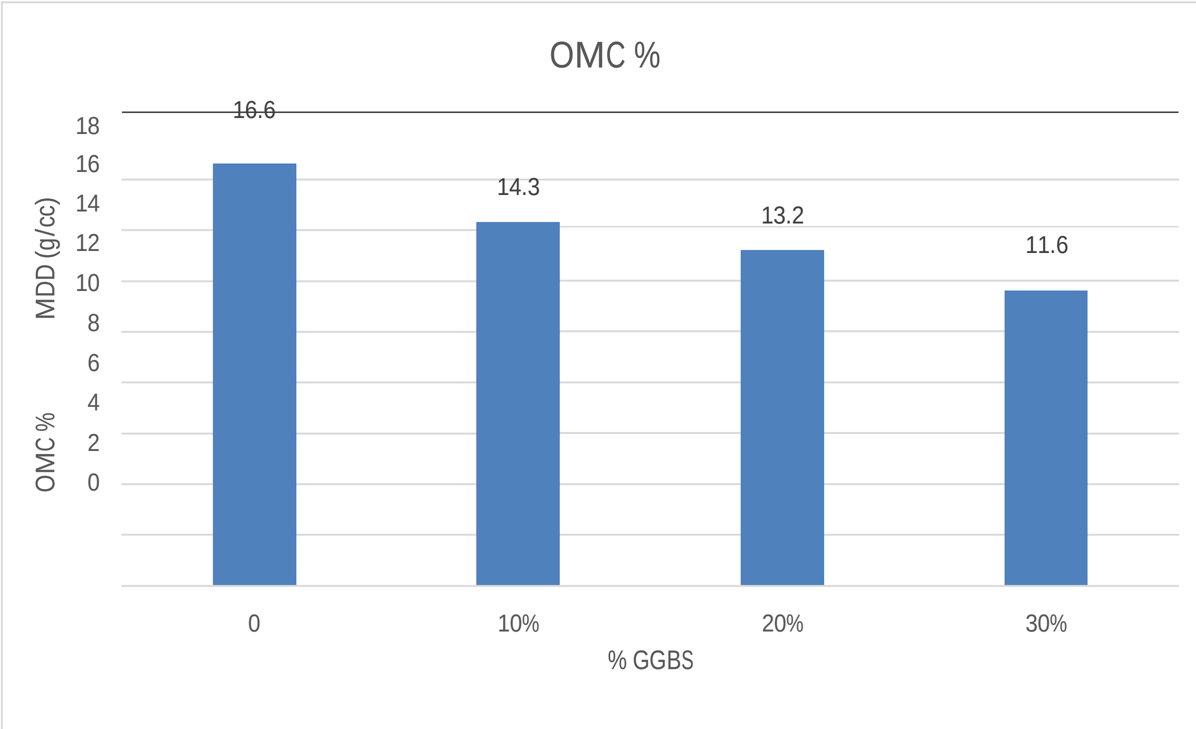
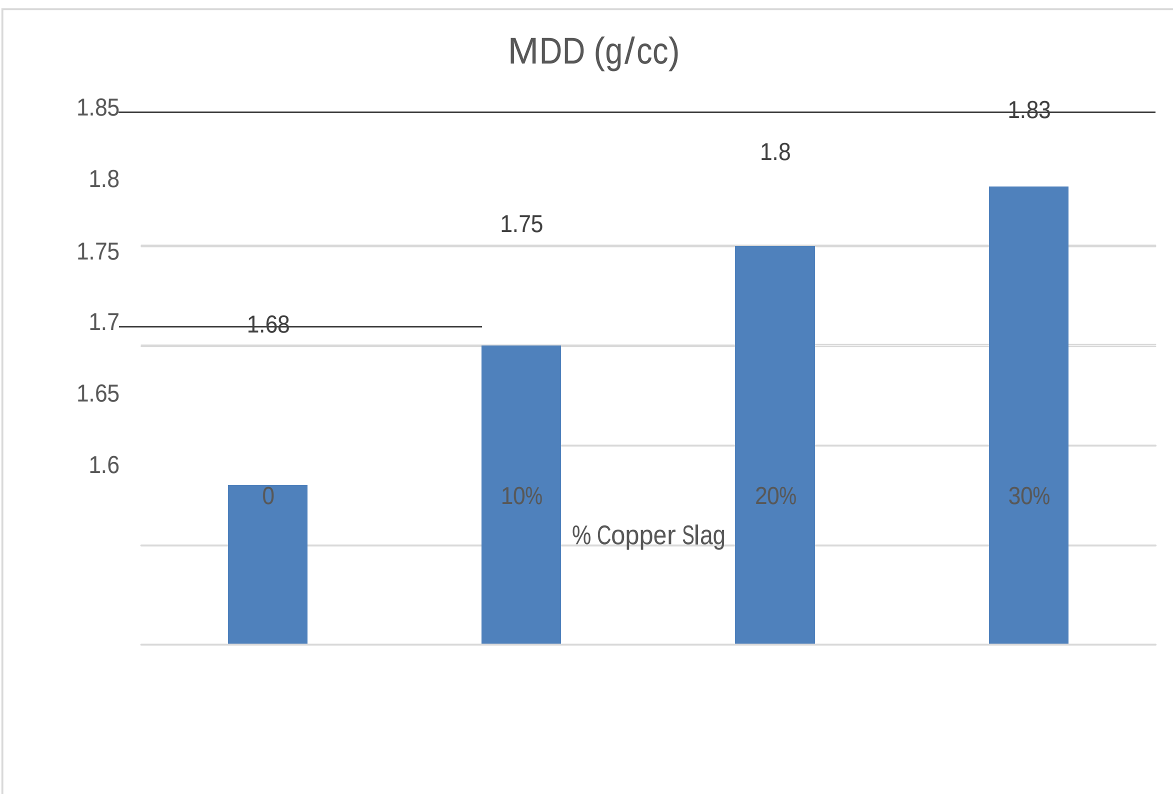


B. Maximum Dry Density



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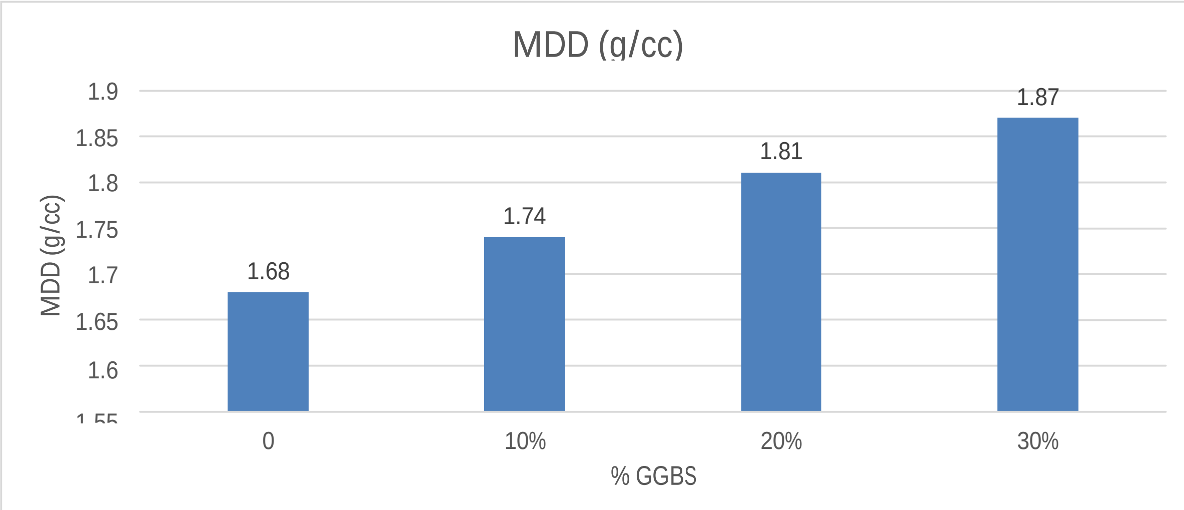
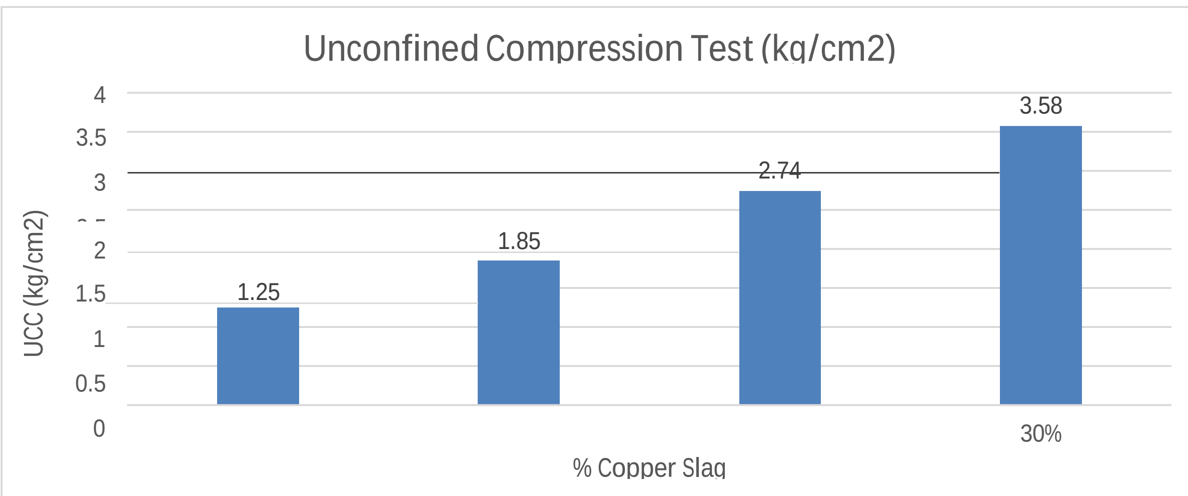
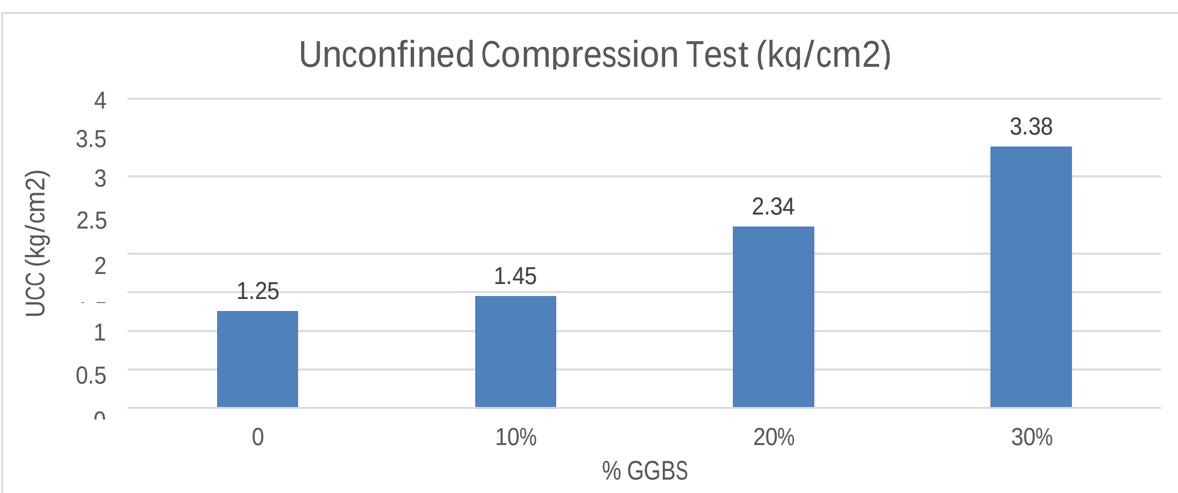
C. MDD different proportion of GGBS

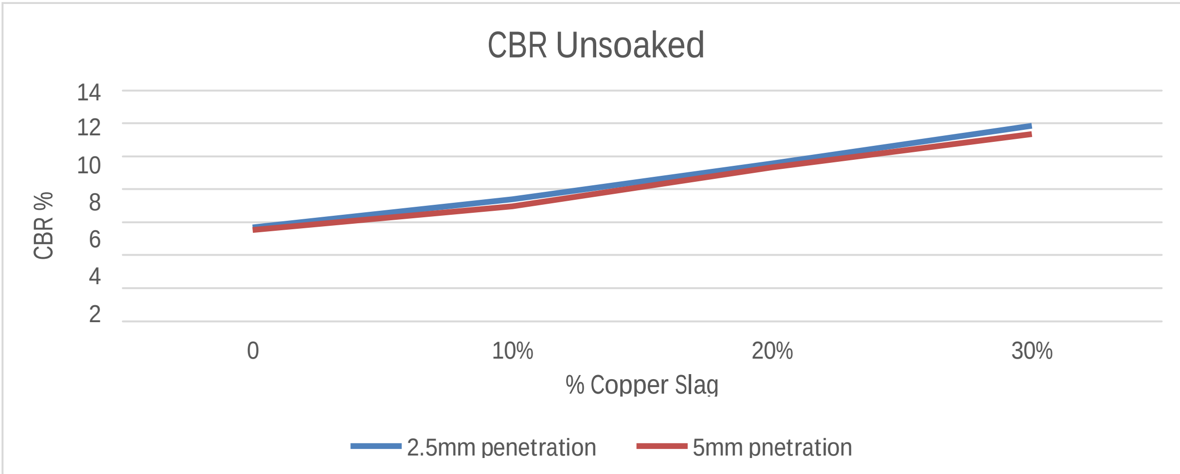


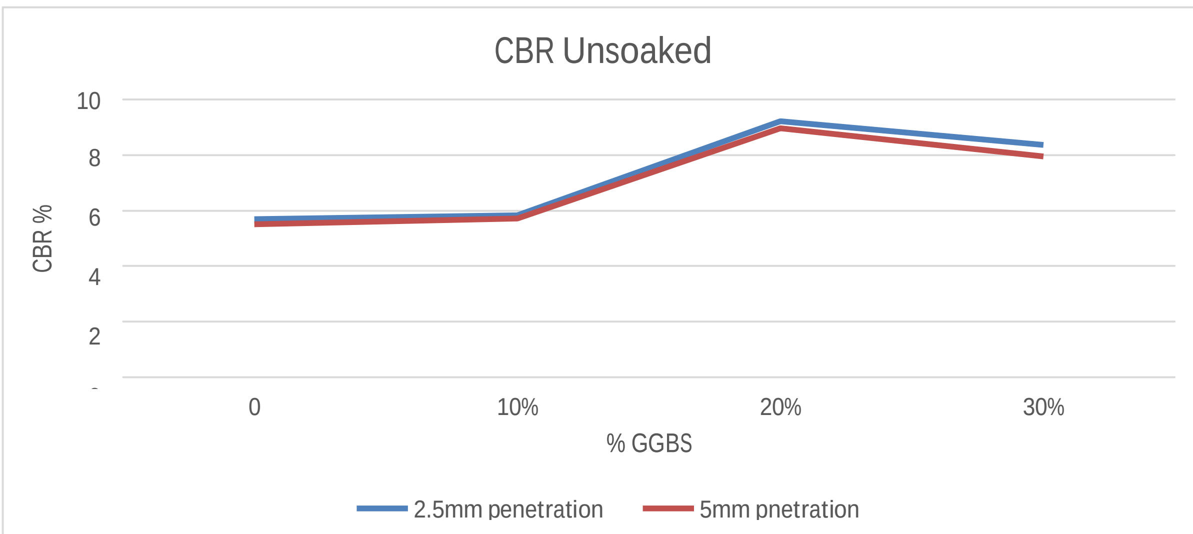
D. Unconfined Compression Test



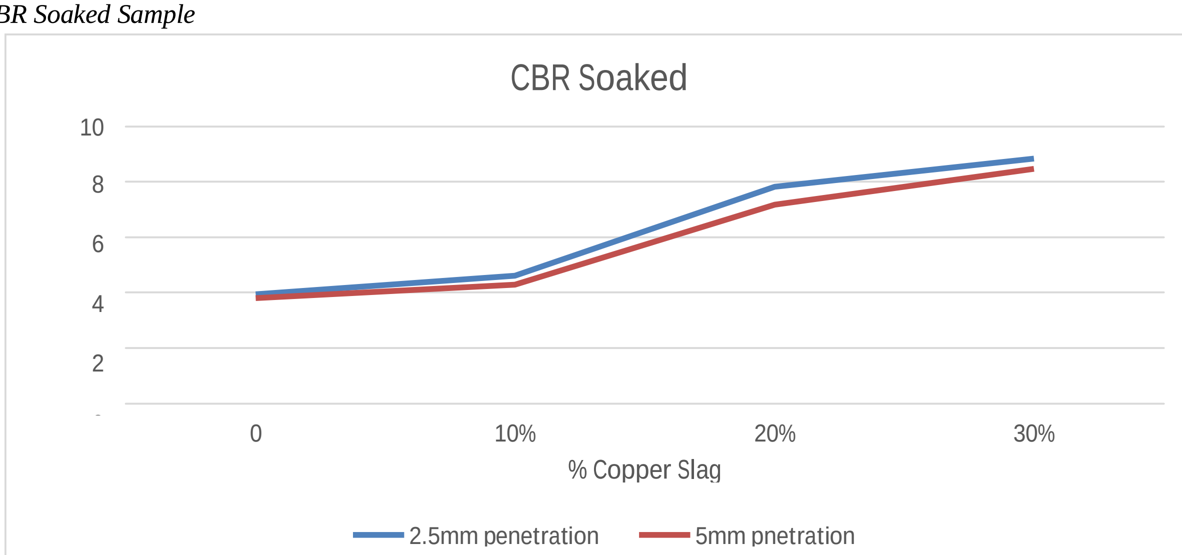


E. CBR Unsoaked Sample





F. CBR Soaked Sample



V. CONCLUSIONS

A. The UCC value of clay soil sample with Copper Slag of 30% has attended high strength when compared to other two proportions.
B. The CBR soaked of sample with copper slag of 20 % showed good results when compared to all other proportions.
C. The CBR unsoaked of sample with copper slag of 30 % showed good results when compared to all other proportions.
D. The Atterberg Limit of Clayey soil by using GGBS as a stabilizer with mix proportion of 10 % showed good results than 20% and 30 %.
E. The soil with GGBS of 30% showed less moisture content and high dry density.
F. The UCC with GGBS with 30% have attended high compression strength.
G. The CBR with GGBS of 20% showed good result than other two mix percentage

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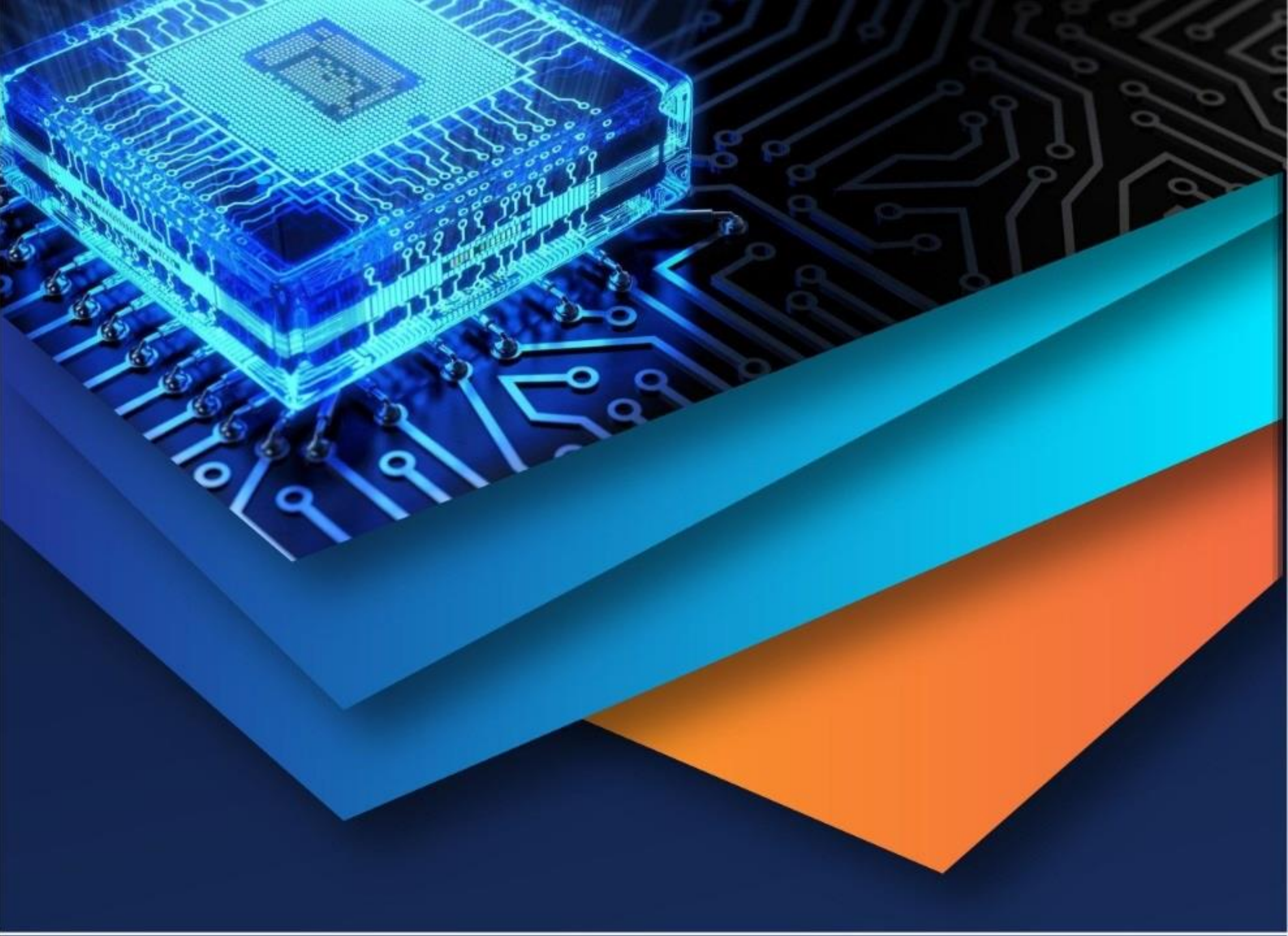

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