A Study on the Influence of Chemical Stabilizers on Geotechnical Properties of Laterite Soil

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Abstract: **The recent development and application in the use of advanced composites for the improvement of soil properties are increasing on the basis of specific requirements and national needs. In the present scenario, there is lack of stable soil for the construction of the buildings. The construction of the building using unstable soil is a risk factor and it has become one of the biggest challenges to overcome those unstable ground soils. The need of efficient soil stabilization and soil strengthening techniques have resulted in research using alternatives for soil stabilization, particularly for the black cotton soils which has high swelling and shrinkage tendencies. Similarly, Laterite & Alluvial soil are associated with issues like high compressibility, variable composition, water retention, erosion & instability etc., & hence they demand great deal of attention for stabilization. Varieties of materials are used for improving the properties of soil ranging from wood-ash, acrylic resins, many fibre polymers, lime etc. As a further step towards an innovative approach for soil stabilization, this study focuses on the use of waste materials like copper slag & fly ash for the improvement of soil properties. As a first consideration, both Laterite & Alluvial soils are stabilized with copper slag of 10, 15 & 20% by the weight of soil. For the second consideration, fly-ash is selected as a stabilizing agent at 10, 15 & 20% by the weight of soil & In the last consideration, samples of both the soil are stabilized with 10%, 15% & 20% of both the stabilizing agents. Specific gravity, Liquid limit, plastic limit, OMC, MDD, CBR & UCS for both alluvial & laterite soils are tested & cross verified with the parent soil.**

***Key words*: Soil, Stabilization, Alluvial soil, Laterite soil, instability, copper slag, flyash.**

1. INTRODUCTION

Soil is one of the most commonly used material in civil engineering. All the structures except few, which are founded on solid rock, eventually rests on soil. Geotechnical engineers all over the world face huge issues, when structures founded on the soil which is expansive in nature [1]. Soil stabilization is a critical aspect of civil engineering and construction, aimed at enhancing the properties of soil to meet specific engineering requirements [2]. It is a technique employed to improve the load-bearing capacity, reduce settlement, and mitigate undesirable soil behaviour [2]. In current years, the use of industrial waste by-products as agents for soil stabilization has gained appreciable attention, as it not only lodges direction to environmental issues but also presents a productive, worthwhile and sustainable solution [2]. This study explores the potential use of copper slag and flyash as additives for soil stabilization. Flyash is the coal combustion residue generated from coal based thermal power plant. Flyash can be utilized as resources materials in number of engineering applications. Flyash is also referred as pulverised fuel ash. It has little Cementitious property compared to that of lime and cement [3]. Copper slag is a by-product of the copper smelting process, and its vast quantities generated worldwide pose environmental challenges due to improper disposal [2]. However, researchers and engineers have discovered that copper slag can be utilized as a valuable resource in soil stabilization due to its pozzolanic properties, which enhances the binding strength of the soil when combined with flyash. The combination of copper slag and flyash presents a unique opportunity for achieving effective soil stabilization, as both materials complement each other's strengths. The judgements of this research could lead to a more sustainable approach for stabilization of soil, thereby lessening the reliance on conventional stabilizing agents and encouraging the responsible use of industrial waste materials. In conclusion, the combination of copper slag and flyash as additives for soil stabilization holds great promise for the construction industry and environmental sustainability. By harnessing the commensal effects of these materials, engineers can ameliorate soil properties and can bring down the environmental burden associated with disposal of industrial wastes. The following modules will delve into the experimental methodologies, results, and conclusions extracted from this study, shedding light on the probable benefits and practical implications of this innovative soil stabilization technique.

2. MATERIALS USED

2.1 Laterite Soil: Laterite is a soil and rock type rich in iron and aluminium and is commonly considered to have formed in hot and wet tropical areas. Nearly all laterites are of rusty-red coloration, because of high iron oxide content. They develop by intensive and long-lasting weathering of the underlying parent rock.

2.2 Alluvial Soil: Alluvial soil is defined as a soil that is formed by the deposition of sediments carried by rivers, characterized by properties influenced by the parent material & development over time, with recent alluvial soils being highly stratified and containing organic carbon at depth, while older alluvial soils are more stable & develop regular distribution of organic carbon with increasing depth. Both alluvial & laterite soil samples were collected from the local surroundings. It was extracted from a depth of 1.5m below the ground level to avoid the top soil, organic matter & non-representative aggregates. The initial properties of both the soils were investigated & presented in table 1.

2.3 Copper Slag: Copper Slag is a by-product developed during the copper smelting process. Copper slag can be used for a number of applications in various fields [1]. Copper slag, which is produced during production of copper from copper ore encompasses minerals like iron (Fe), alumina, calcium oxide, silica, etc. For every tone of metal production about 2.2 tone of slag is generated. Total generation of copper slag is about 24.6 million tonnes throughout the world [5]. 25kgs of copper slag for this experimental work was procured from Sterlite industries Ltd (SIL), Tuticorin, Tamil-nadu.

2.4 Fly ash: Large quantities of coal are being burnt in thermal power stations to meet the ever-increasing demand for thermal power [4]. Combustion of coal results in a remnant consisting of inorganic mineral constituents and organic matter which is not completely burned. The inorganic mineral constituents from the residue contains about 80% of the ash which is considered as fly ash. Fly ash is a by-product of such thermal power plants which uses coal as fuel. A waste material extracted from the gases emanating from coal fired furnaces, generally of a thermal power plant, is called fly ash [4]. This fly ash was believed to be one of the best pozzolanic (binding agent) used in and around the globe. The command for power supply has exponentially intensified these days due to increased urbanization and industrialization actions. 25kgs of flyash for this experimental work was procured from local brick manufacturing industry close to the college campus.

3. METHODOLOGY

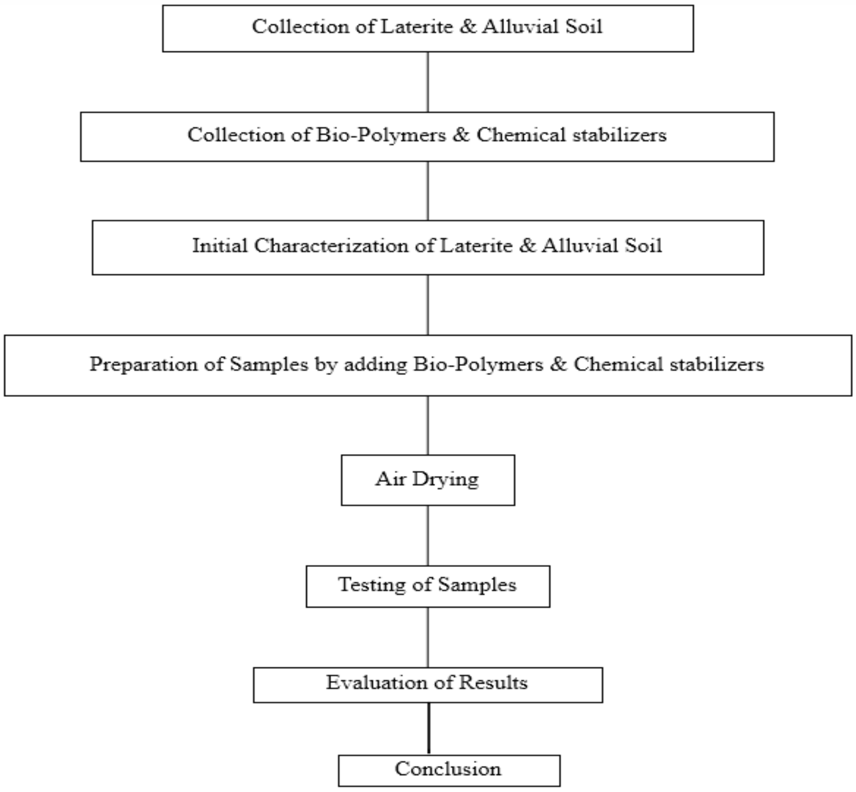

Fig 01 Sequences of operations followed for experimentation

4. RESULTS & DISCUSSIONS

4.1 Initial test results

Table 1 – Initial test results for Soil

Sl.no	Properties	Alluvial Soil	Laterite soil
1	Specific gravity	2.11	2
2	Liquid limit %	12	16
3	Compaction test MDD in g/cc OMC in %	MDD – 1.99 OMC – 10.3	MDD – 1.785 OMC – 10.34
4	CBR	10.41	8.99
5	UCS in Kg/cm2	1.25	1.06

4.2 Results for fly ash as a stabilizer

Table 2 – Test results on variation in % of Fly ash

Fly ash				
Sl.no	Properties	10%	15%	20%
1	Specific gravity	2.14	1.82	1.5
2	Liquid limit %	37.5%	46%	52%
3	Compaction test MDD in g/cc OMC in %	MDD - 1.53 OMC - 25	MDD - 1.52 OMC - 30	MDD - 1.63 OMC - 9.37
4	CBR	6.85%	7.42%	9.14%
5	UCS in Kg/cm2	0.12	0.14	0.13

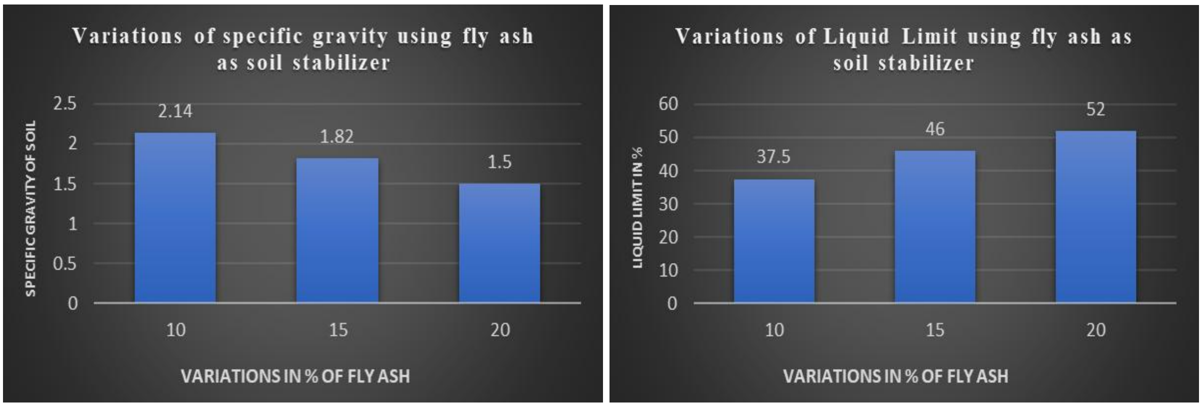

Fig 02 – Graphical results for variation in % of Fly ash for Specific gravity & Liquid limit

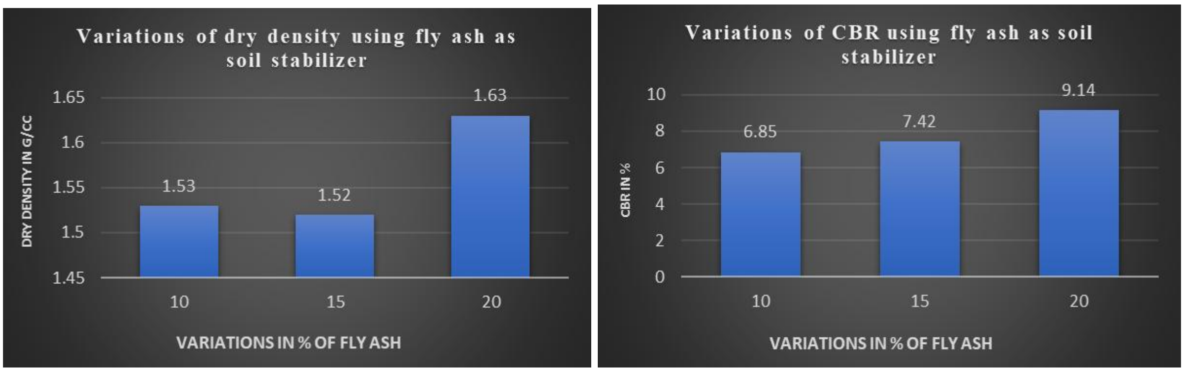

Fig 03 – Graphical results for variation in % of Fly ash for MDD & CBR

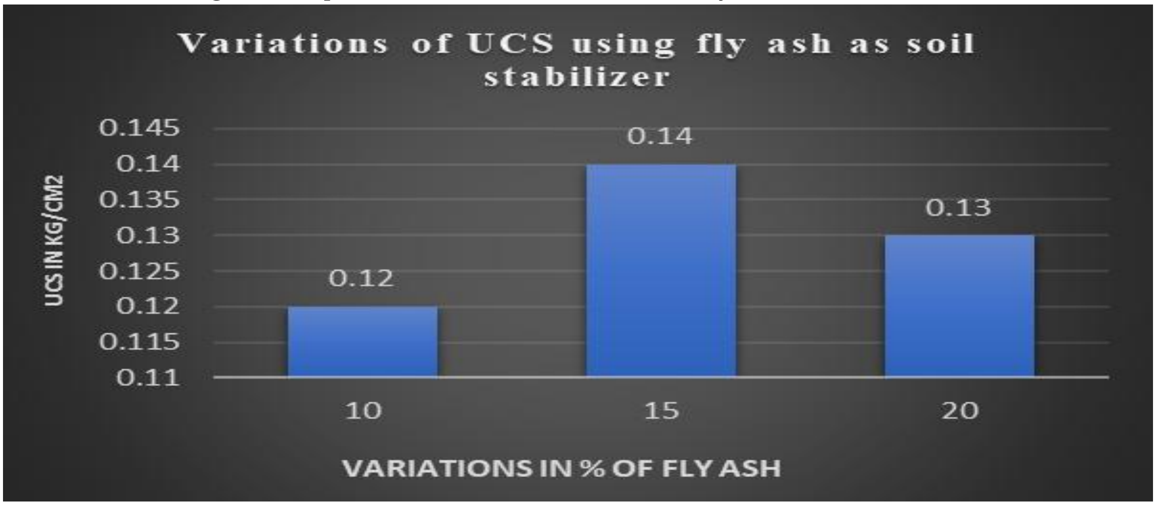

Fig 04 – Graphical results for variation in % of Fly ash for UCS

4.2 Results for Copper Slag as a stabilizer

Table 3 – Test results on variation in % of Copper Slag

Copper Slag				
Sl.no	Properties	10%	15%	20%
1	Specific gravity	2.4	2.27	2.2
2	Liquid limit %	45	41	28
3	Compaction test MDD in g/cc OMC in %	MDD – 1.67 OMC - 20	MDD – 1.78 OMC – 7.69	MDD – 1.90 OMC – 5.55
4	CBR	6.85	10.83	11.85

5	UCS in Kg/cm2	0.15	0.147	0.158

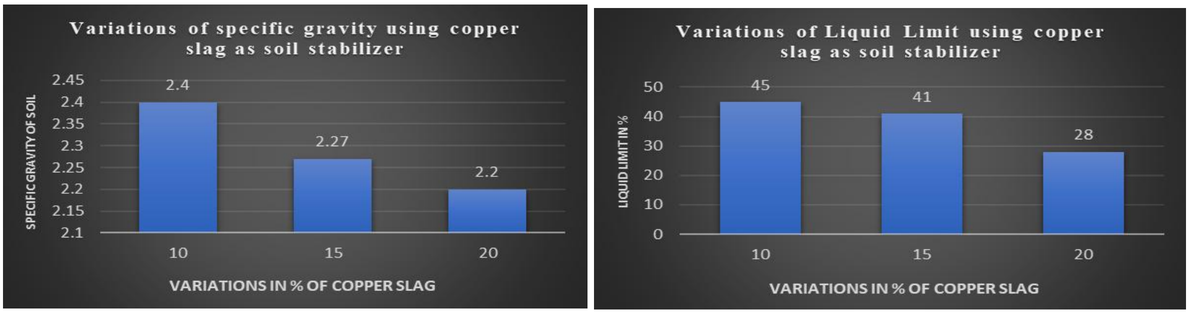

Fig 05 – Graphical results for variation in % of Copper Slag for Specific gravity & Liquid limit

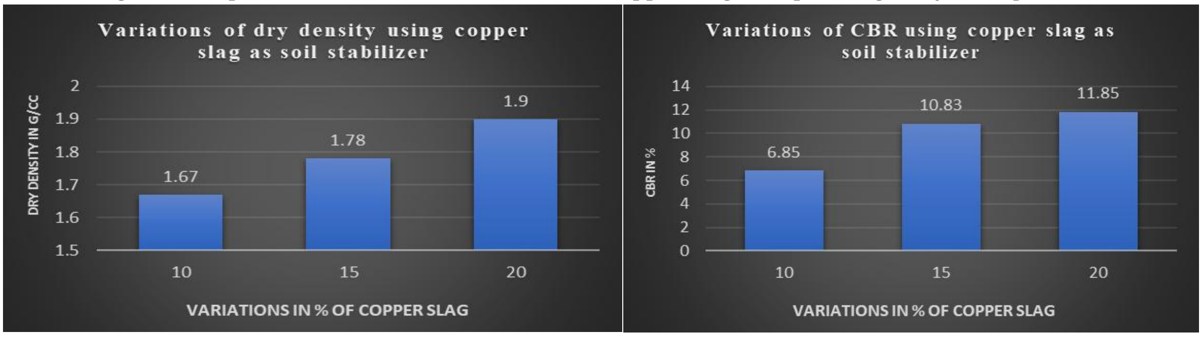

Fig 06 – Graphical results for variation in % of Copper Slag for MDD & CBR

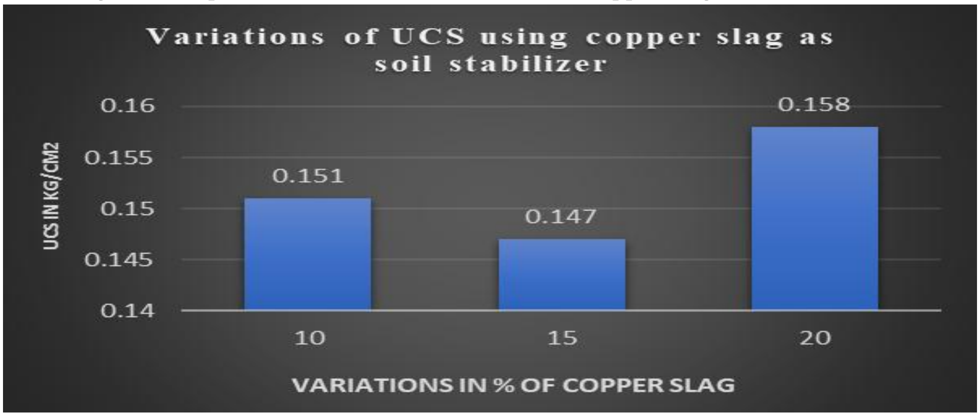

Fig 07 – Graphical results for variation in % of Copper Slag for UCS

4.2 Results for Copper Slag + Fly ash as a stabilizers

Table 4 – Test results on variation in % of Fly ash + Copper lag

Fly ash + Copper Slag				
Sl.no	Properties	10%	15%	20%
1	Specific gravity	2.14	2.16	2.55
2	Liquid limit %	32	70	63
3	Compaction test MDD in g/cc OMC in %	MDD – 1.72 OMC – 14.28	MDD – 1.65 OMC – 16.66	MDD – 1.64 OMC – 15.78
4	CBR	8.14	16.71	9.42
5	UCS in Kg/cm2	0.095	0.129	0.122

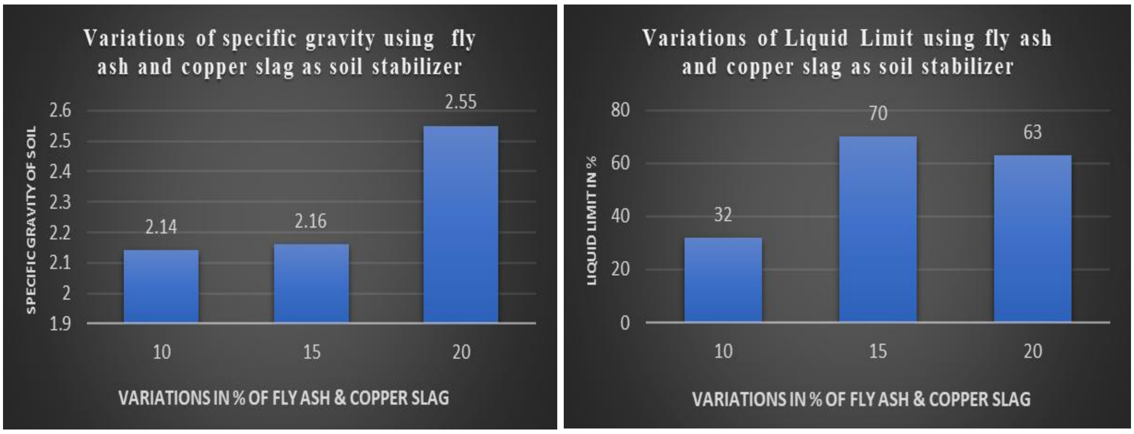

Fig 08 – Graphical results for variation in % of Fly ash + Copper Slag for Specific gravity & Liquid limit

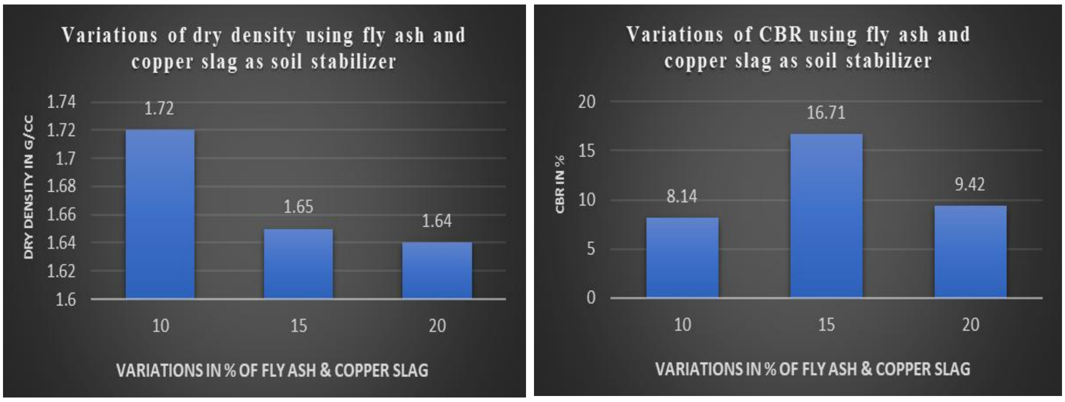

Fig 09 – Graphical results for variation in % of Fly ash + Copper Slag for MDD & CBR

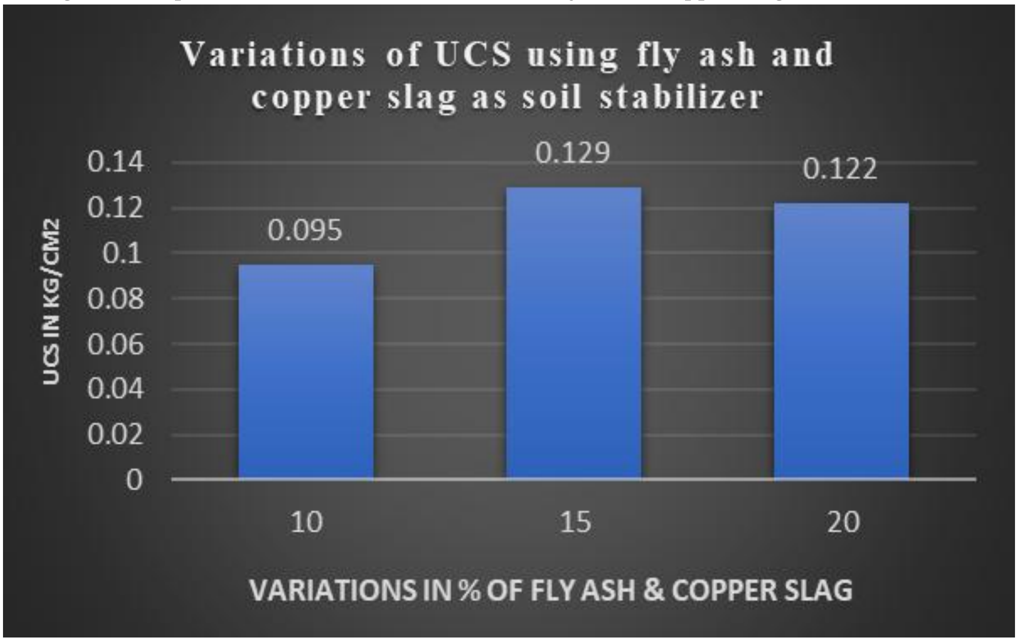

Fig 10 – Graphical results for variation in % of Fly ash +Copper Slag for UCS

CONCLUSION

- Significant improvement in soil stabilization has been observed through the use chemical stabilizers like fly ash & copper slag because of their exceptional bonding properties.
- The results indicate the maximum modification of the geotechnical properties can be observed at 20% of addition of copper slag.
- Copper slag performed 70% more better when compared to flyash. Hence it can be considered as the best stabilizer as per our research.

- After the addition of chemical stabilizers to Laterite soil, it was seen that, the addition of Copper slag of about 20% can significantly increase the MDD, but the addition of fly ash alone or combined fly ash and copper slag decreases the strength parameters. Hence it can be concluded that addition of 20% of copper slag is found to be efficient.

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