



# A Study On The Effect Of Copper Slag On Geotechnical Properties Of Clay

<sup>[1]</sup> Arya S.P, <sup>[2]</sup> Aswathy Sasikumar

<sup>[1]</sup> PG Student, Civil Department, Marian Engineering College, TVM, Kerala, India.

<sup>[2]</sup> Assistant Professor, Civil Department, Marian Engineering College, TVM, Kerala, India.

*Abstract: Million tons of waste materials are produced annually in India and their disposal has become a major environmental concern. The copper slag is a byproduct of copper ore during matte smelting and converting. Various techniques are available like soil stabilization, providing reinforcement etc. to improve load bearing capacity of soil. Soil stabilization is one of the modification techniques used to improve the geotechnical properties of soil and has become the major practice in construction engineering which enables the effective utilization of industrial wastes as a stabilizer. This paper investigates the improvement in the properties of clayey soil stabilized with copper slag. The results shown that, the strength properties of both soils improved with increase in percentages of copper slag. In this way industrial waste can be reduced economically.*

*Keywords: Copper slag, Soil Stabilization, UCS.*

## I. INTRODUCTION

The purpose of the study is to find a solution for the disposal issues of industrial waste materials like copper slag by reusing it in geotechnical applications. Soil stabilization may be defined as the alteration or preservation of one or more soil properties to improve the engineering characteristics and performance of a soil. Soil is one of the most commonly encountered materials in civil engineering. All the structures except some, which are founded on solid rock, rest ultimately on soil. Geotechnical engineers all over the world face huge issues, when structures founded on the soil which is expansive in nature. This expansiveness is imparted to such soils when they contain clay minerals like montmorillonite, illite, kaolinite etc. In considerable amount. Due to the clay minerals, the swelling soils expand on wetting and subjected to shrinkage on drying. These soils are commonly unsaturated.

Copper is one of the basic chemical elements which are a soft and ductile metal, known for its high thermal and electrical conductivity and has a reddish-orange surface in its pure state. It is commonly used in electrical, construction and transportation industries. Pure copper is rarely found in nature, but is usually combined with other chemicals in the form of copper ores. The process of extracting copper from copper ore varies according to the type of ore and the desired purity of the final product. Each process consists of several steps in which unwanted materials are physically or chemically removed, and the concentration of copper is progressively increased.

Once the waste materials have been physically removed from the ore, the remaining copper concentrate must undergo several chemical reactions to remove the iron and sulphur. This process is called smelting. The recovery of sulphuric acid from the copper smelting process not only provides a profitable byproduct, but also significantly reduces the air pollution caused by the furnace exhaust. Copper slag (cs) is a waste product which comes out from the smelting process. (lavanya et al., 2011). Copper slag can be recommended as an effective stabilizing agent for the improvement of soils for highway embankments. The use of copper slag as a stabilizing agent can be economically attractive in regions near the slag source areas. Utilization of copper slag in this manner also has the advantage of reusing an industrial waste by-product without adversely affecting the environment or potential land use.

## II. Materials

Clay soils are highly susceptible to environmental changes. Therefore they are selected for most of the studies. The basic properties of the samples obtained through experimental investigations are presented in subsequent section.

### 2.3 Kaolinite

Kaolinite is a clay mineral with the chemical composition  $al_2si_2o_5(oh)_4$ . For the purpose of the study commercially available kaolinite clay was collected from english indian clay limited, trivandrum. The properties of kaolinite are given in table i.

table 1. Initial properties of kaolinite

Soil properties	Value
Specific gravity	2.6
Liquid limit (%)	33
Plastic limit (%)	21
Shrinkage limit (%)	11
Plasticity index (%)	12
Is classification	Cl
Omc (%)	24.6
Mdd(g/cc)	1.65
Percentage of clay	60
Percentage of silt	36
Percentage of sand	4
Ucs(kg/cm <sup>2</sup> )	0.48
Cbr (%)	4.62

### 2.4 Copper Slag

Copper slag is a blackish granular material similar to coarse sand. The specific gravity of copper slag was found to be 3.22. Normally, the specific gravity of copper slag ranges between 2.8 and 3.8. The values for normal sands range between 2.6 and 2.7. The high specific gravity of copper slag material compared with that of sand is due to the presence of a high content of iron oxide. There was no loss on ignition (havanagi et al., 2017). Copper slag was collected from thoothukudi. The properties of copper slag are presented in table ii.

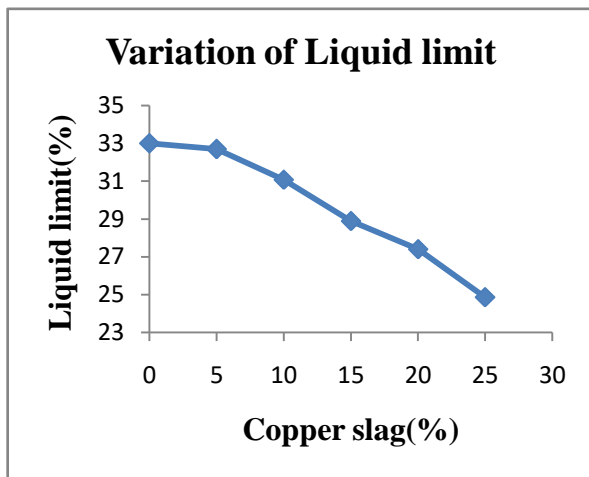
Table 2. Physical properties of copper slag

Properties	Value
Specific gravity	3.8
Plasticity index	Non plastic
Granular shape	Angular, sharp edges
Gravel (%)	1.5
Sand (%)	98.4
Silt + clay	0.1
Color	Black
Angle of internal friction(degree)	45

## III. Results And Discussion

### 3.1 Effect Of Copper Slag On The Liquid Limit Of Clays

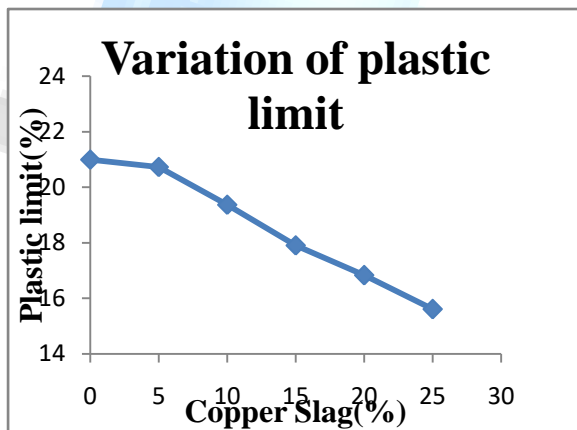
Effect of copper slag on the liquid limit was studied on cl clay by varying percentages. The results obtained are presented in Fig.1.



**Fig. 1.** Variation of liquid limit with various percentages of Copper slag in Clay

### 3.2 Effect of Copper Slag on the Plastic Limit of Clays

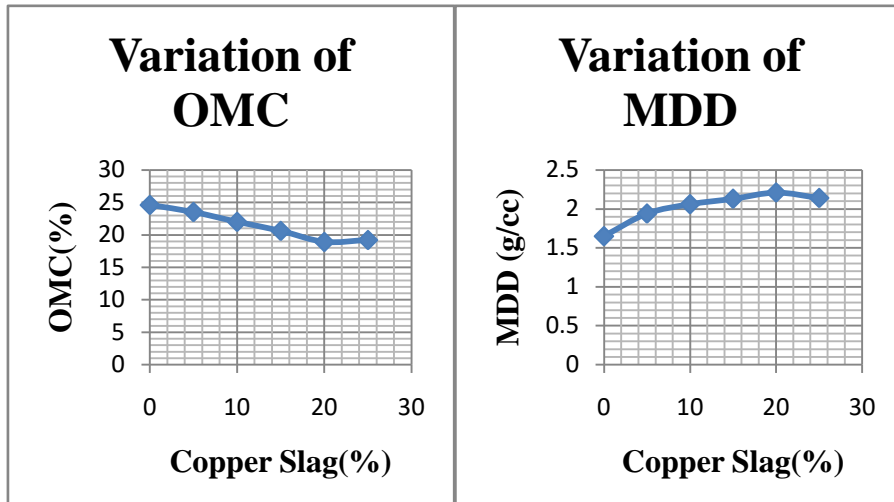
Effect of copper slag on the plastic limit was studied on CL clay by varying percentages. The results obtained are presented in Fig. 2.



**Fig. 2.** Variation of plastic limit with various percentages of Copper slag in Clay

### 3.3 Effect of Copper Slag on the Compaction Characteristics of Clays

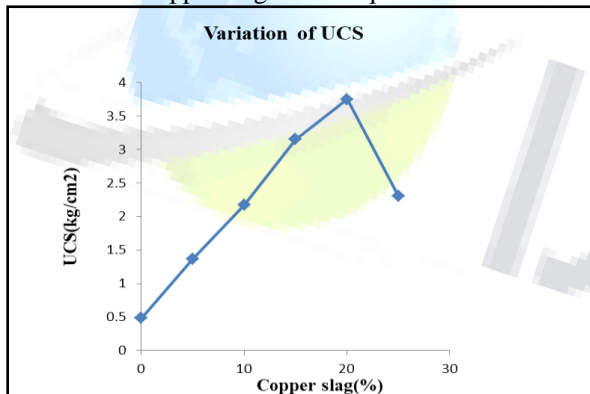
Effect of copper slag on the compaction characteristics of clay was studied at different percentages i.e., 5%, 10%, 15%, 20% and 25% and the results are



**Fig. 3.** Variation of OMC and MDD with various percentages of Copper slag in Clay

### 3.4 Effect of Copper Slag on the Unconfined Compression Strength of Clay

Effect of copper slag on the liquid limit was studied on CL clay by varying percentages. The results obtained are presented in.



**Fig.4.** Variation of UCS with various percentages of Copper slag in Clay

## IV. Conclusion

A study was conducted to analyse the effect of copper slag on clay. The conclusions derived from the study are:

1. The geotechnical properties of copper slag is similar to that of sand and hence when added to fine grained soils, stabilizes them by improving the grading of soil.
2. Copper slag when added in its optimum proportion (which was found to be 25% for this soil) to weak soil, improved its workability, strength and at the same time made the mix more porous.

## References

1. C. LavanyaA, Sreerama Rao,N. Darga Kumar-" A Review on Utilization of copper slag in geotechnical applications" Proceedings of Indian Geotechnical Conference December 15-17,2011, Kochi ,Paper No.H-212..
2. Das. BM, Tarquin AJ Jones, AD, Geotechnical properties of a Copper slag, Transportation Research Record, 941, 1993, DC.

3. Use of waste materials and by-products in Road Construction (1997), Organisation for Economic Cooperation and Development (OECD), pp.68-69.
4. Vasant G. Havanagi, Sudhir Mathur, P.S.Prasad, C. Kamaraj, Feasibility of Copper slag – fly ash - soil mix as a Road construction material, CRRI, Delhi.
5. Venkata Suresh (2016), A Study on the Effect of Copper Slag and Lime Treated Clay, International Conference on Engineering Innovations and solution, E-ISSN :2348 – 8352

