Analyzing the Mechanical Properties of Ferrocement with Partial Substitution of Fine Aggregate by Copper Slag

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***Abstract*-Ferrocement, a versatile composite material comprising a cement-based mortar matrix reinforced with mesh or metal elements, stands out for its exceptional mechanical properties and varied applications in construction. This study delves into exploring the mechanical behavior of ferrocement, focusing specifically on partially replacing its fine aggregate with copper slag, eliminating the conventional metal mesh reinforcement. The primary objective is to assess the impact of incorporating copper slag, an industrial by-product, on the mechanical characteristics of ferrocement.**

In this research, using optimum percentage of 40 % copper slag replace the fine aggregate in the ferrocement mix. The study meticulously examines the impact of this substitution on crucial mechanical property Modulus of Elasticity. Experimental procedures involve preparing ferrocement samples with diverse copper slag optimum replacement, followed by standardized curing processes and rigorous mechanical testing adhering to recognized standards.

The findings sought aim to offer insights into the feasibility of utilizing copper slag as a partial replacement for fine aggregate in ferrocement without relying on a metal mesh for reinforcement. Beyond understanding the mechanical implications, this research aims to evaluate the potential sustainable implications of this alteration in construction practices. Ultimately, the outcomes of this study aspire to provide valuable knowledge for engineers, researchers, and construction professionals, offering innovative and environmentally friendly alternatives in the domain of construction materials.

Keywords: Ferrocement, copper slag, mechanical properties

1. INTRODUCTION

Ferrocement, a composite material composed of a cement-based mortar matrix reinforced with metal mesh, showcases remarkable versatility and strength across various applications in building construction. Its unique properties make it an optimal choice for diverse structural elements and foundation solutions. Copper slag has angular particles with rough surfaces. These characteristics contribute to improved bonding between the cement matrix and the reinforcement, enhancing the overall strength and durability of the ferrocement.When used as a partial replacement for fine aggregate in ferrocement, copper slag can enhance the compressive and flexural strength of the material. The slag's properties can also improve resistance to corrosion and abrasion, making it suitable for various construction applications, especially in environments prone to harsh conditions. Utilizing copper slag as a substitute for fine aggregate in ferrocement can offer economic advantages by reducing the reliance on natural resources and minimizing waste disposal. It contributes to sustainable construction practices by reusing a by-product that might otherwise be discarded. The use of copper slag in ferrocement may contribute to improved impermeability, reducing water penetration and increasing resistance to chloride ion ingress, which is beneficial in enhancing the material's durability, especially in marine or aggressive environments.

2. OBJECTIVES

- To investigate the mechanical properties of the cement mortar by replacing M-sand with the copper slag.
- The results of these tests were compared with that of the normal mortar mixture.
- To investigate the inclusion of Copperslag in Ferrocement based on mechanical properties.

3. MATERIALS USED

CEMENT

OPC 53 grade cement is used.

Characteristics	Values
Specific Gravity	3.16
Consistency	29%
Initial Setting Time	45mins
Final Setting Time	610mins
Fineness	9% Residue

FINE AGGREGATE

Characteristics	Values
Specific Gravity	2.507
Fineness Modulus	2.44
Water Absorption	1.5%
Bulk Density	1632.9kg/M3
Grading Zone	Ii

WATER

The quality of water used is potable water standard which is available is the laboratory for mixing and curing which is used for reinforced concrete structures

COPPER SLAG

Characteristics	Values
Fineness Modulus	2.99
Specificgravity	3.36
Bulk Density	1.782 G/Cc
Water Absorption	0.682
Grading Of Aggregate	Zone II

4. MIX PROPORTION

Mix ratio=1:2

1 part –cement 2parts -M-sand & M-sand is partially replaced with copper slag 40% .W/C=0.41

5. EXPERIMENTAL INVESTIGATION

5.1 MODULUS OF ELASTICITY OF FERRO-COPPER SLAG

The Cylinder of 150 X 300 is cast and cured for 28 days, and then the cylinder is tested in a Computerized Universal testing machine. The Compressometer is fixed to the specimen, and the Gauge length is found. The Load range is selected in the UTM, and the initial correction is done in the dail. The Machine was started, and the load was applied evenly to the specimen. The compressometer reading is noted for every increase of load. Using this observation, strain and strain values are found. From the Stress and Strain values, the modulus of elasticity is found out to be 27842.25 N/mm^2.

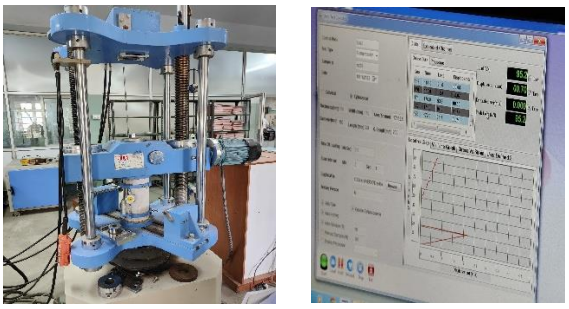

Fig 5.1 - Computerized UTM for Ferro-copper slag

Table 5.1 – Modulus of elasticity of Ferro-copper slag

Stress N/mm^2	Strain	Modulus of elasticity of cement mortar N/mm^2	Average Modulus of Elasticity of cement mortar N/mm^2
4.456462	0.00016	27852.88	
4.44968	0.00016	27810.5	27842.25
4.458942	0.00016	27868.38	

5.2 MODULUS OF ELASTICITY OF FERROCEMENT

The Cylinder of 150 X 300 is cast and cured for 28 days, and then the cylinder is tested in a Computerized Universal testing machine. The Compressometer is fixed to the specimen, and the Gauge length is found.The Load range is selected in the UTM, and the initial correction is done in the dil. The Machine was started, and the load was applied evenly to the specimen. The compressometer reading is noted for every increase of load. Using this observation, strain and strain values are found. From the Stress and Strain values, the modulus of elasticity is found out to be 23715.17 N/mm^2.

TABLE 4.2 - MODULUS OF ELASTICITY OF FERROCEMNT

Stress N/mm^2	Strain	Modulus of elasticity of cement mortar N/mm^2	Average Modulus of Elasticity of cement mortar N/mm^2
10.25383	0.00043	23846.11	
10.27646	0.00043	23898.74	23714.9
10.2991	0.00043	23951.39	

6. RESULTS AND DISCUSSIONS

1. The average modulus of elasticity of ferrocement is 23,714.9 N/mm², while the average modulus of elasticity of the specimen with 40% copperslag replacement is 27,842 N/mm². This indicates a more than 17.40% improvement in the modulus of elasticity of ferrocement when 40% copper slag is substituted compared to the traditional mixture
2. The findings suggest that the 40% replacement contributes to a well-balanced solution, optimizing the mechanical performance of ferrocement.
3. The replacement of fine aggregate with copper slag in ferrocement revealed that a 40% replacement level offers a significant enhancement in various mechanical characteristics.

7. CONCLUSION

In conclusion, traditional ferrocement has an average modulus of elasticity of 23,714.9 N/mm². When 40% of the fine aggregate is replaced with copper slag, this value increases to 27,842 N/mm², demonstrating an improvement of more than 17.40% over conventional ferrocement.

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