Utilization of Copper Slag Jhamma Bricks in High Strength Concrete

SALEEM SHAIK[1], RG NAUMAN KHAN[2]

[1]*Student of M.E, Structural Engineering in Lords Institute of Engineering and Technology Hyderabad India*

[2]*Assistant Professor of Civil Engineering at Lords Institute of Engineering and Technology, Hyderabad, India.*

***Abstract*—An experimental investigation was conducted stating the utilization of Copper Slag as Fine Aggregate as replacement of Cement and Jhamma Bricks as Coarse Aggregate. Concrete isa very useful material and nowadays it is not only used for building construction but also used in construction of roads, dams, bridges and also many other important structures. Copper Slag is a by – product of copper extraction by Smelting. Smelting is a process of extraction of metal from its ore. During Smelting, impurities become Slag which floats onthe molten metal. Slag that is quenched in water produces annular granules which is disposed of waste. Copper Slag is used as a building material, formed into blocks. Flue Ash, also known as Pulverized Fuel Ash is a Coal combustion product that is composed of particulates (fine particles of the burned fuel) that are driven out of the coal – fired of boilers together with the gases. Fly Ash use in concrete improves the workability of the Plastic Concrete, Strength and Durability of the hardened Concrete. Jhamma Brick pieces are the over burned bricks pieces which are used as Coarse Aggregate in Concrete. Further they are used in concrete by replacing the regular Concrete materials and tests are conducted to check their performance with respect to the general Concrete materials. Strength**

***Index Terms*—Copper Slag, Durability, Hardened Concrete, Jhamma Bricks, Plastic Concrete, Pulverized Fuel, Smelting.**

I. INTRODUCTION

Concrete is a strong and moldable construction material made from cement, sand, aggregates, and water. The cement and water form a paste that binds the sand and aggregates together. Due to growing environmental concerns like global warming and resource scarcity, there is a need for sustainable construction practices. Recycling materials in concrete is one such eco-friendly approach. As natural aggregates are becoming scarce, alternative materials are in high demand. This study investigates the use of copper slag as a replacement for fine aggregate, fly ash as a replacement for cement, and jhamma bricks as a replacement for coarse aggregate, focusing on their impact on concrete strength. In the past, lime-based binders like lime putty were commonly used, often mixed with hydraulic cements such as calcium aluminate or Portland cement. Other types of concrete also exist, including asphalt concrete, which uses bitumen as a binder, and polymer concrete, which uses polymers for binding.

Concrete is a widely used construction material made by mixing cement, water, sand, and aggregates, forming a hard, stone-like mass through a chemical reaction. Reinforcement materials like steel (rebar) are often added to enhance tensile strength, resulting in reinforced concrete. It cures over time rather than drying, and its strength is influenced by the water-cement ratio, additives, and curing methods. Though concrete has high compressive strength, its tensile strength is relatively low, requiring reinforcement. Additives such as pozzolans and superplasticizers are used to improve its performance. Globally, concrete usage is higher than steel, wood, plastics, and aluminum combined. While it offers benefits like cost-effectiveness, moldability, water resistance, and energy efficiency, it also has drawbacks including low tensile strength, high weight, and the possibility of efflorescence. To address resource scarcity and environmental concerns, industrial wastes like copper slag and Jhamma bricks are being explored as sustainable alternatives in concrete. Copper slag, a by-product of copper refining, serves as a fine aggregate substitute, enhancing strength, workability, and reducing costs. Jhamma bricks, over-burnt and irregular in shape, are repurposed as coarse aggregates, helping to recycle waste and reduce dependency on natural resources. Both materials offer promising results in improving concrete's mechanical properties while promoting environmental sustainability.

SCOPE OF THE INVESTIGATION:

There is a wide scope of investigation of work to be carried out for long term study for incorporation of fly ash with cement, copper slag with fine aggregate and jhamma bricks with coarse aggregate in high strength concrete and their performance as well as aggressive environment. This has to be studied by measuring tensile strength, permeability, resistance to sulphate and chloride attack and the effect of temperature on residual compressive strength of concrete.

Durability of concrete exposed to severe conditions such as saline water can be studied. For higher percentage of copper slag, fly ash and jhamma bricks, with lower water binder ratio the strength durability parameters can be studied.

OBJECTIVES OF THE INVESTIGATION

The objective of the experimental investigations are to check the effect of use of fly ash, copper slag and jhamma bricks concrete reinforced elements when compared to general concrete elements in aggressive environment and normal conditions are;

- To evaluate the effect of just replacing the cement, fine aggregate, coarse aggregates by fly ash, copper slag, jhamma bricks as well as to study, the effect of varying curing period under different exposure conditions.
- To understand the actual behavior of concrete when regular materials are replaced by fly ash, copper slag, jhamma bricks and to ascertain strength of concrete which is one of the important criteria of the concrete, in different exposure conditions in different loading behavior. To understand the complex interaction of materials in corrosion of reinforcement in aggressive conditions
- To determine the optimum level of cement in concrete elements with highest compressive strength.
- Investigate the feasibility of using copper slag as a partial replacement for fine aggregates in high-strength concrete.
- Explore the potential of using Jhama bricks as a source of aggregate in high-strength concrete.
- Evaluate the effect of copper slag and Jhama bricks on the mechanical properties of high-strength concrete, such as compressive strength, tensile strength, and durability.
- Assess the workability and flowability of high-strength concrete incorporating copper slag and Jhama bricks.
- Investigate the environmental benefits of using copper slag and Jhama bricks in high - strength concrete, such as reduced waste and energy consumption.
- Compare the cost-effectiveness of using copper slag and Jhama bricks in high- strength concrete.

II. METHODOLOGY

The partial replacement of fine aggregate with copper slag, cement with fly ash, and coarse aggregate with jhamma bricks was explored. Based on information gathered from research papers, technical reports, and relevant case studies, the experimental procedures, methodologies, and various tests conducted were thoroughly studied and understood. These sources provided the foundation for developing the experimental methodology used in this project.

The methodology adopted for this study involves the systematic evaluation of the mechanical and durability properties of high-strength concrete using copper slag and Jhama bricks as partial replacements for conventional fine and coarse aggregates, respectively. Ordinary Portland Cement (OPC) of 53 grade was used as the primary binder, while natural river sand and crushed granite served as the reference fine and coarse aggregates. Copper slag, an industrial by-product of copper smelting, was used to replace fine aggregate in varying proportions of 0%, 10%, 20%, 30%, 40%, and 50% by weight, while crushed Jhama bricks, sourced from over-burnt brick waste, replaced coarse aggregate in proportions of 0%, 10%, 20%, and 30% by volume. A high-strength concrete mix (target grade M50) was designed as per IS: 10262-2019 guidelines, ensuring consistent workability and durability performance. Standard concrete specimens, including cubes (150 mm), cylinders (150 × 300 mm), and beams (100 × 100 × 500 mm), were cast and water-cured for 28 days. Tests were conducted to determine compressive strength, split tensile strength, and flexural strength according to IS: 516 and IS: 5816 standards. Additionally, a slump test was performed to assess workability as per IS: 1199. The collected data was analyzed to determine the optimal replacement levels that balance strength, durability, and sustainability, thereby validating the potential use of copper slag and Jhama bricks in high-strength concrete applications.

MATERIALS USED	
	
Cement	Fine Aggregate
	
Coarse Aggregate	Copper Slag
	
Jhamma Bricks	

III. TEST RESULTS

Cement test results

Cement used	OPC 53
Consistency	27%
Specific Gravity	2.89
Initial Setting Time	34 minutes
Final Setting Time	8 hours

Coarse Aggregate test results

Crushing Value	28%
Impact Value	24.3%
Water Absorption	10%
Specific Gravity	2.7

Fine Aggregate test results

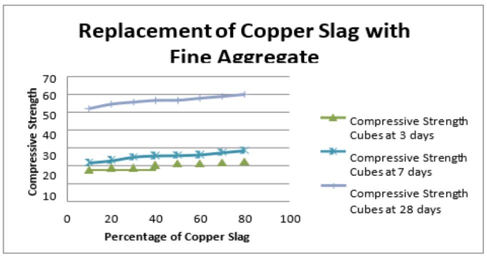
Specific Gravity	2.62
Water Absorption	1.45%
Bulking of Sand	13%

Jhamma Bricks

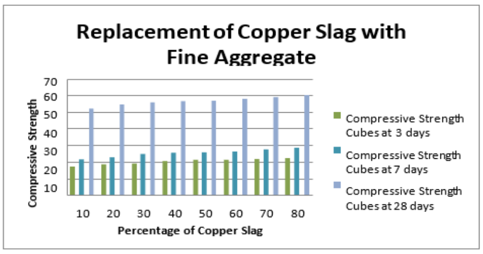
Specific Gravity	3.4
Water Absorption	10.86%
Crushing Value	41%
Impact Value	32.14%

Replacement of Copper Slag with Fine Aggregate

Percentage of Copper Slag	Cubes			Cylinders		
	3 days (N/mm^2)	7 days (N/mm^2)	28 days (N/mm^2)	3 days (N/mm^2)	7 days (N/mm^2)	28 days (N/mm^2)
10%	17.41	21.64	52.1	1.21	2.01	3.1
20%	18.42	22.84	54.54	1.36	2.12	.56
30%	18.8	24.91	55.68	1.54	2.184	4.23
40%	20.4	25.61	56.63	1.58	2.23	4.24
50%	21.1	25.79	56.72	1.68	2.24	4.67
60%	21.1	26.23	57.85	1.79	2.41	4.78
70%	21.63	27.45	58.93	1.82	2.8	4.82
80%	22.12	28.6	59.96	1.96	2.84	4.98

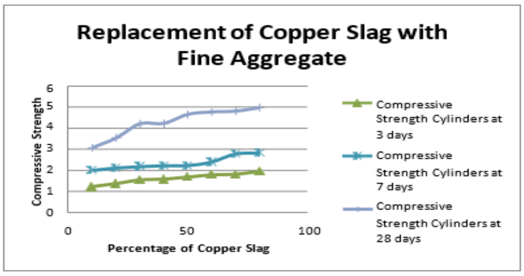


1 Replacement of Copper Slag with Fine Aggregate

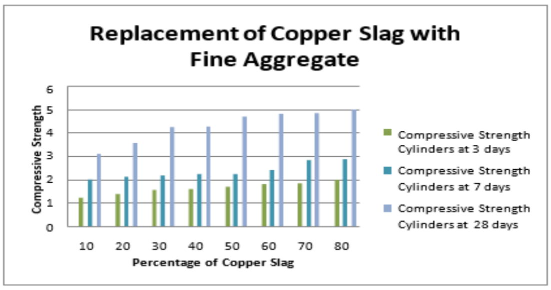


2. Replacement of Copper Slag with Fine Aggregate

(Bar Graph of Cubes)



3. Replacement of Copper Slag with Fine Aggregate
(Line Graph of Cylinders)



4. Replacement of Copper Slag with Fine Aggregate
(Bar Graph of Cylinders)

Replacement of Jhamma Bricks with Coarse Aggregate:

Percentage of jhamma bricks	Cubes			Cylinders		
	3 days (N/mm^2)	7 days (N/mm^2)	28 days (N/mm^2)	3 days (N/mm^2)	7 days (N/mm^2)	28 days (N/mm^2)
5%	20.4	28.1	52.1	1.96	2.812	3.41
10%	20.312	28.01	53.4	1.90	2.714	3.536
15%	20.21	28.00	52.01	1.81	2.684	3.642
20%	20.18	27.86	51.01	1.76	2.664	3.248
25%	19.96	27.41	50.84	1.68	2.512	3.141
30%	19.85	27.01	50.04	1.584	2.508	3.062
35%	19.21	26.68	48.64	1.47	2.41	3.008
40%	18.8	25.14	48.14	1.35	2.26	2.981
45%	18.5	24.84	44.18	1.24	2.1	2.942
50%	17.6	24.41	40.06	1.2	2.01	2.814

IV. CONCLUSION

Through our research we would like to conclude that the utilization of Copper Slag, Fly Ash and Jhamma Bricks in high strength concrete had showed an adverse effect. We designed for M60 grade of concrete by taking few research scholars as reference. Copper Slag is replaced up to 80% at regular intervals of 10%, 20%, 30%, 40%, 50%, 60%, 70% and 80%. The compressive strength has been increasing and the graphs are plotted for the respective strengths after curing. The maximum Compressive Strength is obtained at 80% so we can replace Copper Slag up to 80%. Fly Ash is replaced with Cement up to 20% at regular intervals of 2%, 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18% and 20% in high strength concrete. The strength is been decreasing with the increase of Fly Ash in concrete. The graphs are plotted for the respective strengths fter curing period. The maximum Compressive Strength is obtained at 10%, so Fly Ash can be replaced up to 10% with Cement. Jhamma Bricks are replaced with Coarse Aggregates up to 50% at a regular interval of 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45% and 50%. The compressive strength is been decreasing with the increase of Jhamma Bricks in Concrete materials. The graphs are plotted according to the strengths obtained after the curing period. The maximum Compressive Strength is obtained at 15%, so Jhamma Bricks can be replaced with Coarse Aggregate up to 15%. These results are obtained after curing the moulds for 3 days, 7 days and 28 days

REFERENCES

[1] Utilisation of copper slag JHAMMA BRICKS in High strength concrete Lastest references the International Conference on Sustainable Infrastructure and Materials (2022).
[2] Toshika Ayano (Zairyo/ Journal of the Society of Material Science) Issue 10 Volume Bhanumathi Das & Kalidas (The Indian Concrete Journal) Issue 2 Volume 10 (2018)
[3] Dr. K. Asha and K. P. Deepika (IJIRAE) Issue 10 Volume 3 (2016).
[4] M. V. Patil (International Journal of Advances in Mechanical and Civil Engineering) Issue 2 Volume 2 (2015).
[5] Toshika Ayano (Zairyo/ Journal ofthe Society of Material Science) Issue 10 Volume 49 (2000).
[6] Khalifa S. Al – Jabri (Construction and Building Materials) Issue 6 Volume 23 (2009).
[7] Chatterjee Issue 2 Volume 64 (2015).
[8] Bhanumathi Das & Kalidas (The Indian Concrete Journal) Issue 2 Volume 10 (2018).
[9] Malhotra (Concrete International) Volume 24 Issue 7 (2005).
[10] Hwang, Noguchi & Tomosawa (2004).
[11] G. S. Patil and P. B. Autade (IJERGS) Issue 4 Volume 3 Part 2 (2015).
[12] Ashith Kumar & Dr. Anil Kumar Saxena (International Journal of Advanced Technology in Engineering and Science) Volume 4 Issue 11 (2016).
[13] Code books – IS 10262:2019 (Provides guidelines for designing concrete,IS 456:2000 (Provides provisions for concrete mix design and other aspects of concrete structures)