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AN EXPERIMENTAL INVESTIGATION ON THE FLEXURAL BEHAVIOUR OF CONCRETE BY REPLACEMENT OF FINE AGGREGATE BY POLYPROPYLYNE AND COPPER SLAG

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ABSTRACT

Concrete is a very widely used construction material all over the world. Production of concrete needs usage of large quantities of Fine Aggregates. Hence, to overcome the problem for availability of fine aggregates, the most effective way is to replace sand with other materials. In such case copper slag has been used as replacement material. Copper slag is an abrasive blasting grit extracted from metal smelting process. Production of each ton of copper generates approximately 2.5-3.5 tons of copper slag. Copper slag is one of the industrial waste material which could have a promising future in construction Industry as replacement of aggregates. For this research work, M30 grade concrete was used and tests were conducted for various mixtures of copper slag replacement with sand of 0 to 100% in concrete also to improve the strength, Polypropylene Fibers are added upto 0.4%.The obtained results were compared with those of control concrete made with ordinary Portland cement and sand. In addition to copper slag, various issues related to the Flexural strength of Polypropylene Fiber Reinforced concrete are also discussed.

The Flexural strength increase with addition of copper slag upto 40% and beyond 40% those was decreasing trend in the Flexural strength. When Polypropylene Fibers were added, the Flexural Strength also increased for 0.2% of Fiber fraction. Beyond 0.2% the strength decreased. Hence the number of optimum mix for Flexural strength is replacement of Fine Aggregate with 40% copper slag and addition of 0.2% of Polypropylene fiber.

Introduction

In India, there is great demand of aggregates mainly from civil engineering industry for road and concrete constructions. But now days it is very difficult problem for available of fine aggregates.So researchers developed waste management strategies to apply for replacement of fine aggregates for specific need. Natural resources are depleting worldwide while at the same time the generated wastes from the industry are increasing substantially. Copper slag is one of the materials that is considered as a waste material which could have a promising future in construction industry as partial or full substitute of either cement or aggregates. It is a by-product obtained during the matte smelting

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and refining of copper. To produce every ton of copper, approximately 2.2–3.0 tons copper slag is generated as a by-product material. In Oman approximately 60,000 tons of copper slag is produced every year. Copper slag is a by-product material produced from the process of manufacturing copper. As the copper settles down in the smelter, it has a higher density, impurities stay in the top layer and then are transported to a water basin with a low temperature for solidification. The end product is a solid, hard material that goes to the crusher for further processing.

Copper slag

In the present scenario, as a result of continuous growth in population, rapid industrialization and the accompanying technologies involving waste disposal, the rate of discharge of pollutants into the atmosphere, copper slag is one of the industrial waste which comes out from blast furnace during metal extraction process. Copper slag is produced as a by-product of metallurgical operations in reverberator furnaces.Copper slag is totally inert material and its physical properties are similar to natural sand. Alaboratory study was carried out in the Institute to investigate the potential of using copper slag as a partial replacement of sand in cement concrete. The use of copper slag in cement and concrete provides potential environmental as well as economic benefits for all related industries, particularly in areas where a considerable amount of copper slag is produced. our project is to utilize the copper slag by the replacement for fine aggregate for maintaining economy and increasing the strength of concrete. By this project we can alsosolve the problem of disposal of this type of industrial waste. Different types of slag according to the property can be utilized in different purposes.

Polypropylene fiber

Polypropylene is a versatile and widely used polymer, Polypropylene resins are a general class of thermoplastics produced from propylene gas. Propylene gas is derived from the cracking of natural gas feedstock's or petroleum by-products. Under broad ranges of pressures and temperatures, propylene generally polymerizes to form very long polymer chains. Polypropylene fibers belong to the newest generation of large-scale, manufactured chemical fibers, having the fourth largest volume in production after polyesters, polyamides and acrylics. Polypropylene is one of the most successful commodity fibers, reaching a world production capacity of four million tons a year. Due to its low density (0.9 gm. /cc), high crystalline, high stiffness and excellent chemical/bacterial resistance, is tactic Polypropylene is widely used in many industrial applications such as nonwovens, industrial ropes, packaging materials, furnishing products, etc. Polypropylene fiber has potential, high-volume applications in the carpet, textile, apparel and industrial textile markets.

Materials

Cement

S no	Properties	Values
1	Specific gravity	3.17
2	Fineness	95%
3	Normal consistency	30%
4	Initial setting time	30mins

Fine aggregate

Locally available river sand conforming to Grading zone II of IS 383 –1970

Preliminary results of Fine Aggregate

S no	Properties	Values
1	Specific gravity of FA	2.55
2	Fineness modulus	3.22
3	Zone	II

Coarse aggregate

Locally available crushed blue

Preliminary results of coarse aggregate

.

S no	Properties	Values
1	Specific gravity	2.40

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Copper slag

Copper slag obtained from MariyaIndustries,Chennai.

Physical properties of copper slag

S no	Properties	Values
1	Specific gravity	3.83
2	Fineness	4.6
3	Electric conductivity	4.8ms/m
4	Granule shape	Angular, sharp edges
5	Particle size	0.2mm upto 3.0mm
6	Solubility	Insoluble

Chemical properties of copper slag

s.no	Properties	values
1	Iron oxide	56
2	silica	34
3	Aliminium oxide	3

Polypropylene fibers

Polypropylene recron 3S fiber was used.

Properties of polypropylene fiber

S no	Properties	Values
1	Specific gravity	0.91
2	Electric conductivity	Low
3	Melting point	162°C
4	Ignition point	593°C
5	Thermal conductivity	Low
6	Typical dosage	0.9 kg/m^3
8	Tensile strength	660MPa
9	Modulus of elasticity	4.0 GPa
10	Water absorption	Negative
11	Acid and alkali resistance	Excellent

Super plasticizer

A commercially available sulphonated naphthalene formaldehyde based super plasticizer (CONPLAST SP 430) was used as chemical admixture to enhance the workability of the concrete.350ml of Super plasticizer was used for 1 bag of cement.

Mix proportioning

OPC- M30mix design is calculated using IS 10262: 2000 for 0.1 % of polypropylene,

Material requirement per cubic meter

% replacement of copper slag	cement (kg/m^3)	sand (kg/m^3)	copper slag (kg/m^3)	coarse aggregate (kg/m^3)
0	479	504	0	1142.44
10	479	432.43	71.56	1142.44
50	479	146.16	357.84	1142.44
100	479	0	715.68	1142.44

Mix Calculations

Cement(kg)	Water(kg)	F/A(kg)	C/A(kg)
479	191.6	503.79	1142.44
1	0.40	1.05	2.38

Casting& curing of specimens

Flexural

The control concrete mix was designed according to IS 10262:2000. Copper slag was used to replace fine aggregate at various levels of 0%,10%. 20%, 30%, 40%, 60% and 100% by volume of content. The Polypropylene fibers of0%,0.1%, 0.2%, 0.3% and 0.4% by volume fraction of concrete were used.

Details of casting and curing

In this study, a total number of 36 beams were casted with various copper slag replacement levels of 0%, 10%, 20%, 30%,40%, 50%, 60% and 100%. For the flexure strength, 100mm x 100mm x 500mm moulds were used to cast and tested for each % of copper slag in a particular mix.

All mixtures are mixed in a conventional rotary drum concrete mixer with a capacity of 0.5 m^3. The mixer is first loaded with the coarse aggregate and a portion of the mixing water. After starting the mixer, the fine aggregate, cement, and the rest of water are

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added and mixed for 3 minutes. This is followed by 3 minutes and another 2 minutes of mixing. The fibers are added followed the addition of all other mixed ingredients. At the end, super plasticizer conplast is used to improve the workability of the concrete mix. Superplasticizer was incorporated in all mixes and the quantity was adjusted for each mix to ensure that no segregation would occur.

All freshly cast specimens were left in the moulds as shown in figurefor 24 hours before being demoulded and then submerged in water for curing until the time of testing.

Details of casting and curing

In this study, a total number of 12 cubes were casted with various copper slag replacement levels of 0%, 20%, 30%, 40%, 50% and 60%. For the doing RCPT test, 50mm length x 100mm diamoulds were used to cast as shown in the fig 5.5 and 1 specimens were tested for each % of copper slag in a particular mix.

Flexural strength

For each mix proportions of concrete, standard beams of size 100x100x500 mm were cast and tested as per IS: 516-1959 after 28 days of curing to determine the flexural strength of concrete in Universal testing machine.

Setup of the specimen

The Beams were tested in Universal Testing Machine (UTM) under static two point loading of 100.0 tons capacity. The UTM consists of two simple supports on which the specimen is placed. The bearing shall be wiped clean and if any loose or other material shall remove from the surface of the specimen, above which two point loading is applied gradually. Two point loading produces a constant bending moment along the central part of the testingspecimen.

Flexural strength-Results

Flexural strength, also known as modulus of rupture, bend strength, or fracture strength**,** a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress.

The test results are attained at 28th day for various % of copper slag and polypropylene. The results are tabulated and graphs are plotted for load deflection curves for each %. Based on the test results, the increase in flexural strength for various % of copper slag is also obtained.

Case (1) Effect of Polypropylene Fiber

(i) 10% of copper slag content

`Ultimate Load and Flexural strength for 10% of copper slag

Specimen ID	*Load(kN)*	*Deflection (mm)*	*Flexural strength (N/mm^2)*	*% increase in strength*
10/0	10	0.84	4	0.00
10/0.1	10.5	0.81	4.2	5.00
10/0.4	10	0.63	4	0.00

(ii) 50% of copper slag content

Ultimate Load and Flexural strength for 50% of copper slag

Specimen ID	*Load (kN)*	*Deflection (mm)*	*Flexural strength (N/mm^2)*	*% increase in strength*
50/0	11	0.38	4.4	10.00
50/0.1	11.3	0.33	4.52	13.00
50/0.4	10.8	0.5	4.32	8.00

(iii) 100% of copper slag content

Ultimate Load and Flexural strength for 100% 0f copper slag

Specimen ID	*Load (kN)*	*Deflection (mm)*	*Flexural strength (N/mm^2)*	*% increase in strength*
100/0	10	0.39	4	0.00

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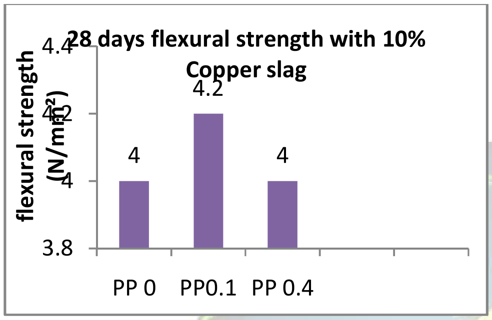
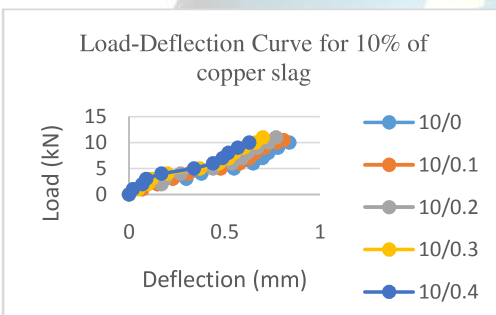
100/0.1	11.5	0.33	4.6	15.00
100/0.4	10	0.33	4	0.00

Effect of Polypropylene Fiber-Charts& Graphs

(i) 10% of copper slag content

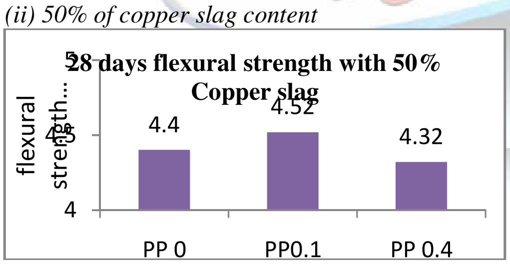


Flexural strength for 10% of copper slag content

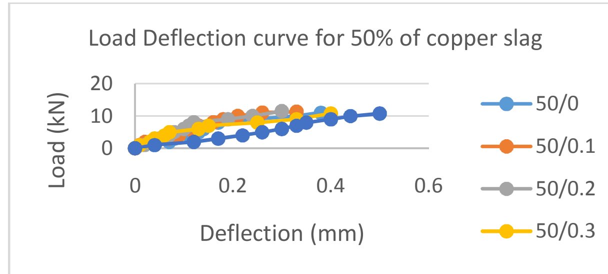


Load Deflection curve for 10% of copper slag

(ii) 50% of copper slag content

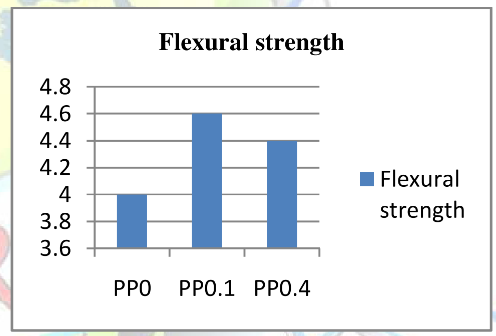


Flexural strength for 50% of copper slag content

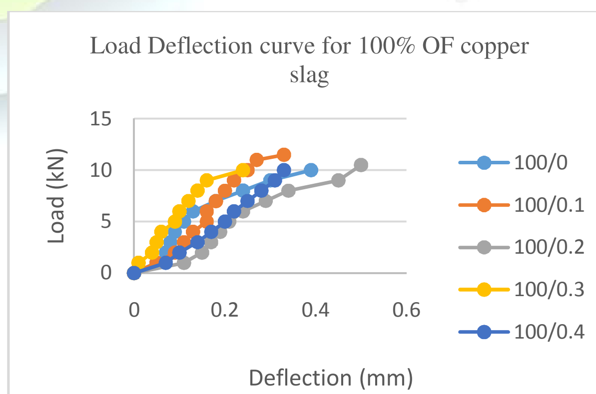


Load Deflection curve for 50% of copper slag

(iii) 100% of copper slag content



Flexural strength for 100% of copper slag content



Load Deflection curve for 100% of copper slag

Case (2) Effect of Copper slag

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Ultimate Load and Flexural strength of Copper slag

(i) 0% of Polypropylene Fiber content

When the copper slag was increase from 0 to 100% without the addition of fiber, it was observed that flexural strength is increasing with increase in copper slag content up to 40% and further decrease in strength due to the addition of copper slag above 40%. For 0, 10, 20, 30, 40, 50, 60, 100 % of copper slag content is given by 4, 4, 4.2, 4.4, 4.8, 4.4, 4.2, 4 N/mm^2 respectively.

(ii) 0.1% of Polypropylene Fiber content

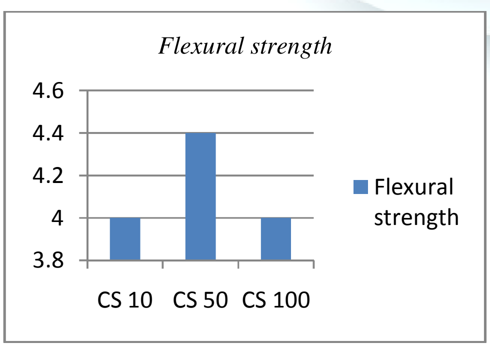
When the copper slag was increase from 10 to 100% keeping constant fiber content of 0.1%, it was observed that flexural strength is increasing with increase in copper slag content up to 40% and further decrease in strength due to the addition of copper slag above 40%. For 10, 20, 30, 40, 50, 60, 100 % of copper slag content is given by 4.2, 4.4, 4.6, 5, 4.52, 4.6, 4.6 N/mm^2 respectively.

(ii) 0.4% of Polypropylene Fiber content

When the copper slag was increase from 10 to 100% keeping constant fiber content of 0.4%, it was observed that flexural strength is increasing with increase in copper slag content up to 40% and further decrease in strength due to the addition of copper slag 40%. For 10, 20, 30, 40, 50, 60, 100 % of copper slag content is given by 4, 4.12, 4.32, 4.4, 4.32, 4, 4 N/mm^2 respectively.

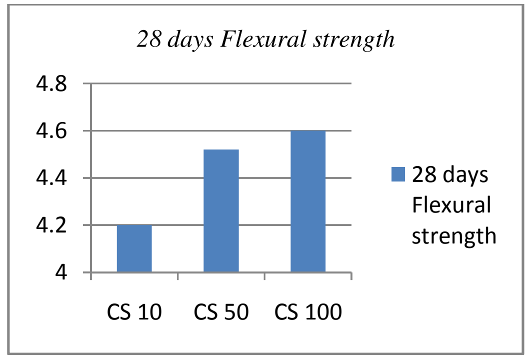
Effect of Copper slag-Charts

(i) 0% of Polypropylene Fiber content



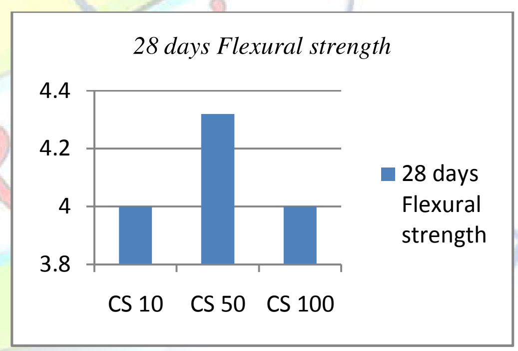
Flexural strength for0% of Polypropylene Fiber content

(ii) 0.1% of Polypropylene Fiber content



Flexural strength for 0.1% of Polypropylene Fiber content

(iii) 0.4% of Polypropylene Fiber content



Conclusions

The Present study investigated the effectiveness of using copper slag for replacement of sand. Addition of Polypropylene fibers increases the Flexural strength and control cracks. Based on the studies and the experimental investigations conducted following results were concluded.

- For higher proportions of copper slag more than 40% by volume the Flexural strength decreases.
- No sudden failures are observed in all beams containing polypropylene

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fibers.With the addition of fibers there is an increase in flexural strength.

- Addition of Polypropylene Fiber more than 0.2% by volume the Flexural strength decreases.

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