

# Effect on Mechanical Properties of M35 Grade Concrete by Partial Replacement of Fine Aggregate with Copper Slag .



G.V.V.Satyanarayana, CH.Saikiran

**Abstract:** In present situation, fast urbanization has made a gigantic interest for regular sand consequently made it considerably more costly. Excess extraction of sand, trending not only depletion of water table but also streams and rivers are diverting in their direction which leads to floods. Elective materials in all types of constructions are acquainted with decrease the weight on normal materials, further maintaining the economical status of project. While additionally dealing with the encompassing condition. Squander Materials like Copper Slag, Flyash, Carbonate Sand, stone residue and so forth having silica synthesis ( $\text{SiO}_2$ ) could be utilized as a substitution for Fine aggregate in a concrete mix. In the process of manufacturing copper the bi-product Copper slag is produced in an heavy quantity. Copper slag has an high specific gravity and has glassy granular texture. Copper slag contains the same particle sizes as of fine aggregate so that it can be used as a replacement for fine aggregate in concrete mix. Here in this paper the main objective is to consider the utilization of Copper slag as an elective substitution material of Fine aggregate. Additionally examines the after effect of substitution of Fine aggregate with Copper slag on mechanical characteristics of cement concrete such as Compressive strength and Flexural strength.

**Keywords:** Concrete, Copper slag, Compressive strength, Fine aggregate, split tensile strength and Flexural strength.

## I. INTRODUCTION

In the present situation, because of constant development in populace and industrialization there is enormous necessity of aggregates generally for construction industry due to excessive usage of natural sand it is causing disturbances to nature and also became more expensive. Day to day the availability of sand become decreased now a days sand is a scare material. So the researchers created plans for managing the waste coming from various Industries. such as substituting the fine aggregates by other materials to reach the explicit needs. Rapid industrialization producing the heavy quantity of waste and substantially natural resources are also getting depleted.

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The eco agreeable and dependable advancement for development comprise the utilization of non customary and diverse waste materials and reusing of waste material for diminishing emanations in conditions and diminishing the utilization of natural resources.

Copper slag has nearly same features as the fine aggregate. Copper slag is one of those materials which is disposed in to land as a waste material and which is produced as a by-product during the refining of copper. Here about 2.2 to 2.5 tons of waste is produced. Now this waste slag can be used as a replacement for the aggregates in concrete. Usage of copper slag as a partial replacement for fine aggregate, the cost of the construction can also be reduced.

About 25%to30% of sand is present in copper slag which is the main component in natural sand and a negligible amount of copper (0.2%) is also present in the copper slag. In this present investigation the mechanical properties of M35 grade concrete were tested when fine aggregate partially replaced with copper slag ,i.e.,10%to50% at a regular interval of 10%. Copper slag is used as a replacement for the fine aggregate as there is a large disposal of it and has the same properties as of fine aggregate investigations had done on the replacement of fine aggregate with copper slag with different percentages like in an investigation[1] the replacement of fine aggregate is done so as to find out the mechanical properties by replacing copper slag at different percentages from 0%to 50% of M40 grade concrete and concluded that maximum strength is achieved at 40% replacement when compared to conventional mix.

In an Performance oriented investigation of M25 grade concrete[2]replacement of fine aggregate from 0 %to 100% the flexural strength and up to 75% has maximum compressive strength than control mix and also stated that increase in compressive and flexural strength is due to high toughness of copper slag. comparing to the conventional mix[3] the strength characteristics were find out by replacement of 20%40%60%80%100% of M20 mix and high strength is gained at 40% replacement which resulted in 37.55% increase in compressive strength and 5.3% increase in split tensile and 40.7% in flexural strength. From[4] the replacements at different levels it is studied that increase in replacement levels increases the compressive strength, flexural strength and split tensile strength up to an optimum point this is due to high percentages of silica and high toughness of copper slag and better heat of hydration.

As per the review[5] on partial substitution of copper slag as a replacement the increase in strength is mainly depended on copper slag and the workability is also increasingly influenced due to the increased copper slag quantity and reduced water absorption characteristics of copper slag and glassy surface. Majorly the presence of copper in copper slag is only 0.2 % which is not so harm full. Here[6] M30 grade mix with replacement percentages between (0%to60%) has been casted and compressive strength is analysed in comparison to conventional and concluded that at 20% 40%and 60% compressive strength is increased and density along with workability also increased with increased in copper slag quantity. In a series of replacements [7]found that workability is increased with increase in copper slag and also concluded that partial replacement by copper slag has a major effect in raise of compressive strength and tensile strength of concrete thus partial replacement serves as a solution for the disposal of copper slag.

**II. MATERIALS**

**1. Cement**

The ordinary Portland cement of 53 grade is used through -out the investigation confining to IS:12269-1987.Test results are mentioned in Table1

**TABLE : 1 Characteristics Of Cement**

CHARACTERISTICS	OBSERVED VALUE
Normal consistency	32%
Initial setting time	65 min
Final setting time	270 min
Specific gravity	3.15
Compressive strength at 28 days	53 Mpa

**2. Water**

Portable water which is available in the premises of the lab is used for the curing and the experimental procedures which are free from the organic matter and dissolved salts.

**3.Coarse aggregate**

Locally available Crushed angular aggregate of size 20mm were used confining to IS 383:1970.Confining to IS 2386:1963 physical properties like specific gravity and water absorption were tested.Test results are mentioned in Table2.

**TABLE: 2 Characteristics Of Coarse Aggregate**

CHARACTERISTICS	OBSERVED VALUES
Water absorption	0.5
Specific gravity	2.64
Fineness modulus	6.8

**3. Fine aggregate**

Locally available fresh sand confining to IS 383:1970. Which is free from organic matter confining to IS 2386:1963 physical properties like specific gravity and water absorption were tested . Test results are mentioned in Table 3.

**TABLE: 3 Charcteristics Of Fine Aggregate**

CHARACTERISTICS	OBSERVED VALUES
Grade zone	II
Specific gravity	2.6
Fineness modulus	2.2

**4. Copper slag**

Copper slag used here was collected from the Sri Sai Metalizers located at Hyderabad. The physical and chemical properties of copper slag are mentioned in Table 4 and Table 5 .

**TABLE :4 Physical Properties Of Copper Slag**

PHYSICAL PROPERTIES	COPPER SLAG
Particle shape	Multifaceted
Appearance	Black and glassy
Specific gravity	3.15

**TABLE: 5 Chemical Properties Of Copper Slag**

Chemical component	Percentage of chemical component
SiO <sub>2</sub>	33-35%
Fe <sub>2</sub> O <sub>3</sub>	40-44%
Al <sub>2</sub> O	4-6%
CaO	0.8_1.5%
MgO	1-2%

**5. Super plasticizer**

Super plastisizer Master Rheobuild 920SH was used to improve the workability of concrete. The properties of Admixture are mentioned in Table 6



**TABLE:6 Properties Of Super Plasticizer**

State	Liquid
Colour	Dark
Density	1.2
Chemical name	Naphthalene formaldehyde polymer
Ph	8.40

**III. EXPERIMENTAL INVESTIGATION**

Experimental investigation was performed on partial replacement of fine aggregate with copper slag to study the mechanical properties of M35 grade concrete. The Replacement of fine aggregate with copper slag is done at different percentages from 0% to 50% at a regular interval of 10% by mass. The materials like cement, coarse aggregate ,fine aggregate and copper slag were tested in laboratory for suitability and used in mix design.

**1. Mix proportion**

The mix proportion of M35 grade concrete for the present investigation designed as per IS 10262-2009. The mix proportion used are 1:2.1:2.86 at w/c 0.17.

**2. Compressive strength test**

The cube specimen of size 150mm x 150mm x 150mm were casted ,cured and tested for compressive strength test in accordance with IS 516-1969. After 3 days 7 days and 28 days and for every test 3 samples were tested.

**3. Split tensile test**

The cylinder specimen of size 150mmdia x 300mm in height were casted, cured and tested for split tensile strength test in accordance with IS 5816-1970. After 3 days 7 days and 28 days and for every test 3 samples were tested.

**4. Flexural strength strength**

The specimen of size 400mm x 100mm x 100 mm were casted cure and tested for flexural strength. After 3 days 7 days and 28 days and for every test 3 samples were tested.

**5. Concrete mix**

MIX1: OPC +(100% fine aggregate + 0% copperslag)+coarse aggregate.

MIX2: OPC +(90% fine aggregate +10% copperslag)+coarse aggregate.

MIX3: OPC +( 80% fine aggregate+20% copperslag)+coarse aggregate.

MIX4: OPC +(70% fine aggregate+30% copperslag)+coarse aggregate.

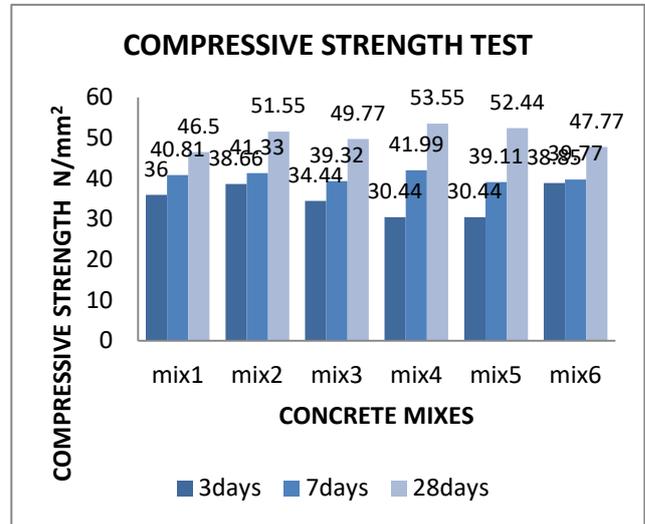
MIX5: OPC +(60% fine aggregate+40% copperslag)+coarse aggregate.

MIX6: OPC +(50% fine aggregate +50% copper slag )+ coarse aggregate.

**IV. TEST RESULTS**

**1. Compressive strength**

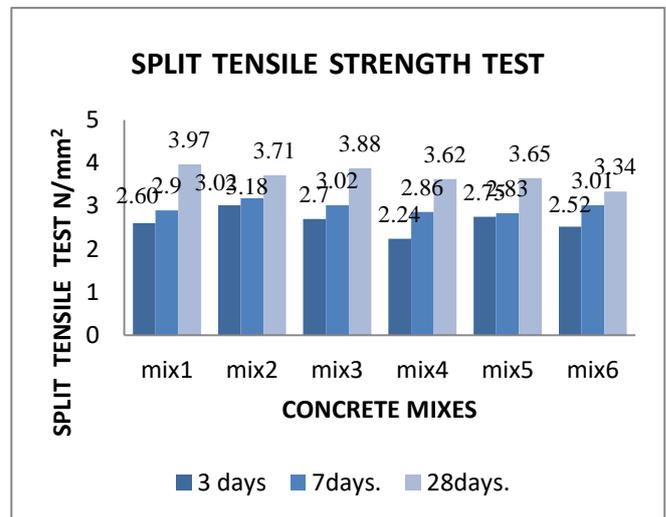
The compressive strength values for all the mixes at 3 days ,7 days and 28 days age are shown graphically in fig 1. It is observed that 40 % replacement is optimum among all replacement and compressive strength for 40% replacement is 23% more than the target mean strength at 28 days.



**Fig(1): Compressive strength results**

**2. Split tensile strength**

Split tensile strength values for all the mixes at 3 days,7 days and 28 days are shown graphically in Fig 2. It is observed that 40% replacement is optimum among all the replacements.



**Fig ( 2) :Split tensile strength results**

**3. Flexural strength**

Flexural strength values for all the mixes at 3 days,7days and 28 days are shown graphically in Fig 3. It is observed that 40% replacement is optimum among all the replacements.

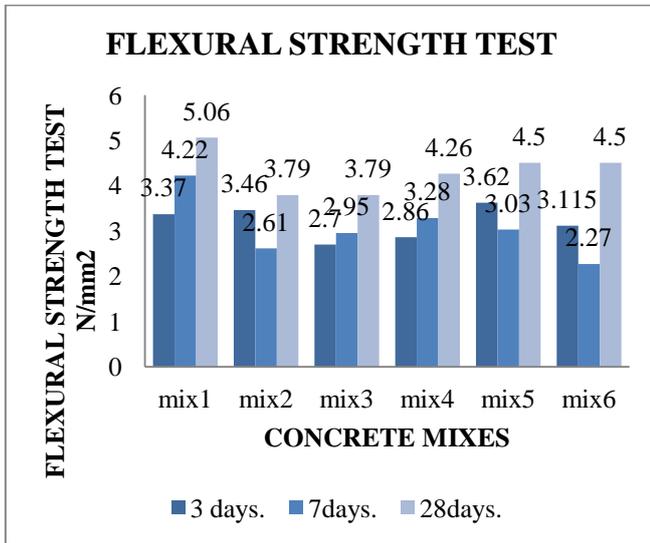


Fig (3) : Flexural strength results

## V. CONCLUSION

following are the conclusions for the experimental investigations.

- i. Considerable increase in compressive strength was seen when the copper slag is used in permissible limits.
- ii. Up to 50% of replacement of fine aggregate copper slag shows better results when compared with conventional concrete
- iii. With 30% replacement of fine aggregate with copper slag showed the 23% increased in compressive strength.
- iv. By experimental results it is observed that the split tensile strength decreased at small percentages it may be due to lesser interlocking capacity between concrete ingredients.
- v. By experimental results it is observed that the flexural strength decreased at small percentages it may be due to lesser interlocking capacity between concrete ingredients .
- vi. The increase in compressive strength is mainly due to the high toughness and the glassy surface of the copper slag.
- vii. The workability is also seen increased depending on the percentages of copper slag used.
- viii. By this investigation it is clear that the copper slag can be used as a elective replacement material for fine aggregate up to 50% helps in keeping up the ecological and economical balance.

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## AUTHORS PROFILE



**Dr.G.V.V. Satyanarayana** Professor of Civil Engineering, completed his Ph.D from JNTUH, Hyderabad and has over Thirty two years of academic, Industrial and research experience in India. His Ph.D work was on Mechanical Response of Slab specimens with Mineral Admixtures Under Different Edge Conditions Subjected to Flexure, Punching Shear and Impact. Prior to PhD, he had earned Bachelors of

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**CH.Saikiran** completed Civil engineering from GITAM university, Hyderabad, Telangana during 2013-2017 with first class. The project he have done in B.tech was on ECO FRIENDLY EPSCRETE WITH GGBS . Presently pursuing masters in structural Engineering at Gokaraju Rangaraju institute of Engineering and Technology (GRIET), His Interested in the studying the special type of concretes. He has been participated in some

of the major conferences conducted by institute of engineers (India) and also participated in workshops like Modern developments in concrete and building technology keenly interested to conduct experimental investigation on replacement of fine aggregate with copper slag under the guidance of Dr.G.V.V.Satyanarayana.