An Experimental Study on Strength Characteristics of Concrete by Partial Replacement of Cement with GGBS and Fine Aggregate with Copper Slag

Kamisetti Durga Sri Varsha [1] | Konla Lalitha Devi [2] | Naidu Venkat [3] | Putta Hari Krishna [4] | A. Rajendra [5]

[1, 2. 3. 4]UG Students, Department of Civil Engineering, Godavari Institute of Engineering and Technology (A), Rajahmundry, Andhra Pradesh, India.

[5]Assistant Professor, Department of Civil Engineering, Godavari Institute of Engineering and Technology (A), Rajahmundry, Andhra Pradesh, India.

Abstract: Utilization of industrial waste (slag) in the concrete is one of the alternative. It not only increases the properties of concrete but also reduces pollution in the environment. The industrial waste were dumped on land or discharged into water bodies and thus become a large source of environmental pollution This paper shows that the results of an experimental study on strength characteristics of concrete. This work is carried out to find out the effects of partially replacing cement with GGBS and fine aggregate with copper slag. Copper slag is an excellent by product due to its chemical composition which includes high iron, silica and aluminium oxide content, it can be used as partial replacement for sand in concrete mix. Our project deals with partial replacement at 5%, 10%, 15%and 20% mass of cement with GGBS and 10%, 20%, 30% and 40% fine aggregate with copper slag in concrete. We compared the properties like compressive strength , split tensile strength , flexural strength of concrete made with replacement of GGBS and copper slag to the conventional concrete. The compressive strength, split tensile strength and flexural strength of concrete with GGBS and copper slag are high when compared with conventional concrete.

KEYWORDS: Compressive strength, flexural strength,split tensile strength, GGBS, Copper Slag

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I. INTRODUCTION

- Concrete is a composite material composed of water, coarse granular material (the fine and coarse aggregate
  or filler) embedded in a hard matrix of material (the cement or binder) that fills the space among the aggregate particles and glues them together.
- The amount of concrete used worldwide, ton for ton, is twice that of steel, wood, plastics, and aluminum combined.
- Copper slag is used in the concrete as one of the alternative materials. It is the waste product of copper from Sterlite Industries India Ltd, Tuticorin.
- The safe disposal of this waste is a lack, costly and causes environmental pollution.
- It is introduced in concrete as a replacement material, it reduces the environmental pollution, space problem and also reduces the cost of concrete.
- The consumption of all type of aggregates has been increasing in recent years. Artificially manufactured aggregates are more expensive to produce and the other factors to be considered is the continuous extraction of natural aggregates which causesadvancement in utilization of wastes in concrete as admixture reduces pollutants in environment and maximizes usage of natural resources.
- During the production of cement Co2 is produced which cause global warming. By reducing cement consumption environment can be protected.

1) 1.1 Objectives

1.1.1 The main objective of the present project is to design eco-friendly concrete (Green Concrete)i.e to reduce co2 emission than the normal conventional concrete.

1.1.2 To investigate the alternative material of fine aggregate for minimizing the effect of natural sand in construction.

1.1.3 To improve strength characteristics of concrete by adding GGBS and copper slag.

LITERATUREREVIEWS

Performance Study of Concrete using GGBS & Copper Slag as a Partial Replacement for Cement & Fine Aggregates- Sachin P. L, Et.Al -may- 2017:

From compression test & split tensile test results of 28-days it is observed that there is gradual increase in its strength. OPC can be partial replaced by GGBS by 15% and copper slag is replaced by 20%.

2. Behavior and Experimental Study on Concrete as Partial Replacement of Fine Aggregate with Copper Slag and Cement with GGBS- GowramIswarya, Et.Al. -Number 7 (2018):

Maximum compressive strength, split tensile andflexural strength has been acquired for substitution of cement by 15% of GGBS and sand by 30% of copper slag. Compressive strength of GGBS and copper slag was accomplished more quality than the control Mix.

MATERIALSUSED

2) 3.1 Cement

Cement is produced by a raw material called clinker. It is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together.

Fig 1 Ordinary Portland Cement

Ordinary Portland Cement (OPC) of 53 grade confirming to IS: 12269-1999, isusedforcastingconcretecubesforstrengthanalysis.ThephysicalpropertiesofOPC are given in the table given below.

Table 1Physical Properties of OPC

S. No.	PROPERTY	VALUE
1	Specific Gravity of 53grade OPC confirming to IS: 12269-1999	3.10
2	Consistency limit	26%
3	Fineness of cement	4.67%
4	Initial setting time	31 mins

5	Final setting time	598 mins

3.2 Coarse Aggregate

Locallyavailablecrushedaggregatesofnominalsize10 mmand20mmareusedin thiswork.Physicalpropertiesofcoarseaggregateuseda regiveninthetablegivenbelow.

Fig 2 Coarse Aggregate

Table 2 Physical Properties of Coarse Aggregate

S.NO	PROPERTY	VALUE
1	Specific gravity of coarse aggregate	2.70
2	Water absorption value	1.0

3.3 Fine Aggregate

The sources of fine aggregate used in this project is river sand. The physical properties of fine aggregate are given below.

Fig 3 Fine Aggregate

a) River Sand

Natural or river sand is generally taken from the river beds or shores. Its physical properties are as follows.

Table 3 Physical Properties of River sand

S.NO	PROPERTY	VALUE
1	Specific gravity of river sand	2.59
2	Fineness modules of river sand	3.10
3	Zone of river sand	II

b) Copper slag

Fig 4 Copper slag

Copper slag is used in the concrete as one of the alternative materials. It is the waste product of copper. The physical properties of copper slag is as given below.

Table 4 Physical properties of Copper slag

S.NO	PROPERTY	VALUE
1	Specific gravity of copper slag	3.35
2	Fineness modules of copper slag	3.62

The chemical composition of copper slag is as follows:

Table 5 Chemical composition of copper slag

S.NO	COMPOSITION	PERCENTAGE
1	SiO_2	25.84
2	Fe_2O_3	68.29
3	Al_2O_3	0.22
4	CaO	0.15
5	Na_2O	0.58

3.4 GGBS

Fig 5 GGBS

The importance of Ground Granulated Blast Furnace Slag (GGBS) lies in its greener wayto becomeasubstituteinconcretematerial. Itisaby-productfromtheblastfurnacewhichisusedto makeiron.Thesefurnacesoperateatatemperatureabov

e1500degreeCelsiusandarefedwith ironore,cokeandlimestone.

Table 6 Physical properties of GGBS

S.NO	PROPERTY	VALUE
1	Colour	White
2	Water absorption	0.75
3	Specific gravity	2.77
4	Fineness	3%

The chemical composition of GGBS is as follows:

Table 7 Chemical composition of GGBS

S.NO	COMPOSITION	PERCENTAGE
1	Calcium oxide	40%
2	Silica	35%
3	Alumina	13%
4	Magnesia	8%

EXPERIMENTS CONDUCTED

COMPRESSIVE STRENGTH TEST:

Compressive strength test was carried out on 150*150*150mm size cubes. Cubes were prepared for 7, 14 and 28 days of curing and tested with UTM. The specimens were loaded at a constant strain rate until failure.

Fig 6 UTM

SPILT TENSILE STRENGTH TEST:

The tensile strength of concrete is obtained by applying a tensile force along the length of the concrete cylinder. The test was carried out on the specimen of dimensions of 150 mm in diameter and 300 mm in length. Cylinder specimens were prepared for 7, 14 and 28 days of curing and tested with UTM Resultant split tensile strength

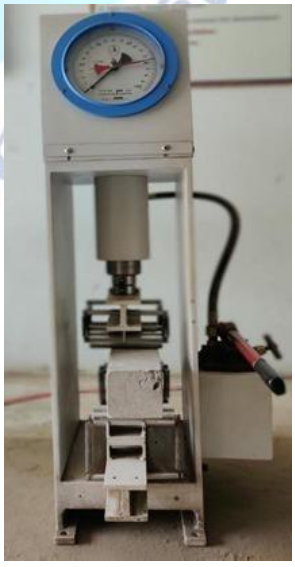
Fig 7 UTM

FLEXURAL STRENGTH TEST:

Flexural strength is one measure of the flexural strength of concrete. It is a measure of unreinforced concrete beam to resist failure in bending .The flexural strength is expressed as modulus of rupture.

The systems of loading used in finding out the flexural tensions are

- Central point loading
- Third point loading



EXPERIMENTALRESULTS

Table 8: Compressive Strength Test

S.no	% Copper slag	% GGBS	COMPRESSIVE STRENGTH VALUES		
			7days	14days	28days
1.	0%	0%	19.05	25.58	31.35
2.	10%	5%	20.09	26.38	32.54
3.	20%	10%	21.31	27.2	33.40
4.	30%	15%	22.40	28.1	34.32
5.	40%	20%	19.80	26.06	32.02

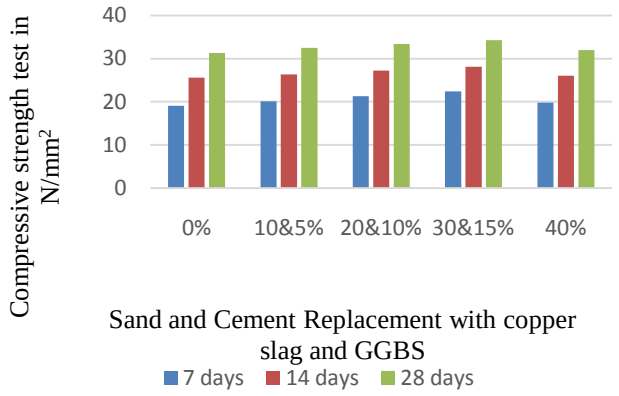


Table 9: Split Tensile Strength Test

S.no	% Copper slag	% GGBS	SPLIT TENSILE STRENGTH VALUES		
			7days	14days	28days
1.	0%	0%	2.18	2.55	3.51
2.	10%	5%	2.28	2.67	3.55
3.	20%	10%	2.40	2.73	3.66
4.	30%	15%	2.46	2.82	3.72
5.	40%	20%	2.24	2.58	3.54

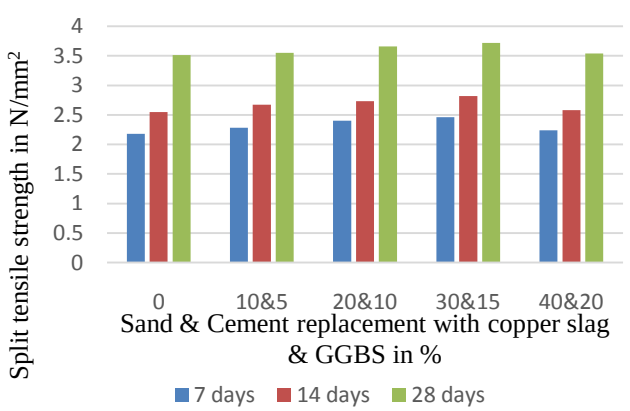
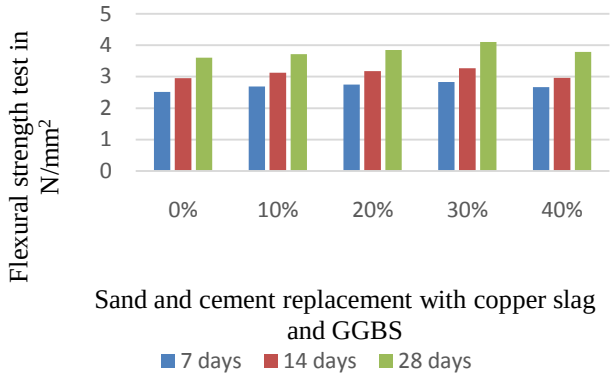


Table 10: Flexural Strength Test

S.no	% Copper slag	% GGBS	FLEXURAL STRENGTH VALUES		
			7days	14days	28days
1.	0%	0%	2.52	2.95	3.6
2.	10%	5%	2.69	3.13	3.72
3.	20%	10%	2.75	3.18	3.85
4.	30%	15%	2.83	3.27	4.1
5.	40%	20%	2.67	2.96	3.79



CONCLUSIONS

- The compressive strength of concrete with 30% copper slag and 15% GGBS is 8.6% greater than compressive strength of conventional concrete.
- The split tensile strength of concretewith 30% copper slag and 15 % GGBS is 5.6% greater than split tensile strength of conventional concrete.
- The flexural strengthof concrete with 30% copper slag and 15% GGBS is 12% greater than flexural strength of conventional concrete.

Fromtheaboveitcanbeconcludedthat**10%to40%**of**G.G.B.Sandcopperslag**canbeused as replacement. But further conclude that **30% replacement** will give more strength than compared to **40%**replacement.

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