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An experimental investigation on concrete by partial replacement of fine aggregate by copper slag and coarse aggregate by ceramic waste tiles

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Abstract-The present study has investigated the properties of concrete with copper slag replacing fine aggregate and ceramic waste tiles replacing coarse aggregate. In this project control concrete is casted for M_{25} grade and partial replacement of fine aggregate by copper slag in range of 10%, 20%, 30% by weight of fine aggregate and the coarse aggregate by ceramic waste tiles replacement in 10% by weight of coarse aggregate. Totally 36-cubes, 24-Cylinders, 24-beams were casted and tested for compression, Flexural strength, Split tension, at 7, 14, 28 days curing of concrete. The obtained results are compared with M_{25} grade conventional concrete.

Keyword: **Copper slag, Ceramic waste tiles, compression strength, flexural strength, tensile strength test, etc.**

I. INTRODUCTION

Concrete is an artificial composite material made cement/ binder, aggregates (course and fine) and water. Studies say that Concrete industry contributes to about 5% of global CO_2 emissions. Every one tons of cement produced 1 tons of CO_2 is generated and released to the atmosphere contributing to global warming[1]. Along with this demand for raw material like river sand and gravel continues to increase it is estimated that the global needs of aggregate was around 25.9 to 29.6 billion tones per the year.

The major source of industrial waste which creates pollution to environment and left at industrial site as non-useable materials such as Copper slag and ceramic waste tiles are used as concreting materials. Copper slag is the strelite industry waste obtained from smelting and refining process of copper at larger rate. Nearly 4-5 tons of copper is obtain as waste slag which contain pozzolonic property and have high density can be used as replacement for all concrete materials like sand, cement and coarse aggregate. Ceramic industry waste is the leading industrial waste obtained in various forms like ceramic powder, broken tiles, slurry waste etc., which is disposed to landfill create pollution at larger rate. In this project work ceramic waste tiles are collected and broken into 20mm tiles for partial replacement with coarse aggregate.

In this experimental work the waste materials are used as partial replacements for concreting materials in varying percentages. Normal concrete is designed for M_{25} grade and their strength were tested, then in the normal mix is partially replaced for copper slag by fine aggregate at different proportions from 10%, 20%, 30% by weight of sand.

The coarse aggregate is replaced in range of 10%, by weight of coarse aggregate. Finally all the strength factors are tested and compared with conventional concrete strength which should satisfy the increased concrete strength requirements. For testing on concrete totally 36-cubes (150 x150 x 150mm) for compression test, 24-cylinder (150mm x 300mm) for Split tensile test, 24-beams (500 x 100 x 100mm) for flexural test cured for 7 days, 14 days and 28 days to have increased strength.

II. MATERIAL DESCRIPTION

In these projects cement, Fine aggregate, coarse aggregate, copper slag, Ceramic waste tiles are used.

CEMENT

Cement is the essential ingredient to bind all other materials to form workable concrete. In these project The Ordinary Portland Cement of 43 grades used. The specific gravity of cement is 3.15. The physical properties of concrete are shown in table 1.

AGGREGATE

The aggregate occupy nearly 70-80% of concrete volume and they give body to the concrete, reduce shrinkage and stiffened the concrete. Good grading implies that a sample fraction of aggregates in required proportion contains minimum voids requirements to use as concreting materials. The physical properties of concrete are shown in table 1.

COARSE AGGREGATE

Aggregates fractions larger than 4.75mm are termed as coarse aggregates. Crushed angular aggregate with maximum grain size of 20mmand downgraded was used under Zone II aggregates conforming to IS: 383-1970. The physical properties of concrete are shown in table 1.

FINE AGGREGATE

Fine aggregates are termed as “filler” which fills the voids in concrete. The aggregates less then 4.75mm are known as fine aggregates. The river sand is used as fine aggregate conforming to requirements of IS: 383-1970 comes under zone II. The physical properties of concrete are shown in table 1.

WATER

In the present investigation, available water within the campus is used for mixing and curing purposes.

COPPER SLAG

Copper slag which is a industrial waste obtained from smelting and refining process of copper from Strelite Industry Ltd. Nearly 4 tons of copper is obtained as waste is disposed to lands cause’s environmental impacts. It can be reused as concreting materials. The physical properties of concrete are shown in table 1.

CERAMIC WASTE TILES

Ceramic industry 15%-30% of daily production goes as waste. It is not recycled any form so this cause impacts to environment and it can be reused as construction materials. The physical properties of concrete are shown in table 1.

Table 1 Physical Properties of Concrete and Replacement Material

Material	Specific Gravity	Finess Modulus (%)	Bulk density (kg/m^3)	Water absorption (%)
Fine aggregate	2.55	3.9	1736.67	1.69
Coarse aggregate	2.71	3.18	1612.67	0.33
Copper slag	3.56	4.1	2200.0	0.50
Ceramic tiles	2.30	3.42	1612.67	8.49

III. DESIGN MIX

The present investigation work M_{25} grade mix was designed as per Indian Standard method IS 10262-2009 for extreme exposure condition and the same is designed for various replacement percentages.partial replacement of fine aggregate by copper slag in the range of 10%, 20%, 30% by weight of fine aggregate and the coarse aggregate by ceramic waste tiles replacement in 10% by weight of coarse aggregate. The design mix proportion is shown in Table 2.

Table -2

Design Mix Proportions (Kg/m^3) For M_{25} Grade and Mix Ratio

Grade	Cement	Water	Fine aggregate	Coarse aggregate
M_{25}	450	197	580	1040
Ratio	1	0.40	1.2	2.3

TABLE-3 DESIGN MIX PROPORTION FOR VARIOUS PERCENTAGE REPLACEMENTS

MIX NO	PARTIAL REPLACEMNT OF AGGREGATE	
	F.A BY C.S	**C.A BY C.W.T**
Conventional concrete	0% C.S	0% C.W.T
Mix 1	10%C.S	10% C.W.T
Mix 2	20%C.S	10% C.W.T
Mix 3	30%C.S	10%C.W.T
C.S- Copper Slag , C.W.T- Ceramic Waste Tiles,		

IV. EXPERIMENTAL PROCEDURE

The evaluation of concrete with copper slag and ceramic waste tiles used as partial replacement of aggregate materials. Concrete contain cement, water, fine aggregate, coarse aggregate for normal concrete of ratio 1:1.2:2.3. The copper slag is used as partial replacement for fine aggregate in the range of 10%, 20% and 30% by weight of sand and

Mix No	Compressive Strength (Mpa)		
	7th days	14^{th} days	28^{th} days
Conventional concrete	14.79	21.99	26.36
Mix 1	16.81	22.74	29.52
Mix 2	15.81	21.8	28.37
Mix 3	17.52	21.52	32.3

the ceramic waste tiles is used as partial replacement for coarse aggregate ranging from 10%, with optimum slag content as constant and testing the strength of normal and other variation mix totally 36-cubes of size 150x150x150mm were casted for compression strength test. Then 24-beam of size 500x100x100mm is casted for flexural strength testing. For testing the 24-cylinders of size 150mmx300mm is casted for Split tensile strengthas per mix design proportions.

After 24 hours from casting the concrete specimens are de-moulded and allowed for continuous curing in a tank with portable water. The specimen are taken and tested at required 7^{th} day, 14^{th} day, 28^{th} day from curing for compression test at 7^{th}, 28^{th} day and flexural, tensile strength test.

V. TESTING METHODS

The designed concrete is subjected to various tests to estimate the strength and other properties of the casting concrete. The main aim of the project is to developed strength attained by the concrete at various testing days from curing. Proper casting and curing of concrete will increase the strength of the concrete. Each test carried out 3 samples for every mix ratio and tested at required curing time. Then the average values are used for these strength analyzing. The testing procedure is detailed below:

COMPRESSIVE STRENGTH TEST

One of the most important properties of concrete is to withstand the designed compressive strength. Concrete is weak in tension and strong in compression so the concrete should be strong to attain high compression. Each mix 3-samples were tested and the average strength is compared with nominal mix of M_{25} grade. Totally 36-cubes of size 150mm x 150mm x 150mm is casted and tested at 7,14,28 days from curing. The compression test on concrete is applying constant load after placing concrete between plates and the failure load is note down then the load reversal occurs, cracks appears on concrete show the compressive strength of concrete.

The compressive strength of concrete is calculated by following expression:

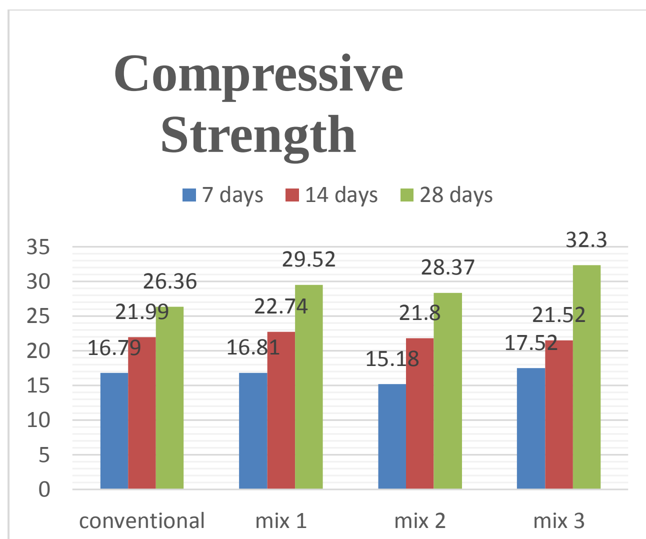
Compressive strength (N/mm^2) =

$$\text{(applied load)} / \text{(cross sectional area)}$$

TABLE 4 COMPRESSIVE STRENGTH ON CONCRETE (M_{25}) CUBES

From the compressive strength test result done on 7, 14, 28 days curing for normal and other replaced concrete, shows the increased strength obtained at mix 3 with 30% partial replacement of sand by copper slag 10% partial replacement of coarse aggregate by ceramic tiles of 32.3Mpa at 28^{th} day testing. The obtained results for all other replacements also have increased strength compared to normal M_{25} grade concrete.

Graph No.1 Compressive Strength of Concrete (M_{25}) (N/mm^2)



Split Tensile Strength Test

The split tensile strength of concrete is tested by casting cylinder of size 150mm x 300mm and is continuously cured for 7 days and 28 days testing. Totally 24 cylinders were casted for normal M_{25} grade and for 10%, 20%, 30% partial replacement of copper slag for sand and the ceramic tiles are partially replaced by 10% with optimum slag in normal mix and is cured for testing, for each mix 3samples are tested and the average values is taken as tensile strength of concrete. The values of the split tensile strength for normal and other variation mix are shown in Table 5 and are clearly differentiated by a graph. The split tensile strength of the concrete is calculated by using an empirical equation:

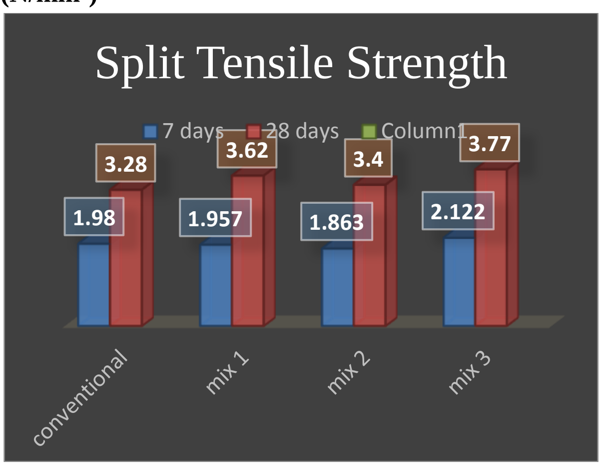
Split Tensile strength (N/mm^2)= $\frac{2P}{\pi * d * l}$

Where P- maximum Load at failure, l- Length of the Cylindrical Specimen in mm, d- Diameter of Cylindrical specimen in mm.

TABLE 5 SPLIT TENSILE STRENGTH OF CONCRETE AT 7 DAYS AND 28 DAYS

MIX NO	SPLIT TENSILE STRENGTH (Mpa)	
	7th days	28th days
Normal Mix	1.98	3.28
Mix1	1.957	3.62
Mix 2	1.863	3.48
Mix 3	2.122	3.77

Graph No.2 Split Tensile Strength at 7 days and 28 Days (N/mm^2)



Flexural Strength Test

Flexural strength of concrete is tested by casting beams with or without reinforcement. In concrete flexure is the bending moment caused by the applied load, in which a concrete beam has compression at top and tensile stress at the bottom side. Beams on testing will fail in tension due to its property and shear will appear on concrete. In this experimental works totally 24-beams of size 500 x 100 x 100 mm are casted without reinforcement for normal M_{25} grade concrete and other percentage of replacements as 10%, 20%, 30% of copper slag with sand and 10% ceramic tiles for coarse aggregate are tested at 7 days and 28 days from curing. For every mix 3-samples were tested in UTM and the average strength is compared with normal mix strength.

Flexural test on concrete beam is done using Universal Testing machine by applying two point loads. A constant load is applied on beams and after the load reversal the strength is noted. The flexural values for various mixes are displayed in Table.6. The maximum strength is obtained at 30% copper slag replacement at 28 days curing is shown in Graphical representation. The flexural strength of concrete is measured by using equation:

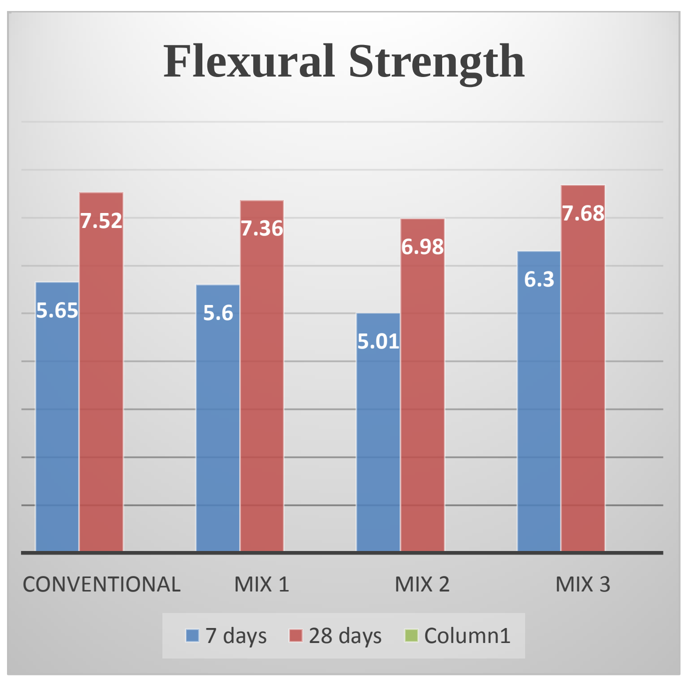
Flexural Strength (N/mm^2) = $\frac{PL}{B * D^2}$

Where P- Maximum Applied Load (kN), L- Length of the beam (mm) , B- Width of the specimen (mm), D- Depth of the specimen (mm).

Table 6 Flexural Strength of Normal & Variation Beams

MIX NO	FLEXURAL STRENGTH (Mpa)	
	7th days	28th days
Normal Mix	5.65	7.52
Mix1	5.6	7.36
Mix 2	5.01	6.98
Mix 3	6.3	7.68

Graph No.3 Variation in Flexural Strength at 7 days and 28 days (N/mm^2)



VI. CONCLUSION

Improve the characteristic strength of M_{25} grade concrete replaced with 10%, 20%, 30% copper slag and constant the coarse aggregate is replaced with ceramic waste tiles by 10% to have increased strength. The main features from these investigations below:

1) For compression strength, the maximum strength attained is 32.3Mpa at 28days at mix 3 compared to normal M_{25} grade concrete. All other mix percentage of partial replacements also has increased strength compared to the conventional concrete.

2) For Split tensile strength the maximum strength is attained at 28 day testing has increased strength. For all variation percentages also have increased strength compared to conventional concrete.

3) The flexural strength of concrete is done at 28 days is higher than the designed mix. The flexural strength of the concrete will have increased strength for all percentage of replacement compared to the conventional concrete.

4) The replacement of copper slag as sand attained high strength of at 30% replacement than conventional concrete, further replacements also has increased strength. The replacement of ceramic tiles alone will not have sufficient strength, so it is replaced with optimum slag content as 10% constant also have increased strength compared to control concrete.

REFERENCES

[1] Arivalagan.S (2013): “Experimental Study On The FlexturalBehaviour Of Reinforcement Concrete Beams As Replacement Of Copper Slag As Fine Aggregate” Journal Of Civil Engineering And Urbanism Volume 3, Issue 4(176-182).

[2] AyanoToshiki, Kuramamoto Osamu, and Sakata Kenji. 2000 “Concrete With copper Slag Fine Aggregate“, Society Of Material Science, Vol.49, Pp. 1097-1102.

[3] D.BRINDHA and S.NAGAN “Utilization Of Copper Slag As A Partial Replacement Of Fine Aggregate In Concrete“. International Journal Of Earth Science And Engineering (2010).

[4] Dr. T.Ch.Madhavi “Copper Slag In Concrete As Replacement Material”. International Journal of Civil Engineering and Technology (IJCIET) (2014).

[5] Umapathy U, Mala C, Siva K “Assessment of Concrete Strength Using Partial Replacement of Coarse Aggregate for Waste Tiles and Cement for Rice Husk Ash in Concrete”. International Journal of Engineering Research and Applications (2014).