An Experimental Investigation on Partial Replacement of Blast Furnace Slag and Ceramic Tiles for Coarse Aggregate in Concrete

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Abstract— The Concrete is an engineering composite material made with cement, aggregates and admixtures in some cases. Due to the day by day innovative usages and developments in construction field, the world wide consumption of natural aggregate is very high and at the same time production of solid wastes from the demolitions and manufacturing units is also very high. Extensive use of concrete leads to the scarcity and unavailable of natural aggregate. Because of this reasons the reuse of demolished construction wastes and solid wastes from manufacturing came into the trend to reduce the solid wastes from demolition and manufacturing units and as well as to decrease the scarcity of natural basic aggregate. To overcome the issues many research were done to use many industrial waste as alternative material for concreting. In this project control concrete is casted for M25 grade and the partial replacement of concrete material were decided to reuse industrial waste such as blast furnace slag and ceramics tiles as coarse aggregate replacement in rage of 20%, 25%, 30% by weight of 20mm sieve size coarse aggregate. Concrete mixtures were produced, tested and compared in terms of compressive strength to the conventional concrete. . These tests were carried out to evaluate the mechanical properties for 7, 14, and 28 days. This project work is concerned with the experimental investigation on strength and mechanical properties of concrete and optimum percentage of the partial replacement by replacing 20%, 25%, 30% of ceramic waste and blast furnace slag.

Keywords: Coarse Aggregate, Blast Furnace Slag and Ceramic Tiles

I. Introduction

Generally in design of concrete mix, cement, fine aggregates and coarse aggregates are using from long back, which plays a crucial role in designing of a particular grade of concrete. But now a day there is a scarcity in aggregates. So, some new materials which are locally available for low cost have to introduce for replacing the fine aggregates, coarse aggregates and as well as cement to get the same strength as that these basic materials can give. So, we have to search for different materials to reduce the quantity of basic natural materials in the concrete mix without changing any mix design procedure and considerations

Use of cheaper material without loss of performance is very crucial to the growth of developing countries. We cannot replace the whole basic material in the concrete, but we can replace with other materials to some extent. In the present world, huge amount of solid wastes are obtaining from manufacturing units and demolitions of construction from human daily habitats. Some researchers are working on solid waste as partial replacing substances based on the locally available waste materials like crushed plastic, Stone dust, over burnt bricks, M – sand, glass powder, coconut shells, waste tires, slag, fly ash produced from industries, broken glass pieces, rice husk ash, coconut shell ash, etc., to use them in concrete to partially replace the basic materials.
And studies have been going on to preserve the natural basic aggregates and to promote use of the recycled aggregates to the next level in the concrete mix and to reuse the solid waste from construction again as a material in the concrete to decrease the land fill of solid waste and decrease the scarcity of natural aggregates like gravel and sand. Huge usage of ceramic tiles, Blast furnace slag other ceramic for architectural appearance, the productions of which are drastically increased. As 30 to 40% of the total production from manufacturing units is solid waste. So, we selected these ceramics waste tiles and blast furnace slag as a replacement material to the basic natural aggregate.

II. Material properties

The various material used in this project work are shown in the following table.

S.NO	DESCRIPTION	PARAMETER
1.	Grade of concrete	M25
2.	Cement	OPC 43 grade
3.	Fine aggregate	Sand confirming to zone II of IS 383-1978
4.	Coarse aggregate	20mm nominal size
5.	Type & shape of C.A	Angular
6.	W/C ratio for M25	0.4
7.	BFS & Ceramic tiles	20mm nominal size
8.	Age of curing	7days, 14 days & 28days

Table 1: Properties of various materials used

A. *Preliminary Experimental investigations*

1) *Specific Gravity for Cement*

The specific gravity of cement was found in the laboratory by using pycnometer and other accessories the test was done on the sample thrice the average of which reported
Weight of empty bottle (W1) = 620gm
Weight of bottle + Cement (W2) = 745m
Weight of bottle + Cement + Kerosene (W3) = 1335gm
Weight of bottle + Kerosene (W4) = 1292gm
Specific gravity of cement
= (W2-W1) / ((W4 –W1) – (W3 – W4))
= (745 – 620) / ((1292 – 620) –(1335 – 1292))
= 3.15

2) *Fineness Test for Cement*

The fineness test of cement was found in the laboratory by using IS sieve of 90microns, the test was done on the given sample.

Weight of sample (W1) = 100gms
Retained on IS sieve of 90microns
= W2 / W1 X 100
= 0

III. TEST RESULTS

s.no	wt. of cement	water added	penetration index	quantity in %
1	200	50	33	25
2	200	54	29	27
3	200	58	22	29
4	200	62	9	31
5	200	66	4	33

Table 2: Consistency Test for Cement

A. *Sieve Analysis Test of Fine Aggregate*

This is the name given to the operation of dividing a sample of aggregates into various fractions each consisting of particles of the same size. The sieve analysis is conducted to determine to determine aggregate which we call as gradation.

Size	Retaing	(g)	retaining	
100mm	0	0	100	100
4.75mm	16	16	98.4	90 – 100
2.36mm	82	98	90.2	85 – 100
1.18mm	150	248	75.2	75 – 100
600 Micron	133	381	61.9	60 – 100
300 Micron	298	679	32.1	12 – 40
150 Micron	257	936	6.2	0 – 10

Table 3: Sieve analysis test of fine aggregate

PROPRTIES	TEST RESUT
Specific gravity	2.6
Water absorption	1
Bulk density(kg/m3)	1602
Fineness moduls	2.64

Table 4: Properties of fine aggregate

Sieve	Mass Retained	% Retained	% passing	Cumulative Retained
80mm	0	0	100	0
40mm	0	0	100	0
20mm	87.5	6.75	89.25	8.75
12.5mm	73.4	70.4	14.85	85.15
10micron	143.5	14.35	2.5	97.5
6.3micron	27.5	2.75	0.99	94.25
4.75 micron	5	0.5	0.25	97.75
Pan	2.5	0.25	0	37.44

Table 5: Sieve analysis test for C.A

Properties	Test results
Specific gravity	2.5
Water absorption	2
Bulk density(kg/m3)	1586
Impact strength	14.30%

Table 6: Properties of Coarse aggregate

B. *Blast Furnace Slag:*

Blast furnace slag were obtained from local foundries and broken and crushed with 20mm sieve size.Its bulk density and water absorption were 1.305 g/ccand 2.59% respectively.And the value of impact strength and crushing strength of blast furnace slag is 14.70& 14.50 respectively.

S.no	Properties	Values	Range as per code is: 383-1970
1	Specific gravity	2.56	2.30 – 2.90
2	bulk density(kg/m3)	1490	1280 – 1920
3	Fineness modulus	2.40	2.10 – 3.20

Table 7: Physical properties of blast furnace slag:

calcium oxide	(CaO)
Silicon oxide	(SiO2)
Iron oxide	(Fe2O3)
Magnesium oxide	(MgO)
Manganese oxide	(MnO)
Aluminium oxide	(Al2O3)
Sulfur oxide	(SO3)

Table 8: chemical properties of blast furnace slag:

IV. MIX DESIGN

A. *Mix Calculation:*

The mix calculation per unit volume of concrete shall be as follows:

1) Volume of concrete = 1m3
2) Volume of cement = mass of cement /(specific gravity of Cement * 1000

= 465/3.15* (1/1000)
=0.147m3

3) Volume of water = mass of water /(s. gravity of Water* 1000)

= 184.14/1.14* (1/1000)
=0.184m3
= 0.018m3

4) Volume of all aggregate = [a-(b+c)]z

= 1- (0.147 + 0.184 + 0.018 + 0.0012)
= 0.758

5) Mass of coarse aggregate = (d* volume of C.A* volume of C.A*1000)

=0.75*0.56*2.74*1000
=1151kg/m3

6) Mass of fine aggregate = (d* volume of F.A* volume of F.A*1000)

= 0.75*0.44*2.56*1000
= 573.3kg/m3

S.no	Material	Quantity(per m3)	Proportion
1	Water	184.14 lit	0.4
2	Cement	465 kg	1
3	Fine aggregate	573.3 kg	1.1
4	Coarse aggregate	1151kg	2

Table 9: Mix Proportion of Normal Concrete

V. RESULT

S.no	Percentage of lime sludge	7 days av. Comp.	14 days av. Comp.	28 days av. Comp.

		Strength (mpa)	Strength (mpa)	Strength (mpa)
1.	0%	19.67	23.11	26.10
2.	20%	20.88	22.55	24.60
3.	25%	21.02	23.66	28.85
4.	30%	21.44	24.88	29.13

Table 10: Compressive Strength for various replacement percentages

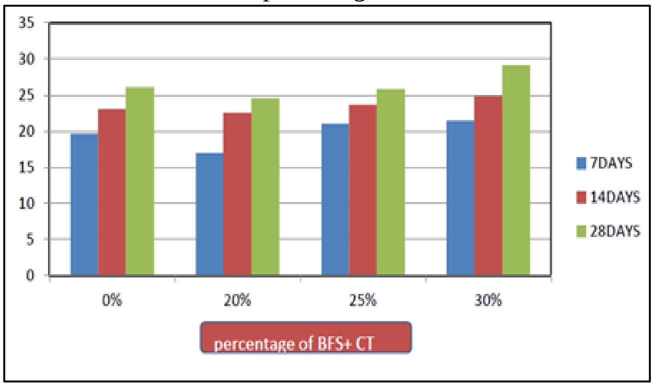

Fig. 1: % BFS+CT

S.no	Percentage of lime sludge	7 days av. Tensile. Strength (mpa)	14 days av. Tensile. Strength (mpa)	28days av. Tensile. Strength (mpa)
1.	0%	1.27	1.69	2.68
2.	20%	1.35	1.78	2.75
3.	25%	1.55	1.84	2.81
4.	30%	1.66	1.92	2.95

Table 11: Split Tensile Strength for various replacement percentages

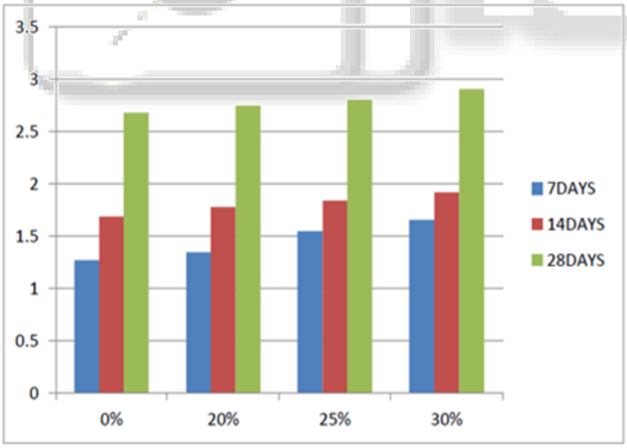

Fig. 2: Split Tensile Strength % graph

S.no	Percentage of lime sludge	7 days av.flexural. Strength (mpa)	14 days av.flexural. Strength (mpa)	28days av.flexural. Strength (mpa)
1.	0%	2.13	3.0	4.67
2.	20%	2.53	3.96	5.85
3.	25%	2.55	4.08	6.90
4.	30%	3.79	5.18	7.97

Table 12: Flexural Strength for various replacement percentage

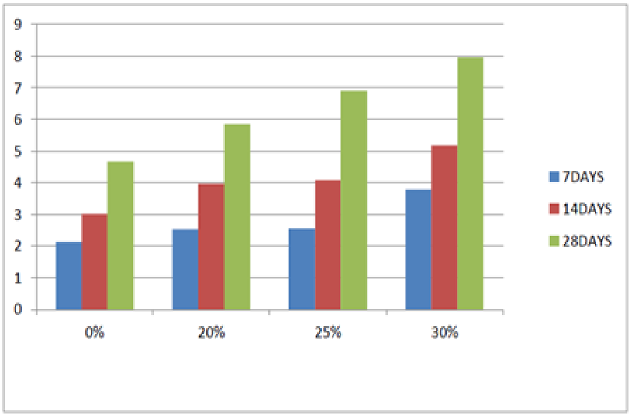

Fig. 3: Flexural Strength %

VI. CONCLUSION

- Based on the Compression Strength, 20%, 25%, 30% replacement of blast furnace slag and ceramic tiles the 30 % replacement shows 29.13 Mpa strength as the average strength on 28 days of curing.
- Based on the Split Tensile Strength, 20%, 25%, 30% replacement of blast furnace slag and ceramic tiles the 30% replacement shows 2.95 MPa strength as the average strength on 28 days of curing.
- Based on the Flexural Strength, 20%, 25%, 30% replacement of blast furnace slag and ceramic tiles the 30% replacement shows 4.97 MPa strength as the average strength on 28days of curing.

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