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Comparative Strength Analysis of Concrete by Partial Replacement of Sand with Basic Oxygen Furnace Slag

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***Abstract*— Environmental pollution is one of the major concerns of all the environment related departments. Industrialization is at culmination, releasing millions of tones of wastes & by-products every day, thereby producing a great threat to the environment existing living creatures of the universe. So it is the dire need of the hour to tackle with such problems, in a technical manner so that the hazards of these wastes will be reduced to minimum extent. As far Basic oxygen furnace slag is concerned, it is considered to be a waste materials & is thrown unused .In this present research work we are going to bring such a said waste in use, this will not only increase the practical utility of this product but also will make the concrete mixes economical & will reduce the threat of environment by being polluted by wastes like Basic oxygen furnace slag. In this study the fine aggregates were partially replaced with Basic oxygen furnace Slag with different proportions by weight i.e., 15%, 25%, 35% of Basic oxygen furnace Slag Compressive strength on M-25 grade of concrete at 0.46 water cement ratio was investigated. The results thus found from performed tests were compared with conventional concrete. The results revealed that the use of Basic oxygen furnace Slag up to a certain percentage enhances the strength of concrete.**

***Keywords*— Basic oxygen furnace Slag, water cement ratio, Compressive strength, concrete.'**

I INTRODUCTION

Basic Oxygen Furnace slag is formed during the conversion of hot metal from the blast furnace into steel in a basic oxygen furnace. In this process the hot metal is treated by blowing oxygen to remove carbon and other elements that have a high affinity to oxygen. The slag is generated by the addition of fluxes, such as lime [stone] and dolomite that combine with silicates and oxides to form liquid slag. Some amounts of scrap are also added in order to control the temperature of the exothermal reactions.

When the reaction process is complete, molten crude steel collects on the bottom of the furnace and the liquid slag floats on top of it. The crude steel and the slag are tapped into separate ladles/pots at temperatures typically above 1600°C. After tapping, the liquid slag in the pot can further be treated by injection of SiO_2 and oxygen in order to increase volume stability. The molten slag is then poured into pits or ground bays where it air-cools under controlled conditions forming crystalline slag. In order to adjust the required technical properties for a specific use, different measures like weathering, crushing and sieving are performed on the crystalline slag. The composition of basic oxygen furnace slag is presented in Table:1

Table : 1 - Composition of Basic Oxygen Furnace Slag

Element	Weight%	Atomic%
C	8.85	15.87
O	44.29	59.63
Mg	0.44	0.39
Al	8.57	6.84
Si	6.15	4.72
Ca	0.79	0.42
Ti	0.64	0.29
Cr	4.24	1.76
Mn	6.10	2.39
Fe	19.92	7.68

II MATERIALS USED

A Cement

Ordinary Portland Cement of 43 grade was used throughout the investigation. The cement was available in the local market Ambala City and kept in dry location. The tests were conducted to determine the properties of cement. Table: 2 shows the physical properties of Ordinary Portland Cement which were evaluated from the experimental work.

Table: 2 - Physical properties of Ordinary Portland Cement

S.No	Property	Results	Standards as per IS:8112-1989
1	Fineness	3%	10%
2	Soundness	1 mm	10mm (minimum)
3	Setting time	Initial = 95 min Final= 165 min	Initial = 30 min (minimum) , Final = 600 min (maximum)
4	Specific gravity	3.15	-
5	Compressive strength	After 7 days = 33.2 MPa	After 7 days = 33 MPa
		After 28 days = 44.32 MPa	After 28 days = 42 MPa

B Water

Tap water, potable without any salts or chemicals was used in the study. The water source was the concrete laboratory in Ram Devi Jindal College.

C Natural Aggregates

In this study, both coarse and fine aggregates were used to prepare a controlled as well as treated concrete. The various physical properties of coarse aggregate and fine aggregate were assessed with IS 383:1970. The physical properties of coarse aggregates and fine aggregates are tabulated in Table: 3 & 4.

Table : 3 - Physical Properties of Natural Coarse Aggregates

Characteristics	Value
Colour	Grey
Shape	Angular
Maximum size	20 mm
Specific Gravity	2.64
Total water absorption	1.01%
Fineness Modulus	6.96

Table : 4 - Physical Properties of Natural fine Aggregate

Characteristics	Value
Water absorption	2.04
Fineness modulus	2.63
Bulk density	2.60
Specific Gravity	2.57

III TEST PROGRAM

The experiments and steps carried out in this research work to study the effect Basic oxygen furnace slag on concrete properties are as under:

- Collection of raw materials. Sieve Analysis of Fine aggregate, coarse aggregate, Basic oxygen furnace slag is done.
- Prepare the concrete mix samples like cube, beam, cylinder (3-from each mix , at every percentage level) i.e., from the control mix A and also from the concrete mix which are made after replacing the 15% , 25 % & 35% of sand with Basic oxygen furnace slag respectively.
- Compressive Strength Test is done after 7 days and 28 days for every concrete mix sample.

IV MIX PROPORTIONS

The proportions in this mix was designed using fine aggregates (F.M=2.63), and natural aggregate as a coarse aggregate (FM=6.96), with 0.46 water cement ratio. Table 5 & 6 represent the mix proportions & ratios respectively.

Table : 5 - Various Mix Proportions of M- 25 Control mix Concrete

Material	Quantiy Kg/m^3	Standards as per IS: 10262-2009 & IS: 456-2000
Cement	418	300 Kg/m^3 (minimum)
Coarse aggregate	1105	-
Fine aggregate	660	-
Water	192	186 (maximum) for 20mm aggregates
Water cement ratio	0.46	0.50 (maximum)

Table : 6 - Ratios of different Mixes

S.No	Mix	Percentage Replacement	Ratio
Control Mix (Cement : Fine Aggregates : Coarse Aggregates)			
1	Mix A	-	1 : 1.57 : 2.64
Basic oxygen furnace slag concrete (Cement : Fine Aggregates : Basic oxygen furnace slag : Coarse Aggregates)			
2	Mix B	15%	1 : 1.34 : 0.21 : 2.64
3	Mix C	25%	1 : 1.18 : 0.39 : 2.64
4	Mix D	35%	1 : 1.02 : 0.55 : 2.64

V COMPRESSIVE STRENGTH TEST

All batches described above in the experimental program were prepared, cured, and tested for compressive strength after 7 and 28 day. Standard 150 x 150 x 150 mm cubes were used for compressive strength. As shown in Figure 1, three identical specimens were crushed at 7 days and three identical specimens were crushed at 28 days. The compressive strength was calculated by dividing the failure load by average cross sectional area.

Figure : 1 - Compressive strength testing machine

The results shows that the compressive strength has increased by 31.26%, 56.13%, 73.53% after 7 days & 38%, 62.62% & 75.36% after 28 days at 15%, 25%, 35% replacement levels of Basic oxygen furnace slag respectively adding Basic oxygen furnace slag to the concrete .The 7 days and 28 days results are presented in Table 7

Table : 7 - Compressive strength test results for cube samples (150mm x 150mmx150mm)

Basic oxygen furnace slag				
Mix	Compressive strength N/mm²		Average compressive strength N/mm²	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS
CM	23.8	32.1	23.8	32.1
	25.2	31.9		
	22.69	33.45		
15%	31.1	43.1	31.24	44.3
	32.22	45.30		
	30.39	44.52		
25%	35.81	51.26	37.16	52.2
	38.45	52.58		
	37.22	52.69		
35%	40.69	55.61	41.30	56.29
	42.72	56.31		
	40.56	56.94		

The test results are represented graphically in figure 2

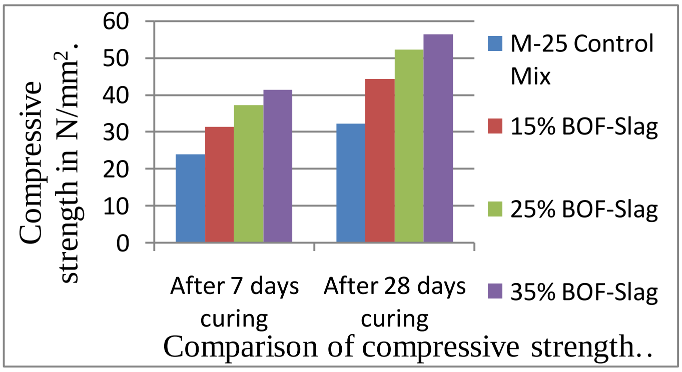

Figure 2- Comparison of compressive strength of M-25 control mix with 15%, 25%, 35% Basic Oxygen furnace slag added concrete

VI CONCLUSIONS

- The compressive strength tends to increase with increase in the percentage of Basic Oxygen furnace slag, by weight to the concrete. A direct relationship was seen between the addition of Basic Oxygen furnace slag & the compressive strength achieved in the mixes that too at all the three replacement levels i.e., 15%, 25% & 35%. The maximum values of compressive strength i.e., 41.30 N/mm^2 after 7 days & 56.29 N/mm^2 after 28 days were achieved at 35% replacement of sand with Basic Oxygen furnace slag .
- The results shows that the compressive strength has increased by 31.26%, 56.13%, 73.53% after 7 days & 38%, 62.62% & 75.36% after 28 days at 15%, 25%, 35% replacement levels of Basic oxygen furnace slag respectively adding Basic oxygen furnace slag to the concrete.
- From the obtained values of density Basic Oxygen furnace slag based concrete gives greater density than controlled M-25 grade of concrete & gives a maximum value 2497.2 Kg/m^3 at 35% replacement.
- Thus It can be said that Basic Oxygen furnace slag can be confidently & economically used instead of natural sand, to produce concrete of commendable strength, in the areas where there is deficiency of natural sand & in the areas where Basic Oxygen furnace slag is available in abundance.

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