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Effect of Partial Replacement of Cement with Blast Furnace Slag and Sand with Cast Iron Chips on the Strength of Concrete

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***Abstract*— Environmental pollution is one of the major concerns of all the environment related departments. Industrialization is at peak, releasing billions of tones of wastes & byproducts every day, thereby producing a great threat to the 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 Blast furnace slag & Cast Iron Chips are concerned they were considered to be as waste materials & were thrown unused. In this present research work we are going to bring such said wastes in, this will not only increase the practical utility of these products but also will make the concrete mixes economical & will reduce the threat of environment by being polluted by such wastes. In the present study firstly we will fabricate Mix A i.e., M-20 grade of concrete, with 0.5 water cement ratio & secondly we will prepare concrete mixes first by partially replacing the fine aggregates with cast iron chips, by weight. The range of replacement of fine aggregates varies as 10%, 20% & 30% respectively & such mixes are named as Mix B, Mix C & Mix D respectively. In the second context we are replacing cement with Blast Furnace Slag, but the percentage of Cast Iron Chips remains the same i.e., 30%. Here the levels of replacement will remain the same as in previous case i.e., 10%, 20% & 30%. So Mix E is composed of 30% by weight of Cast Iron Chips (replacement of sand by weight =30% with Cast Iron Chips), 10% by weight of Blast Furnace Slag & other ingredients of concrete. Mix F is composed of 30% by weight of Cast Iron Chips (replacement of sand by weight =30% with Cast Iron Chips), 20% by weight of Blast Furnace Slag, with 20% replacement of cement & rest of the constituents remaining the same. Mix G will be the composition of 30% by weight of Cast Iron Chips (replacement of sand by weight = 30% with Cast Iron Chips), 30% by weight of Blast Furnace Slag, replacing 30% of cement in the mix. The results recommend the use of Cast Iron Chips in concrete instead of sand & use of Blast Furnace Slag instead of cement as well , up to certain level of replacement& improves the compressive strength of concrete mixes fabricated by bringing such wastes in use.**

Keywords*— *Blast Furnace Slag, Cast Iron Chips, water cement ratio, Compressive strength, concrete.

I INTRODUCTION

A blast furnace is a type of metallurgical furnace that is used to produce a metal from its ore. In the iron making process, blast furnace is continuously charged with iron bearing materials in the form of iron ore lumps, fluxing agents such as limestone and coke from the top of the furnace as a fuel and reducing agent in the production of iron. From the iron ore and the added fluxing agents like coke and limestone, molten iron and slag is formed. Oxygen in the preheated air blown into the furnace combines with the carbon of the coke to produce the needed heat and carbon monoxide. At the same time, the iron ore is reduced to iron, mainly through the dioxide. The oxides of calcium and magnesium combine with silica and alumina to form slag. The reaction of the carbon monoxide with the iron oxide yields carbon dioxide (CO_2) and metallic iron. The fluxing agents dissociate into calcium and magnesium oxides and carbon dioxide. The oxides of calcium and magnesium combine with silica and alumina to form slag.

Table 1: Chemical Composition of Blast Furnace Slag by EDS

Element	Weight%	Atomic%
C	4.65	7.28
O	60.51	71.17
Mg	5.58	4.32
Al	3.79	2.64
Si	14.41	9.65
K	0.47	0.23
Ca	8.57	4.02
Mn	0.84	0.29
Fe	1.19	0.40
Totals	100.00	

Numerous industrial and mechanical techniques utilized for the production of mechanical goods and instruments, include turning, milling, shaping, threading, drilling etc. The chips of the material thus produced can be brought into use in a number of ways. If these mechanical devices are being

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produced from the cast iron, then surely Cast Iron Chips will be produced.

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: Properties of Ordinary Portland Cement 43 Grade

Characteristics	Experimentally Obtained Values	Values Required as per IS 8112:1989
Specific Gravity	3.14	-
Fineness	3%	10% (maximum)
Standard Consistency, percent	31	-
Soundness:- By Le Chatelier method, mm	3	10 (maximum)
Initial Setting Time, minutes	149	30 (minimum)
Final Setting Time, minutes	312	600 (minimum)
Compressive Strength 3 days 7 days 28 days	 24.6 N/mm^2 38.3 N/mm^2 47.8 N/mm^2	 23 N/mm^2 (min.) 37.5 N/mm^2 (min) 43-58 N/mm^2

B Water

Tap water, potable without any salts or chemicals was used in the study. The water source was the concrete laboratory in Ramgarhia Institute of Engg. and Tech.

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 coarse aggregates

Characteristics	Experimentally Obtained Value
Colour	Grey
Shape	Angular
Maximum Size	20mm
Specific gravity	2.64
Fineness modulus	6.95
Water absorption, %	0.81

Table 4: Physical Properties of fine aggregates

Characteristics	Experimentally Obtained Value
Specific gravity	2.63
Bulk density	2.60
Fineness modulus	2.47
Water absorption, %	0.88

III TEST PROGRAM

The experiments and steps carried out in this research work to study the effect of Blast furnace slag & Cast iron chips on concrete properties are as under:

- Collection of raw materials. Sieve Analysis of Fine aggregate, coarse aggregate, Blast furnace slag & Cast Iron Chips is done.
- Prepare the concrete mix samples like cube (3-from each mix, at every percentage level) i.e., from the control Mix A and also from the concrete mixes which are made after replacing the 10%, 20% & 30% respectively of sand with Cast iron chips and then replacing cement with Blast Furnace slag, with the same percentage but the percentage of cast iron chips remains the same i.e., 30%.
- Test of compression is done on the cube samples after 7 and 28 days to determine the compressive strength gained by the designed mixes.

IV MIX PROPORTIONS

The proportions in this mix was designed using fine aggregates (F.M=2.47), and natural aggregate as a coarse aggregate (FM=6.95), with 0.5 water cement ratio. Table 5 & 6 represent the mix proportions & ratios respectively.

Table : 5 - Various Mix Proportions of M- 20 Control mix Concrete

Material Description	Weight (Kg/m3)
Cement (OPC) 43 Grade	384
Natural Fine sand	687
Natural coarse Aggregate	1125
Water	192
Water-cement ratio	0.5

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Table : 6 - Ratios of different Mixes

MIX	%age replacement of		Ratio
	Cement with Blast Furnace Slag	Sand with Cast Iron Chips	
Control Mix (Cement : Fine Aggregates : Coarse Aggregates)			
A	0	0	1 : 1.78 : 2.92
Cast Iron Chips added concrete (Cement : Fine Aggregates : Cast Iron Chips : Coarse Aggregates)			
B	0	10	1 : 1.60 : 0.18 :2.92
C	0	20	1 : 1.43 : 0.36 : 2.92
D	0	30	1 : 1.25 : 0.53 : 2.92
Blast Furnace Slag & Cast Iron Chips added concrete (Cement : Blast Furnace Slag : Fine Aggregates : Cast Iron Chips : Coarse Aggregates)			
E	10	30	1 : 0.11 : 1.39 : 0.59 : 3.25
F	20	30	1 : 0.25 : 1.56 : 0.67 : 3.66
G	30	30	1 : 0.42 : 1.78 : 0.76 : 4.18

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. 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 load of failure with average cross sectional area of the cube sample.

The evaluated results predicted increments in compressive strength gained in the range of 38.53%, 83.74%, 89.56% after 7 days for 3 samples respectively, increments in the range of 38.79%, 43.74%, 48.28% for 3 samples respectively

Figure : 1 - Compressive strength testing machine

at the age of 28 days in Mixes B, C & D respectively, when the comparison of these mixes was done with that of control Mix A. As for Mixes E & F are concerned, the 7days compressive strength increases by 97.74% & 2.48% and 78.91% & 1.86% after 28 days for mixes E & F respectively. But when Mix-G was analyzed, it revealed a decrease by 6.12% after 7 days and 1.4% after 28 days when compared with 7& 28 days strength of Mix-A. The 7 days and 28 days results are presented in Table 7. The test results are represented graphically in figure 2.

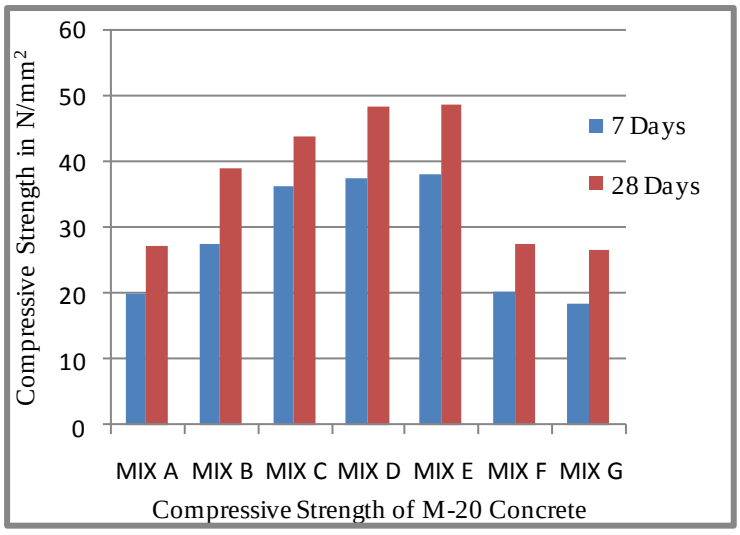

Figure 2: Graphical representation of Compressive Strength of Various Mix Proportions

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

MIX	%age replacement of		Compressive Strength (N/mm²)		Average Compressive Strength (N/mm²)	
	Cement with Blast Furnace Slag	Sand with Cast Iron Chips	7 Days	28 Days	7 Days	28 Days
A	0	0	18.13	25.98	19.75	27
			20.58	28.16		
			20.54	26.86		
B	0	10	27.86	39.42	27.36	38.79
			26.82	38.32		
			27.41	38.64		
C	0	20	36.18	44.22	36.29	43.74
			36.78	43.8		
			35.92	43.22		
D	0	30	36.92	47.2	37.44	48.21
			37.53	48.82		
			37.88	48.63		
E	10	30	37.29	48.43	37.87	48.55
			38.22	49.01		
			38.1	48.23		
F	20	30	18.39	26.1	20.24	27.5
			21.68	27.98		
			20.66	28.43		
G	30	30	17.92	25.45	18.54	26.62
			18.88	26.43		
			18.82	27.98		

VI CONCLUSIONS

•From the test results a direct relationship was observed between the addition of Cast iron chips to the concrete mix and the compressive strength.

•The maximum range of strength in compression achieved in the mixes after 7 days is 37.87N/mm^{2}and same was 48.55N/mm^2 after 28 days. This was observed for Mix E which was fabricated with 10% replacement of cement with Blast Furnace Slag and 30% replacement of Sand with Cast Iron Chips.

• The increment in percentage of compressive strength were in the range of 38.53%, 83.74%, 89.56% after 7 days &38.79%, 43.74%, 48.28% after 28 days at 10%, 20%, 30% replacement levels of Cast Iron Chips respectively in the concrete. Also by replacing cement with Blast Furnace slag at 10%, 20%, and retaining the percentage level of the Cast Iron chips to 30%, the compressive strength of the concrete marginally tends to increase, but when the replacement levels of Blast furnace slag and Cast iron chips were raised to 30%, the values of compressive strength obtained got decreased by 6.12% and 1.4 % respectively after 7 & 28 days.

• In the nut shell it could be said that the wastes like Blast Furnace Slag & Cast Iron Chips can be added to concrete to enhance the compressive strength. The natural environment and the elements of environment could be prevented from being polluted with the addition of such wastes.

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