AN EXPERIMENTAL INVESTIGATION FOR THE USE OF BLAST FURNACE SLAG FOR IMPROVING MECHANICAL PROPERTY OF CONCRETE

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ABSTRACT

This paper presents result of an experimental investigation carried out to evaluate effects of replacing aggregates (fine) with that of Slag which is an industrial waste by-product on concrete strength properties. The basic objective of this study was to identify alternative source of good quality aggregates which is depleting very fast due to the fast pace of construction activities in India.Use of slag a waste industrial byproduct of iron and steel production provides great opportunity to utilize it as an alternative to normally available aggregates. In this study, Concrete of M25 grades were considered for a W/C ratio of 0.5 for the replacements of 0 , 20, 40,60,80 % 0f fine aggregate.Whole study was done in replacement of natural fine aggregate with granular slag. The investigation revealed improvement in compressive strength ,split tensile and flexure strength.

Keywords: slag aggregate, fine aggregate replacement ,Material for concrete.

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1. Introduction

The proper use of waste materials fundamentally affects our economy and environment. Over a period of time waste management has become one of the most complex and challenging problems in India affecting the environment. The rapid growth of industrialization gave birth to numerous kinds of waste byproducts which are environ- mentally hazard and create problems of storage. The construction industry has always been at forefront in consuming these waste products. The consumption of Slag which is waste generated by steel industry, in concrete not only helps in reducing green house gases but also helps in making environmentally friendly material. During the production of iron and steel, fluxes (limestone and/or dolomite) are charged into blast furnace along with coke for fuel. The coke is combusted to produce carbon monoxide, which reduces iron ore into molten iron product. Fluxing agents separate impurities and slag is produced during separation of molten steel. Slag is a nonmetallic inert byproduct primarily consists of silicates, alumino silicates, and calcium-alumina-silicates. The mol- ten slag which absorbs much of the sulfur from the charge comprises about 20 percent by mass of iron production.

,	Analysis	o.p.c(53 grade)
1	Cao	65.9
2	Sio_2	21.94
3	AL_2O_3	4.82
4	FE_2O_3	3.94
5	Mgo	1.65
6	K_2o	0.6
7	So_3	0.48
8	Na_2o_3	0.1

1.2 Research Significance in Indian Context

The availability of good quality aggregates is depleting day by day due to tremendous growth in Indian construction industry. Aggregates are the main ingredient of concrete occupying approximately 75% of its volume and directly affecting the fresh & hardened properties. Concrete being the largest man made material used on earth is continuously requiring good quality of aggregates in large volumes. A need was felt to identify potential alternative source of aggregate to fulfill the future growth aspiration of Indian construction industry. Use of slag as aggregates provides great opportunity to utilize this waste material as an alternative to normally available aggregates. The total steel production in India is about 72.20 Million Tones and the waste generated annually is around 18 Million Tones (considerably higher than the world average) but hardly 25% are being used mostly in cement production

1.3 Study Scope

In this study, concrete of M25 grade were considered for a W/C ratio of 0.5, with the targeted slump of 4 ± 1 in. (100 ± 25 mm) for the replacement of 0%, 20%, 40%, 60% & 80% of fine aggregate with that of slag aggregate. These concrete mixes were studied for the properties like compressive, split tensile and flexure strengths.

2. Experimental Investigation

2.1. Raw Materials

1:-Granulated blast furnace slag(GBFS)

In this investigation, slag from the local steel making plant. The chemical properties of the material are given in table 1

Table 1 -: Chemical property of GBFS

S.No.	Test Parameters	Results
1	Calcium Oxide (CaO)	1.84
2	Silicon Dioxide (SiO_2)	6.03
3	Aluminum Oxide (Al_2O_3)	2.28
4	Magnesium Oxide (MgO)	0.47
5	Iron (Fe_2O_3)	83.51
6	Manganese Oxide (MnO)	0.63
7	Sulfur (S)	0.04
8	Phosphorous Pentoxide (P_2O_5)	0.31
9	Chromium Oxide (Cr_2O_3)	0.06

2:- Properties of Conventional, Supplementary Cement & Aggregate Material.

Cement in general can be defined as material which possesses very good adhesive and cohesive properties that make it possible to bond with other materials to form a compact mass. Ordinary Portland cement (53 grade) cement conforming to IS 12269:1987 was used. The different laboratory tests were conducted on cement to determine soundness test, initial and final setting time, and compressive strength . The results conforms to the IS recommendations. Locally available river sand was used as fine aggregate. The fineness modulus of the sand is 2.63 and it is conforming to Zone-II of IS: 383-1970. The sand was dried before use to avoid the problem of bulking.

The shape and particle size distribution of the aggregate is very important as it affects the packing and voids content. Aggregate should be of uniform quality with respect to shape and grading. Coarse aggregate used in this project had a maximum size of 20mm

Table 2 : Test Result of Cement and Aggregate Material

Test	Test results for	Results
Sieve test of cement	Average fineness residue	1.6 %
Standard consistency test	Standard consistency	33 %
Initial setting time	Initial setting time	43 min
Compressive strength of cement	3 days	25.58
	7 days	39.36
	28 days	51.17
Specific gravity of aggregate	Fine aggregate	2.36
	Coarse aggregate	2.62
Fineness modulus	Fine aggregate	2.875
	Coarse aggregate	7.46
Bulking of sand	% Bulking	5.26 %

2.2 Mix Proportions

The mix proportions were made for a conventional mix of slump 100mm for M25 grade of concrete. Five mixes were made by replacing fine aggregate with slag by 0,20,40,60and80% replacement given in table3.

Table 3: Replacement proportion of aggregates

S.N	Course aggregate in %	Natural sand in %	Granulated Blast Furnace Slag in %
1	100	100	0
2	100	80	20
3	100	60	40
4	100	40	60
5	100	20	80

Table 4:- Mix proportions of conventional concrete.

Mix proportion for M25 grade concrete for 1 m^3

S.N	Mix proportion for one cum of concrete	M 25 grade
1	Mass of cement in kg /m^3	394 kg /m^3
2	Mass of water in kg /m^3	197 kg / m^3
3	Mass of fine aggregate in kg /m^3	640.03 kg / m^3
4	Mass of coarse aggregate in kg /m^3	1065.82 kg / m^3
5	Water cement ratio	0.5

2.3 Test set-up

The 15cm cubes (set of 3) each were cast for compressive strength (7,14and 28 days) , cylindrical test specimen have a diameter 15 cm and length 30 cm for split tensile strength and beam mould (50cm x10 cm x 10 cm) for flexural strength (28 days)

2.4 Fresh concrete properties:-

The concrete was tested for slump cone test , compaction factor test as per the IS-1199-Methods of Sampling of concrete, for each mix of concrete.

Table 5:- Results of slump test and compaction factor test

S.N.	Type of concrete	Sand replace by GBFS in %	Slump test (mm)	Compaction Factor test
1	Plain concrete	--	15	0.86
2	GBFS Concrete	20%	40	0.88

3	GBFS Concrete	40%	40	0.88
4	GBFS Concrete	60%	60	0.90
5	GBFS Concrete	80%	80	0.92

2.5 Hardened concrete properties:-

The test of 15 cm cubes (3nos) were tested for compressive strength at 7, 14, 28 days. Similarly cylindrical test specimen have a diameter 15 cm and length 30 cm for split tensile strength were tested. specimen have a diameter 15 cm and length 30 for split tensile strength and beam mould (50cm x10 cm x 10 cm) for flexural strength (28 days)

Result of compressive strength:-

Table 6:- Compressive strength of different % sample

Mix	Curing period in days	Partial replacement of sand by following % of Granulated blast furnace slag in concrete				
M25 grade concrete		0	20	40	60	80
		Average compressive strength (Mpa)				
	7	16	18.12	21.9	23.56	22.5
	14	21.89	24.01	25.37	29.74	23.86
	28	30.2	26.58	30.35	37	24.31

Result of split tensile and flexural test:-

Table 6:- Split tensile and flexural test of different % sample

Mix	Curing period in days	Partial replacement of sand by following % of Granulated blast furnace slag in concrete				
M25 grade concrete		0	20	40	60	80
		Average tensile strength (Mpa)				
	28	2.82	2.78	2.87	2.95	2.59
		Average flexural strength (Mpa)				
	28	1.58	1.49	1.64	1.94	1.07

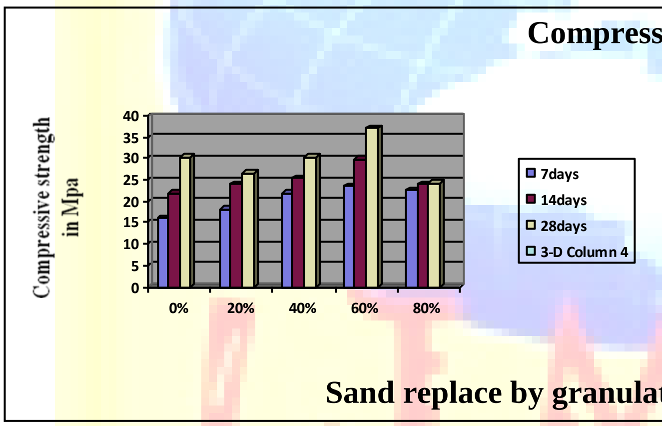
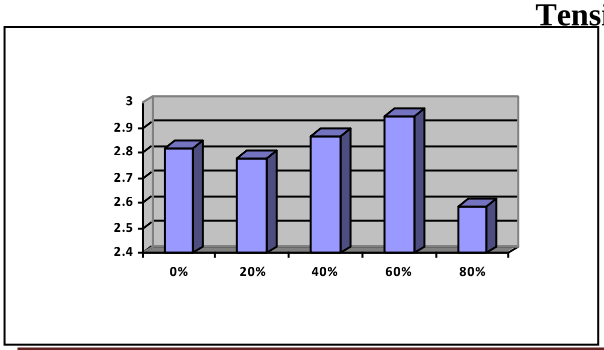


Fig 1. shows the comparison of conventional concrete with GBFS concrete for compressive strength.

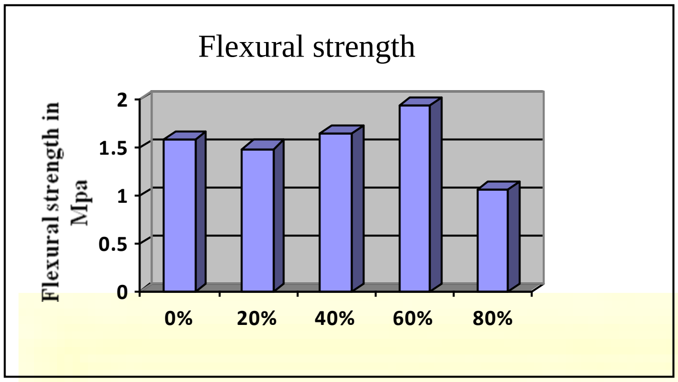
Tensile strength



Sand replace by Granulated blast furnace slag in %

Fig 2. shows the comparison of conventional concrete with GBFS concrete for tensile

strength



Sand replace by Granulated blast furnace slag in %

Fig 3. shows the comparison of conventional concrete with GBFS concrete for Flexural strength.

Conclusion:-

1) Results concluded that compressive strength of concrete reduced at 20 % upto 11.98 and increase at 60 % upto 22.52 and again reduced at 80 % upto 19.5 % compared to conventional concrete

2) The tensile strength improved by 4.61 % at 60 % replacement and reduced upto 8.16 % at 80 % replacement.

3) The flexural strength improved by 22.78 % at 60% replacement and reduced upto 32.28 % at 80 % replacement.

Hence, concluded that 60 % partial replacement of sand by slag is giving the highest result for compressive strength , tensile strength and flexural strength.hence it could be recommended that slag aggregate could be effectively utilized at fine aggregate in concrete application as partial replacement of fine aggregate.

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