HIGH PERFORMANCE CONCRETE WITH GGBS AND ROBO SAND

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Abstract:
Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete plays a vital role in the development of infrastructure Viz., buildings, industrial structures, bridges and highways etc. leading to utilization of large quantity of concrete. High Performance Concrete (HPC) is a concrete meeting special combinations of performance and uniformity requirements that cannot be always achieved routinely by using conventional constituents and normal mixing. This leads to examine the admixtures to improve the performance of the concrete. On the other side, cost of concrete is attributed to the cost of its ingredients which is scarce and expensive, this leading to usage of economically alternative materials in its production. This requirement is drawn the attention of investigators to explore new replacements of ingredients of concrete.

The present paper focuses on investigating characteristics of M_{30} concrete with partial replacement of cement with Ground Granulated Blastfurnace Slag (GGBS) and sand with the ROBO sand (crusher dust). The cubes and cylinders are tested for both compressive and tensile strengths. It is found that by the partial replacement of cement with GGBS and sand with ROBO sand helped in improving the strength of the concrete substantially compared to normal mix concrete.

Keywords: High Performance Concrete (HPC), Compressive Strength, Ground Granulated Blastfurnace Slag (GGBS), ROBO sand, Tensile Strength.

Introduction:

Concrete is basically a mixture of cement, fine and coarse aggregates. High-performance concrete (HPC) conforms to a set of standards above those of the most common applications, but not limited to strength. Some of the standards are ease of placement, compaction without segregation, early age strength, permeability etc. The researchers have done considerable work on replacing the cement with fly ash and blast furnace slag without affecting the strength. River sand (Fine aggregate), which is one of the constituents used in the production of concrete, has become expensive and scarce. So there is large demand for alternative materials.

The crusher dust produced from granite crushers is one of the alternative materials for river sand. The utilization of crusher dust which can be called as ROBO sand has been accepted as a building material in the western countries. Lot of research has been done regarding the crusher dust as alternative materials for river sand. Misra (1984) studied the effect of complete replacement of sand by stone dust in the cement – sand mortar cubes. Ahmad et. al. (1989) investigated by replacing sand with crusher sand (fine sand i.e. passing through 75µ). They found that the compressive strength of concrete having constant slump decreased linearly with increase in percentage of very fine sand. Similarly the slump of concrete is decreased when increasing the percentage of very fine sand. Sahu et al (2003) reported significant increase in compressive strength, modulus of rupture and split tensile strength when 40% of sand is replaced by quarry rock dust in concrete. Rajamane et al (2003) studied the properties of high performance concrete with partial replacement of cement by GGBS. They found that the compressive strength of concrete increased by 10.2 MPa at 28 days age compared to conventional concrete. Ilangovan et. al. (2008) studied on the feasibility of the usage of quarry rock dust as hundred percent substitutes for natural sand in concrete. They found that the compressive strength, flexural strength of concrete made of quarry rock dust is nearly 10% more than the conventional concrete.

This paper presents the study of compressive strength and split tensile strength of M_{30} conventional concrete by replacing the 0 to 30% (5% increment) of sand with ROBO sand and 40 to 60% of cement with GGBS. Tests were conducted on concrete cubes and cylinders to study compressive and split tensile strengths. The results are compared with the normal conventional concrete.

Materials:

Cement: Ordinary Portland cement of 43 grade confirming to IS 8112-1989. The properties of cement given in Table No.1.

Table 1. Properties of cement

Properties	Test Results	Limits as per IS8112-1989
Fineness (m2/Kg) (Specific surface)	296	225
Initial Setting time (minutes)	160	30
Final setting Time (Minutes)	305	600
Soundness (mm) by Lechatelier	2	10
Compressive strength (MPa)		
3 days	33	23
7 days	42.3	33
28 days	59	43

Fine Aggregate: River sand having bulk density 1754 kg/m^3 and fineness modulus 3.16. The specific gravity was found to be 2.57. Sieve analysis results are shown in Fig.No.1 represents the grain size distribution of fine aggregate.

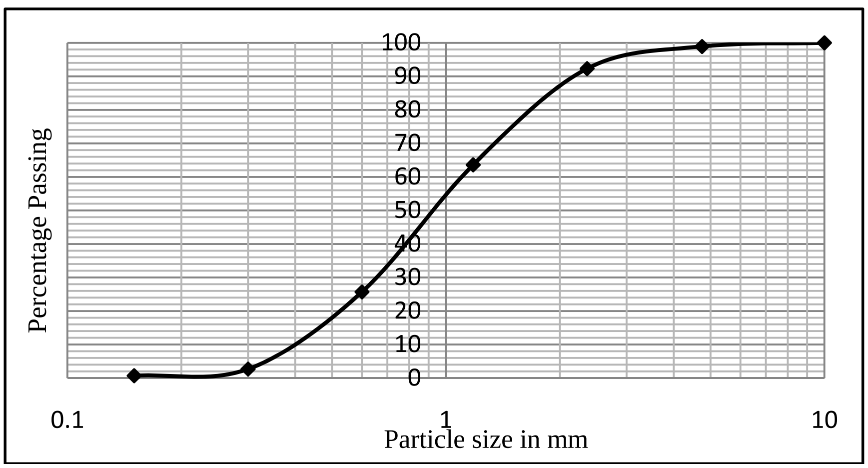

Fig.1. Grain size distribution curve for fine aggregate

Coarse aggregate: Natural granite aggregates having fineness modulus of 7.18 and bulk density of 1618kg/m^3. The specific gravity of coarse aggregate is 2.67. The flakiness and elongation indices are 28 and 17% respectively. Sieve analysis results are shown in Table No.2.

Table 2. Sieve analysis of Coarse aggregates

IS Sieve	Weight retained (gm)	% weight retained	Cumulative % weight retained	% passing	Limits as per IS 383 – 1970, IS 2386 – 1963
80	0	0	0	100	100
40	0	0	0	100	100
20	956	19.12	19.12	80.88	85– 100
10	4024	80.48	99.6	0.4	0 – 20
4.75	20	0.4	100	0	0 – 5
2.36	0	0	100	0	0
1.18	0	0	100	0	0
600	0	0	100	0	0
300	0	0	100	0	0
150	0	0	100	0	0
Total cumulative % of weight retained			718.72		

Ground Granulated Blast Furnace Slag (GGBS): GGBS is obtained by quenching molten iron slag (a by-product of iron and steel making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. GGBS is used to make durable concrete structures in combination with ordinary port land cement and/or other pozzolanic materials. GGBS has been widely used in Europe, and increasingly in the United States and in Asia (particularly in Japan and Singapore) for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years. Use of GGBS significantly reduces the risk of damages caused by alkali-silica reaction, higher resistance to chloride, and provides higher resistance to attacks by sulfate and other chemicals. GGBS is procured from vizag steel plant (VSP). The fineness modulus of GGBS using blaine's fineness is 320 m^2/kg and other properties of GGBS given in Table No.3.

Table 3. Properties of GGBS

Chemical Properties	GGBS (%)
SiO_2	34.06
Al_2O_3	18.8
Fe_2O_3	0.7
CaO	32.4
MgO	10.75
SO_3	0.85
S	0.65
MnO	0.49
Na_2O	0.31
K_2O	0.98
Cl	0.008

ROBO sand: ROBO sand or crusher dust obtained from local granite crushers was used in concrete to cast the cubes and cylinders. The bulk density of ROBO sand or crusher dust is 1768 kg/m^3. The specific gravity and fineness modulus of ROBO sand are 2.66 and 2.88 respectively. Sieve analysis results are shown in Fig. No. 2 represents the grain size distribution of ROBO sand.

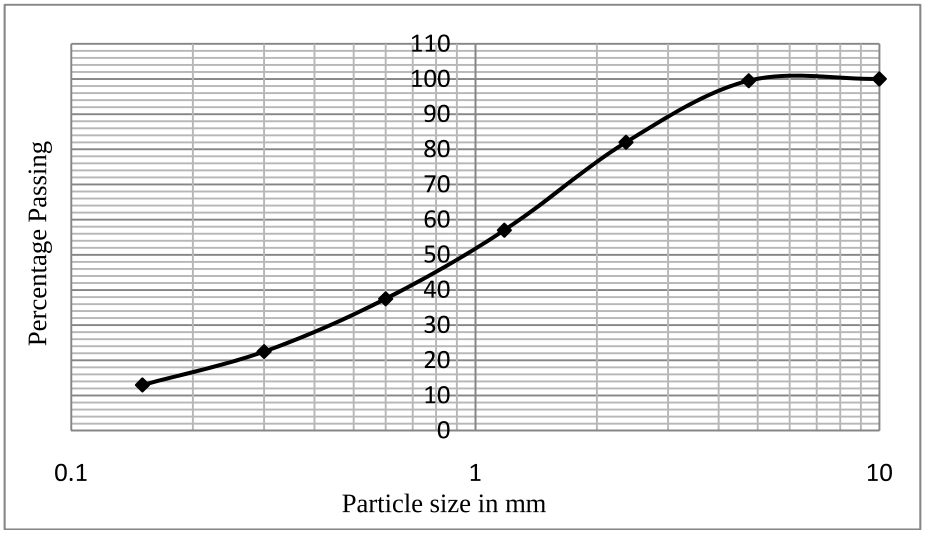

Fig.2. Grain size distribution curve for ROBO sand

Admixtures: A locally available admixture by the name SAVEMIX SP111 has been used to enhance the workability of the concrete.

Mix Design: The concrete mix is designed as per IS 10262 – 1982, IS 456-2000 and SP 23 for the conventional concrete and finally 0 to 30% river sand has been replaced by ROBO sand and 40 to 60% cement replaced with GGBS by volume. The water cement ratio is 0.42. The mix proportions of M_{30} concrete are 1:2.05:3.38.

Test Specimens and test procedure: The concrete cubes of 150mm size, cylinders of size 150mm diameter and 300mm length were used as test specimens to determine the compressive strength of concrete and split tensile strength of concrete for the both cases i.e. normal concrete and modified concrete. The ingredients of concrete were thoroughly mixed till uniform consistency was achieved. The cubes and cylinders were compacted on a vibrating table. The properties of fresh concrete were measured according to IS 1199 – 1959.

Results and Discussions: Experiments were conducted on normal concrete and modified concrete by replacing sand with ROBO sand and cement with GGBS. It is observed that the workability of concrete decreases with increase in percentages of ROBO sand.

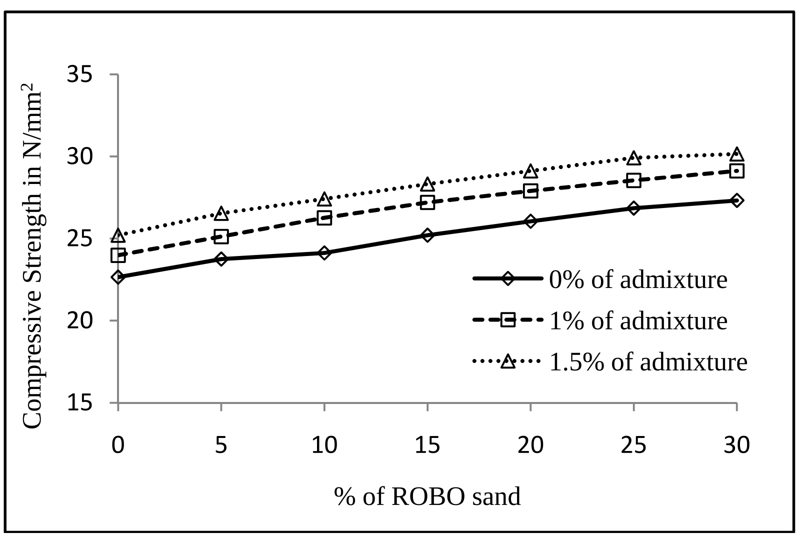

Fig.3. Compressive strength of concrete at the age of 7 days

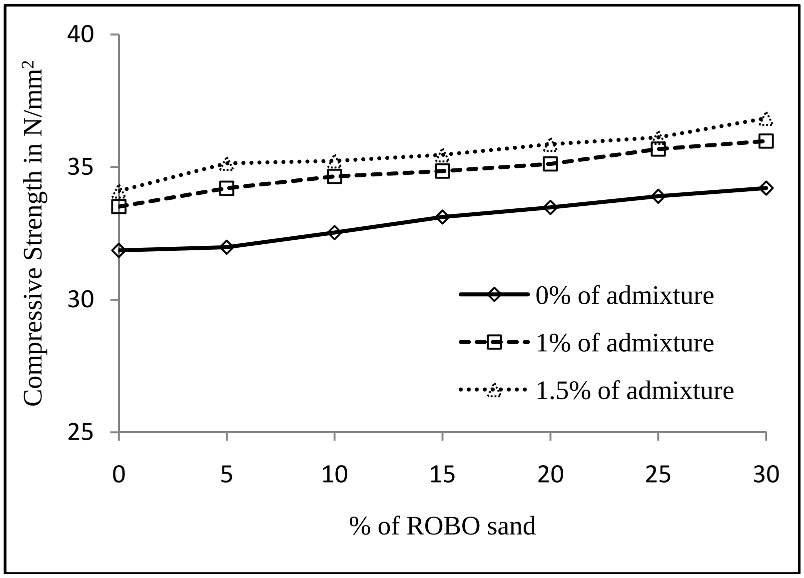

Fig.4. Compressive strength of concrete at the age of 28 days

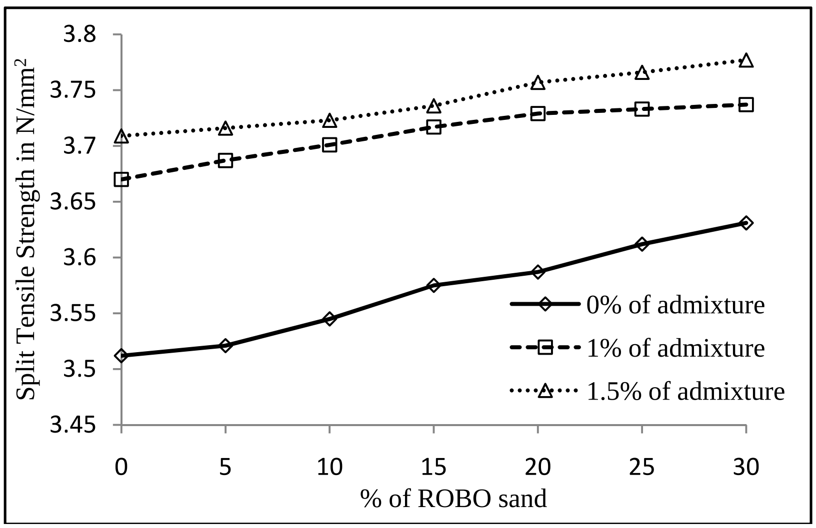

Fig.5. Split Tensile strength of concrete at the age of 28 days

Figure no. 3, 4, and 5 represents the compressive strength of conventional concrete and modified concrete i.e. with the replacement of sand with ROBO sand at the age 7 and 28 days and split tensile strength at the age of 28 days with the admixtures percentages 0, 1 and 1.5 respectively. The compressive strength and split tensile strength of concrete is increase as the percentage of ROBO sand increases with 1.5% of admixture when compared to 1% of admixture.

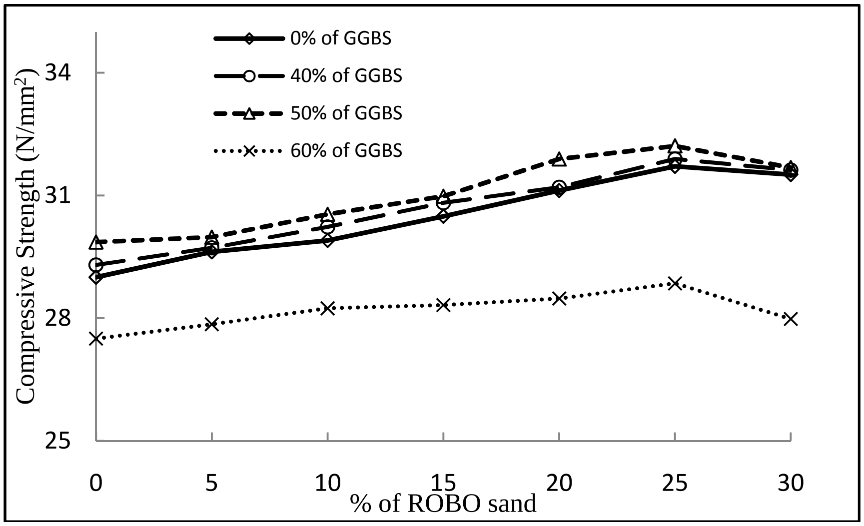

Fig.6. Compressive strength of concrete at the age of 7 days

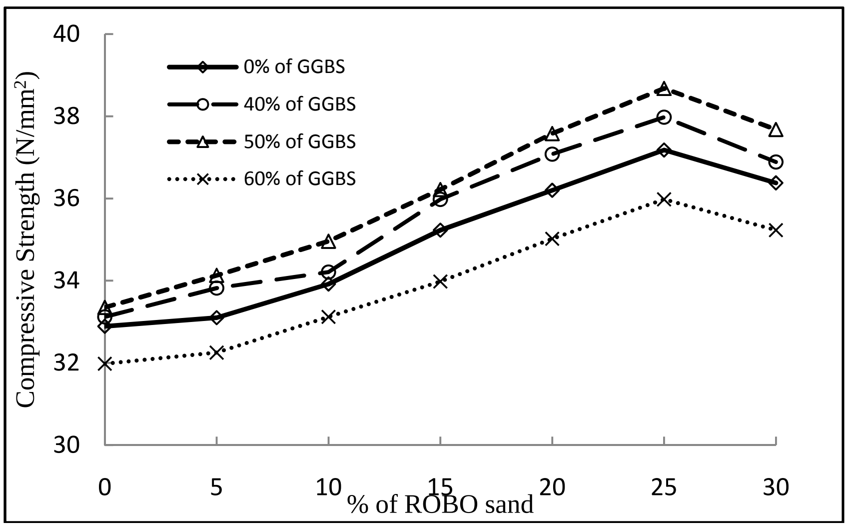

Fig.7. Compressive strength of concrete at the age of 28 days

Figure no. 6 and 7 represents the compressive strength of conventional concrete and modified concrete i.e. sand replaced with ROBO sand and cement replaced with GGBS with 1.5% of admixture. Compressive strength of concrete is increased as the percentage of ROBO sand and percentage of GGBS increases. The maximum compressive strength of concrete is achieved at the combination of 25% ROBO sand and 50% of GGBS.

Conclusions:

Based on the present and experimental investigation studies the following conclusions can be drawn

1. Compressive strength of concrete can be improved by using admixtures.
2. From the above experimental results it is proved that, ROBO sand can be used as alternative material for the fine aggregate i.e. sand. Based on the results the compressive and split tensile strengths are increased as the percentage of ROBO sand increased.
3. The percentage of increase in the compressive strength are 19.64 and 8.03% at the age of 7 and 28 days and the percentage of increase in the split tensile strength is 1.83% at the age of 28 days, by replacing 30% of sand with ROBO sand with 1.5% admixture.
4. GGBS can be used as one of the alternative material for the cement.
5. From the experimental results 50% of cement can be replaced with GGBS.
6. The percentage increase of compressive strength of concrete is 11.06 and 17.6% at the age of 7 and 28 days by replacing 50% of cement with GGBS and 25% of sand with ROBO sand.

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