Experimental Study on Partial Replacement of the Cement by RHA & GGBS and Natural Sand by Quarry Sand in Concrete

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Abstract— In civil engineering industry Concrete is an extraordinary and key structural material in the human history. Presently Portland cement and supplementary cementitious materials are cheapest binders which maintain the performance of concrete. However, out of these binders, production of Portland cement is very energy exhaustive along with CO2 production. About 1 tonne of CO2 is produced in manufacturing of each tonne of Portland cement (PC). Concrete is a heterogeneous mix of cement, aggregates and water. The samples were tested at the age of 7 days, 28 days. The test on hardened concrete are destructive test while the destructive test includes compressive strength test as per IS: 516-1959, split tensile strength test as per IS: 5816-1999, flexure strength test as per IS: 516-1959.The research is carried out in total three phase. In first phase, mix of M 30 grades concrete with replacement of 0%, 20%, 40%, 60%, 80% and 100% of quarry sand with natural sand is carried out. From this first phase to determine the optimum percentage of quarry sand this gives maximum compressive strength. It is observed that maximum strength is achieved when natural sand is partially replaced with 60% quarry sand. In second phase, the cement is partially replaced with GGBS by 10%, 20% and 30%. In third phase, combination of GGBS and RHA is partially replaced with cement. It is observed that the composition of 7.5% RHA + 22.5% GGBS+ 60% of quarry sand gives good strength results.

Key words: Rice husk ash (RHA), Cement(C), Ground granulated blast furnace slag (GGBS), Quarry sand (QS)

I. Introduction

Concrete is typically the most massive individual material element in the built environment. In order to fulfil its commitment to the sustainable development of the whole society, the concrete of tomorrow will not only be more durable, but also should be developed to satisfy socioeconomic needs at the lowest environmental impact. So the problem is related to environment, problem is related to cost minimization but structural engineer will give the solution by proper analyzing the properties of concrete made by using industrial waste material. If concrete is mixed with ground granulated blast furnace slag and rice husk ash as a partial replacement for Portland cement and quarry sand as a partial replacement for natural sand it would provide environmental and economic benefits and the required workability, durability, and strength necessary for the design of the structures. Ground granulated blast furnace slag rice husk ash and quarry sand concrete can protect the steel reinforcement more efficiently, so that it can resist corrosion, and thus the structure as a whole.

A. The objectives and scope of present study are:

1) To prove that the industrial waste from Steel industries can be a replacement for Cement and to find out the optimum percentage of partial replacement of natural sand with quarry sand and partial replacement of Cement with GGBS and RHA in concrete.
2) To study the physical and chemical properties of industrial waste and are the ingredients in concrete.
3) To determine the compressive strength, split tensile strength test and flexural strength test of concrete cubes, cylinders, beams respectively at 7 days, and 28days curing with and without GGBS, RHA and QS.
4) To provide economical construction material for all construction projects.
5) To provide safeguard to the environment by utilizing solid wastes properly.
6) To carried out acid resistant test.
7) To carried out Chloride Attack test.

II. Materials Used

The materials are used in experimental investigation include:

A. Cement:

Ordinary Portland cement available in local market of standard brand will be used in the investigation. The cement used must be tested for various properties as per IS 4031-1988 and found to conform various specifications as per IS 12269-1987. Cement must be conforming to 53 Grade having specific gravity 3.15.

Chemical Properties:

Material	Cement	RHA	GGBS (%)
SiO_2	19.71	83.87	35
Al_2O_3	5.20	(SiO_2 + Al_2O_3 +	(SiO_2 + Al_2O_3 +
Fe_2O_3	3.73	Fe_2O_3)=86.19	Fe_2O_3)=48.63
CaO	62.91	0.20	40
MgO	2.54	0.52	8
SO_3	2.72	0.11	0.85
K_2O	0.90	0.13	1.28
Na_2O	0.25	0.16	1.32
LOI	0.96	0.44	13.61

Table 1: following are the chemical properties of Cement (OPC 53 Grade), RHA and GGBS:

B. Ground Granulated Blast Furnace Slag (GGBS):

Ready to use ground granulated blast furnace slag is having physical and chemical properties in conformation with IS: 12089-1987. The GGBS which is used in this research is obtained from JSW Plant (Pune). Ground granulated blast-furnace slag (GGBS) is the granular material formed when molten iron blast furnace slag is rapidly chilled by immersion in water. It is a granular product with limited crystal formation and is highly cementations in nature and also ground to cement fineness and hydrates just like Portland Pozzolana Cement (PPC). The specific gravity of GGBS is 2.43.

C. Rice Husk Ash (RHA):

Rice husk ash used in this research was obtained from KEYA Enterprises Plant located in Solu in Alandi (Pune). RHA, produced after burning of Rice husk (RH). The rice husk has high reactivity and pozzolanic property. The Specific gravity of rice husk ash (RHA) was 2.80 and fineness of RHA 71.80.

D. Aggregate:

The good quality river sand that is natural sand was used as a fine aggregate conforming to Zone- I of IS: 383- 1970. The fineness modulus of natural sand was 2.735, specific gravity of natural sand was 2.40 and water absorption was 1.80%. Quarry sand obtained from Kurkum quarry plant Daund, Pune, conforming to Zone-I of IS: 383- 1970 having fineness modulus of 2.85, specific gravity of 2.54 and water absorption was 1%. The coarse aggregate which is passing through 20 mm and retained on 10 mm sieve was used in the research. The specific gravity of coarse aggregates was 2.79 and water absorption was 1.75%.

E. Water

In this research potable water which is free from organic substance and impurities was used for mixing as well as curing of concrete. Water used for mixing and curing is fresh potable ware, conforming to IS:3025-1964 part 22, part23, and IS: 456-2000.

III. EXPERIMENTAL PROGRAMME

A. Mixture Proportioning:

The M30 mix proportioning is designed as per IS guidelines, according to the Indian Standard (IS 10262-2009) Recommended Method. The total binder content was 438 kg/m³, fine aggregate was taken 618.696 kg/m³, coarse aggregate was taken 1130.06 kg/m³.This research is carried out in total three phase, in first phase mix of M30 grade concrete with replacement of 0%, 20%, 40%, 60%, 80% and 100% of quarry sand with natural sand is carried out and to determine the optimum percentage of partial replacement at which maximum compressive strength is achieved. In second phase, the cement is partially replaced with GGBS by 10%, 20% and 30% and in third phase combination of GGBS and RHA is partially replaced with cement and natural sand with quarry sand in concrete. Cubes, beams and cylinder moulds were used for testing and casting. The total mixing time was 7 minutes; Compaction of concrete is done in three layers with 25 strokes of 16 mm rod was carried out for each layer is done in concreting process. The concrete was left in the mould and allowed to set for 24 hrs before the cubes were remoulded and placed in curing tank until the day of testing that is 7 days and 28 days. The three specimens of each set was prepared and left for curing in the curing tank for 7 and 28 days.

Sr.no	Identification of Specimens	Replacement of Quarry sand	(w/c)
1	A	0%	0.4531
2	A1	20%	0.4533
3	A2	40%	0.4540
4	A3	60%	0.4553
5	A4	80%	0.4565
6	A5	100%	0.4569

Table 2: Workability of concrete (slump 100mm)

Sr. No	Identification of Specimens	Replacement of GGBS	Replacement of RHA	QS:NS
1.	A	0%	0%	00:100
2.	A3	0%	0%	60:40
3.	B1	10%	0%	60:40
4.	B2	20%	0%	60:40
5.	B3	30%	0%	60:40
6.	C1	25%	5%	60:40
7.	C2	23%	7%	60:40
8.	C3	22.5%	7.5%	60:40
9.	C4	20%	10%	60:40

Table 3: Details of mix proportions of replacements of GGBS and RHA with cement

B. Testing Method:

Testing is done as per following IS code. The testing is carried out for compressive strength on cubes as per IS: 516 –1959, split tensile strength on cylinder as per IS: 5816 –1999, flexural strength on beam of as per IS: 516 –1959. Following tests have been carried out:

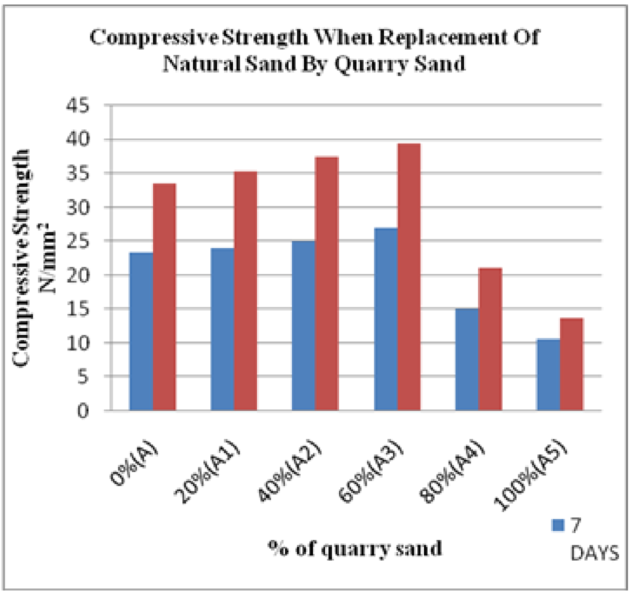
Durability Test

Acid Resistant Test

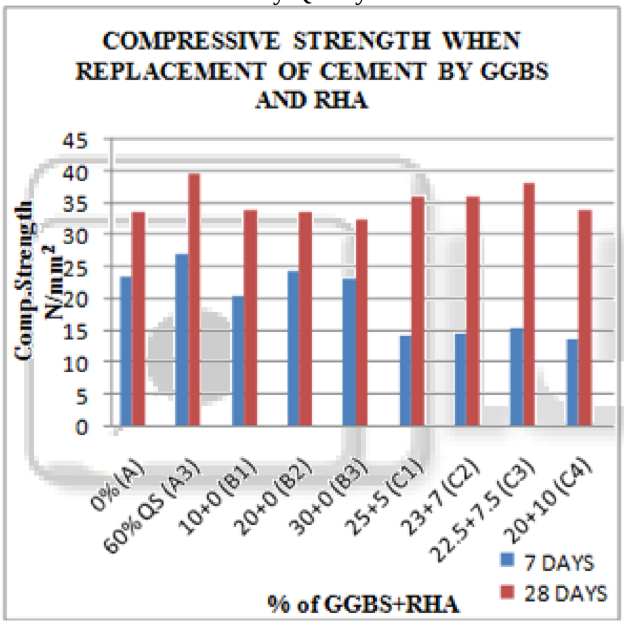
Chloride Attack Test

Sr. No	MIX	7 DAYS N/Mm²	28 DAYS N/Mm²	FLEXURE STRENGTH AFTER 28 DAYS N/Mm²	SPLIT TENSILE TEST AFTER 28 DAYS N/Mm²
1.	A	23.34	33.54	4.08	2.85
2.	A1	24.00	35.30	4.02	2.97
3.	A2	24.96	37.49	4.86	2.97
4.	A3	27.00	39.47	5.07	3.09
5.	A4	15.00	21.04	3.90	1.92
6.	A5	10.65	13.73	3.72	1.80
7.	B1	20.34	34.01	3.54	3.18
8.	B2	24.33	33.54	5.10	3.27
9.	B3	22.98	32.25	3.87	3.48
10.	C1	14.10	35.92	4.92	2.97
11.	C2	14.34	36.15	4.53	2.97
12.	C3	15.18	38.06	4.62	2.97
13.	C4	13.53	33.81	3.45	2.76

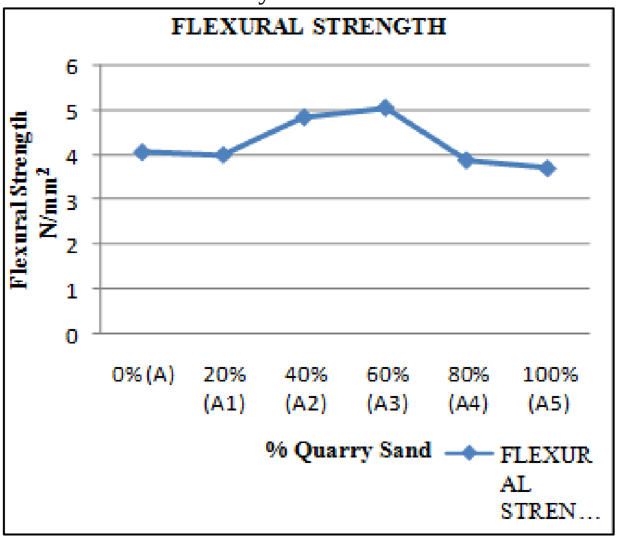
Table 4: Compressive strength, Flexural strength, Split tensile strength



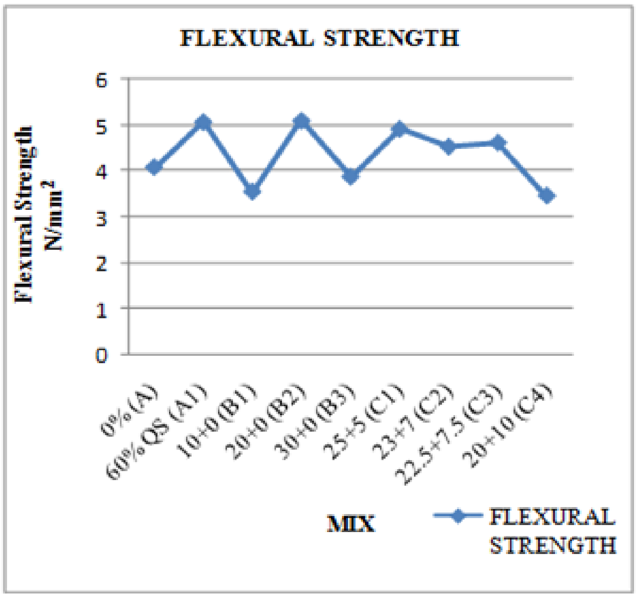
Graph 1: Compressive Strength with replacement of Natural Sand by Quarry Sand



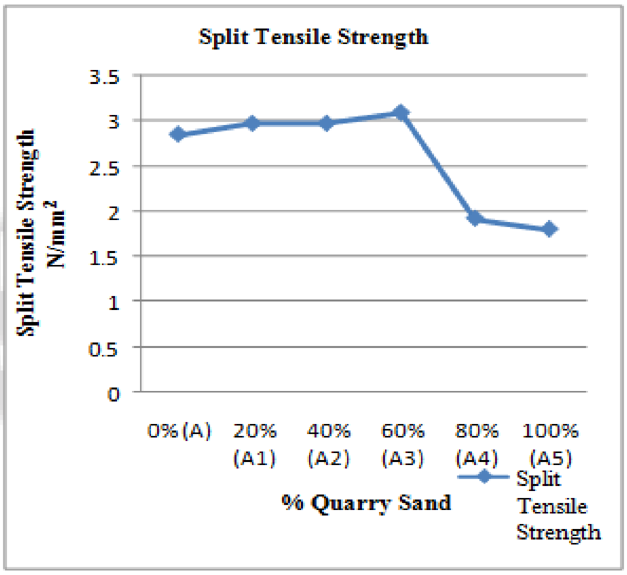
Graph 2: Compressive Strength when replacement of cement by GGBS and RHA



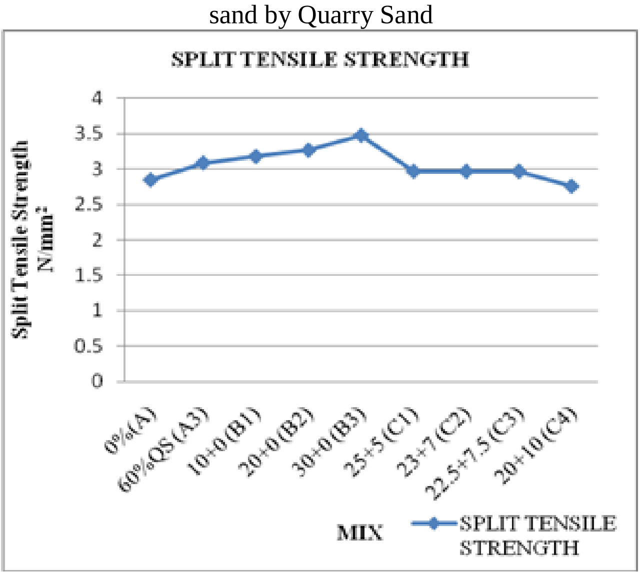
Graph 3: Flexural Strength when replacement of Natural Sand by Quarry Sand



Graph 4: Flexural Strength when replacement of cement by GGBS and combination of GGBS and RHA



Graph 5: Split tensile strength when Replacement of Natural sand by Quarry Sand



Graph 6: Split tensile strength when replacement of cement by GGBS and combination of GGBS and RHA

Sr. No	Mix designation	Avg. Weight of cubes before Immersion in Kg	Avg. Weight of cubes after immersion in Kg	Reduction in weight %	Avg. Compressive strength of cubes before immersion in N/mm²	Avg. Compressive strength of cubes after immersion in N/mm²	Reduction in Compressive strength %
1.	Control mix (A)	8.350	8.237	1.35	33.54	30.98	7.63
2.	60%QS &40% NS (A3)	8.700	8.586	1.31	39.47	37.10	6.00
3.	20% GGBS +60%QS &40% NS (B2)	8.680	8.582	1.132	33.54	31.97	4.68
4.	30% GGBS +60%QS (B3)	8.640	8.545	1.093	32.25	30.77	4.58
5.	22.5%GGBS+7.5%RH A+60% QS (C3)	8.950	8.882	0.759	38.06	37.17	2.33

Table 5: Reduction in weight and compressive strength of concrete cubes immersed in 1% Sulphuric acid solution.

Sr. No	Mix Designation	Avg. Weight Of Cubes Before Immersion In Kg	Avg. Weight Of Cubes After Immersion In Kg	Reduction In Weight %	Avg. Compressive Strength Of Cubes Before Immersion In N/Mm²	Avg. Compressive Strength Of Cubes After Immersion In N/Mm²	Reduction In Compressive Strength %
1.	Control Mix (A)	8.350	8.237	1.35	33.54	31.32	6.61
2.	60%QS &40% NS (A3)	8.700	8.586	1.31	39.47	37.75	4.35
3.	20% GGBS +60%QS &40% NS (B2)	8.680	8.582	1.132	33.54	31.77	5.27
4.	30% GGBS +60%QS (B3)	8.640	8.545	1.093	32.25	30.47	5.51
5.	22.5%GGBS+7.5%RH A+60% QS (C3)	8.950	8.882	0.759	38.06	36.93	2.96

Table 6: Reduction in weight and compressive strength of concrete cubes immersed in 3% Hydrochloric acid solution.

IV. CONCLUSION

1) Based on the results presented above, the following conclusion can be drawn:
2) Compressive strength increases with increase of percent of quarry sand up to certain limit.
3) Concrete acquires maximum increase in compressive strength at 60% quarry sand replaced by natural sand for M30 grade of concrete. This mix is named as critical mix.
4) By adopting same critical mix and replacing cement by GGBS, it is found that by increasing the percentage of GGBS; workability increases but strength decreases.
5) In order to increase the strength cement is replaced by combination of GGBS and RHA.
6) Good compressive strength is obtained when 22.5% GGBS + 7.5% RHA is replaced with cement and natural sand is replaced by 60% quarry sand.
7) The maximum 28 days split tensile strength was obtained with 30% GGBS replaced with cement.
8) The maximum 28 days flexural strength was obtained at A3 mix (60% QS and 40% NS) and B2 mix (20% cement is replaced with GGBS).
9) The workability of concrete had been found to be decrease with increase of quarry sand in concrete.
10) The workability of concrete had been found to be decrease with increase of RHA but the GGBS increases the workability of concrete.
11) Durability test carried out in the investigation through acid attack test and chloride test with 1% sulphuric acid and 3% hydrochloric revealed that 22.5%

GGBS+7.5%RHA replaced with cement and 60% quarry sand replaced with natural sand in concrete is more durable in terms of durability factors than control mix.

12) It is observed that combination of GGBS and Rice Husk Ash with QS concrete will be durable as compared to control concrete.

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