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Experimental Study on Strength of Concrete by Partial Replacement of Cement with GGBS

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ABSTRACT: Today's construction industry, use of concrete is going on increasing rapidly. Cement is major constituent material of the concrete which produced by natural raw material like lime and silica. Industrial waste like GGBS show chemical properties similar to cement use of GGBS cement replacement simultaneously reduces cost of concrete and reduces the rate of cement consumption. The study report of strength analysis of GGBS concrete will give assurance to encourage people working in the construction industry for beneficial use of it. This research work focuses on strength characteristics analysis of M40 grade concrete with replacement of cement by 30%, 50%, 70%, and 80% are compared with PCC.

KEY WORDS: GGBS, compressive strength test, split cylinder tensile strength, workability

I. INTRODUCTION

Ground Granulated Blast Furnace Slag (GGBS) is a by-product from the blast furnaces used to make iron. These operate at a temperature of about 1500 degrees centigrade and are fed with a carefully controlled mixture of iron ore, coke and limestone. The iron ore is reduced to iron and the remaining materials from a slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching optimises the cementitious properties and produces granules similar to coarse sand. This „granulated" slag is then dried and ground to a fine powder.

Blast furnace slag (BFS) have a long history of use as industrial by-products, going back almost 100 years in the United States and 150 years in Europe. Ground granulated blast furnace slag (GGBS) has been used in composite cements and as a cementitious component of concrete for many years. The first industrial commercial use (about 1859) was the production of bricks using unground granulated blast furnace slag (GBS). In the second half of the 19th century, its cementitious properties were discovered, and by the end of 19th century, the first cements containing GBS were produced. Since the late 1950s, the use of GGBS as a separately ground material added at the concrete mixer together with Portland cement has gained acceptance. In some countries, the term 'slag cement' is used for pure GGBS.

Air-cooled BFS produces a durable aggregate that performs well in unbound applications as well as in Portland cement and asphalt concretes. Cooling the slag with water produces a lightweight aggregate for use in masonry blocks and lightweight concrete. Pelletised and granulated BFS can be ground and used to make slag cement. Compared to regular Portland cement, slag cement provides reduced heat of hydration and improved resistance to sulphate attack and alkali-silica reaction. It is also resistant to chloride penetration, sulphate and thaumasitesulphate attack. It has low risk of thermal cracking and a high electrolytic resistance.

II. LITERATURE REVIEW

A. S. Arivalagan- This research work is an extinguished to develop a greenery concrete by using several industrial waste material In this report the M 35 mix design is used the GGBS replacement level is up to 40 % cement replacement, the maximum strength was obtained at the 20 % replacement at the age of 28 days. In this report the split tensile and flexure strength are also discussed at the replacement level of up to 40 % replacement and mechanical properties are compared with normal plain concrete.

B. Sonali k. Gadpalliwar, R.S. Deotale, Abhijeet R.Narde. (2014) In this report for M 40 mix design the mechanical properties are compared by adding quarry dust and GGBS. They concluded that the compressive strength increasers with percentage increase of quarry sand for certain limit. By the replacing the cement with GGBS the

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strength decreases and the workability increases They concluded that the maximum flexure strength is obtained at the 30 % replacement of GGBS with cement. They also concluded that the maximum split tensile strength is obtained at the 20 % replacement level of GGBS with cement.

B. Vinayak Awasare, Prof. M. V. Nagendra In this paper they have studied on the GGBS Blended cement concretes for M 20 mix design the compressive strength and flexure strength are determined with addition nof 20,30,50. % of GGBS with OPC 53 grade cement. And they by concluded that the ordinary cement concrete prepared by OPC cement and natural sand of M20 grade. The compressive strength of maximum achieved is 32.59 MPa at 30% of GGBS replacement and achieved for 20, 40, and 50% of concrete is 31.11Mpa, 30.7Mpa and 27.74Mpa respectively as compare to 29.11 MPa of strength of plain cement concrete for 28 days. The flexural strength achieved are 3.17 MPa, 3.62 MPa, 3.87 MPa, 3.55Mpa and 3. 41 MPa at 0%, 20%, 30%, 40% and 50% for GGBS concrete respectively for M20 grade concrete of OPC cement and natural sand. this report shows that tensile strength also give good performance for 20 %, 30%, and 40% replacement which is more than normal plain concrete.

III. EXPERIMENTAL PROGRAMME

The materials used in the project are as follows

- Cement
- Ground Granulated Blast Furnace Slag (GGBS)
- Coarse aggregate
- Fine aggregate
- Water
- 3Rheobuild

Cement:

Ordinary Portland cement of "KCP" brand 43 GRADE confirming to Indian standards is used in the present investigation. The cement is tested for its various properties as per IS:4031-1988 and found to be confirming to the requirements as per IS:8122-1989.

S.No	Physical Test	Obtained Results	Requirements as Per Is Codes
1	Fineness	2.6%	Not>10% as per IS 4031 part 1
2	Standard Consistency	27.5%	IS 4031 part 4
3	Initial Setting Time	47 min 11 sec	Not less than 30 min as per IS 4031 part 5
4	Final Setting Time	498 min	Not more than 600 min as per IS 4031 part 5
5	Soundness	5mm	Not>10mm as per IS 4031 part 3
6	Specific gravity	3.01	IS 2720 part 3(3.15 is general value)

Ground Granulated Blast Furnace Slag

Ground granulated blast furnace slag (GGBS) confirming to IS: 12089 may be used as part replacement of Ordinary Portland Cement. GGBS is obtained from Jindal steel and power ltd., Vijayawada office. The specific gravity of GGBS IS 2.9. Bulk density is 1200kg/m³ and Fineness is >350m²/kg. The colour of GGBS is off-white.

Coarse Aggregate

Machine crushed angular Basalt metal used as coarse aggregate. The coarse aggregate is free from clayey matter, silt and organic impurities etc. The coarse aggregate is also tested for specific gravity and it is 2.68 . Fineness modulus of coarse aggregate is 4.20. Aggregate of nominal size 20mm and 10mm is used in the experimental work which is acceptable according to IS: 383-1970.

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S.NO	Physical Tests	Obtained results	Requirements as per IS 383
1	Crushing Test	38%	Not more than 45% (other than wearing surfaces)
2	Impact Test	32.95%	Not more than 45% (other than wearing surfaces)
3	Los Angeles Abrasion Test	28.5%	Not more than 50% (other than wearing surfaces)
4	Flakiness Index	20.12%	Not>35%as per MORTH

Fine Aggregate

The sand obtained from Krishna River near Vijayawada is used as aggregate. In this project investigation. The sand is free from clayey matter, silt and organic impurities etc.The sand is tested for specific gravity, in accordance with IS: 2386-1963 and it is 2.719, whereas its fineness modulus is 2.31. The sieve analysis results are presented in table. The sand confirms to zone-2.

S.NO	Physical Property	Result
1	Fineness modulus	2.6%
2	Specific gravity	2.67

Water

The locally available potable water, which is free from concentration of acid and organic substances, is used for mixing the concrete.

Rheobuild Super Plasticizer

RHEOBUILD 920(SH) is composed of synthetic polymers specially designed to impart rheoplastic qualities to concrete.

MIX DESIGN (For M40)

Maximum nominal size of coarse aggregates= 20mm
Value of slump = 50mm
Specific gravity of cement = 3.15
Specific gravity of fine aggregate = 2.41
Specific gravity of coarse aggregate = 2.42
Water/cement ratio = 0.4
Water = 186 lit
Cement = 186/0.4 =465 kg
Fine aggregate =524.89 kg
Coarse aggregate =1070.12 kg

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Water	Cement	Fine Aggregate	Coarse Aggregate
186	465	524.89	1070.12
0.4	1	1.12	2.3

COMPRESSIVE STRENGTH FOR CONVENTIONAL AND GGBS CONCRETE MIXES:

S.NO	Time(days)	Compressive load KN	Compressive strength N/mm^2	Average strength N/mm^2
1	3	860	38.2	38
		850	37.2	
		860	38.2	
2	7	1010	44.8	45.18
		1020	45.3	
		1020	45.3	
3	28	1280	56.8	57
		1290	57.3	
		1280	56.8	

COMPRESSIVE TEST RESULTS FOR GGBS CONCRETE MIX

S.NO	**MIX**	**Compressive strength (N/mm^2)**	
		7 days	**28 days**
1	Conventional	43.66	55.25
2	30%GGBS	39.7	46.5
3	50%GGBS	39.5	46.3
4	70%GGBS	29.45	37.8
5	80%GGBS	22.34	31.4

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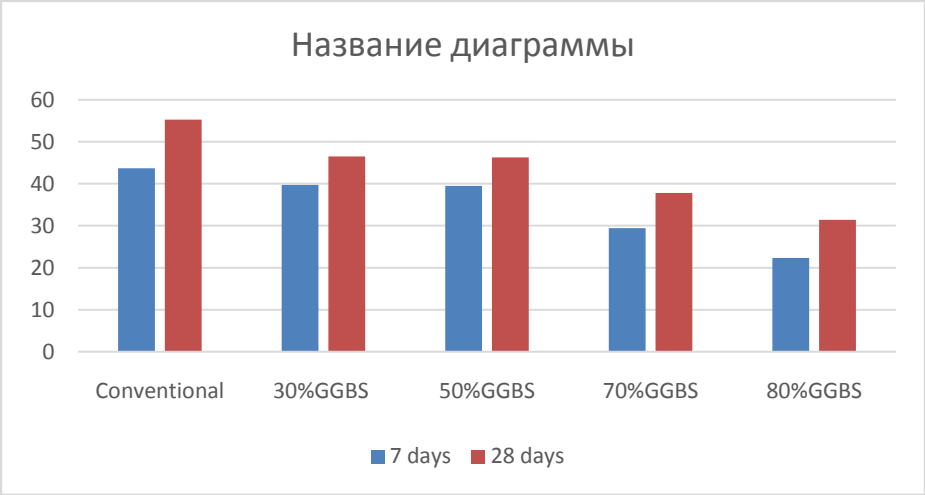
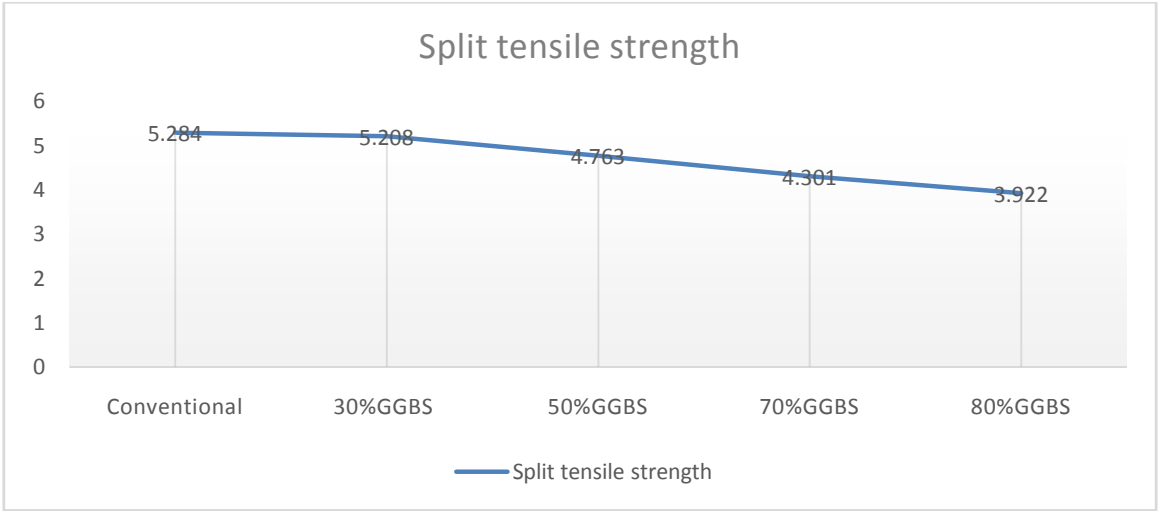


COMPRESSIVE TEST RESULTS

SPLIT TENSILE STRENGTH TEST RESULTS

S.NO	MIX	SPLIT TENSILE STRENGTH N/mm^2 (28 days)
1	Conventional	5.284
2	30%GGBS	5.208
3	50%GGBS	4.763
4	70%GGBS	4.301
5	80%GGBS	3.922



SPLIT TENSILE STRENGTH TEST RESULTS

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V. CONCLUSION

Based on experimental investigations conducted on concrete the following conclusions are drawn

- From the above results it is apparent that the compressive strength for 30% and 50% are nearly equal to the compressive strength of conventional concrete.
- The strength of GGBS Concrete increases as the number of days of curing increases for 30% and 50%.
- From the above results it is clear that industrial wastes can also be used in concrete as substitute materials for cement and fine aggregate which can produce required compressive strength.
- By using these industrial wastes in concrete, we can reduce the environmental pollution as they with conventional concrete. And there is no highly difference of 7, 14- and 28-days strength properties of
- At 20% replacement of coarse aggregates with ceramic waste and with 20% replacement of sand with quarry dust. The observed compressive strengths for M40 grade concrete is 50MPa. And the observed split tensile strength for m40 grade concrete is 2.70MPa.

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