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STRENGTH AND DURABILITY STUDIES ON CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY GGBS

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ABSTRACT

The Concrete is probably the most extensively used construction material in the world with about six billion tones being produced every year. It is only next to water in terms of per-capita consumption. However, environmental sustainability is at stake both in terms of damage caused by the extraction of raw material and CO_2 *emission during cement manufacture. This brought pressures on researchers for the reduction of cement consumption by partial replacement of cement by supplementary materials. These materials may be naturally occurring, industrial wastes or byproducts that are less energy intensive. These materials (called pozzalonas) when combined with calcium hydroxide, exhibits cementetious properties. Most commonly used pozzalonas are fly ash, silica fume, metakaolin, ground granulated blast furnace slag (GGBS). This needs to examine the admixtures performance when blended with concrete so as to ensure a reduced life cycle cost. The present paper focuses on investigating characteristics of M40 grade concrete with partial replacement of cement with ground granulated blast furnace slag (GGBS) by replacing cement via 20%, 35%, 50%. The cubes, cylinders and prisms are tested for compressive strength, split tensile strength, flexural strength. Durability studies with sodium Hydroxide and Hydrochloric acid were also conducted.*

Keywords *:Ground Granulated Blast furnace Slag (GGBS, Fly ash, Silica fume, Metakaolin*

1. INTRODUCTION

Sustainability was a big issue that being concern in making a development. This is because sustainable development has become a key aspect in society, Economics and development. Sustainable development shall meet the needs of the present without compromising ability of future generation to meets their own needs. It also shows that development that going to be made to sustain the planetary resources by using them effectively without making unnecessary wastage.

The usage of GGBS to replace the cement is because the production of the cement emits carbon dioxide gas to atmosphere. The cement industry is held responsible for some of the carbon dioxide emission, because the production of one ton Portland cement emits approximately one ton of carbon dioxide gas into the atmosphere. The emission of carbon dioxide will increase the effect of global warming due to the emission of greenhouse gasses. Among the greenhouse gasses, carbon dioxide contributes about 65% of global warming.

In the present situation as a result of rapid industrialization lots of industrial waste like fly ash, GGBS, silica fume and copper slag were accumulating day by day. The disposal of such industrial waste is becoming major issue. In other way concrete has occupied significant place in construction field since few decades. It has been used in mass concrete works as well as RCC structure like multi storied buildings, Flyovers, Bridges deck slabs and water retaining works.

1.1 OBJECTIVE

1. To determine the most optimized mix of GGBS- based concrete.
2. The main objective of this project work is to study strength characteristics like compressive strength, split tensile strength, flexural strength of concrete containing 40% constant partial replacement of cement by GGBS, adding in different percentages (100-00%, 80-20%, 65-35%,&50-50%) in 0.75% by weight of cement & completely replacement of fine aggregate by M-sand.
3. The workability characteristics such as slump test and compaction factor for the fresh concrete.
4. To utilize the ground granulated blast furnace slag in the concrete as a partial replacement of cement.
5. To reduce the environmental problems.

6. To reduce the consumption of natural sand.

2.METHODOLOGY

1.The materials for M-40 grade of concrete, such as cement, Ground Granulated Blast Furnace Slag, fine aggregate, coarse aggregate, super plasticizer are chosen.
2. The materials should be collected from a specific location and basic properties have to be studied.
3. Using these basic properties, mix design is carried out with suitable w/c ratiofor M-40 grade ofconcrete.
4. Required slump is obtained experimentally by slump cone test.
5. Concret cubes for all the trials will be cast to study the compressive strength ofconcrete. Then the cubes will be tested in compressive testing machine.
6. The compressive strength of the concrete will be determined by using 150 mm x150 mm x150 mm concrete cubespecimens. The specimens will be tested at 3 days, 7 days and 28 days of age, in compressive testing machine. The compressive strength will be obtained by considering the average of three specimens at each age.
7. Cylinder of size 150 mm x 300 mm and Beam of size 100 mm x 100 mm x 500 mm is used to determine Split tensile strength and Flexural strength respectively for 3 days, 7 days and 28 days of age, age ofcuring.
8. To evaluate the durability studies of M40 grade GGBS replacement concrete, with 1% and 5% concentrations of Hydro chloric acid (HCl) and Sodium Hydroxide (NaOH)
9. Using these test results suitable graphs is plotted.
10. Conclusions are drawn based on test results.

2.1 BASIC MATERIAL TESTING

a. Cement

In this present work RamcoOrdinary Portland Cement of 53(S) also called IRS: T-40-1985 Special grade

Table 1: Physical properties of Cement

S.NO	PROPERTY	VALUES
1	Specific gravity	3.13
2	Fineness of cement by sieving	2%
3	Normal consistency	32%
4	Setting time a)Initial setting time b)final setting time	 118 min 242 min
5	Compressive strength a) 3days b)7days c)28days	 25.3N/mm^2 36.6N/mm^2 25.26N/mm^2

a. Fine aggregate

Here manufactured sand has been used as fine aggregate and tested the same as per IS 2386-1963. The results are tabulated in Table 2.

Table2:Physical properties of manufactured sand

1	Specific gravity	2.52
2	Water absorption (%)	3.8
3	Zone	III

C. Coarse aggregate

In this investigation 20mm downsize of coarse aggregate were used and they were tested as per IS 2386-1963. The results are shown in Table 3.

Table 3: Physical properties of Coarse aggregate

1	Specific gravity	2.72
2	Water absorption (%)	0.7
3	Impact value (%)	18.46
4	Crushing Value (%)	20.73
5	Flakiness index (%)	18.63
6	Elongation index(%)	19.48

D. GGBS And Its Properties

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 15000C and are fed with carefully controlled mixture of iron-ore; 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 form manufacture of GGBS it has to be rapidly quenched in large volumes of water the quenching optimizes the cementations properties and produces granules similar to coarse sand this granulated slag is ten dried and ground to a fine powder.

Table 4: Physical properties of GGBS

Sl.no	Physical properties	Slag
1	Particle shape	Spherical
2	Appearance	White
3	Specific gravity	2.85
4	Bulk density	1200kg/m^3
5	Fineness	>350m^2/kg

2.2.MIX DESIGN OF M40 GRADE CONCRETE BY USING IS10262-2009

The concrete mix design is done under the guidelines of IS: 456 - 2000 and IS: 10262 – 2009.

Cement: 394 kg/m^3

Water: 157.6 liters

Fine aggregate: 720 kg/m^3

Coarse aggregate: 1174.5 kg/m^3

Super plasticizer: 3.152 kg/m^3

From the abovecalculations, we get the proportions as:

Cement: Fine aggregate: Coarse aggregate

1: 1.827: 2.98 with 0.4 as w/c ratio

Table 5: Details of Mix Proportions

Mix	Cement (kg)	GGBS (kg)	M-Sand (kg)	CA (kg)	Water in liters	SP in%
0	394	-	720	1174.5	157.6	0.8
20	315.2	78.8	720	1174.5	157.6	0.8
35	256.1	137.9	720	1174.5	157.6	0.8
50	315.2	197	720	1174.5	157.6	0.8

3.RESULTS

3.1 COMPRESSIVE STRENGTH TEST according to IS: 516-1959

This test meant for conducting to know the compressive strength of hardened concrete the cubes were taken out from curing tank dried and placed in compressive testing machine of 300T capacity the cube will be placed in testing machine.this test has been carried out on cube specimens at 3,7,and 28days of age the values are presented in table Compressive strength =P/4

Table 6: Compressive strength of M40 grade concrete

Compressive strength of specimens in (N/mm^2)			
% of cement replacement	Normal curing		
	3days	7days	28days
100	33.63	63.23	53.08
20	32.34	40.84	53.14
35	30.53	40.67	49.73
50	26.86	35.61	48.11

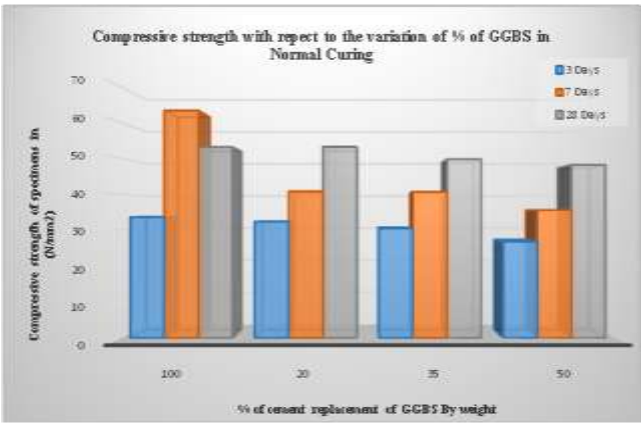

Chart 1: Comparison of compressive strength

Table 7: Compressive strength of M40 grade concrete

Compressive strength of specimens in (N/mm2)			
% of cement replacement	Base curing		
	3days	7days	28days
100	32.6	58.84	46.19
20	31.73	38.38	47.28
35	29.92	38.64	44.26
50	26.59	33.84	43.47

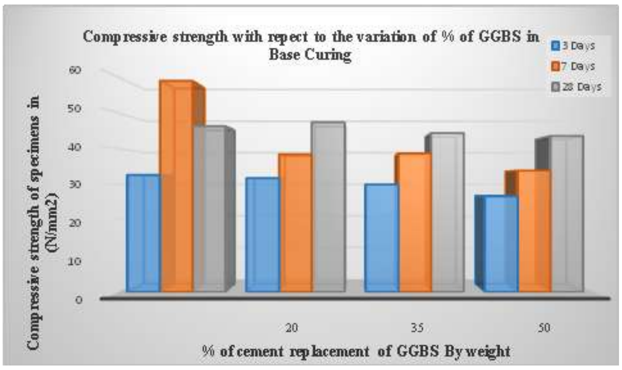

Chart 2: Comparison of compressive strength

Table 8: Compressive strength of M40 grade concrete

Compressive strength of specimens in (N/mm^2)			
% of cement replacement	Acid curing		
	3days	7days	28days
100	31.64	54.72	40.19
20	31.1	36.09	42.09
35	29.32	36.71	39.39
50	26.33	32.15	38.95

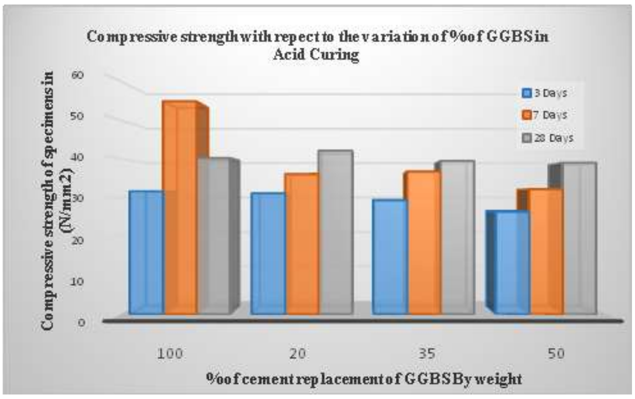

Chart 3: Comparison of compressive strength

3.2 SPLIT TENSILE TEST According to IS: 5816-1999

This test is conducted on 300T compression testing machine as shown in plate no. The cylinders prepared for testing are 150mm on diameter and 300mm height. In the present work, this test has been conducted on cylinder specimens after 3,7 and 28days of curing. The values are presented in the table.

Fct $=\frac{2P}{\pi DL}$

Table 9: Split Tensile strength of M40 grade concrete

Split tensile strength of specimens in (N/mm2)			
% of cement replacement	Normal curing		
	3days	7days	28days
100	2.06	2.52	3.45
20	1.99	2.47	3.2
35	1.84	2.31	2.99
50	1.59	2.19	3.19

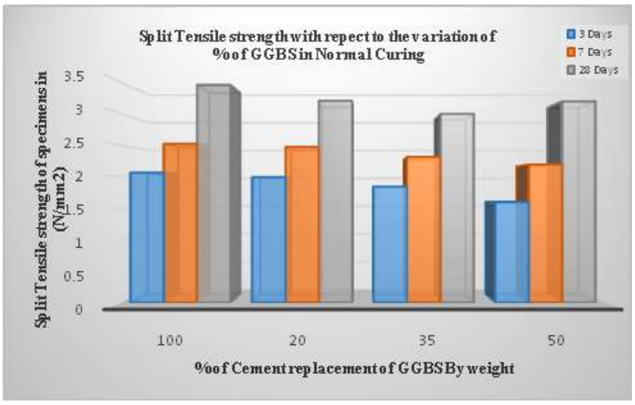

Chart 4: Comparison of split tensile strength

Table 10: Split tensile strength of M40 grade concrete

Split tensile strength of specimens in (N/mm^2)			
% of cement replacement	Base curing		
	3days	7days	28days
100	1.94	2.27	2.97
20	1.91	2.27	2.82
35	1.77	2.13	2.65
50	1.54	2.14	2.87

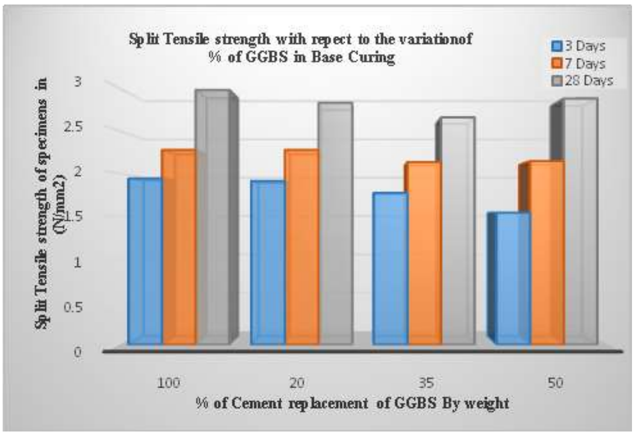

Chart 5: Comparison of split tensile strength

Table 11: Split tensile strength of M40 grade concrete

Split tensile strength of specimens in (N/mm2)			
% of cement replacement	Acid curing		
	3days	7days	28days
100	1.82	2.04	2.59
20	1.83	2.09	2.48
35	1.73	1.96	2.37
50	1.55	1.9	2.59

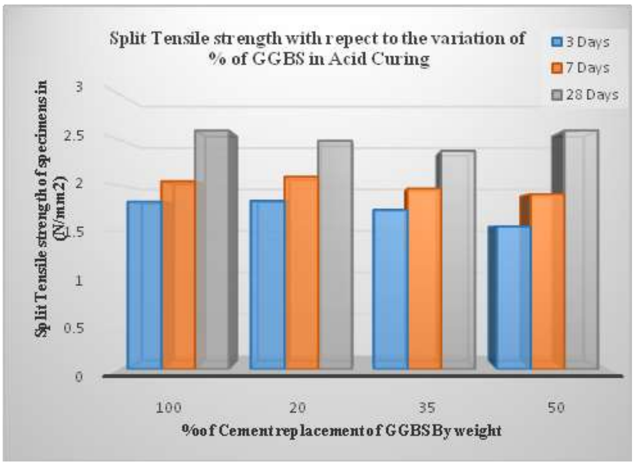

Chart 6: Comparison of split tensile strength

3.2.FLEXURAL STRENGTH TEST According to IS: 516-1959.

This test is conducted on 10T Universal Testing Machine. In the present investigation, this test has been conducted obeam specimens after 3,7 and 28 days of curing. The values are presented in the table

$$Fb = \frac{p \times l}{b \times d \times d}$$

Table 12: Flexural strength of M40 grade concrete

Flexural strength of specimens in (N/mm^2)			
% of cement replacement	Normal curing		
	3days	7days	28days
100	6.83	10.5	12
20	7.33	10.67	12.67
35	6.17	7.5	12.67
50	6	9	12

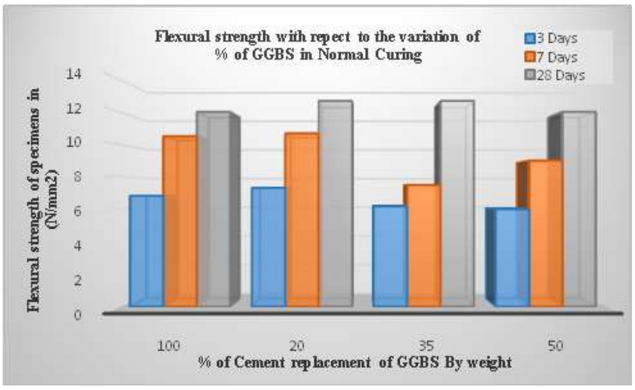

Chart 7: Comparison of Flexural strength

Table 13: Flexural strength of M40 grade concrete

Flexural strength of specimens in (N/mm^2)			
% of cement replacement	Base curing		
	3days	7days	28days
100	5.83	7.83	9.5
20	6.5	8.83	10
35	5.5	6.5	10
50	5.5	7.67	9.83

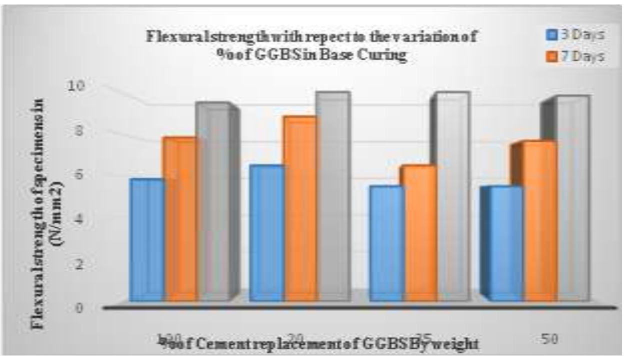

Chart 8: Comparison of Flexural strength

Table 14: Flexural strength of M40 grade concrete

Flexural strength of specimens in (N/mm2)			
% of cement replacement	Acid curing		
	3days	7days	28days
100	4.83	7	7.33
20	5.67	7.17	7.83
35	4.83	5.17	8
50	5	6.67	8

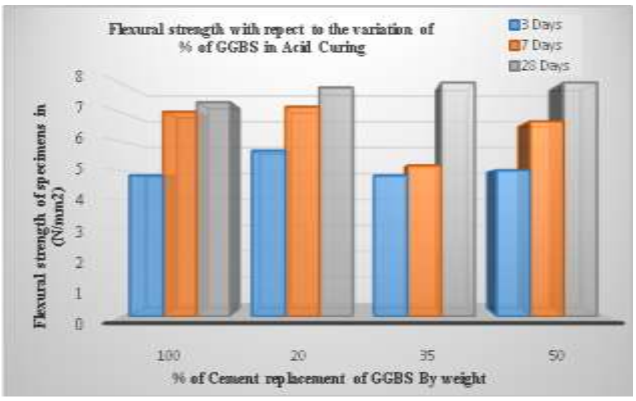

Chart 9: Comparison of Flexural strength

4. CONCLUSION

1. It is observed that at 20% replacement of cement with GGBS, concrete attains its maximum compressive strength, at 3,7,28,day of normal curing when the replacement exceeds 20%, the compressive is found to be decreasing slightly.
2. It is observed that at about 20% replacement of cement with GGBS, concrete attains its maximum Split Tensile strength at 3,7,28 days, when the replacement exceed 20%, the flexural is found to be decreasing slightly.
3. It is observed that at about 20% replacement of cement with GGBS, concrete attains its maximum Flexural strength than conventional concrete, when the replacement exceeds 20%, the flexural is found to be decreasing slightly.
4. It is observed that the compressive strength values of 5% concentration Hydrochloric acid (HCl) containing M40 grade concrete decreases, but resistance power of concrete increases with replacement of GGBS against to HCl, up to 20% replacement at 3,28 days the resistance power increases beyond that resistance power decreases, but at 20% replacement of GGBS the resistance power of concrete is more.
5. It is observed that the compressive strength values of 5% concentration Sodium Hydroxide (NaOH) containing M40 grade concrete decreases, but resistance power of concrete increases with replacement of GGBS against to (NaOH), up to 20% replacement at 3,28 days the resistance power increases beyond that resistance power decreases, but at 20% replacement of GGBS the resistance power of concrete is more.
6. it is observed that the Split Tensile strength values of 5% concentration Hydrochloric acid (HCl) containing M40 grade concrete decreases, but resistance power of concrete increases with replacement of GGBS against to HCl, up to 50% replacement at 28 days the resistance power increases beyond that resistance power decreases.
7. It is observed that the Split Tensile values of 5% concentration Sodium Hydroxide (NaOH) containing M40 grade concrete decreases, But resistance power of concrete increases with replacement of GGBS against to (NaOH), up to 50% replacement at 28 days the resistance power increases beyond that resistance power decreases. But at 50% replacement of GGBS the resistance power of concrete is more.
8. It is observed that the Flexural strength values of 5% concentration Hydrochloric acid (HCl) containing M40 grade concrete decreases, but resistance power of concrete increases with replacement of GGBS against to HCl, up to 20% replacement at 3,7,and 28 days, the resistance power increases beyond that resistance power decreases.
9. It is observed that the Flexural strength values of 5% concentration Sodium Hydroxide (NaOH) containing M40 grade concrete decreases, but resistance power of concrete increases with replacement of GGBS against to (NaOH) up to 20% replacement at 3,7, and 28 days the resistance power increases beyond that resistance power decreases, but at 20% replacement of GGBS the resistance power of concrete is more. And it is maximum than conventional concrete.

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