SUSTAINABLE GREEN CONCRETE USING G.G.B.S

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Abstract: Construction industry is an important sector which contributes greatly in the economic growth of a nation. In addition, it also greatly impacts the carbon emissions of a nation. In construction, production of concrete places the major contribution for the carbon emissions. So, to reduce the emission, various replacements were done to the conventional concrete. This is termed as Green concrete. The replacements are waste products such as fly ash, silica fumes, GGBS etc., Production of cement contributes majorly in the emission of CO_2. Using various supplementary materials as replacement for cement results in reduction of cement usage as well as reduction of CO_2 emission. In this experimental work, GGBS is replaced partially to cement with different proportions and exposed to atmosphere to study the various parameters.

Key words: Green concrete, GGBS, CO2 emission, various parameters.

1. Introduction: The term green concrete doesn't resemble the color of a concrete, but it covers every aspect of mix design to structural design of a concrete. The actual meaning of green concrete is to reduce the carbon emission by replacing or altering the materials of a conventional concrete. The conventional concrete practices are focused on short term economic considerations whereas sustainable construction practices are focused on long term affordability, durability and effectiveness. At present green concrete is the best sustainable concrete practice. Any construction done in a sustainable way minimizes the use of resources by achieving maximum results. In this practice green concrete places, a vital role in achieving it. Green concrete is the present best technique for the future whereas natural resources are on the edge of extinction.

Selection of materials is the main aspect of sustainable concrete which minimizes the negative impact on the environment. The production of cement and using it in concrete, both produce the CO_2. Production of one ton of cement produces one ton of CO_2 into the atmosphere. CO_2 is the main greenhouse gas that contributes to global warming. 90% of all carbon emissions from concrete are from manufacturing of cement. Here in this paper a study is done on partial replacement of cement with GGBS (Ground Granulated Blast Furnace Slag). The GGBS is a by-product in the manufacturing of iron and the amounts of iron and slag obtained are of the same order. GGBS concrete has better water impermeability characteristics as well as improved resistance to corrosion and sulphate attack.

2. Methodology:

- M40 mix design of concrete is done and its various strengths are determined. GGBS is replaced partially with cement to achieve reduction in CO_2 emissions and similar strength as of conventional concrete.
- To find the optimum replacement of GGBS, we increase the percentage from 10%,20%,30%,40%.
- Later cubes, beams and cylinders of the specimen were casted and cured.
- The cube mound sizes are 150*150*150mm and the beam mound sizes are 150*150*600mm and the cylindrical mound sizes are 150*300mm.
- The tests done are compressive, flexural and split tensile tests.
- Comparison is done based on various parameters for the different percentages of replaced concrete.

3. Experimental work:

Properties of the various materials used in the concrete are

3.1 Cement:

Cement used is OPC (Ordinary Portland Cement) of grade53, confirming to IS:269-1976 and IS:4031-1988.

Sr.No.	Tests	Obtained Values	Standard Values
1	Fineness	1.5%	<10%
2	Specific gravity(gm/cc)	3.14	3.1-3.2
3	Normal consistency	29%	26%-30%
4	Initial setting time(min)	48	30
5	Final setting time(min)	470	600

Table 3.1.1: **Properties of cement**

3.2 Fine aggregates:

River sand passing through 475mm IS sieve and retained on 150 microns confirming to IS:383-1970.

Sr.No.	Tests	Obtained values	Standard values
1	Grading zone	II	I-IV
2	Specific gravity(gm/cc)	2.56	2.5-2.8
3	Water absorption	1.3%	1%-2%

Table 3.2.1: **Properties of fine aggregates**

3.3 Coarse aggregates:

Kankar of size 20mm is used conforming to IS:383-1970.

Sr.No.	Tests	Obtained values	Standard values
1	Specific gravity(gm/cc)	2.85	2.5-3
2	Water absorption	0.35%	1%
3	Crushing values	26.2%	30%
4	Impact values	18.69%	45%

Table 3.3.1: **Properties of coarse aggregates**

3.4 GGBS: In concrete GGBS ranges typically from 30%-40%. The GGBS properties were confirmed to IS:269-1976.

Sr. No.	Tests	Obtained values	Standard values
1	Specific gravity(gm/cc)	2.76	<3
2	Moisture content	0.10%	<1.0%
3	Sulphide content	0.50%	<2.0%
4	Manganese content	0.12%	<3.0%

Table 3.4.1: **Properties of GGBS**

3.5 Mix Design: Mix design was done based on IS: 456-2000 for M40 grade concrete. Following shows the mix proportion of concrete per 1m3.

- Cement content - 410 kg
- Fine aggregate - 690.5 kg
- Coarse aggregate - 1148 kg
- w/c ratio - 0.34
- Cement: fine aggregate: coarse aggregate - 1: 1.685: 2.8

Fig: 3.5.1MIXTURE OF CEMENT, GGBS AND FINE AGGERATE

4. Test results and comparison:

4.1 compression test:

The test was done conforming to IS: 516-2002 to obtain compressive strength of concrete at the age of 7,14,28 days. The cubes were tested using a compression testing machine (CTM) of capacity 2000KN.

PERCENTAGE OF GGBS	COMPRESSIVE STRENGTH (MPA)		
	7 days	14 days	28 days
0%	40.83	46.68	50.8
10%	36.5	44.3	47.7

20%	44.15	47.5	52.6
30%	47.11	50.13	54.52
40%	45.18	48.24	51.88

Table: 4.1.1 Compressive strength

Fig: 4.1.2 compressive test

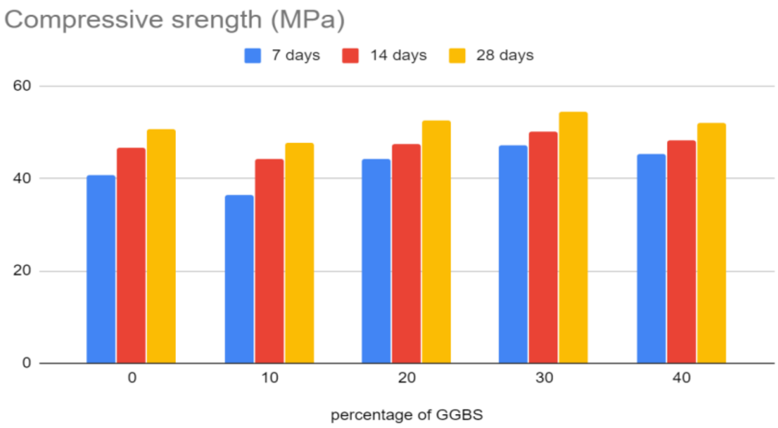

Fig4.1.3: percentage vs STRENGTH

4.2 Flexural strength: The test was performed confirming to IS:516-2002 to obtain flexural strength of concrete at the age of 14 & 28 days. The beams were tested by using UTM of 2000KN capacity.

percentage of GGBS	flexural strength (MPa)	
	14 days	28 days
0	4.14	5.49
10	3.67	4.12
20	4.23	4.86
30	4.96	5.68
40	4.17	5.13

Table 4.2.1: flexural strength

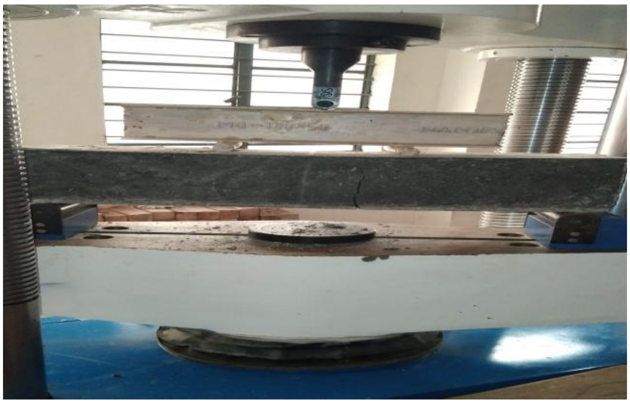

Fig: 4.2.2flexural text

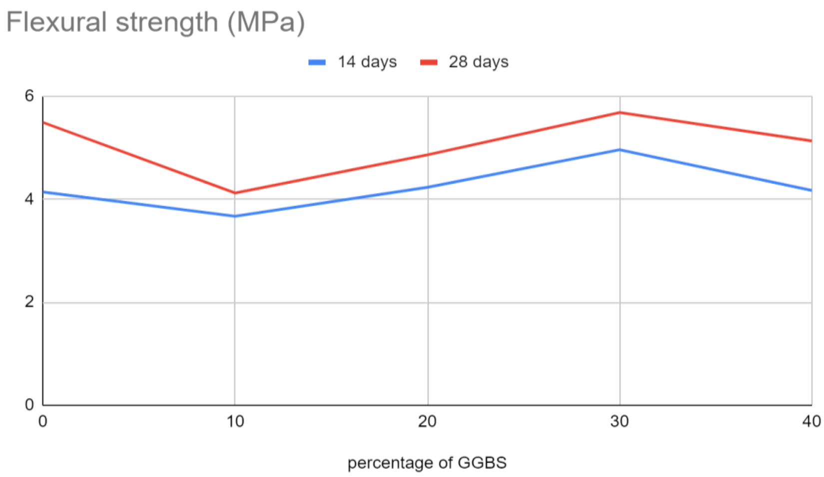

Fig: 4.2.3percentages vs STRENGTH

4.3 Split tensile strength: The test was performed confirming to IS:5816-1999 to obtain the split tensile strength of concrete at the age of 14 & 28 days. The cylinders were tested using split tensile testing devices.

Fig:4.3.1 split test

percentage of GGBS	split tensile strength (MPa)	
	14 days	28 days
0%	4.68	5.61
10%	3.85	4.34
20%	4.14	4.98

30%	4.68	5.49
40%	4.32	5.12

Table :4.3 split strength

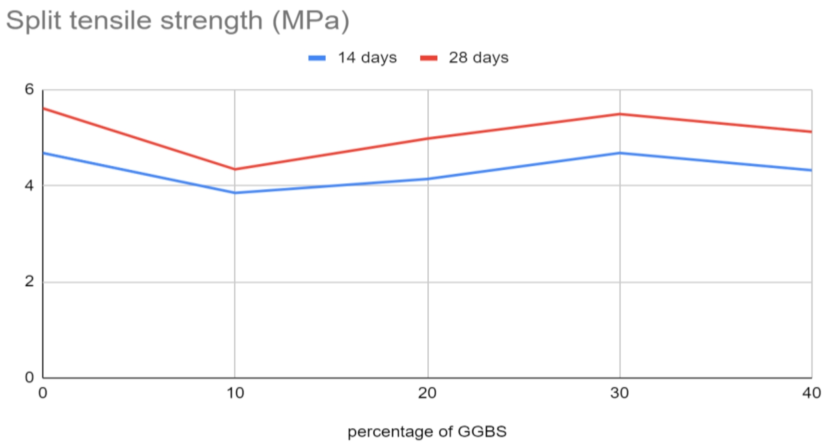

FIG: 4.3.1 PERCENTAGE VS STRENGTH

4.4 Cost Analysis:

By replacing the cement with GGBS the cost to produce concrete reduces. Below table shows the cost to produce concrete in various replacements.

Cost to produce $1m^3$ concrete:

- Cement : ⍰ 340/50kg
- Fine aggregate : ⍰ 450/MT
- Coarse aggregate: ⍰ 800/MT
- GGBS : ⍰ 3.4/kg

percentage of replacement	cost per 1 m^3 concrete (⍰)
0%	4196.1
10%	4056.7
20%	3917.3
30%	3777.9
40%	3638.5

Table: 4.4.1 COST ANALYSIS

5. Environmental considerations:

Carbon emissions from the manufacturing of cement is 1 ton to produce 1 ton of cement. Whereas the carbon emissions from the manufacturing of GGBS is about 35kg to produce 1 ton of GGBS. It is less than 4% of the carbon footprint of cement production. By replacing the cement with GGBS we made Green concrete which emphasizes the reduction of carbon footprint by construction.

6. Conclusions:

The experimental results obtained show that partial substitution of cement by GGBS gives better results over the verified range from 0%, 10%, 20%, 30% and 40% replacement. From mechanical properties optimum cement replacement by GGBS was found to be 30%. GGBS has positive effects on workability. So, it increases the consistency of concrete and achieves more strength compared to conventional concrete.

By replacing the cement with GGBS there isn't much difference in strength, but overall cost is reduced by 15%. So economically concrete is more significant than conventional concrete.

7. References:

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