GGBS As Alternative To OPC In Concrete As An Environment Pollution Reduction Approach

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ABSTRACT

The major problem the world is facing today is the environmental pollution. In the construction industry mainly the production of Portland cement will causes the emission of pollutants results in environmental pollution. We can reduce the pollution effect on environment, by increasing the usage of industrial by-products in our construction industry. In the present study to produce the concrete the Portland cement is fully replaced with GGBS (Ground granulated blast furnace slag) and alkaline liquids are used for the binding of materials. The alkaline liquids used in this study for the polymerization are the solutions of Sodium hydroxide (NaOH) and sodium silicate (Na_2Sio_3). The cube specimens and cylindrical specimens and beam specimens were made of size 150mm x 150mm x 150mm, 150 mm diameter and 300 height and 500mmx100mmx100mm respectively. Compressive strength test, split tensile strength test and flexural strength test were conducted and the results obtained after the chemical curing of specimens were carried out at 65ºc in an oven. The results were compared with conventional concrete.

Keywords: Environmental Pollution, Portland cement, GGBS, Concrete, Compressive Strength, Split Tensile Strength and Flexural Strength.

INTRODUCTION

Concrete is conventionally produced by using the ordinary Portland cement (OPC) as the primary binder. The amount of the carbon dioxide released during the manufacture of OPC due to the calcinations of limestone and combustion of fossil fuel is in the order of one ton for every ton of OPC produced. In addition, the amount of energy required to produce OPC is also huge next to steel and aluminum production. On the other side, the abundance availability of GGBS worldwide create opportunity to utilize this by-product of burning coal, as partial replacement or as performance enhancer for OPC. The main binder produced is a C-S-H gel, as the result of a hydration process also known polymerization. Davidovits (1999)

The most common alkaline liquid used in the geo-polymerization is the combination of Sodium hydroxide/ Potassium hydroxide and Sodium silicate/ Potassium silicate.

CO_2 emission during cement production during the following activities such as Combustion of fossil fuels to operate the rotary kiln and the chemical process of calcinations limestone into lime in the cement kiln is the one of the main source of cause of environmental pollution. The cement industry contributes about 5% of total global carbon dioxide emissions. And also, the cement is manufactured by using the raw materials such as lime stone, clay and other minerals. Quarrying of these raw materials is also causes environmental degradation of another kind. So to overcome this problem, the concrete to be produced should be environmental friendly as avoiding use of cement. Hence a study has been made with partial replacement of cement with GGBS.

MATERIALS

Fine Aggregate

Locally available river sand conforming to grading zone-II as per IS: 383 – 1970 was used.

Coarse Aggregate

Locally available coarse aggregate of 20 mm, 14mm and 7mm in proportion as per the mix design was used.

Alkaline solutions

The solutions of Sodium hydroxide and Sodium Silicate are used as alkaline solutions in the present study. Commercial grade Sodium Hydroxide in flakes form (97%-100% purity) and Sodium silicate solution having 7.5%-8.5% of Na2O and 25% -28% and water of 67.5%- 63.5% were used.

Ground Granulated Blast Furnace Slag (GGBS)

GGBS is obtained from nearby iron industry then dried and ground into a fine powder.

Table.1. Composition of GGBS Concrete

S.NO	INGREDIENT	Percentage recommended
1	GGBS	17 to 20
2	Coarse Aggregate	45 to 55
3	Fine Aggregate	20 to 25
4	Alkaline Activator	6 to 8
	a) NaoH	1.5 to 2
	b) Na_2Sio_3	4 to 6

METHODS

Preparation of Alkaline solutions

Since the molecular weight of sodium hydroxide is 40, to prepare 3M [i.e. 3 molar] sodium hydroxide solutions, 120g of sodium hydroxide flakes are weighed and they can be dissolved in distilled water to form 1 liter solution. For this, volumetric flask of 1 liter capacity is taken, sodium hydroxide flakes are added slowly to distilled water to prepare 1liter solution.

Preparation of GGBS Concrete

The sodium hydroxide flakes were dissolved in distilled water to make a solution with a desired concentration at least one day prior to use. The GGBS and the aggregates were first mixed together in a pan mixer for about three minutes. The sodium hydroxide and the sodium silicate solutions were mixed together with super plasticizer and the extra water and then added to the dry materials and mixed for about four minutes. The fresh concrete was cast into the moulds immediately after mixing, in three layers and compacted with manual strokes and vibrating table. After casting, the specimens were cured at 60°C for 24 hours.

Figure 1 View of GGBS Powder

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Two types of curing were applied, dry curing and steam curing. For dry curing, the specimens were cured in an oven and for steam curing the specimens were cured in the steam curing chamber. After curing, the specimens were left to air-dry in the laboratory for the next six days until testing on the 7th day

Table.2. Mix Design of GGBS Concrete as M55

Materials	Quantity
20 mm aggregates	277 kg/m^3
14 mm aggregates	370 kg/m^3
7 mm aggregates	647 kg/m^3
Fine sand	554 kg/m^3
GGBS	408 kg/m^3
Super plasticizer	= 6 kg/m^3
Sodium silicate solution	103 kg/m^3
sodium hydroxide solution	41 kg/m^3
Mix Proportion	1:1.3.8:3.04

RESULTS AND DISCUSSION

Compressive Strength of Concrete

This tests were carried out in accordance with IS 516-1999 standards conducted on concrete specimen size 150mm x 150mm x 150mm. The compressive strength of conventional concrete as well as GGBS concrete are shown in table 1 and figure 2

Table 1 Compressive strength of Conventional and GGBS Concrete

Trail No	Conventional Concrete		GGBS Concrete	
	Load At Failure, in kN	Comp. Strength, in N/mm^2	Load At Failure, in kN	Comp. Strength, in N/mm^2
1	1383.75	61.50	1575.00	70
2	1395.00	62.00	1586.25	70.5
3	1372.50	61.00	1563.75	69.5
4	1390.00	61.75	1597.50	71
5	1398.00	62.10	1569.35	69.75
6	1383.75	61.50	15716.60	69.85
Average Strength		61.64 MPa		70.1MPa

Split tensile strength

This tests were carried out in accordance with IS 516-1999 standards conducted on concrete cylinders of 150 mm diameter and 300 mm length. The Split tensile strength of conventional concrete as well as GGBS concrete are shown in table 2 and figure 3

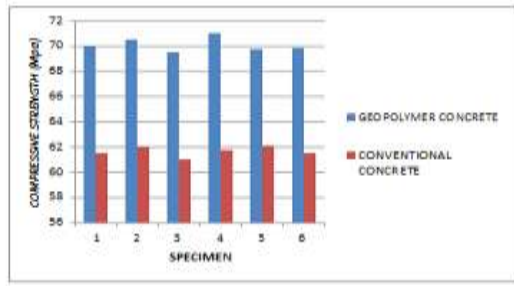

Figure 2 Compressive strength of Conventional and GGBS Concrete

Table 2 Split Tensile strength of Conventional and GGBS Concrete

Trail No	Conventional Concrete		GGBS Concrete	
	Load At Failure , in kN	Split Tensile Strength, in N/mm^2	Load At Failure , in kN	Split Tensile Strength, in N/mm^2
1	360.49	5.10	417	5.9
2	361.91	5.12	425	6
3	359.00	5.08	438	6.2
4	360.25	5.10	432	6.11
5	361.35	5.11	430	6.08
6	360.75	5.10	433	6.12
Average Strength		5.1025		6.07

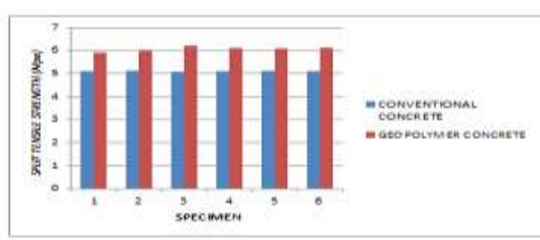

Figure 3 Split tensile strength of Conventional and GGBS Concrete

Flexural Strength of Concrete

Determination of flexural strength is essential to estimate the loads at which concrete members may crack. The load was applied without shock and increasing continuously on a specimen of size 500x100x100mm. The line of fracture measured on the centre line of the tensile side of the specimen and the results are shown in table 3 and figure 4.

Table 3 Flexural strength of Conventional and GGBS Concrete

Trail No	Conventional Concrete		GGBS Concrete	
	Load At Failure, in kN	Flexural Strength, in N/mm^2	Load At Failure, in kN	Flexural Strength, in N/mm^2
1	10.24	5.12	13	6.5
2	10.15	5.08	14	7
3	10.22	5.11	13.6	6.80
4	10.20	5.10	13.75	6.88
5	10.75	5.38	13.25	6.63
6	10.35	5.18	13.90	6.95
Average Strength		5.16		6.77

Figure 4 Failure of Beam Specimen at Flexural Load

DURABILITY TEST

Chloride attack is primarily cause's corrosion of reinforcement. The BIS specified the maximum chloride content in cement as 0.1%.To test the effect of chloride on concrete, 150x150x150 size conventional as well as GGBS concrete cubes were casted and kept at a room temperature. After 24 hours the specimens were cured in clean fresh water for 28 days. After curing the cubes were immersed in 5% concentric Hydrochloric acid (HCL) and tested for their weight loss 14 days and 28 days of acid curing and there by durability were assessed.

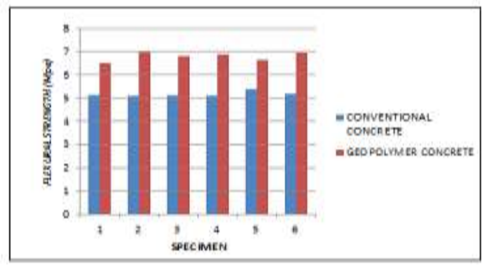

Figure 5 Split Flexural strength of Conventional and GGBS Concrete

Table 4 a Percentage Weight Loss of Specimen Subjected 14 days Chloride Attack

Trail No	Type of Concrete	Initial Weight	Weight after 14 days curing in HCl	%of Weight Loss
1	Conventional Concrete	8.678	8.665	0.14
		8.646	8.662	0.18
		8.652	8.667	0.17
2	GGBS Concrete	8.435	8.420	0.17
		8.437	8.425	0.14
		8.434	8.423	0.13

Table 4 b Percentage Weight Loss of Specimen Subjected 28 days Chloride Attack

Trail No	Type of Concrete	Initial Weight	Weight after 14 days curing in HCl	%of Weight Loss
1	Conventional Concrete	8.82	8.72	1.03
		8.83	8.74	1.01
		8.82	8.73	1.02
2	GGBS Concrete	8.68	8.59	1.03
		8.66	8.58	0.93
		8.68	8.6	0.93

Fig 6 shows the specimen after subjected to chloride attack. The weight of the specimens initially before subjected to chloride attack and 14 days and 28 days after were shown in table 4 a and table 4 b. The percentage weight loss in different periods of specimen subjected to chloride attack also shown in figure 7.

Figure 6 View of Specimen After Subjected to Chloride Attack

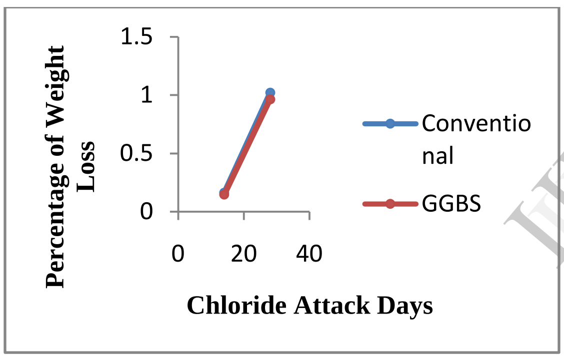

Figure 7 Percentage Weight Loss of Conventional and GGBS Concrete Subjected to Chloride Attack

CONCLUSIONS

The test results shows that GGBS concrete shows increase in compressive strength of 13.82% as compared with conventional concrete.

Split tensile strength of GGBS concrete is 18.23% more than that of conventional concrete as compared with conventional concrete.

30.19% increase in flexural strength was noticed in the GGBS concrete comparatively with the conventional concrete as compared with conventional concrete.

Percentage loss of weight due to chloride attack was measured 1.02% averagely in the case of conventional concrete where as it was 0.963 in the GGBS based concrete.

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