A Study on Hardened Properties of High Performance Concrete by Partial Replacement of Cement with GGBS and Fly Ash

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Abstract— concrete is probably the most extensively used construction material in the world. Anyway, the production of the Portland cement (PC) as a necessary constituent of concrete can basically lead to the dangerous impacts on our environment by such as releasing the consequential amount of CO_2 that is one of the greenhouse gases responsible for global warming. The emission CO_2 level for PC is cited as nearly one ton per ton. It means that production of one ton of PC can lead to produce about one ton of CO_2 and other greenhouse gases. Decreasing in use of PC and its replacement with industrial waste products as cement partial replacement will have positive effect on environmental, social and economic aspects of each society which are essential in Sustainable Development (SD). The purpose of this paper is to review on the specifications, production method and the degree of effectiveness of some industrial byproducts such as GGBS, and Fly Ash as the cement replacement in achieving high strength and sustainable concrete which can lead to not only improving the strength of the concrete but also reduction of ECO_2 by reducing the amount of PC, and that how they can affect in cheap, environmental and social aspects positively. Most of the fly ash is considered as waste, vacant in landfills and GGBS exhibits cementitious as well as pozzolanic uniqueness so it is quite right in choosing of fly ash and GGBS for concrete mix.

Key words: Ceramic Waste, Ceramic Coarse Aggregate, Flyash (FA), Concrete and Strength

I. INTRODUCTION

After the water the cement is the second largest material used in the world. One of the facts is that the concrete is the most used man mad material in the world, which is not widely unknown fact. Ordinary Portland Cement (OPC) becomes most durable and the most popular material in the production of the concrete which have a function of binder to bind the all the aggregates together. But the manufacturing of the cement is causing the pollution to the environment. Also the manufacturing of cement is reduced in the raw material such as limestone etc. India's cement manufacture enlarged at a complex growth rate of 6.7 per cent. India is the second most cement manufacturer in the world and accounts for 6.7 per cent of worlds cement productivity. The industry of cement produces around 2.6 billion tons of cement per annum. A total of 209 large cement plants collectively account for 97 per cent of the whole installed capability in the country, while 365 small plants make up the rest. The raw materials are used for the production of cement such as limestone, clay and other minerals are also causes the environmental dreadful conditions. A cement industry accounts for approximately 5 percentage of universal Carbon Dioxide (CO2) emissions. The manufacture of cement releases greenhouse gas emissions both directly and indirectly. The heating of limestone releases CO2 directly, at the same time as the aflame of fossil fuels to heat up the kiln indirectly cost in CO2 emissions. For the production of the 1 ton of the cement approx 1.5 ton of the raw materials are required. The need of time to manufacturing of the limestone and other raw materials is lot more than the rate at which human use it. On another side the demand of concrete is increasing day by day for its simplicity of preparing and fabricating in all sorts of suitable shapes. The use of cement in the production of the concrete, it is twice to the amount of material which is used than the total of all other building materials used to construct buildings, pavement dams etc. To make environmental responsive concrete, its need to be swaps the cement with the industrial by products such as Fly Ash, Ground Granulated Blast Furnace Slag (GGBS), and Silica Fume etc.

II. HIGH PERFORMANCE CONCRETE

High Performance Concrete is defined as the concrete which is meeting the special combination of special performance and uniformity requirements such as the high workability, High dense Concrete, High Strength, High modulus of Elasticity, low permeability, and resistance against the chemical attack etc., which is cannot be achieved in normal concrete. In between of High Strength Concrete (HSC) and High Performance Concrete (HPC) have a little controversy. High Performance Concrete also has a one of attributes of High Strength with other more attributes specifically designed mix as mentioned. In the normal concrete has relatively low strength and elastic modulus are the result of nature of structure of the material, mainly the porous and the weak transition zone, which existing at the paste of cement and aggregate interface. By densification and strengthening of the transition zone, many desirable properties can be improved many fold. A substantial reduction of quantity of mixing water is the basic step for making High Performance Concrete (HPC). Reduction of the water-cement ratio in concrete will result in high compressive strength. However reduction of the water-cement ratio to the lesser than the 0.3 wills remarkable improvement in the qualities of transition zone to give the inherent qualities expected in High Performance Concrete. For the improvement of the quality of transition zone in High Performance Concrete, use of Silica Fume (SF) becomes a necessary ingredient for strength above to the 80 MPa. With the good quality of the Fly Ash (FA) and the Ground Granulated Blast Furnace Slag (GGBS) also used for other nominal benefits like the Durability and Permeability. In spite of that these pozzolanic (cementious) materials increases the water demand, their benefits in High Performance Concrete will outweigh the disadvantages. The core of whole problem lies in using very low water-cement ratio, consistent with high workability at the time of placing and compacting. Adopted water-cement ratio in the range of 0.25 to 0.3 and getting a high slump is only possible with using of superlasticizer in the concrete. Therefore use of appropriate and suitable superplasticizer is a key material in the making of mix design of High Performance Concrete. The associated problem is the selection of superplasticizer and that of cement so that they are well-suited and retain the slump and rheological properties for a adequately long time till concrete is placed and compacted. High-performance concrete (HPC) is concrete that has been designed to be more durable and, if necessary stronger than conventional concrete. High Performance Concrete mixtures are composed of essentially the same materials as conventional concrete mixtures, but the proportions are designed, or engineered, to provide the strength and durability needed for the structural and environmental requirements of the project. High-strength concrete is defined as having a specified compressive strength of 55 MPa or greater. The value of 55 MPa was selected because it represented a strength level at which special care is required for production and testing of the concrete and at which special structural design requirements may be needed.

III. LITERATURE SUMMARY

High Performance Concrete (HPC) has established increased attention in the development of infrastructure Viz., High-Rise Buildings, Industrial Structures, Hydraulic Structures, Bridges and Highways etc. leading to utilization of large amount of concrete. The consumption of supplementary cementation materials is well accepted, because it leads to a number of probable improvements in the concrete combination, as well as the in general economy. The cement alternate materials along with Mineral & chemical admixtures can get better the durability and strength characteristics of concrete. GGBS and FA can use as a replacement material for cement, dropping cement consumption and dropping the cost of construction. Use of industrial by products saves the environment and conserves usual resources. The necessary ingredients of HPC such as FA, slag and SF which are mostly industrial byproducts make the product environmentally friendly. GGBS and FA, due to its pozzolanic nature, could be a great asset for the modern construction needs, because slag concretes can be of high performance, if appropriately designed. . GGBS and Fly Ash concrete is characterized by high strength, lower heat of hydration, and resistance to chemical corrosion. The demand of cement increases speedily with the development.

IV. CONCRETE MIX DESIGN

The mix design is calculated as per the IS 10262:2009. The Plasticizer is used Conplast P211 @ of 1.5% by the weight of Cement.

After the different mixes the final mix design is fixed by the practical result is

Water (lit/Kg)	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (20 mm) (Kg)	Coarse Aggregate (10 mm) (Kg)	Super Plasticizer (Kg)
168	480	653	449.6	674.4	7.2
0.35	1	1.36	2.34		0.015

Table 1: Practical result

V. TEST RESULT AND ANALYSIS

A. *Slump Test*

Slump test is the most commonly used method to measuring consistency of concrete which can be employed either in laboratory or at site of work. It is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch.

VI. COMPACTING FACTOR TEST

The compacting factor test is designed primarily for use in the laboratory but it can also be used in the field. This test work on the principle of determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height.

The result of Slump test:

Sr. No.	Percentage of Fly Ash	Percentage of GGBS	Slump (mm)
1	0	0	69
2	30	0	78
3	25	5	76
4	20	10	79
5	15	15	78
6	10	20	81
7	5	25	80
8	0	30	75

Table 2: Slump Test

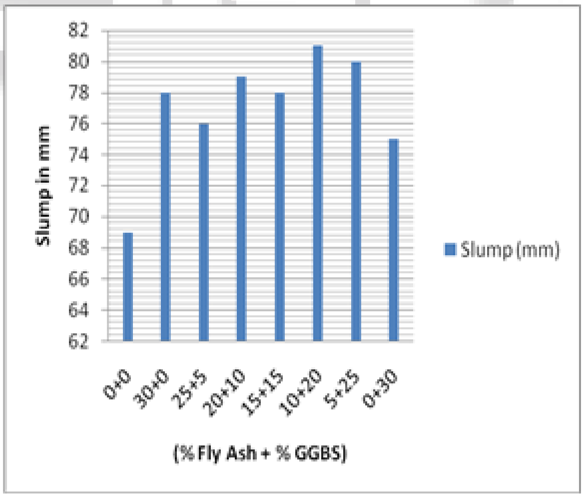

Fig. 1: Slump Test

The Result of Compacting Factor Test:

Sr. No.	Percentage of Fly Ash	Percentage of GGBS	Compacting Factor
1	0	0	0.925
2	30	0	0.867
3	25	5	0.88
4	20	10	0.853
5	15	15	0.87
6	10	20	0.894
7	5	25	0.886
8	0	30	0.89

Table 3: Compacting Factor

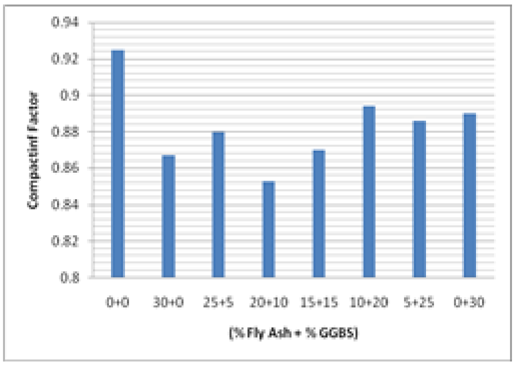

Fig. 2: Compacting Factor

A. Compression Test

Test result of the compressive strength of the concrete with different mixes at the age of 7 and 28 days.

Sr. No.	Percentage of Fly Ash	Percentage of GGBS	Compressive Strength (N/mm^2)	
			7 Days	28 Days
1	0	0	41.26	64.29
2	30	0	28.36	56.07
3	25	5	30.23	59.12
4	20	10	34.75	61.21
5	15	15	37.22	63.66
6	10	20	39.86	66.07
7	5	25	40.78	68.25
8	0	30	40.05	69.92

Table 4: Compressive Strength after 7 days and 28 days.

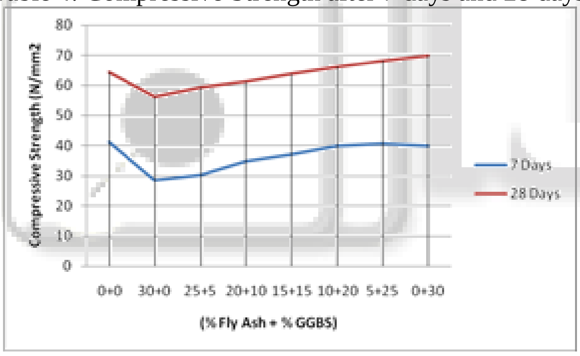

Fig. 3: Line chart of Compressive Strength of 7 & 28 days

B. Flexural Strength

Test result of the Flexural strength of the concrete with different mixes at the age of 7 and 28 days.

Sr. No.	Percentage of Fly Ash	Percentage of GGBS	Flexural Strength (N/mm^2)	
			7 Days	28 Days
1	0	0	4.23	5.41
2	30	0	3.13	4.82
3	25	5	3.24	4.88
4	20	10	3.52	4.97
5	15	15	3.67	5.28
6	10	20	3.91	5.16
7	5	25	4.07	5.37
8	0	30	4.26	5.65

Table 5: Flexural Strength after 7 days and 28 days.

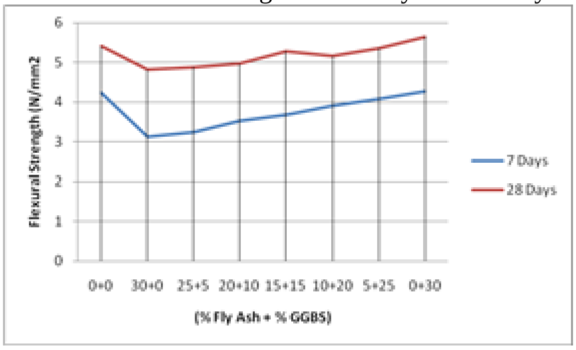

Fig. 4: Line chart of Flexural Strength of 7 & 28 days

C. Split-Tensile Strength

Test result of the Flexural strength of the concrete with different mixes at the age of 7 and 28 days.

Sr. No.	Percentage of Fly Ash	Percentage of GGBS	Split-Tensile Strength (N/mm^2)	
			7 Days	28 Days
1	0	0	3.93	5.01
2	30	0	2.98	3.92
3	25	5	3.04	4.14
4	20	10	2.84	4.27
5	15	15	3.27	4.48
6	10	20	3.41	4.66
7	5	25	3.68	4.96
8	0	30	3.60	5.23

Table 6: Percentage changes in Split-Tensile Strength after 7 days and 28 days

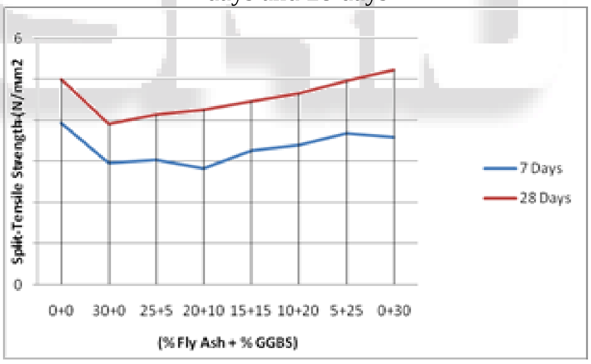

Fig. 5: Line chart of Split-Tensile Strength of 7 & 28 days

D. Durability

The durability of cement concrete is defined as its ability to resist weathering action, chemical attack, abrasion, or any other process of deterioration. Durable concrete will retain its original form, quality, and serviceability when exposed to its environment. The durability is checked by the attack of HCl and MgSO4. The sample of concrete is curing of 28 days of normal water and then the 28 days curing of the water contain 5 percentage chemical by its mass. The compressive strength checked after the 56 days.

The test result of the durability test.

Sr. No.	Percentage of Fly Ash	Percentage of GGBS	Compressive Strength (N/mm^2)		
			Normal Water	HCl	$MgSO_4$
1	0	0	71.29	67.23	68.34
2	30	0	65.25	63.51	63.78
3	25	5	67.32	63.85	64.19
4	20	10	66.12	64.07	64.33

5	15	15	68.67	64.19	64.78
6	10	20	69.33	65.32	66.08
7	5	25	70.09	66.73	66.96
8	0	30	73.34	70.12	71.36

Table 7: The durability test at 56 days

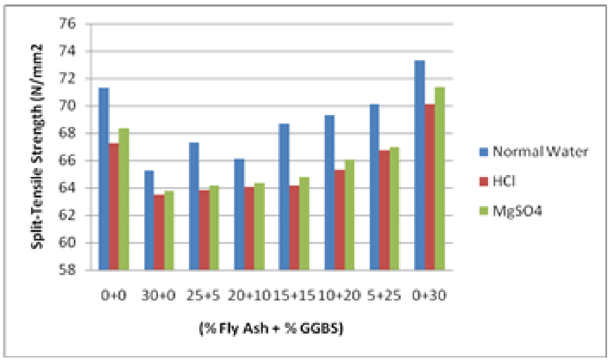

Fig. 6: The Durability Test

E. Rapid Chloride Penetration Test

This test method covers the determination of the electrical conductance of concrete to provide a rapid indication of its resistance to the penetration of chloride ions. The test method also provides an indirect measure of the permeability of the concrete. A 50 mm. thick section is obtained from a 102mm diameter lab molded cylinder. Electrical current is passed from one side of the core section to the other side while it is contained within a cell that has a sodium chloride solution on one side of the core and a sodium hydroxide solution on the other side. The electric current is applied and measured for six hours.

The RCPT is done at the age of 28 days with different mixes of concrete.

Sr. No.	Percentage of Fly Ash	Percentage of GGBS	Charge Passed (Columbus)
1	0	0	986.27
2	30	0	823.52
3	25	5	827.52
4	20	10	852.26
5	15	15	826.51
6	10	20	831.71
7	5	25	825.88
8	0	30	863.70

Table 8: RCPT after 28 Days in Different Mix

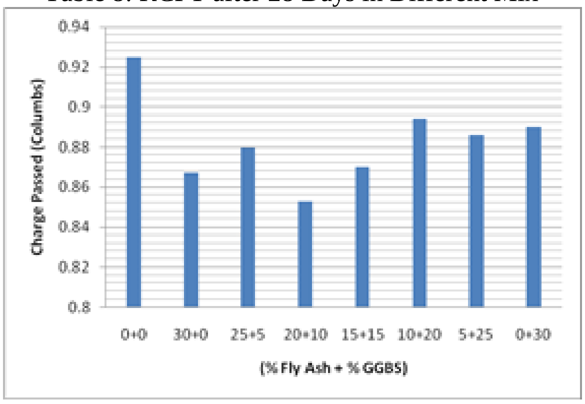

Fig. 7: RCPT after 28 Days in Different Mix

VII. Conclusion

The compressive strength, flexural strength, split tensile strength and, Durability of concrete are improved with the addition of fly ash and GGBS as partial replacement to cement. The compressive strength concrete increased by a maximum of 8.75% at 28 days with (0% of fly ash + 30% of GGBS) replacement. The compressive strength of other mixes is less than the nominal mix. The pozzalanic material give the less early strength. The flexural strength concrete increased by a maximum of 4.43% at 28 days with (0% of fly ash + 30% of GGBS) replacement. The split tensile strength concrete increased by a maximum of 4.39% at 28 days with (0% of fly ash + 30% of GGBS) replacement. The durability, the strength is less decreased in combination of 30% flash and 0% of GGBS after 28 days of normal curing and 28 days of curing in the 5% solution of HCl and $MgSO_4$. Also the combination of 0% Fly Ash and 30% of GGBS is performed well then the normal mix in Durability test. In the Rapid Chloride Penetration Test (RCPT) the mix of 5% of Fly Ash and 25% GGBS is replacement of cement is gives the less effect of Chloride Penetration than the others mixes. Also the effect of Chloride on mixes of 0% Fly Ash and 30% GGBS the then normal concrete. After the all result and analysis the 0 % of Fly ash and 30 % of GGBS is optimum mixes with additional advantages like economic.

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