Experimental Investigation on Partial Replacement of Cement With GGBS In Concrete

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Abstract- *This project represents the results of an experimental investigations accomplish to understand the suitability of GGBS in production of concrete the characteristics of concrete with partial replacement of cement with Ground Granulated Blast furnace Slag (GGBS) by replacing cement on M60 Grade Concrete. The replacement level of GGBS in concrete is 0%, 10%, 20%, 30%, 40% and 50% by the total weight of cement. Workability tests like Slump Cone and Compaction Factor Test is conducted on concrete with various percentages of cement replaced with GGBS also all specimens were cured for 7, 14, 28 and 56 days to evaluate the strength characteristics study, Compressive strength, Split tensile strength and Flexural strength of concrete. In durability study conventional and GGBS concrete is tested by conducting acid attack, sulphate attack.*

Keywords*-* acid attack, durability, GGBS, sulphate attack

I. INTRODUCTION

Concrete is the most widely used construction material in civil engineering industry because of its high structural strength and stability. Concrete contains primarily cement, aggregate and water. Even though cement typically only includes 12% of the concrete mass, it accounts for approximately 93% of the total embodied energy of the concrete and 6 to 7% of the global CO_2 emissions. For the production of cement, a large amount of energy is consumed and it is one of the largest sources of CO_2 gas emission. About 13500 million tonnes of CO_2 gas is released during the production of cement.

The use of waste material having cementitious properties as a replacement of cement in cement concrete has become the thrust area for construction material experts and researchers. The main focus now a days is on search of waste material or bye product from manufacturing processes, which can be used as partial replacement of cement in concrete, without compromising on its desired strength. The ground granulated blast furnace slag (GGBS) is a waste product from the iron manufacturing industry, which may be used as partial replacement of cement in concrete due to its inherent cementing properties.

In this present experimental work an attempt is made to replace cement by GGBS to overcome these problems. If concrete is mixed with ground granulated blast furnace slag as a partial replacement for Portland cement, it would provide environmental and economic benefits and the required workability, durability, and strength necessary for the design of the structures.

II. OBJECTIVES

a) To determine the performance of concrete by partial replacement of cement by Ground granulated blast furnace slag in 10%, 20%, 30%, 40%, 50% variants.
b) To determine the workability of concrete with varying percentages of GGBS 10%, 20%, 30%, 40%, 50% variants.
c) To determine the compressive strength for 3days, 7days and 28 days.
d) To determine the split tensile strength and flexural strength of concrete for 7 days and 28 days curing.
e) To determine the most optimized mix of GGBS- based concrete.

III. MATERIALS USED

Cement- Ordinary Portland cement conforming to IS 269-1976 and IS 4031-1968 was adopted in this work. The cement used is 53 grade.

Fine Aggregate- The river sand (Zone-II) is used as fine aggregate conforming to the requirements of IS: 383-1970.

Coarse Aggregate-Locally available crushed stones conforming to graded aggregate of nominal size 20mm as per IS 383 1970.

GGBS- Ground Granulated Blast furnace Slag, a co-product produced simultaneously with iron. The chemical composition of slag is similar to that of cement clinker. Cao 30-45%, SiO2

17-38%, Al_2O_3 15-25%, Fe_2O_3 0.5-2.0% MgO 4.0-17.0%, MnO_2 1.0- 5.0%, Glass 85-98%.

Conplast SP430- Is a chloride free, super plasticizing admixture is used for concrete making. It is supplied as a brown solution which instantly disperses in water. Conplast SP430 acts as a dispersing agent and reduces water content about 30%.

IV. MIX DESIGN

Mix design is the process of selecting suitable ingredients if concrete and determines their relative proportions with the object of certain minimum strength and durability as economically possible. The grade of concrete used in the present study is M60. The mix design of the concrete is carried as per the specific code IS 10262 – 2009.

Table 1: Mix Proportions

Mix Proportion	Cement	Fine Aggregate	Coarse Aggregate	W/C Ratio
Kg/ m^3	450	615.2784	1267.64	0.25
Ratio	1	1.36	2.81	0.25

V. EXPERIMENTAL PROGRAM

(1) Tests on Fresh Concrete

a) *Workability by Slump Cone Test*- Slump cone test is to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of the work. Concrete slump test is carried out from batch to batch to check the uniform quality of concrete during construction.
b) *Workability by* Compaction factor Test- Is the workability test for concrete conducted in laboratory. The compaction factor is the ratio of weights of partially compacted to fully compacted concrete.

(2) Tests on Hardened Concrete

A. Strength Tests:

a) *Compressive Strength Test*- This test was conducted as per IS 516-1959. The cubes of standard size 150x150x150mm were used to find the compressive strength of concrete.
b) *Split Tensile Strength*- The cylinders were tested by placing them uniformly in the UTM. The test is carried out at the loading rate of 1 kN/s specified IS: 5816 - 1999.
c) *Flexural Strength Test*- The beams were tested by placing them uniformly in the universal testing machine of capacity 1000 kN. Specimen were taken out from curing tank at the age of 28 days of standard curing and tested after surface water dipped down from specimens. This test was performed on universal testing machine (UTM) as shown in figure. The test is carried out at the loading rate of 70 kN/min.

B. Durability Tests:

Durability of concrete is defined as its ability to withstand weathering action, chemical attack or any other process of deterioration. A durable concrete requires little or no maintenance and retains its original form, quality and serviceability when exposed to its environment expect harsh or highly aggressive environment.

a) *Acid Resistance Test*- The cube specimens were weighed and immersed in water diluted with one percent by weight of Hydrochloric acid for 28 days continuously. Then the specimens were taken out from the acid water and the surfaces of the cubes were cleaned. Next the weight and the compressive strengths of the specimens were found out and the average percentage of loss of weight and compressive strengths were calculated.
b) *Sulphate Resistance Test*- The resistance of concrete to sulphate attacks was studied by determining the loss of compressive strength for variation in compressive strength and weight of concrete cubes immersed in sulphate water having 5% of sodium sulphate (Na_2SO_4) by weight of water. The concrete cube of 150mm x 150mm x 150mm size after 28 days of water curing and dried for 2 days were immersed in 5% of Na_2SO_4 added water for two weeks.
c) Chloride Resistance Test- Chloride attack on concrete has been reported from many other parts of the world. 150mm x 150mm x150mm size cube specimens are taken out from after 28 days of water curing then the cube specimens are allow drying and noting the initial. weight.

The surfaces of the specimens are thoroughly noted. Then 3% NaCl are mixed per liter of ordinary water. Cube specimens are then immersed completely in the chloride solution for 28 days and maintain uniformity.

VI. RESULTS & DISCUSSIONS

Chart 1: Compressive Strength of Concrete for Various Percentages of Replacement of Cement with GGBS

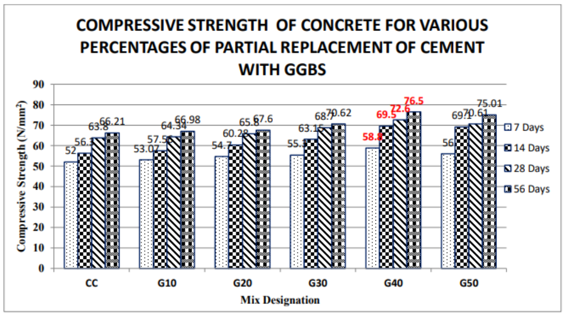


Chart 2: Variation of 7 Days Compressive Strength of Concrete with Varying Percentages of Cement Replaced with GGBS

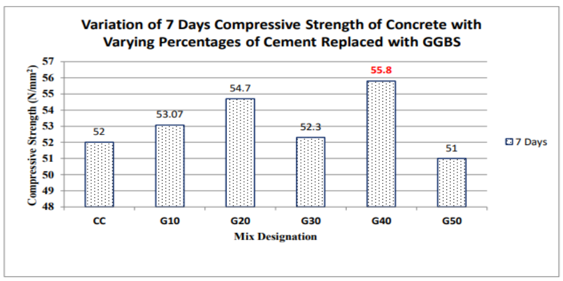


Chart 3: Variation of 14 Days Compressive Strength of Concrete with Varying Percentages of Cement Replaced with GGBS

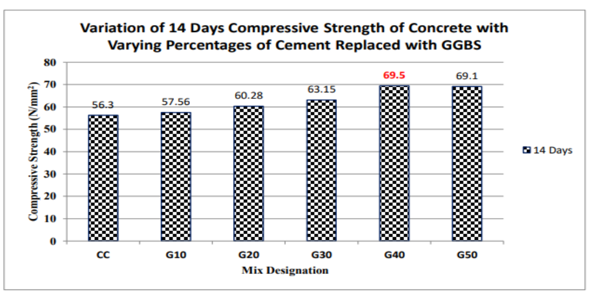


Chart 4: Variation of 28 Days Compressive Strength of Concrete with Varying Percentages of Cement Replaced with GGBS

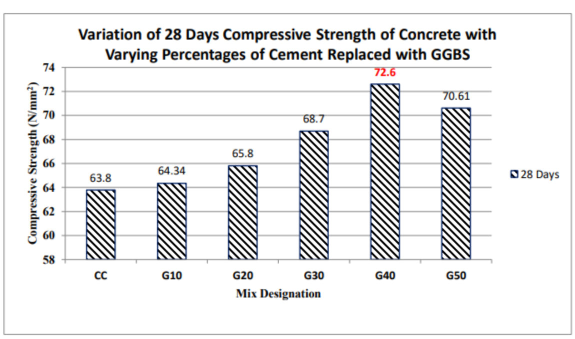


Chart 5: Variation of 56 Days Compressive Strength of Concrete with Varying Percentages of Cement Replaced with GGBS

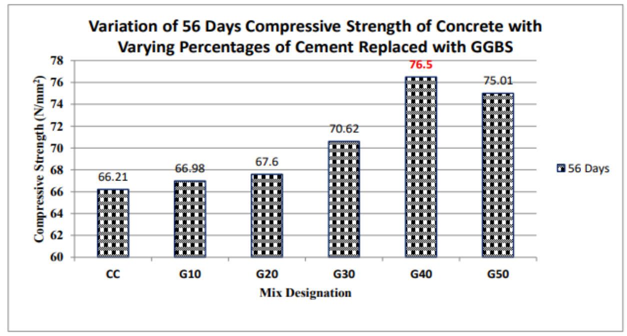


Chart 6: Split Tensile Strength of Concrete for Various Percentages of Replacement of Cement with GGBS

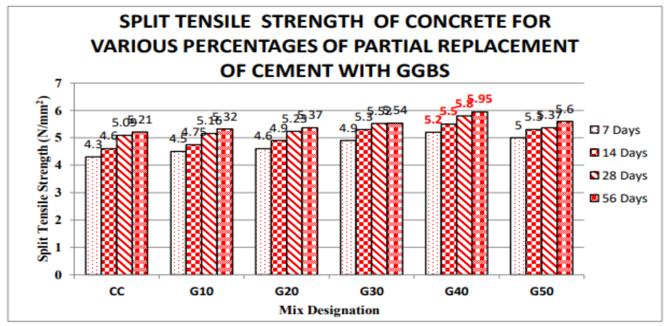


Chart 7: Variation of 7 Days Split Tensile Strength of Concrete with Varying Percentages of Cement Replaced with GGBS

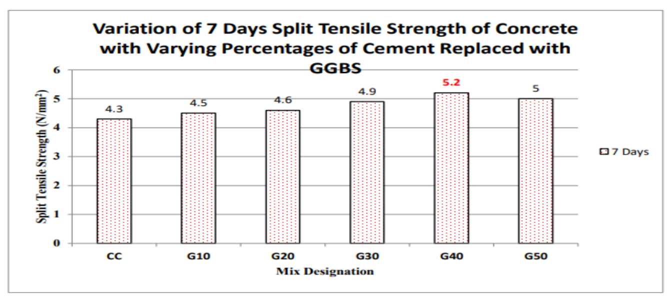


Chart 8: Variation of 14 Days Split Tensile Strength of Concrete with Varying Percentages of Cement Replaced with GGBS

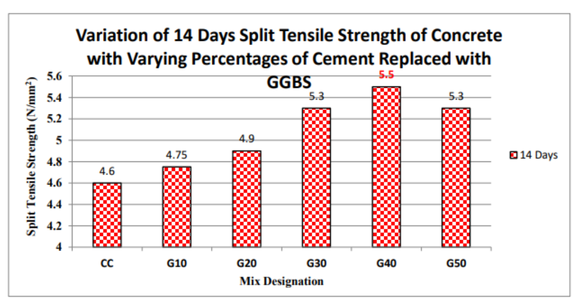


Chart 9: Variation of 28 Days Split Tensile Strength of Concrete with Varying Percentages of Cement Replaced with GGBS

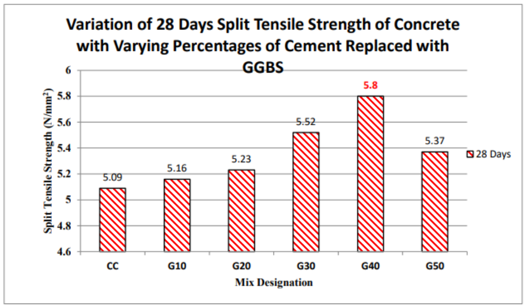


Chart 10: Variation of 56 Days Split Tensile Strength of Concrete with Varying Percentages of Cement Replaced with GGBS

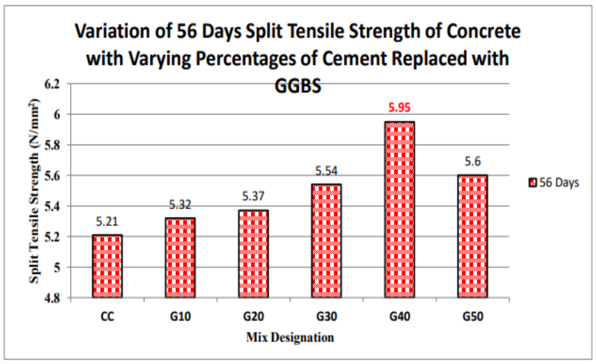


Chart 11: Flexural Strength of Concrete for Various Percentages of Replacement of Cement with GGBS

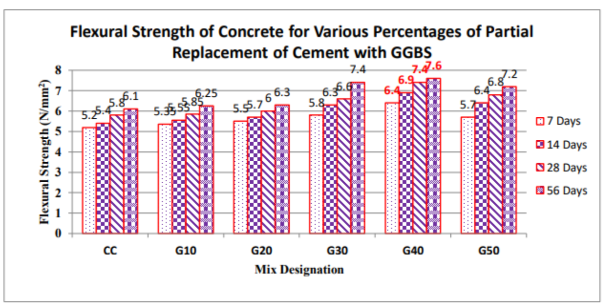


Chart 12: Variation of 7 Days Flexural Strength of Concrete with Varying Percentages of Cement Replaced with GGBS

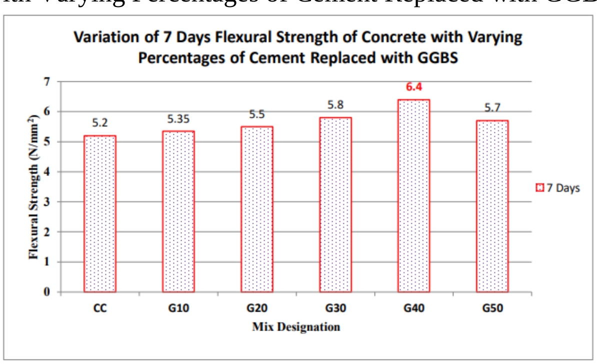


Chart 13: Variation of 14 Days Flexural Strength of Concrete with Varying Percentages of Cement Replaced with GGBS

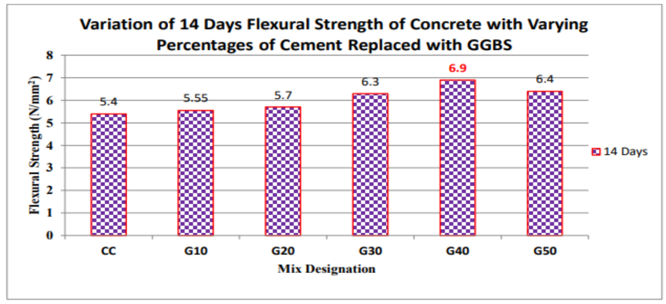


Chart 14: Variation of 28 Days Flexural Strength of Concrete with Varying Percentages of Cement Replaced with GGBS

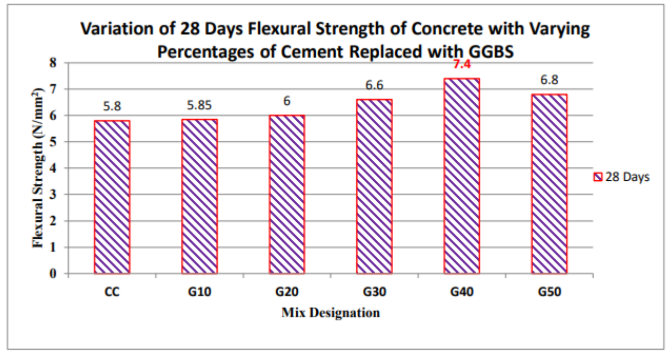


Chart 15: Variation of 56 Days Flexural Strength of Concrete with Varying Percentages of Cement Replaced with GGBS

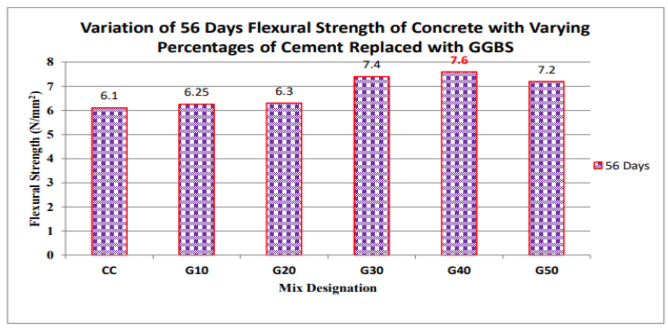


Chart 16: Percentage loss in weight due to acid curing

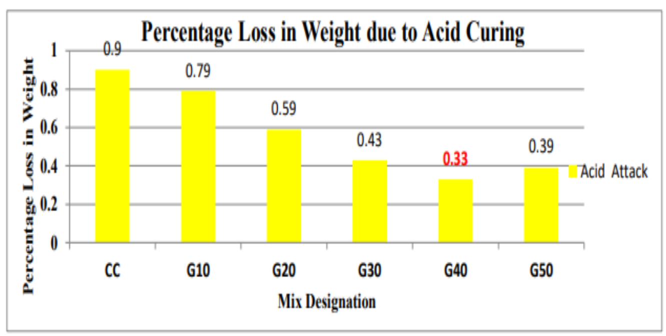


Chart 17: Percentage loss in strength due to acid curing

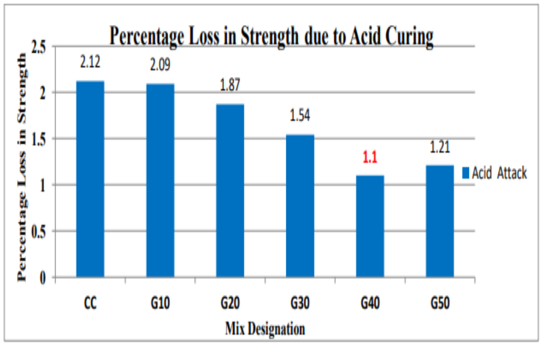


Chart 18: Percentage loss in weight due to chloride curing

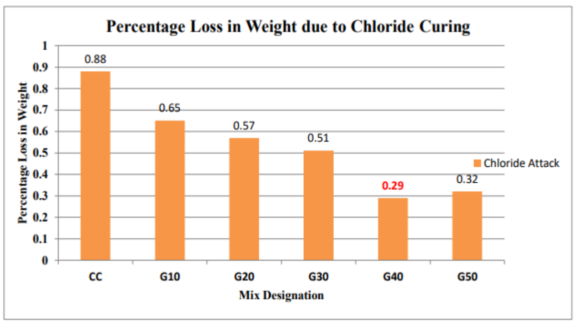


Chart 19: Percentage loss in strength due to chloride curing

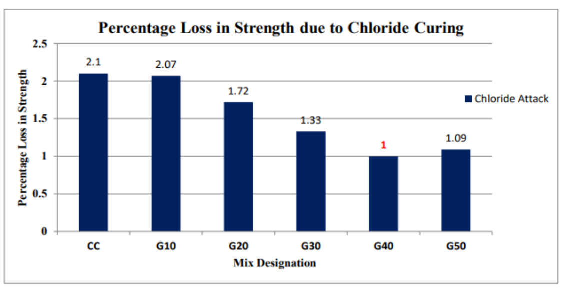


Chart 20: Percentage loss in weight due to sulphate curing

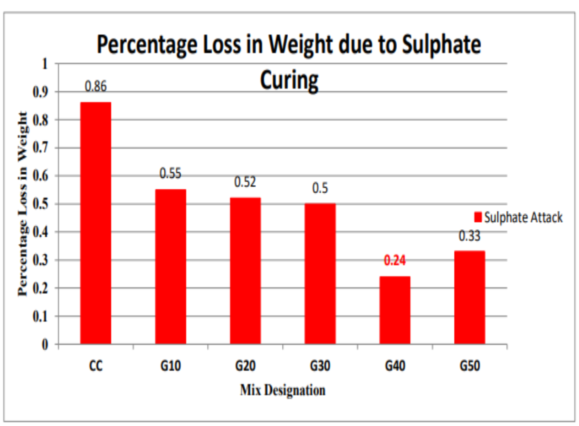


Chart 21: Percentage loss in strength due to sulphate curing

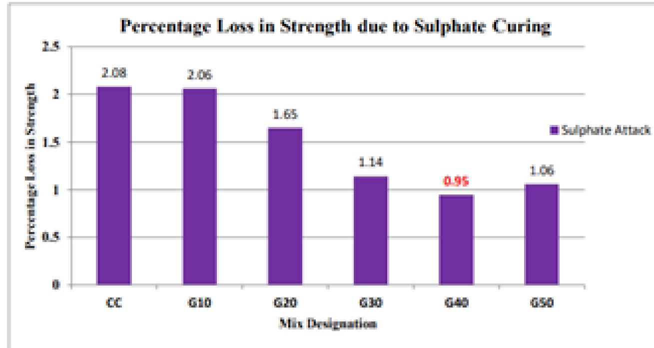


Chart 22: Percentage loss in weight due to various curing effects

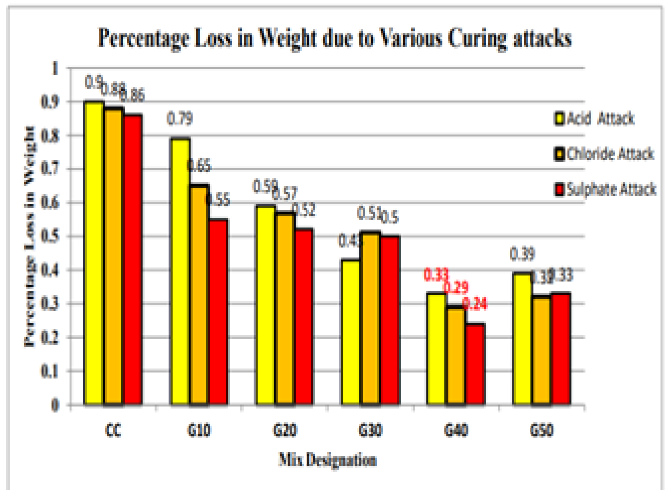
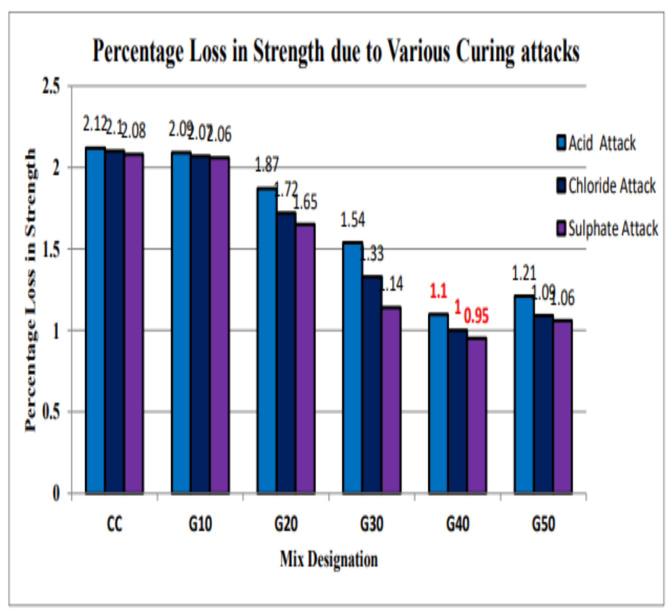


Chart 23: Percentage loss in strength due to various curing effects



VII. CONCLUSIONS

a) The inclusion of GGBS has desirable effect on concrete durability properties also which is comparable to normal concrete.
b) The usage of GGBS in concrete as cement replacement materials will lessen the CO2 is being emitted during its manufacture and acts as an eco-friendly material reducing the Greenhouse effect.
c) Incorporation of these types of mineral admixtures in cement helps in making it more economical.
d) Making concrete with the combination of GGBS and cement with different percentages gives good results compared to control concrete. So the best way to use these materials is in combination.
e) As far as cost is concerned, the cost of GGBS in the market including packaging and transporting is three times less than that of OPC.
f) As GGBS is partially replaced with the cement, the consumption of the cement is reduced and also the cost of construction is reduced.
g) It is concluded that the GGBS is good replacement for cementitious material in concrete.

REFERENCES

[1] J.Vengadesh Marshall Raman and V.Murali Krishnan, "Partial Replacement of Cement with GGBS in Self Compacting Concrete for Sustainable Construction", SSRG International Journal of Civil Engineering (SSRG – IJCE) – Vol 4, Issue 3, March-2017, pp: 22-25.

[2] Santosh Kumar Karri ,G.V.Rama Rao and P.Markandeya Raju, "Strength and Durability Studies on GGBS Concrete", SSRG International Journal of Civil Engineering (SSRG-IJCE) – Vol 2, Issue 10, October-2015, pp: 34-41.

[3] Chaithra H L , Pramod K and Dr. Chandrashekar A, "An Experimental Study on Partial Replacement of Cement by Ggbs and Natural Sand by Quarry Sand in Concrete", International Journal of Engineering Research & Technology (IJERT), Vol. 4 Issue 05, May-2015, pp: 1539-1544.

[4] M. Ramalakshmi, R. Sheeja and R. Gopinath, "Experimental Behaviour of Reinforced Concrete with Partial Replacement of Cement with Ground Granulated Blast Furnace Slag", International Journal of Engineering Research & Technology (IJERT), Vol. 3 Issue 3, March – 2014, pp: 525-534.

[5] Arivalagan. S, "Sustainable Studies on Concrete with GGBS as a Replacement Material in Cement", Jordan Journal of Civil Engineering, Vol 8, Issue 3, 2014, pp: 263-270.