Accelerated Curing Method for Concrete Mix Proportion by Adding GGBS

M. Sowjanya, B. Kameswara Rao

Abstract: ***Accelerated curing method is a steam or hot water curing which is sometimes adopted and the strength development of concrete is very rapid in this method. It fastens the process of hydration of cement and attains the strength of nearly 28 days curing within a shorter time. In this study, the method of accelerated curing was done by adding different percentages of Ground Granulated Blast Furnace Slag (GGBS) 90%, 80%, 70%, 60%, 50% have been varied for different water-binder ratios such as 0.3, 0.4 and 0.5.For this study, around 105 cubes of standard size (150mm X 150mm X 150mm) were tested under compression. In this research, the correlations among the boiling water method, 28 days and 90 days curing of GGBS will be developed. The compressive strength of GGBS 70% of w/c ratio 0.3 will give better results while compared to other percentages.***

Index Terms: ***Accelerated method, Correlation, GGBS, water-binder ratio.***

I. INTRODUCTION

Compressive strength of the concrete is the main parameter to know the quality of concrete. This parameter specifies the Compressive strength of concrete at the age of 28days as prescribed by Indian standard IS 456:2000. Usually the 28 days compressive strength procedure is adopted from IS 516: 1959. But this period is too long and not suitable for speed construction practices. Thus assessment of compressive strength of concrete at an early stage is demanded and specified by the accelerated curing test method prescribed in IS 9013:1978.The new method of accelerated curing needs to be compared with the actual results of traditional method of 28days period. GGBS is a good replacement to cement in some cases and serves effectively but it can't replace cement completely. [1] High early concrete strengths are mostly produced by increasing the internal temperature of the concrete by maintaining a high moisture content in the curing environment [2] GGBS used to make durable concrete it replaces cement [3]The present study is about to develop the correlation between the accelerated curing method of concrete and normal curing conditions of concrete by using the combination of Ground Granulated Blast Furnace Slag (GGBS) This method was done by the mix design for concrete by using combination of Ground Granulated Blast Furnace Slag (GGBS) by varying different water-binder ratios such as 0.3, 0.4 and 0.5, whereas the percentages of GGBS have been varied from 90%, 80%, 70%, 60% and 50%.

II. RESEARCH SIGNIFICANCE

Generally, the construction period influences the total cost of concrete construction. As per IS 9013-1978 code book method of making, curing and determining compressive strength of accelerated curing concrete test specimens are done only for plain concrete. In early ages of 1982 there is no awareness of using Ground Granulated Blast Furnace Slag (GGBS). In accelerated curing method, correlation of conventional concrete is only developed. From this present research, the correlation has been developed among the Boiling water strength and normal curing strength of 28 days, 90 days strength of GGBS. This correlation may be useful for the further studies while performing the accelerated method of Mix design.

III. MATERIALS

Materials used for this experimental investigation are given below:

- Cement
- Ground Granulated Blast Furnace Slag
- Fine Aggregate
- Coarse Aggregate
- Super Plasticizer

A. Cement

The physical and chemical properties of Ordinary Portland Cement are given in the below Table I & II.

Table I: Physical Properties of Cement

Tests conducted	Results
fineness	2%
Specific gravity	3.15
Consistency test	36%
setting time • Initial setting time • final setting time	 60 minutes 240 minutes
Soundness test	1.5 mm

Table II: Chemical Properties of Cement

Constituents	Results (%)
Silicon Dioxide (SiO_2)	18.62
Aluminum Oxide (Al_2O_3)	4.75
Ferric Oxide (Fe_2O_3)	3.02

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Calcium Oxide (CaO)	61.42
Magnesium Oxide (MgO)	3.21
Sodium Oxide (Na_2O)	1.51
Potassium Oxide (K_2O)	1.42
Sulphate (SO_4)	2.29
Loss on Ignition	3.55

B. Ground Granulated Blast Furnace Slag (GGBS)

GGBS is a non-metallic product consisting essentially of silicates and aluminates of calcium and other bases. The molten slag at a temperature of about 1500°C (2730°F) in the production of pig iron is rapidly chilled by quenching in water to form a glassy sand like granulated material called GGBS. The physical and chemical properties of GGBS are given in the below Table III & IV.

Table III: Physical Properties of GGBS

Test Particulars	Results
Specific Surface Area (Blaine Fineness)	400 to 600 (m^2/kg)
Specific Gravity	2.90
Bulk Density	1050 to 1375 (kg/m^3)
Physical form	Powdered form

Table IV: Chemical Properties of GGBS

Constituents	Results (%)
Silicon Dioxide (SiO_2)	33.05
Aluminium Oxide (Al_2O_3)	20.62
Titanium	0.10
Ferric Oxide (Fe_2O_3)	1.34
Manganese Oxide (Mn_2O_3)	0.19
Calcium Oxide (CaO)	34.09
Magnesium Oxide (MgO)	9.06
Sulphur Trioxide (SO_3)	0.58
Sodium Oxide (Na_2O)	0.23
Potassium Oxide (K_2O)	0.30
Sulphide as Sulphur	0.34

C. Fine Aggregate

The properties of fine aggregate are given in the below Table V.

Table V: Properties of Fine Aggregate

Sieve size	Requirement as per IS: 383-1970 (20 mm)	Percentage Passing
40 mm	100%	100%
20 mm	85-100%	93%
16 mm	-	-
12.5 mm	-	-
10 mm	0-20%	12%
Specific gravity		2.9

D. Coarse aggregate

The properties of coarse aggregates are given in the below Table VI.

Table VI: Properties of Coarse Aggregate

Sieve size	Percentage Passing
10 mm	100%
4.75 mm	100%
2.36 mm	99.50%
1.18 mm	86.70%
600 µ	35.80%
300 µ	8.60%
150 µ	0.80%
Zone	II
Fineness modulus	2.7
Specific gravity	2.6

IV. ACCELERATED CURING METHOD

Accelerated method of mix design is very effective method for producing high performance characteristics in the starting ages of concrete. Accelerated curing of concrete hastens the process of hydration of cement and as a result the essential portion of the strength to be attained in 28 days under normal curing conditions is achieved within a short period. The frequently used curing techniques are boiling water curing and warm water curing.

The estimated compressive strength (28 days & 90 days) is **R=8.09+1.64Ra**, where Ra is the Compressive strength of accelerated curing and R is the compressive strength of normal curing (28 days and 90 days).

V. METHODOLOGY

A. Casting:

In this present study, the normal curing was done with conventional concrete and blended concrete for 28 days and 90 days. In this present work different water-binder ratios such as 0.3, 0.4 and 0.5 are used by considering different percentages of GGBS (90%, 80%, 70%, 60% and 50%). By casting 6 lab specimens (150x150x150) for each water-binder ratio for 28 days and 90 days. And for blended concrete with different percentages of replacing cement with GGBS for 28 days and 90 days.

Figure I: Casting of Specimens

B. Curing:

The specimens which are casted for conventional concrete and blended concrete are kept under normal curing and accelerated curing for 28 days and 90 days in curing tank. These specimens are taken out after completion of curing period and are tested under compression. The accelerated specimens are taken out of the curing tank after exposing the specimens under 100 degrees for 3 and half hours. After accelerated curing the specimens are taken out of the curing and are kept under normal curing for one hour and then the specimens are tested under compression.

Figure II: Normal Curing of Specimens

Figure III: Accelerated Curing of Specimen

C. Testing:

The specimens are tested under compression strength for 28 days and 90 days and the values obtained are taken.

Figure IV: Compression Test

VI. RESULTS

The results that are obtained from the compressive strength of normal curing and accelerated curing are plotted in the following graphs.

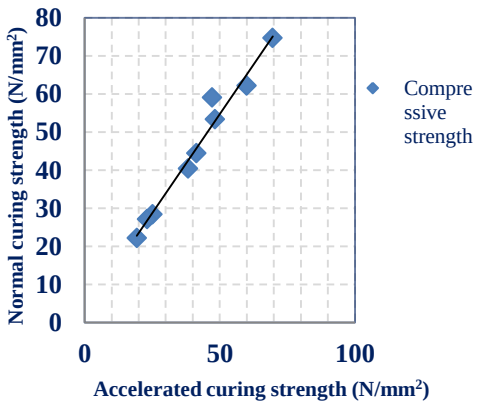

Figure V: Normal curing v/s Accelerated Curing for Plain concrete (28 days)

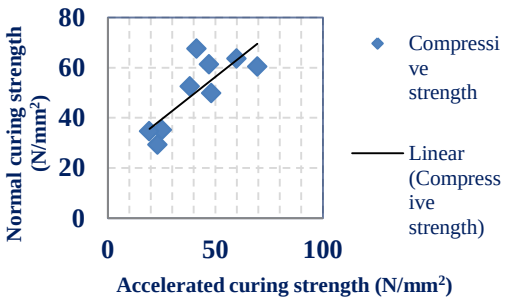

Figure VI: Normal curing v/s Accelerated Curing for Plain concrete (90 days)

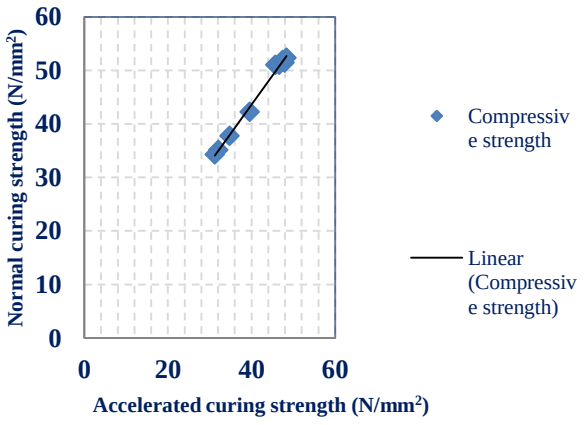

Figure VII: Normal curing v/s Accelerated Curing for blended concrete (0.3 w/c 28days)

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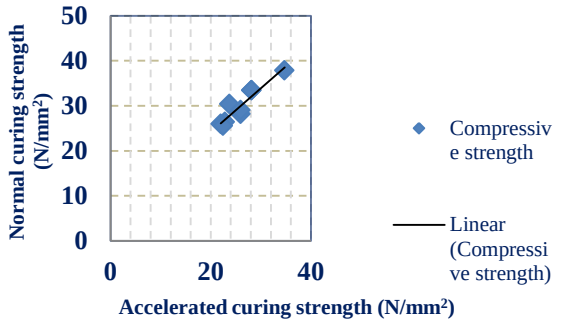

Figure VIII: Normal curing v/s Accelerated Curing for blended concrete (0.4 w/c 28days)

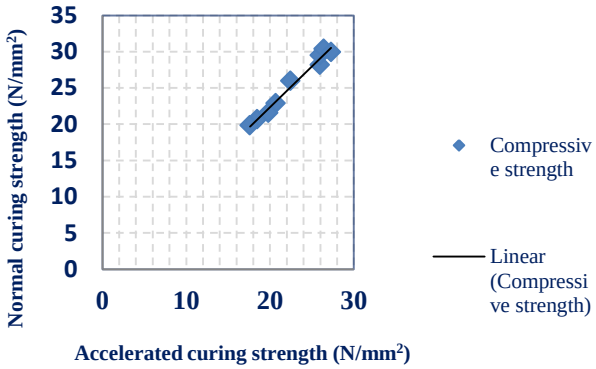

Figure IX: Normal curing v/s Accelerated Curing for blended concrete (0.5 w/c 28days)

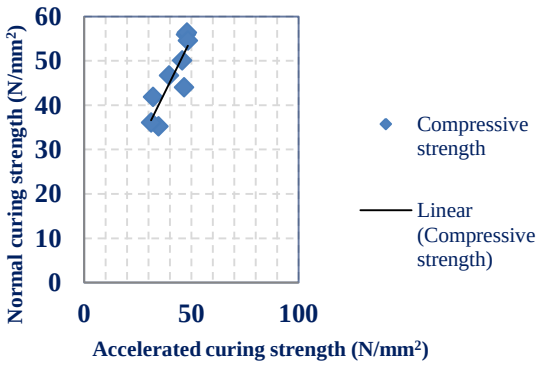

Figure X: Normal curing v/s Accelerated Curing for blended concrete (0.3 w/c 90 days)

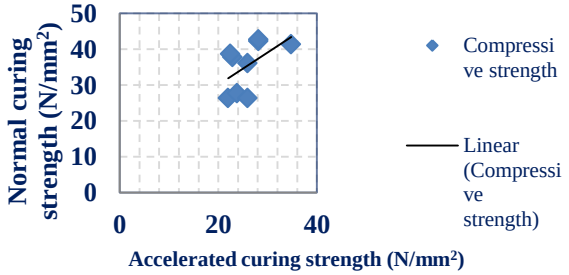

Figure 7: Normal curing v/s Accelerated Curing for blended concrete (0.4 w/c 90 days)

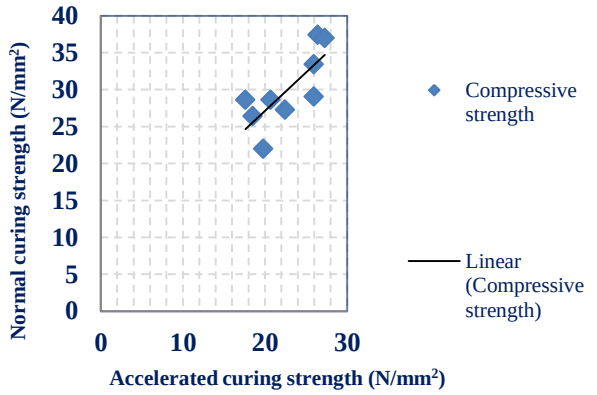

Figure XII: Normal curing v/s Accelerated Curing for blended concrete (0.5 w/c 90 days)

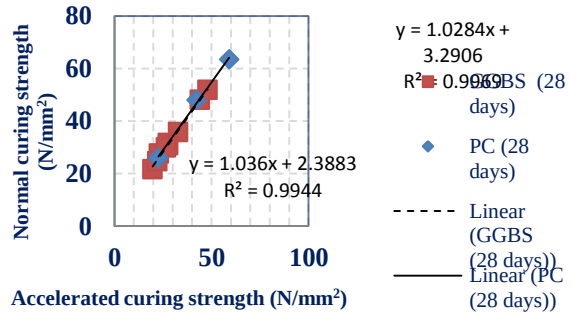

Figure XIII: Regression equation for Normal curing and Accelerated Curing (28 days)

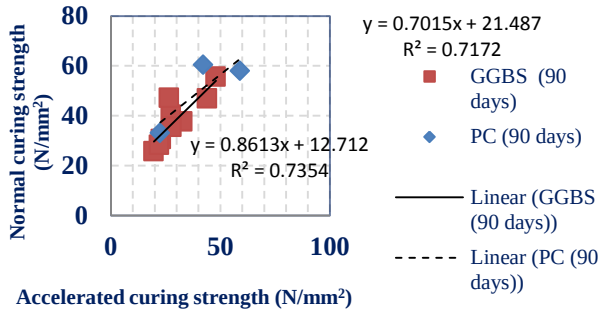

Figure XIV: Regression equation for Normal curing and Accelerated Curing (90 days)

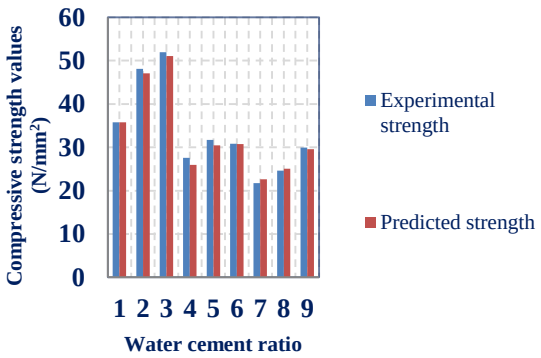

Figure XV: Experimental vs predicted values for blended concrete (28 days)

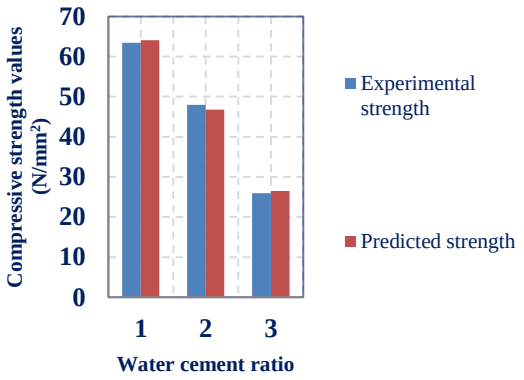

Figure XVI: Experimental vs predicted values for plain concrete (28 days)

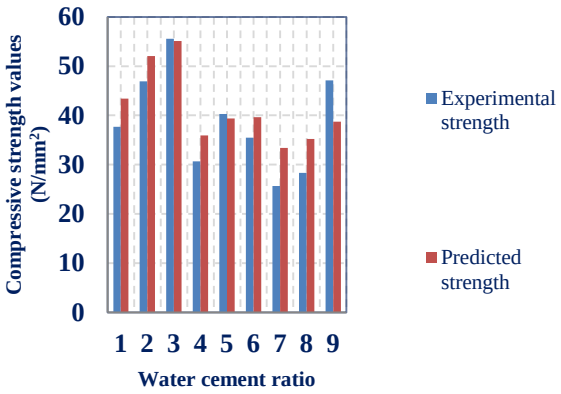

Figure XVII: Experimental vs predicted values for blended concrete (90 days)

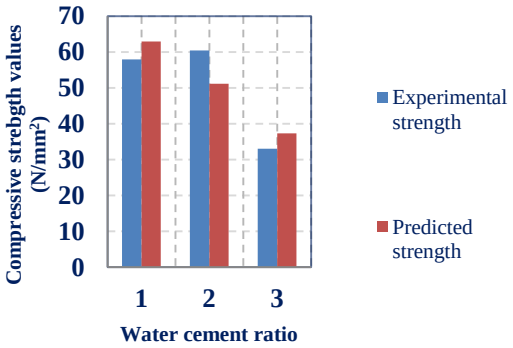

Figure XVIII: Experimental vs predicted values for plain concrete (90 days)

VII. CONCLUSION

We can replace GGBS but not 100 % at 0.3 water binder ratio 70 % of replacement of GGBS gives the best results. We can get early results in accelerated curing.

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