Evaluation of GGBSs As One of The Potential Replacements To The Cement In The Concrete-A Experimental Study

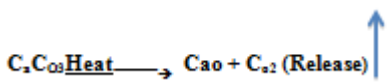
Shaik Chandini
Dept of Structural Engineering
Lincoln University College Malaysia

Abstract- *India is the 2nd largest country after china in the production of the cement. The cement is most essential component in the concrete as it is the component, which keeps the materials bind together. Cement is classified in to many different types depending upon the environment in which they are used for example sulphate resisting cement, rapid hardening cement etc., The growth in quality and the strength of the cement is seen clearly with upgrading technology but it is unavoidable fact that the cement emits 8% of carbon dioxide in the atmosphere as per statics provided by the Tank Chatham House. If this keeps continuing it increases the rate of the global warming. By keeping the risk of usage of cement in the concrete in mind, the present research work is done as a small step to reduce the use of cement in the concrete. In the present research work the GGBS is partially replaced with the cement in the concrete by 0%, 10%, 20%, 30% and the durability properties are tested on the 7, 14, 28, 56, 90 days.*

Keywords- Carbon dioxide, Cement, Environment, GGBS, Strength.

I. INTRODUCTION

Concrete is the combination of cement, F.A, C.A and water. The cement paste in concrete acts as the binding materials of the concrete. The concrete is known for its properties for example strength, workability, durability, ability to bear the loads etc.; the concrete is classified in different types again depending upon the environment in which it is used. In any type of concrete the one most common material and most needed material is cement, which has capacity to hold the materials. Where as on the other hand the cement is also criticized by public due to its intensive emission of carbon dioxide at its production of about 5 – 8%.



Tough it is unavoidable to stop the use of cement but through recent years research many materials have come upfront as potential replacements to the cement, these are called pozzolonic materials. The pozzolonic materials are not fully replaceable to the cement but they have shown good acceptable results as partial replacement s to the cement. The pozzolonic materials are Fly Ash, GGBS, Nano Silica, Copper Slag etc., the best part of the pozzolonic materials are they are industrial by products, which are disposed on the dumping yards resulting in causing the pollution. The wastes, which are thrown in dump yards, are now being reuse. The uses of these materials also reduce the pollution. Fly Ash can be partially replaced up to 50% to the cement. The GGBS is one the residue product of the iron manufacturing process. When it comes to structural point of view the GGBS has shown the promising results of low heat of hydration, higher durability and high resistance to sulphate compare to the normal concrete. The use of GGBS will work in 2 ways one is reducing the emission of carbon dioxide by minimizing the amount use of cement and the other is reducing the dumping of the wastes in the dumping yards.

II. REVIEW OF LITERATURE

Santos' Kumar Karri et al studied on the efficiency of GGBS concrete relating to the strength and durability. The GGBS is added at different percentages of at 0%, 10%, 20%, 40%, and 50% in the place of cement. The specimens prepared were cured in HCL and H_2S0_4. The result was obtained as the GGBS shown effective results at 40% replacement with cement and the HCL has shown less effect on concrete specimens where as H_2S0_4 has shown more damage to the specimens.

J.Vengadesh Marshall Raman et.al. Studied on self-compacting concrete. The GGBS is partially replaced with the cement at the percentages at 0%, 25%, 30%, 35%, 40% at water cement ratio of about 0.40. the study concluded that GGBS of about 25% can be successfully replaced.

P.R. PotePatil et.al; Studied GGBS concrete where the GGBS is added at different percentages in the place of cement. M25 mix was adopted and cement was replaced at 0%, 20%,

40%, and 60% and concluded that addition of GGBS has shown improved workability. The super plasticizer at 0.5% weight of cement. The study stated that GGGBS of about 40% gives good strength to the concrete addition of GGBS beyond 40% reduces the strength of the concrete.

KasuNaveeena et.al; Studied on the GGBS and metakolin. The GGBS is replaced T 0%, 10%, 20%, 30%. The M30mix was adopted at 0.45 water-cement ratio. The maximum strength was obtained at 30%. Beyond 30% has sown the decrease on the strength of the concrete.

III. OBJECTICES OF THE RESEARCH WORK

- To know the consequence of GGBS on the Strength of the concrete.
- Examining of the resistance of GGBS to the Acid Attack.
- For evaluating the extent of the GGGBS in the concrete when used in place of cement.
- To know the cost reduction by using of GGBS.
- To reduce the emission of the Co_2.
- To reduce the waste disposal of industries by-products which has cementing properties.

IV. MATERIALS USED IN PROCESS

4.1CEMENT:

The cement used in the following work is OPC 53 grade cement confirming to the IS. The cement has been from brought from Bharathicement company.

4.1.1Basic Properties of Cement:

Table 1

S.NO	Characteristics	Value
1.	Specific Gravity	3.15
2.	Normal Consistency	31%

Source: Primary data

4.2 COARSE AGGREGATES(C.A):

The C.A used in the work are 10mm natural aggregates. The tests are done on the coarse aggregates in the laboratory to access their quality and the results obtained showed that the aggregates matched to he required quality and can be safely used in the concrete. The properties of the C.A are as follows.

Table 2

S.No	Characteristics	Value
1.	Nominal Size	10mm
2.	Specific Gravity	2.84
3.	Density	1625.83 kg/m^3

Source: Primary data

4.3FINE AGGREGATES(F.A):

The F.A used in the present research work is natural river sand.

Table 3

S.No	Characteristics	Value
1.	Nominal Size	10mm
2.	Specific Gravity	2.84
3.	Density	1625.83 kg/m^3

Source: Primary data

4.4 WATER:

The water used in the research work is normal water.

4.5 GGBS:

The GGBS is the by-product of the Iron manufacturing process. In the present research work the GGBS used is been ordered from steel plant located in the Vishakhapatnam. The primary tests are conducted on the GGBS to check the quality of the GGSB so that it meets the requirements to be added in the concrete in place of cement. The tests values are given in table no.5.

4.5.1 Typical Substantial Properties Ground Granulated Blast Furnace Slag (GGBS):

Table 4

Shade	Creamy White
Specific Gravity	2.9
Bulk Density	1200kg/m^3
Fineness	350 kg/m^2

Source: Primary data

.

4.5.2 Chemical Composition:

Table 5

Compound	Content Wt.%
Cao	36.5
SiO_2	38.1
Al_2O_3	12.4
MgO	10.9
K_2O	0.6

Source: Primary data

4.5.3Uses Of Ground Granulated Blast Slag (GGBS):

- Improved workability.
- Low heat of hydration
- Reduce pollution, global warming.
- Low cost compare tot the cement.
- High endurance to the sulphate attack.
- High endurance to the chloride.
- Reduces corrosion due to the reinforcement.
- Reduce the Thermal cracking in large pours.

V. MIX DESIGN M_{40} (as per IS 10262: 2019)

Table 6

Grade	Cement(kg/m³)	F.A(kg/m³)	C.A(kg/m³)	Water(kg/m³)	W/C Ratio
M_{40}	443	611	1168	186	0.42

Source: Primary data

VI. TEST REUSLTS

6.1 SLUMP CONE TEST:

Table 7

S.No	GGBS %	Slump Cone Test(mm)
1.	0%	40
2.	30%	44
3.	40%	49
4.	50%	53

Source: Primary data

6.2. COMPRESSIVE STRENGTH:

The at least 3 cub specimens are casted fro each percentage and their average is taken as the final value for each percentage.The cube specimens are casted and cured at room temperature and their respective values are given in below table.The automatic compressive machine is used to measure the compressive strength of the cube specimens. The compressive strength is improved from 46.13 N/mm^2 to 53.81N/mm^2 for 28days at 0% of GGBS to 40% of GGBS. The values are clearly shown in Table no. 8.

Fig.1 showing the testing of the cube specimens in the compressive s=testing machine.

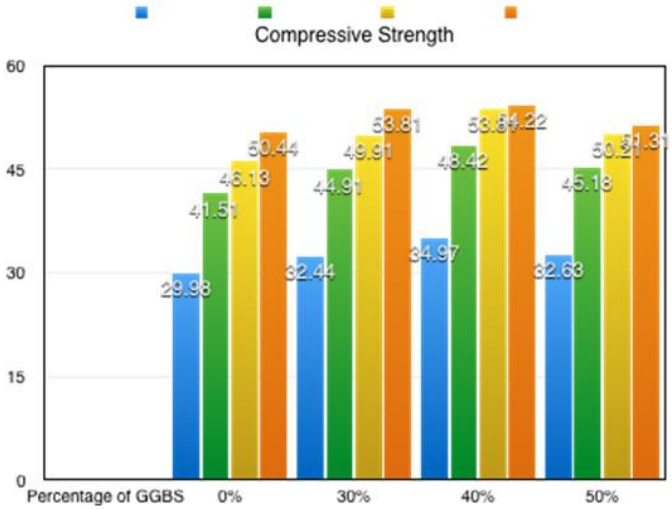
6.2.1 COMPRESSIVE STRENGTH FOR DIFFERENT PERCENTAGES OF GGBS:

Table 8

S.NO	Percentage of GGBS	7Days	14Days	28Days	90Days
1	0%	29.98	41.51	46.13	50.44
2	30%	32.44	44.91	49.91	53.81
3	40%	34.97	48.42	53.81	54.22
4	50%	32.63	45.18	50.21	51.31

Source: Primary data

6.2.1 GRAPHICAL REPRESENTATION OF COMPRESSIVE STRENGTH FOR DIFFERENT PERCENTAGES OF GGBS:



Blue = 7Day
Green = 14days
Yellow = 28days
Orange = 90days
Source: Primary data

The above graph clearly shows us that the highest valued obtained is53.81N/mm^2 at 28days and 54.22 N/mm^2 at 90 days at 40% of GGBS.

6.3 FLEXURAL STRENGTH:

The beams are casted wand cured at room temperature. The maximum flexural strength is obtained at addition of 40% of GGBS and the addition of GGBS beyond 40% shows the decrease of the flexural strength and which is more clearly shown in below in no. Table 9.

Fig.2 showing the testing of Flexural Strength specimens.

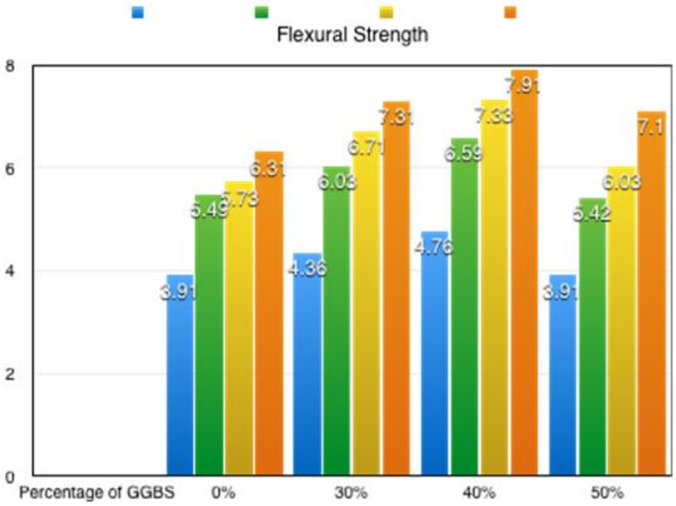
6.3.1 FLEXURAL STRENGTH FOR DIFFERENT PERCENTAGES OF GGBS:

Table 9

S.NO	Percentage of GGBS	7Days	14Days	28Days	90Days
1	0%	3.91	5.49	5.73	6.31
2	30%	4.36	6.03	6.71	7.31
3	40%	4.76	6.59	7.33	7.91
4	50%	3.91	5.42	6.03	7.1

Source: Primary data

6.3.2 GRAPHICAL REPRESENTATION OF FLEXURAL STRENGTH FOR DIFFERENT PERCENTAGES OF GGBS:



Blue = 7Day
Green = 14days
Yellow = 28days
Orange = 90days
Source: Primary data

The above graph shows that the replacement of GGBS to the cement at 40% is showing the e higher strength that is 7.33N/mm^2 for 28days and 7.91 N/mm^2 for 90days when compared to the other percentages.

6.4 SPLIT TENSILE STRENGTH:

The cylinders are casted and cured at room temperature and the split tensile strength has shown the improvement in thevalues of strength when GGBS is added to the concrete and the maximum value obtained is 4.44N/mm^2 for a period of 28days and 4.78 N/mm^2 for a period of 90days and the maximum percentage, which gives this value, is 40%. The values are more clearly shown in table no. 10.

Fig.3 showing the Flexural Test.

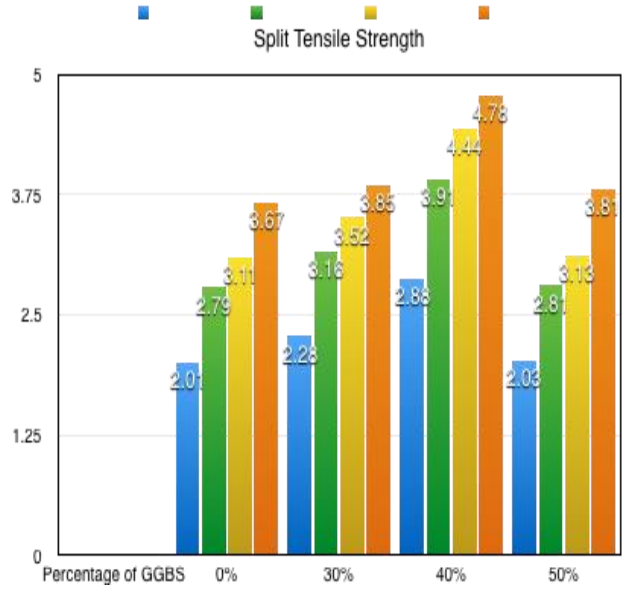
6.4.1SPLIT TENSILE STRENGTH FOR DIFFERENT PERCENTAGES OF GGBS:

Table 10

S.NO	Percentage of GGBS	7Days	14Days	28Days	90Days
1	0%	2.01	2.79	3.11	3.67
2	30%	2.28	3.16	3.52	3.85
3	40%	2.88	3.91	4.44	4.78
4	50%	2.03	2.81	3.13	3.81

Source: Primary data

6.4.2 GRAPHICAL REPRESENTATION OF SPLIT TENSILE STRENGTH FOR DIFFERENT PERCENTAGES OF GGBS:



Blue = 7Day
Green = 14days
Yellow = 28days
Orange = 90days
Source: Primary data

The above graph clearly shows us that the maximum split tensile strength is obtained at 40% replacement of GGBS and it is higher than the normal concrete strength that is 4.44 N/mm^2 for 28days and 4.78 N/mm^2 for 90 dyas.

6.5 PERCENTAGE OF INCREASE OF STRENGTH OF CONCRETE AT ADDITION OF 0% AND 40% OF GGBS FOR 28DAYS:

Table 11

S.No	Type of Strength	Strength at 0% of GGBS	Strength at 40% of GGBS	Percentage of increases of the Strength
1.	Compressive Strength	46.13	53.81	16.64%
2.	Split Tensile Strength	3.11	4.44	42%
3.	Flexural Strength	5.73	7.33	27.92%

Source: Primary data

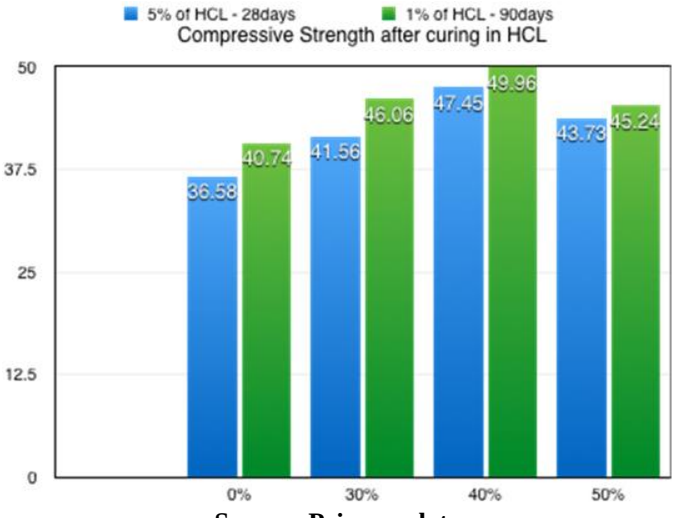
6.6 COMPRESSIVE STRENGTH WITH CURING IN HCL:

Table 12

Mix	Compressive Strength	
	28days(5% of HCL)	56days(1% of HCL)
0%	36.58	40.74
30%	41.56	46.06
40%	47.45	49.96
50%	43.73	45.24

Source: Primary data

6.6.1. GRAPHICAL REPRESENTATION OF COMPRESSIVE STRENGTH WITH CURING IN HCL:



Source: Primary data

The above graph clearly shows that the samples which contains the GGBS percentages has shown better resistance to the acid attack in both 1% and 5% of the HCL acid percentages when compare to the normal concrete. The specimens with 40% of GGBS has shown high strength and also high resistance to the acid attack when compare to other percentages and the normal concrete.

COST ESTIMATION:

6.1 COST ESTIMATION OF NORMAL M_{40} CONCRETE:

Table 13

S.No	Materials	Price per Kg	Price per Kg/m^3
1.	Cement	7	3101 (443kgs x 7rs)
2.	Fine Aggregates	1.5	916.5 (611kgs X 1.5rs)
3.	Coarse Aggregates	1.7	1985.6(1168kgs X 1.7rs)

Source: Primary data
TOTAL = 6002.5 rs.

6.2 COST ESTIMATION OF M_{40} FOR 40% REPLCEMENT OF CEMENT WITH GGBS:

Table 14

S.No	Materials	Price per Kg	Price per Kg/m^3
1.	Cement	7	1862 (266kgs X 7)
2.	Fine Aggregates	1.5	916.5 (611kgs X 1.5rs)
3.	Coarse Aggregates	1.7	1985.6(1168kgs X 1.7rs)
4.	40% of GGBS		177 (177kgs X 1rs)

Source: Primary data
TOTAL = 4941.1 rs.

VII. CONCLUSION

- The study concludes that the GGBS increase the strength of the concrete when it is replaced up to 40% to the weight of the cement increase of the amount of the GGBS more than the 40% decreases the strength of the concrete.
- The addition of the GGBS to the amount of the cement decreases the total cost of the construction.
- The addition of GGBS to the weight of the cement increases the compressive strength of the concrete from 46.13 KN/m^2 at 0% of GGBS for 28days to 53.81$KN/m^2$for 28days.
- The addition of GGBS to the weight of the cement results in increases of the tensile strength of the concrete from 3.11 KN/m^2 at0% of GGBS for 28days to 4.44KN/m^2at 40% of GGBS for a period of28days.
- The count of GGBS to the concrete increases the flexural strength of the concrete from5.73 KN/m^2 at 0% of GGBS for 28days to 7.33KN/m^2 at 40% of GGBS for 28 days.
- The study concluded that the GGBS could be successfully used in the place of cement up to 40%.
- the study has concluded that the GGBS has shown more resistance to acid attack compare to the normal concrete.

VIII. ACKNOWLEDGMENT

I would whole heartedly like to thank my parents Shaik.Abdul.Razack and SayidawBanu and my sister Shaik.BalkhisBanu and Shaik. RehanaBanu who has supported me financially and morally to do this research work and I would like to thank to the lab assistants who have helped me in this research work with which, I was able to do the physical work easily.

I would whole heartedly like to thank my parents Shaik.Abdul.Razack and SayidawBanu and my sister Shaik.BalkhisBanu and Shaik. RehanaBanu who has supported me financially and morally to do this research work and I would like to thank to the lab assistants who have helped me in this research work with which, I was able to do the physical work easily.

REFERENCES

[1] Latha K.S, Rao M.V.S, and Reddy V. S. "Estimation of GGBS and HVFA strength efficiencies in concrete with age", International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Vol. 2, Issue 2, December (2012)

[2] Dubey A, Chandak R, and Yadav R.K. "Effect of blast furnace slag powder on compressive strength of concrete", International Journal of Scientific & Engineering Research. ISSN 2229-5518, Vol. 3, Issue 8, August (2012)

[3] Pathan V.G, Ghutke V.S, and Pathan G. "Evaluation of concrete properties using ground granulated blast furnace slag", International Journal of Innovative Research in Science, Engineering and Technology Vol. 1, Issue 1, November (2012)

[4] Gudissa W, and Dinku A. "The use of limestone powder as an alternative cement replacement material: An experimental study

[5] Harrison A J W 2003 TecEco cement concretes—abatement, sequestration and waste utilization in the built

environment. TecEco Pty. Ltd., Hobart, Tasmania, Australia. Available at: http://www.tececo.com/files/conference%20papers/TecEco TechnologyAbatementSequestrationandWasteUtilsation2901 05.pdf. (Accessed March 12, 2012)

[6] Alaa M R, Hosam El-Din H S and Amir F S 2014 Effect of silica fume and slag on compressive strength and abrasion resistance of HVFA concrete. Int. J. Concr. Struct. Mater. 8(1): 69–81

[7] Ujhelyi J E and Ibrahim A J 1991 Hot weather concreting with hydraulic additives.Cem. Concr. Res. 21(2–3): 345–354

[8] Siddique R and Deepinder K 2012 Properties of concrete containing ground granulated blast furnace slag (GGBS) at elevated temperatures. J. Adv. Res. 3: 45–51

[9] Darren T Y, Limda DA XU, Divsholi B, SabetKondraivendhan B and Susanto T 2011 Effect of ultra fine slag replacement on durability and mechanical properties of high strength concrete. 36th Conference on 'Our world in Concrete and Structures', Singapore 10

[10] Malhotra V M and Mehta P K 1996 Pozzolanic and cementitious materials. Overseas, p 191