ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 1, January 2018

Effect of Elevated Temperatures on Concrete with Ground Granulated Blast Furnace Slag (GGBFS) as a Replacement of Cement

[1] Vinayak D. Vaidya, [2] Dr. Valsson Varghese, [3] P.K.Morey, [4] D.B. Awchat, [5] S.S. Borkar
[1][3][4][5]Asst. Prof, [2] Prof & Head Department of Civil Engineering
K.D.K. College of Engineering, Nagpur

Abstract: **-- In This proposed work is an experimental investigation are underway to investigate the impact of raise in temperatures on different properties of conventional and concrete with Ground Granulated blast furnace slag (GGBFS) as an additive. In the analysis, effect on compressive strength, split tensile strength and flexure strength was investigated. This study presents Effect of partial replacement of cement by using GGBFS by 20 %, 40% and 60% with an addition 1 % of steel fibers. The said samples were heated from 200 0C to 1000oC in the increment of 200oC for 1 hour. The compressive strength, split tensile and flexure strength was executed for heated samples at different temperature at the age of 28 days. At different elevated temperatures, GGBFS1 (20% GGBFS +1% steel fiber) found the suitable combination as compared to conventional concrete and other combinations.**

Index Terms**: - Ground Granulated blast furnace slag (GGBFS), Cement, Compressive strength, Split tensile strength, Flexural strength.**

I. INTRODUCTION

To make a structure functionally viable after the damage due to fire has become a challenge for the civil engineering community. It is very important that we create buildings and structures should protect people and property. One of the advantages of concrete over other building materials is its inherent fire-resistive properties. However, concrete structures should be designed for fire effects damages that may cause collapse of structure. Structural components like beams, columns and slabs should be able to withstand various dead loads, imposed loads and others if any without collapse even at elevated temperature which causes a decrease in the strength (Compressive, tensile and flexural) & modulus of elasticity (E) for concrete. Fire resistance is measured in terms of structural stability, structural integrity and insulation. Stability refers to the ability to remain standing without collapse. Integrity refers to the ability to remain intact and not move and buckle to create openings through which flames can escape. Insulation relates to the ability to either contain the fire within the building and not to ignite any material outside, or to insulate what is inside the building from being ignited by a fire outside Blast furnace slag is a non-metallic by-product produced in the process of iron making (pig iron) in a blast furnace and 300kg of Blast furnace slag is generated when 1 ton of pig iron produced. In India, annual productions of pig iron is 75-85 million tons and corresponding blast furnace slag are about 22-26 million tons. Blast furnace slag is an alkaline and exhibits a pH value in the range of 8 to 10 and does not present a corrosion risk to steel embedded in concrete made with blast furnace slag cement or aggregates. The blast furnace slag is mainly used for the cement raw material, the mineral admixture for concrete and aggregate for concrete. The property of blast furnace slag is similar to coarser aggregate, the price is cheap and the output is large too, could be regarded as the substitute of the coarser aggregate. But there is no experience about application of blast furnace slag coarse aggregate in concrete and the reports about the research are also few.

II EXPERIMENTAL WORK

A. Material Testing [2]

1. Cement - Although all materials that go into concrete mix are essential, cement is very often the most important because it is usually the delicate link in the chain. The function of cement is first of all to bind the sand and stone together and second to fill up the voids in between sand and stone particles to form a compact mass. It constitutes only about 20 percent

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 1, January 2018

of the total volume of concrete mix; it is the active portion of binding medium and is the only scientifically controlled ingredient of concrete. Any variation in its quantity affects the compressive strength of the concrete mix. Portland cement referred as (Ordinary Portland Cement) is the most important type of cement and is a fine powder produced by grinding Portland cement clinker. Maintaining the Integrity of the Specifications

TABLE- 1 Properties of cement

Sr. No.	Properties	Result Obtained	Standard Values
1	Standard Consistency	29%	-
2	Initial Setting Time (minutes)	34	Not be less than 30 minutes
3	Final Setting Time(minutes)	340	Not be greater than 600 minutes
4	Soundness(mm)	5	<10
5	Fineness	8%	<10
6	Specific gravity	3.15	-

2. Fine Aggregate - In this experimental program, locally available river sand was used as fine aggregate and conformed to Indian Standard Specifications IS: 383-1970. The sand was sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm and conforming to grading zone II.

TABLE-2 Properties of Fine Aggregate

Sr. No	Name of Test	Result
01	Specific gravity	2.62
02	Fineness Modulus	2.47

3. Coarse Aggregate- The normal maximum size is gradually 10-20 mm; however particle sizes up to 40 mm or more have been used in Self Compacting Concrete. Gap graded aggregates are frequently better than those continuously graded, which might expensive grader internal friction and give reduced flow. Regarding the characteristics of different types of aggregate, crushed aggregates tend to improve the strength because of interlocking of angular particles, while rounded aggregates improved the flow because of lower internal friction. Locally available coarse aggregate having the maximum size of 20 mm was used in this work. The aggregates were washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested as per IS: 383-1970.

TABLE-3 Properties of Coarse Aggregate

Sr.N	Name of Test	Result
01	Specific gravity	2.72
02	Fineness Modulus	7.20

4. Ground Granulated Blast furnace slag(GGBFS)- Ground Granulated Blast furnace slag is collected from JSW ,Nagpur and was tested in lab to find out chemical analysis (calcium Oxide, silicon dioxide, Aluminium Oxide, Magnesium Oxide, Iron, Manganese Oxide, Sulfur,Phosporous pentoxide, Chromium Oxide)

Physical property of GGBFS

TABLE-4 Physical Properties of GGBFS

Sr.N	Name of Test	Result
01	Specific gravity	2.87
02	Fineness Modulus(90u/45u)	0/0.8 %

Chemical property of GGBFS-

TABLE-5 Chemical property of GGBFS

Sr. No.	Characteristics	Requirement as Per BS: 6633	Test Result
	Chemical Requirements		
1	Fineness (M2/Kg)	275 (Min)	441
2	Insoluble Residue (%)	1.5 (Max)	0.36
3	Magnesia Content (%)	14.0 (Max)	6.82
4	Sulphide Sulphur (%)	2.00 (Max)	0.26
5	Sulphite Content (%)	2.50 (Max)	0.36
6	Loss of Ignition (%)	3.00 (Max)	-0.26
7	Manganese Content (%)	2.00 (Max)	0.16
8	Chloride Content (%)	0.10 (Max)	0.028
9	Glass Content (%)	67 (Min)	94.5
10	Moisture Content (%)	1.00 (Max)	0.09
11 A B C	Chemical Modulus CaO + MgO + SiO2 CaO + MgO / SiO2 CaO / SiO2	 66.66 (Min) >1.0 <1.40	 78.29 1.23 1.03

5. Steel Fibre (Hooked ends)

TABLE-6 Properties of steel Fibrs

PROPERTIES	STEEL FIBRE
Density(kg/m^3)	7840
Tensile Strength (MPa)	1100
Length(mm)	60
Diameter(mm)	1

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 1, January 2018

Steel fibre addition (%)	1
Aspect ratio	60

B. Mix Design[3]

TABLE-7 Mix Design

S.N	Mix proportion for 1 m3 of Concrete	M25 grade
1	Mass of cement in kg /m3	413.13 kg /m3
2	Mass of water in kg /m3	186 kg / m3
3	Mass of fine aggregate in kg /m3	662.1 kg / m3
4	Mass of coarse aggregate in kg /m3	1183.29kg / m3
5	Water cement ratio	0.45

Ratio found as 1:1.60:2.86

C. Test on fresh concrete [4]

TABLE-8 Test on fresh concrete

Type of concrete	Partial Replacement of Cement by GGBS	Slump(mm)
Conventional	0%	80
GB1	20%	83
GB2	40%	86
GB3	60%	90

III RESULTS AND DISCUSSION

1. Compressive strength of concrete –

TABLE- 9 Compressive strength of concrete

Temperature	Normal Concrete	GGBFS1(20%)	GGBFS2(40%)	GGBFS3(60%)
Room temp.	29.41	42.71	40.53	39.66
200	27.32	35.30	31.82	27.02
400	24.1	28.77	28.33	26.59
600	21.69	27.89	25.28	25.28
800	17.41	19.61	15.25	13.95
1000	7.6	12.64	10.46	7.85

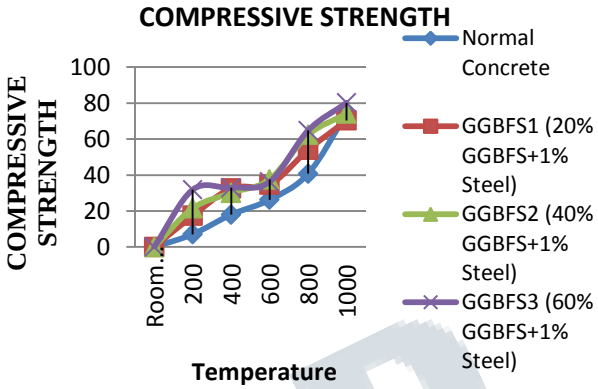

Fig 1. Compressive strength

III. DISCUSSION

As the temperature increases compressive strength of concrete gets reduced for all combinations.

GGBFS1(20% GBFS+1% steel fiber) gives higher compressive strength as compare to other combinations and conventional concrete.

2. Tensile strength of concrete –

TABLE- 10 Tensile strength of concrete

Temperature	Normal Concrete	GGBFS1 (20%)	GGBFS2 (40%)	GGBFS3(60 %)
Room temp.	2.16	3.33	3.19	2.36
200	2.07	2.91	2.78	2.22
400	1.68	2.78	2.64	2.08
600	1.33	2.36	2.22	1.39
800	1.23	1.67	1.39	0.83
1000	0.73	0.83	0.56	0.28

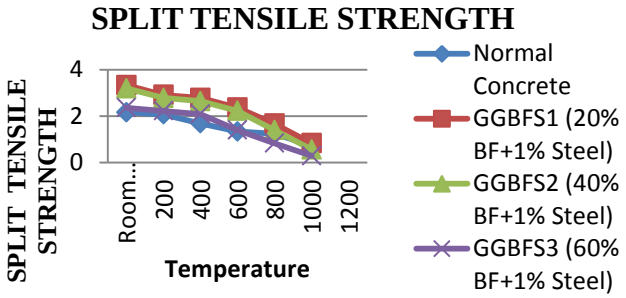

Fig 2 Tensile strength

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 1, January 2018

Discussion –
As the temperature increases split tensile strength of concrete gets reduced for all combinations.
GGBFS1(20% BFS+1% steel fiber) gives higher tensile strength as compare to other combinations.

3. Flexural strength

TABLE- 11 Flexural strength

Temperature	Normal Concrete	GGBFS1(20%)	GGBFS2 (40%)	GGBFS 3(60%)
Room temp.	1.1	2.26	1.62	1.37
200	1.03	1.81	1.18	0.69
400	0.86	1.47	1.03	0.54
600	0.55	1.13	0.69	0.44
800	0.49	0.74	0.39	0.25
1000	0.26	0.44	0.15	0.05

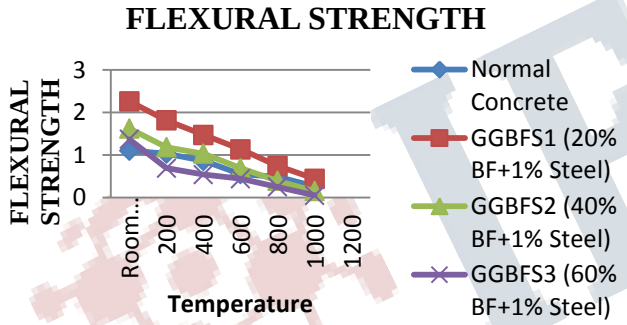

Fig 3 Flexural strength

Discussion –
As the temperature increases Flexural strength of concrete gets reduced for all combinations.
GGBFS1 (20% GBFS+1% steel fiber) gives higher flexural strength as compare to other combinations.

IV. CONCLUSIONS

Based on experimental work carried out in this particular study, the Following conclusions have been drawn out,

- With the increasing temperature upto 1000^0C, the compressive strength, Split tensile strength and flexural strength of concrete gets reduced, due to the hardening of cement paste caused by drying, due to which the bond of cementations materials was got loss.
- At elevated temperature upto 1000^0C, GGBFS1 (20% Ground granulated blast furnace slag +1% steel fibre) concrete found suitable combination. In this the Increase in strength, which is due to the high reactivity of GGBFS with cement and the filler effect of GGBFS.
- When the sample is heated between 300^0C to 600^0C the colour of concrete changes to red, due to siliceous aggregate present in concrete.
- When the sample is heated between 600^0C to 900^0C the colour of concrete changes to whitish grey, due to the reaction of calcium carbonate in the calcinations process CaCO3 which turns to lime and give pale shades of white and grey colour.
- When the temperature range is between 900^0C to 1200^0C concrete shows light yellow colour is due to oxidation of mineral components.
- After 1000°C temperature concrete will not functional to its strength.
- At enhanced temperature GGBFS1 (20% GBFS+1% steel fiber) found suitable combination.

REFERENCES

[1] Aveline Darquennes, Stephanie Staquet, and Bernard Espion. (2011). “Behaviour of Slag Cement Concrete under Restraint Conditions”. European Journal of Environmental and Civil Engineering,15 (5), 787-798.

[2] Elsayed, A.A. (2011). “Influence of Silica Fume, Fly Ash, Super Pozz and High Slag Cement on Water Permeability and Strength of Concrete”. Jordan Journal of Civil Engineering , 5 (2), 245-257. Martin O’Connell, Ciaran McNally, and Mark G.

[3] Richardson. (2012). “Performance of Concrete Incorporating GGBS in Aggressive Wastewater Environments”. Construction and Building Materials, 27 (1), 368-374.

[4] Shariq, M., Prasad, J., and Ahuja, A.K. (2008). “Strength Development of Cement Mortar and Concrete Incorporating GGBFS”. Asian Journal of Civil Engineering (Building and Housing), 9 (1), 61-74 .

[5] Shetty, M. S. (2005). "Concrete Technology". S. Chand and Co., Ltd., New Delhi.

[6] Wang Ling, Tian Pei, and Yao Yan. (2004).“Application of Ground Granulated Blast Furnace Slag

in High-Performance Concrete in China". International Workshop on Sustainable Development and Concrete Technology, Organized by China Building Materials Academy, PRC, 309-317.

[7] Peter W.C. Leung, and Wong, H.D. (2010). "Final Report on Durability and Strength Development of Ground Granulated Blast Furnace Slag Concrete". Geotechnical Engineering Office, Civil Engineering and Development Department, The Government of Hong Kong.

[8] Reginald B. Kogbara, and Abir Al-Tabbaa. (2011). "Mechanical and Leaching Behavior of Slag-Cement and Lime-activated Slag Stabilized/Solidified Contaminated Soil". Science of the Total Environment, 409 (11), 2325-2335.

[09] K.Ganesh Babu and V.Sree Rama Kumar,"Efficiency of GGBS in concrete" Cement and concrete Research Volume 30, Issue 7 July 2000 Pages 1031-1036

[10] K Ganesh Babu and V Sree Rama Kumar , Efficiency of GGBS in Concrete , Science Direct Cement and Concrete Research (2000),pp 1031-1036

[11] K Ganesh Babu and G S N Rao and P V S Prakash, Efficiency of pozzolans in cement composites,Concrete 2000(1993),pp. 497-509

[12] K Ganesh Babu and G S N Rao, Efficiency of flyash in concrete, Cement Concrete Composites (1993),pp. 223-229