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Impact of GGBFS on the Flexural Tensile Strength of Concrete

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ABSTRACT

The deformation and cracking behavior of concrete structure absolutely depends on the flexural tensile strength of concrete. Many factors have been studied in previous researches shows the flexural tensile strength of concrete is influenced particularly by the level of stress, size, age and confinement to concrete flexure member, etc. these can be overrides by confining the reinforcement in the concrete elements which increases ductility and large deflections in structures provide a good warning of failure prior to complete failure of the flexure member but it does not increase the ductility of cement concrete. The ductility of concrete can be increased by increasing the tensile strength of concrete. These findings short out the important factors which influences the major role of various fibres and GGBS used in concrete cubes.

KEYWORDS: Compressive strength, Flexural tensile strength, Modulus of rupture, Statistical procedures, Concrete confinement, Age of concrete

1. OBJECTIVES OF THE STUDY

The main objectives of the present experimental work are to assess the Flexural Tensile and Compressive Strength of Concrete for different grades (M20, M25, M30 and M35).

2. MATERIALS AND METHODS

The Ground Granulated Blast Furnace Slag is a by-product obtained from iron manufacturing industry. Iron ore, coke and limestone are fed into the furnace and the resulting molten slag at a temperature of about 15000C to 16000C. The molten slag has constitutions of about 30% to 40% SiO2 and about 40% CaO, which is nearest to the chemical composition of Portland cement. After the molten iron is tapped off, the remaining molten slag, which consists of mainly siliceous and aluminous residue is then dried and ground to the required size, which is known as Ground Granulated Blast Furnace Slag (GGBFS). It has higher durability, workability, reduces permeability to external agencies, which helps in making, placing and compaction easier. As a result, the service life of a structure is enhanced and the maintenance cost reduced.

2.1 MIX DESIGN:

The Mix design of total four grades of concrete has been designed as M20, M25, M30 and M35 using 43grade of PPC cement has been done. The proportion of various constituent materials like Coarse aggregate, sand, cement, water and admixtures have been calculated as per the mix design procedure explained in IS 10262-2009. The Quantities of different ingredients used for various grades of concrete are shown in Table -1.

Table :1 Mix ingredients for different mixes

S. No.	Grade	Cement (kg) + 15% of GGBS	Sand (kg)	C.A (kg)	Water (kg)	W/C	Density (kg/m3)	Proportion (C:FA:CA)
I	M20	320	634	1340	160	0.48	2512	1:1.98:4.19
II	M25	345	652	1320	156	0.45	2503	1:1.89:3.83
III	M30	390	605	1216	159	0.41	2479	1:1.55:3.12
IV	M35	410	615	1230	155	0.38	2469	1:1.50:3.00

2.2. NUMBER OF SPECIMEN CASTED AND CURED:

For testing compressive strength 6 cubes of size 150 mmx150 mmx150mm were casted (3 for 7 days strength and rest three for 28 days strength) for each grade and overall 24 cubes were casted.

3. COMPRESSIVE STRENGTH:

Compressive strength of concrete was calculated using load verses area method. After 28 days curing of different grades of concrete cubes were kept for air drying for 24 hours and tested using CTM

3.1 FLEXURAL STRENGTH OF CONCRETE:-

Flexural strength is one which measures the strength and also unreinforced concrete beams to resist failure load in bending. It is also known as modulus of rupture or fracture strength.

Test beam specimens of dimension 100x100x500 mm were cast. After the casting of specimens was done, those were de-moulded and transferred to the curing tank and allowed to cure for 28 days. The strength was tested under two point loading as per I.S.516-1959, the 500mm of effective span divided into three equal parts. Those were rest on a testing machine of flexural strength. While testing was done the load was increased gradually and the failure point load was noted at which the beam was cracked. For each percentage of mix two beams were tested and the average value was considered. The flexural strength can be calculated using below formula.

Flexural Strength (Mpa) = PL/bd^2

Here, P = Failure Load, L = Distance between the supports from centre to centre = 600mm

Table :2 Test results for Sample:1

S.I.no	Grade	Age on Test	Load KN	Compressive Stress	Load kN	Split tensile Stress	Flexural Tensil Stress N/mm^2	Ultimate Stress
1	M20	7	420	11.57	189	1.8	2.43	3.12
2			415	11.07	187	1.9	2.40	3.09
3			470	13.37	212	1.9	2.72	3.50
4		28	565	24.36	254	3.7	4.97	4.20
5			595	25.65	268	3.9	5.24	4.43
6			600	25.87	270	4.0	5.28	4.46

Table :3 Test results for Sample:2

S.I.no	Grade	Age on Test	Load KN	Compressive Stress	Load kN	Split tensile Stress	Flexural Tensil Stress N/mm2	Ultimate Stress
1	M25	7	550	15.16	248	2.4	3.18	4.09
2			650	17.33	293	3.0	3.76	4.83
3			405	11.52	182	1.6	2.34	3.01
4		28	620	26.73	279	4.1	5.46	4.61
5			650	28.02	293	4.3	5.72	4.83
6			625	26.94	281	4.1	5.50	4.65

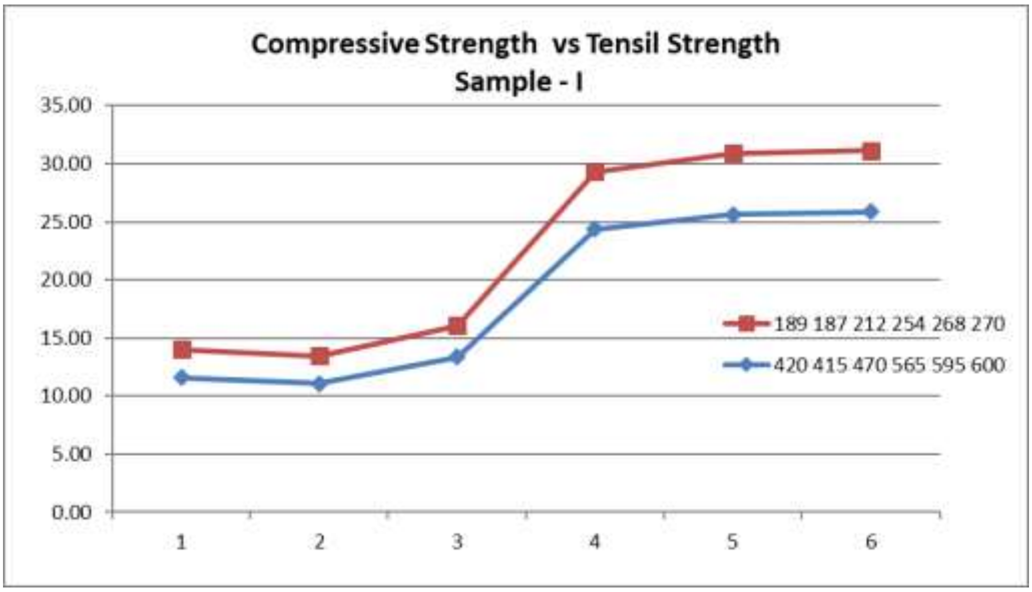
Table :4 Test results for Sample:3

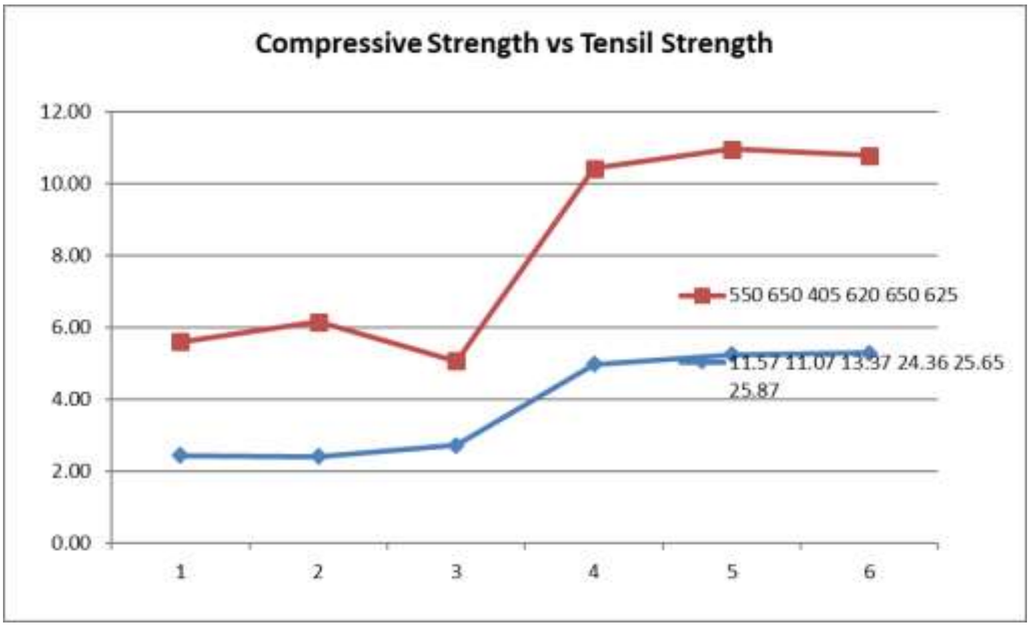
S.I.no	Grade	Age on Test	Load KN	Compressive Stress	Load kN	Split tensile Stress	Flexural Tensil Stress N/mm2	Ultimate Stress
1	M30	7	630	17.36	284	2.7	3.64	4.69
2			645	17.20	290	3.0	3.73	4.80

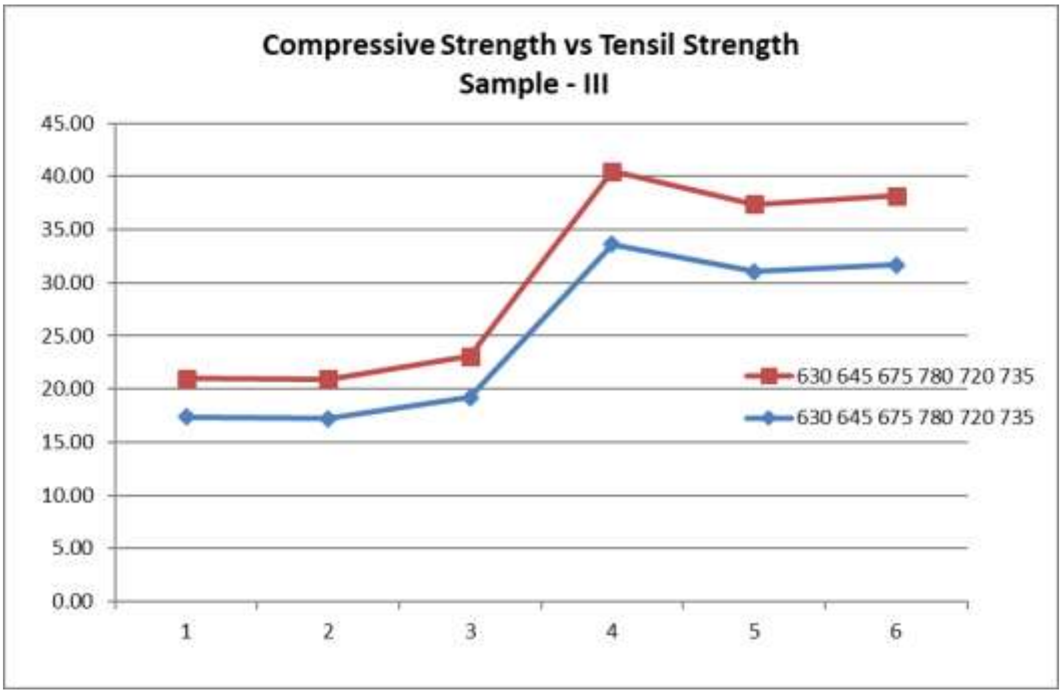
3			675	19.20	304	2.7	3.90	5.02
4		28	780	33.63	351	5.1	6.86	5.80
5			720	31.04	324	4.8	6.34	5.36
6			735	31.69	331	4.9	6.47	5.47

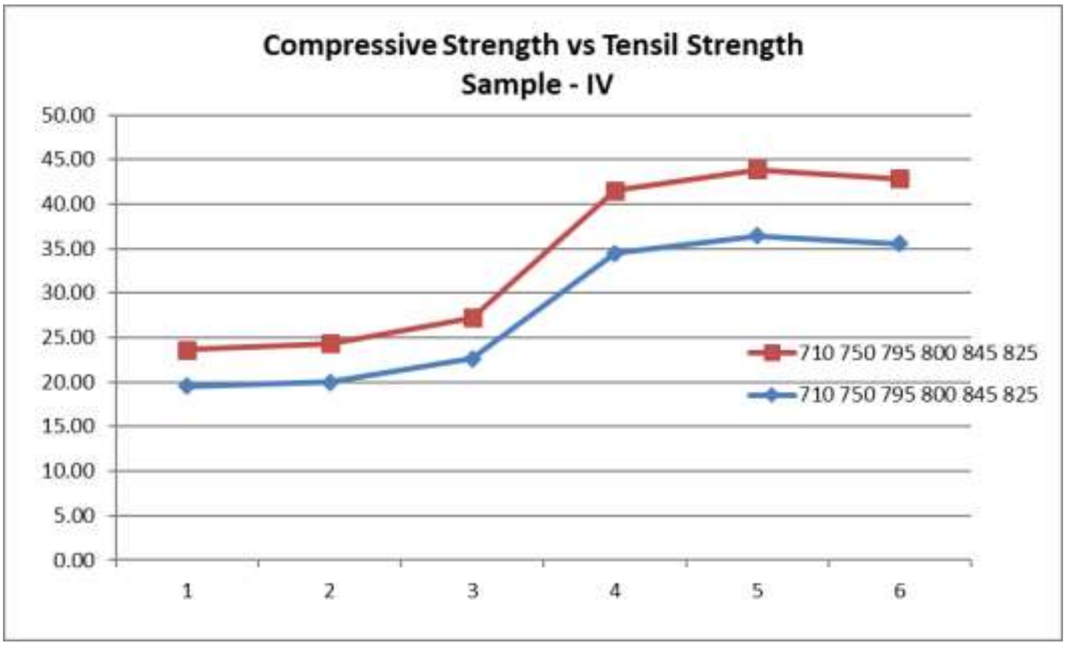
Table :5 Test results for Sample:4

S.I.no	Grade	Age on Test	Load KN	Compressive Stress	Load kN	Split tensile Stress	Flexural Tensil Stress N/mm2	Ultimate Stress
1	M35	7	710	19.56	320	3.1	4.10	5.28
2			750	20.00	338	3.5	4.33	5.58
3			795	22.61	358	3.2	4.59	5.91
4		28	800	34.49	360	5.3	7.04	5.95
5			845	36.43	380	5.6	7.44	6.29
6			825	35.57	371	5.4	7.26	6.14






Compressive Strength vs Tensil Strength
Sample - III
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
1
2
3
4
5
6
630 645 675 780 720 735
630 645 675 780 720 735


Compressive Strength vs Tensil Strength
Sample - IV
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
1
2
3
4
5
6
710 750 795 800 845 825
710 750 795 800 845 825

4. RESULTS AND DISCUSSION

Moreover, the increase in the flexural strength is lower than the corresponding increase in the compressive strength at same age of concrete. The percentage increase in flexural tensile strength decreases with the increase of level of concrete strength. For compressive strength of 25.29 MPa, 27.23 MPa, 31.12 MPa and 35.49 MPa, the flexural strength are 5.163 MPa, 5.559 MPa,6.556 MPa and 7.245 MPa at 28-days respectively whereas for compressive strength of 25.29 MPa, 27.23 MPa, 31.12 MPa and 35.49 MPa, the splitting tensile strength are 3.872MPa, 4.169MPa, 4.917MPa and 5.434MPa.

The crack began in the interface region due to tensile strain produced by the compressive load and then micro crack extended into the mortar matrix. Under the flexure loading, the cracks are initiated in the interfacial zone at low stresses and extend into the mortar matrix at high stresses and the resistant to cracks results from the cement paste only.

Table :6 Various test results of Compressive, Split tensile Stress and Flexural Strength for different mixes

Mix	Compressive Strength		Split tensile Stress		Flexural Strength	
	7 days	28 days	7 -days	28 -days	7 -days	28 -days
I	12.00	25.29	1.88	3.872	2.513	5.163
II	14.67	27.23	2.342	4.169	3.091	5.559
III	17.92	31.12	2.814	4.917	3.756	6.556
IV	20.73	35.49	3.253	5.434	4.343	7.245

5. CONCLUSIONS

A series of compression tests for 24 concrete specimens and the cylinder, cast from the same batch with the concrete compressive strength of 20 MPa, 25 MPa, 30 MPa AND 35 MPa, were carried out to evaluate the effect of GGBSon the flexural compressive strength and from test analysis and the results, the following conclusions are drawn:

1. Size effect is apparent, that is, the flexural compressive strength at failure decreases as the percentage of GGBFS increases.
2. Effect of GGBFS based concrete posses higher flexural, compressive and tensile strength of concrete than normal concrete.
3. The highest compressive strength of sample I was observed 21% compared with the control concrete mix. The increasing percentage of compressive strength of samples I,II,III and IV are 9.1%, 8%, 6.6% and 2.2% respectively compared with the control concrete mix.
4. The highest flexural strength was found to be 9.1% and 8% for sample I and II and the remaining two other samples, shows lesser flexural strength. These decrements are due to the lesser percentage effect of GGBS over the concrete prepared with higher cement content for the sample III and IV.
5. It was observed that the tensile strength of concrete increases rapidly in case of lower grade than the higher grade of concrete which shows that the GGBS content modify and lubricate the mix with higher degree of workability.

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