A Study on Polymer Modified High Volume GGBFS Concrete

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Abstract— *This technical investigation represents a study on polymer modified high volume GGBFS concrete on providing durable and stable constructional material and increasing in utilisation of high volume of GGBFS in concrete and reduction of usage of portland cement and reduction of CO2 in the atmosphere. There was the many number of studies done on the polymer concrete, the polymer concrete is introduced in 1960's based on the technical and practical situation in the construction industry. As considering the past history of polymer concrete and present situation of modern methods of strengthening, reparing and increasing in stability and life span civil engineering structure the technique of polymer concrete is introduced.*

The high volume GGBFS concrete is one of the specific type of GGBFS concrete with lower water cementitious material ratio and at least 50% of Portland cement by mass is replaced by GGBFS. Due to lower water content, superplasticizer is essential in order to achieve the desired workability. GGBFS is used to improve workability of fresh concrete to reduce the heat of hydration, to increase durability and the strength of concrete, due to its pozzolanic activity.

In this study the GGBFS of 50% and 60% is used as the cement replacing material, SBR latex polymer, Super plasticizer of conplast-430 is used. This work is conducted to study the polymer modified high volume GGBFS concrete. Mix design is as per the high volume fly ash concrete technology best practice guidelines was used. The M30 grade concrete mix was prepared. The total number of specimens were casted 330. The 165 specimens as 50% and 165 specimens as 60% GGBFS replacement were casted. Polymer added to the concrete in the percentage of 0% to 5% in a 0.5% increment. The polymer added to the concrete with weight of the cementitious materials. The super plasticizer is added 1.2% throught the mix with weight of the cementitious materials. The higher workability is found at the 2.5% of polymer addition to the concrete. The strength of concrete is calculated at different percentages of polymers addition to the concrete. After the 28days of curing the test results shows the 2.5% of polymer and 50% of GGBFS replacement has the increase in strength as compared to 60% of GGBFS replacement for all strengths, i.e compressive strength, split tensile strength, flexural strength, shear strength, impact strength. Along with this the near surface characteristics such as water absorption and sorptivity are studied. By this study shows the percentages addition of polymer in concrete increases the strengths as compared to conventional concrete.

Keywords— Polymer (SBR Latex), GGBFS, Conplast SP430, strength properties, workability, water absorption, soroptivity.

I. INTRODUCTION

Polymer-modified concrete is the concrete made up off combining two or more materials with polymer composites, Polymer-modified or polymer cement mortar (PCM) and concrete (PCC) are a category of concrete-polymer composites. Polymer modified concrete are made by partially replacing the cement in concrete by different pozzolona materials and there by hydrating binders of conventional cement mortar or concrete with polymers, i.e., polymeric admixtures, superplasticizers or cement modifiers, thereby strengthening the binding agent with the polymers. Polymer- modified or polymer cement paste, which is prepared without any aggregate, is sometimes used. Polymer concrete (PC) is a type of composite where thermoset resins binds inorganic fine aggregates or coarse aggregates instead of the water and cement binder mostly used in Portland cement concrete (PCC). Polymer concrete includes the matrix of polymers and strengthening phases having a dispersed particles. The properties of polymer determines the composites behavior of polymers, which are dependent on time, structure and temperature. These composites have some advantages compared to ordinary cement concrete such as: fast hardening, high mechanical strength and high chemical resistance. The features of polymeric concrete depend on the polymer properties, type of filler and aggregates, and the component concentrations. Its applications are continuously diversifying including the building cladding dating from 1958. Polymer concrete applications construction and repair of structures, highway pavements, bridge decks, waste water pipes and even structural and decorative construction panels. In recent years the applications include: cultured marble for counter tops, as repair material, overlays for bridge and floors, sport arenas and stadiums, laboratories, hospitals, factories; also precast polymer concrete is used for drains, underground boxes, manholes, acid tanks and cells, tunnel lining, shells, floor tiles, architectural moldings and machine tools and bases.

The blast furnace slag is a by-product of the iron manufacturing industry. Iron ore, coke and limestone are fed into the furnace and the resulting molten slag floats above the molten iron at a temperature of about 1500oC to 1600oC. The molten slag has a composition of about 30% to 40% SiO2 and about 40% CaO, which is close to the chemical composition of Portland cement. The hydraulic potential of blast furnace slag was first discovered in Germany in 1862.

Synthetic latexes are made by dispersing polymer particles in water to form a polymer emulsion. When these emulsions are added to portland cement concrete, the spheres of polymer will coalesce or come together to form a film that coats the aggregate particle sand the hydrating cement grains and seals off voids. However, some air is entrained by the latex during the mixing process so it is common for a specification to include a maximum air content, say 6.5 percent, but not a minimum. Nitobond SBR(Latex) is modified styrene butadiene emulsion specially designed for use as a bonding aid and gauging liquid for cementitious systems. It is resistant to hydrolysis and can therefore be used for external applications too.

II. MATERIALS AND METHODOLOGY

In this experimental work, ordinary Portland cement (OPC) 43 grade conforming to IS: 8112 – 1989 was used. Ground granulated blast furnance slag received from jindal steel work (JSW), jindal Nagar, Torangallu, Dist: Bellary, Karnataka. Confirming to IS: 3812 (Part 1) – 2003 was used. Locally available river sand belonging to zone II of IS: 383-1970 was used. and locally available crushed aggregates confirming to IS 383-1970 are used. Water fit for drinking was used. Styrene Butadiene Rubber Latex polymer from Fosroc Company was used. The Super plasticizers used in the experimentation was (Sulphonated Napthalene Formaldehyde) Conplast SP430 DIS, it is manufactured by Fosroc Company.

In this experimentation, the mix design was done as per High-volume Fly Ash Concrete Technology Best Practice Guidelines and the obtained mix proportion for 50% replacement of cement by GGBFS is 1:1.41:2.63 with W/C of 0.32 and for 60% replacement of cement by GGBFS is 1:1.20:2.24 with W/C of 0.27 for M30 mix.

In this experimentation, the dosages of SBR latex adopted in the experimentation are 0% to 5% in the increment of 0.5% by the weight of cementitious material was used and 1.2% of super plasticizer by the weight of cementitious material was used with partial replacement of cement by GGBFS of 50% and 60% are prepared.Specimens are cured for 28days.

The following workability tests are conducted on fresh concrete.

1. Slump cone test.
2. Compaction factor test.
3. Vee-Bee consistometer test.
4. Flow table test.

Following tests are conducted on hardened concrete after 28 days curing

1. Compressive strength test on 150mmX150mmX150mm cube.
2. Tensile strength test on 150mmϕX300mmL cylinder.
3. Flexural strength test on 100mmX100mmX500mm beam.
4. Impact strength test on 150mmϕX60mmL cylinder.
5. Shear strength test on L shaped specimen.
6. Water absorption and sorptivity tests.

III. RESULTS AND DISCUSSIONS

Table 1 gives the slump test results for polymer modified high volume GGBFS concrete produced by different dosages of polymer addition with 50% and 60% replacement of cement by GGBFS, and fig. 1 shows the variation of slump values. Table 2 gives the compaction factor test results for polymer modified high volume GGBFS concrete produced by different dosages of polymer addition with 50% and 60% replacement of cement by GGBFS, and fig. 2 shows the variation of compaction factor. Table 3 gives the Vee–Bee test results for polymer modified high volume GGBFS concrete produced by different dosages of polymer addition with 50% and 60% replacement of cement by GGBFS, and fig. 3 shows the variation of Vee–Bee degree. Table 4 gives the flow table test results for Polymer modified high volume GGBFS concrete produced by different dosages of polymer addition with 50% and 60% replacement of cement by GGBFS, and fig. 4 shows the variation in percentage flow.

TABLE 1 SLUMP TESTS RESULTS

Percentage addition of	Slump values (mm)	
	With 50%	**With 60%**
0%	52	48
0.5%	58	54
1%	70	66
1.5%	75	72
2%	80	75
2.5%	105	100
3%	102	98
3.5%	88	80
4%	84	82
4.5%	82	79
5%	80	77

TABLE 2 COMPACTION FACTOR TESTS RESULTS

Percentage addition of	Compaction factor	
	With 50%	**With 60%**
0%	0.930	0.920
0.5%	0.938	0.927
1%	0.936	0.917
1.5%	0.947	0.931
2%	0.953	0.937
2.5%	0.988	0.985
3%	0.970	0.960
3.5%	0.966	0.955
4%	0.964	0.953
4.5%	0.950	0.938
5%	0.948	0.936

TABLE 3 VEE-BEE CONSISTOMETER TEST RESULTS

Percentage addition of polymer	Vee Bee time (sec)	
	With 50% replacement	**With 60% replacement**
0%	30	32
0.5%	29	31
1%	27	33
1.5%	26	35
2%	25	27
2.5%	19	21
3%	22	24
3.5%	23	28
4%	21	23
4.5%	24	26
5%	25	27

TABLE 4 FLOW TABLE TEST RESULTS

Percentage addition of polymer	Flow test (%)	
	With 50%	**With 60%**
0%	28.85	27.85
0.5%	30.45	29.25
1%	31.85	30.85
1.5%	34.15	33.45
2%	35.05	34.25
2.5%	36.45	36.05
3%	32.35	31.75
3.5%	29.60	28.35
4%	27.60	25.75
4.5%	26.55	24.35
5%	25.45	22.90

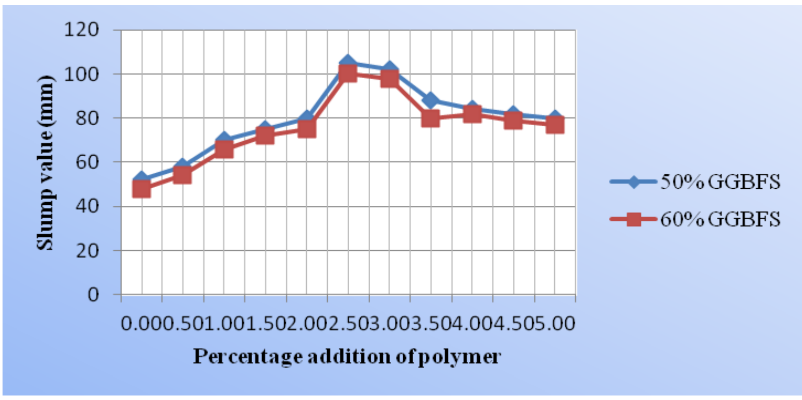

FIG. 1 VARIATION OF SLUMP VALUES

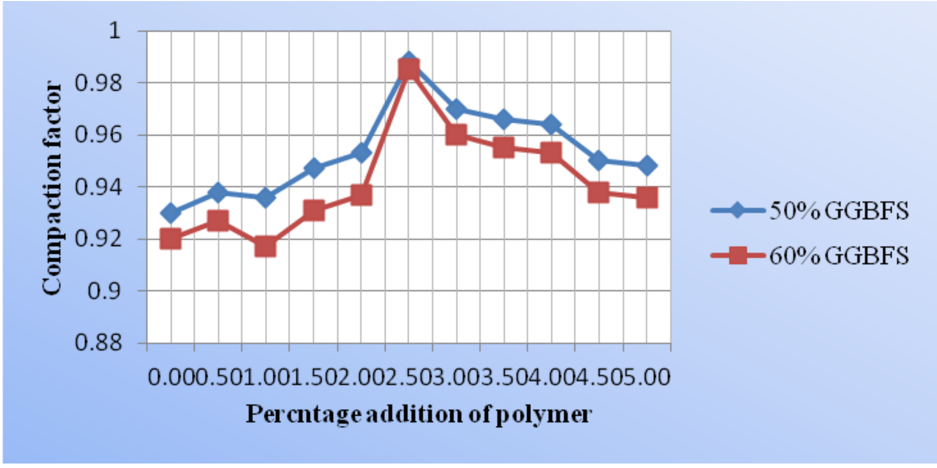

FIG. 2 VARIATION OF COMPACTION FACTOR

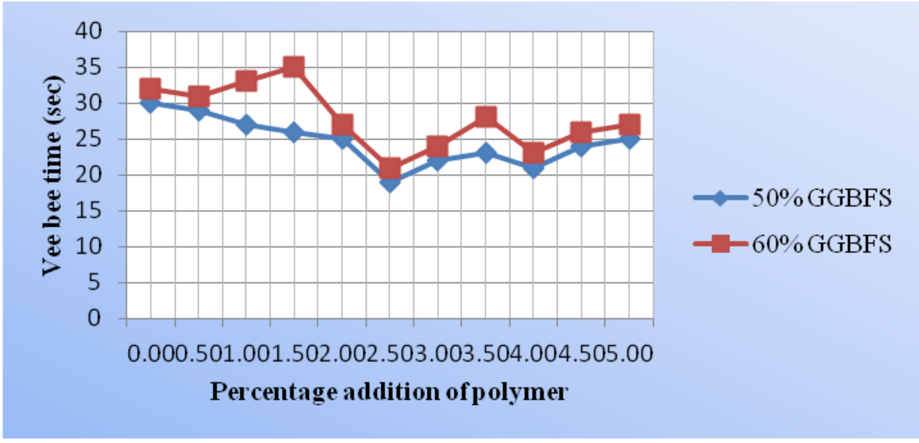

FIG. 3 VARIATION OF VEE-BEE DEGREE

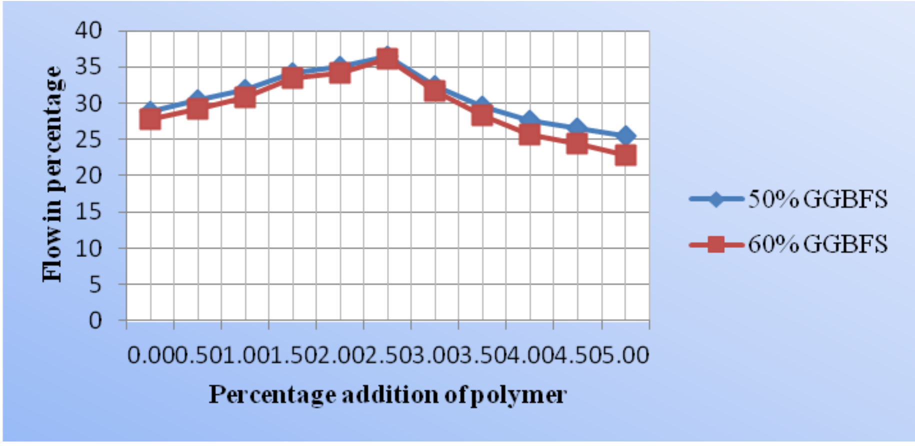

FIG. 4 VARIATION OF PERCENTAGE FLOW

Table 5 gives the water absorption test results for polymer modified high volume GGBFS concrete produced by different dosages of polymer addition with 50% and 60% replacement of cement by GGBFS, and fig 5 shows the variation of water absorbtion. Table 6 gives the soroptivity test results for polymer modified high volume GGBFS concrete produced by different dosages of polymer addition with 50% and 60% replacement of cement by GGBFS, and fig 6 shows the variation of soroptivity values.

TABLE 5 WATER ABSORPTION TEST RESULTS

Percentage addition of polymer	Water absorption (%)	
	With 50%	With 60%
0%	0.98	0.99
0.5%	0.96	0.98
1%	0.94	0.97
1.5%	0.92	0.96
2%	0.80	0.85
2.5%	0.72	0.74
3%	0.82	0.86
3.5%	0.79	0.81
4%	0.82	0.85
4.5%	0.91	0.96
5%	0.95	0.97

TABLE 6 SORPTIVITY TEST RESULTS

Percentage addition of polymer	Soroptivity (mm/Min$^{0.5}$)	
	With 50%	With 60%
0%	5.92	6.03
0.5%	5.88	6.00
1%	5.80	5.95
1.5%	5.59	5.72
2%	5.16	5.19
2.5%	4.70	4.77
3%	4.98	5.08
3.5%	5.04	5.11
4%	5.03	5.10
4.5%	5.15	5.20
5%	5.66	5.86

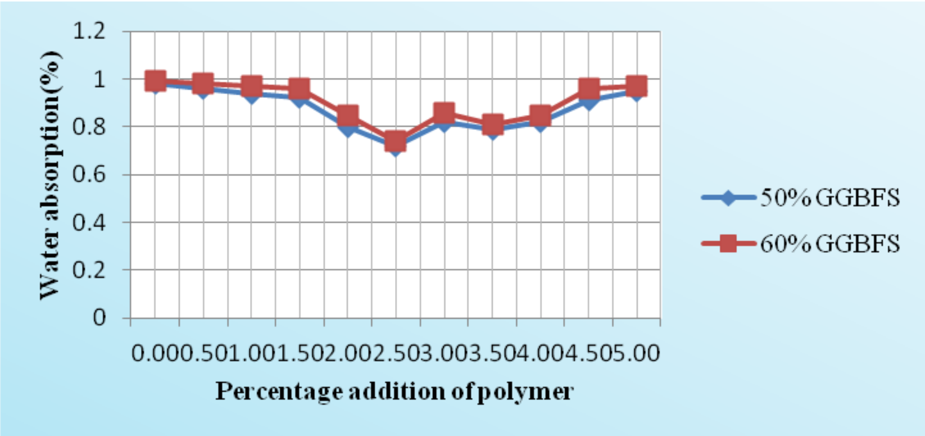

FIG. 5 VARIATION OF WATER ABSORPTION

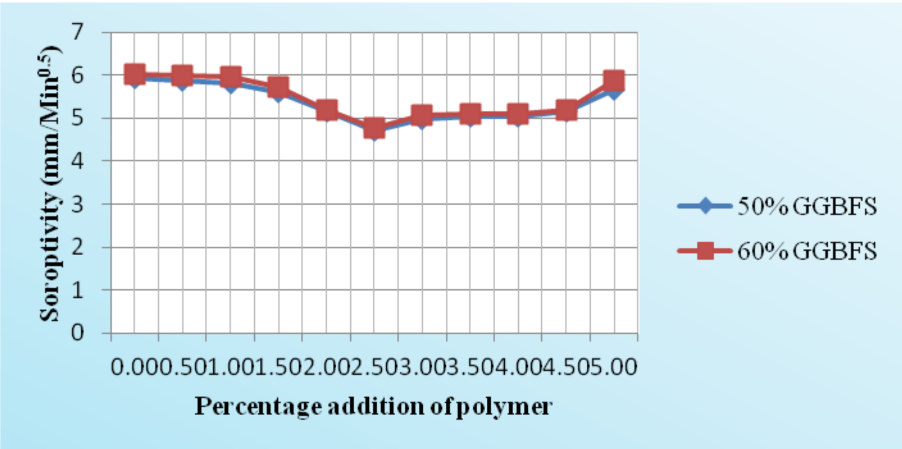

FIG. 6 VARIATION OF SORPTIVITY VALUES

Tables 7 give the compressive strength test results for polymer modified high volume GGBFS concrete produced by different dosages of polymer addition with 50% and 60% replacement of cement by GGBFS and when subjected to 28days of curing, and fig. 7 shows the variation of compressive strength. Tables 8 give the tensile strength test results for polymer modified high volume GGBFS concrete produced by different dosages of polymer addition with 50% and 60% replacement of cement by GGBFS and when subjected to 28days of curing, and fig. 8 shows the variation of tensile strength. Tables 9 give the flexural strength test results for polymer modified high volume GGBFS concrete produced by different dosages of polymer addition with 50% and 60% replacement of cement by GGBFS and when subjected to 28days of curing, and fig. 9 shows the variation of flexural strength. Tables 10 give the shear strength test results for polymer modified high volume GGBFS concrete produced by different dosages of polymer addition with 50% and 60% replacement of cement by GGBFS and when subjected to 28days of curing, and fig. 10 shows the variation of shear strength. Tables 11 give the impact strength for initial crack test results for polymer modified high volume GGBFS concrete produced by different dosages of polymer addition with 50% and 60% replacement of cement by GGBFS and when subjected to 28days of curing, and fig. 11 shows the variation of impact strength for initial crack, Tables 12 give the impact strength for final crack test results for polymer modified high volume GGBFS concrete produced by different dosages of polymer addition with 50% and 60% replacement of cement by GGBFS and when subjected to 28days of curing, and fig. 12 shows the variation of impact strength for final crack.

TABLE 7 COMPRESSIVE STRENGTH TEST RESULTS

Percentage addition of polymer	Percentage of Super plasticizer	Compressive strength of polymer modified concrete with 50% replacement of cement by GGBFS (MPa)	Percentage increase or decrease of compressive strength w.r.t reference mix	Compressive strength of polymer modified concrete with 60% replacement of cement by GGBFS (MPa)	Percentage increase or decrease of compressive strength w.r.t reference mix	Percentage increase of compressive strength for 50% replacement as compared to 60% replacement
0%	**1.2%**	22.37	0	19.04	0	15
0.5%	**1.2%**	24.15	8	20.81	9	14
1%	**1.2%**	24.67	10	21.48	13	13
1.5%	**1.2%**	25.56	14	22.52	18	12
2%	**1.2%**	28.96	29	27.19	43	6
2.5%	**1.2%**	30.81	38	29.93	57	3
3%	**1.2%**	30.52	36	28.96	52	5
3.5%	**1.2%**	27.33	22	25.56	34	6
4%	**1.2%**	27.19	22	25.63	35	6
4.5%	**1.2%**	23.56	5	20.67	9	12
5%	**1.2%**	24.67	10	23.56	24	4

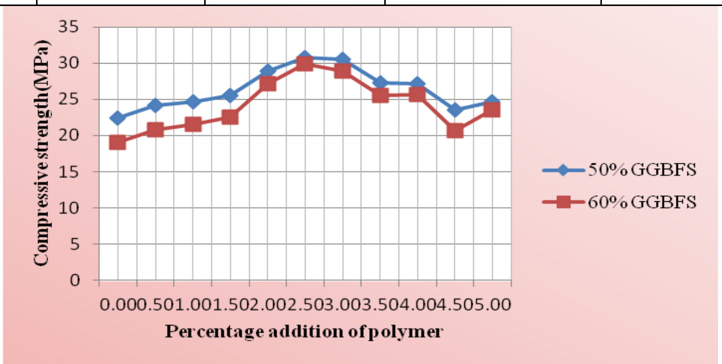

FIG. 7 VARIATION OF COMPRESSIVE STRENGTH

TABLE 8 TENSILE STRENGTH TEST RESULTS

Percentage addition of polymer	Percentage of Super plasticizer	Tensile strength of polymer modified concrete with 50% replacement of cement by GGBFS (MPa)	Percentage increase or decrease of tensile strength w.r.t reference mix	Tensile strength of polymer modified concrete with 60% replacement of cement by GGBFS (MPa)	Percentage increase or decrease of tensile strength w.r.t reference mix	Percentage increase of tensile strength for 50% replacement as compared to 60% replacement
0%	**1.2%**	1.39	0	1.25	0	10
0.5%	**1.2%**	1.63	17	1.56	25	4
1%	**1.2%**	1.70	22	1.63	30	4
1.5%	**1.2%**	1.77	27	1.63	30	8
2%	**1.2%**	1.84	32	1.63	30	11
2.5%	**1.2%**	2.00	44	1.79	43	11
3%	**1.2%**	1.91	37	1.77	42	7
3.5%	**1.2%**	1.60	15	1.34	7	16
4%	**1.2%**	1.58	14	1.49	19	6
4.5%	**1.2%**	1.56	12	1.49	19	4
5%	**1.2%**	1.25	-10	1.18	-6	6

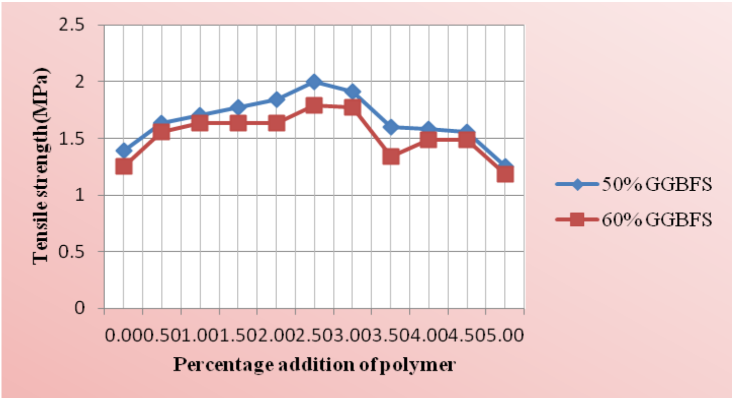

FIG. 8 VARIATION OF TENSILE STRENGTH

TABLE 9 FLEXURAL STRENGTH TEST RESULTS

Percentage addition of polymer	Percentageof Super plasticizer	Flexural strength of polymer modified concrete with 50% replacement of cement by GGBFS	Percentage increase or decrease of flexural strength w.r.t reference mix	Flexural strength of polymer modified concrete with 60% replacement of cement by GGBFS	Percentage increase or decrease of flexural strength w.r.t reference mix	Percentage increase of flexural strength for 50% replacement as compared to 60% replacement
0%	**1.2%**	2.99	0	2.84	0	5
0.5%	**1.2%**	3.15	5	3.00	6	5
1%	**1.2%**	3.27	9	3.15	11	4
1.5%	**1.2%**	3.29	10	3.11	10	5
2%	**1.2%**	3.35	12	3.13	10	7
2.5%	**1.2%**	3.55	19	3.37	19	5
3%	**1.2%**	3.31	11	3.09	9	7
3.5%	**1.2%**	3.13	5	2.89	2	8
4%	**1.2%**	3.23	8	3.12	10	3
4.5%	**1.2%**	3.12	4	2.99	5	4
5%	**1.2%**	2.92	-2	2.73	-4	7

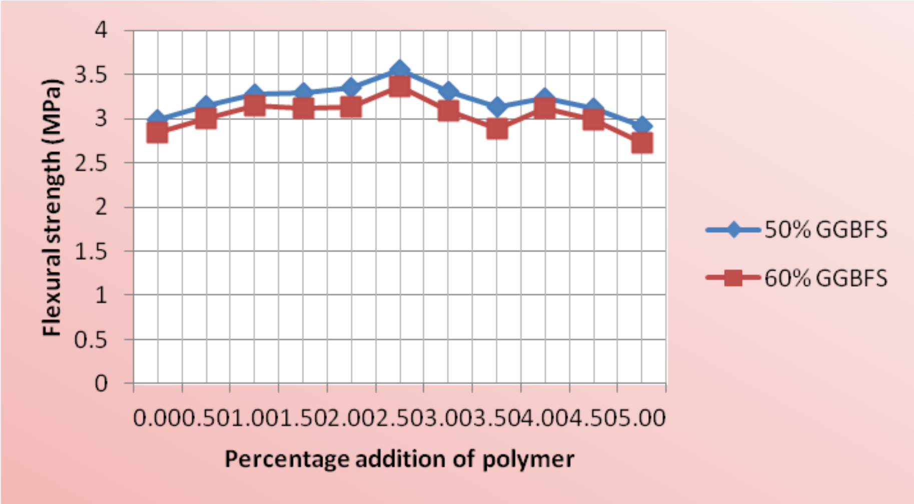

FIG. 9 VARIATION OF FLEXURAL STRENGTH

TABLE 10 SHEAR STRENGTH TEST RESULTS

Percentage addition of polymer	Percentage of Super plasticizer	Shear strength of polymer modified concrete with 50% replacement of cement by GGBFS (MPa)	Percentage increase or decrease of shear strength w.r.t reference mix	Shear strength of polymer modified concrete with 60% replacement of cement by GGBFS (MPa)	Percentage increase or decrease of shear strength w.r.t reference mix	Percentage increase of shear strength for 50% replacement as compared to 60% replacement
0%	**1.2%**	4.54	0	3.98	0	12
0.5%	**1.2%**	5.00	10	4.72	19	6
1%	**1.2%**	4.91	8	4.26	7	13
1.5%	**1.2%**	5.09	12	4.35	9	15
2%	**1.2%**	5.19	14	4.81	21	7
2.5%	**1.2%**	6.30	39	5.46	37	13
3%	**1.2%**	5.09	12	4.44	12	13
3.5%	**1.2%**	4.07	-10	3.24	-19	20
4%	**1.2%**	3.70	-19	3.24	-19	12
4.5%	**1.2%**	3.52	-22	3.24	-19	8
5%	**1.2%**	3.61	-20	3.33	-16	8

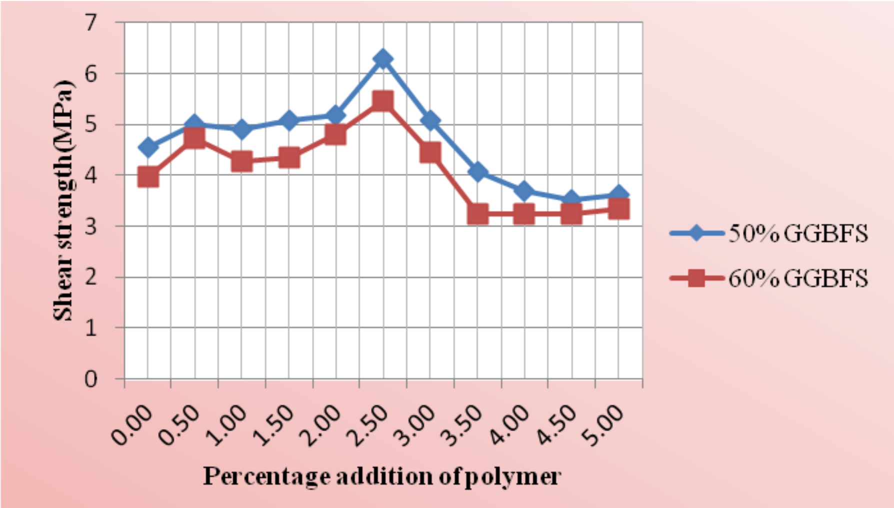

FIG. 10 VARIATION OF SHEAR STRENGTH

TABLE 11 IMPACT STRENGTH FOR INITIAL CRACK TEST RESULTS

Percentage addition of polymer	Percentage of Super plasticizer	Initial crack impact strength of polymer concrete with 50% replacement of cement by GGBFS (N-m)	Percentage increase or decrease of initial impact strength w.r.t reference mix	Initial crack impact strength of polymer concrete with 60% replacement of cement by GGBFS (N-m)	Percentage increase or decrease of final impact strength w.r.t reference mix
0%	**1.2%**	186.73	0	159.07	0
0.5%	**1.2%**	200.56	7	165.98	4
1%	**1.2%**	290.47	56	221.31	39
1.5%	**1.2%**	311.22	67	255.89	61
2%	**1.2%**	401.12	115	325.05	104
2.5%	**1.2%**	463.37	148	421.87	165
3%	**1.2%**	352.71	89	304.30	91
3.5%	**1.2%**	276.64	48	221.31	39
4%	**1.2%**	255.89	37	200.56	26
4.5%	**1.2%**	242.06	30	193.65	22
5%	**1.2%**	200.56	7	179.81	13

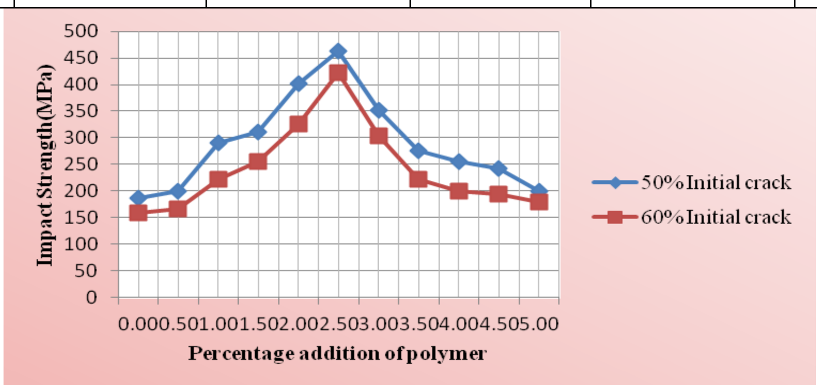

FIG. 11 VARIATION OF IMPACT STRENGTH FOR INITIAL CRACK

TABLE 12 IMPACT STRENGTH FOR FINAL FAILURE TEST RESULTS

Percentage addition of polymer	Percentageof Super plasticizer	Final failure impact strength of polymer concrete with 50% replacement of cement by GGBFS (N-m)	Percentage increase or decrease of initial impact strength w.r.t reference mix	Final failure impact strength of polymer concrete with 60% replacement of cement by GGBFS (N-m)	Percentage increase or decrease of final impact strength w.r.t reference mix
0%	**1.2%**	235.14	0	207.48	0
0.5%	**1.2%**	290.47	24	242.06	17
1%	**1.2%**	331.96	41	262.81	27
1.5%	**1.2%**	366.54	56	311.22	50
2%	**1.2%**	449.54	91	387.29	87
2.5%	**1.2%**	518.70	121	477.20	130
3%	**1.2%**	414.96	76	366.54	77
3.5%	**1.2%**	325.05	38	283.55	37
4%	**1.2%**	304.30	29	255.89	23
4.5%	**1.2%**	290.47	24	248.97	20
5%	**1.2%**	255.89	9	235.14	13

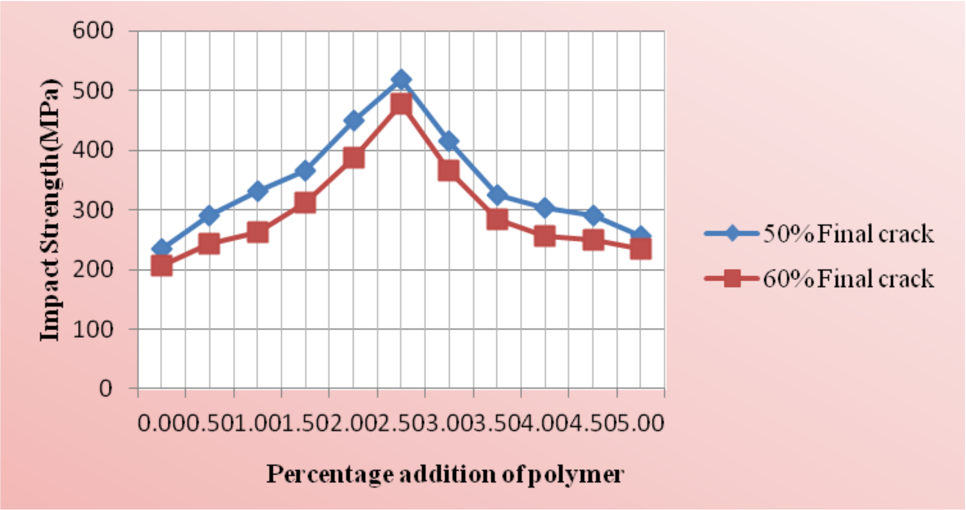

FIG. 12 VARIATION OF IMPACT STRENGTH FOR FINAL CRACK

It is observed that the workability values of polymer modified high volume GGBFS concrete as measured from slump, compaction factor, % flow and vee-bee degree go on increasing as the percentage of polymer addition go on increasing up to 2.5%. Beyond 2.5 % addition of polymer, the workability decreases. Thus, the higher value of workability is obtained by adding 2.5% polymer in polymer modified high volume GGBFS concrete. Also it is observed that workability values of polymer modified high volume GGBFS concrete produced by replacing 50% cement by GGBFS are higher as compared to 60% replacement. This may be due to the fact that the addition of 2.5% polymer to polymer modified high volume GGBFS concrete may induce the right flow thereby increasing the workability.

It is observed that the water absorption and sorptivity values of polymer modified high volume GGBFS concrete go on decreasing as the percentage of polymer addition go on increasing up to 2.5%. Beyond this, the water absorption and sorptivity values increase. Thus the least water absorption and sorptivity values may be achieved by adding 2.5% polymer in polymer modified high volume GGBFS concrete. Also it is observed that the water absorption and sorptivity values of polymer concrete produced by replacing 50% cement by GGBFS are lower as compared to 60% replacement. This may be due to the fact that the addition of 2.5% polymer in polymer modified high volume GGBFS concrete will fill all the pores of concrete and develop a good bond between the particles of cement, sand and aggregates, thereby decreasing the water absorption and sorptivity.

It is observed that the compressive strength of polymer modified high volume GGBFS concrete go on increasing as the percentage of polymer addition go on increasing up to 2.5%. Beyond this the compressive strength decreases. Compressive strength of polymer modified high volume GGBFS concrete produced by replacing 50% and 60% cement by GGBFS is 30.81MPa and 29.93MPa respectively. Thus the higher compressive strength may be achieved by adding 2.5% polymer in polymer modified high volume GGBFS concrete. Also it is observed that the compressive strength of polymer modified high volume GGBFS concrete produced by replacing 50% cement by GGBFS is higher as compared to 60% replacement. It is found that the polymer modified high volume GGBFS concrete with 50% and 60% replacement of cement by GGBFS and 2.5% addition of polymer shows 38% and 57% increase in compressive strength respectively as compared to the reference mix. Also it is observed at the 2.5% addition of polymer to the polymer modified high volume GGBFS concrete show the percentage increase of compressive strength for 50% replacement as compared to 60% replacement is 3%. The polymer modified high volume GGBFS concrete with 50% replacement of cement by GGBFS shows higher compressive strength to that of 60% replacement for all the percentage addition of polymer. This may be due to the fact that the addition of 2.5% polymer in polymer modified high volume GGBFS concrete will fill all the pores of concrete and develop a good bond between the particles of cement, sand and aggregates, thereby increasing the strength properties.

It is observed that the tensile strength of polymer modified high volume GGBFS concrete go on increasing as the percentage of polymer addition go on increasing up to 2.5%. Beyond this, the tensile strength decreases. Tensile strength of polymer concrete produced by replacing 50% and 60% cement by GGBFS is 2MPa and 1.79MPa respectively. Thus the higher tensile strength may be achieved by adding 2.5% polymer in polymer modified high volume GGBFS concrete. Also it is observed that the tensile strength of polymer concrete produced by replacing 50% cement by GGBFS is higher as compared to 60% replacement. It is found that the polymer concrete with 50% and 60% replacement cement by GGBFS and 2.5% addition of polymer shows 44% and 43% increase in tensile strength respectively as compared to the reference mix. Also it is observed at the 2.5% addition of polymer to the polymer modified high volume GGBFS concrete show the percentage increase of compressive strength for 50% replacement as compared to 60% replacement is 11%. The polymer concrete with 50% replacement of cement by GGBFS shows higher tensile strength to that of 60% replacement for all the percentage addition of polymer. This may be due to the fact that the addition of 2.5% polymer in polymer modified high volume GGBFS concrete will fill all the pores of concrete and develop a good bond between the particles of cement, sand and aggregates, thereby increasing the strength properties.

It is observed that the flexural strength of polymer modified high volume GGBFS concrete go on increasing as the percentage of polymer addition go on increasing up to 2.5%. Beyond this, the flexural strength decreases. Flexural strength of polymer modified high volume GGBFS concrete produced by replacing 50% and 60% cement by GGBFS is 3.55MPa and 3.37MPa respectively. Thus the higher flexural strength may be achieved by adding 2.5% polymer in polymer modified high volume GGBFS concrete. Also it is observed that the flexural strength of polymer modified high volume GGBFS concrete produced by replacing 50% cement by GGBFS is higher as compared to 60% replacement. It is found that the polymer modified high volume GGBFS concrete with 50% and 60% replacement cement by GGBFS and 2.5% addition of polymer shows 19% and 19% equal in flexural strength respectively as compared to the reference mix. Also it is observed at the 2.5% addition of polymer to the polymer modified high volume GGBFS concrete show the percentage increase of compressive strength for 50% replacement as compared to 60% replacement is 5%. The polymer modified high volume GGBFS concrete with 50% replacement of cement by GGBFS shows higher flexural strength to that of 60% replacement for all the percentage addition of polymer. This may be due to the fact that the addition of 2.5% polymer in polymer modified high volume GGBFS concrete will fill all the pores of concrete and develop a good bond between the particles of cement, sand and aggregates, thereby increasing the strength properties.

It is observed that the shear strength of polymer modified high volume GGBFS concrete go on increasing as the percentage of polymer addition go on increasing up to 2.5%. Beyond this, the shear strength decreases. Shear strength of polymer modified high volume GGBFS concrete produced by replacing 50% and 60% cement by GGBFS is 6.30MPa and 5.46MPa respectively. Thus the higher shear strength may be achieved by adding 2.5% polymer in polymer modified high volume GGBFS concrete. Also it is observed that the shear strength of polymer concrete produced by replacing 50% cement by GGBFS is higher as compared to 60% replacement. It is found that the polymer modified high volume GGBFS concrete with 50% and 60% replacement cement by GGBFS and 2.5% addition of polymer shows 39% and 37% increase in shear strength respectively as compared to the reference mix. Also it is observed at the 2.5% addition of polymer to the polymer modified high volume GGBFS concrete show the percentage increase of compressive strength for 50% replacement as compared to 60% replacement is 13%. The polymer modified high volume GGBFS concrete with 50% replacement of cement by GGBFS shows higher shear strength to that of 60% replacement for all the percentage addition of polymer. This may be due to the fact that the addition of 2.5% polymer in polymer modified high volume GGBFS concrete will fill all the pores of concrete and develop a good bond between the particles of cement, sand and aggregates, thereby increasing the strength properties.

It is observed that the impact strength of polymer modified high volume GGBFS concrete go on increasing as the percentage of polymer addition go on increasing up to 2.5%. Beyond this, the impact strength decreases. Final impact strength of polymer modified high volume GGBFS concrete produced by replacing 50% and 60% cement by GGBFS is

518.70Nm and 477.2Nm respectively. Thus the higher impact strength may be achieved by adding 2.5% polymer in polymer modified high volume GGBFS concrete. Also it is observed that the final impact strength of polymer modified high volume GGBFS concrete produced by replacing 50% cement by GGBFS is higher as compared to 60% replacement. It is found that the polymer modified high volume GGBFS concrete with 50% and 60% replacement cement by GGBFS and 2.5% addition of polymer shows 121% and 130% increase in final impact strength respectively as compared to the reference mix. Also it is observed at the 2.5% addition of polymer to the polymer modified high volume GGBFS concrete show the percentage increase of final impact strength for 50% replacement as compared to 60% replacement is 8%. The polymer modified high volume GGBFS concrete with 50% replacement of cement by GGBFS shows higher impact strength to that of 60% replacement for all the percentage addition of polymer. This may be due to the fact that the addition of 2.5% polymer in polymer modified high volume GGBFS concrete will fill all the pores of concrete and develop a good bond between the particles of cement, sand and aggregates, thereby increasing the strength properties.

IV. CONCLUSIONS

Following conclusions may be drawn based on experimentations conducted on polymer modified high volume GGBFS concrete.

1. Higher workability may be achieved by adding 2.5% polymer in polymer modified high volume GGBFS concrete. Also the polymer concrete produced by replacing 50% cement by GGBFS show higher workability as compared to 60% replacement.
2. Better water absorption and sorptivity values may be achieved by adding 2.5% polymer in polymer modified high volume GGBFS concrete. Beyond 2.5% addition, the water absorption and soroptivity values increases. Also the polymer concrete produced by replacing 50% cement by GGBFS show better water absorption and sorptivity values as compared to 60% replacement.
3. Compressive strength of polymer modified high volume GGBFS concrete is higher at 2.5% addition of polymer. Beyond 2.5% addition, the compressive strength starts decreasing. Also it can be concluded that the compressive strength of polymer modified high volume GGBFS concrete with 50% replacement of cement by GGBFS is higher as compared to 60% replacement.
4. Tensile strength of polymer modified high volume GGBFS concrete is higher at 2.5% addition of polymer. Beyond 2.5% addition, the tensile strength starts decreasing. Also it can be concluded that the tensile strength of polymer modified high volume GGBFS concrete with 50% replacement of cement by GGBFS is higher as compared to 60% replacement.
5. Flexural strength of polymer modified high volume GGBFS concrete is higher at 2.5% addition of polymer. Beyond 2.5% addition, the flexural strength starts decreasing. Also it can be concluded that the flexural strength of polymer modified high volume GGBFS concrete with 50% replacement of cement by GGBFS is higher as compared to 60%replacement.
6. Shear strength of polymer modified high volume GGBFS concrete is higher at 2.5% addition of polymer. Beyond 2.5% addition, the shear strength starts decreasing. Also it can be concluded that the shear strength of polymer modified high volume GGBFS concrete with 50% replacement of cement by GGBFS is higher as compared to 60% replacement.
7. Impact strength of polymer modified high volume GGBFS concrete is higher at 2.5% addition of polymer. Beyond 2.5% addition, the impact strength starts decreasing. Also it can be concluded that the impact strength of polymer modified high volume GGBFS concrete with 50% replacement of cement by GGBFS is higher as compared to 60% replacement.

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