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Influence of Microfine GGBS on Concrete of Grade M35 & M40 Made with Pozzolana Cement

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***Abstract*— In this study development of concrete by making an efficient concrete mix design blending with mineral admixtures on micro fine GGBS for higher grade concrete has been undertaken. Development of efficient concrete mix design plays an important & vital role in producing eco-economical concrete. This study represents the effect of presence of mineral admixture micro fine GGBS.GGBS partially replaced & added in cement concrete for evaluating the workability and strength of concrete along with flexural & split tensile strength. This study has been done by varying (5% to 25%) GGBS on partial replacement & addition in cement by weight of Portland pozzolana cement. About twenty-four trial mix, control mix and other variation mix were developed for M35 & M40 grade of concrete. Compressive strength 7 days and 28 days using cube (150mm x 150mm x 150mm) specimen, flexural strength for 28 days using beam (700mm x 150mm x 150mm) and splitting tensile strength for 28 days using cylinder (300mm length x 150mm diameter) were evaluated for this study by casting these in institute lab. All these concrete specimens were cured for 7 days and 28 days in deep water tank on normal 27+20C degree atmospheric temperature.**

Keywords— High grade concrete, compressive strength, mix design, GGBS, workability, flexural strength and splitting tensile strength.

I. INTRODUCTION

Concrete is building material made of coarse aggregate, fine aggregate making pure matrix required water and cement. At present many type of concrete technologies, its application improves construction work in durability, strength and thermal resistance condition.

A. Supplementary Cementitious Materials / Mineral admixture

Mix design of concrete play an important role for the concrete and mix design of concrete give standard design for better performance and desired strength ability. At present the concrete development is based on the use of industrial wastage such on supplementary cementitious material. Industrial wastage has pozzolanic as well as cementitious properties. There have very fine grained-particles; having Cementitious Materials improve the properties of concrete mix. This type of Cementitious Materials called, Supplementary Cementitious Materials. Mineral admixtures such on GGBS improve the concrete strength, low cost of preparation, thermal resisting and improved durability. A good concrete mix requires workability, strength and durability. Silica fume is also been used as mineral admixture, it increases the strength and durability. Pozzolanic material fly ash and GGBS have very fine particles. Silica fume have 100 times small particles compare to Fly ash/cement, it give high surface-to-volume ratios compare to fly ash. GGBS also is a good mineral admixture. It is used to partially replace Portland cement. Silica fume is similar to fly ash/GGBS as mineral admixture, but has a particle size 100 times smaller. All mineral admixture surface- volume ratios give higher value and good pozzolanic action.

II. EXPERIMENTAL PROGRAM

A. Introduction

Concrete is a mixture of cement, sand, coarse aggregate and water. Evaluate the performance of concrete containing supplementary cementations materials such micro fine GGBS. Cement replaced with Mineral admixtures can recover the strength and durability of concrete. The challenge for civil engineering community to improve the properties of concrete and concrete has eco-friendly condition.

In present concrete required economic & good blending material property. So, some industrial wastes use as blending material to improve property of concrete.

B. Materials

Concrete is a composite material of coarse aggregate, fine aggregate, water and cement. A good concrete mix requires workability, strength and durability.

C. Coarse Aggregate

- Coarse aggregate Particle sizes more than 4.75mm and in this experimental work uses 10mm and 20 mm aggregates.

Concrete mixture makes up majority of Fine and coarse aggregates. In concrete mix uses aggregates like natural gravel, Sand and crushed stone. The concrete a true composite material when the coarse aggregate are presence greatly and necessary cement material composite it proper type. That type material makes a brittle and high strength composite.

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TABLE I. PROPERTIES OF COARSE AGGREGATE 10MM &20MM

Tests	Coarse Aggregate	
	10mm	20mm
Density (SSD)	1478 kg/m^3	1560 kg/m^3
Sp. Gravity (SSD)	2.66	2.66
Water Absorption	0.43%	0.44%

D. Fine Aggregate

Fine aggregate (sand) particle size less than 4.75mm sieve and Sand shall be fresh hard, hard-wearing, angular, sharp, and free from mica, silts, and alkalis, organic and vegetable matters. It should not contain more than 5% of clay or silt. Sand should be perfectly drying before measured. IS code specification classifying the fine aggregate Zone-1 to Zone-4grade.Fine aggregate passing percentage various sieves and there are mainly four zones and they all have different passing percentage.

TABLE II. PROPERTIES OF FINE AGGREGATE

Tests	Coarse Aggregate
Density (SSD)	1675 kg/m3
Sp. Gravity (SSD)	2.64
Water Absorption	1.20 %

E. Cement

Cement is binding material in the cement concrete. It is used for various engineering works where strength and durability are of Prime importance. Cement property depend upon quantity of water in cement concrete. Potable water is required to make a good concrete. PPC has fly ash in cement it react calcium hydroxide and produces calcium silicate hydrate. Calcium silicate hydrate gives strength and durability and makes eco-friendly.

Chemical reaction of OPC & PPC

In OPC

$2[2CaO.SiO_2]$ + $4[H_2O]$ = $[3(CaO)2(SiO_2)3(H_2O)]$ + $Ca(OH)_2$
(OPC) (Water) (C – S – H) (Free Lime)

In PPC

$2[2CaO.SiO_2]$ + $4[H_2O]$ = $[3(CaO)2(SiO_2)3(H_2O)]$ + $Ca(OH)_2$
(OPC) (Water) (C – S – H) (Free Lime)

$3[Ca(OH)_2]$ + $2[SiO_2]$ = $[3(CaO)2(SiO_2)3(H_2O)]$
(Free lime) (Silica from Fly ash) (C – S – H)

TABLE III. PROPERTIES OF CEMENT PPC 43 MPA

Properties	Range%
CaO	50-60
SiO_2	36-40
Al_2O_3	6-8
MgO	0.1-3
SO_3	1-3
Na_2O	0-1
Fe_2O_3	4-5
Specific Gravity	3.00

F. Admixture

Admixture is components in concrete other than coarse aggregate, fine aggregate Portland cement and water. It leads main role make concrete good composite material. Admixture use primary hardening and workability or deliver extra properties for concrete mix.
Type of admixture

- mineral admixture
- chemical admixture

1) Mineral admixture (Micro fine Ground granulated blast slag

Well-ordered granulation procedure with high reactivity found Micro fine GGBS. It has high glass content. The processing with other select constituents results in under controlled partial size distribution (PSD).The calculated blain value based on PSD is about 9000cm^2/gm and is actually ultrafine. Micro fine GGBS delivers condensed water demand for assumed workability, even up to 70% replacement and addition near as per condition of concrete performance. Micro fine GGBS can also be used as a great range water reducer to recover compressive strength or as a super workability add to improve flow. Micro fine GGBS is pozzolanic materials that can be used to produce highly hard-wearing concrete composites.

TABLE IV. PHYSICAL PROPERTIES OF MICRO FINE GGBS

Physical Analysis	Range
Bulk Density	700-900 kg/m^3
Surface Area(finesse)	9000cm^2/gm
Particle Shape	Irregular
Specific gravity	2.9

TABLE V. CHEMICAL PROPERTIES OF MICRO FINE GGBS

Chemical Analysis	Mass%
CaO	36-40
Al_2O_3	5-5.6
Fe_2O_3	3.8-4.4
SO_3	2-2.4
MgO	6.5-8
SiO_2	30-34

2) Chemical Admixture

Chemical admixtures are material in the form of powder or fluids which are added to the concrete to reduce the water in plain concrete mixes. Water reducing super plasticizer used in this experimental work. Plasticizers increase the workability of plastic or "fresh" concrete, permitting it is sited more simply, with fewer consolidating strength. Plasticizers can be castoff to decrease the water contented of a concrete while improving workability and are called water-reducers due to this usage. Naptha based water reducing superplasticizer as per IS9103:1999used.The superplasticizer which is used for the experimental performance is Shaliplast SP-431. Properties of Chemical Admixture

Type of admixture	Super plasticizer chloride free & IS: 9103
SP. GRAVITY@27°C	1.20 +/- 0.04
DRY MATERIAL %	41- 45 %
CHLORIDE %	NIL
ASH CONTENT	10.00-14.00%
ALKALIES	NIL
PH	7-9
COLOUR	Faint Black Brown Liquid

G. *Sieve Analysis*

Particle size gradation test are called, sieve analysis. This process used in civil engineering granular material particle size distribution. The particle size distribution by sieve arrangement this type arrangement for particle distribution, called practical size distribution. Sieve arrangement as per IS: 2386 (Part I) – 1963. When collect different size partials' then sieves arrange standardized by the IS 2386 (Part I)– 1963 code.

1) *Fine Aggregate Grading*

- Codes is recommended IS-383:1970.
- Sand type Banas Sand zone - II.
- The Sieves arrangement 10mm, 4.75mm, 2.36mm, 1.18mm, 600 micron, 300 micron and 150 micron.

TABLE VI. SIEVE ANALYSIS FOR SAND (IS 383/2386)

Sieve size	Retained (gm)			% Retained weight	Cumulative % Retained	Cumulative % Passing	Limit as per IS 383
	Sample 1	Sample 2	Average				
10 mm	0	0	0	0	0	100	100
4.75 mm	11.6	11.5	11.5 5	1.155	1.15	98.85	90-100
2.36 mm	17	18	17.5	1.75	2.9	97.1	75-100
1.18 mm	71	76	73.5	7.35	10.25	89.95	55-90
600 micron	517.4	497	507. 5	50.72	61	39	35-59
300 micron	280	351	315. 5	31.55	92.5	7.5	8.0-30
150 micron	991	41	66	6.6	99.1	0.9	0-10
PAN	12	5.5	8.75	0.875	266.9		
Total	1000	1000	1000	100			

Fineness Modulus = 266.9/100 = 2.66

Grading Zone = II

2) *Coarse Aggregate Grading (10mm)*

- Codes are recommended IS-383:1970.
- Aggregate type hathipura Aggregate.
- The Sieves arrangement 12.5mm, 10mm, 4.75mm and 2.36mm.

TABLE VII. SIEVE ANALYSIS OF 10MM AGGREGATE (IS 383/2386)

Sieve size	Retained (gm)			% Retained weight	Cumulative % Retained	Cumulative % Passing	Limit as per IS 383
	Sample 1	Sample 2	Average				
12.5 mm	0	0	0	0	0	100	100
10 mm	38	42	40	2	2	98	85-100
4.75 mm	1362	1360	1361	68.05	70.05	29.95	0-20
2.36 mm	493	492	492.5	24.62	94.67	5.33	0-5
1.18 mm	107	106	106.5	5.325	100	0	
600 micron	0	0	0	0	100	0	
300 micron	0	0	0	0	100	0	
150 micron	0	0	0	0	100	0	
PAN	0	0	0	0	566.7 2		
Total	2000	2000	2000	100.0 0			

Fineness Modulus = 566.72/100 = 5.66

TABLE VIII. SIEVE ANALYSIS OF 20MM AGGREGATE (IS 383/2386)

Sieve size	Retained (gm)			% Retained weight	Cumulative % Retained	Cumulative % Passing	Limit as per IS 383
	Sample 1	Sample 2	Average				
40 mm	0	0	0	0	0	100	100
20 mm	1182	1169	1175.5	58.77	58.80	41.2	85-100
10 mm	730	740	735	36.75	95.55	4.45	0-20
4.75 mm	70	90	80	4	99.55	0.45	0-5
2.36 mm	18	1	9.5	0.47	100	0	
1.18 mm	0	0	0	0	100	0	
600 micron	0	0	0	0	100	0	
300 micron	0	0	0	0	100	0	
150 micron	0	0	0	0	100	0	
PAN	0	0	0	0	757.9		
Total	2000	2000	2000	100			

Fineness Modulus = 757.9/100 = 7.57

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H. Proportion Mix

Counting water, coarse aggregate, fine aggregate and cement in specific quantity which required to proper mixing ratio, this type mix called proportion mix. Proper mixing ratio uses for trial mix, control mix and conrtrol mix some variation with GGBS in this experimental work are given below.

I. Trial Mix

Which concrete mix prepare by coarse aggregate, fine aggregate, water and cement in ordinary ratio and provide exect strength of concrete as per IS 456:2000, this type mix called trial mix. In this experimental work prepared four trial mix without using admixture.

J. Control Mix

As per IS 10262:2009 suggestion and condition Control mix was designed which are given below

TABLE IX. CONTROL MIX PROPORTION FOR M35 WITH 125MM SLUMP

S.No.	Materials	Weight(Kg)
1	Cement(PPC-43)	404
2	Coarse Aggregate(20mm)	693.00
3	Coarse Aggregate(10mm)	461.44
4	Fine Aggregate	702.24
5	Water	162
6	Admixture @ 1.2% of cement	4.8
7	W/C Ratio	0.40

TABLE X. CONTROL MIX PROPORTION FOR M40 WITH 135MM SLUMP

S.No.	Materials	Weight(Kg)
1	Cement(PPC-43)	453
2	Coarse Aggregate(20mm)	683.72
3	Coarse Aggregate(10mm)	455.81
4	Fine Aggregate	664.00
5	Water	167.45
6	Admixture @ 1.6% of cement	7.24
7	W/C Ratio	0.37

K. Proportion of Mineral admixture in Control Mix

In control mix, cement has two difference variations with GGBS. First difference addition 0% to 25% GGBS of the weight of cement at interval of 5% concrete mixes for M35 & M40 and second difference partial replacement 0% to 25% GGBS of the weight of cement at interval of 5% concrete mixes for M35 & M40.

TABLE XI. MICRO FINE GGBS ADDITION INTO PPC FOR M35 GRADE

S.No	Mix Name	cement (Kg)	GGBS (Kg)	Coarse Aggregate(Kg)		Fine Aggregate (Kg)	Water (Kg)	Admixture (Kg)
				20mm	10mm			
1	PPC +GGBS (100+0)	404	0.00	693	461.44	702.24	161.6	4.8
2	PPC +GGBS (100+5)	404	20.2	685.83	457.22	692.20	161.6	4.8
3	PPC +GGBS (100+10)	404	40.4	679.80	453.2	689.19	161.6	4.8
4	PPC +GGBS (100+15)	404	60.6	672.87	448.58	682.17	161.6	4.8
5	PPC +GGBS (100+20)	404	80.8	665.94	443.96	675.15	161.6	4.8
6	PPC +GGBS (100+25)	404	101	659.02	439.34	668.15	161.6	4.8

TABLE XII. REPLACEMENT OF MICRO FINE GGBS INTO PPC FOR M35 GRADE

S.No	Mix Name	cement (Kg)	GGBS (Kg)	Coarse Aggregate(Kg)		Fine Aggregate (Kg)	Water (Kg)	Admixture (Kg)
				20mm	10mm			
1	PPC +GGBS (100+0)	404	0.00	693	461.44	702.24	161.6	4.8
2	PPC +GGBS (95+5)	383.8	20.2	693.55	462.36	702.24	161.6	4.8
3	PPC +GGBS (90+10)	363.6	40.4	689.69	459.79	699.23	161.6	4.8
4	PPC +GGBS (85+15)	343.4	60.6	688.70	459.13	698.22	161.6	4.8
5	PPC +GGBS (80+20)	323.2	80.8	688.70	459.13	698.22	161.6	4.8
6	PPC +GGBS (75+25)	303	101	688.01	458.67	697.52	161.6	4.8

TABLE XIII. MICRO FINE GGBS ADDITION INTO PPC FOR M40 GRADE

S. No	Mix Name	cement (Kg)	GGBS (Kg)	Coarse Aggregate(Kg)		Fine Aggregate (Kg)	Water (Kg)	Admixture (Kg)
				20mm	10mm			
1	PPC +GGBS (100+0)	453	0	683.72	455.61	664	167.45	7.24
2	PPC +GGBS (100+5)	453	22.65	676.68	451.12	657.38	167.45	7.24
3	PPC +GGBS (100+10)	453	45.3	688.04	445.36	648.59	167.45	7.24
4	PPC +GGBS (100+15)	453	67.95	660.60	440.4	641.75	167.45	7.24
5	PPC +GGBS (100+20)	453	90.56	652.55	435.03	633.94	167.45	7.24
6	PPC +GGBS (100+25)	453	113.19	644.51	429.67	626.12	167.45	7.24

TABLE XIV. REPLACEMENT OF PPC BY MICRO FINE GGBS FOR M40 GRADE

S. No	Mix Name	cement (Kg)	GGBS (Kg)	Coarse Aggregate(Kg)		Fine Aggregate (Kg)	Water (Kg)	Admixture (Kg)
				20mm	10mm			
1	PPC +GGBS (100+0)	452.56	0	683.72	455.61	664	167.45	7.24
2	PPC +GGBS (95+5)	429.94	22.65	684.73	456.48	665.2	167.45	7.24
3	PPC +GGBS (90+10)	407.31	45.3	684.12	456.08	664.22	167.45	7.24
4	PPC +GGBS (85+15)	384.68	67.95	683.72	455.81	664.22	167.45	7.24
5	PPC +GGBS (80+20)	362.05	90.56	683.72	455.81	664.22	167.45	7.24
6	PPC +GGBS (75+25)	339.42	113.19	682.72	455.14	663.24	167.45	7.24

III. RESULTS AND ANALYSIS

A. Introduction

In this study find out the M35 & M40 grade specimens result on deferent type variation of GGBS in cement concrete and compare each other and represented it draw by graphs.

In this experiment work make different variation specimens of concrete mix. Concrete mix has two type variations, first partial addition of cement by Micro fine GGBS material 5% to 25% interval 5% and second partial replacement of cement by GGBS material 5% to 25% interval 5%. This type variation same all cube specimen, cylinder specimen and beam specimen for find out the density, compressive strength, split tensile strength and flexural strength of M35 & M40 grade concrete.

B. Workability Test Result

Slump increased and decrease by addition and partial replacement of mineral admixtures such as Micro fine GGBS material. The workability has been used to improve placing of concrete, flexibility, compatibility and finishing capacity. Slump can be increased by addition of chemical admixtures such as plasticizer or super plasticizer without changing the water-cement ratio. Some other admixtures, especially air-entraining admixture, can raise the slump of concrete mix.

Concrete mix designs source 125 mm slump for M35 and 135 mm slump for M40 grade concrete. Graphs are given as result find out

TABLE XV. COMPARISON OF SLUMP ON ADDITION & REPLACEMENT FOR M35 GRADE

S.No	Percentage of GGBS	Addition (mm)	Replacement (mm)
1	0	125	125
2	5	154	137
3	10	146	152
4	15	138	156
5	20	132	161
6	25	128	164

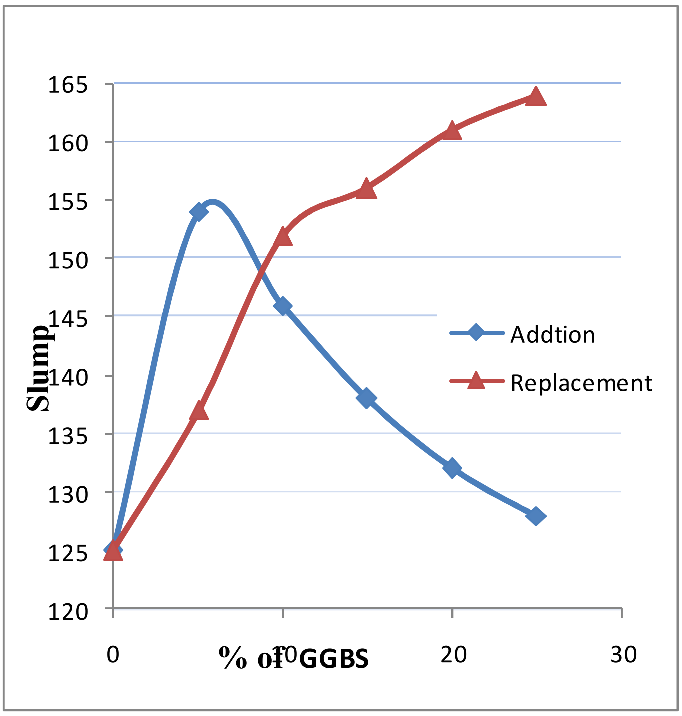

Fig. 1. Influence of Micro fine GGBS on Slump of Concrete (M-35) on Addition & Replacement

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TABLE XVI. COMPARISON OF SLUMP ON ADDITION & REPLACEMENT FOR M40 GRADE

S.No	Percentage of GGBS	Addition (mm)	Replacement (mm)
1	0	135	135
2	5	160	145
3	10	146	158
4	15	138	160
5	20	130	162
6	25	126	169

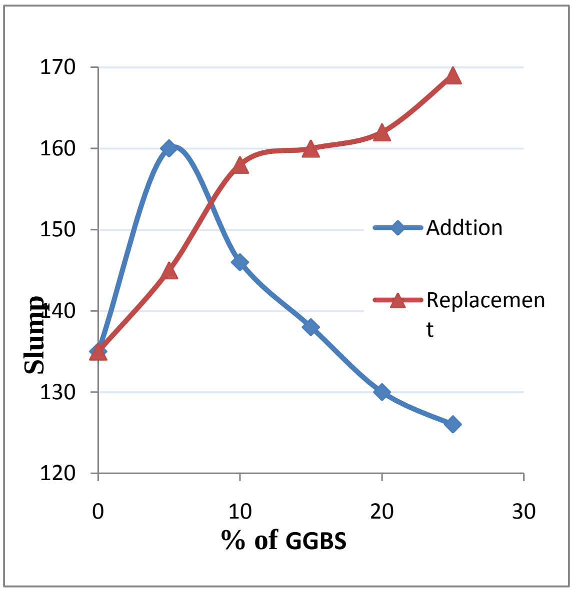

Fig. 2. Influence of Micro fine GGBS on Slump of Concrete (M-40) on Addition & Replacement

C. *Density Test Result*

The specimen of cube, beam & cylinder density was determined before testing. Average weight of Cube, Beam and Cylinder are 8.28Kg (for 7 days)& 8.30 Kg (for 28 days), 12.80Kg (for 28 days) and 39.35 Kg (for 28 days) respectively and volume of Cube Beam and Cylinder are 0.003375 meter cube, 0.01575 meter cube and 0.0052 meter cube respectively.

TABLE XVII. DENSITY OF HARDENED CONCRETE ON ADDITION OF MICRO FINE GGBS INTO PPC & REPLACEMENT OF PPC BY MICRO FINE GGBS FOR M35

S.No	Percentage of GGBS	Density of Hardened Concrete (Kg/m^3)	
		Addition	Replacement
1	0	2441.33	2441.33
2	5	2450.15	2448.12
3	10	2460.25	2455.15
4	15	2464.20	2459.86
5	20	2468.32	2464.32
6	25	2474.12	2465.18

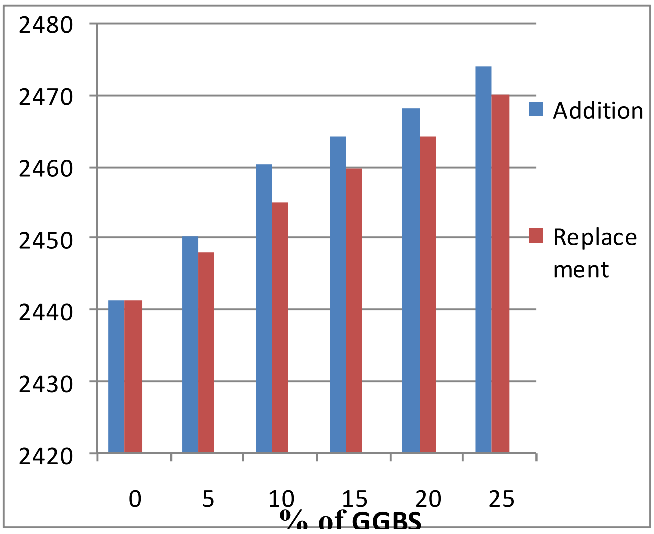

Fig. 3. Influence of Micro fine GGBS on Density of Hardened Concrete (M-35) on Addition & Replacement

TABLE XVIII. DENSITY OF HARDENED CONCRETE ON ADDITION OF MICRO FINE GGBS INTO PPC & REPLACEMENT OF PPC BY MICRO FINE GGBS FOR M40 GRADE

S.No	Percentage of GGBS	Density of Hardened Concrete (Kg/m^3)	
		Addition	Replacement
1	0	2449.33	2449.33
2	5	2453.33	2451.15
3	10	2465.25	2454.15
4	15	2470.26	24560.86
5	20	2474.38	2465.32
6	25	2482.33	2471.12

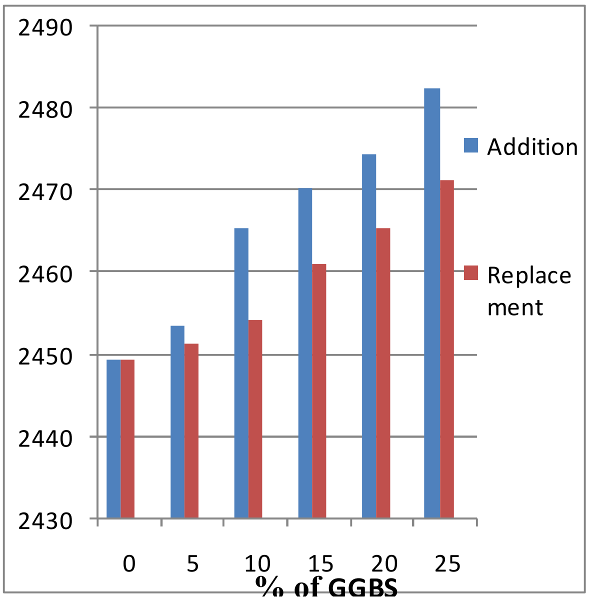

Fig. 4. Influence of Micro fine GGBS on Density of Hardened Concrete (M-40) on Addition & Replacement

D. Compressive Strength

The specimens were cured in water tank for 7 days and 28 days before compressive strength testing after specimens were came out in curing tank and cleaned cotton cloths. Compressive strength of all cube specimens 150mm(length) x 150mm(width) x 150mm(depth) measured as per IS 516:1959.

TABLE XIX. COMPARISON OF COMPRESSIVE STRENGTH FOR 7 DAYS ON ADDITION & REPLACEMENT FOR M35 GRADE

S.No	Percentage of GGBS	Addition (N/mm^2)	Replacement (N/mm^2)
1	0	29.55	29.55
2	5	31.77	30.00
3	10	31.91	31.33
4	15	32.26	31.33
5	20	32.17	30.66
6	25	32.22	31.00

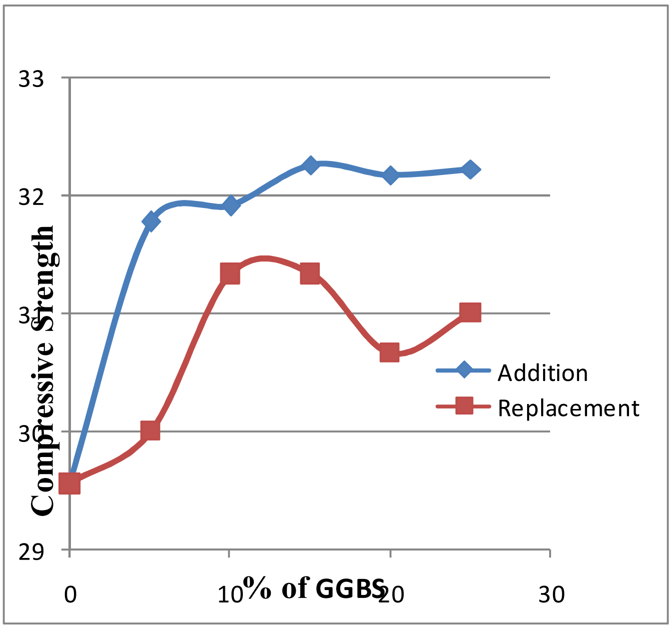

Fig. 5. Influence of Micro fine GGBS on Concrete of M35 Grade on Addition & Replacement for 7 Days Compressive Strength of Cube

TABLE XX. COMPARISON OF COMPRESSIVE STRENGTH FOR 28 DAYS ON ADDITION & REPLACEMENT FOR M35 GRADE

S.No	Percentage of GGBS	Addition (N/mm^2)	Replacement (N/mm^2)
1	0	43.30	43.30
2	5	45.39	44.25
3	10	46.26	44.54
4	15	47.87	45.14
5	20	48.71	45.37
6	25	49.54	45.67

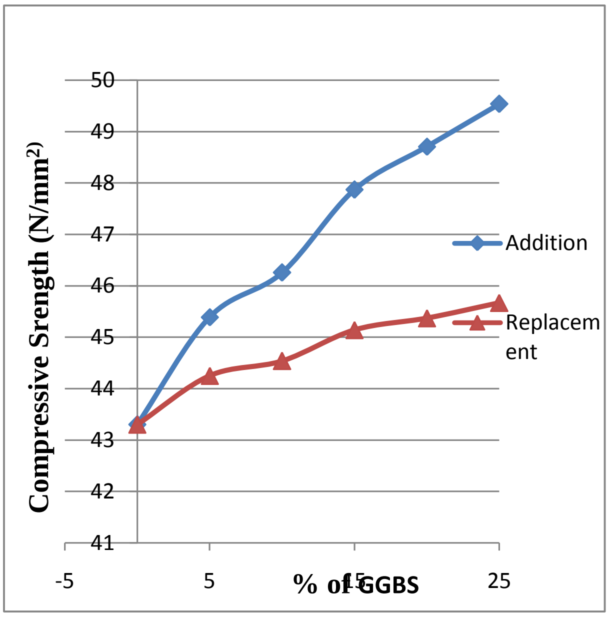

Fig. 6. Influence of Micro fine GGBS on Concrete of M35 Grade on Addition & Replacement for 28 Days Compressive Strength of Cube

TABLE XXI. COMPARISON OF COMPRESSIVE STRENGTH FOR 7 DAYS ON ADDITION & REPLACEMENT FOR M40 GRADE

S.No	Percentage of GGBS	Addition (N/mm^2)	Replacement (N/mm^2)
1	0	32.66	32.66
2	5	34.33	33.55
3	10	35.33	34.33
4	15	35.60	34.77
5	20	36.62	34.44
6	25	36.97	34.48

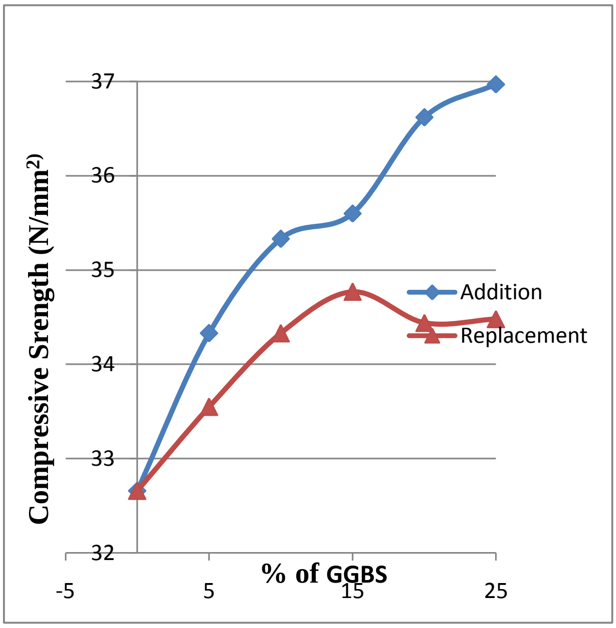

Fig. 7. Influence of Micro fine GGBS on Concrete of M40 Grade on Addition & Replacement for 7 Days Compressive Strength of Cube

TABLE XXII. COMPARISON OF COMPRESSIVE STRENGTH FOR 28 DAYS ON ADDITION & REPLACEMENT FOR M40 GRADE

S.No	Percentage of GGBS	Addition(N/mm^2)	Replacement(N/mm^2)
1	0	48.29	48.29
2	5	50.75	48.93
3	10	51.83	49.79
4	15	53.27	50.23
5	20	54.31	50.42
6	25	55.18	50.69

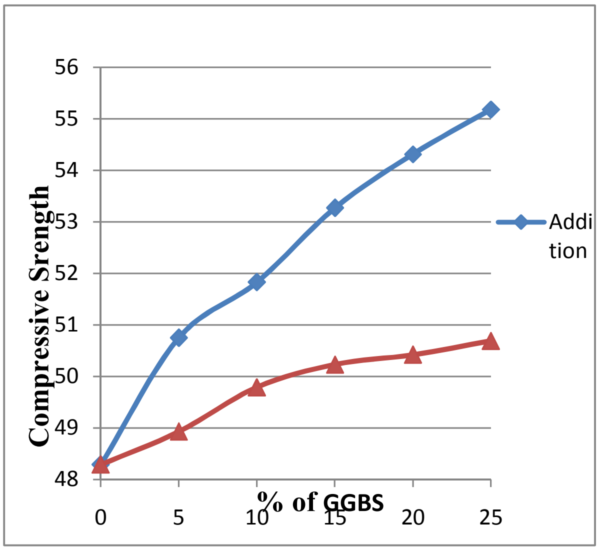

Fig. 8. Influence of Micro fine GGBS on Concrete of M40 Grade on Addition & Replacement for 28 Days Compressive Strength of Cube

E. Flexural Strength:

The specimens were cured in water tank for 28 days before flexural strength testing after specimens were came out in curing tank and cleaned cotton cloths. The central point loading method was applied for this testing. flexural strength of all beam specimens 700mm(length) x 150mm(width) x 150mm(depth) measured as per IS 516:1959.

TABLE XXIII. COMPARISON OF FLEXURAL STRENGTH FOR 28 DAYS ON ADDITION & REPLACEMENT FOR M35 GRADE

S.No	Percentage of GGBS	Addition (N/mm^2)	Replacement (N/mm^2)
1	0	5.96	5.96
2	5	7.47	6.58
3	10	7.83	6.76
4	15	7.92	7.12
5	20	8.36	7.29
6	25	8.01	6.85

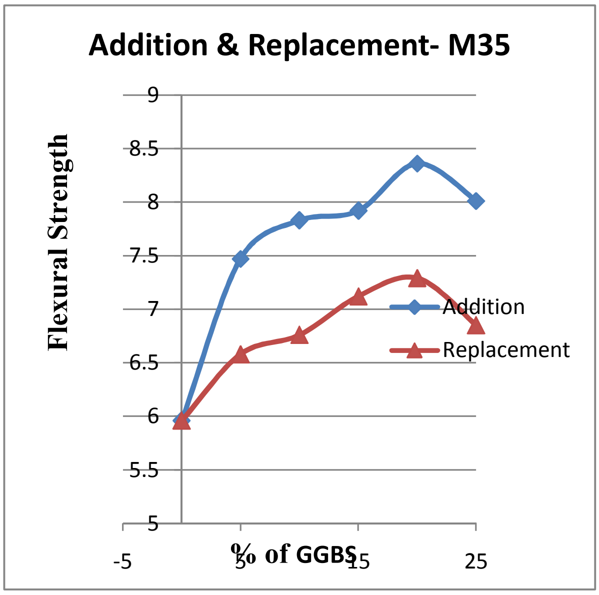

Fig. 9. Influence of Micro fine GGBS on Concrete of M35 Grade on Addition & Replacement for 28 Days Flexural Strength of Beam

TABLE XXIV. COMPARISON OF FLEXURAL STRENGTH FOR 28 DAYS ON ADDITION & REPLACEMENT FOR M40 GRADE

S.No	Percentage of GGBS	Addition(N/mm^2)	Replacement(N/mm^2)
1	0	6.85	6.85
2	5	8.55	7.47
3	10	9.2	7.83
4	15	9.52	8.03
5	20	9.74	8.72
6	25	9.61	8.41

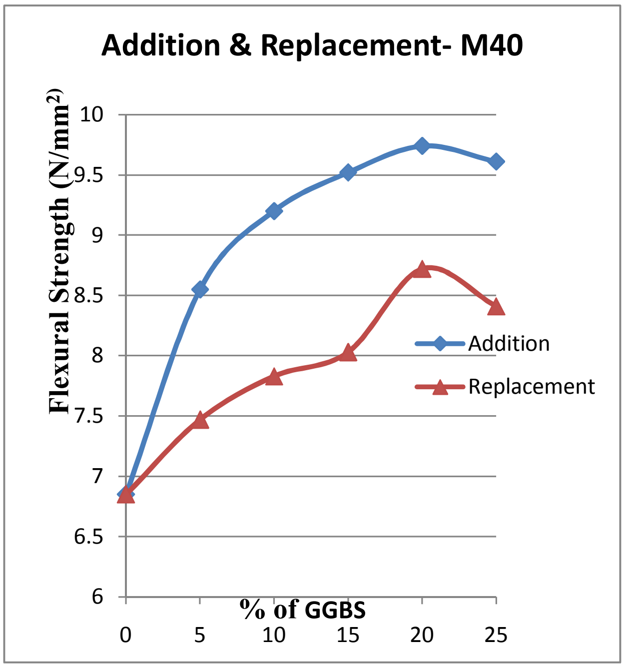

Fig. 10. Influence of Micro fine GGBS on Concrete of M40 Grade on Addition & Replacement for 28 Days Flexural Strength of Beam

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F. Splitting Tensile Strength

The specimens were cured in water tank for 28 days before split tensile strength testing after specimens were came out in curing tank and cleaned cotton cloths. split tensile strength of all cylinder specimens 300mm (length) x 150mm (diameter) measured as per IS 516:1959.

TABLE XXV. COMPARISON OF SPLITTING TENSILE STRENGTH FOR 28 DAYS ON ADDITION & REPLACEMENT FOR M35 GRADE

S.No	Percentage of GGBS	Addition (N/mm^2)	Replacement (N/mm^2)
1	0	2.70	2.70
2	5	2.95	2.89
3	10	3.20	2.97
4	15	3.28	3.02
5	20	3.35	3.20
6	25	3.38	3.31

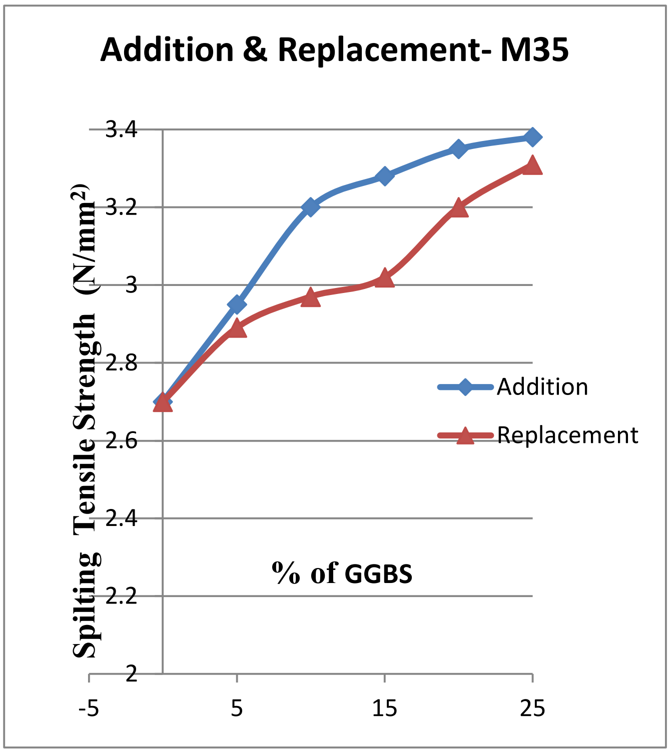

Fig. 11. Influence of Micro fine GGBS on Concrete of M35 Grade on Addition & Replacement for 28 Days Splitting Tensile Strength of Cylinder

TABLE XXVI. COMPARISON OF SPLITTING TENSILE STRENGTH FOR 28 DAYS ON ADDITION & REPLACEMENT FOR M40 GRADE

S.No	Percentage of GGBS	Addition(N/mm^2)	Replacement(N/mm^2)
1	0	2.97	2.97
2	5	3.61	3.30
3	10	3.65	3.54
4	15	3.76	3.68
5	20	3.80	3.78
6	25	3.90	3.73

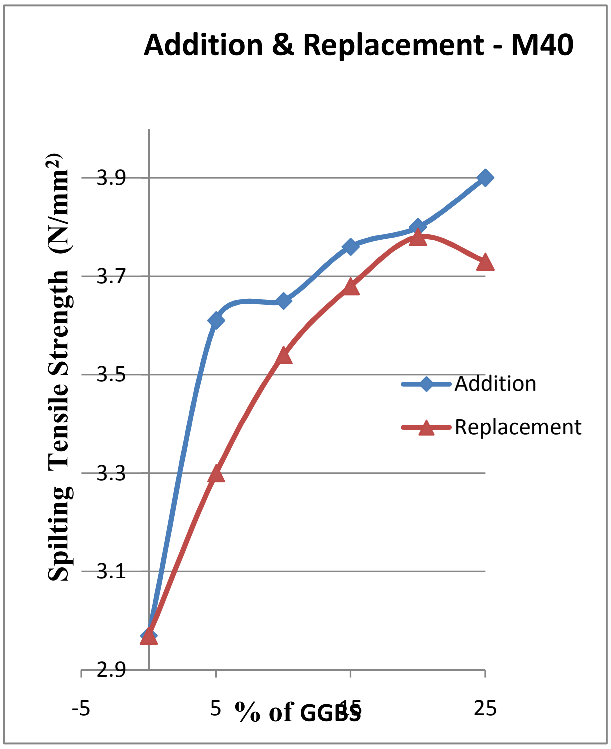

Fig. 12. Influence of Micro fine GGBS on Concrete of M40 Grade on Addition & Replacement for 28 Days Splitting Tensile Strength of Cylinder

IV. CONCLUSIONS

A. Evaluate the results of Slump by fresh concrete, it give conclusions

- Concrete mix slump was decreased with addition of Micro fine GGBS in PPC, because number of fine particle increased or surface area increased than concrete mix water demand increased. Slump on 25% addition of Micro fine GGBS in PPC was closed to the control mix concrete slump.

- Concrete mix slump was increased with partial replacement of Micro fine GGBS in PPC, because cement replaced by micro fine GGBS than concrete mix water demand decreased. Partial replacement of Micro fine GGBS in PPC Slump was increased at all percentage interval compare to the control mix concrete slump.

- 154mm slump was found addition of 5% micro fine GGBS into PPC & 152mm slump was found partial replacement of 10% micro fine GGBS into PPC for M35 grade. 164mm high slump was found partial replacement 25% micro fine GGBS into PPC for M35 grade.

- 160mm slump was found addition of 5% micro fine GGBS into PPC & 160mm slump was found partial replacement of 15% micro fine GGBS into PPC for M40 grade. 169mm high slump was found partial replacement 25% micro fine GGBS into PPC for M40 grade.

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B. Evaluate the results of density by hardened concrete specimens, it give conclusions

- Control mix for M35 & M40 grade concrete specimens density was lower compare to M35 & M40 grade concrete specimens with addition & partial replacement of Micro fine GGBS in PPC. Addition and replacement of Micro fine GGBS in PPC for grade M35 & M40 was make a packing material, there internal system develops gel pores, which are smaller than the normal concrete pores of PPC, So compressive strength, flexural strength, Splitting tensile strength greater compare to normal concrete compressive strength, flexural strength, Splitting tensile strength.

C. Evaluate the results of compressive Strength by cube specimens, it give conclusions

- Concrete compressive strength was greater in addition of Micro fine GGBS in PPC compare to partial replacement of Micro fine GGBS in PPC. The compressive strength addition and replacement greater than control mix concrete for M35 & M40 grade.

- The maximum compressive strength 49.54 N/mm^2 was found addition of Micro fine GGBS in PPC for M35 grade, this compressive strength was 14.41% greater than compare to M35 grade control mix concrete. Similarly maximum compressive strength 55.18 N/mm^2 was found addition of Micro fine GGBS in PPC for M40 grade, this compressive strength was 14.26% greater than compare to M40 grade control mix concrete.

- 48.71 N/mm^2 compressive strength was found addition 20% micro fine GGBS into PPC for grade M35; it was equal to the target value of M40 grade concrete. Similarly 53.27N/mm^2 compressive strength was found addition 15% micro fine GGBS into PPC for grade M40; it was equal to the target value of M45 grade concrete.

D. Evaluate the results of flexural Strength by beam specimens

- Concrete Flexural strength was greater in addition of Micro fine GGBS in PPC compare to partial replacement of Micro fine GGBS in PPC. Flexural strength in addition was greater than control mix concrete of M35 & M40 grade.
- The maximum flexural strength 8.36N/mm^2 was found addition 20% Micro fine GGBS in PPC for M35 grade, this flexural strength was 40.26% greater than compare to M35 grade control mix concrete. Similarly maximum flexural strength 9.74N/mm^2 was found addition 20% Micro fine GGBS in PPC for M40 grade, this flexural strength was 42.18% greater than compare to M40 grade control mix concrete.

E. Evaluate the results of split Tensile Strength by cylinder, it give conclusions

- Concrete Split tensile strength was greater in addition of Micro fine GGBS in PPC compare to partial replacement of Micro fine GGBS in PPC. Splitting tensile strength in addition was greater than control mix concrete of M35 & M40 grade.

- The maximum Split tensile strength 3.38N/mm^2 was found addition 25% Micro fine GGBS in PPC for M35 grade, this Split tensile strength was 25.18% greater than compare to M35 grade control mix concrete. Similarly maximum Split tensile strength 3.90 N/mm^2 was found addition 25% Micro fine GGBS in PPC for M40 grade, this Split tensile strength was 31.31% greater than compare to M40 grade control mix concrete.

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