EXPERIMENTAL STUDY ON HIGH PERFORMANCE OF FRC WITH USE OF METAKAOLIN,GGBS AND FLYASH

Manan Kalathiya[1], Kishan Vekariya[2]

[1] *Post Graduation Student,Department Of Civil Engineering,Noble Group Of Institute Junagadh, Gujarat,India*
[2] *Assistance professor,Department Of Civil Engineering,Noble Group Of Institute Junagadh, Gujarat,India*

ABSTRACT

The production of Ordinary Portland Cement (OPC) is increasing in world over. Further, the production of every tonne of OPC generates one tonne of green house gases, (CO2) which results in Global Warming. Usage of OPC is more in construction industry as it is a major ingredient in Concrete. As the usage of Concrete is rising year by year in the OPC production and hence the environment is getting polluted added to this undesirable scenario, the natural resources use to manufacture cement are limited. In order to prevent the usage of large amounts of OPC in Concrete, mineral admixtures like Ground Granulated Blast furnace Slag (GGBS), Fly Ash and Metakaolin which are pozzolanic and cementitious in nature are adopted to replace certain percentages of OPC. Experimental investigation is conducted on fiber reinforced concrete with steel fibers up to 1% of weight of binder by casting requisite number of cubes and cylinders of concrete of grade M25 in these mixes OPC is replaced with GGBS, Fly Ash and Metakaolin up to 50%. Mechanical properties are determined by various test like compressive test, flexural test and split tensile test. Test results are compared between controlled concrete and innovative concrete of present investigation.

Keyword : - Metakaoline,Steel fiber,GGBS,Flyash,concrete

1. INTRODUCTION

Concrete is a widely used material around planet. Large quantities of different types of concrete are used due to its structural advantages and strength. The enhaced properties of the concretein freshly prepared and hardened states,durability and its environmental impact are very remarkable topics for analysis. One methodology to extend some manufacturing properties of concrete is that the use of fibers as an additional material within the concrete mixture. Steel fiber is a metal reinforcement. A certain amount of steel fiber in concrete can cause qualitative changes in concrete's physical property. It can greatly increase resistance to cracking, impact, fatigue, and bending, tenacity, durability, and others.

2. EXPERIMENTAL RESEARCH

For Any kind of work, study or research we need to define method first, before the work is carried out. It should be divide following two phase of investigation Initial phase & Final phase. In First phase or initial phase of investigation Finalization of mix design will be carried out. Before Finalization of concrete mix design, setting time of cement, sieve analysis of aggregates, specific gravity of the aggregate, water absorption and fineness modulus are required. Mix design should be carried out as per IS-10262-2009.

2.1 MATERIALS

1. Cement :- In this research Ordinary Portland cement (53 grades) of Ultratech is used.
2. Aggregates :-
   (i)Fine Aggregates :- Depending on composition, shape, size and other properties of fine aggregate you can have a significant impact on the output.

(ii)Coarse aggregates :- Coarse aggregates are irregular broken stone or naturally-occurring rounded gravel used For making concrete.

3. Water:- To assess suitability of water for use in concrete mix.
4. Flyash:- Class-F fly ash of STALLIN ENERGY PVT. LTD. is to be used.
5. GGBS:- GGBS of STALLIN ENERGY PVT. LTD is used.
6. Metakaolin:- Metakaolin of SINDHU CHEMICAL PRODUCT is used.
7. Steel fiber:- SHAKTIMAN@ MSH 7560, HOOKED END Steel fibers are used.

Sr. No.	Properties	Units	Value
1.	Shape	--	Hooked end
2.	Diameter	Mm	0.75
3.	Length	Mm	60
4.	Aspect ration L/D	--	80
5.	Tensile strength of the wire	Mpa	>1200
6.	Strain failure	%	<4

Table -1**:** PHYSICAL properties of HOOKED END Steel fibers

2.2 Mix Design

The mix design of M25 Grade of concrete as per IS 10262(CONCRETE MIX PROPORTIONING GUIDELINES) and IS 456 (PLAIN REINFORCED CONCRETE-CODE OF PRACTICE) codbook.

Final mix proportion is 1:1.85:3.21.

Table 2 FINAL MIX PROPORTIONS BY MASS(1:1.85:3.21)

DESCRIPTION	**WATER**	**ADMIXTURE**	**CEMENT**	**FINE AGGREGATE**	**COARSE AGGREGATE**	
					20mm	**10mm**
Quantity Per cubic meter	187.93	N.A	376 kg	696.28 kg	724.02kg	482.68 kg
Quantity per bag	24.99	N.A	50 kg	92.59 kg	96.28kg	64.18 kg

2.3 Casting And curing Of Cube Specimens

Total 34 mix proportion are prepared.Initially M25 Grade of concrete are used. I n this mixture cement replaced with GGBS,Flyash and Metakaolin are 10 to 50% at 10% intervals and steel fiber are replaced with its volume 0.25 to 1% at 0.25% intervals.like 25MK01,25GGBS01,25FA01,25SF01.

Similarly second mixing sample is steel fiber mix with 0.75% replaced and cement replaced with GGBS,Metakaolin and Fly ash 10 to 50% at 10% intervals.like 25MKSF01,25GGBSSF01,25FASF01.

We made total 390 specimens like.cube beam and cylinder.

3. Results

1 slump test

Slump test is a laboratory or at site test used to measure the consistency of concrete. Slump test shows an indication of the uniformity of concrete in different batches. The shape of the concrete slumps shows the information on the workability and quality of concrete. The characteristics of concrete with

respect to the tendency of segregation can be also judgedby making a few tamping or blows by tapping rod on the base plate. This test continues using since 1922 due to the simplicity of apparatus and simple procedure. The shape ofthe Slump cone shows the workability of concrete.

MIX	**MATERIAL**				**slump**	**MIX**	**MATERIALS**				**Slump**
Name	SF %	MK %	GGBS %	FA %	Slump value (mm)	Name	SF %	MK %	GGBS %	FA %	Value mm
25NC00	0	-	-	-	98	25NC00	-	-	-	-	98
25SF01	0.25	-	-	-	98	25MKSF01	0.75	10	-	-	99
25SF02	0.50	-	-	-	96	25MKSF02	0.75	20	-	-	101
25SF03	0.75	-	-	-	97	25MKSF03	0.75	30	-	-	100
25SF04	1.0	-	-	-	94	25MKSF04	0.75	40	-	-	102
25MK01	-	10	-	-	100	25MKSF05	0.75	50	-	-	103
25MK02	-	20	-	-	103	25GGBSSF01	0.75	-	10	-	101
25MK03	-	30	-	-	99	25GGBSSF02	0.75	-	20	-	103
25MK04	-	40	-	-	101	25GGBSSF03	0.75	-	30	-	104
25MK05	-	50	-	-	104	25GGBSSF04	0.75	-	40	-	106
25GGBS01	-	-	10	-	99	25GGBSSF05	0.75	-	50	-	102
25GGBS02	-	-	20	-	101	25FASF01	0.75	-	-	10	98
25GGBS03	-	-	30	-	102	25FASF02	0.75	-	-	20	99
25GGBS04	-	-	40	-	105	25FASF03	0.75	-	-	30	104
25GGBS05	-	-	50	-	104	25FASF04	0.75	-	-	40	105
25FA01	-	-	-	10	99	25FASF05	0.75	-	-	50	107
25FA02	-	-	-	20	97						
25FA03	-	-	-	30	102						
25FA04	-	-	-	40	103						
25FA05	-	-	-	50	106						

2 Compressive test

Compressive strength is the capacity of material or structure to resist or withstand under compression. The Compressive strength of a material is determined by the ability of the material to resist failure in the form cracks and fissure. Concrete gains maximum strength at 28days.This test carried out by CTM machine.

MIX	**MATERIAL**				**Compr-essive strength n/mm^2**	**MIX**	**MATERIALS**				**Compressive strength n/mm^2**
Name	SF %	MK %	GGBS %	FA %		Name	SF %	MK %	GGBS %	FA %	
25NC00	0	-	-	-	31.82	25NC00	-	-	-	-	31.82
25SF01	0.25	-	-	-	32.53	25MKSF01	0.75	10	-	-	34.44
25SF02	0.50	-	-	-	33.73	25MKSF02	0.75	20	-	-	35.33
25SF03	0.75	-	-	-	35.07	25MKSF03	0.75	30	-	-	33.73
25SF04	1.0	-	-	-	33.02	25MKSF04	0.75	40	-	-	32.58
25MK01	-	10	-	-	35.47	25MKSF05	0.75	50	-	-	31.16
25MK02	-	20	-	-	34.09	25GGBSSF01	0.75	-	10	-	32.31
25MK03	-	30	-	-	33.46	25GGBSSF02	0.75	-	20	-	34.13
25MK04	-	40	-	-	32.4	25GGBSSF03	0.75	-	30	-	37.02
25MK05	-	50	-	-	30.98	25GGBSSF04	0.75	-	40	-	34.62
25GGBS01	-	-	10	-	30.67	25GGBSSF05	0.75	-	50	-	33.69
25GGBS02	-	-	20	-	33.73	25FASF01	0.75	-	-	10	34.31
25GGBS03	-	-	30	-	36.31	25FASF02	0.75	-	-	20	35.6
25GGBS04	-	-	40	-	34.13	25FASF03	0.75	-	-	30	34.27
25GGBS05	-	-	50	-	33.29	25FASF04	0.75	-	-	40	33.64
25FA01	-	-	-	10	33.38	25FASF05	0.75	-	-	50	33.11
25FA02	-	-	-	20	35.37						
25FA03	-	-	-	30	33.91						
25FA04	-	-	-	40	33.2						
25FA05	-	-	-	50	32.53						

3 Split tensile test

The important property of concrete is “tensile strength” as structural loads make concrete vulnerable to tensile cracking. Tensile strength of concrete is much lower than its compressive strength (that’s why steel is used to carry the tension forces). It has been estimated that tensile strength of concrete equals roughly about 10% of compressive strength. Specimen used for this test is of size 150 mm diameter and 300 mm height.

MIX	**MATERIAL**				**Split tensile strength n/mm^2**	**MIX**	**MATERIALS**				**Split tensile strength n/mm^2**
Name	SF %	MK %	GGBS %	FA %		Name	SF %	MK %	GGBS %	FA %	
25NC00	0	-	-	-	3.54	25NC00	-	-	-	-	3.54
25SF01	0.25	-	-	-	3.43	25MKSF01	0.75	10	-	-	3.93
25SF02	0.50	-	-	-	3.69	25MKSF02	0.75	20	-	-	4.09
25SF03	0.75	-	-	-	4.16	25MKSF03	0.75	30	-	-	3.89
25SF04	1.0	-	-	-	4.32	25MKSF04	0.75	40	-	-	3.72
25MK01	-	10	-	-	3.97	25MKSF05	0.75	50	-	-	3.32
25MK02	-	20	-	-	3.89	25GGBSSF01	0.75	-	10	-	3.73
25MK03	-	30	-	-	3.81	25GGBSSF02	0.75	-	20	-	3.95
25MK04	-	40	-	-	3.68	25GGBSSF03	0.75	-	30	-	4.21
25MK05	-	50	-	-	3.23	25GGBSSF04	0.75	-	40	-	4.05
25GGBS01	-	-	10	-	3.68	25GGBSSF05	0.75	-	50	-	3.71
25GGBS02	-	-	20	-	3.91	25FASF01	0.75	-	-	10	4.05
25GGBS03	-	-	30	-	4.10	25FASF02	0.75	-	-	20	4.34
25GGBS04	-	-	40	-	3.94	25FASF03	0.75	-	-	30	4.17
25GGBS05	-	-	50	-	3.62	25FASF04	0.75	-	-	40	4.00
25FA01	-	-	-	10	3.75	25FASF05	0.75	-	-	50	3.81
25FA02	-	-	-	20	4.22						
25FA03	-	-	-	30	4.15						
25FA04	-	-	-	40	3.62						
25FA05	-	-	-	50	3.47						

4 Flexural test

Flexural test evaluates the tensile strength of concrete indirectly. It tests the ability of unreinforced concrete beam or slab to withstand failure in bending. The results of flexural test on concrete expressed as a modulus of rupture which denotes as (*MR*) in MPa or psi. The flexural test on concrete can be conducted using either three point load test or center point load test.

MIX	MATERIAL				Split tensile strength n/mm^2	MIX	MATERIALS				Split tensile strength n/mm^2
Name	SF %	MK %	GGBS %	FA %		Name	SF %	MK %	GGBS %	FA %	
25NC00	0	-	-	-	3.94	25NC00	-	-	-	-	3.94
25SF01	0.25	-	-	-	3.99	25MKSF01	0.75	10	-	-	4.35
25SF02	0.50	-	-	-	4.45	25MKSF02	0.75	20	-	-	4.65
25SF03	0.75	-	-	-	5.15	25MKSF03	0.75	30	-	-	4.37
25SF04	1.0	-	-	-	4.1	25MKSF04	0.75	40	-	-	4.06
25MK01	-	10	-	-	4.68	25MKSF05	0.75	50	-	-	3.99
25MK02	-	20	-	-	4.49	25GGBSSF01	0.75	-	10	-	4.18
25MK03	-	30	-	-	4.33	25GGBSSF02	0.75	-	20	-	4.43
25MK04	-	40	-	-	4.15	25GGBSSF03	0.75	-	30	-	4.81
25MK05	-	50	-	-	3.86	25GGBSSF04	0.75	-	40	-	4.53
25GGBS01	-	-	10	-	4.07	25GGBSSF05	0.75	-	50	-	4.30
25GGBS02	-	-	20	-	4.37	25FASF01	0.75	-	-	10	4.62
25GGBS03	-	-	30	-	4.74	25FASF02	0.75	-	-	20	4.93
25GGBS04	-	-	40	-	4.23	25FASF03	0.75	-	-	30	4.84
25GGBS05	-	-	50	-	3.87	25FASF04	0.75	-	-	40	4.62
25FA01	-	-	-	10	4.67	25FASF05	0.75	-	-	50	4.31
25FA02	-	-	-	20	5.06						
25FA03	-	-	-	30	4.88						
25FA04	-	-	-	40	4.52						
25FA05	-	-	-	50	4.32						

5 Acid attack test

Concrete is susceptible to acid attack because of its alkaline nature. “The components of the cement paste break down during contact with acids as a process of disintegration. The acid attack test concrete cube of size 150 x 150 x 150 mm are prepared. The specimen are cast and cured in mould for 24 hours, after 24 hours, all the specimen are remolded and kept in curing tank for 28-days. After 28-days all specimens are kept in

atmosphere and immersed in 5% sulphuric acid (H_2SO_4) solution for 28-days. pH value of the acidic media was at 0.3.

MIX	**MATERIAL**				**PROPERTIES OF CUBES**		**Compression test Normal CURING (N/mm2)**	**Acid Resistance (curing with 5% H2So4)**
Name	SF %	MK %	GGBS %	FA %	WEIGHT OF CUBE (KG)	WEIGHT OF CUBE (curing with 5% H2So4) (KG)	28 Days	56 Days
25NC00	0	-	-	-	8.39	8.08	31.82	31.05
25SF03	0.75	-	-	-	8.37	7.99	35.07	34.43
25MK01	-	10	-	-	8.74	8.45	35.47	34.99
25MKSF02	0.75	20	-	-	8.83	8.36	35.33	34.82
25GGBS03	-	-	30	-	8.45	8.01	36.31	35.96
25GGBSSF0	0.75	-	30	-	8.62	8.17	37.02	36.68
25FA02	-	-	-	20	8.23	7.87	35.37	34.98
25FASF02	0.75	-	-	20	8.79	8.12	35.6	35.01

6 Sulphate attack test

Sulphate Attack test requires specimens of size 150 mm x 150 mm x 150 mm. The acidic attack test solution of 5% H_2So_4 is required, but here for the sulphate attack test, the solution of magnesium sulphate ($MgSo_4$) with same proportion of 5% of total water is required.

MIX	**MATERIAL**				**PROPERTIES OF CUBES**		**Compression test Normal CURING (N/mm2)**	**Acid Resistance (curing with 5% MgSo4)**
Name	SF %	MK %	GGBS %	FA %	WEIGHT OF CUBE (KG)	WEIGHT OF CUBE (curing with 5% MgSo4) (KG)	28 Days	56 Days
25NC00	0	-	-	-	8.27	7.89	31.82	31.12
25SF03	0.75	-	-	-	8.48	8.02	35.07	34.57
25MK01	-	10	-	-	8.79	8.22	35.47	35.01
25MKSF02	0.75	20	-	-	8.82	8.37	35.33	34.96
25GGBS03	-	-	30	-	8.48	8.01	36.31	35.99
25GGBSSF0	0.75	-	30	-	8.61	8.03	37.02	36.76
25FA02	-	-	-	20	8.25	7.81	35.37	34.89

25FASF02	0.75	-	-	20	8.82	8.23	35.6	34.97

7 RCPT test

RCPT was used to determine the resistance to penetration of chloride iron. This investigation was carried out in accordance with ASTM C1202-09. Concrete disc of size 100 mm diameters and 50 mm thickness were casted and permitted to cure for 28 days. After curing, the concrete specimens were subjected to RCPT test by impressing a voltage of 60V.

MIX	**MATERIAL**				Cumulative Current in (MA)	Charge Passed in Coulombs	REMARK
Name	SF %	MK %	GGBS %	FA %			
25NC00	-	-	-	-	1506	1355.4	LOW
25SF03	0.75	-	-	-	1204	1083.6	LOW
25MK01	-	10	-	-	1108	997.2	VERY LOW
25MKSF02	0.75	20	-	-	1145	1030.5	LOW
25GGBS03	-	-	30	-	1023	920.7	VERY LOW
25GGBSSF03	0.75	-	30	-	1078	970.2	VERY LOW
25FA02	-	-	-	20	1011	909.9	VERY LOW
25FASF02	0.75	-	-	20	1202	1081.8	VERY LOW

8 Water sorptivity test

This method is used t determine the rate of absorption of water concrete with measuring the increase in the mass of a specimens resulting from absoption of water as a function of time when only one surface of the specimens is exposed to water. It is also known as sorptivity test. The standard test specimens is a 100 $\pm$ 6 mm dia. And 50$\pm$ 3 mm in length is used.

MIX	Dry weight W_1 (gm)	wet weight W_2 (gm)	Change in weight (gm)	Sorptivity (10^{-4}mm/min$^{0.5}$)
25NC00	1112.5	1108.3	4.2	2.932
25SF03	1124.3	1120.4	3.9	2.722
25MK01	1098.9	1095.3	3.6	2.31
25MKSF02	1153.7	1150.3	3.4	2.375
25GGBS03	1135.9	1132.4	3.5	2.443

25GGBSSF03	1151.3	1146.1	3.2	2.23
25FA02	1123.5	1120.34	3.16	2.21
25FASF02	1145.2	1142.3	2.9	2.025

4. CONCLUSIONS

- GGBS,Metakaolin and flyash can be used as partial replacement of cement
- Using Metakaolin,GGBS and flyash the compressive strength, flexural strength and split tensile strengh of concrete increase up to some extent (10% only mk,and 20% with 0.75% SF,30% GGBS in both mixes and 20% Flyash in both mixes)
- In durability test all test are result in good or appropriate result
- Based on the result strength and durability it is determine that when the Metakaolin,GGBS, flyash and Steel fiber as replacement with cement in concrete better performance.

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