PROPERTIES OF SELF COMPACTING CONCRETE WITH METAKAOLIN REPLACING SAND WITH GBFS

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Abstract

After Agriculture Industry in India. Construction sector contribute 11% to the GDP. Hence construction Industry plays a crucial role in economic development for any construction. Sand is the major material for preparation of mortar and self compacting concrete. But the problem here is sand is largest basic consumer non-renewable resource. Hence it is our responsibility to safeguard the sand for future generation. Today this is an almost scarcity of national sand and due to continuous excavation of river beds there is some serious effect on ecology ever. It's the time to think for alternate material to replace the river sand and for any mix design of self compacting concrete higher %age of powder content & sand is required. In the present paper we have put an effort to replace the sand with GBFS by–product of steel and iron manufacturing plant. Test result of GBFS meets the national standard of fine aggregates (IS 38 3 -1970) GBFS does not contain material that may affect the strength and durability of concrete such as chlorides, organics impurities. It is free from emission of Co2. In the present paper M40 grade of SCC was considered with different replacement of sand with G.B.F.S. Further it is studied that the effect of MetaKaolin on the properties of GBFS self compacting concrete, the studies include the effect of GBFS and MetaKaolin on the fresh and hardened mechanical properties of SCC made with GBFS and MetaKaolin. The observation made that river sand can be replaced up to 60% with constant W/C ratio 0.38% the only problem with GBFS, it takes long time to gain strength. If we add the admixtures METAKAOLIN by 10%, then quick setting & early strength is possible.

The GBFS is free from Co2, Alkalis and silt, Co2.The fresh properties & compressive strength of SCC increases with the increase in the percentage of GBFS. But limited to 60% replacement provided by adding 10% MetaKaolin. It is found that 70% replacement not reached satisfactory results. It is economical when compared with natural sand and also reliable alternative material in terms of workability, strength and durability. As there is broader slope for advancement in construction Industry. Therefore there is an immense necessity to know for alternative to natural river sand, this paper further detail about the fresh and hardened properties chemical properties briefly in full length submission.

The fresh properties and compressive strength of self compacting concrete is improved as percentage of GBFS increases with constant MetaKaolin (%). The study has revealed that using MetaKaolin in the replacement f river sand with GBFS gives better flow properties and compressive strength in comparison to only GBFS

Keywords*:, Super Plasticizer, Viscosity Modify agent, MetaKaolin, Fine aggregate replacement, Granulated Blast Furnace Slag.*

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1. INTRODUCTION

The sand is the most reliable natural material used for concreting, plastering and masonry work. The main problem is due to acute shortage, high price and enormous usage of river sand in the construction [1, 2] Day by day it's getting depleted therefore sufficient amount of river sand is not available, meanwhile over use of river sand leads to damage of natural environment [3]. Hence it is desirable that a substitute which is economical is to be considered as an alternative material like GBFS [4].

GBFS is a waste industrial by-product of iron and steel production, when 1000 tons of steel is produced, nearly 400 tons of slag is obtained as a residue, the properties of this slag are similar to river sand [5], and the cost is Rs 120/ton at site, therefore it is economical compared to natural sand. Tests conducted on it are as per IS383-1970, slag sand was of zone 1 [5, 6] GBFS is non metallic granulate which possesses silicates and aluminous silicate of calcium, this helps to enhance long term strength, durability and reduction in the emission of carbon dioxide. Marine products, oversized materials, clay and silt in slag sand are nil, low pozzolanic by-product fly-ash is also used in the present work. [7, 8] It decreases early strength but improves the workability [9].

MetaKaolin is obtained from natural Kaolin clay, by heating this clay at a temperature of 650 -900 degree centigrade MetaKaolin is obtained [10, 11]. The specific surface area, silica & alumina content of MetaKaolin is higher than O.P.C[12].During the hydration of Portland cement ca(OH)2 is produced which has no contribution towards the strength development of concrete but when MetaKaolin combines with ca(OH)2 produces additional cementation compounds and makes concrete strengthen[13,14].

In the present experimental work focused on properties of SCC using MetaKaolin with different replacement of sand by GBFS.

2. MATERIALS USED AND ITS PROPERTIES

Table 1: Physical properties of MetaKaolin

S.no	Description of physical properties	Units	Results
1	Color		1Close To Std
2	Appearance		1 OFF white Powder
3	Bulk Density	Gm/liter	356
4	Oil Absorption	Gm/100gm	
5	Moisture (EX-Work)	%	0.22
6	PH (10% A2 Slurry)		6.22
7	RESIDUE on 325 Mesh	%	0.13
8	PSD –D(50)-50% particles	μ	1.68
9	Specific gravity		2.63

Table 2: Chemical Properties of MetaKaolin

Sio_2	Fe_2o_3	Al_2o_3	Cao	Mgo	k_2o	Loi
52.4 %	4.3%	36.1 %	0.1 %	0.84 %	1.38 %	3.37 %

Table 3: Physical Properties of fine aggregate GBFS (Granulated Blast furnace clay sand)

S.No	Source : JSW slag , Bellary
1	a)Dry Rotted bulk density 1531kg/m^3 b) Loose bulk density 1337 kg/m^3
2	Specific gravity 2.67
3	Water absorption 6.5 %
4	Sieve Analysis

Table 4: Chemical properties of GBFS

S.No	Characteristics	Requirement as per IS-12089	Test Results
1	SIO_2 (%)	-	32.51
2	AL_2O_3 (%)	-	21.76
3	Fe_2o_3	-	1.1
4	Cao (%)	-	35.68
5	Mgo (%)	17 (Max)	7.6
6	Loss on Ignition (%)		0.35
7	IK (%)	5.0 (Max)	0.45
8	Manganese Content	5.5 (Max)	0.15
9	Sulphide sulphur	2.0 (Max)	0.47
10	Glass Content	85(min)	92
11	Moisture Content	-	5.2
12	Particle size passing 50mm	95%	100 %
13	Chemical moduli (Cao + Mgo + Al_2O_3) /sio_2	Greater than or equal to 1.0	2

Mix Proportions of 0% MK

Table 5: Quantities of materials for 1m3 of SCC mix with 0% MetaKaolin

% of replacement of river sand with GBFS	Cement	Fly ash	River sand	GBFS	C.A	Water
0	351	207	876		726	195
30	351	207	614	262	726	195
40	351	207	526	350	726	195
50	351	207	428	438	726	195
60	351	207	351	525	726	195
70	351	207	263	613	726	195

Mix Proportions of 10 % MK

Table 6 Quantities of materials for 1m3 of SCC mix with 10% MetaKaolin

% of replacement of river sand with GBFS	Cement	Meta Kaolin	Fly ash	River sand	GBFS	C.A	Water
30	315	36	207	614	262	726	195
40	315	36	207	526	350	726	195
50	315	36	207	438	438	726	195
60	315	36	207	351	525	726	195
70	315	36	207	263	613	726	195

Table 7: property of SCC with 0% MetaKaolin.

% of replacement of river sand with GBFS	0 %	30%	40%	50%	60%	70 %
Slump flow	700x 700	630x 630	600x 600	560x 560	500x 500	280
V-Funnel	5 sec	6 sec	8 sec	13 sec	16 sec	18 sec
L-box	0.86	0.72	0.7	0.64	0.62	0.6

Table 8: Fresh properties of SCC With 10% MetaKaolin.

% of replacement of river sand with GBFS	0%	30%	40%	50%	60%	70%
Slump flow	720x 720	680x 680	630x 630	600x 600	550x 550	350x 350
V-Funnel	4 sec	4.5 sec	1 sec	11 sec	15 sec	16 sec
L-Box	0.91	0.84	0.8	0.75	0.72	0.68

Table 9: Compressive strength values for SCC (in Mpa)

% of replacement of river sand with GBFS	Compressive strength 7 days		Compressive strength 28 days	
	0% M.K	10 % M.K	0% M.K	10 % M.K
0%	30		43	
30%	30	35	45	51
40%	30.8	36.2	46.1	53
50%	32.1	37.1	47	55
60%	33	38	48.6	55.8
70 %	34.2	39	47.5	51

3. MIX PROPORTIONS

The experimental study was done for concrete grade m40 to evaluate the result after replacing river sand by GBFS using MetaKaolin five trial mixes were done and best mix were adopted. The present work was carried out with different replacement of sand by GBFS and cement with 36% of fly-ash, same result of work compared with replacing cement by using 10% MetaKaolin. In both the cases (w/c) ratio is 0.37and replacement of sand with GBFS 0%, 30%, 40%, 50%, 60%, 70%, totally six mixes were preferred without and with replacement of cement by MetaKaolin.

4. RESULTS AND DISCUSSION

River sand contains high percentage of silt, clay, and other impurities. It reduces the strength of concrete; hence it makes useless concrete for construction. GBFS is free from all above characteristics. Hence replacement of sand with GBFS gives the satisfactory results.

To improve the fresh properties and compressive strength cement is replaced with 10% of MetaKaolin The specific surface area of MetaKaolin is higher than OPC .It helps to improve the strength and other properties. During the hydration of Portland cement ca $(OH)_2$ is produced when MetaKaolin combines with ca$(OH)_2$. It develops additional cementing compounds and it makes concrete stronger.

Test on Fresh Properties of SCC

4.1 Fresh Properties of SCC

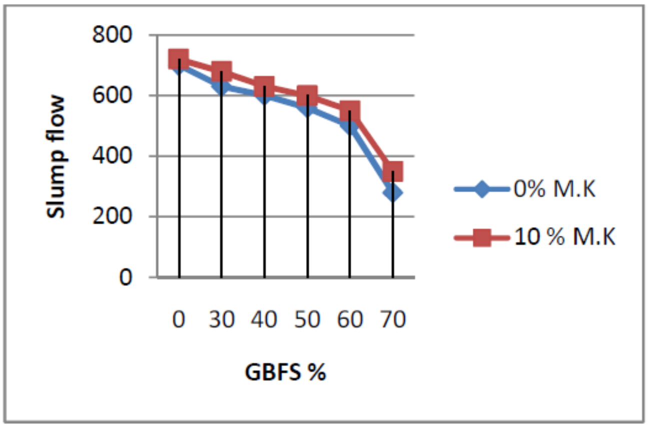
1. The diameters of slump flow for different concrete mixes were measured in the range of 700mm to 500mm up to 60% replacement and it is reduced to 280mm for 70 % replacement. Same mix by replacing cement with 10 % MetaKaolin 720mm to 550mm up to 60 % replacement and it reduces to 350 mm for 70 % replacement.
2. V- funnel flow time increase from 5s to 16s up to 60% of replacement and 18s for 70 % of replacement , Same result of work with 10% MetaKaolin flow time from 4s to 15 s and 16s for 70%.

3. The blocking ratio (H2/H1) for L-box is from 0.86 to 0.6 up to 70% replacement but same result of work with 10% MetaKaolin is from 0.91 to 0.68. The concrete mix flow increases by using MetaKaolin.

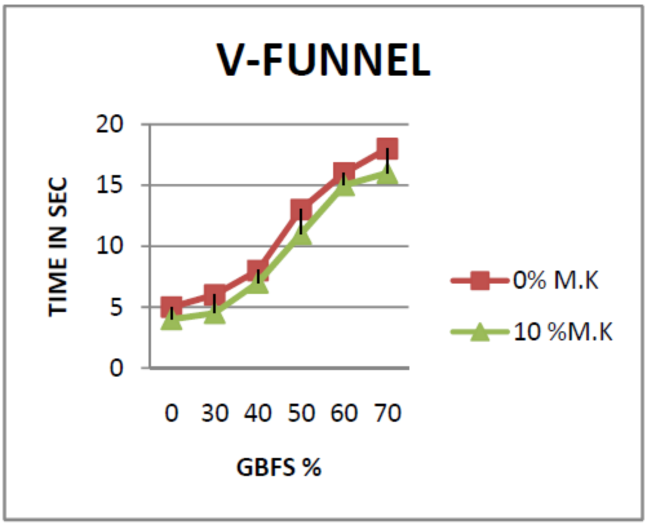
4.2 Compressive Strength

The results showed that there was an enhancement in the compressive strength up to 60%, replacement by 9% for 7 days and 13% for 28 days without the use of MetaKaolin By using MetaKaolin for replacement of 60% sand with GBFS, compressive strength of 7 days increased by 27% and 28 days by 31%

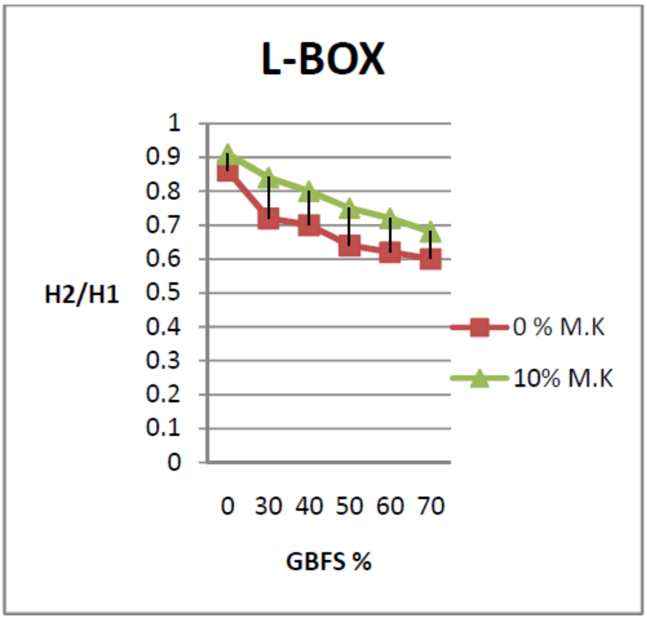
Graphs



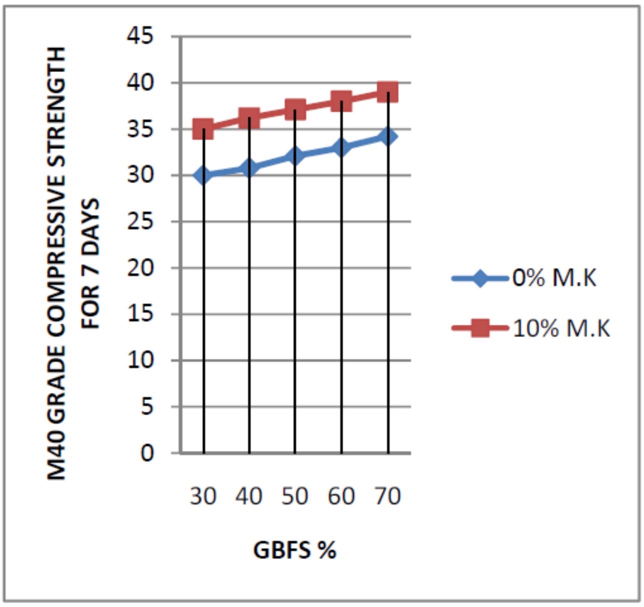
Graph1



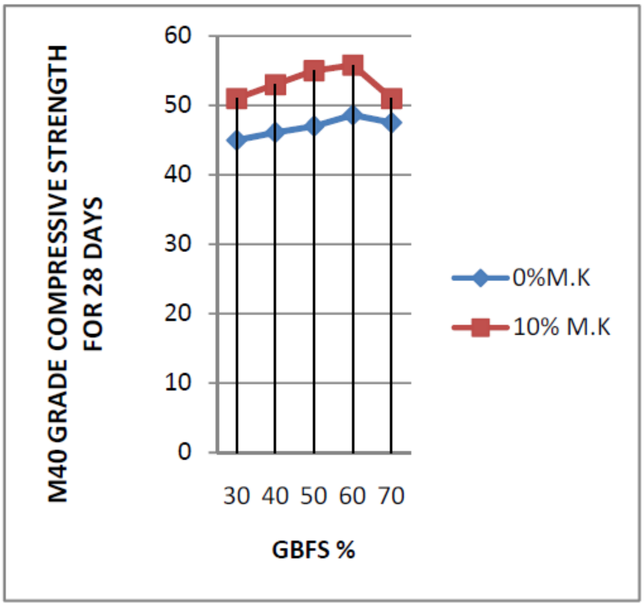
Graph2



Graph3



Graph4



Graph5

5. CONCLUSION

1. Fresh properties of SCC replacing up to 60% of sand with GBFS were found to be good.
2. Fresh properties of concrete mix decreases above 60% replacement of sand with GBFS.
3. Fine particles of GBFS of 150μ and 75 μ are very less hence 100% replacement of GBFS is not possible.
4. It is advisable to mix at least 30-40% of river sand with GBFS.
5. In the trial mixing, it was found that use of MetaKaolin decreases workability of SCC, but this can be improved by using super
plasticizer and change in w/b ratio 6. During the hydration of cement $Ca(OH_2)$ will be produced, it
7. By replacing cement with MetaKaolin, $Ca(OH_2)$will be converted into (C-S-H) gel, this will help to develop to additional compressive strength and makes the concrete stronger by blocking existing pores

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