Strength and Durability properties of SCC with GBFS and MetaKaolin

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ABSTRACT

In the present years, there is reduction in the availability of river sand due to increase in the demand in the construction industry, because sand is the basic material for the preparation of concrete and mortar. For the mix design of self-compacting concrete large amount of powder content is required therefore higher % of sand is needed. But over use of river sand causes environmental co-balance vegetation loss, Lowering of water table.

On the other hand, NTP and manufacturing steel and iron industries are facing problem for the disposal of waste industrial by product such as fly ash, GGBS, GBFS.

To satisfy both of these problems the experimental work carried to reuse of this waste by-product. Therefore need to think a waste material to replace the river sand as GBFS or any other industrial by-product. GBFS is obtained during the manufacture of iron and steel.

The physical and chemical properties of GBFS are similar to river sand and it meets the national standards of river sand (IS: 383-1970).

In the present days for normal concrete many works were carried out for the partial replacement of cement as fly ash, Meta Kaolin to obtain better workability and strength.

Also by the use of granulated blast furnace slag with fly ash showed better flow properties and long term strength up to 25% of fly ash. By increasing the fly ash %the results are not satisfactory. Here the work carried out for SCC increasing % of fly ash and replacing cement with Meta Kaolin.

In the present experimental work replacement of cement by 38%of fly ash and 10% Meta Kaolin as cement whereas replacement of 40%GBFS as river sand were used. In the present experimental work M40 grade of SCC was considered. Here sand replaced by 0% GBFS with replacement of cement by 0% MK, 40% GBFS and 0% Meta Kaolin, 40%GBFS and 10% Meta Kaolin with constant of 0.28% of fly ash and constant water/powder ratio of 0.38

The experimental results are evaluated the mechanical and durability properties such as compressive strength of cubes, cylinders, split tensile strength, water absorption and RCPT

KEY WORDS: Meta Kaolin, GBFS, Fly ash, Fine aggregate, Replacement, Concrete, Strength, cement, Durability, Chloride permeability.

1. INTRODUCTION

The basic need for the production of concrete matrix are cement, river sand and coarse aggregate, among these materials river sand usage is more in the production of self-compacting concrete due to higher powder content

For the production of concrete mix contribution of natural sand plays importance role towards the enhancement of workability and hardened properties of concrete Day by day scarcity of river sand occurring due to continuous excavation of river beds its depletion of river sand .This shortage causes many serious problems and damage to the environment and society, Due to extraction of river sand as a construction material in Sri Lanka has lead to many harmful problems (Taylor, 2006; Gartner, 2004) as losing retaining soil, Strata loss of vegetarian lowering water table Therefore restrictions imposed on the extraction of natural sand. Due to this situation, in the present work substitution of environmental friendly, cheap industrial by- products GBFS is used. Its purpose is to reduce CO_2 emission being the preferred option of waste disposal (Filho, 2007) and reuse of GBFS.

GBFS is industrial by product produced during manufacturing of steel and iron it is used as replacement of natural fine sand (Chinsu, 2007), This waste material It will solve the problems of waste disposal side by side and preserve the river sand (Mehta, 2007), It is a non-metallic cost about Rs.100 per tonnes on site cheaper than the river sand .In the manufacture of 1000 tonns of steel nearly 500 tonnes of slag is produced GBFS is easily available and inexpensive used as alternate to natural sand (Jadhava and Kulkarni 2012; Khajuria and Siddique, 2014; Bouzouba, 2000)

Concrete made with replacing natural sand with GBFS and Fly ash affects the concrete durability, Mineral admixtures like Fly ash, Meta Kaolin will reduce the emission of CO_2 (Isa yuksel, 2006) These are pozzolanic admixtures during the hydration of cement $Ca(OH)_2$ is produced . Pozzolanic admixtures reacts with $Ca(OH)_2$ and generate C-S-H Fly ash possess very slow rate of hydration and Meta Kaolin possess a high reactivity combination of these admixtures will help to dense the concrete, improve the workability, mechanical properties, durability, and lowering the environmental impact.

The use of supplementary cementititous materials like rice-husk ash, fly ash granulated blast furnace slag, Meta Kaolin silica fumes is alternatives binders to cement.

The use of Meta Kaolin with fly ash greatly improves consistency and early and long term strength of concrete Incorporating high reactivity Meta Kaolin with GBFS and Fly Ash in SCC reduces the dosage of super plasticizer (Whiting, 1981).

A concrete mix of wetter specimen consists of lower air permeability because wetter mix has more blockage of air permeability (Singha Roy, 2011) Lowering of air permeability increases with increase of time for the passage for the same temperature and same period of curing Lower the percentage of water absorption greater is the strength of concrete (Chinsu, 2007). The concrete made with river sand have higher permeability but replacing sand with GBFS and cement with Meta Kaolin it reduces permeability. Both Meta Kaolin and GBFS have greater surface area and provides excellent bond with Portland cement.

Meta Kaolin is obtained by heating the Kaolin clay by calcination at a temperature 650 to 800^{o}c. Both Fly Ash and Meta Kaolin are pozzolanic admixtures used for the replacement of cement RCPT is conducted for six hours. This test measures resistance of concrete to the chloride ion penetration this represent that higher the coulomb number, for mix greater permeability and lower the coulomb number lower permeability. In the present experimental work mechanical and durability properties of self-compacting concrete with Meta Kaolin replacing sand with GBFS for M40 grade was studied

2. METHODS & MATERIALS

Material used and properties:

Table.1. Physical properties of MetaKaolin

Description of physical properties	Units	Results
Color		1Close To Std
Appearance		1 OFF white Powder
Bulk Density	Gm/liter	356
Oil Absorption	Gm/100gm	
Moisture (EX-Work)	%	0.22
PH (10% A2 Slurry)		6.22
RESIDUE on 325 Mesh	%	0.13
PSD –D(50)- 50% particles	µ	1.68
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)

Source	JSW slag , Bellary
Dry Rotted bulk density	1531kg/m^3
Loose bulk density	1337 kg/m^3
Specific gravity	2.67
Water absorption	6.5%
Sieve Analysis	

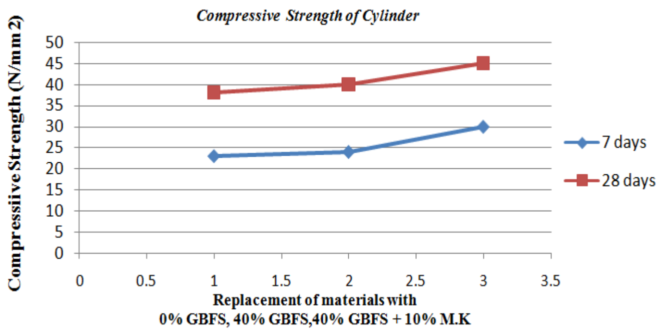
Table.4. Chemical properties of GBFS

Characteristics	Requirement as per IS-12089	Test Results
SiO_2 (%)	-	32.51
Al_2O_3 (%)	-	21.76
Fe_2O_3	-	1.1
CaO (%)	-	35.68
MgO (%)	17 (Max)	7.6
Loss on Ignition (%)		0.35
IK (%)	5.0 (Max)	0.45
Manganese Content	5.5 (Max)	0.15
Sulphide sulphur	2.0 (Max)	0.47
Glass Content	85(min)	92
Moisture Content	-	5.2
Particle size passing 50mm	95%	100 %
Chemical moduli (CaO + MgO + Al_20_3) /SiO_2	Greater than or equal to 1.0	2

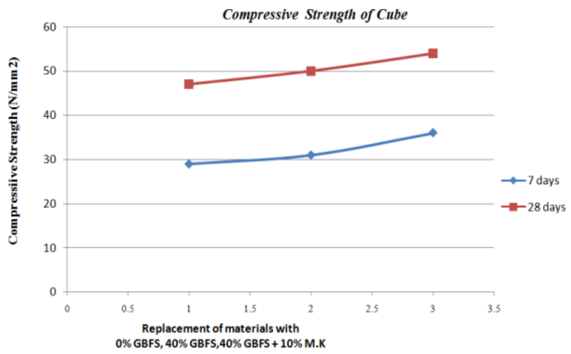
Mix proportions: The experimental work carried out for M40 grade of SCC to determine mechanical and durability properties of concrete made with Meta Kaolin replacing river sand with GBFS. Five mixes were tried and best is adopted with constant of 0.36 % Fly Ash and constant water/cement ratio of 0.37, Here 100% of river sand with 0% replacement of GBFS, 40% of GBFS as river sand and 40% of GBFS as river sand with 10% replacement of cement with Meta Kaolin.

Table.5. Quantities of materials for 1m^3 of SCC mix with 10% Meta Kaolin

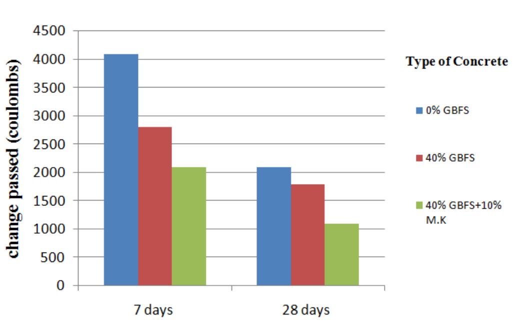
% of replacement of river sand with GBFS	Cement	Meta Kaolin	Fly ash	River sand	GBFS	C.A	Water
30	315	36	207	614	262	726	195
40	315	36	207	526	350	726	195
50	315	36	207	438	438	726	195
60	315	36	207	351	525	726	195
70	315	36	207	263	613	726	195



Graph.1. Compressive strength of Cylinder



Graph.2. Compressive strength of Cube



Graph.3. RCPT for M40 grade of concrete

3. TEST RESULT AND DISCUSSION

Mechanical properties: Mechanical properties such as compressive strength of cubes and cylinders are evaluated for 7 days and 28 days Split tensile strength test for cylinders were conducted for 28 days; here size of cubical specimen 150x150x150 mm and cylindrical specimen 300mm height and 150 mm diameter For each mix 3 cylindrical specimens were prepared and average of 3 test results is taken. The experiment result shows that there is increase in strength 1.6% for 40% replacement of GBFS and 3.8 for 40% replacement of GBFS with 10% Meta Kaolin. Compressive strength was lower for 100% of river sand for 7 and 28 days and higher for 40% of GBFS as river sand with 10% Meta Kaolin as cement. This increase was found for 7 days 24.14% and 28 days 15%

Table.6. Compressive strength of cube test for M40 grade of SCC

% GBFS	% MK	Compressive strength in Mpa	
		7 days	28 days
0	0	29	47
40	0	31	50
40	10	36	54

Table.7. Compressive strength of cylinder test for M40 grade of SCC

% GBFS	% MK	Compressive strength in Mpa	
		7 days	28 days
0	0	23	38
40	0	24	40
40	10	30	45

Table.8. Split tensile strength

% GBFS	% M.K	Split tensile strength N/mm^2
0	0	4.49
40	0	4.56
40	10	4.66

Rapid chloride permeability test: The object of experimental work was to determine the performance of SCC made with 100% river sand, 40% GBFS as river sand and 40% GBFS as river sand with 10% replacement of cement with MK.

The test conducted on cylindrical specimen for 7 days and 28 days, for 100% river sand charge in coulomb is more for 7 days and 28 days this represent higher permeability, But for 40% GBFS as river sand and 10% MetaKaolin showed the lower charge and lower permeability. This mix gives the satisfactory result Size of cylinder 100x200 mm. A concrete mix of wetter specimen consists of lower air permeability this occurs due to blockage of concrete pores. Lowering of air permeability increases with increase of time for the passage. Rcpt are used for quality control and specification. This test result is shown in table.9, permeability depends on rate of hydration and internal pore in the concrete structures as the curing time increases permeability decreases.

Table.9. RCPT for M40 Grade of SCC

% of replacement	Chloride permeability			
	7 Days		28 Days	
	Coulombs	Remark	Coulombs	Remark
0% replacement of GBFS	4100	H	2100	M
40 % replacement of GBFS	2800	M	1800	L
40% replacement of GBFS and 10% replacement of MK	2100	M	1100	V

Water absorption: The size of cylindrical specimen 100mm of diameterx50mm height. These cylinders were immersed in water for 28 days curing, and then these cylindrical specimens kept in oven dried for 24 hours, at constant temperature of 100°c Dry weight was considered as W_1 after that cylinder was kept in water at temperature 80°c for 4 hours. This wet weight was taken as W_2 Water absorption = W_2-W_1/W_1 X100 Percentage of water absorption is higher for 100% of river sand and lower for 40% of GBFS as river sand with 10% of Meta Kaolin as replacement of cement

Table.10. Water absorption %

% of GBFS	% of MetaKaolin	Dry weight	Wet Weight in Grams	% of water absorption
0	0	927	938	1.19
40	0	904	913	1%
40	10	891	898	0.78

4. CONCLUSION

- The physical and chemical properties of GIBFS are suitable for the production of concrete mix.
- The compressive strength and split tensile strength are higher for replacement of sand with 40% of GIBFS and replacement of cement with 10% Meta Kaolin.
- The compressive strength and split tensile strength are lower for 0% replacement.
- The results showed that using Meta Kaolin and increasing % of flash with GIBFS an improvement in the impermeability of concrete.
- % of water absorption gradually decreases with the use of GIBFS with Meta Kaolin.
- The replacement of cement by MK leads to decrease in pore space
- Results proved that combination of MK with GBFS gradually decrease in Coulomb charge

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