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Evaluation of High Performance Concrete by Partial Replacement of Cement with Silica Fume Natural Sand and Manufactured Sand

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Abstract: *In this paper the remedial work for scarcity of the building materials are carried out. Instead of conventional materials it is replaced using the manufacturable resources. Those materials are M sand with River sand for the replacement of fine aggregate and also the combination of M sand and silica fume for the replacement of cement. To prove that the strength related properties are much better than the conventional materials. The important strength such as compressive flexural strength are taken into care and proved with the test results. This is to protect the naturally available resources and the ecofriendly materials to save the environment.*

Keywords: *M-sand, River sand, Silica fume, High performance concrete*

I. Introduction

Concrete with the conventional materials are used vastly in our world largely. Mineral admixture are widely used in concrete for various reasons especially for reducing the amount of cement required for making concrete which shows to a reduction in construction cost. The main field of application is as pozzolanic material is for high performance concrete. Silica fume, also known as micro silica, is an amorphous (non-crystalline) polymorph of silicon dioxide. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical with an average particle diameter of 150mm.This silica fume is used as a partial replacement with cement.

Manufactured Sand is sand produced from crushing of granite stones in required grading to be used for construction purposes as a replacement for river sand. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm. It is well graded in the required proportion. It does not contain organic and soluble compound that affects the setting time and properties of cement, thus the required strength of concrete can be maintained. It does not have the presence of impurities such as clay, dust and silt coatings, increase water requirement as in the case of river sand which impair bond between cement paste and aggregate. M-Sand is obtained from specific hard rock (granite) using the state-of-the-art International technology, thus the required property of sand is obtained. M-Sand is cubical in shape and is manufactured using technology like High Carbon steel hit rock and then rock on rock process which is synonymous to that of natural process undergoing in river sand information. Modern and imported machines are used to produce M-Sand to ensure required grading zone for the sand. The main objective of this work is to evaluate the strength of concrete with the replacement of M-sand by river sand, at an addition of silica fume with cement

II. MATERIALS

Silica Fume: The American concrete institute (ACI) defines silica fume as a ‘‘very fine non crystalline silica produced in electric arc furnaces as a by-product of production of elemental silicon or alloys containing silicon’ ’Silica fume is also known as micro silica, condensed silica fume, volatized silica or silica dust. It can exhibit both pozzolanic and cementitious properties. Silica fume has been recognized as a pozzolanic admixture that is effective in enhancing the mechanical properties to a great extent. Addition of silica fume to concrete improves the durability of concrete and also in protecting the embedded steel from corrosion.

Table 1: Properties of Silica fume

Specific gravity	2.2
Bulk density	576 Kg/m^3
Size	0.1 Micron
Surface area	20000 m^2/Kg
Sio_2	90-96 %
Al_2o_3	0.5-0.8 %

M sand: It is well graded in the required proportion. It does not contain organic and soluble compound that affects the setting time and properties of cement, thus the required strength of concrete can be maintained. It does not have the presence of impurities such as clay, dust and silt coatings, increase water requirement as in the case of river sand which impair bond between cement paste and aggregate. Thus, increased quality and durability of concrete. M-Sand is obtained from specific hard rock (granite) using the state-of-the-art International technology, thus the required property of sand is obtained.

Table 2: Properties of M sand and River sand

S.No	Properties	Type of sand	
		M-sand	River sand
1.	**Textural composition (%by weight)**		
	Coarse sand (4.75 – 2.00 mm)	28.1	6.6
	Medium sand (2.00 – 0.425 mm)	44.8	73.6
	Fine sand(0.425 – 0.075 mm)	27.1	19.8
2.	**Specific Gravity**	2.63	2.67
3.	**Bulk Density(kN/m^3)**	15.1	14.5
4.	**pH**	10.11	8.66
5.	**Chemical composition of M sand**	Si,Al,Ca,Mg Na,K,Fe,etc	

Fine Aggregate: Locally available river sand was used as a fine aggregate which passed through 2.36mm sieve and retained in 1.18mm sieve was used.

Cement used: Ordinary Portland cement of 43grade was used throughout the work

Water: Potable water was used for mixing and curing purposes

Table 3: Physical test for materials

S.No	Name of the test	Cement	Coarse aggregate	Fine aggregate	M Sand
1.	Specific Gravity test	3.1	2.54	2.74	**2.64**
2.	Finess Test	5%			
3.	Consistency	31%	-		

III. Experimental work and Results

Mix design: Mix design on recommended guide lines is really a process of making an initial guess at optimum combination of ingredients and final mix proportion is obtained only on the basis of further rail mixes. As mentioned earlier under the project a comparative study is being carried, as such only type on fine aggregate is varied and all other ingredients are kept constant. To arrive at a concrete mix for this study mix design kept constant. To arrive at a concrete mix design for this study M30 concrete was carried as per IS code.

Table 4: Mix Proportion for M30 Grade Concrete (1:1.85:3.2)

Water	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)
175	389	720	1257

4. Mixing, Casting and Curing of Cubes:

Table 5: Details of Size and Mix Proportion (River sand and M sand)

Specimen Tested	Silica fume in River sand	Silica fume in M sand	Size (mm)	No. of specimens
Cube (28 days compressive strength)	Conventional	conventional	150x150x150	6
	5% replacement	5% replacement	150x150x150	6
	10% replacement	10% replacement	150x150x150	6
	15% replacement	15% replacement	150x150x150	6
	20% replacement	20% replacement	150x150x150	6

Table 6: Details of PCC Prism Specimen

Specimen Tested	Silica fume in River sand	Silica fume in M sand	Size (mm)	No. of specimens
PCC prism (28 days compressive strength)	Conventional	conventional	700x150x150	2
	5% replacement	5% replacement	700x150x150	2
	10% replacement	10% replacement	700x150x150	2
	15% replacement	15% replacement	700x150x150	2
	20% replacement	20% replacement	700x150x150	2

Table 7: Details of Reinforced Beam Specimen

Specimen Tested	Silica fume in River sand	Silica fume in M sand	Size (mm)	No. of specimens
Beam (28 days compressive strength)	Conventional	conventional	1000x150x200	2
	5% replacement	5% replacement	1000x150x200	2
	10% replacement	10% replacement	1000x150x200	2
	15% replacement	15% replacement	1000x150x200	2
	20% replacement	20% replacement	1000x150x200	2

Fig 1: Unmolded specimen

Fig 2: Loading setup for specimen

Table 8: Load Vs Deflection value for River sand and M-sand for Beam

Load (kN)	Conventional Beam Deflection (mm)		5% silica fume Deflection (mm)		10% silica fume Deflection (mm)		15% silica fume Deflection (mm)		20% silica fume Deflection (mm)	
	River Sand	M-Sand	River Sand	M-Sand	River Sand	M-Sand	River Sand	M-Sand	River Sand	M-Sand
5	0	0	0	0	0	0	0	0	0	0
10	0.30	0.19	0.26	0.21	0	0	0	0	0	0
15	0.82	0.55	0.56	0.51	0.25	0	0	0	0	0
20	1.04	0.78	0.85	0.70	0.64	0.55	0.10	0	0	0.08
25	1.52	1.10	1.26	1.15	1.10	1.20	0.19	0.20	0.15	0.19
30	1.93	1.35	1.44	1.35	1.44	1.38	0.40	0.33	0.45	0.35
35	2.41	1.75	1.70	1.60	1.68	1.60	0.55	0.50	0.58	0.54
40	3.02	2.05	2.20	2.10	2.00	1.90	0.95	0.90	0.82	0.79
45	3.82	2.38	2.55	2.40	2.40	2.10	1.20	1.10	1.12	1.03
50	4.56	3.00	2.70	2.55	2.65	2.45	1.26	1.22	1.35	1.26
55	5.09	3.80	2.95	2.80	2.95	2.70	1.60	1.50	1.56	1.50
60	5.78	4.40	3.40	3.10	3.20	3.00	2.50	2.40	1.82	1.77
65	6.03	5.20	3.80	3.60	3.50	3.40	3.10	3.05	1.97	1.94
70	6.64	5.80	4.20	3.90	4.00	3.90	3.35	3.20	2.10	2.02
75	7.00	6.30	4.45	4.10	4.25	4.10	3.60	3.45	2.42	2.34
80	7.35	6.90	4.60	4.30	4.45	4.35	3.95	3.85	2.60	2.56

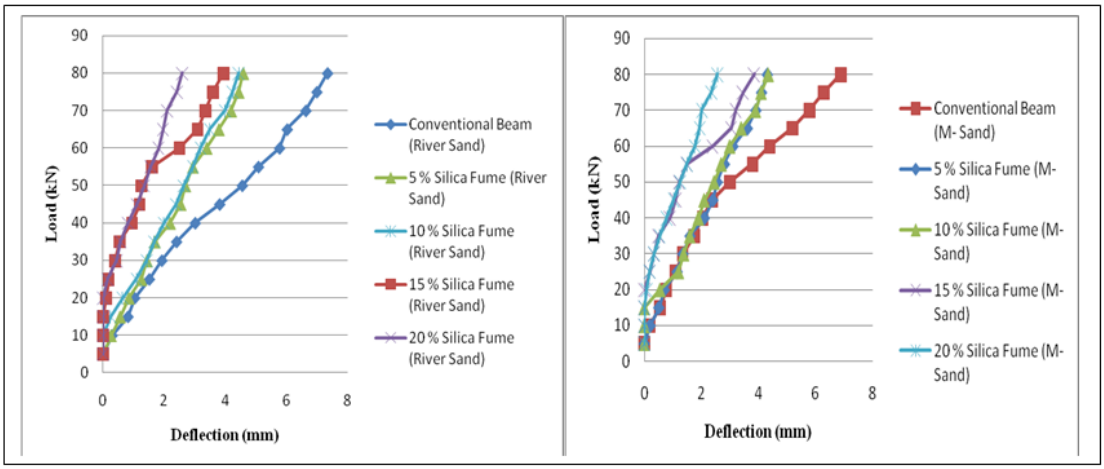

Fig 3: Load Vs Deflection curve for Beam (River sand) **Fig 4: Load Vs Deflection curve for Beam (M-sand)**

Table 9: Compressive Strength value for Cubes and Flexural Strength value for Prisms

S.No	Types of specimen	Compressive Strength (N/mm^2)		Flexural Strength (N/mm^2)	
	Silica fume	River Sand	M-Sand	River Sand	M-Sand
1	Conventional	31.6	34.61	3.90	4.66
2	5% Replacement	32.5	38.54	5.60	6.53
3	10% replacement	34.0	39.75	6.84	8.01
4	15% replacement	36.1	41.33	10.57	11.51
5	20% replacement	37.5	42.10	16.80	17.10

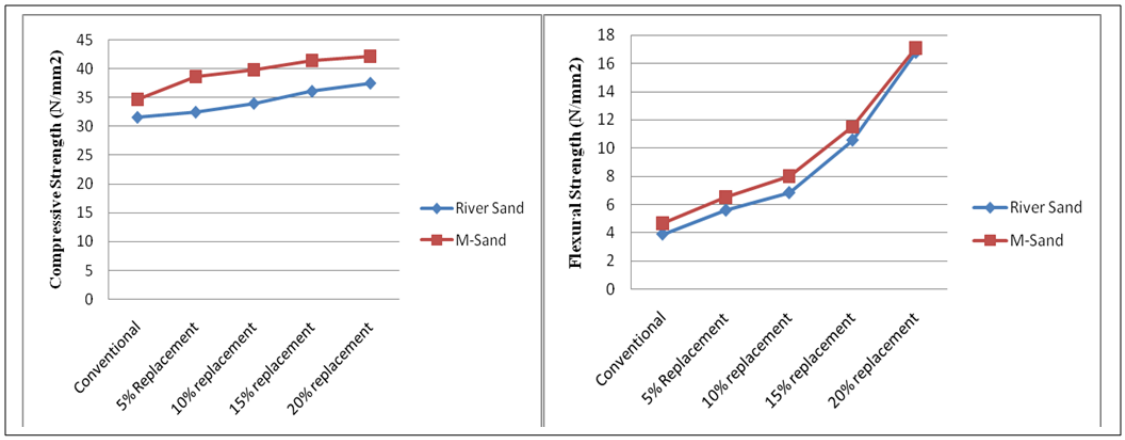

Fig.5 : Compressive Strength Curve for Cubes **Fig.6 :** Flexural Strength Curve for Prisms

IV. Conclusion

Based on the experimental investigation, the following results have been found. 28 days strength of concrete with M-sand is higher than that of with River sand. Also, due to the superior gradation of M-sand gave good plasticity to mortar providing excellent workability. Silica fume with manufactured sand combination has achieved 5%, 10%, 15%, 20% higher than the target strength at age of 28 days and other strength parameters such as compressive strength and flexural strength also slightly increased in this combination comparatively. The usage of M-sand for high strength high performance concrete provides stronger and durable concrete structures which will be economical as well as environment friendly by preserving natural resources such as river sand.

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