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To Investigate the Effect of Permeability Properties on HSC Using Different Mineral Admixture

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Abstract – In recent years, high-strength concrete (HSC) has been widely applied as an excellent material for civil and infrastructure engineering. Although HSC has significant advantages in strength and durability, many studies have indicated that the elevated temperature deteriorates the compressive strength, tensile strength, elastic modulus and even durability of HSC. HSC has wide applications in the pre-stressed bridges, cable stayed bridges, long span bridges etc. It allows for the greater span for concrete girders than that with the normal strength concrete. The HSC enhance the girder capacities and ultimately reduces the number of girders. Thus, it is economical to use HSC in the projects where strength required is more. In this paper we used manufactured sand with partial replacement of mineral admixture such as silica fume, and GGBS for experimental work and results are obtain after curing.

Keywords – High Strength Concrete, Pre-stressed Bridge, Silica fume, Ground Granulated Blast Furness Slag.

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1. INTRODUCTION

Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures. To meet the requirement of globalization, in the construction of buildings and other structures concrete plays very important role. In concrete there are many ingredient which gives good proportion. This ingredient gives strength, durability etc. The river sand is most widely used in concrete. Also rapid growth in construction field leads to huge exploitation of rives sand. Because of this over use of rive sand it adversely effect on river banks. So now days we use artificial sand for construction. The properties of artificial sand are influenced by physical properties of its parent rock. The properties of artificial sand influences the workability and finishing of the fresh concrete. There is a growing interest in the use of high performance concrete which provides overall durability and high strength. Method of estimating the durability of porous material is by measuring the rate at which a fluid a gas permeates through the material under given pressure. Therefore, the measurements of the permeability of concrete were used as an indication of durability. From this it is observed that permeability is the key to all durability problems.

In High strength concrete is major problem made because of shortage of natural sand. Hence artificial sand is emerging an available everywhere to produce concrete. Important governing factors for HPC (High Performance Concrete) are strength and long term durability.

As seen in previous literature study most of research is carried out on effect of temperature and permeability on high strength concrete. Also the study is carried out on natural sand. The study is not seen based on artificial sand and different admixture based on it. So it is need to study the permeability effect on HSC using artificial sand.

II. METHODOLOGY

Mix design is done according to IS-10262:2009. After manual calculation experimental work is done for different water to binder ration and also for different mineral admixture such as silica fume and GGBS. Experimental work is done for manufacture and natural sand. Then permeability tests are carried out .And the results are compare.

III. MATERIAL SPECIFICATIONS

Following are the materials used for the experimental work

1. Cement - The type of cement used during project work is OPC53 grade confirming to IS 8112. The cement should be fresh, uniform consistency and free of lumps and foreign matter. It should be stored under dry conditions and for as short duration as possible

2. Coarse Aggregate - For experimental work20mm the size of coarse aggregate is used. The gradation is done by using sieve analysis method.

3. Fine Aggregate (Manufactured Sand) - The sand used for this work should be clean, fresh, dust free, and free from organic matter.

4. Water - The water used for concrete mix must be potable.

5. Mineral Admixture - For greater strength the mineral admixture plays vital role. These are used for various purposes, depending upon their properties. For this work we used silica fume and GGBS as mineral admixture

6. Silica Fume - Silica fume giving specific gravity 2.21 is partially replaced with cement. In this study proportion used is 8%, 10%, 12% respectively about cementatious material.

7. GGBS - Ground Granulated Blast furnace Slag (GGBS) is a byproduct from the blast furnaces used to make iron. The cement in concrete is replaced accordingly with the percentage of 20%, 30%, 40%, 50 by weight of GGBS.

8. Super plasticizer - Super plasticizers are the improved chemical admixture over plasticizer with highly effective plasticizing effect on wet concrete. Here the super plasticizer used is Master Glenium ACE 30JP.

IV. TESTS CONDUCTED ON MATERIAL

For knowing properties of material used in experimental work tests are carried out. Specific gravity and absorption test is conducted on aggregate.

Table No 1 Test Conducted on Aggregate

Sr. No.	Aggregate	Specific Gravity	Abrasion Test
1	Coarse Aggregate	2.93	1.47
2	Fine Aggregate	2.74	1.6

Table No 2 Test Conducted on Cement

Sr. No.	Test conducted on cement Brand-chettinad opc 53 grade	Result	Standard values of opc as per is : (12269-1987)
1	Initial setting time	35 min	>30
2	Final setting time	265 min	<600
3	Soundness	5mm	<10
4	Specific gravity of cement	3.15	-
5	Consistency	32%	-

A. Mix design for different mineral admixture

In this experimental work following are the trials taken for mix design of M60 grade concrete using silica fume and natural sand. For natural sand 10% replacement of silica fume is used. For artificial sand, 8%, 10%, and 12% replacement of silica fume is used by considering water binder ratio as 0.28. And again 10%, and 12% replacement of silica fume is used by considering water binder ratio as 0.3 as shown in table no3.

Following is the table no4. For M70 grade concrete using silica fume as a mineral admixture. In this work natural sand is used with 10%silica fume as water to binder ratio 0.26. For this trial quantities are shown in first column. The artificial sand is used with 10% and 12% of silica fume by considering 0.26 and 0.27 water binder ratio. The calculated quantities are shown in below.

For mix design 20%, 30%, 40%of GGBS is used. For design by using natural sand as well as artificial sand0.3 Water to binder ratio is used. Here only percentage of GGBS is changed. As shown in table no5.

There are two trials taken for M70 grade concrete using GGBS for artificial sand. Here water to binder ratio is kept constant as 0.27. And the percentage of GGBS is varying that is 40%for natural sand and 30% and 40% for artificial sand. As shown in table no6.

Table 5.1.1 Trial Mix Proportioning Using Manufactured Sand and Silica Fume.

W/B Ratio	SF (%)	SP (%)	Binder (kg/m³)	FA (kg/m³)	CA (kg/m³)	SF (kg/m³)	SP (kg/m³)
0.3	12	1.2	525.76	689.066	1202.22	63.09	6.309
	10	1.2	525.76	690.627	1204.95	52.576	6.309
	8	1.2	585	748.26	914.54	46.80	6.579
0.28	12	1.2	563.32	676.78	1180.79	67.60	6.579
	10	1.2	563.32	677.717	1182.42	56.32	6.579
	8	1.2	563.32	678.75	1184.24	45.06	6.579

Table 5.1.2: Trial Mix Proportioning Using Natural Sand and Silica Fume

W/B Ratio	SF (%)	SP (%)	Binder (kg/m³)	FA (kg/m³)	CA (kg/m³)	SF (kg/m³)	SP (kg/m³)
0.3	12	1.2	525.76	633.632	1202.22	63.09	6.309
	10	1.2	525.76	650.299	1204.95	52.576	6.309
	8	1.2	585	748.26	914.54	46.80	6.579
0.28	12	1.2	563.32	637.260	1180.79	67.60	6.579
	10	1.2	563.32	638.142	1182.42	56.32	6.579
	8	1.2	563.32	678.75	1184.24	45.06	6.579

Table 5.1.3 Trial Mix Proportioning Using Manufactured Sand and GGBS

W/B Ratio	GGBS (%)	SP (%)	Binder (kg/m³)	FA (kg/m³)	CA (kg/m³)	GGBS (kg/m³)
0.28	20	1.2	450.656	673.65	1175.34	112.664
	30	1.2	394.324	668.45	1166.25	168.996
	40	1.2	337.992	662.20	1155.35	225.33
0.3	20	1.2	525.76	697.604	1217.122	105.15
	30	1.2	525.76	680.94	1188.06	157.72
	40	1.2	525.76	655.95	1144.45	210.30
0.32	20	1.2	394.32	704.89	1229.83	98.58
	30	1.2	345.03	694.48	1211.67	147.87
	40	1.2	295.74	689.27	1202.58	197.16

Table 5.1.4 Trial Mix Proportioning Using Natural Sand and GGBS

W/B Ratio	GGBS (%)	SP (%)	Binder (kg/m³)	FA (kg/m³)	CA (kg/m³)	GGBS (kg/m³)
0.28	20	1.2	450.65	634.32	1175.3	112.66
	30	1.2	394.32	629.41	1166.2	168.99
	40	1.2	337.99	623.53	1155.3	225.33
0.3	20	1.2	420.60	647.06	1198.9	105.15
	30	1.2	368.03	642.16	1189.8	157.73
	40	1.2	315.45	636.28	1178.9	210.30
0.32	20	1.2	394.32	663.73	1229.8	98.58
	30	1.2	345.03	653.93	1211.6	147.87
	40	1.2	295.74	649.02	1202.5	197.16

VI. PERMIABILITY TESTS-

Water Permeability Test (WPT)

The WPT test is carried out according to British Standard BS/EN 12390-8:2009. Part 8 consist of depth of penetration water. The test is carried on M60 grade cube having admixture of silica fume and GGBS the results are compare with normal M60 grade concrete cube. This European Standard specifies a method for determining the depth of penetration of water under pressure in hardened concrete which has been water cured. Water is applied under pressure to the surface of hardened concrete. The specimen is then split and the depth of penetration of the waterfront is measured.

Rapid Chloride Penetration Test (RCPT)

Procedure of Test-

The test method involves obtaining a 100 mm (4 in.) diameter core or cylinder sample from the concrete being tested. A 50 mm (2 in.) specimen is cut from the sample. The side of the cylindrical specimen is coated with epoxy, and after the epoxy is dried, it is put in a vacuum chamber for 3 hours. The specimen is vacuum saturated for 1 hour and allowed to soak for 18 hours. It is then placed in the test device (see test method for schematic of device). The left-hand side (–) of the test cell is filled with a 3% NaCl solution. The right-hand side (+) of the test cell is filled with 0.3N NaOH solution. The system is then connected and a 60-volt potential is applied for 6 hours. Readings are taken every 30 minutes. At the end of 6 hours the sample is removed from the cell and the amount of coulombs passed through the Specimen is calculated. The test results are compared to the values in the chart below. This chart was originally referenced in FHWA/RD-81/119 and is also used in AASHTO T277-83 and ASTM C1202 specifications.

The classification of specimen permeability according to the charge passed through the specimen is as follows-

Table 6.1: Classification of specimen according to values of charge passed

Charge passing (coulomb)	Chloride Permeability	Typical of
>4000	High	High W/C ratio (>0.60) conventional PCC
2000 – 4000	Moderate	Moderate W/C ratio (0.40–0.50) conventional PCC
1000 – 2000	Low	Low W/C ratio (<0.40) conventional PCC
100 – 1000	Very low	Latex-modified concrete or internally-sealed concrete
<100	Negligible	Polymer-impregnated concrete, Polymer concrete

From the above table we can compare the results. The RCPT test is carried out on desired strength of concrete specimen. The changes between manufacture and natural sand after addition of silica fume and GGBS is compared.

VII. RESULTS AND DISSCUSION-

The compressive strength of M60 grade concrete having mineral admixture silica fume and GGBS for 7 days and 28 days are shown in following table.

Table 7.1.1 Compressive Strength Results for Trial Proportions Using M- Sand and SF

Sr. No.	W/B Ratio	SF (%)	Slump (mm)	Compressive strength (MPa)	
				7 days	28 days
1	0.3	12	93	39.42	58.56
		10	91	40.23	60.34
		8	78	42.17	60.31
2	0.28	12	82	42.82	64.47
		10	81	44.8	66.11 (M60)
		8	78	42.54	63.58

Table 7.1.2 Compressive Strength Results for Trial Proportions Using Natural Sand and Silica Fume

Sr. No.	W/B Ratio	SF (%)	Slump (mm)	Compressive strength (MPa)	
				7 days	28 days
1	0.3	12	96	37.61	58.35
		10	98	41.08	61.98
		8	93	42.71	61.2
2	0.28	12	88	42.67	65.26
		10	85	44.85	68.41
		8	94	42.61	64.21

Table 7.1.3 Compressive Strength Results for Trial Proportions Using M- Sand and GGBS

Sr. No.	W/B Ratio	GGBS (%)	Slump (mm)	Compressive strength (MPa)	
				7 days	28 days
1	0.28	20	90	39.21	52.41
		30	89	38.89	55.32
		40	93	40.32	53.12
2	0.3	20	85	37.65	63.62
		30	81	41.11	65.71
		40	84	39.21	62.82
3	0.32	20	83	38.23	61.30
		30	86	34.54	60.34
		40	83	36.71	62.71

Table 7.1.4 Compressive Strength Results for Trial Proportions Using Natural Sand and GGBS

Sr. No.	W/B Ratio	GGBS (%)	Slump (mm)	Compressive strength (MPa)	
				7 days	28 days
1	0.28	20	93	38.23	53.50
		30	96	34.54	56.71
		40	92	36.71	69.42
2	0.3	20	91	41.61	66.41
		30	88	43.21	67.81
		40	90	42.91	65.21
3	0.32	20	92	40.71	66.61
		30	91	39.11	63.11
		40	89	37.43	60.34

Water Penetration Test Results-

The test was carried as per BS/EN12390-2009 part 8. Standard cube of the size 150 mm x 150 mm x 150 mm were used. The cubes were exposed to continuous water pressure of 5 kg/ m^3 in an enclosed water tight apparatus for 72 hours.

The results of the water penetration test are as given below:

Table 7.3.1 Average Depth of Penetration

Sr. No.	Sample ID	Avg. Depth of penetration in mm	At pressure for 72 Hrs +/- 2Hrs
1	10%SF +NS	17.41	5 kg/ cm^2
2	30%GGBS+NS	20.18	5 kg/ cm^2
3	10%SF+MS	19.01	5 kg/ cm^2
4	30%GGBS+MS	21.08	5 kg/ cm^2

Reference Codes-

BS/EN12390-2009 part 8-Testing of hardened concrete, depth of penetration of water under pressure

Rapid Chloride Penetration test Results-

The test was carried out according to ASTM C-12202/AASHTO: T277. The average charge passed through the specimen was calculated.

Table 7.4.1 Average Charge Passed Through Specimen.

Sr. No.	Sample ID	Time T (min)	Avg. Charge Passed
1	10%SF +NS	360	1464
2	30%GGBS+NS	360	1532
3	10%SF+MS	360	1646
4	30%GGBS+MS	360	1743

CONCLUSION

The optimum replacement of silica fume and GGBS was found to be 10% and 30% by weight of cement resp.

The maximum compressive strength obtains by using natural sand and silica fume is 3.36% more than that of manufactures sand.

The maximum compressive strength obtains by using natural sand and GGBS is 3.09% more than that of manufactures sand.

Average depth of penetration is 9.1% less for 10%silica fume and natural sand than of manufacture sand.

Average depth of penetration is 4.4% less for 30%GGBS fume and natural sand than of manufacture sand.

As per ASTM C- 12202/AASHTO: T277 the chloride ion permeability is reduced by16% in case of natural sand as compare to manufactured sand

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