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Application of Blast Furnace Slag Sand in Cement Concrete–A Case Study

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Abstract

This paper highlights a case study of Granulated Blast Furnace Slag (GBFS/GBS) sand application as a partial substitute of Crushed Stone Sand (CSS) in cement concrete. Laboratory Studies were conducted for different grades of concrete viz. M30 to M70 using blend of crushed stone sand and granulated slag sand in the ratio of 50:50 of total fine aggregate in concrete. From this study it is observed that GBS sand and CSS blend could be used as alternative construction material for natural sand in cement concrete applications.

Keywords: Cement concrete; granulated blast furnace slag sand; crushed stone sand; workability; compressive strength; alternate fine aggregate;

1. Introduction

The Concrete Industry is very large consumer of natural resources like sand, gravel, crushed rock, etc as building material. Environmental restrictions of sand extraction from river beds have resulted in search for alternative sources of fine aggregate, particularly near the larger metropolitan areas. In this context we have conducted a study to check feasibility of use of GBS sand as alternate to river sand in cement concrete.

2. Objective of Work

Conduct laboratory experimental investigations for concrete from M30 to M70 grades to evaluate effect of replacing CSS fine aggregate produced cement concrete mix with Slag sand by 50% (by weight of total fine aggregate). A comparison of these mixes property was studied with reference to 100% CSS (as fine aggregate) mix. Conduct

field trial by casting of concrete slab in a construction site to assess the performance of mix in fresh as well as hardened concrete properties.

3. Material Properties

Ordinary Portland cement: 53grade confirming to specification IS: 12269-1987 used.

Pulverised Fuel Ash: Calcareous PFA conforming to IS: 3812- Part 1; 2003 is used.

Coarse aggregate: Crushed basalt rock aggregate from Ambernath quarry, Mumbai conforming to IS 383 used.

Fine aggregate: Crushed Stone Sand and Granulated Blast Furnace Slag sand with 50:50 blend conformed to Zone II grading as per IS 383:1970. The physical properties of fine aggregate such as sieve analysis, specific gravity, bulk density, water absorption were determined as per relevant Indian standards.

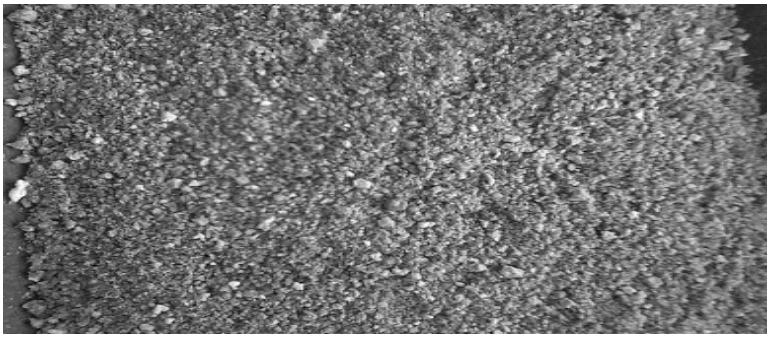
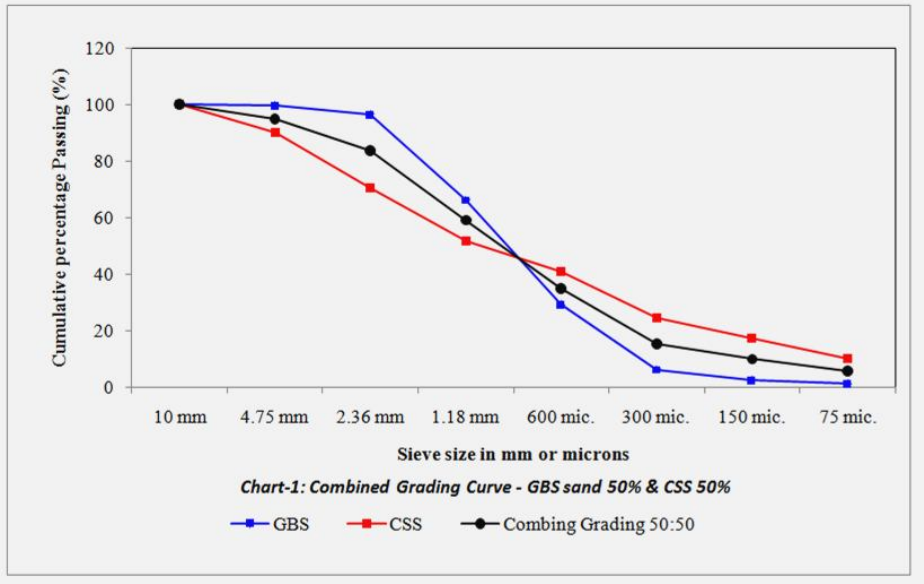


Fig. 1: GBS Sand.



Superplasticizer: Superplasticizer used complied with IS:9103-1999 and it was of sulphonated naphthalene formaldehyde base for concretes from grade M25 to M40. For concretes of grade from M50 to M70 Polycarboxylic Ether based admixture was used.

Water for mixing : Potable water conforming to requirements of IS: 456 – 2000 was used.

Table 1: Lab Trial Report – M30 to M40 Grade of concrete.

	100% CSS mixes			**50% GBS with 50% CSS mixes**		
	M30	**M35**	**M40**	**M30**	**M35**	**M40**
Binder content, kg/m3(OPC+PFA)	410	440	490	410	440	490
CA2(20mm):CA1(10 mm): CSS: GBS	36:15:49 :0	37:16: 47:0	41:14:4 5:0	34:14:26:26	36:15:25: 25	37:15:24: 24
Water/binder ratio	0.43	0.40	0.37	0.41	0.38	0.35
Initial slump (mm)	135	145	180	180	170	180
Cube compressive strength at 28day ages, MPa	38	44	49	40	48	55.5

Table 2: Lab Trial Report – M50 to M70 Grade of concrete

	100% CSS mixes			**50% GBS with 50% CSS mixes**		
	M50	**M60**	**M70**	**M50**	**M60**	**M70**
Binder content, kg/m3(OPC+PFA)	550	580	630	550	580	630
CA2(20mm):CA1(10mm):CSS: GBS	37:16:4 8: 0	38:16: 45: 0	38:16 :46: 0	36:15:25:25	33:14:27: 27	37:16:23: 23
Water/binder ratio	0.30	0.27	0.24	0.31	0.28	0.25
Slump after 90mins (mm)	140	130	130	190	210	200
Cube compressive strength at 28days age, MPa	62	74	80.5	64.5	78.5	89.5

Table 3: Comparative Properties of 100% CSS mix Vs (GBS+CSS) blended mixes

	M40 with 100% CSS	**M40 with GBS & CSS at 50:50 blend ratio**
Total binder content in kg/m3	490	490
Water to binder ratio by weight	0.37	0.35
Fine Aggregate (percent of total aggregate by weight)	45	48

Compressive strength at 28 day age in MPa (IS:516)	49	55.5
Flexural strength at 28 days in MPa (IS:516)	4.81	5.15
Split Tensile strength at 28 days in MPa (IS:5816)	4.97	4.80
Drying shrinkage percent linear at 28 days (IS: 1199)	0.028	0.020
Moisture movement percent linear at 28 days (IS: 1199)	0.005	0.004
Water permeability at 28 days in mm (DIN:1048)	16	18
Initial Surface Absorption at 28 days in ml/m2/sec (BS:1881)	0.0116	0.0121
Rapid Chloride Permeability at 28 days in coulombs (ASTM C1202M)	2190	2210
Rapid Chloride Permeability at 90days in coulomb(ASTM C1202 M)	1520	1475

Table 4: Field Trial results with GBS & CSS blended mix.

Compressive strength of M30-Pumpable concrete site sample results.						
	50% GBS & 50% CSS mix			**100% CSS mixes**		
Age:	**28days**	**56days**	**90days**	**28days**	**56days**	**90days**
Cube Compressive strength (MPa)	39.3	41.3	44	36	40	42

Due to higher glass content in GBS, concrete placement workers at site were asked to use proper safety personal protections while concrete was handled at site. Any negligence on this account was dangerous as glass particles in GBS are sharp and pose risk of causing wounds to skin.

Fig. 2: GBS& CSS blended concrete in pump hopper.

4. Conclusion

The substitution of natural aggregate with slag sand has positive impact on workability, compressive strength and durability. The GBS and CSS blended concrete laboratory trials experiment carried out and case study of actual concrete supplied at construction site shows that GBS could be used as alternative to fine aggregate for various civil engineering works with blend of CSS. As GBS has high glass content with sharp particles precautions while handling concrete have to be implemented.

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