EXPERIMENTAL INVESTIGATION ON STRENGTH BEHAVIOR OF HIGH VOLUMES OF SLAG CONCRETE AND OPC CONCRETE

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ABSTRACT:

A major challenge with concrete industry in India is to meet the demand posed by enormous infrastructure needs due to rapid industrialization and urbanization.In this paper our research work presented the study of behavior of high volume of slag concrete and OPC concrete.The influence of slag content on compressive strength of high volume of slag concrete (cement :ggbs is 50:50) with different water/binder ratios and Ordinary Portland cement with different W/c ratios are investigated. The strength of concrete is increasing with decrease in water/binder ratio. Due to slow pozzolanic reaction the high volumes of slag concrete achieves significant improvement in its mechanical properties at later ages.

Keywords: *High Volumes of Slag Concrete, Compressive Strength, Portland cement, GGBS, POZZOLANIC.*

INTRODUCTION

The use of ground granulated blast furnace slag (GGBS) to BS 66991 is a well-established means of producing durable concrete for the most demanding applications. GGBS modifies the properties of both fresh and hardened concrete and this Fact Sheet summarizes the most important effects of using GGBS in concrete. Granulated Blast-furnace Slag, consisting essentially of silicates and alumino-silicates of calcium and other bases, is formed when molten iron blast-furnace slag is rapidly chilled (quenched) by immersion in water. It is a granular product with very limited crystal formation, is highly Cementitious in nature and hydrates like Portland cement when ground to cement fineness.

In the United Kingdom, GGBS has been used in concrete from the beginning of the century. Granulated blast furnace slag was ground with Portland cement 2 clinker to produce Portland blast furnace cement. The British Standard for this cement, BS 146 3, dates from 1923. In the early 1960's dry ground granulated blast furnace slag (GGBS) was blended with Portland cement in the concrete mixer and this concept of "within-mixer blending" established GGBS as an important component of concrete. These include ready mixed and site batched concrete, precast concrete, mortar, grout and other specialized applications with the largest amount of GGBS taken by the ready mixed concrete industry. GGBS is widely used in all types of concrete including high strength, lightweight aggregate and foamed concrete. GGBS is routinely used with water-reducing, super-plasticizing and air-entraining admixtures as well as in concrete incorporating polypropylene and steel fibers. Advantages and Benefits of Using GGBSSuperior Quality Concrete, Superior Appearance, Low Environmental Impact, Better Value for Money, Chemical Composition

2. SYSTEM STUDY

As our presented system it was examined on The use of high volumes of GGBS and also demonstrates the important role of Pozzolanic admixtures are generally being used along with the cement in concrete mixes so as to derive certain benefits like economy, durability, chemical resistance in permeability etc. The use of high volumes of GGBS has become one of the current topics of research possibility promoted by the availability of a wide range of chemical and mineral admixtures. In the present experimental investigation GGBS has been used in large volumes as an additional ingredient in concrete mixes. The strength of concrete is increasing with decrease in water/binder ratio. Due to slow pozzolanic reaction the high volumes of slag concrete achieves significant improvement in its mechanical properties at later ages.

Objective of the system:

To examine the properties of concrete using GGBFS.Comparing properties of ordinary concrete to slag concrete.To study the variations in compressive strength for various w/b ratios and age.Establishing relationship between w/c ratio and compressive strength. To establish relationship between w/b ratio for high volume slag concrete. From established equations predicting compressive strength of high volume slag concrete.

GGBS

GGBS is one such cement replacing pozzolanic material. The positive effect of using GGBS in concrete are now well known which includes the following.

- Producing concrete of better rheology, higher strength and enhanced durability.
- Saving in energy requirements in the production of opc.
- Preservation of limestone and coal reserves.
- Minimizing greenhouse gas emissions associated with manufacturing of opc.
- Environment friendly and economical disposal of millions tones of GGBS.

3. EXPERIMENTAL INVESTIGATION

In the present experimental investigation GGBFS has been used in large volume as an additional ingredient in concrete mixes. The effect of replacing high volumes of GGBFS as additional material to concrete mixes on their compressive strength.

Physical Properties of GGBS

Properties	**Values**
Specific Gravity	**2.86**
Fineness – Specific surface in m2/kg by Blaine's permeability method	**420.0**
Comparative compressive strength, % , **7 days** **28 days**	 **47.0** **63.0**
Residue on 45 micron sieve,%	**5.0**
Colour	**Off – white powder**
Bulk density (loose)	**1.0–1.1 tones/m3**
Bulk density (vibrated)	**1.2–1.3 tones/m3**

Chemical properties of GGBS

Components	**Mass %**
Silica as SiO_2	20
Calcium as CaO	65
Aluminum as Al_2O_3	5-10
Magnesium as MgO	2-8

4. TESTS CONDUCTED

4.1. Mix Design

Thequantities of materials for one cubic meter of high volume slag concrete are shown in table 1. And for OPC concrete are shown in Table 2, Concrete mixes are designed as per IS: 10262-1982.And also using the data obtained from the tests on cement, ggbs, aggregates, admixture and water. The designed mix proportions for high volume slag concrete are shown in the table 2. And for OPC concrete are shown in Table 4

Table.1 Quantities of Materials Required Per 1 Cu.m of High Volumes Slag Concrete

S.No	W/Binder ratio	Water (Lts)	Cement (kg)	GGBS (kg)	Fine Aggregate (kg)	Coarse Aggregate in Kg		Admixture in Kg	Mix cost per Cum
						20MM	12MM		
1	0.55	176	160	160	772	688	459	1.28	2372
2	0.5	176	176	176	760	677	452	1.41	2489
3	0.45	176	196	196	728	676	450	1.96	2647
4	0.4	176	220	220	693	671	447	2.2	2824
5	0.36	176	244	244	659	665	444	2.68	3008
6	0.32	176	275	275	621	654	436	3.3	3245
7	0.3	176	293	293	593	652	434	3.81	3387
8	0.27	176	326	326	571	628	418	4.56	3644

Table 2 : The designed mix proportions for high volume slag concrete

Sl. No	W/B Ratio	Cement and Slag contents (opc+ggbs)	Total cementitious in kg/cum	Designed mix proportions cem : fa : ca
1	0.55	(160+160)	320	1 : 2.41 :3.58
2	0.50	(176+176)	352	1 : 2.16 : 3.21
3	0.45	(196+196)	392	1 : 1.86 : 2.87
4	0.40	(220+220)	440	1 : 1.57 : 2.54
5	0.36	(244+244)	488	1 : 1.35 : 2.27
6	0.32	(275+275)	550	1 : 1.13 : 1.98
7	0.30	(293+293)	586	1 : 1.01 : 1.85
8	0.27	(326+326)	652	1 : 0.88 : 1.6

Table 3. Workability Test Results

Cube Notation	W/binder ratio	Slump Values(mm)
HS1	0.55	75
HS2	0.5	80
HS3	0.45	65
HS4	0.4	90
HS5	0.36	100
HS6	0.32	120
HS7	0.3	130
HS8	0.27	140

Table 4. Quantities of Materials Required Per 1 Cu.m of OPC Concrete

Sl. No	W/Cement ratio	Water (Lts)	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate in Kg 20MM	Coarse Aggregate in Kg 12MM	Admixture in Kg	Mix cost per Cum
1	0.55	176	320	777	693	462	1.6	2692
2	0.50	176	352	766	682	455	1.76	2842
3	0.45	176	392	733	681	454	2.35	3039
4	0.40	176	440	699	677	451	2.64	3264
5	0.36	176	488	666	672	448	3.17	3496
6	0.32	176	550	629	662	441	3.85	3795
7	0.30	176	586	601	660	440	4.4	3974
8	0.27	176	652	580	637	425	5.22	4297

Table.5 : The designed mix proportions for OPC concrete

Sl.No	W/C Ratio	Cement contents (opc)	Total cementitious in kg/cum	Designed mix proportions cem : fa : ca : water
1	0.55	320	320	1 : 2.43 :3.61
2	0.50	352	352	1 : 2.17 : 3.23
3	0.45	392	392	1 : 1.87 : 2.9
4	0.40	440	440	1 : 1.59 : 2.56
5	0.36	488	488	1 : 1.36 : 2.30
6	0.32	550	550	1 : 1.14 : 2.01
7	0.30	586	586	1 : 1.03 : 1.88
8	0.27	652	652	1 : 0.89 : 1.63

4.2. WORKABILITY

The workability was measured using the compaction factor apparatus as per IS 1197 for various water / cement and water / binder ratios of high volume ggbs concrete. The results are tabulated in table 3.

4.3. COMPRESSIVE STRENGTH OF CONCRETE SPECIMENS

Concrete specimens of size 150mm x 150mm x 150mm and 100mm x100mm x 100mm were used to determine the compressive strength of high volume ggbs concrete and OPC concrete as per IS 516-1969. The results are tabulated in table 8 and table 9 .respectively.

Table 8 .Compressive strength of High Volumes of Slag Concrete for 28 days, 90 days & 180 days

Cube Notation	W/binder ratio	Compressive Strength (Mpa) (f_c)							
		7 Days	% increase	28 Days	% increase	90 Days	% increase	180 Days	% increase
HS1	0.55	19	65	29.09	100	35.70	123	39.26	135
HS2	0.50	21.12	69	30.60	100	37.50	123	40.52	132
HS3	0.45	23.2	68	33.90	100	40.31	119	43.51	128
HS4	0.40	25.65	69	37.30	100	44.00	118	48.11	129
HS5	0.36	28.56	68	42.00	100	51.30	122	53.40	127
HS6	0.32	32.8	73	45.00	100	53.50	119	55.50	123
HS7	0.30	34.58	72	48.00	100	56.50	118	58.50	122
HS8	0.27	39.12	72	54.00	100	62.00	115	65.10	121

Table 9 .Compressive strength of OPC Concrete for 28 days, 90 days & 180 days

Cube Notation	W/binder ratio	Compressive Strength (Mpa) (f_c)							
		7 Days	% increase	28 Days	% increase	90 Days	% increase	180 Days	% increase
OC1	0.55	23.02	72	32.18	100	33.28	103	33.98	106
OC2	0.50	24.86	74	33.46	100	34.6	103	35.20	105
OC3	0.45	28.86	80	36.12	100	37.25	103	37.86	105
OC4	0.40	30.12	75	40.28	100	41.38	103	42.0	104
OC5	0.36	33.86	77	44.82	100	45.90	102	46.60	104
OC6	0.32	40.82	85	48.12	100	49.20	102	49.80	103
OC7	0.30	42.96	86	50.12	100	51.30	102	51.76	103
OC8	0.27	48.62	86	56.82	100	58.12	102	58.60	103

5. DISCUSSION OF THE TEST RESULTS

5.1 Studies On Water/Cement Ratio And Compressive Strength Of High Volume Slag Concrete & Opc Concrete

5.1.1 Mix Design

The quantities of materials for one cubic meter of high volume slag concrete are shown in table 1. And for OPC concrete are shown in Table.4, Concrete mixes are designed as per IS: 10262-1982.And also using the data obtained from the tests on cement, ggbs, aggregates, admixture and water. The designed mix proportions for high volume slag concrete are shown in the table 2. And for OPC concrete are shown in Table 5

5.1.2 Workability

The workability of different concrete mixes was measured using slump test. The test results are given in Table 3.for high volume slag concrete and for OPC concrete are shown in Table 6. It can be seen from the tables GGBS mixes giving more workability than OPC mixes, was maintained for all the mixes by addition of suitable quantities of super plasticizer.

5.1.3 Variation of Compressive Strength

The 28 days compressive strength for GGBS mixes are given in table 8, and for OPC mixes shown in table 9 It can be seen that the strength gaining with decrease in water/binder ratio.

The 7days and 28 days strength for OPC mixes are comparatively high with GGBS mixes, but after 90 days, 180days compressive strength of GGBS mixes are very high and continuously gaining with comparative OPC mixes are given in table 8 and 9 and are represented Graphically.

Table 8 shows the percentage variation of compressive strength of high volume slag concrete at 7 days, 28 days, 90 days and 180 days. The percentage increase in compressive strength in high volume slag concrete is in between 15% to 25% for 90days. The percentage increase in compressive strength in high volume slag concrete is in between 20% to 35% for 180days.

Table 9 shows the percentage variation of compressive strength of OPC concrete at 7 days, 28 days, 90 days and 180 days. The percentage increase in compressive strength in OPC concrete is in between 2% to 3% for 90days. The percentage increase in compressive strength in high volume slag concrete is in between 3% to 6% for 180days.

6. CONCLUSION

GGBS blended concrete have been used successfully in concrete for many years in many countries throughout the world. From all the available technical literature it is suggested that there are potentially many technical benefits to be gained from using the GGBS. Where structures have to be designed for durability requirements in very aggressive environment GGBS blend mixes are recommended in standards of most developed and developing countries. Many countries have accepted the benefits and have recommended its use in their national standards. Once the user is made aware of the properties of the material and understood the benefits to be gained there is no reason why it should not continue to be used successfully and more often in existing and future project.

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