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Effect of Granulated Blast Furnace Slag (GBS) Sand on Strength and Durability of Concrete

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Abstract

In this research the strength and durability of concrete with replacement of river sand with GBS sand are studied. Parameters of GBS sand are studied to determine the optimum quantity of GBS sand that can be used as substitute for natural sand without affecting the strength of concrete. Compression test, flexural strength, split tensile test, water absorption test and Water penetration test were conducted on specimens of Grade M20, M25 and M30 with 0, 15, 30 and 50 percentages of replacement. For compression test the cube was cured for 28 days, and for durability (Water permeability test and Water absorption test) cubes were cured for 28 days. The results were obtained and compared with that of natural sand concrete. It is found that use of GBS sand will not reduce the strength of concrete.
Keywords: GBS Sand, Durability, Compressive Strength, Flexural Strength, Split Tensile Strength

I. Introduction

As per the previous data available it can be conclude that with the increasing urban development and population, demand of sustainable structures increased. Due to high demand of sustainable structures, demand of river sand increased which is one of the ingredient required for preparation of concrete. Due to erosion of rivers and other environmental problems there is a lack of river sand. The demand for sand is increasing that will increase the price of sand and leads to lack of sand. Due to unavailability of river sand, it is essential to search out the new alternative material to substitute the river sand. However, by use of the waste materials, the environmental impact may be reduced. Hence in this project GBS sand one of the industrial by product of steel industry is used. Researchers and engineers have set out with their own concepts to decrease or totally replace the employment of river sand and use recent innovations like manufactured sand (M-sand), Granulated blast furnace slag (GBS) sand, stone crusher dust, sheet glass powder etc.

II. Objectives

- Utilization of industrial waste (GBS sand) as a fine aggregates in concrete.
- To determine the mechanical properties of GBS sand such as compressive strength, flexure strength and split tensile test.
- To study the durability of concrete such as water absorption test and water permeability test.
- Cost comparison between GBS sand concrete and conventional concrete.

III. Methodology

Data required for the casting of specimens and mix designs were collected. Mix designs prepared using IS 10626-2009 and on the basis of trials final mix designs were formulated. Procured materials were tested for different properties. Cubes were casted for different grades of mix and different replacements of GBS sand and they were immersed in curing tank for 28 days. After completion of curing period cubes were removed from curing tank and were left there to dry. Compressive testing was done on these cubes to determine the compressive strength. In same manner the cubes casted for durability test were removed from the curing tank and were tested for absorption test i.e. for durability test. After testing compressive strength of natural concrete and GBS sand concrete were compared. The GBS sand procured for the experimental work shown below.

IV. Results

A. *Results for Compressive Strength Test*

Table – 1
Compressive Strength Results (M20)

Sr. No.	*Weight of cube (kg)*	*Compressive strength (MPa)*	*Average compressive strength (MPa)*
0% Replacement			
1	*8.840*	*30.26*	

2	8.750	31.46	30.20
3	8.810	28.89	
15% Replacement			
1	8.860	37.37	36.89
2	8.630	36.44	
3	8.845	36.88	
30% Replacement			
1	8.850	37.73	38.28
2	8.870	38.22	
3	8.900	38.88	
50% Replacement			
1	8.507	40.66	40.07
2	8.520	39.55	
3	8.500	40	

Table – 2
Compressive Strength Results (M25)

Sr. No.	Weight of cube (kg)	Compressive strength (MPa)	Average compressive strength (MPa)
0% Replacement			
1	8.974	36.8	36.42
2	8.990	36	
3	8.964	36.48	
15% Replacement			
1	8.973	36.88	38.36
2	8.910	40	
3	8.890	38.22	
30% Replacement			
1	8.650	42.84	40.69
2	8.634	38.97	
3	8.640	40.26	
50% Replacement			
1	8.674	53.33	47.08
2	8.536	43.82	
3	8.590	44	

Table – 3
Compressive Strength Results (M30)

Sr. No.	Weight of cube (kg)	Compressive strength (MPa)	Average compressive strength (MPa)
0% Replacement			
1	8.890	30	30.6
2	8.903	31.1	
3	8.880	29.6	
15% Replacement			
1	8.621	35.33	36.91
2	8.546	38.97	
3	8.610	36.44	
30% Replacement			
1	8.559	40.08	41.75
2	8.638	44.31	
3	8.620	40.88	
50% Replacement			
1	8.503	44.66	50.27
2	8.492	50.8	
3	8.510	55.55	

B. Flexural Strength Test

Table – 4
Flexural Strength of Beam

Sr. No.	Weight of cube (kg)	Flexural strength (MPa)	Average flexural strength (MPa)
0% Replacement			
1	40.6	4.160	4.168
2	41.6	4.176	

15% Replacement			
1	*42.8*	*4.350*	*4.323*
2	*43*	*4.296*	
30% Replacement			
1	*41.2*	*4.614*	*4.591*
2	*41.9*	*4.568*	
50% Replacement			
1	*42.6*	*4.921*	*4.908*
2	*41.6*	*4.896*	

C. *Split Tensile Strength Test*

Table – 5
Split Tensile Strength of Cylinder

Sr. No.	*Weight of cylinder (kg)*	*Split tensile strength (MPa)*	*Average split tensile strength (MPa)*
0% Replacement			
1	*13.88*	*3.640*	*3.632*
2	*14.14*	*6.624*	
15% Replacement			
1	*14.35*	*3.924*	*3.969*
2	*14.10*	*4.015*	
30% Replacement			
1	*14.50*	*4.285*	*4.219*
2	*14.26*	*4.153*	
50% Replacement			
1	*14.26*	*5.075*	*5.101*
2	*13.98*	*5.128*	

D. *Water Absorption Test*

Table – 6
Water Absorption Test Results (M20)

Grade	*Replacement Percentage*	*Specimen*	*Wet Wt. (kg)*	*Dry Wt. (kg)*	*% water Absorption*
M20	*0%*	*1*	*8.792*	*8.727*	*0.62*
		2	*8.780*	*8.730*	*0.57*
	15%	*1*	*8.870*	*8.850*	*0.22*
		2	*8.860*	*8.840*	*0.22*
	30%	*1*	*8.900*	*8.850*	*0.56*
		2	*8.890*	*8.850*	*0.45*
	50%	*1*	*8.547*	*8.537*	*0.11*
		2	*8.560*	*8.550*	*0.11*

Table – 7
Water Absorption Test Results (M25)

Grade	*Replacement Percentage*	*Specimen*	*Wet Wt. (kg)*	*Dry Wt. (kg)*	*% water Absorption*
M25	*0%*	*1*	*8.499*	*8.464*	*0.41*
		2	*8.496*	*8.454*	*0.49*
	15%	*1*	*8.972*	*8.947*	*0.27*
		2	*8.960*	*8.930*	*0.33*
	30%	*1*	*8.649*	*8.630*	*0.22*
		2	*8.680*	*8.664*	*0.18*
	50%	*1*	*9.193*	*9.173*	*0.21*
		2	*9.650*	*9.626*	*0.24*

Table – 8
Water Absorption Test Results (M30)

Grade	Replacement Percentage	Specimen	Wet Wt. (kg)	Dry Wt. (kg)	% water Absorption
M30	0%	1	8.859	8.830	0.33
		2	8.850	8.829	0.24
	15%	1	8.643	8.610	0.38
		2	8.629	8.598	0.36
	30%	1	8.698	8.660	0.44
		2	8.708	8.674	0.39
	50%	1	8.536	8.523	0.15
		2	8.528	8.515	0.15

E. Water Permeability Test

Table – 9
Water Permeability Test Results (M20)

Grade	*Replacement Percentage*	*Avg. depth of penetration (mm)*
M20	*0%*	*44*
	15%	*41*
	30%	*36*
	50%	*30*

Table – 10
Water Permeability Test Results (M25)

Grade	*Replacement Percentage*	*Avg. depth of penetration (mm)*
M25	*0%*	*38*
	15%	*35*
	30%	*32*
	50%	*30*

Table – 11
Water Permeability Test Results (M30)

Grade	*Replacement Percentage*	*Avg. depth of penetration (mm)*
M30	*0%*	*41*
	15%	*39*
	30%	*35*
	50%	*31*

F. Cost Analysis

Table – 12
100% River Sand Sample

Sr. No.	*Item*	*Quantity (Kg)*	*Cost (Rs)*	*Total cost (Rs)*
1	*Cement*	*362*	*2172*	*4064*
2	*River sand*	*871*	*810*	
3	*GBS sand*	*-*	*-*	
4	*Coarse aggregate*	*1176*	*1082*	

Table – 13
50% River Sand and 50% GBS Sand

Sr. No.	*Item*	*Quantity (Kg)*	*Cost (Rs)*	*Total cost (Rs)*
1	*Cement*	*362*	*2172*	*3890*
2	*River sand*	*435*	*405*	
3	*GBS sand*	*420*	*231*	
4	*Coarse aggregate*	*1176*	*1082*	

V. CONCLUSIONS

- Compressive strength of concrete is increased as percentage of GBS sand increased.
- Compressive strength of for M20, M25 and M30 grade of concrete with GBS sand shows the better results as compared to natural sand concrete.
- 50% replacement of river sand with GBS sand gives better results in compression.
- 50% replacement of river sand with GBS sand gives better result for flexure.
- Increase in replacement of river sand with GBS sand gives good split tensile strength.
- 50% river sand can replace by GBS sand for split tensile strength.
- Water absorption is less in case of GBS sand concrete.
- 50% replacement of river sand with GBS sand shows minimum percentage of water absorption.
- Water permeability of GBS sand concrete is less than natural sand concrete hence, GBS sand concrete is more durable than natural concrete.
- River sand can replace by GBS sand by up to 50% for M20, M25 and M30 grade of concrete.
- Cost comparison shows that the use of GBS sand concrete is economical than natural sand concrete.

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REFERENCES

[1] A. Oner and S. Akyuz, "An experimental study on optimum usage of GGBS for the compressive strength of concrete", Cement and Concrete Composites, 29, (2007), 505-514
[2] Dongsheng Shi, Qiang Liu, Xinxin Xue and Peiyuan He, "Study on the durability of concrete using granulated blast furnace slag as fine aggregate", Materials Science and Engineering, 322, (2018)
[3] Erdogan ozbay, Mustafa Erdemir and Halil Ibrahim Durmus, "Utilization of ground granulated blast furnace slag on concrete properties – A review", construction and building materials, 105, (2016), 423-434
[4] Gaurav Singh,Souvik Das, Abdullahi ahmed, Showmen Saha and Somnath Karmakar, "Study of Granulated Blast Furnace Slag as Fine Aggregates in Concrete for Sustainable infrastructure", Procedia - Social and Behavioral Sciences, 195, (2015), 2272-2279
[5] Gulden Cagin Ulubeyli and Recep Artir. "Sustainability for Blast Furnace Slag: Use of Some Construction Wastes", Procedia – Social and Behavioral Sciences, 195, (2015), 2191-2198
[6] K. Suvarna Latha, M V Seshagiri Rao and Srinivasa Reddy V, "Feasibility Studies on Granulated Blast Furnace Slag as Cement and Sand Replacement", Engineering Sciences International Research Journal, (2013)
[7] M.S. Rao and U. Bhandare "Application of Blast Furnace Slag Sand in Cement Concrete–A Case Study", International Journal of Civil Engineering Research, ISSN 2278-3652, Volume 5, (2014), pp. 453-458
[8] Patel Hardik, Vinubhai, Nihil Sorathia and Amol D. Pund, "Effect of Partial Replacement of River Sand by GBS Sand and Crushed Sand on Strength Characteristics of Concrete", International Journal for Scientific Research & Development, Vol. 6, Issue 02, 2018
[9] Rakesh Kumar Patra and Bibhuti Bhusan Mukharjee, "Influence of Incorporation of Granulated Blast Furnace Slag as Replacement of Fine Aggregate on Properties of Concrete", Cleaner production, (2017)
[10] Rakesh Kumar Patra and Bibhuti Bhusan Mukharjee, "Strength and durability properties of concrete incorporating granulated blast furnace slag", International Journal of Innovations in Engineering, Research and Technology, ISSN:2394-3696, 2016
[11] Sarvesh Pratap Singh Rajput, Mrityunjay Singh Chouhan and Kamlesh Kumar Ahirwa, "Evaluation of Blast Furnace Slag as Alternative of Natural Sand in Cement Concrete and Cement Mortar", Vol. 5, Issue 9, September 2016
[12] Sunil N Manjunath, P V Sivapullaiah and M Prasanna Kumar, Implication of partial replacement of cement with fa and sand by gbs on setting time and workability of mortar", International Journal of Research in Engineering and Technology, ISSN: 2319-1163
[13] Sumana K.K., Sreeja P.P., Aswathy M., Indu M. and Dr. Jino John, "Replacement of fine aggregates by Granulated Blast Furnace Slag (GBFS) in cement mortar", International journal of Engineering Research &Technology, ISSN: 2278-0181, VOL.5, Issue 03, March-2016
[14] IS 10262-2009 - guideline for concrete mix design
[15] IS 383 (1970) - specification for coarse and fine aggregates
[16] M. S. shetty, "concrete technology: theory and practice" 2000