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AN EXPERIMENTAL STUDY ON PROPERTIES OF TERNARY BLENDED CONCRETE USING GGBS AND MARBLE POWDER

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Abstract*— Ground granulated blast furnace slag (GGBS) is a by-product obtained from the blast furnaces used in the iron manufacturing industry. The disposal of the marble powder obtained from marble industry constitutes one of the environmental problems around the world. One of the possible solutions for the effective use of GGBS and marble powder is to partially replace cement in concrete. This paper presents the results of an experimental study on concrete in which the cement is partially replaced by both GGBS and marble powder. In this study, different percentages of GGBS and marble powder are used for partial replacement of cement by 30%. Tests conducted includes workability of fresh concrete (Slump test), strength of hardened concrete (Compressive strength, Split tensile strength and Flexural strength) and durability properties of concrete (Chloride resistance and Sulphate resistance).

***Keywords*— GGBS, Marble powder, Compressive strength, Split tensile strength, Flexural strength, Durability**

I. INTRODUCTION

The scarcity of natural raw materials, depleting energy resources, problems of disposal of waste materials and global warming due to emissions of green house gases are the long-term results of rapid industrialization. Every industry tries its best to minimize these global problems. As far as construction industry is concerned, it is important to reduce the content of cement in concrete. One of the efficient methods to reduce the cement content in concrete is to replace cement by some other industrial by-products. The use of the replacement materials offer cost reduction, energy savings, arguably superior products, and fewer hazards in the environment.

Ground granulated blast furnace slag (GGBS) is a by-product from the blast furnaces used in the iron manufacturing industry. GGBS is obtained by quenching molten iron slag (a by-product of iron and steel-making) in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. Marble has been commonly used as a building material since the ancient times. The industry's disposal of the marble powder material constitutes one of the environmental problems around the world. Marble blocks are cut into smaller blocks in order to give them the desired smooth shape. During the cutting process about 25% the original mass is lost in the form of dust. Marble dust is settled by sedimentation and then dumped away which results in environmental pollution. In this study, ternary blend cement system is used where cement is replaced by two different mineral admixtures- GGBS and marble powder. As GGBS and marble powder are available at cheap cost, it seems to be very suitable for Indian construction industry.

II. EXPERIMENTAL INVESTIGATION

In this experimental work, cubes, beams and cylinders were casted. The standard size of cube 150 mm, cylinder 150 mm diameter and 300 mm height and beam of 100 mm x100 mm x500mm were used. The mix design of M30 grade concrete was done according to IS 10262.All materials were batched separately by weight. The ingredients of concrete were mixed thoroughly in mixer machine till the uniform consistency was obtained. Concrete was poured into the mould, compacted and the top surface was finished by means of a trowel. The specimens were removed from the mould after 24 hours and water curing was done for a period of 28 and 56 days. The specimens were taken out from the curing tank just before the test. The tests were conducted as per the relevant Indian standard specifications.

A. Material Details

The materials used in the investigation are:

1) *Cement: 53 grade Ordinary Portland cement with standard consistency 32% and initial setting time 40 minutes was used.*

2) *Fine Aggregate: Manufactured Sand (M-Sand) which is washed and sieved rock powder has been used as fine aggregate in the present study. It confirms to Zone II of IS 383 with a specific gravity 2.62 and fineness modulus 2.93.*
3) *Coarse Aggregates: Coarse aggregates of 20 mm and 12 mm sizes were used. The specific gravity of aggregate is 2.67 and fineness modulus is 2.66.*
4) *Water: Water available in the campus conforming to the requirements of water for concreting and curing as per IS:456-2009.*
5) *Super plasticizer: The superplasticizer used in this study was Master Glenium Sky 8233. It is a high range water reducing, superplasticizer based on polycarboxylic ether formulation. The product shall have specific gravity of 1.08. It shall comply with IS: 9103 and shall be of type F when tested to ASTM C-494.*
6) *GGBS: In this study, GGBS was collected from JSW cements. The specific gravity of GGBS sample was 3.44.*
7) *Marble Powder: Marble powder obtained from Asttra Chemicals, Chennai was used for the present investigation. The specific gravity of the marble powder sample was 2.5.Table 1 shows the chemical composition of GGBS and marble powder.*

TABLE 1: CHEMICAL COMPOSITION OF GGBS AND MARBLE POWDER

COMPONENT	GGBS MASS %	MARBLE POWDER MASS %
SIO2	37.73	11.38
AL2O3	14.42	0.23
CAO	37.34	45.18
FE2O3	1.11	0.09
MGO	8.71	0.20
SO3	0.008	0.008

TABLE 2: MIX PROPORTION OF M30 CONCRETE

MIX DESIGNATION	**NC**	**TM1**	**TM2**	**TM3**	**TM4**
MARBLE POWDER %	0	5	7.5	10	12.5
GGBS %	0	25	22.5	20	17.5
CEMENT (KG/M^3)	388	272	272	272	272
MARBLE POWDER (KG/M^3)	0	19	29	39	49
GGBS (KG/M^3)	0	97	87	77	67
FINE AGGREGATE (KG/M^3)	670	670	670	670	670
COARSE AGGREGATE (KG/M^3)	1200	1200	1200	1200	1200
WATER (KG/M^3)	167	167	167	167	167
SUPERPLASTICIZER (KG/M^3)	1.3	1.3	1.3	1.3	1.3

B. Tests on Concrete

1) *Slump Test: Workability of fresh concrete was measured using slump test. Slump test was conducted as per IS 516:1959.*
2) *Compressive Strength Test: Compressive strength test was conducted on cube of size 150 mm as per IS 516:1959.The test was done after 28 and 56 days of water curing.*
3) *Split Tensile Strength Test: Split tensile strength test was conducted on cylinders of size 150 mm diameter and 300 mm height. The test was done after 28 days of water curing as per IS 5816:1999.*
4) *Flexural Strength Test: Flexural test was conducted as per IS 516:1959 .The test was conducted on beams of size 100 mm x 100 mm x 500 mm after 28 days of water curing.*
5) *Sulphate Attack: Cube specimens of size 150mm were cast and after 7 days of water curing were taken out and dried in air and then kept immersed in $MgSO_4$ solution for a period of 28 and 56 days. The concentration of $MgSO_4$ solution used is 20 g/lit. Compressive strengths of modified concrete mixes were compared with that of control mix.*
6) *Chloride attack: Cube specimens of size 150mm were cast and after 7 days of water curing were taken out and dried in air and then kept immersed in NaCl solution for a period of 28 and 56 days. The concentration of NaCl solution used is 100 g/lit. Compressive strengths of modified concrete mixes were compared with that of control mix.*

III. RESULTS AND DISCUSSIONS

The strength results obtained from the experimental study are shown in the following tables.

TABLE 3: RESULTS OF SLUMP TEST

MIX DESIGNATION	GGBS %	MARBLE POWDER %	SLUMP (MM)
NC	0	0	150

TM1	25	5	155
TM2	22.5	7.5	135
TM3	20	10	120
TM4	17.5	12.5	110

TABLE 4: COMPRESSIVE STRENGTH TEST RESULTS

MIX DESIGNATION	GGBS %	MARBLE POWDER %	CUBE COMPRESSIVE STRENGTH IN N/MM^2	
			28 DAYS	56 DAYS
NC	0	0	39.80	40.81
TM1	25	5	37.43	39.33
TM2	22.5	7.5	38.21	40.11
TM3	20	10	39.15	42.50
TM4	17.5	12.5	36.92	38.17

TABLE 5: SPLIT TENSILE STRENGTH TEST RESULTS

MIX DESIGNATION	GGBS %	MARBLE POWDER %	SPLIT TENSILE STRENGTH IN N/MM2
NC	0	0	2.83
TM1	25	5	2.74
TM2	22.5	7.5	3.09
TM3	20	10	3.21
TM4	17.5	12.5	2.55

TABLE 6: FLEXURAL STRENGTH TEST RESULTS

MIX DESIGNATION	GGBS %	MARBLE POWDER %	FLEXURAL STRENGTH IN N/MM^2
NC	0	0	5.3
TM1	25	5	5.22
TM2	22.5	7.5	5.62
TM3	20	10	5.86
TM4	17.5	12.5	4.93

TABLE 7: COMPRESSIVE STRENGTH AFTER 28 AND 56 DAYS IN MGSO4 SOLUTION

MIX DESIGNATION	GGBS %	MARBLE POWDER %	COMPRESSIVE STRENGTH AFTER 28 DAYS IN MGSO4 SOLUTION	COMPRESSIVE STRENGTH AFTER 56 DAYS IN MGSO4 SOLUTION
NC	0	0	32.78	35.2
TM1	25	5	34.31	37.92
TM2	22.5	7.5	35.43	38.72
TM3	20	10	37.85	40.94
TM4	17.5	12.5	33.41	35.82

TABLE 8 : COMPRESSIVE STRENGTH AFTER 28 AND 56 DAYS IN NACL SOLUTION

MIX DESIGNATION	GGBS %	MARBLE POWDER %	COMPRESSIVE STRENGTH AFTER 28 DAYS IN NACL SOLUTION	COMPRESSIVE STRENGTH AFTER 56 DAYS IN NACL SOLUTION
NC	0	0	36.21	37.3
TM1	25	5	34.48	38.12
TM2	22.5	7.5	36.73	39.45
TM3	20	10	37.81	41.94
TM4	17.5	12.5	33.57	37.92

IV. CONCLUSIONS

The following results were obtained from the experimental study on the ternary blended concrete.

1) *Improved workability was shown for the mix with higher percentage of GGBS (ie. mix in which cement is replaced with 25% GGBS and 5% marble powder).Workability reduced for all other mixes as the GGBS content was decreased and the marble powder was increased.*
2) *At 28 days, compressive strength almost equal to that of control mix was obtained for the mix with cement partially replaced by 20% GGBS and 10% marble powder. For all the other mixes, it was found that the compressive strength was slightly less than that of control mix.*
3) *At 56 days, compressive strength of the mix with cement partially replaced by 20% GGBS and 10% marble powder was found to be greater than that of control mix.*
4) *Split tensile strength of TM2 (replacement of cement by 22.5% GGBS and 7.5% marble powder)and TM3 (replacement of cement by 20% GGBS and 10% marble powder)were found to be greater than that of the control mix.*
5) *The above said mixes (TM2 and TM3) shown higher flexural strength when compared to that of control mix.*
6) *It was found that durability increases with increase in marble powder content upto 10%.The percentage reduction in strength due to sulphate and chloride attack for the mix with partial cement replacement by 20% GGBS and 10% marble powder were found to be less than that of all other mixes including the control mix.*
7) *Considering all the tests, the optimum percentage of replacement of cement by GGBS and marble powder was obtained as 20% for GGBS and 10% for marble powder.*

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