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A STUDY ON BEHAVIOR OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH WASTE MARBLE POWDER AND FLYASH

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Abstract - *In the present investigation, a prospect is made to use Waste Marble Powder (WMP) and Fly ash as Partial Replacement with Cement in Concrete, and an attempt has been made to investigate the strength parameters of concrete and Workability. For control concrete, IS method of mix design is adopted and considering this a basis, mix design for replacement method has been made. Five different replacement levels namely 4%, 8%, 12%, 16% & 20% of WMP and 20% of Fly ash are chosen for the study concern to replacement method. Large range of curing periods starting from 7 days, 14 days & 28 days are considered in the present study.*

In this study, effect of Waste Marble Powder (WMP) as Partial Replacement with Cement in Concrete has been investigated with casting of a total of 162 specimens. The specimens have been prepared of the Mix-Design M- 30 Grade concrete based on IS 10262: 2009. All specimens were of the dimension of 150 mm x 150 mm x 150 mm for cubes, 150mm dia. and 300mm length for cylinders and 100mm x 100mm x 500mm for beams tested at three different ages 7 days, 14 days and 28 days.

Key Words: Cement, Waste Marble Powder, Fly Ash, Compressive Strength, Split-tensile Strength, Flexural Strength, Workability.

1. INTRODUCTION

Rajasthan is famous for its marble deposits. There are around 4000 marble mines and about 1100 marble cutters in medium sector spread over the 16 districts of Rajasthan. Marble is generally a white based elegant looking stone, geologically a thermally metamorphosed rock belonging mainly to pre-cambrian rock formations of Rajasthan. Marble slurry is generated as a by-product during cutting of marble. The waste is approximately in the range of 20% of the total marble handled. The amount of marble slurry generated in Rajasthan every year is very substantial being in the range of 5-6 million tones. The marble cutting industries are dumping the marble slurry in any nearby pit or vacant spaces, near their unit although notified areas have been marked for dumping. This leads to serious environmental and dust pollution and occupation of vast area of land especially after the slurry dries up. This also contaminates the underground water reserves. Traditionally, WMP products are disposed of as land fill. However, there might be reusing or recycling alternatives that should be investigated and eventually implemented. Now days numerous uses of waste marble powder have been introduced, including use in tiles manufacturing, concrete mixes, sub-grade fill, and modified binder. The waste marble powder can be used in many building materials such as hollow bricks, solid bricks, cement concrete flooring tiles and pavement blocks. This waste product has provided a specific effect on the properties of fresh and hardened concrete. The use of waste product in concrete while replacing cement not only makes it economical, but also helps in reducing disposal problems. The main objective of the present work is to investigate the usability of the marble powder and fly ash as partial replacement of cement in concrete. Effect of waste marble powder in concrete has been investigated by experimental tests on conventional concrete without marble powder and with varying quantities of marble powder by replacing the cement partially.

2. MATERIALS USED

2.1 Marble Powder

In the present work marble slurry was taken from the industrial site situated in Kishangarh in Ajmer district. Specific gravity of marble dust powder is 2.64 and water absorption is 0.97%. It was sieved by IS-90 micron sieve before mixing in concrete. The Chemical and physical properties is given in Table 1.

Table -1: Marble slurry specifications used

Properties	Chemical Properties		Percentage
Chemical Properties	Calcium Oxide	CaO	28.19
	Silica	SiO2	3.71
	Iron	Fe2O3	0.40
	Alumina	Al2O3	1.05
	Magnesium Oxide	MgO	14.70
	Loss on Ignition	L.O.I.	33.70
Physical Properties	Moisture Content (%)	5.0	
	Specific gravity	2.64	

2.2 Fly ash

Owing to its pozzolanic properties, fly ash is used as a replacement of cement as 20% of the cement content is replaced by fly ash in every case. As pozzolan greatly improves the strength and durability of concrete, the use of ash is a key factor in their preservation.

Table-2: Fly ash specification used

Properties			Percentage
Chemical Properties	Calcium Oxide	CaO	6.90
	Silica	SiO2	55.3
	Iron	Fe2O3	3.20
	Alumina	Al2O3	18.52
	Loss on Ignition	L.O.I.	1.02

2.3 Cement

43 grade of ordinary Portland cement (IS 8112-2000) was used in present experimentation of Nirmax cement. Physical and chemical properties provided by the manufacturer are given in table 4 and 5.

Table-3: Physical properties of procured OPC

Particulars	Test Results
Specific Gravity	3.15
Fineness (m2/kg)	225
Normal Consistency	33%
Setting Time (Minutes): Initial Final	 30 min 600 (Max.)
Soundness Le Chatelier Expansion Autoclave Expansion	 10 0.8
Compressive Strength (Mpa) 72 + 1 hr. (3 days) 168 + 2 hr. (7 days) 672 + 4 hr. (28 days)	 23 33 43

Table-4: Chemicals properties of procured OPC

Particulars	Requirements of IS: 1489-1991
Total Loss on Ignition (% by mass)	Not more than 5.0
Magnesia (% by mass)	Not more than 6.0
Sulphuric anhydride(% by mass)	Not more than 2.5 and 3.0 when C3A percent by mass is 5 or less and greater than 5 respectively
Insoluble residue (% by mass)	Not more than 5.0
Chloride (%)	Not more than 0.05
Lime saturation factor (ratio of %)	Not greater than 1.02 and not less than 0.66
Alumina to iron oxide (ratio of %)	Not less than 0.66

2.4 Aggregates

Aggregates are important constituent of concrete mix. They play a major role in influencing both the properties of fresh and hardened concrete.

Fine aggregate

Fine aggregate was purchased which satisfied the required properties of fine aggregate required for experimental work and the sand conforming to grading Zone I of Table 4 of IS 383:1970. The specific gravity is 2.74 and fineness modulus is 2.74.

Coarse aggregate

Crushed gravel of 20 mm & 10 mm maximum size has been used as coarse aggregate. The sieve analysis of combined aggregates confirms to the specifications of IS 383: 1970 for graded aggregates. The specific gravity is 2.74 and fineness modulus is 6.9.

2.5 Super plasticizer

In this study Master Glenium Sky 8233 super plasticizer was used to reduce water cement ratio for the concrete mixes prepared. Master Glenium SKY 8233 is an admixture based on modified poly-carboxylic ether. The product is used for applications in high performance concrete where high durability is required.

2.6 Water

In this study clean potable water available in concrete laboratory of Poornima University was used for preparation and curing of concrete mixes.

3. METHOD

Based on the Indian Standard (IS: 10262 – 1982), design mix for M30 grade of concrete was prepared by partially replacing cement with six different percentages by weight of marble powder (0%, 4%, 8%, 12%, 16% and 20%,) and a fix 20% replacement of cement by fly ash was done and 150x150x150 mm concrete cubes, 150 mm dia. and 300 mm length cylinders and 100x100x500 mm beams were casted. Total 162 specimens were prepared with 54 specimens of each. Each batch of concrete was tested for workability after mixing, using slump cone test. After 24 hrs the specimens were removed from the mould subjected to water curing for 7, 14 and 28 days. After curing, the specimens were tested for compressive strength for cubes, split tensile strength for cylinders and flexural strength for beams using a calibrated compression testing machine, universal testing machine and flexural testing machine.

Table-5: Mix proportioning for concrete mix for cubes

Mix proportioning of constituent Materials						
Constituent Materials	@ 0 % WMP	@ 4 % WMP	@ 8 % WMP	@ 12 % WMP	@ 16 % WMP	@ 20 % WMP
Cement	0.8912 Kg	0.8555 Kg	0.8199 Kg	0.7842 Kg	0.7486 Kg	0.7129 Kg

20 % fly ash	0.228 Kg	0.228 Kg	0.228 Kg	0.228 Kg	0.228 Kg	0.228 Kg
Water	0.5 ltr	0.5 ltr	0.5 ltr	0.5 ltr	0.5 ltr	0.5 ltr
Super-plasticizer	20 ml	20 ml	20 ml	20 ml	20 ml	20 ml
Coarse Aggregate	4.19 Kg	4.19 Kg	4.19 Kg	4.19 Kg	4.19 Kg	4.19 Kg
20 mm	2.51 Kg	2.51 Kg	2.51 Kg	2.51 Kg	2.51 Kg	2.51 Kg
10 mm	1.68 Kg	1.68 Kg	1.68 Kg	1.68 Kg	1.68 Kg	1.68 Kg
Fine Aggregate	2.67 Kg	2.67 Kg	2.67 Kg	2.67 Kg	2.67 Kg	2.67 Kg
WMP content	0	36 g	72 g	107 g	143 g	179 g

Table-6: Mix proportioning for concrete mix for cylinders

Mix proportioning of constituent Materials						
Constituent Materials	@ 0 % WMP	@ 4 % WMP	@ 8 % WMP	@ 12 % WMP	@ 16 % WMP	@ 20 % WMP
Cement	1.4 Kg	1.34 Kg	1.29 Kg	1.23 Kg	1.18 Kg	1.12 Kg
20 % fly ash	0.35 Kg	0.35 Kg	0.35 Kg	0.35 Kg	0.35 Kg	0.35 Kg
Water	0.78 ltr	0.78 ltr	0.78 ltr	0.78 ltr	0.78 ltr	0.78 ltr
Super-plasticizer	35 ml	35 ml	35 ml	35 ml	35 ml	35 ml
Coarse Aggregate	6.57 Kg	6.57 Kg	6.57 Kg	6.57 Kg	6.57 Kg	6.57 Kg
20 mm	3.94 Kg	3.94 Kg	3.94 Kg	3.94 Kg	3.94 Kg	3.94 Kg
10 mm	2.63 Kg	2.63 Kg	2.63 Kg	2.63 Kg	2.63 Kg	2.63 Kg
Fine Aggregate	4.20 Kg	4.20 Kg	4.20 Kg	4.20 Kg	4.20 Kg	4.20 Kg
WMP content	0	56 g	112 g	168 g	224 g	280 g

Table-7: Mix proportioning for concrete mix for beams

Mix proportioning of constituent Materials						
Constituent Materials	@ 0 % WMP	@ 4 % WMP	@ 8 % WMP	@ 12 % WMP	@ 16 % WMP	@ 20 % WMP
Cement	1.32 Kg	1.27 Kg	1.21 Kg	1.16 Kg	1.11 Kg	1.06 Kg
20 % fly ash	0.33 Kg	0.33 Kg	0.33 Kg	0.33 Kg	0.33 Kg	0.33 Kg
Water	0.74 ltr	0.74 ltr	0.74 ltr	0.74 ltr	0.74 ltr	0.74 ltr
Super-plasticizer	33 ml	33 ml	33 ml	33 ml	33 ml	33 ml
Coarse Aggregate	6.2 Kg	6.2 Kg	6.2 Kg	6.2 Kg	6.2 Kg	6.2 Kg
20 mm	3.72 Kg	3.72 Kg	3.72 Kg	3.72 Kg	3.72 Kg	3.72 Kg
10 mm	2.48 Kg	2.48 Kg	2.48 Kg	2.48 Kg	2.48 Kg	2.48 Kg
Fine Aggregate	3.96 Kg	3.96 Kg	3.96 Kg	3.96 Kg	3.96 Kg	3.96 Kg
WMP content	0	53 g	106 g	159 g	211 g	264 g

4. TEST RESULTS

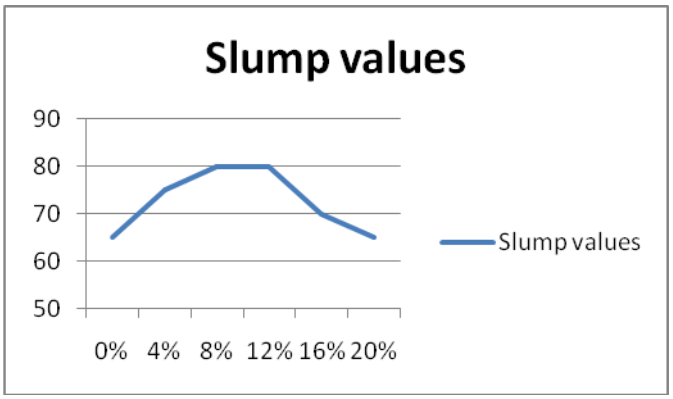
Fresh concrete

Each batch of concrete was tested for consistency after mixing, using slump cone test. After mixing the concrete properly, workability of concrete is determined by slump cone apparatus. The following table-8 shows the slump values for different grades of concrete for various proportions of waste marble powder and represented in Graph-1.

Table-8: Slump of Concrete w.r.t. WMP Percentage

WMP%	Compaction factor (mm)
0%	65
4%	75
8%	80
12%	80
16%	70
20%	65

Figure-1: Slump values of Concrete w.r.t. WMP Percentage



It is observed that as the WMP content in concrete increases Slump values of concrete decreases accordingly hence the workability decreases. So concrete with 0% WMP has high workability and concrete with 20% WMP has lowest workability.

Hardened concrete

A series of test was carried out on the concrete to obtain the strength characteristics of concrete with and without waste marble powder as binder, which is a replacement for cement in various percentages.

Table-9: Compressive strength of cubes

% WMP	% Fly ash	7 Days Compressive Strength		14 Days Compressive Strength		28 Days Compressive Strength		% Increase in Strength from 7 to 28 Days
		Strength (N/mm²)	% Change w.r.t control mix	Strength (N/mm²)	% Change w.r.t control mix	Strength (N/mm²)	% Change w.r.t control mix	
0%	20%	21.38		31.11		32.89		53.84
4%		23.11	8.09	33.78	8.58	35.56	8.12	53.87
8%		23.98	12.16	35.56	14.30	36.89	12.16	53.84
12%		25.42	18.90	37.78	21.44	39.11	18.91	53.86
16%		26	21.61	39.11	25.72	40	21.62	53.85
20%		26.29	22.97	38.67	24.30	40.44	22.96	53.82

Table-10: Split tensile strength of cylinders

%WMP	% Fly ash	7 Days Split tensile Strength		14 Days Split tensile Strength		28 Days Split tensile Strength		% Increase in Strength from 7 to 28 Days
		Strength (N/mm²)	% Change w.r.t control mix	Strength (N/mm²)	% Change w.r.t control mix	Strength (N/mm²)	% Change w.r.t control mix	
0%	20% %	2.5		3.1		3.4		36
4%		2.6	4	3.12	0.65	3.54	4.12	36.15
8%		2.64	5.6	3.3	6.45	3.68	8.24	39.39
12%		2.64	5.6	3.4	9.68	3.68	8.24	39.39
16%		2.82	12.8	3.68	18.71	3.96	16.47	40.43
20%		2.82	12.8	3.53	13.87	3.96	16.47	40.43

Table-10: Flexural strength of beams

% WMP	% Flyash	7 Days Flexural Strength		14 Days Flexural Strength		28 Days Flexural Strength		% Increase in Strength from 7 to 28 Days
		Flexural Strength	% Increased wrt control mix	Flexural Strength	% Increased wrt control mix	Flexural Strength	% Increased wrt control mix	
0%	20 %	2.88		3.61		3.85		33.68
4%		3.29	14.24	3.86	6.93	4.01	4.16	21.88
8%		3.43	19.10	3.92	8.59	4.04	4.94	17.78
12%		3.48	20.83	3.90	8.03	4.18	8.57	20.11
16%		3.41	18.40	3.83	6.1	4.10	6.49	20.23
20%		3.22	11.81	3.62	0.28	4.00	3.90	24.22

3. CONCLUSIONS

1) From the study it was observed that compressive strength gets increased as we increase the percentage of WMP after 7, 14 & 28 days. It was also observed that optimum percentage increment in compressive strength of concrete was 53.87% for 7 to 28 days of curing.

2) Further it was observed that split tensile strength also increases when percentage of WMP in concrete was increased after 7, 14 & 28 days curing. The optimum percentage increment in split tensile strength was 40.43% for 7 to 28 days curing.

3) It was also noted that flexural strength of concrete increases gradually with addition of WMP and minimum flexural strength was obtained at 0% (3.85 N/mm2). 4.18 N/mm2 optimum flexural strength was obtained with addition of 12% WMP after 28 days of curing.

4) All these tests also indicate that the waste marble powder can be successfully utilized as partial replacement of cement in concrete production. Their use in concrete will alleviate the problem of their disposal and environmental pollution.

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