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Experimental Study of Mechanical & Durability Properties of M30 Grade of Marble Powder Based Concrete

Vatsal N Patel[1], Arshdeep Singh[2], Parth Gheewala[3], Tirth N Thakkar[4], Dhairya Bhatt[5]

[1]A.D Patel Institute of Technology, New V V Nagar, India
[2]A.D Patel Institute of Technology, New V V Nagar, India
[3]A.D Patel Institute of Technology, New V V Nagar, India
[4]A.D Patel Institute of Technology, New V V Nagar, India
[5]A.D Patel Institute of Technology, New V VNagar, India

Abstract

The study is carries out to check the M30 grade concrete performance by replacing cement with 4%, 8% and 12% with marble powder. Different tests to check Mechanical Properties like Compressive Strength, Split Tensile Strength and Flexural Strength were performed. Also To check the Durability Aspects Different Tests like Sulphate Attack, Acid Attack and Carbonation Test were performed. Results show that at 8% optimum replacement of marble powder mechanical and durability properties are coming better in comparison with control and other replacement levels of marble powder.

Keywords: *Marble Powder, Durability, Carbonation, Slphate Attack, Acid Attack.*

1. Introduction

Concrete comes on the second place in terms of usage of things after water. Based on many surveys conducted, concrete needs to get more strength and durability in order to withstand more life span to any structure. In order to attain a strong structure concrete must be of high quality so that its performance can be better in all stages. In this study admixture will be used to improve the properties of concrete and to increase strength and durability. Many structures needs high strength and durability for have a better life span where marble powder will help to customize the usual properties of concrete. By changing the concrete mix design and adding admixture it will improve the mechanical and durability which will help every structure to perform well in every aspect or against nature's act. As for instance many times the structure has been experienced a lag in durability like acid rain or else. To with stand this many problem regarding strength or resistance to factors affecting durability these tests will perform. Tests performed will give us the scenario regarding changes accepted by concrete for improving its own strength and durability. Marble Powder admixture which is been selected has a good availability and is economic in rates which is helpful to engineer to make it use in types of construction.

2. Materials and Properties

2.1 Cement

The cement used in this experimental work is Coromandel King Cement of 53 grade ordinary Portland cement with physical properties as shown in Table1. The specific gravity of cement is 3.15, having standard consistency of 28 %. All properties has been tested by the reference of IS 12269-1987.

Table 1: Physical Properties of Cement

Property	Value	IS Code Specification (8112-1989)
Specific Gravity	3.15	3.10-3.15
Consistency	28%	30-35
Initial setting time	35 minutes	30 minutes
Final setting time	178 minutes	600 minutes
Compressive strength at 7 days N/mm2	38.4	43
Compressive strength at 28 days N/mm2	52.31	53

2.2 Fine Aggregates

Sand passed through of 4.75mm sieve is used which was available locally. The specific gravity of sand is 2.60 and fineness of modulus 2.84 is used with water absorption rate of 1.23%.

2.3 Coarse Aggregate

The coarse aggregate with the size of 15mm to 20mm are used with specific gravity of 2.88.

2.4 Water

Portable water is used which is free from any acid, organic or inorganic compounds. Portable water is being used for mixing and for purpose of curing.

2.5 Marble Powder

Marble is a double carbonate rock with composition of calcium and magnesium and it exhibits a granular structure. It has high natural whiteness and it's noted for their ease of dispersion. Its use improves properties such as weather ability, reduces shrinkage, fissure development and water absorption. This is harder and denser than the calcite form of calcium carbonate or limestone. The whiteness of this grade is up to 98%. Marble powder is obtained as a by-product of marble sawing and shaping which is characterized from a physical and chemical point of view in order to use into concretes and mortars. Marble powder shows a very high blaine fineness value of about 1500m^2/kg, with finer particles about 90%. The properties of Marble powder are shown in Table 2.

Table 2: Properties of Marble Powder

Charactertics	Proportion
Sio_2	1.28 %
CaO	30.80 %
Mgo	20.10 %
Fe_2o_3	0.68 %
Al_2O_3	0.39 %
L.O.I	46.30 %
Brightness	83 %
$CaCo_3$	55%
BD	1087 gm/cc
Acid Insoluble	1.43 %
$MgCo_3$	42.21 %
Water Absorption	9.90 ml/100gm
pH Value	7.40

3. Experimental Work

3.1 Mix Proportion

Mass of Cement kg/m3	Mass of water kg/m3	Mass of fine aggregate kg/m3	Mass of coarse aggregate kg/m3	Water cement ratio
380	160	711	1283	0.42

3.2 Casting and Curing

Casting was done by replacing cement with marble powder 4%, 8% and 12%. Casting was done according to IS: 516 for mixing, mixed material was taken and filled into cubes, beams and cylinders for different testing. Specimens were taken out after 24 hours and put for curing for durations of 7, 28, 56 days.

4.Testing

Tests were performed to check mechanical and durability aspects of concrete at age of 7, 28, and 56 days of curing.

4.1 Mechanical Properties

4.1.1 Compression test

Compression test was carried out on cubes of size 150mm×150mm×150mm of M30 grade Concrete having cement replacement with marble powder at 4%, % and 12% and on control mix. Each category of three cubes were tested on compression test machine and failure load was noted down with the average value of three cube obtained. Table 2 shows results of compression test.

Table 3: Compressive strength results

Casting Duration	Control Specimens	Proportion of Admixture in specimens		
		4%	8%	12%
7 days	16.1	12.2	18.05	15.3
28 days	33.80	34.53	35.25	32.95
56 days	53.75	56.4	60	50.7

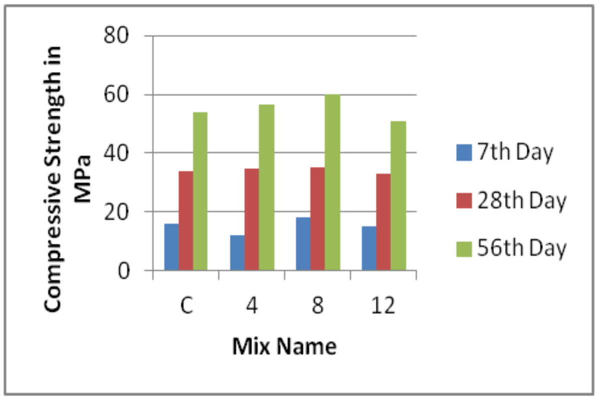

Figure 1.Compression Test

4.1.2 Flexural test

Flexural test was performed on beams on universal testing machine according to IS: 516-1959. Failure load to each beam was noted for finding flexural strength. Table 3 shows the results on flexural testing.

Table 4: Flexural Strength results

Casting Duration	Control Specimens	Proportion of Admixture in specimens		
		4%	8%	12%
7 days	3.19	3.96	5.17	3.67
28 days	3.15	3.5	5.19	4.3
56 days	3.61	3.60	5.11	4.97

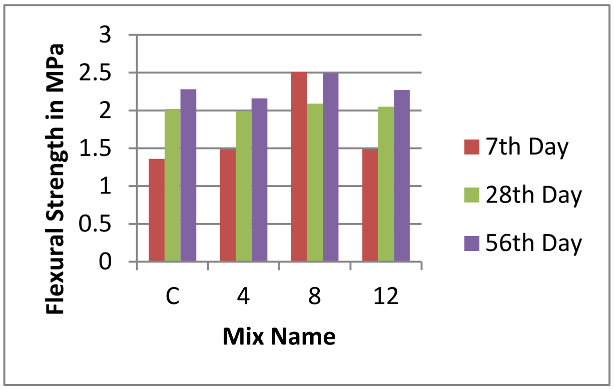

Figure 2.Flexure Test

4.1.3 Split Tensile test

Split tensile test was performed on cylinder of size 150mmx 300mm on a Universal testing machine as per IS: 5816-1999. Failure load was noted for each cylinder and Table 5 shows the results on Split tensile strength.

Table 5: Split tensile strength

Casting Duration	Control Specimens	Proportion of Admixture in specimens		
		4%	8%	12%
7 days	1.36	1.49	2.51	1.49
28 days	2.02	1.99	2.09	2.05
56 days	2.28	2.16	2.49	2.27

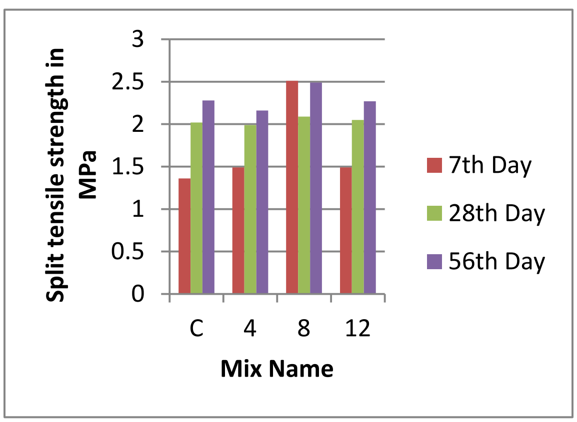

Figure 3.Split Tensile Strength Test

4.2 Durability Properties

4.2.1 Acid Attack

Acid attack is done in order to know the resistance of concrete cubes against effect of acid. The casted cubes of 150mm×150mm×150mm is being taken out from the curing tank and being prepared for the curing in acid for duration of 28 days. Concrete cubes are immersed in the solution of 5% of HCl in which acidic medium is maintained at pH value of 3 for the duration of 28 days. After 28-days of immersing in acid solution, the specimens are taken out and were washed in running water and kept in atmosphere for 2-day for constant weight. Specimens are weighed and tested for compressive strength and the percentage loss of weight and percentage loss in compressive strength was calculated.

Table 6: Acid attack test results

Duration-Proportion	Compressive Strength (N/mm^2)	Compressive strength after Sulfate Effect(N/mm^2)	Percentage reduction in strength	Mass of Specimens(Kg)	Mass of Specimen after Sulfate Effect (kg)	Percentage reduction in mass (%)
28 Days - Control	33.80	28.73	15%	8.227	7.708	6.3%
28 Days - 4%	34.53	31.13	10%	8.153	7.737	5.1%
28 Days - 8%	35.25	32.74	7.1%	8.344	7.993	4.2%
28 Days - 12%	32.95	28.99	12%	8.387	7.782	7.1%

4.2.2 Sulfate Attack

Sulfate attack is a way to know the deterioration of concrete by the sulphate content available. In this test concrete cube is being tested to give it a better resistance against expansion, cracking, or loss of strength and sometimes the disintegration. 5% $Na2SO_4$ is added in water of appropriate volume and it is in powder form which is being allowed to mix it properly. After the curing water containing sodium sulfate is ready the concrete cubes are placed for the duration of 28 days. After the curing duration gets over weight of cube is noted and the compressive strength is found.

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Table 7: Sulfate Attack test results

Duration-Proportion	Compressive Strength (N/mm^2)	Compressive strength after Sulphate Effect(N/mm^2)	Percentage reduction in strength	Mass of Specimens(Kg)	Mass of Specimen after Acid Effect (kg)	Percentage reduction in mass (%)
28 Days - Control	33.80	30.08	11%	8.227	7.552	8.2%
28 Days - 4%	34.53	31.13	10%	8.153	7.321	10.5%
28 Days - 8%	35.25	32.14	8.8%	8.344	7.835	6.1%
28 Days - 12%	32.95	27.67	16%	8.387	6.680	18.2%

4.2.3 Carbonation

Structure deterioration is mainly caused by the effect of carbonation; it is the reaction of hydration products dissolved in the pore water with the addition of carbon dioxide in air which reduces the pH of concrete solution and accelerate the corrosion process. Carbonation test has been performed by adding 1% of Phenolphthalein in solution of 70% of ethyl alcohol, and then solution is sprayed on the concrete surface which has been cleaned from dust and loose particles. As phenolphthalein is a colorless acid indicator which will turn in red color when pH value is above 9.5 and concrete becomes alkaline. If no coloration occurs then carbonation has taken place and depth of carbonation layer can be measured.

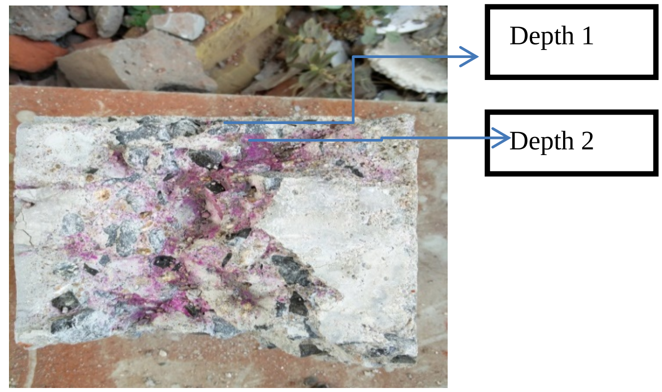

Fig.4 ControlSpecimen

Fig. 5 4% Proportion Specimen

Depth 1 and Depth 2 in figure 4 shows the method to calculate the depth of carbonation in which it is measured by the measuring scale and depth is found.

Fig. 6 8% Proportion Specimen

Fig. 7 12% Proportion Specimen

5.Conclusions

In the above study concrete was tested with and without admixture in order to improve properties like mechanical and durability.

In compression test 8% of admixture proportioned concrete obtained a optimum value as maximum strengths obtained is 35.25MPa. Among all values obtained the 8% value proved to be stable for adding admixture to concrete.

In flexure test conducted on beams, 8% value is considered optimum with the strenght obtained 5.19Mpa.

In the Split tensile test conducted on cylinder, obtained 2.09MPa with the optimum value of admixture 8%.

Durability test gained good results, acid attack on cube showed there was less reduction in strenght and mass by the addition of 8% of admixture. In sulfate attack same above 8% proportion proved to be the stable addition of admixture to concrete.

Carbonation was not leaded in any of the concrete cubes but, it can be say that admixtures gives a better resistance to 8% as well as 4% because of the more pinkish color created on surface of concrete.

It is concluded that 8% marble powder replacement produces dense and impervious concrete and hence mechanical and durability prioperties are improved.

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