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Effect of Mechanical Properties on Marble Dust as Partial Replacement of Cement for M-30 Concrete

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ABSTRACT—

In the present investigation the marble dust was replaced with cement at 0%, 5%, 10%, 15%, & 20% by weight of cement for M30 grade concrete. Concrete mixes for cubes, beams and cylinders were casted and experimentally tested and compared in terms of strength of the conventional cement concrete mixes at 7 days, 14 days and 28 days for 150x150mm cubes, 500x100x100mm beams and 150x300mm cylinders respectively. By addition of some good quality binding materials like marble dust, the various properties of concrete viz. workability, strength, resistance to crack can be effectively improved. The subsequent modification in microstructure of cement composites may enhance the properties like workability, compressive strength, flexural strength & split tensile strength.

Keywords: Marble Dust, water cement ratio, compressive strength, lexural strength, Tensile Strength

1. INTRODUCTION

The technical importance of using wastes and by-products in concrete production is expressed by performance improvement of concrete. Marble is metamorphosed limestone, composed of fairly pure calcite (a crystalline form of calcium carbonate, CaCO3). Marble has been usually used as a building material, sculpture, palaces and monuments since the ancient times. The marble industries dispose the marble powder material, consisting of very fine powder which finally results in constitutes that causes diverse environmental issues. Marble blocks are cut into smaller blocks so as to give them the specified classy form. Throughout the cutting method 25% the initial marble mass is lost within the type of dust. If the waste is disposed on soils, the porosity and permeability of topsoil will be reduced, the fine marble dust reduces the fertility of the soil by increasing its alkalinity when the waste is dumped and dried out, the fine marble dust suspends in the air and slowly spread out through wind to nearby area. When dumped along a catchment area of natural reservoir, it results in contamination of over ground water reservoir and also cause drainage problem. Marble dust is evidenced to be terribly effective in reassuring excellent cohesiveness of mortar and concrete. Physically, marble is re-crystallized hard, compact, fine to very fine metamorphosed rocks. From the studies, it's concluded that marble dust will be used as a replacement material for cement and marble dust offers a wonderful in ends up in strength side and quality aspect. The varied analysis results shows that the substitution of cement content by marble dust evoked higher compressive strength and properties associated with durability. Therefore, the aim of this current study is each to avoid the environmental pollution and to research the usability of the marble dust.

2. PROJECT OBJECTIVE

1) To study the influence of percentage replacement of cement by marble waste powder on the properties of Ordinary Portland Cement paste.
2) To study the effects of percentage replacement of cement by marble waste powder on different properties of concrete.
3) To find out optimum percentage of marble dust powder for best performance in manufacture of concrete.
4) To study concrete behavior with or without using marble dust powder.
5) To achieve desired strength of M-30 grade of concrete.

3. Material Used

3.1 Cement:

Ordinary Portland cement (simply called ordinary cement) refers to the hydraulic binding material ground by mixing Portland cement clinker, 6% ~ 15% blended materials, and appropriate amount of gypsum. The Ordinary Portland cement 43 Grade is used (Accordance with IS: 12269-1987).

Fig.3.1 Ordinary Portland cement 43 Grade

3.2 Sand:

River sand is used as fine aggregate in many cases because it is free from impurities and it also has good property to use as fine aggregate. (The fine aggregate used confirms to zone II, accordance with IS: 383-1970).

Fig:3.2 River Sand

3.3 Natural aggregate:

Coarse Aggregate are particles greater than 4.75mm IS sieve. In this study, coarse aggregate of 20mm down size are used. Coarse aggregate shall consist of naturally occurring materials such as gravel, or resulting from the crushing of parent rock, to include natural rock, slags, expanded clays and shales (light weight aggregate) and other approved inert materials with similar characteristics, having hard, strong, durable particles, conforming to the specific requirements of this section. The coarse aggregate used in gravel which is obtained locally.

Fig: 3.3 Coarse Aggregate

3.4 Marble Dust:

Marble has been commonly used for various purposes like tiles, shell etc., as a building material since the ancient times. The industry's removal of the marble powder material, consisting of extremely fine powder, today constitutes one of the environmental problems around the world Therefore, utilization

of the marble dust in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. Some attempts have been made to find and assess the possibilities of using waste marble powder in mortars and concretes and results about strength and workability were compared with control samples of conventional concrete. The use of the replacement materials offer cost decrease, energy reserves, arguably superior products, and smaller amount hazards in the environment. These materials contribute in the hydraulic reactions, contributing significantly to the composition and microstructure of hydrated product.

Fig: 3.4 Marble Dust

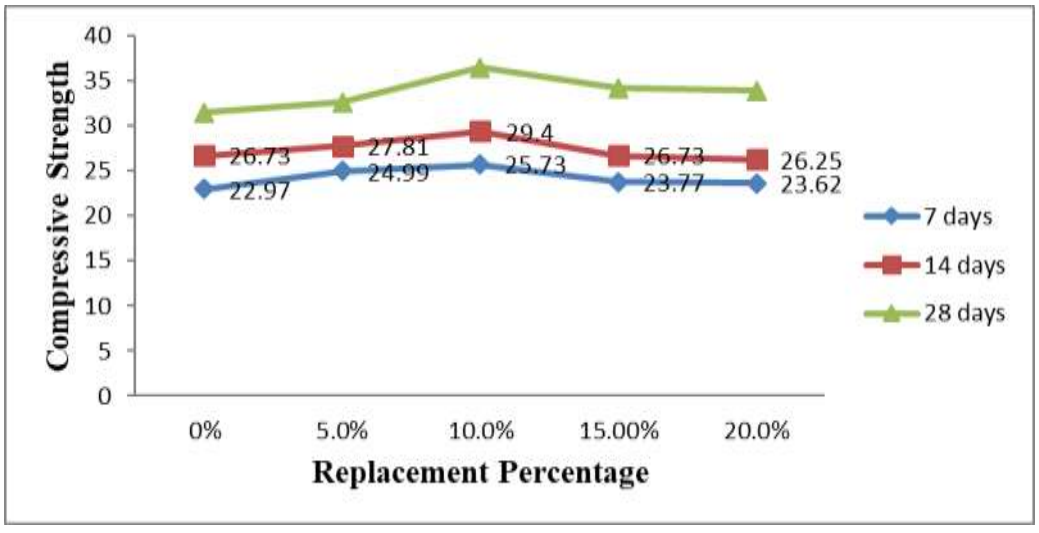
4. TEST RESULTS

4.1 Compressive Strength;

A minimum of three cubes are casted in each batch mix for determining compressive strength. Tests are performed at the age of 7 days, 14 days & 28 days of the specimens. Specimens are placed in the test machine as per IS: 516-1959 clause no 5.5.1 page no 11, also loading is applied on the specimen as per the same IS code. Calculation are made by dividing the maximum applied load by the cross sectional area of the specimen. As there are three specimens for each batch mix, the average of the three values is taken & calculates the compressive strength (for 7,14 & 28 days) as shown in table below

Table 4.1: Variation of compressive strength with age (M-30 Concrete)

% of MD	**0%**	**5%**	**10%**	**15%**	**20%**
7 Days	22.97 N/mm^2	24.99 N/mm^2	25.73 N/mm^2	23.77 N/mm^2	23.62 N/mm^2
14 Days	26.73 N/mm2	27.81 N/mm2	29.40 N/mm2	26.73 N/mm2	26.25 N/mm2
28 Days	31.47 N/mm^2	32.62 N/mm^2	36.51 N/mm^2	34.17 N/mm^2	33.95 N/mm^2



Graph:4 Compressive Strength in N/mm^2 at Various age (days)

Discussion:

As shown in the graph (7 days strength), when cement is partially replaced 10% by MD, compressive strength is increased by 12.01%. Afterwards when addition of % of MD is replaced, strength starts decreasing, a minimum strength is achieved.

As shown in the graph (14 days strength), when cement is partially replaced 10% by MD, compressive strength is increased by 9.98%. Afterwards when addition of % of MD is replaced, strength starts decreasing, a minimum strength is achieved.

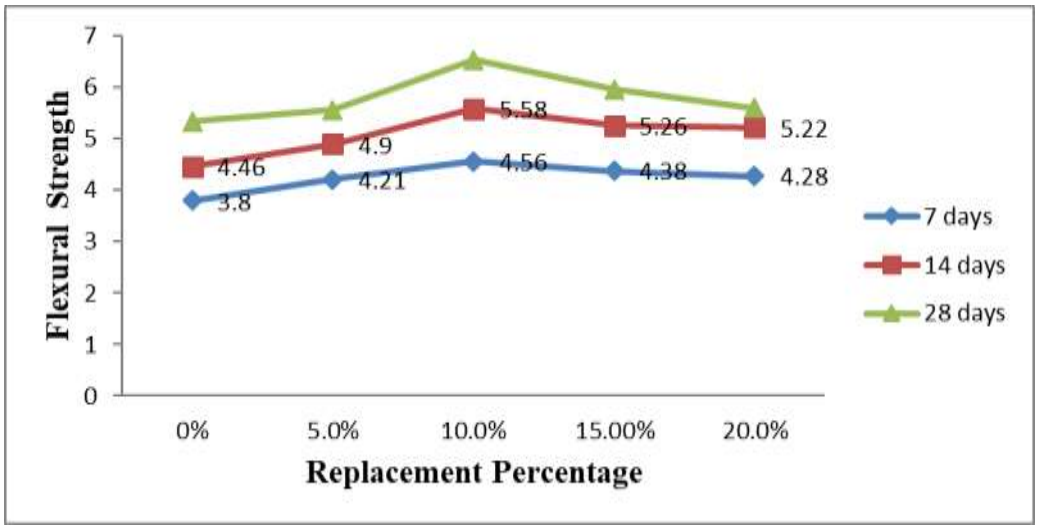
28 days strength in graph show an increment of 16.01% of strength of 10% replacement of MD as compared with conventional concrete. Again strength is decreased when addition of percentage of MD.

4.2 Flexural Strength

Beams of size 10cm*10cm*50cm are casted for determining flexural strength. Test on beams are performed at the age of 7 days, 14 days & 28 days of the specimen. Placement of specimen in machine is done as per IS: 516-1959 in the clause no 8.3.1 page no 17. Load is applied at increasing rate of 108KN/min. Load is applied until specimen fails and load at which specimen fails is recorded. As specified in the IS code flexural strength is calculated and tabulated below:

Table 4.2: Variation of flexural strength with age

% of MD	**0%**	**5%**	**10%**	**15%**	**20%**
7 Days	3.8MPa	4.21 MPa	4.56MPa	4.38MPa	4.28MPa
14 Days	4.46MPa	4.90 MPa	5.58 MPa	5.26 MPa	5.22 MPa
28 Days	5.34 MPa	5.56MPa	6.54MPa	5.96MPa	5.60MPa



Graph: 2 Flexural Strength in N/mm^2 at various age (Days)

Discussion:

As shown in the graph (7 days strength), when cement is partially replaced 10% by MD i.e. flexural strength is increased by 20%. Afterwards when % of MD is increased the strength starts decreasing

As shown in the graph (14 days strength), when cement is partially replaced 10% by MD i.e. flexural strength is increased by 25.11%. Afterwards when % of MD is increased the strength starts decreasing

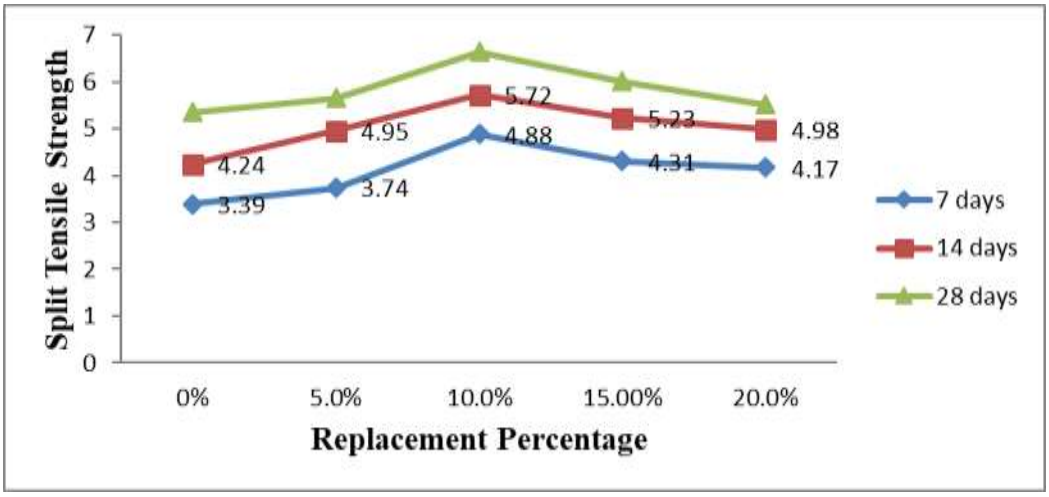
When graph (28 days strength) is analyzed, 10% replacement of MD gives 22.47% more flexural strength when compared with normal concrete. Here also, when % of MD is increased, strength starts decreasing.

4.3 Split Tensile Strength

Cylinders of size 15 cm diameter and 30 cm height are casted for determining Split Tensile Strength. Test on cylinders are performed at the age of 7days, 14 days & 28 days of the specimen. Placement of specimen in machine is done as per IS: 516-1959. Load is applied until specimen fails and load at which specimen fails is recorded. As specified in the IS code Split Tensile Strength is calculated and tabulated below:-

Table 4.3: Variation of Split Tensile strength with age

% of MD	**0%**	**5%**	**10%**	**15%**	**20%**
7 Days	3.39 MPa	3.74MPa	4.88 MPa	4.31MPa	4.17 MPa
14 Days	4.24 MPa	4.95 MPa	5.72 MPa	5.23 MPa	4.98 MPa
28 Days	5.35 MPa	5.65 MPa	6.64 MPa	6.01 MPa	5.51 MPa



Graph: 3 Split Tensile Strength in N/mm^2 at various age (Days)

Discussion:

As shown in the graph (7 days strength), when cement is partially replaced 10% by MD i.e. split tensile strength is increased by 43.95%. Afterwards when % of MD is increased the strength starts decreasing As shown in the graph (14 days strength), when cement is partially replaced 10% by MD i.e. split tensile strength is increased by 34.90%. Afterwards when % of MD is increased the strength starts decreasing When graph (28 days strength) is analyzed, 10% replacement of MD gives 24.11% more split tensile strength when compared with normal concrete. Here also, when % of MD is increased, strength starts decreasing

4.4 Cost Analysis

Cost Analysis of Coventional Concrete & partial replacement with silica fume for M -30 Concrete				
Normal Concrete				
S.No	Materials	Quantity	Rate in Rs	Amount in RS
1	Cement	8.1 Bags	310 Rs per bag	2511
2	Sand	0.48 m3	1800 per cubic metre	864
3	Aggregate	0.75 m3	1500 per cubic metre	1125
			Total	Rs 4500

Partial Replacement of cement with Marble dust (10%)				
S.No	Materials	Quantity	Rate in Rs	Amount in RS
1	Cement	7.29 Bags	310 Rs per bag	2260
2	Marble Dust	0.81 bags	44 Rs per bag	35.64
3	Sand	0.48 m3	1800 per cubic metre	864
4	Aggregate	0.75 m3	1500 per cubic metre	1125
			Total	Rs 4284.64

Discussion:

1. From the cost analysis it is clear that the cost of normal concrete is more than the optimal replacement 10% of marble dust with cement for M-30 grade of concrete.

5. CONCLUSIONS:

Based on the various tests conducted on concrete with varying proportion of MD the results were obtained and discussed in previous chapter from which the following conclusions are drawn.

1. Maximum compressive strength was observed 25.73 N/mm^2, 29.40 N/mm^2 & 36.51 N/mm^2 (for 7,14 & 28 days) when Marble Dust replacement is about 10% for M-30 grade concrete and after that there is decrease in compressive strength of concrete with further replacement of cement.
2. Maximum flexural strength was observed 4.56 N/mm^2, 5.58 N/mm^2 & 6.54 N/mm^2 (for 7, 14 & 28 days) when Marble Dust replacement is about 10% for M-30 grade concrete and after that there is decrease in flexural strength of concrete with further replacement of cement
3. Maximum split tensile strength was observed 4.88 N/mm^2,5.72 N/mm^2 & 6.64 N/mm^2 (for 7,14 & 28 days) when Marble Dust replacement is about 10 % for M-30 grade concrete and after that there is decrease in split tensile strength of concrete with further replacement of cement
4. Workability is decreased due to increase in water absorption as the replacement level increased for M-30 grade of concrete. It is possible that some of the mixing water necessary to sustain the strength forming hydration process may have been entrapped or absorbed by the MD.
5. From the cost analysis it is clear that the cost of normal concrete (Rs 4500) is more than the cost of optimal replacement 10% of marble dust (Rs 4284.64) with cement for M-30 grade of concrete.

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