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Experimental Investigation on Partial Replacement of Cement with Marble Dust Powder on Properties of Concrete

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ABSTRACT:
Concrete is the most extensively used and adaptable building material which is generally used to resist compressive forces. Since the use of cement and production of cement creates much more environmental issues and also it is costlier process. Hence Marble Dust Powder (MDP) can be used as a developing binding material that will allow the concrete industry to optimize materiel use, produce financial profit and construct structures that will be strong, durable and sensitive to the environment. The probable usage of MDP can is an ideal choice if used as a substitute in a cementitious binder as its reacting efficiency increases due to the presence of lime. The surplus generated from the marble industries causes environmental problems. Hence the reuse of this surplus material has to be emphasized. It has been estimated that several million tons of MDP are produced during quarrying worldwide. Hence consumption of MDP has become a significant substitute materials towards the effective application in concrete for enhanced harden properties of concrete. A MDP, obtained as a by-product of marble cutting, sawing, shaping was characterized from physical and chemical point of view for using it as binding material in production of concrete and mortar. Marble is a metamorphic rock resulting from the transformation of a pure limestone. MDP contains high calcium oxide content of more than 50%. To avoid adverse environmental circumstances, the content of cement is reduced in concrete and replaced by MDP which reduces cost and addition of MDP also increases strength and durability of concrete. The MDP was replaced with cement at 0%, 3.5%, 7%, 10.5%, 14%, 17.5% & 21% by weight for M25 grade concrete.

Keywords: Compressive Strength, Flexural Strength, Durability, Marble Dust Powder.

1. INTRODUCTION:

It has been estimated that several million tons of MDP are produced during quarrying worldwide. Hence utilization of marble powder has become an important alternative materials towards the efficient utilization in concrete for improved harden properties of concrete. Marble is a metamorphic rock resulting from the transformation of a pure limestone. The purity of the marble is responsible for its colour and appearance it is white if the limestone is composed solely of calcite (100% CaCO3). Marble is used for construction and decoration; marble is durable, has a noble appearance, and is consequently in great demand. Chemically, marbles are crystalline rocks composed predominantly of calcite, dolomite or serpentine minerals. The other mineral constituents vary from origin to origin. The main impurities in raw limestone (for cement) which can affect the properties of finished cement are magnesia, phosphate, leads, zinc, alkalis and sulfides. A large quantity of MDP is generated during the cutting process. The result is that the mass of marble waste which is 20% of total marble quarried has reached as high as millions of tons. Leaving these waste materials to the environment directly can cause environmental problem. Moreover, there is a limit on the availability of natural aggregate and minerals used for making cement, and it is necessary to reduce energy consumption and emission of carbon dioxide resulting from construction processes, solution to this problem are sought through usage of MDP as partial replacement of Portland slag cement. In India, MDP is settled by sedimentation and then dumped away which results an environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health. Therefore, utilization of the MDP in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently

2. Material Used:

2.1 Cement: Ordinary Portland cement is used to prepare the mix design of M-25 grade. The cement used was fresh and \without any lumps Water – cement ratio is 0.42 for this mix design using IS 456:2007. Cement is an extremely ground material having adhesive and cohesive properties which provide a binding medium for the discrete ingredients. Chemically cement constitutes 60-67% Lime (CaO), 17-25% Silica (SiO_2), 3-8% Alumina (Al_2O_3), 0.5-6% Iron Oxide (Fe_2O_3), 0.1-6% Magnesia (MgO), 1-3% Sulphur Trioxide (SO_3), 0.5-3% Soda And Potash (Na_2O+K_2O).

2.2 Sand: Natural sand which is easily available and low in price was used in the work. It has cubical or rounded shape with smooth surface texture. Being cubical, rounded and smooth texture it give good workability. Sand which is used here is taken from River. Particles of this sand have smooth texture and are blackish. Sieve analysis was done to find out fineness modulus which comes out to be 3.14% which is under limit as per IS 383-1970.

2.3 Coarse aggregate: The aggregate used in this project mainly of basalt rock which comes under normal weight category. The aggregates are locally available. 50% of the aggregate used are of 10-12 mm size and remaining50% is of 20mm size.

2.4 Marble Dust Powder: 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. In India, MDP is settled by sedimentation and then dumped away which results in environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health. Some attempts have been made to find and assess the possibilities of using waste MDP 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 fewer hazards in the environment. These materials participate in the hydraulic reactions, contributing significantly to the composition and microstructure of hydrated product.

Fig: Marble Dust Powder

3. Results

3.1 Compressive Strength Test: A minimum of three cubes are casted in each batch mix for determining compressive strength. Tests are performed at the age of 7, 14 and 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.

Table No. 1 Results on Cubes

Mix		Compressive Strength (N/mm^2)		
Replacement (%)		7 days	14 days	28 days
M-1	0	18.17	20.63	24.13
M-2	3.5	15.36	17.71	20.32
M-3	7	17.23	19.87	22.86
M-4	10.5	18.91	21.75	25.16
M-5	14	21.74	24.72	28.67
M-6	17.5	21.08	24.03	27.36
M-7	21	21.56	23.06	28.17

3.2Flexural Strength Test:

Beams of size 10cm*10cm*50cm are casted for determining flexural strength. Test on beams are performed at the age of 7, 14 and 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 per IS code flexural strength is tabulated below:-

Table No.2 Results on Beams

Mix		Compressive Strength (N/mm^2)		
Replacement (%)		7 days	14 days	28 days
M-1	0	3.88	4.45	5.14
M-2	3.5	3.62	4.23	4.75
M-3	7	3.88	4.41	5.13
M-4	10.5	4.21	4.89	5.57
M-5	14	4.46	5.19	5.98
M-6	17.5	4.53	5.34	6.43
M-7	21	4.35	5.18	6.02

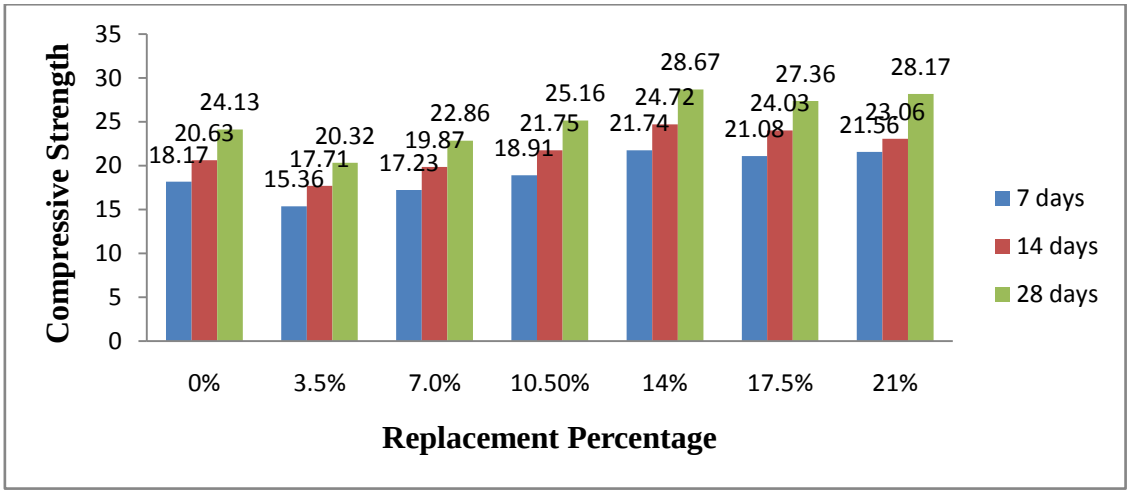
3.3 Durability Test:

3.3.1 Acid Resistance:

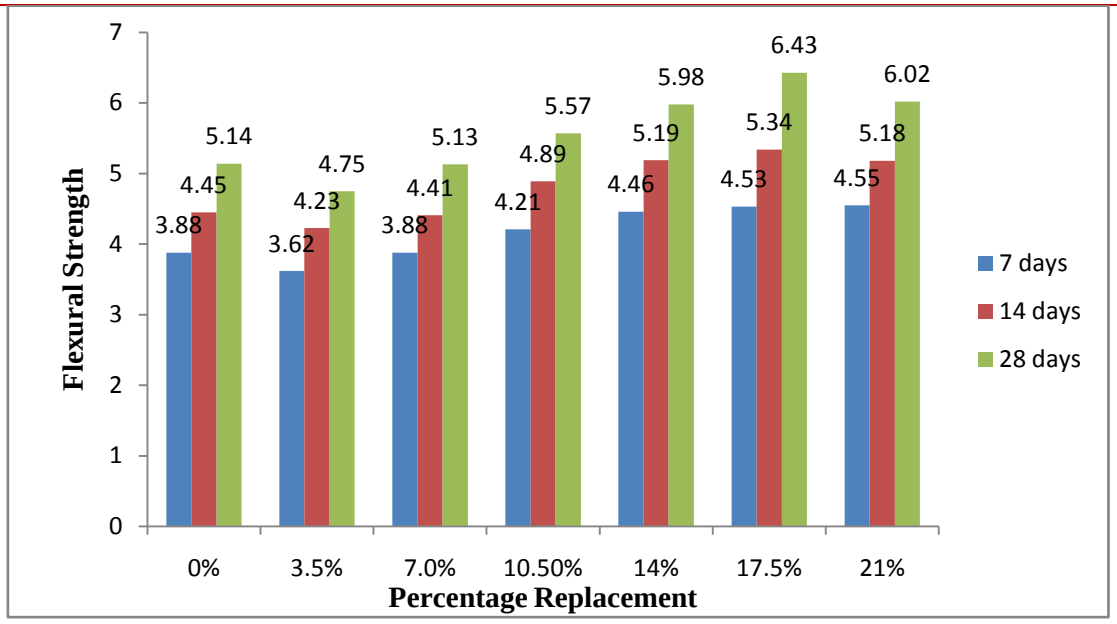
Cubes of sizes 150mm were cast and cured for 28 days. After 28 days curing cubes were taken out and allowed for drying for 24 hours and weights were taken. For acid attack 5% dilute hydrochloric acid is used. The cubes were to be immersed in acid solution for a period of 30 days. The concentration is to be maintained throughout this period. After 30 days the specimens were taken from acid solution. The surface of specimen was cleaned and weights were measured. The specimen was tested in the compression testing machine under a uniform rate of loading 140Kg/cm2 as per IS 516. The mass loss and strength of specimen due to acid attack was determined.

Table 3: Effect of Acid Attack on Weight and Compressive Strength of Cubes

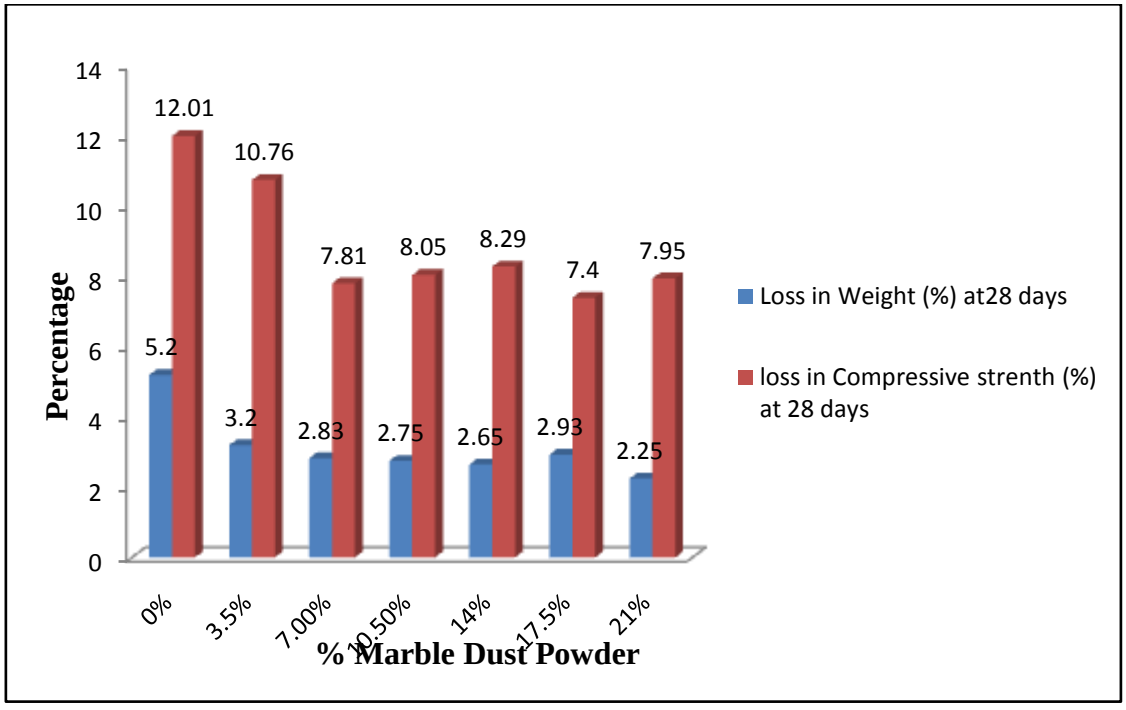
S.No	MDP (%)	Loss in Weight (%) At 28 Days	Loss in Compressive strength (%) At 28 days
1.	0	5.2	12.01
2.	3.5	3.2	10.76
3.	7	2.83	7.81
4.	10.5	2.75	8.05
5.	14	2.65	8.29
6.	17.5	2.93	7.40
7.	21	2.25	7.95



Graph 1: Compressive Strength in N/mm^2 at 7, 14& 28 Days



Graph 2: Flexural Strength in N/mm^2 at7, 14 & 28 Days



Graph 3: Effect of acid attack on weight and Compressive Strength of cubes

4. Conclusion

After performing all the tests and analyzing their result, the following conclusions have been derived:

1. The results achieved from the existing study shows that MDP is great potential for the utilization in concrete as replacement of cement.

3. Maximum compressive strength was observed when MDP replacement with cement is about 14%.

4. Maximum flexural strength was observed when MDP replacement with cement is about 17.5%.

5. Extreme value of Durability against acid attack was obtained when cement is replaced with MDP at3.5%.

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