

## Effect of Various Replacement Levels of Waste Marble Dust In Place of Fine Aggregate to Study the Fresh and Hardened Properties of Concrete

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### ABSTRACT

Marble has been widely used in structures since ancient times. Most of the monuments and ancient sculptures were made with the help of marbles. Nowadays, marbles are used for the decoration purpose, which increases its demand in the market. With the increase in production of marbles it increases the waste that obtained from it. As marble powder is the waste product, obtained during the process of sawing and shaping of marble by parent marble rock, contains heavy metals which makes the water unfit for use. Marble powder creates environmental problems. Due to environmental problems, it has a great impact on human health as well as on nature. To control its effects we have to use this waste in the production of concrete. The present study is aimed at utilizing waste marble dust (WMD) in construction industry itself as fine aggregate in concrete, replacing natural sand. The replacement is done partially and fully in the various proportions like 0%, 25%, 50%, 75% and 100% and its effect on properties of concrete were investigated. The study indicated that waste marble dust can effectively be used as fine aggregate replacement (up to 50%) without substantial change in strength.

**Keywords** - Compressive Strength, Concrete, Fine Aggregate, Marble dust and Workability.

### I. INTRODUCTION

Marble is a metamorphic rock resulting from the transformation of a pure limestone. The purity of the marble is responsible for its color and appearance. It is white if the limestone is composed solely of calcite (100% CaCO<sub>3</sub>). 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. Quartz, muscovite, tremolite, actinolite, microcline, talc, garnet, osterite and biotite are the major mineral impurities whereas SiO<sub>2</sub>, limonite, Fe<sub>2</sub>O<sub>3</sub>, manganese, 3H<sub>2</sub>O and FeS<sub>2</sub> (pyrite) are the major chemical impurities associated with marble. 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 powder 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. The advancement of concrete technology can reduce the consumption of natural resources and energy sources

which in turn further lessen the burden of pollutants on the environment. Presently, large amount of marble dust are generated in natural stone processing plants with an important impact on the environment and humans [1].

In India, marble dust 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. Therefore, utilization of the marble dust in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. Hence the reuse of waste material has been emphasized. Waste can be used to produce new products or can be used as an admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. There are several reuse and recycling solutions for this industrial by-product, both at an experimental phase and in practical applications. On the other hand, recycling waste without properly based scientific research and development can result in environmental problems greater than the waste itself. One of the logical means for reduction of the waste marble masses calls for utilizing them in building industry itself. 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 cements and mortar or concrete [2].

## II. LITERATURE REVIEW

Bahar Demirel (2010) presented the use of marble dust as in place of fine aggregate in concrete mix and check the mechanical properties of mix. In this experimental study, the effects of using waste marble powder have been studied as a fine material on the mechanical properties of the concrete. Four different series of concrete mixtures were prepared by replacing the fine sand (passing 0.25 mm sieve) with waste marble powder at different proportions like 0, 25, 50 and 100% by weight. For determining the effect of the waste marble powder on the compressive strength with respect to the curing age, compressive strengths of the samples were recorded at the curing ages of 3, 7, 28 and 90 days. Different properties like the porosity values, ultrasonic pulse velocity (UPV), and dynamic modulus of elasticity and the unit weights of the series were determined and compared with each other. It had been observed that the addition of WMD such that it would replace the fine material passing through a 0.25 mm sieve at particular proportions enhances the effect on compressive strength [3].

Er. Raj et al., (2015) presented in his paper that the marble can be utilized in concrete mix by replacement of fine aggregates. Different mechanical properties of marble slurry are determined like specific gravity, fineness modulus was founded and it also showed that utilization of marble slurry by replacing it with sand upto 30% which shows equal strength as of conventional concrete i.e., 1:2:4 cement concrete ratio with 0% marble slurry. It concludes that marble slurry can easily be utilized in cement concrete mix [4].

Agarwal and Gulati demonstrated that the presence of marble dust in the matrix enhances the early compressive strength of the mortar, and the strength of the mortar decreases with the increasing marble dust content. According to authors, both of the early and long term strength of the mortar can be improved by the inclusion of slag and fly ash in the matrix [5].

V. M. Sounthararajan and A. Sivakumar (2013) adds lime content in marble powder and check its effects on concrete mix. In this research work, the waste marble powder upto 10% by weight of cement was investigated for hardened concrete properties. The effect of different percentage replacement of marble powder on the compressive strength, splitting tensile strength and flexural strength was calculated. It can be noted that the influence of fine to coarse aggregate ratio (F/C) and cement-to-total aggregate

ratio (C/TA) had a higher influence on the improvement in strength properties. The immense increase in the compressive strength of 46.80 MPa at 7 days for 10% replacement of marble powder in cement content was calculated and also showed an improvement in mechanical properties as compared to the conventional concrete [6].

Animesh Mishra et al., (2013) uses marble dust in green cement for sustainable concrete. They showed that the feasibility of the usage of marble sludge dust as hundred percent substitutes for natural sand in concrete. The compressive strength and mechanical properties were investigated in this study. The hydration products of cements were examined by means of scanning electron microscopy. Compressive strength was discussed as a function of different parameters like curing time, binder composition. It gives the result that the blended cements developed higher strength, at 28 days compared to 7 days. It observed that strength increases as the marble content increased. So, it helps in the lower consumption of the natural resources and also the pollution [7].

Prof. Veena G. et al., studied feasibility of marble powder as the constituent of concrete mix. They have studied that the compressive strength and split tensile strength of concrete can be increases as the addition of waste marble powder as the replacement of cement by 10%. This research also investigates that the marble dust had a great impact on the properties such as consistency, setting time, insoluble residue and soundness. The use of cheaper constituent like wastes can solve the ecological problems as well as environmental problems. Therefore there is a scope for more researches in the field of durable concrete with this waste [8].

Baboo Rai and Khan Naushad (2011) studied the influence of marble powder in cement concrete mix. In this paper the effect of use of marble powder and granules has been studied by partially replacing with mortar and concrete constituents and checked the different properties like relative workability and compressive and flexure strengths. By partial replacing the constituents it reveals that increased waste powder or waste marble granules ratio resulted in increased workability and compressive strengths of the mortar and concrete [9].

## III. MATERIALS USED IN THE PRESENT STUDY

### 3.1 Cement

Ordinary Portland cement Zuari-53 grade conforming to IS: 12269-1987 [10] was used in concrete.

The physical properties of the cement are listed in Table 1.

Table 1: Physical Properties of Zuari-53 Grade Cement.

Sno	1	2	3	4	5		
Properties	Sp. Gr	Normal consistency	Initial setting time	Final setting time	Compressive strength (Mpa)		
Values	3.15	32%	60 min	320 min	3 days	7 days	28 days
					29.4	44.8	56.5

### 3.2 Aggregates

#### 3.2.1 Fine Aggregate

Natural sand from Swarnamukhi River in Srikalahasthi with specific gravity of 2.60 was used as fine aggregate conforming to zone- II of IS :383-1970[11] . The individual aggregates were blended to get the desired combined grading.

#### 3.2.2 Coarse Aggregate

Locally available coarse aggregate having the maximum size of 20 mm was used in our work. The aggregates were washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested as per Indian Standard Specifications IS: 383-1970[11].

### 3.3 Water

Potable water was used for mixing and curing of concrete cubes.

### 3.4 Waste Marble dust

Marble powder is produced from the marble processing plants during the cutting, shaping and polishing. During this process, about 20-25% of the process marble is turn into the powder form. India being the topmost exporter of marble, every year million tons of marble waste form processing plants are released. The disposal of this waste marble on soils causes reduction in permeability and contaminates the over ground water when deposited along catchment area. Thus, utilizing these marble wastes in construction industry itself would help to protect the environment from dumpsites of marble and also limit the excessive mining of natural resources of sand. The Marble powder is collected from M/S.Astra Chemicals, Chennai, Tamil Nadu.

Table 2: Chemical Composition of the Waste Marble Dust

Composition mass/property	(% by Marble dust)
Silica (SiO <sub>2</sub> )	28.35
Alumina (Al <sub>2</sub> O <sub>3</sub> )	0.42
Iron oxide (Fe <sub>2</sub> O <sub>3</sub> )	9.70
Calcium oxide (CaO)	40.45
Magnesium oxide (MgO)	16.62



Fig 1: Sieved Marble Dust

## IV. MIX PROPORTIONING

In the present work, proportions for concrete mix design of M25 were carried out according to IS: 10262-2009 [12] recommendations. The mix proportions are presented in Table 6.

Table 3: Mix proportion for M25 Concrete

PARAMETERS	Percentage replacement of marble dust powder in fine aggregate				
	CONTROL MIX	MIX 1 (25%)	MIX 2 (50%)	MIX 3 (75%)	MIX 4(100%)
W/C Ratio	0.475	0.475	0.475	0.475	0.475
Water kg/cu.m	190.6	190.6	190.6	190.6	190.6
Cement kg/cu.m	398	398	398	398	398
Fine aggregates kg/cu.m	717	537.75	358.50	179.25	0.0
Coarse aggregates kg/cu.m	1110	1110	1110	1110	1110
Marble Dust Powder kg/cu.m	0.0	179.25	358.50	537.75	717

## V. RESULTS AND DISCUSSIONS

### 5.1 Workability Results

The workability results are presented in Table.4 and Fig 2.

Table 4 :Workability Test (Slump Cone Test)

Replacement of Waste Marble dust with fine aggregate (%)	WORKABILITY (Slump in cm)
CONTROL MIX	24
MIX 1	26
MIX 2	28
MIX 3	27
MIX 4	23

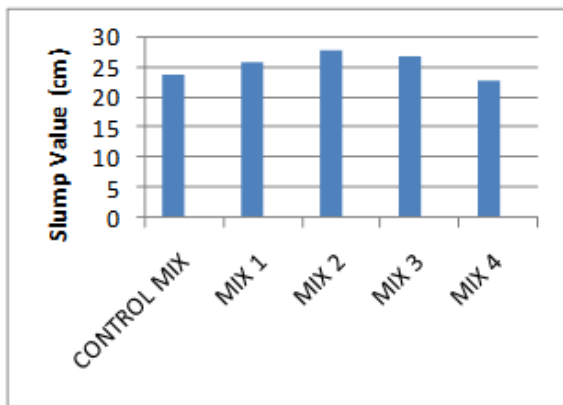


Fig 2: Variation of Slump Value for Different Trail Mixes

### 5.2 Compressive Strength

The tests were carried out as per IS: 516-1959 [13]. The 150mm size cubes of various concrete mixtures were cast to test compressive strength. The cubes specimens after de-moulding were stored in curing tanks and on removal of cubes from water the compressive strength were conducted at 7days, 28days and the results are represented in Table 5 and Fig 3. The test results were compared with controlled concrete.

Table 5: Compressive Strength for Different Trail Mixes

Percentage of Replacement of Waste Marble Dust with Fine aggregate	Compressive Strength N/mm <sup>2</sup>	
	7 Days	28 Days
CONTROL MIX	16.86	31.73
MIX 1	22.34	33.11
MIX 2	23.91	35.54
MIX 3	21.89	32.1
MIX 4	20.82	30.96

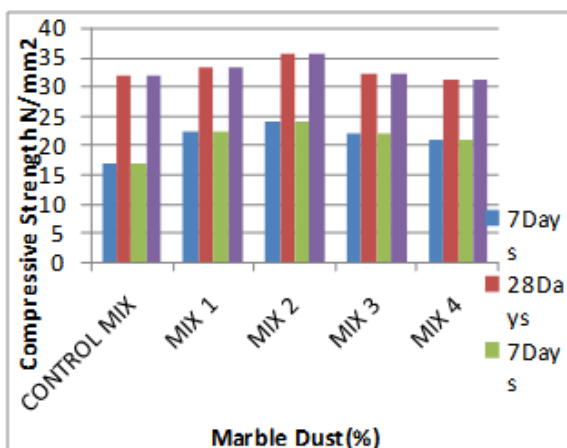


Fig 3: Variation of Compressive Strength for Different Trail Mixes

## VI. CONCLUSIONS

- The maximum compressive strength of M25 grade concrete for seven days curing period is 23.91 MPa by partial replacement of fine aggregate by 50% replacement of waste marble dust .
- The maximum compressive strength of M25 grade concrete for 28 days curing period is 35.54 MPa by partial replacement of fine aggregate by 50% replacement of waste marble dust .
- The compressive strength of concrete is increased with addition of waste marble powder up to 50% by weight in place of sand and further any addition of waste marble powder the compressive strength decreases.

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