Utilisation of Waste Marble Dust as Fine Aggregate in Concrete

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Abstract: Concrete is the important construction material and it is used in the construction industry due to its high compressive strength and its durability. Now a day's various studies have been conducted to make concrete with waste material with the intention of reducing cost and unavailability of conventional materials. This paper investigates the strength properties of concrete specimens cast using waste marble dust as replacement of fine aggregate. The marble pieces are finely crushed to powdered and the gradation is compared with conventional fine aggregate. Concrete specimen were cast using wmd in the laboratory with different proportion (25%, 50% and 100%) by weight of cement and from the studies it reveals that addition of waste marble dust as a replacement of fine aggregate marginally improves compressive, tensile and flexural strength in concrete.

Keywords: WMD-Waste Marble Dust, Concrete, Strength, Reuse, Replacement

1. Introduction
Concrete is an extensively used building item and consists of cement, coarse aggregate, fine aggregate and deliberate amount of water. Natural sand is usually used as fine aggregate. For appropriate rapid growth in structural activities, accessible natural sand supply is exhausting. In addition, there are times when it is necessary to transport high-class sand from a long distance, and because of the expense of construction, it is essential to partially or completely substitute the ordinary sand in the concrete with a substitute matter without weakening the superiority of the concrete. To substitute sand as fine aggregate, waste marble dust can be used. This research aims to exploit the usage of waste marble powder in concrete instead of sand as fine aggregate.

2. Literature Survey
Based on the extensive review of literature, following critical observation was made:

- The focus of the study so far, has understood the effect of WMD on concrete, with a view to understand / identify the mechanisms responsible for in properties of the concrete.
- Very few studies have reported on the effect of WMD on concrete and the studies were carried out under room conditions.
- Most reported studies on the effect of WMD have been carried out laboratory conditions and experimental studies for M30 grade of concrete were rarely attempted. However, such studies are essential for better understanding the effect of WMD for M30 grade of concrete.
- The effect of WMD on the concrete characteristics sophisticated method like split tensile and compression test.
3. Methodology
Conventional concrete with a water cement proportion of 0.42 was produced. The cement used was ordinary Portland cement of 53 grade using WMD. The substitution ratio of Waste Marble Dust (WMD) was 25%, 50%, 100% of the weight of cement. Sieve aggregates with sizes of 20 mm and 10 mm, fine sand with a fine modulus (FM) of 1.94 were used. In order to obtain sufficient workability, the relative ratio of coarse aggregate and sand was determined for the standard weight concrete as a reference.

4. Materials Used

4.1 Cement
The cement exploited for the study is 53 grade ordinary Portland cement of IS: 8112-1989. The specific gravity of cement is 3.15

4.2 Waste Marble Dust
Wastes generated in the marble stone industry is proclaimed and used as Waste Marble Dust.

4.3 Graded Fine Aggregate
Sand grains passing through a 4.75 mm sieve are called fine aggregates. Natural sand is used as fine aggregate. Regionally available river sand compliant with zone II of IS: 383-19707 was used as fine aggregate having a specific gravity of 2.54.

4.4 Graded Coarse Aggregate
Commonly sized, locally available well-graded aggregates larger than 4.75 mm and smaller than 12.5 mm are used as coarse aggregate. ACI Mix Design Procedure: crushed stone of 20 mm and 10 mm size, taken from a local quarry with a specific gravity of 2.68.

4.5 Water
Portable water available at the university campus was used to prepare concrete in the entire project.

5. Mix Proposition
The concrete mix was designed for M30 grade concrete according to IS 10262-2009 and the mixing ratio was 1: 1.87: 3.39 with a W/C ratio of 0.42. We prepared 12 types of concrete cubes and 4 kinds of concrete cylinders and With Waste Marble Dust 4 concrete prisms of various replacements were used in total. The amounts of aggregate, water content, additives and cement are listed in the Table 1.

| S. No. | Description          | Mass (kg/m³) |
|--------|----------------------|--------------|
| 1      | Cement               | 380          |
| 2      | Fine Aggregate       | 710          |
| 3      | Coarse Aggregate     | 1290         |
| 4      | Water                | 160          |
| 5      | Water-Cement Ratio   | 0.42         |

6. Specimens for the Experiment
6.1 Standard Cube Specimens
To test the compressive strength of concrete, totally twelve standard cube specimens of dimension 15cm x 15cm x 15cm were cast. Three specimens were cast for each mix with 0%, 25%, 50% and 100% replacement of Waste Marble Dust with fine aggregate.
6.2 Standard Cylinder Specimens
Four-cylinder sample of diameter 100mm and altitude 200mm were prepared for each replacement mix to test the split tensile strength of the concrete.

6.3 Standard Prism Specimens
To test the flexural strength of concrete, four standard prism specimens per each fraction of replacement were cast

7. Tests Performed
7.1 Test on Physical Properties of Materials
7.1.1 Specific Gravity Test. Specific gravity is usually defined as the ratio between the weight of a given volume of material and the volume of water. The specific gravity of cement and WMD is obtained by using a density bottle with kerosene as a standard substance. Determine the specific gravity of fine aggregate and coarse aggregate using a hydrometer and a wire basket. The specific gravity of the materials used for this project work is shown in Table 2.

| Table 2. Specific Gravity |
|---------------------------|
| Materials             | Specific Gravity |
|------------------------|------------------|
| Cement                | 3.15             |
| Marble                | 2.67             |

7.1.2 Sieve Analysis. The sieve analysis is a practice or procedure used to evaluate the particle size distribution of the particulate material. Size distribution is often very important to the way the material performs during use. Sieve analysis is a precise method of all sorts of non-organic or organic particulate matter including sand, crushed rock, clay, granite, feldspar, coal, soil, a wide range of manufactured powders, cereals and seeds. Probably the most common as it is a simple technique like particle sizing. Fineness modules of given marble dust is 2.505.

| Table 3. Sieve analysis of WMD |
|-------------------------------|
| S. No. | IS Sieve | Particle Size (mm) | Wt retained (g) | % retained | Cumulative % retained | % finer |
|-------|----------|--------------------|-----------------|------------|-----------------------|--------|
| 1     | 4.75     | 4.75               | 0.014           | 1.4        | 0                     | 0      |
| 2     | 2.36     | 2.36               | 0.013           | 1.3        | 2.7                   | 97.3   |
| 3     | 1.18     | 1.18               | 0.148           | 1.48       | 17.8                  | 82.8   |
| 4     | 600micron| 0.60               | 0.256           | 2.56       | 43.1                  | 86.9   |
| 5     | 300micron| 0.30               | 0.428           | 4.28       | 85.9                  | 14.1   |
| 6     | 150micron| 0.15               | 0.141           | 1.41       | 100                   | 0      |
| 7     | Pan      | <0.75              | 0               | 0          | 0                     | 0      |
7.2 Test on Mechanical Properties of Concrete

7.2.1 Compressive Strength of Concrete. For the cubic compression test of concrete, a cube of 150 mm × 150 mm × 150 mm size was used. All cubes were tested in the ambient curing process. For the different proportions, cubes were tested using a 3000 kN volume compression tester 7 days and 28 days after curing. After placing the test piece in the center of the testing machine, the test was conducted with a uniform stress of 10 kg / cm² / min. Loading continued until the readings were reversed from the incremented value. Reversal of the reading indicates that the test piece has failed. The machine stopped, and it turned out that reading at that moment was the ultimate load. The value obtained by isolating the final load by the cross-sectional area of the sample is equal to the final cubic compressive strength.

7.2.2 Split Tensile Strength of Concrete. This is an indirect test to determine the tensile strength of a cylindrical specimen. In the divided tensile strength test, a cylinder test piece having a span of 100 mm and a length of 200 mm was subjected to curing for 28 days using a 3000KN capacity compression tester. To avoid direct loading on the test specimen, a cylindrical specimen was placed under the woody specimen. The test piece was cracked and the load was gradually added until the measured value was recorded.

7.2.3 Flexural Strength of Concrete. Flexural strength familiarized as the modulus of rupture, or flexural strength or transverse breaking strength is a property of material identified as the stress of the material before the bending test. The transverse bending test is most commonly adopted and uses a three-point bending test technique to bend a specimen either rectangular or circularin cross section to rupture or yield. Flexural strength signifies the maximum stress experienced in the material in that instant. Four-point bending is considered. In rectangular sample below a load in a four-point bending setup where the loading span is one-third of the support span.

8. Results and Discussion
The test results of specimens with varied fractions of WMD replacement are compared with the results given by the control check specimens. The table gives the comparison of 28 day split tensile, compressive and flexural strength results.
Table 4. Strength Characteristics

| Percentage of Sand Replaced | Strength (N/mm²) |
|-----------------------------|------------------|
|                             | Compressive      |
|                             | Split Tensile    |
|                             | Strength         |
|                             | Strength         |
|                             | Flexural         |
|                             | Strength         |
| 0%                          | 31.42            |
| 25%                         | 33.02            |
| 50%                         | 40.22            |
| 100%                        | 29.28            |

Figure 2. 28th Day Compression Strength

Figure 3. 28th Day Split Tensile Strength
8. Discussions

- Including waste marble powder, the compressive strength of concrete progressively increases to a certain limit, but steadily decreases.
- Including marbled powder up to 50% increases the compressive strength inclusive of 28 days curing.
- Ultimate tensile strength is found with 0% replacement of marble powder and the strength gradually decreases by addition of WMD.
- Flexural strength of prism concrete increases up to 50% and then gets decreasing.
- Therefore, it was found that the optimum replacement rate by marble powder to sand in concrete was almost 50%.

9. Conclusion

This project work is intended to analyze the feasibilities of using waste marble dust as replacement with fine aggregate. It offers unique advantages of being abundant, easily accessible and cost efficient. The test result shows that the use of these Waste Marble Dust have the capability of improving the performance of the hardened concrete. From the above results, the use of Waste marble dust up to 50% replacement with the fine aggregate is recommendable. The result of flexural strength test shows the familiar behavior with the results of the compression strength test.

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