Influence of Marble powder/granules in Concrete mix

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ABSTRACT

In this paper the effect of using marble powder and granules as constituents of fines in mortar or concrete by partially reducing quantities of cement as well as other conventional fines has been studied in terms of the relative workability & compressive as well as flexural strengths. Partial replacement of cement and usual fine aggregates by varying percentage of marble powder and marble granules reveals that increased waste marble powder (WMP) or waste marble granule (WMG) ratio result in increased workability and compressive strengths of the mortar and concrete.

Keywords: Marble Powder, Marble Granules, Compressive Strength, Flexural Strength

1. Introduction

Marble as a building material especially in palaces and monuments has been in use for ages. However the use is limited as stone bricks in wall or arches or as lining slabs in walls, roofs or floors, leaving its wastage at quarry or at the sizing industry generally unattended for use in the building industry itself as filler or plasticizer in mortar or concrete. The result is that the mass which is 40% of total marble quarried has reached as high as millions of tons. This huge unattended mass of marble waste consisting of very fine particles is today one of the environmental problems around the world (Corinaldesi et al., 2010). 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 cement-sand mortar/concrete. Valeria et al (2005) in their study observed that marble powder had very high Blaine fineness value of about1.5 m²/g, with 90% of particles passing through 50 μm-sieves and 50% through 7 μm. The authors also noticed that the marble powder had a high specific surface area, implying that its addition as mineral in mortars and concretes, especially in self-compacting concrete should impart more cohesiveness. Hanifi Binici et al (2007) found that marble-dust concrete has higher compressive strength than that of the corresponding lime stone -dust concrete having equal w/c and mix proportion. The results indicated that the Marble dust -concrete would probably have lower water permeability than the lime stone concrete. As nonpuzzolanic fines it is at present the limestone and dolomite ones which are most
frequently used to increase the content of fine particles in self compacting concretes (Billberg, 1999). Compared to normal plain concrete of the same w/c ratio and the same cement, the concrete having high limestone filler content of suitable particle-size-distribution generally improves the strength characteristics (Sonerbi et al., 2000, Petersson, 2001). A step further Ali Ergun (2011) carried out laboratory investigation of mechanical properties of the concrete specimens containing diatomite and waste marble powder (WMP) by partially replacing 5% cement content by weight with WMP in one case and by replacing 5% cement by weight as well as 10% diatomite by weight with WMP in the other and found better compressive and flexural strength and came to the conclusion that the mechanical properties of concrete could be improved by reducing cement and diatomite content and by adding equal amount of WMP as a super plasticising admixture. Kursat & Ragip (2009) found some relationship between properties of fresh and hardened self compacting concrete (SCC). They also described a method of preliminary mix design for SCC based on monogram. In this paper, too, efficacy of waste marble powders in concrete has been investigated by experimental tests on concrete without WM Powder/Granuals and with varying quantity of WM Powder/Granuals.

2. Methodology

To carry out the proposed study cubes of mortar (1:3) with varying partial replacement of cement with the same amount of WMP were cast and tested at three different intervals of 7 days. Also cubes of (1:3) mortar with partial replacement of sand with the same amount of WM Granuals were cast and their strength was evaluated after 7, 14, and 28 days in different lots. Their results were compared with those of standard (1:3) mortar and concrete cubes. Detail of mortar mix has been shown in Table 1 & 2.

<table>
<thead>
<tr>
<th>Mix Proportion-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Replacement</td>
</tr>
<tr>
<td>Cement</td>
</tr>
<tr>
<td>Sand</td>
</tr>
<tr>
<td>Marble Powder</td>
</tr>
<tr>
<td>Water</td>
</tr>
<tr>
<td>W/C Ratio</td>
</tr>
</tbody>
</table>

Table 1: Mortar Mix (1:3) Proportion when cement was replaced.
In the same way thirty cube specimens and eight beams samples of M30 grade of concrete have been tested in laboratory for which six samples for each percentage of marble granules i.e. 0%, 5%, 10%, 15% and 20%. Three properties of concrete namely workability, compressive strength and flexural strength have been selected for study and evaluated according to IS: 1199-1959 and IS: 516-1959 respectively. Before initiating the test properties of materials were determined according to respective IS codes. The properties are shown in Table 3.

Table 3: Material Properties

<table>
<thead>
<tr>
<th>Material</th>
<th>Fineness/Fineness Modulus</th>
<th>Specific Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Cement</td>
<td>0.225 (m²/g)</td>
<td>3.12</td>
</tr>
<tr>
<td>**Fine Aggregate</td>
<td>2.60</td>
<td>2.71</td>
</tr>
<tr>
<td>Course Aggregate</td>
<td>2.96</td>
<td>2.85</td>
</tr>
<tr>
<td>Marble Powder</td>
<td>1.5 (m²/g)</td>
<td>2.67</td>
</tr>
<tr>
<td>Marble Granular</td>
<td>2.72</td>
<td>2.57</td>
</tr>
</tbody>
</table>

*Consistency of cement is 30%. Initial and final setting time of cement is 50 minutes and 520 minutes respectively.

**Fine aggregate conforms to zone III as per IS: 383 —1970.

2.1 Mix Design

Based on the Indian Standard (IS: 10262 - 1982), design mix for M30 grade of concrete was prepared by partially replacing fine aggregate with five different percentages by weight of marble granules (0%, 5%, 10%, 15%, and 20%). The mix proportion for M30 Grades of concrete with varying percentage of marble granules is presented in Table 4.
### Table 4: Mix Proportion for Concrete Mix

<table>
<thead>
<tr>
<th>Mix</th>
<th>Material by Weight</th>
<th>Mix Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Marble</td>
<td>Sand (kg)</td>
</tr>
<tr>
<td>M30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>527.0</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>500.6</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>474.3</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td>447.9</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>421.6</td>
</tr>
</tbody>
</table>

Cement content and coarse aggregate is 423 kg and 1272 kg respectively while W/C is 0.44 for each mix proportion.

3. Results and Discussions

3.1 Mortar Mix

3.1.1 28 days Compressive Strength Test on Mortar

Test results for every specimen were plotted with strength as ordinate. It is observed here that with increase of WMP (replacing cement) the strength falls remarkably up to 10N when the WMP is 15% or 20%, the rate of fall being uniform up to 15% replacement (Fig. 1).

![Figure 1: 28 Days Compressive Strength of Mortar Mix (1: 3) with Partial Replacement of Marble](image)

This trend can be attributed to decrease in adhesive strength between the surface of marble powder and cement. When marble waste granules are partially replaced in fine aggregate by weight then there is increase in compressive strength at each curing age. This trend is shown only up to 15% replacement of fine aggregate with marble granules. This trend can be attributed to the marble granules to have cementing properties. On increasing the percentage replacement beyond 10%, there is a slight reduction in the compressive strength value. Figure 2 & Figure 3 shows the increase in compressive strength of mortar cube with curing days.
3.2 Concrete Mix

3.2.1 Workability

It is observed here that degree of workability is medium as per IS 456-2000. The slump values of the concretes obtained from waste marble granules mix are almost identical in the same water-cement ratio, with the same cement and WMG contents as illustrated in Fig. 4. This means that the effect of partially replacing fine aggregates with varying weight percentage of marble granules can be negligible for practical purposes.
3.2.2 Compressive Strength

The test results are also presented graphically in Figure 5. By increasing the waste marble granules the compressive strength values of concrete tends to increase at each curing age. This trend can be attributed to the fact that marble granules possess cementing properties. It is also as much effective in enhancing cohesiveness due to lower fineness modulus of the marble powder or granules both. Furthermore, the mean strength of concrete mixes with marble granules was 5-10% higher than the reference concretes. However, there is a slight decrease in compressive strength value concrete mix when 20% marble granule is used as compared with that of 15% marble granule mix.

3.2.3 Flexural Strength Test

The results of the flexural strength tests for the waste plastic mix concrete are illustrated in Fig. 6. The flexural strength calculations are done as per IS: 516-1959. These results show that the flexural strength of waste marble mix concrete increases with the increase of the
waste marble ratio in these mixtures. This trend can again be attributed to the fact that marble granules possess cementing properties.

![Figure 6: Flexural Strength Test Results](image)

4. Conclusions

4.1 Mortar Mix

When marble powder is partially replaced in cement by weight, there is a marked reduction in compressive strength values of mortar mix with increasing marble powder content when compared with control sample at each curing age. No mortar cube with partial replacement of marble granules conform to the standard of IS: 8112 – 1989. Surprisingly when sand is partial replaced by marble powder, all mortar cubes except that replacement of 20% does not conform to IS: 8112 – 1989. On increasing marble waste fine aggregate ratio i.e. when marble waste / granules are partially replaced in fine aggregate by weight then there is increase in compressive strength values of marble waste mortar at each curing age.

4.2 Marble Mix Concrete

The slump values of the concretes obtained from waste marble granules mix are almost identical in the same water-to-cement ratio, same cement content and same marble granules type. Degree of workability is medium conforming to IS: 456 – 2000. The mean strength of all concrete mixes with marble granules was 5-10% higher than the references concrete conforming to IS: 456 - 2000. The flexural strength of waste marble mix concrete increases with the increase of the waste marble ratio in these mixtures.

5. References


