Effect of Marble Dust Powder on the Properties of Fresh and Hard Concrete

Shekhar Singh¹, Hanumant Sharan Singh², Nakul Gupta³, K Hemalatha⁴, Sudarshan T A⁵*, Navdeep Singh⁶, Praveen⁷, Q. Mohammad⁸

¹Department of Civil Engineering, Moradabad Institute of Technology, Moradabad, Uttar Pradesh-244001, India.
²Department of Civil Engineering, Maharishi University of Information Technology, Lucknow, Uttar Pradesh-226020, India.
³Department of Civil Engineering, GLA University, Mathura, Uttar Pradesh, India-281 406
⁴Department of Civil Engineering, GRIET, Hyderabad, Telangana-500090, India.
⁵Department of Mechanical Engineering, New Horizon College of Engineering, Bangalore.
⁶Lovely Professional University, Phagwara, India
⁷Lloyd Institute of Engineering & Technology, Knowledge Park II, Greater Noida, Uttar Pradesh 201306.
⁸Hilla University College, Babylon, Iraq.

Abstract. The goal is to investigate the potential for employing byproducts from various industrial processes in the creation of ground-breaking mortar and concrete. The dust produced during the marble-cutting operation is put to good use. Different percentages of this garbage were recommended to be used in conjunction with or in place of cement in the making of concrete. The research looked into the possibility of using marble dust, which is produced during the shaping of marble blocks, as a cementitious material in concrete. In areas where they are readily available and can reduce construction costs, the study found that dust from marble slabs could be employed as a cementitious material in concrete mixtures. The discarded marble dust is mixed with cement in proportions of 5, 10, 15, and 20% of the standard concrete mix. Both the fresh and hardened characteristics of the produced combinations were investigated. Compressive and tensile strengths were measured after being cured for varying periods of time, both when marble dust was used as a partial replacement and when it was not.

Keywords: Concrete, Marble Dust Powder, Compression Testing Machine, Slump test, Split Tensile Testing.

1 Introduction

*Corresponding Author: sudarshan88ta@gmail.com

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In the world of construction, concrete is a material of primary importance. The generation of greenhouse gases is directly impacted by the massive cement production in industries [1], [2]. The ability to produce high-quality cement is adversely affected by shortages of high-quality limestone. Due to increased shrinkage and more precise determination of heat of hydration, the quality of hardened High Strength Concrete is negatively impacted by an increase in cement content. It drives up construction costs and can be harmful to the environment if waste is dumped in uncontrolled areas [3-5]. Many studies have focused on blended cements in which wastes partially replace Portland cement clinker (PC). There will be less of an impact on the environment from pollution and the depletion of natural resources thanks to developments in concrete technology. Substituting alternative materials can save money, cut down on energy use, produce equivalent or better results, and pose fewer risks to human health and the natural world [6-8].

The composition and microstructure of the hydrated product are greatly influenced by these elements due to their involvement in the hydraulic processes. Partially substituting industrial waste like marble dust in cement can help alleviate all these issues. The quarrying and cutting of marble results in the creation of both solid waste and stone slurry. Stone slurry is a semi-liquid fluid composed of particles from the sawing and polishing processes and water used to cool and lubricate the saws and polishers. Solid trash is the consequence of rejects at mine sites or processing units [9]. About 40% of the stone industry's end product is the slurry that is created during processing. Since the annual output of the stone sector is 68 million tonnes of processed products, this is important information. Marble has been utilised as flooring, cladding, and other construction material since ancient times [10]. Nowadays, one of the world's environmental issues is the way in which the industry disposes of marble dust, a material consisting of very fine powder. Since marble processing is one of India's most successful businesses, the country's policy of settling marble dust through sedimentation and then dumping it elsewhere has serious environmental and public health consequences [11]. This means the scientific and industrial communities need to work together to adopt more environmentally friendly procedures. Physical and mechanical qualities of both fresh and hardened concrete have been studied in relation to varied marble dust levels due to the fact that it is both an inexpensive material and an enhancer of the properties of the concrete [12].

In this investigation marble dust powder was used as a substitution of cement at level of 5%, 10%, 15% and 20% and checks the impact on the properties of fresh and hard concrete.

## 2 Materials

The investigation employed 43 grades of Ordinary Portland Cement that met IS 8112:2013 standards [13-14]. The specific gravity of cement was 3.12 and setting time of cement at initial and final state were 78 minutes and 192 minutes [15]. Fine aggregate consists of particles with sizes ranging from 4.75 millimetres to 150 microns. Fine aggregate used must meet the specifications of IS 383:1970 [13], which is met by using locally available river sand that has been sieved through a 4.75mm IS sieve. Sand has a fineness modulus of 3.28 and a specific gravity of 2.63. Both the un compacted and compacted bulk densities are 1665 Kg/m3, whereas the water absorption is 1.14 percent. As coarse aggregate, sizes between 20 mm and 4.75 mm are typically employed [16-21]. Coarse aggregate is sourced from a nearby quarry and is required to meet IS 383:1970 standards. The maximum size of the 20 mm coarse aggregate has a specific gravity of 2.68 and a fineness modulus of 6.45. Bulk densities of 1590 Kg/m3 (un compacted) and 1810 Kg/m3 (compacted) were measured, with water
absorption of 1.48%. The Marble dust powder was gathered from a local manufacturing facility in Faridabad, Haryana, India. The powdered marble has a specific gravity of 2.68 and a water absorption rate of 0.94 percent. Before being added to the concrete, it was sieved via an IS-90 micron sieve. The chemical composition of cement and marble dust powder were shown in table 1.

Table 1. Chemical composition of marble dust and cement

<table>
<thead>
<tr>
<th>Composition</th>
<th>Marble Dust Powder (%)</th>
<th>Cement (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO</td>
<td>43.20</td>
<td>62.2</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>2.50</td>
<td>5.4</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>1.90</td>
<td>3.6</td>
</tr>
<tr>
<td>MgO</td>
<td>2.70</td>
<td>0.8</td>
</tr>
<tr>
<td>SiO₂</td>
<td>13.8</td>
<td>19.5</td>
</tr>
<tr>
<td>SO₃</td>
<td>0.07</td>
<td>2.8</td>
</tr>
<tr>
<td>K₂O</td>
<td>0.60</td>
<td>0.7</td>
</tr>
</tbody>
</table>

3 Methodology

Specimens of various shapes and sizes were cast by adjusting the mix ratio and substituting marble powder for cement [22]. These shapes and sizes included a cube with a 150 mm side, a cylinder with a 150 mm diameter and 300 mm height. Compression testing machines (CTM) with capacities of 1000 KN and space rates of 2.5 KN/sec were used to evaluate concrete samples aged 7, 14, and 28 days. Table-3 displays the results of a slump test, which may be used to evaluate the workability of newly mixed concrete, for several percentages of marble powder replacement (0, 5, 10, 15, and 20%). Adding marble powder to concrete has been shown to reduce its workability. The mix id of samples was shown in table-2.

Table 2. Mix ID of marble dust powder and cement

<table>
<thead>
<tr>
<th>Sample Name</th>
<th>Marble Dust (%)</th>
<th>Cement (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N100</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>N95M5</td>
<td>5</td>
<td>95</td>
</tr>
<tr>
<td>N90M10</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>N85M15</td>
<td>15</td>
<td>85</td>
</tr>
<tr>
<td>N80M20</td>
<td>20</td>
<td>80</td>
</tr>
</tbody>
</table>
4 Result and Discussion

4.1 Workability

For the purpose of determining the concrete's workability, a slump test was conducted, with the values of various concrete mix samples being measured and compared to the guidelines established by IS 7320 (1974). Marble powder was used to replace sand and cement at 0%, 10%, 15% and 20% replacement rates individually and in combination. Figure 1 compiles the overall findings from the tests [24].

The increased specific area and porous nature of marble dust powder particles meant that they absorbed more water, reducing the amount of water available for lubricating the cement and reducing its workability [25-28]. And the slump went down as the percentage of marble dust powder used in the mix went up. When fine-sized particles were used, workability of the concrete decreased, which is consistent with earlier findings.

4.2 Compressive Strength

All of the concrete mixtures were tested for compressive strength at 7, 14, and 28 days of curing, as required by IS 516 (1959). The specimens were cubes of 150 mm on a side, 150 mm in height, and 150 mm in depth, and were evaluated for compressive strength. Figures 2 provide a visual summary of the findings.
The results reveal that the strengths at 7, 14, and 28 days rise with enhanced in substitution level up to 10%; after that, a drop is noted [29-31]. Findings suggest that a compressive strength of around 10% is optimal for the materials used in this investigation. Up to 10% substitution, the impact of higher fineness of marble dust powder particles seems leading, increasing density and compactness of the mix. The water to cement ratio is lesser due to high absorption of marble dust powder particles, increasing strength and decreasing voids [32].

### 4.3 Split Tensile Strength

All of the concrete mixtures were tested for split tensile strength at 7, 14, and 28 days of curing. 150 mm (diameter) by 300 mm (length) cylinders were split to determine the tensile strength (length). Figures 3 provide a visual summary of the findings.
The split tensile strength at 7, 14 and 28 days were 3.3, 3.7 and 4MPa for 10% replacement of marble dust powder with cement [33-35]. Increases in both compressive and tensile strengths follow a similar pattern. Clearly, the parameter adheres to the same criteria as compressive strength. Tensile strength is another parameter for which 10% seems to be the sweet spot for both maintenance and replacement.

4.4 Ultrasonic Pulse Velocity

The UPV values were calculated using the Indian standard method IS: 13311 (Part 1) - 1992. The values of UPV test were shown in figure 4.
The major goal of a UPV test is to determine the quality and uniformity of the material and to discover internal faults such as voids, cracks, and other similar defects [36-43]. Even if the compressive strength reduces beyond 10% substitution, the improving UPV with increasing substitution amount suggests that the addition of marble dust powder increases the homogeneity of the material.

5 Conclusion

1. Compressive and tensile strength in concrete are both improved by using marble dust powder at a replacement rate of 10% and higher. Because marble dust powder binds to the cement matrix and the water-to-cement ratio is reduced, the strength is increased.
2. The workability of concrete were decreasing as the increasing the level of marble dust powder in the concrete mix.
3. The UPV data show that the homogeneity of the material improves with increasing levels of marble dust powder replacement, despite a general weakening of the material.

References


emission characteristics of a CRDi diesel engine fueled with WHDPE oil/diesel blends. Fuel, 278, 118304.