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# Utilization of Marble Powder in Making of Cement Concrete and Analysis of Its Strength Characteristics

**Manish Kumar[1], Hirendra Pratap Singh[2], Rakesh Sakale[3]**

[1]PG Student, [2]Assistant Professor, [3]HOD & Professor,
[1, 2, 3]School of Research and Technology, People's University, Bhopal, Madhya Pradesh, India

## ABSTRACT

Cement clinker production is a high-energy, resource-intensive process that contributes significantly to annual global detrimental greenhouse gas emissions. Reduced clinker content in the manufacture of concrete by partial substitution of cement with supplemental cementitious materials is one possible technique to alleviate environmental difficulties or problems associated with cement-based materials. Quarrying typically generates a large amount of waste. In general, processed quarrying production accounts for 30% of total stone removed, whereas waste (quarrying trash and processing waste) accounts for 70% of total stone extracted during this procedure. This wastage not only causes financial losses but also produces environmental issues, so in this experimental inquiry programme, we partially substitute the cement with marble dust in varied percentages, i.e. 0%, 5%, 10%, and 15%.

In this project, we make concrete samples with varied mixes containing different percentages of marble dust. We execute several tests on these prepared samples, such as compressive strength testing, split tensile strength testing, and flexural strength testing. When we compared the test results of the prepared samples to conventional concrete, we discovered that with a partial replacement level of cement of up to 10% by marble dust, all physical properties such as compressive strength, split tensile strength, and flexural strength increased.

***KEYWORDS:*** *Compressive Strength, Split Tensile Strength, Flexural Strength*

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## I. INTRODUCTION

Binding material, fine aggregate, coarse aggregate, and water are all used to make concrete. Concrete's value is enhanced by the fact that it may be constructed to withstand the worst environmental conditions. In recent years, concern about environmental issues has grown, and a shift from the past's mass-waste, mass-consumption, mass-production culture to a zero-emission civilization is increasingly recognized as significant. Normally, lime stone powder and marble dust do not harm the environment because they do not emit pollutants, but they can injure humans and animals if not handled carefully, and they are less environmentally beneficial because they are non-biodegradable. As a result, new technology development has been necessary. Calcium carbonate and silica, alumina, iron oxide, calcium oxide, and magnesia are all chemical components of lime stone powder and marble dust, respectively. Until now, these forms of marble dust have been widely employed as pozzolana materials in cement and aggregate mixtures for civil engineering projects. The addition of lime stone powder and marble dust to cement concrete raises the cement's alkali content. It also aids in the production of bricks and ceramics, protects raw resources, and reduces energy consumption and trash transported to landfills.

Metamorphic marble is a metamorphic stone. It comes from metamorphosed limestone, which is reformed into an interlocking structure of calcite, dolomite, or a combination of both minerals after being exposed to high temperatures and pressure. Furthermore, commercial marbles may contain any other calcium carbonate-based stone that may be polished, such as limestone. Despite being sedimentary rocks, they are primarily made up of calcium carbonate and marble. This means that the phrase "commercial marble" used in the dimension stone industry encompasses both metamorphosed marble and sedimentary limestone, despite the fact that they derive from different rock types. As a result, these rock types will be considered in the future when referring to "commercial marble" or "calcareous stone" in this study.

The marble business has grown in importance over the previous two decades. Marble deposits can be found in the United States, China, India, France, Belgium, and other nations. Because it is smaller in size and/or has an uneven shape, 30 percent of marble is scrapped during processing. During the extraction process, millions of tonnes of marble powder are processed annually all over the world. As a result, the massive amounts of marble dust created in these sectors cause severe environmental damage. Allergies to marble dust are also a possibility. Apart from these drawbacks, marble powder is one of the most useful substances on the world, with applications in a variety of fields and in a variety of shapes. It's mostly utilized as a supplement, filler, or additive in a variety of industrial settings. Many studies have looked into marble waste as a possible construction material in the past.

It's mostly utilised as a supplement, filler, or additive in a variety of industrial settings. Many studies have looked into marble waste as a possible construction material in the past. In Asian countries, waste management has become a serious concern. Asia's influence in global economic development has expanded in recent decades. In reality, this region handles a third of the world economy. Despite this, people in Asian countries have a wide range of economic and living conditions. "Asian countries" is a broad word that encompasses countries with similar geographic locations but differing economic output, industrialization levels, and urbanisation percentages compared to rural areas. All of these variables could have an impact on waste output. According to World Bank Analytical Classifications, this geographic region includes low-income countries (e.g. Bangladesh, Cambodia, and the Democratic People's Republic of Korea), developing countries (e.g. India, Pakistan, Sri Lanka, and Vietnam), and some of the world's top economies (China). About 60% of industrial and hazardous waste is dumped in landfills in these countries, while up to 10% is dumped in the ocean, and the rest is either incinerated or chemically treated, resulting in higher waste management costs.

To address this issue, researchers are currently conducting research to find ways to overcome these types of issues economically.

The following are some proposals for waste management solutions:

1. Proper waste management in terms of waste prevention, re-use, material recycling, composting, recovery, and final disposal.
2. In the case of natural stone waste, there is a growing recognition that wasted stones from the quarrying industry should not be regarded waste but rather potential by-products of tremendous economic value.

## II. LITERATURE REVIEW

**Abdul Ghani, Zeeshan Ali , Fasih Ahmed Khan,· Said Rehan Shah, Sajjad Wali Khan, Muhammad Rashid (2020)**, presented the research paper on the use of marble dust, the incorporation of Waste Marble Powder as a fine aggregate in conventional concrete has a positive impact on the concrete properties. The WMP was used as a partial substitute of sand at 20%, 40%, 60%, and 80%. The workability, bulk density, compressive strength, tensile strength, and water penetration rate of concrete were evaluated. The recycled product results were compared with the control mix (SR-0). The incorporation of WMP in concrete is one of the viable solutions to protect the environment and natural resources. The use of constant w/c ratio for all mixes resulted in a reduction in the workability when WMP was introduced as a sand replacement in concrete. As compared to SR-0, the overall reductions at 20%, 40%, 60%, and 80% replacement were found to be 26%, 65%, 93%, and 100%, respectively. Due to the relatively low density of WMP, the unit weight of concrete was found to be decreased with the increasing percentages of WMP. Less porous concrete was produced as compared to reference concrete with the use of WMP as a partial substitute for sand. The compressive strength of concrete was improved with the use of WMP up to 40% replacement of fine aggregate; beyond this limit, the strength consistently decreased with the increase in WMP in concrete and was thus minimum for 80% replacement. There were no marked variations in the split tensile strengths with the addition of increased percentages, as a substitute to sand. The permeability of concrete was found to decrease with the increasing percentages of sand replacement; however, a sudden rise in the permeability was observed at 80% replacement, which was even lower than the control mix. Based on this study, the use of WMP up to 40% as partial replacement of sand is recommended, as overconsumption reduces the strength and decreases the workability of concrete.

**Ofuyatan, O. M., Olowofoyeku, A. M., Obatoki, J., and Oluwafemi, J. (2019),** presented the research paper on the addition of waste marble dust as a constitutive material of concrete had a good slump of fresh concrete. At 25%, marble dust had a strength greater than the control at 56days. However, the addition of waste marble dust increased the tensile strength by 17% at 25%. The addition of waste marble dust increased the compressive strength of concrete by 11% at 25%. Marble dust content. The optimum percentage for replacement of sand with Marble waste is at 25% for both cubes and cylinders. This research put forth a simple and effective way to minimize costs incurred in the production of concrete since Waste Marble Dust is cheaply available. Based on the observations gotten from the test results and analyses of WMD concrete, the integration of waste marble dust in making green concrete would be a promising strategy to improve the performance of concrete. The significant improvement in toughness allows WMD concrete resist greater amount of stress and hence, concrete structures made of WMD concrete have greater load bearing capacity.

**Nadhir Toubal Seghir , Mekki Mellas , Łukasz Sadowski, Aleksandra Krolicka ,Andrzej Z and Krzysztof Ostrowski (2019),** The utilization of WMD (Waste Marble Dust) as a partial replacement of cement does not significantly act the flow property of fresh mortar, where the results were found to be compatible with ASTM C270. The macro properties of mortars were affected negatively due to the incorporation of WMD and to the air-curing conditions that caused an incomplete hydration process in which the compressive strength and apparent density decreased, and the porosity increased. The compressive strength and apparent density of ACM mixed with and without WMD grew with an increase in curing duration and fell with a corresponding increase of WMD.

## III. MIX DESIGNING AND SAMPLE PREPARATION

### 3.1. General:-

The fourth part of our thesis covers the mix design process (I.S. Code) as well as numerous tests performed on test samples created by these mixes. This chapter will conduct several tests on the concrete mix having partial replacement of PPC by lime stone powder and marble dust, such as workability by slump cone test, compressive strength test, and flexural strength of the concrete mix.

### 3.2. Method of Concrete Mix Design:-

Concrete mix design is the process of selecting suitable concrete materials and determining their relative proportions with the goal of producing a concrete with the needed strength, workability, and durability while being as cost-effective as feasible. The BIS mix design approach was used in our study, which is based on Bureau of Indian Standards BIS: 10262-2009.

### 3.2.1. BIS Mix Design Method:-

The basic steps involved in the concrete mix design process can be summarized as follows:

1. The desired mean strength is determined from the stated characteristic strength based on the level of quality control.
2. For the goal mean strength, the water/cement ratio is chosen and the durability criteria are confirmed.
3. The slump cone test is used to determine the water content for the acceptable workability.
4. The cement content is calculated using the water/cement ratio indicated by the slump cone test and the water content obtained in steps (ii) and (iii), and the water requirements are confirmed.
5. The relative percentage of fine and coarse aggregates is chosen based on coarse and fine aggregate characteristics.
6. The proportions of the trial mix are determined.
7. The compressive strength of the trial mixes is verified, and appropriate adjustments are made to arrive at the final mix composition.

**Table-1 Proportion of Different Materials in our Mix**

| Cement | Fine aggregate | Coarse aggregate | Water |
|---|---|---|---|
| 372 | 724.68 kg | 1130.58 kg | 186 litre |
| 1 | 1.948 | 3.039 | 0.50 |

#### 3.2.2.1. Preparation of Trial Mixes:-

Four trial mixes were created using the Bureau of Indian Standard (BIS) approach for concrete mix design. Two experimental mixes were made with a W/C ratio of 0.50, while the other two were made with a W/C ratio of 0.55. For each mix, six cubes were cast and examined after seven and twenty-eight days. Table-2 summarizes the proportions of various ingredients in the mix.

**Table-2 Quantities Per Cubic Meter for Trial Mixes (M-25)**

| Mix No. | W/C ratio | Slump (mm) | Water ($l/m^3$) | Cement Kg/m3 | Sand $Kg/m^3$ | Coarse Aggregate $Kg/m^3$ | Average cube Strength at 7 days (MPa) | Average cube strength at 28 days (MPa) |
|---|---|---|---|---|---|---|---|---|
| **Mix-A** | **0.50** | **50** | **186** | **372** | **724.68** | **1130.58** | **22.1** | **32.3** |
| Mix-B | 0.50 | 100 | 208 | 416 | 633.18 | 1162.58 | 19.93 | 30.2 |
| Mix-C | 0.55 | 50 | 186 | 338.18 | 724.32 | 1126.62 | 20.53 | 31.1 |
| Mix-D | 0.55 | 100 | 208 | 378.18 | 712.33 | 1139.52 | 20.95 | 30.8 |

Mix-A was chosen as the design mix from all of the trial mixes because its average cube strength is exceptionally near to the concrete's objective mean strength with acceptable cement content.

### 3.3. Prepared Mixes for Testing of the Compressive Strength:-

We prepared various concrete mixes for the fabrication of cubes for compressive strength testing with varying percentages of partial substitution of PPC by marble dust in the range of 5%, 10%, and 15%.

**Table-3 Prepared Mixes for Tests of Compressive Strength of Concrete**

| Mix No. | W/C ratio | Slump (mm) | Marble dust | Water ($l/m^3$) | Cement $Kg/m^3$ | Sand $Kg/m^3$ | Coarse Aggregate $Kg/m^3$ |
|---|---|---|---|---|---|---|---|
| Mix-I | 0.50 | 50 | 0% | 186 | 372 | 724.68 | 1130.58 |
| Mix-II | 0.50 | 50 | 5% | 186 | 353.4 | 719.39 | 1143.52 |
| Mix-III | 0.50 | 50 | 10% | 186 | 334.5 | 719.39 | 1143.52 |
| Mix-IV | 0.50 | 50 | 15% | 186 | 316.2 | 719.39 | 1143.52 |

## IV. ANALYSIS OF RESULTS

### 4.1. General:-

Series of the tests were carried out on the samples prepared with various mixes i.e. variable percentage of supplementary cementitious materials in partial replacement of cement (5%, 10% and 15%). The tests conducted were compressive strength, split tensile strength and flexural strength of concrete mixes. The obtain results are given in the Table below.

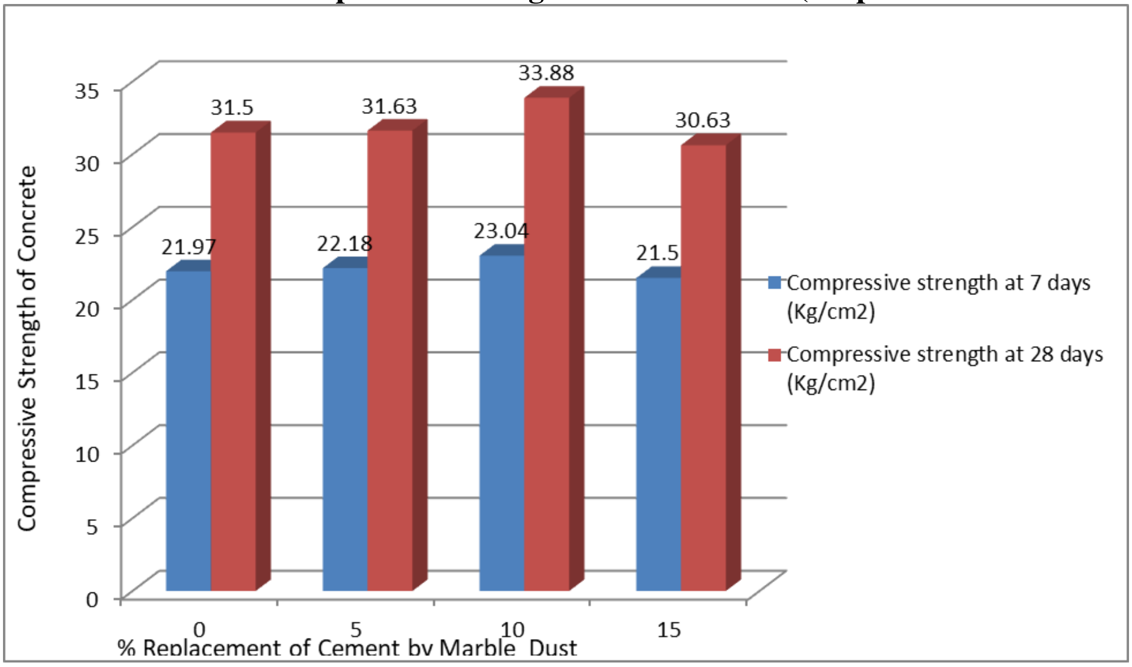
### 4.2. Compressive Strength Test Results:-

The laboratory test results are presented below in the tabular form for different mixes with variable percentage of marble dust.

**Table-4 Test Results of Compressive Strength of all Mixes**

| S. No. | Marble dust (%) | Cement Content (%) | Compressive strength at 7 days ($Kg/cm^2$) | Compressive strength at 28 days ($Kg/cm^2$) |
|---|---|---|---|---|
| 1 | 0 | 100 | 21.97 | 31.50 |
| 2 | 5 | 95 | 22.18 | 31.63 |
| 3 | 10 | 90 | 23.04 | 33.88 |
| 4 | 15 | 85 | 21.50 | 30.63 |

**Graph-1 Test Results of Compressive Strength of all the Mixes (Prepared with Marble Dust)**




After analysing all of these test results, we discovered that when 10% cement is replaced with Marble dust, compressive strength increases by around 5 percent after 7 days and by approximately 8% after 28 days.

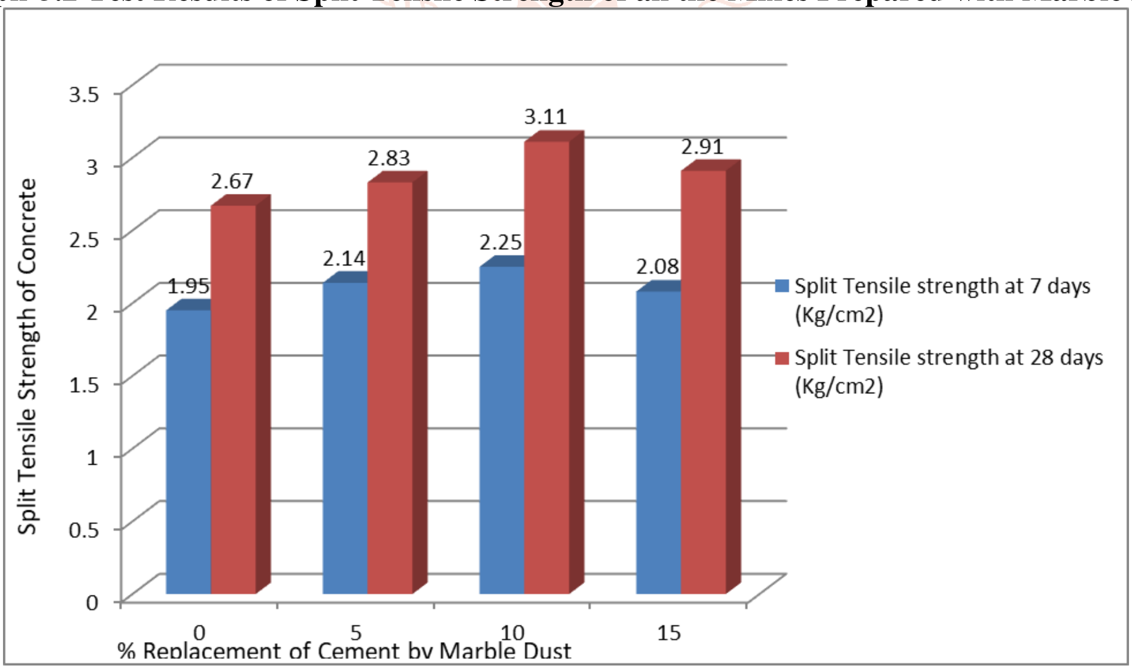
### 4.3. Split Tensile Strength Test Results:-

The laboratory test results are presented below in the tabular form for different mixes with variable percentage of marble dust.

**Table-5 Test Results of Split Tensile Strength of all the Mixes Prepared with Marble Dust**

| S. No. | Marble dust (%) | Cement Content (%) | Split tensile strength after 7 days (Kg/cm$^2$) | Split tensile strength after 28 days (Kg/cm$^2$) |
|---|---|---|---|---|
| 1 | 0 | 100 | 1.95 | 2.67 |
| 2 | 5 | 95 | 2.14 | 2.83 |
| 3 | 10 | 90 | 2.25 | 3.11 |
| 4 | 15 | 85 | 2.08 | 2.91 |

**Graph-5.2 Test Results of Split Tensile Strength of all the Mixes Prepared with Marble Dust**




After analyzing all of these results, we can conclude that marble dust increases the compressive strength of a concrete mix up to 15.5% and 16.5% beyond 7 and 28 days of curing, respectively, until a certain point, after which it begins to lose strength.

## V. CONCLUSION AND RECOMMENDATION FOR FUTURE RESEARCH

### 5.1. Conclusion:-

The main objective of this research was to understand the effect of partial replacement of cement by marble dust. In this study we determine the composition of the marble dust and their normal consistency and the value of setting times. For determination of compressive strength, split tensile strength and flexural strength of the various mix prepared with partial replacement of cement by lime stone powder and marble dust. These are the following conclusions of this research.

1. By this research we found that the compressive strength of concrete can be increase up to 5% at 7 days curing and 8% at 28 days curing with partial replacement of cement by marble dust.
2. We found that the split tensile strength of concrete can we increase up to 15.5% and 16.5% at 7 days and 28 days respectively by replacing 10% cement by marble dust.
3. The results for flexural strength test are for marble dust 17.20% and 18.50% increment respectively for 7 days and at 28 days curing.

By these test results we can say that lime stone powder and marble dust can be a useful material in civil engineering construction work as a partial replacement of cement.

### 5.2. Recommendation for Future Research:-

Theses are some recommendation for future work in this field.

1. In future research work some additional materials like glass powder, granite dust and other stone's powder with these materials could be tested for all types of strength.
2. The effect of using admixtures in these mixes can be tested in future study.
3. The long term properties of the various types structures made by these mixes could be study for detailed information on these materials.

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