# LABORATORY STUDY ON THE CONCRETE USING MARBLE POWDER AS A PARTIAL REPLACEMENT FOR CEMENT

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**Abstract:**

Concrete plays a very important part in civil engineering construction, consisting of aggregate, cement, water, and occasionally additives, hence exhibiting amazing strength and versatility. In recent times, there has been a noticeable reduction in natural resources due to their extensive utilization. Therefore, it is necessary to employ alternate materials for the production of concrete. Various industrial waste products, including fly ash, slag, and marble powder, are being utilized as substitutes in concrete production.. The current study focuses on the utilization of marble dust as a partial substitute for cement in laboratory. The study demonstrates that the partial replacement of marble powder in concrete results in enhanced strength and cost reduction. Furthermore, this solution effectively addresses the issue of marble dust disposal, mitigating the potential environmental damage.

**Index Terms**- Concrete, Industrial Waste, Marble Powder, Environmental damage

## I. INTRODUCTION

Concrete is a building material that is made by mixing cement, coarse aggregate, fine aggregate cement, sand with the right amount of water. Over time, the concrete hardens. Most of the time, Portland cement is what is used to make concrete.
Concrete is the most common building material used all over the world. In civil engineering construction, concrete is used to make buildings, roads, bridges, dams, and many other structures. With the improvement of concrete technology, energy sources and natural resources can be used. This helps to reduce the amount of pollution in the environment even more. One smart way to cut down on the amount of wasted marble is to use it in building projects. Use of marble powder as a possible cementitious material in the making of concrete will also help with problems of disposal and environmental pollution.

### 1.1 Types of concrete

Some of the important types of concrete are listed below:
**Plain Concrete:** This kind won't have any reinforcement in it. Most of the time, a 1:2:4 or 1:1.5:3 mix is used for the concrete preparation. Density ranges from 2200 to 2500 kg/ $m^3$ for plain concrete.
**Reinforced Concrete:** This concrete represents reinforcement being introduced in concrete to sustain tensile strength. For R.C.C. work consists of steel bars or meshes, commonly used to build the superstructures.
**Prestressed Concrete:** This type of concrete is most often used in heavy structures. It is made up of cables or bars in the concrete that are put under stress before the load is applied during service. PSC is used to build structures such as bridges and roofs with long spans.
**Polymer Concrete:** This concrete will be the same as normal concrete, except that instead of cement, polymer will be used to hold the gravel together. These are helpful for reducing voids and volume in bulk, and they also help to get the maximum density possible.
**Asphalt Concrete:** is a mixture of asphalt and small rocks. It is used in parking lots, on surface roads, at airports, and in the core of dam embankments.

### 1.2 Different types of alternate materials for cement

Some of the important alternate materials used as a partial replacement for cement in concrete are listed below:
**Fly ash** is a residual substance derived from the combustion of coal in power plants. It exhibits pozzolanic characteristics, which enable it to undergo a chemical reaction with calcium hydroxide, resulting in the formation of supplementary cementitious compounds. The inclusion of fly ash in concrete serves to decrease the reliance on cement while simultaneously improving workability, durability, and resistance to specific chemical substances.
**Ground Granulated Blast Furnace Slag (GGBFS)** is a residual material that arises as a result of the iron production process. The composition of concrete includes silicates and aluminates, which play a significant role in its cementitious capabilities. Like fly ash, slag has the potential to enhance the performance of concrete by reducing the reliance on cement.
**Rice Husk Ash (RHA)** is derived from the processing of rice husk, an agricultural waste, and has pozzolanic characteristics. It possesses the potential to serve as a partial substitute for cement, enhancing the development of strength and durability.

**Silica Fume (SF)** is a fine particle that is produced as a byproduct of the production of silicon and ferrosilicon alloys. It has been found to significantly improve the mechanical qualities and durability of concrete. The enhancement of particle arrangement results in improved packing efficiency, resulting in heightened structural integrity and decreased permeability.

**Natural pozzolans,** such as volcanic ash, calcined clay, and shale, have been historically employed in the production of robust concrete. These materials exhibit a chemical reaction with calcium hydroxide, resulting in the formation of supplementary cementitious compounds. This reaction serves to decrease the dependence on cement.

### 1.3 Marble powder as an alternate material to cement in Concrete

The byproduct created during the cutting and processing of marble stones is marble dust powder. Researchers and engineers are looking into the possibility of using marble dust powder as a partial replacement for cement in concrete as sustainability gains popularity in the building sector. This strategy strives to improve the qualities of concrete in addition to waste management. However, there are advantages and disadvantages of using marble dust or powder in concrete.

Some of the advantages are listed below:

**Environmental Sustainability:** Using marble dust powder helps prevent waste from going to landfills, lowering the environmental effect of disposal, and promoting environmentally friendly building methods.

**Reduced Cement Consumption:** By substituting marble dust powder for some of the cement, the need for this energy and carbon dioxide (CO2) consuming substance can be lessened. Lower carbon dioxide emissions from producing concrete results in less environmental pollution.

**Fine particles** in marble dust powder can improve the workability of concrete mixtures, making them simpler to handle and place during construction.

**Improved Strength and Durability:** Concrete mixes with marble dust powder, properly constructed, can display improved compressive and flexural strengths. The powder's pozzolanic characteristics further improve durability by decreasing permeability and increasing resistance to chemicals and harsh conditions.

**Aesthetic Appeal:** Using marble dust powder can introduce aesthetic variances in the appearance of concrete, possibly leading to aesthetically pleasing architectural finishes.

Likewise, some of the disadvantages are listed below:

**Lack of Consistency:** Marble dust powder's characteristics might vary depending on the source and processing techniques, resulting in inconsistent performance as a cement substitute. To guarantee constant concrete quality, thorough testing and quality control are necessary.

**Setting Time and Strength Gain:** The addition of marble dust powder may result in slower early-age strength growth and prolonged setting times, which may impact construction schedules and initial load-bearing capacities.

**Particle Size Distribution:** The mechanical characteristics and workability of concrete can be affected by the marble dust powder's particle size distribution. Poor compaction and decreased strength could result from an improper particle size distribution.

**Potential Alkali-Silica Reaction:** When marble dust is used in concrete, there may be a danger of alkali-silica reaction (ASR), which might cause cracking and lower long-term durability depending on the mineral makeup of the marble dust.

**Cost factors:** Regional differences might be found in marble dust powder availability and processing costs. Careful consideration must be given to whether employing marble dust powder as a cement substitute is cost-effective, depending on elements like transportation and regional market conditions.

### 1.4 Objectives of the Present Research

- Perform the basic tests on the components of concrete, including cement, M-sand, coarse aggregate, and marble powder.
- To prepare the design mix for M40 grade concrete as per Indian Standard (IS) 10262-2009.
- To determine the optimum percentage of marble powder for the partial replacement of cement.
- To conduct compressive strength on concrete cubes cast for the various percentages of marble powder for a partial replacement for cement.
- Comparison of results

## II. MATERIALS AND METHODOLOGY

### 2.1 Materials and Equipment

**Coarse Aggregate**: The material passing through the Indian Standard (IS) sieve 20 mm and being retained at 4.75 mm is used.

**Fine aggregate:** The material passing through the Indian Standard (IS) sieve 4.75 mm and being retained on 0.075 mm is used.

**Cement:** Ordinary Portland Cement (OPC) of grade 53, confirming to IS 12269-1987 is used.

**Water:** Clean, potable water is used.

**Superplasticizer:** For the workability of Concrete.

**Marble Powder:** As a Partial replacement of cement
**Concrete Mixer**: For proper mixing of concrete ingredients.
**Moulds:** Cube moulds of standard size (typically 150mm x 150mm x 150mm) made of steel or cast iron.
**Trowel, Scoop, and Vibrator**: Tools for Casting and Compacting concrete.
**Compression Testing Machine**: A hydraulic machine to apply compressive loads to the concrete cubes.

### 2.2 Preparation

**Mix Proportioning:** Design is carried out to attain a suitable water-cement ratio, aggregate-cement ratio, and other relevant parameters.
**Cube Moulds:** Ensuring that the cube moulds are clean and free from debris. Apply a thin layer of mold release agent or oil to facilitate cube removal after curing, as shown in Figure 1(a).
**Mixing:** materials are mixed in the mixer gradually by adding cement, aggregates, and water while continuously mixing until a homogeneous mixture is achieved. Mix for a minimum of 3-5 minutes to ensure thorough distribution of ingredients.
**Casting:** Place the cube moulds on a flat surface. Fill each mould in layers, compacting each layer using a trowel or scoop. Ensure proper compaction to eliminate voids and ensure uniform density.
**Finishing:** After filling, strike off the excess concrete using a straightedge or trowel. The surface should be smooth and level with the top edges of the mould.
**Curing:** Cover the moulds with a damp cloth or plastic sheet to prevent moisture loss. Allow the cubes to cure in a curing tank for 28 days. The Cubes are prepared by using cement along with different percentages of marble powder, say 0%, 5%, 15%, 15%, 20%, as a partial replacement for cement.

### 2.3 Testing

**Demoulding:** After 28 days of curing, carefully remove the cubes from the moulds.
**Compression Testing:** Place the cubes on the Compression Testing Machine's (CTM) platen, ensuring proper alignment with the load axis. The load should be applied gradually and smoothly.
**Load Application:** Start applying the load at a constant rate and continue loading until the cube fails (crushes) and the load begins to drop, as shown in Figure 1(b).
**Recording Data:** Monitor the load and deformation during the test. Record the maximum load sustained by the cube and the corresponding deformation.
**Calculations:** Calculate the compressive strength using the formula.

**Compressive Strength ($N/mm^2$) = Maximum Load (N) / Cross-sectional Area of Cube ($mm^2$)**

Figure1 (a) Casting of Concrete Cubes Figure1 (b) Testing of Concrete Cubes

## III. RESULTS AND DISCUSSIONS

The results of coarse aggregate, cement, and the obtained mix design for M40grade concrete are shown in Table 1, Table 2 and Table 3 respectively**.** The sieve analysis chart of all in aggregates is shown in Figure 2**.**

Table 1 Results of tests on Aggregate

| Sr No | Properties | Obtained Results | Permissible Limits as per IS Code | Method Adopted | Remarks |
|---|---|---|---|---|---|
| 1 | Aggregate Impact value, % | 18.56 | 30.0 | IS 2386 (Part IV) | Satisfactory |
| 2 | Aggregate abrasion Value, % | 14.10 | 35.0 | IS 2386 (Part IV) | Satisfactory |
| 3 | Specific gravity | 2.52 | 2.50-3.00 | IS 2386 (Part III) | Satisfactory |

| | | | | | |
|---|---|---|---|---|---|
| 4 | Water absorption , % | 0.90 | 2.0 | IS 2386 (Part III) | Satisfactory |
| 5 | Shape Test , % | 12.45 | 40 | IS 2386 (Part I) | Satisfactory |

Table 2 Results of Tests on Cement

| Sr No | Properties | Obtained Results | Permissible Limits as per IS Code | Method Adopted | Remarks |
|---|---|---|---|---|---|
| 1 | Type of Cement | -- | -- | -- | OPC 53 |
| 2 | Brand of Cement | -- | -- | -- | Birla Super |
| 3 | Specific Gravity | 3.12 | -- | IS 12269 (1987) | Satisfactory |
| 4 | Initial Setting Time, min | 37 | > 30 | IS 12269 (1987) | Satisfactory |
| 5 | Final Setting Time, min | 465 | <600 | IS 12269 (1987) | Satisfactory |
| 6 | Normal Consistency, % | 29 | 26-33 | IS 12269 (1987) | Satisfactory |

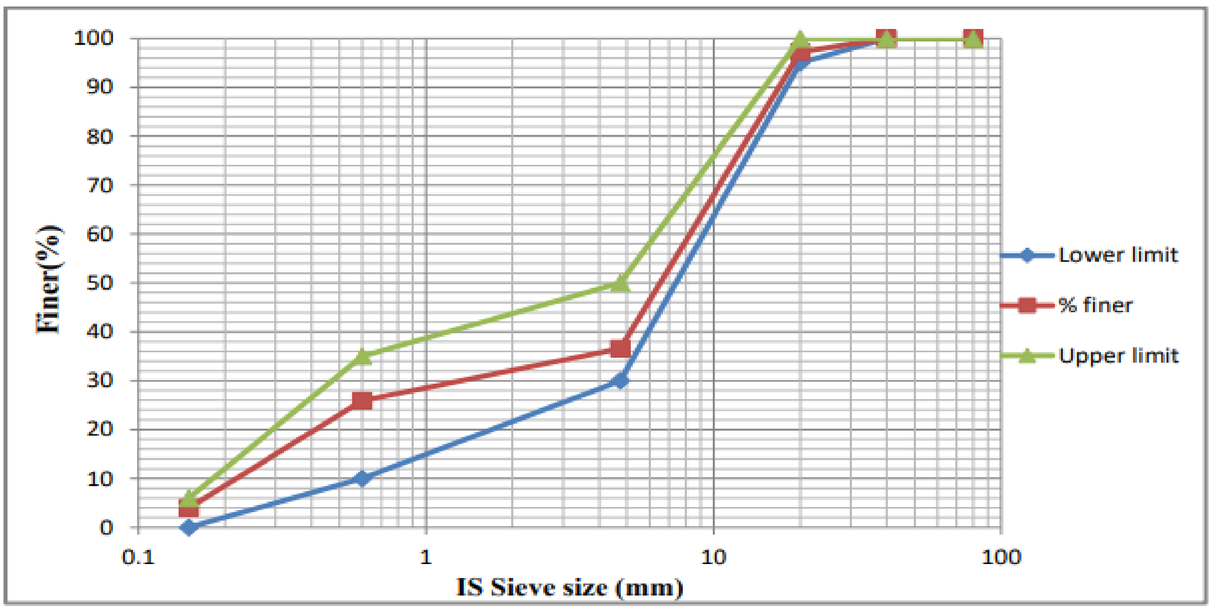


Figure 2 Sieve Analysis Chart of All in Aggregate

Table 3 Mix Design for M40 Grade Concrete

| Sr No | Materials | Weight in kg/m$^3$ |
|---|---|---|
| 1 | Cement | 395 |
| 2 | Coarse aggregate | 1123 |
| 3 | Fine aggregate | 856 |
| 4 | Water | 152 |
| 5 | Chemical admixture | 3.85 |
| 6 | Water/ Cement Ratio | 0.385 |

Table 4 shows that the optimum percentage of replacement of marble powder for cement is obtained at 10%. The materials used in the research, namely coarse aggregate, fine aggregate, and cement satisfy the requirement of relevant code specifications. The obtained cement content for M40 grade concrete is 395 kg/ cum of concrete with water to cement ratio of 0.385. The 10% partial replacement of marble powder increases the 28 day compressive strength by 16.20%

Table 4 Results of Compressive Strength of Concrete with Marble Powder

| Sr No | Marble Powder, (%) | 7 days Average Compressive Strength Value (N/mm$^2$) | 28 days Average Compressive Strength Value (N/mm$^2$) |
|---|---|---|---|
| 1 | 0 | 28.78 | 48.30 |
| 2 | 5 | 31.67 | 49.67 |
| 3 | **10** | **37.21** | **56.10** |
| 4 | 15 | 33.89 | 51.78 |
| 5 | 20 | 33.13 | 49.34 |

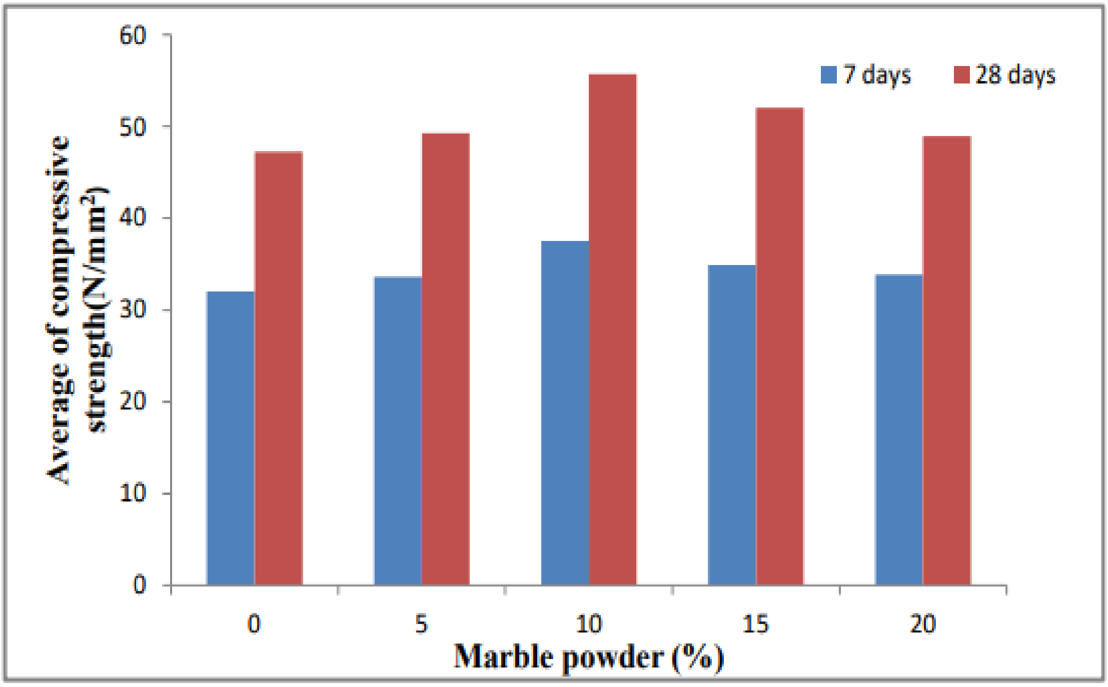


Figure 3 7 day and 28 day Compressive Strength of Concrete at different Percentages of Marble Powder

## IV. CONCLUSIONS

- The materials used in the present research, namely coarse aggregate, fine aggregate, and cement, satisfy the relevant code specifications.
- The Mix design for M40 grade concrete is obtained meeting the requirements of Indian Standard (IS) 10262-2009.
- The compression test results meet the minimum values of strength as per the code requirement. The optimum percentage replacement of marble powder is obtained at 10%.
- The 10% replacement of cement with marble powder increased the compressive strength of M40 grade concrete by 16.20%. This also considerably reduces the cost of concrete, which in turn reduces the cost of construction.

In summary, the research focused on exploring the feasibility of using marble powder as a partial replacement for cement in concrete, with the aim of enhancing the sustainability and performance of the building material. The study encompassed a comprehensive investigation of various aspects, from material characteristics and mix design to testing and analysis of the resulting concrete. In addition, it showed the potential benefits, including environmental sustainability, improved concrete properties, and potential cost reduction.

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