



# International Journal of Engineering Research and Science & Technology

[www.ijerst.org](http://www.ijerst.org)

ISSN : 2319-5991

Vol. 21 No. 4 (2025)



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## Research Paper

# EXPERIMENTAL STUDIES ON STEEL FIBRE REINFORCED CONCRETE WITH MARBLE DUST PARTIAL REPLACEMENT OF CONCRETE

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**Abstract** There is growing interest in the construction of concrete pavements, due to its high strength, durability, better serviceability and overall economy in the long run. Present day construction cost is at its height with using basic materials like cement, coarse aggregates and fine aggregates. Leaving waste materials to nature specifically can bring about environmental issues. Therefore, reuse of waste materials has been emphasized. Industries produce lots of waste materials, which might be helpful in partial replacement of basic materials due to their composition and it can be proved economical. The concrete industry is always searching for supplementary material with the target of decreasing the solid waste disposal issue. As we know concrete is weak in tension so, to overcome this, steel fibers has been used. There are few reuse and recycling solutions for this industrial by-product, both in experimental phase and have useful applications. These mechanical wastes are dumped in the close-by areas and natural fruitfulness of the soil is ruined. The physical, mechanical & chemical properties of wastes are discussed.

In this present study a study of strength and durability is carried out on M30 grade concrete by using marble dust and steel fibers. The cement is replaced with 0%MP+0%SF, 5%MP+0.5%SF, 10%MP+1%SF, 15%MP+1.5%SF, and 20%MP+2%SF. The compressive and split tensile strength of concrete is determined for 7 days, 14 days and 28 days curing with different percentages of marble powder and steel fibers, the durability of

concrete is determined for curing the specimens for 90days in acid, alkaline and sulphate solutions.

**KEY WORDS:** strength, durability, serviceability, waste materials, marble powder, silica fume, steel fibers

## 1. INTRODUCTION

Marble is a non-foliated metamorphic rock composed of re-crystallized carbonate minerals, most commonly calcite or dolomite. Geologists use the term "marble" to refer to metamorphosed limestone; however, stonemasons use the term more broadly to encompass un-metamorphosed limestone. Marble is a metamorphic rock resulting from the transformation of a pure limestone. The purity of the marble is responsible for its color and appearance: it is white if the limestone is composed solely of calcite (100%CaCO<sub>3</sub>). Marble is used for construction and decoration; marble is durable, has a noble appearance, and is consequently in great demand. Chemically, marbles are crystalline rocks composed predominantly of calcite, dolomite or serpentine minerals. The other mineral constituents vary from origin to origin. Quartz, muscovite, tremolite, actinolite, micro line, talc, garnet, osterite and biotite are the major mineral impurities whereas SiO<sub>2</sub>, limonite, Fe<sub>2</sub>O<sub>3</sub>, manganese, 3H<sub>2</sub>O and FeS<sub>2</sub> (pyrite) are the major chemical impurities associated with marble. The main impurities in raw limestone (for cement) which can affect the properties of finished cement are magnesia, phosphate, leads, zinc, alkalis and sulfides.

The advancement of concrete technology can reduce the consumption of natural resources and energy sources and lessen the burden of pollutants on environment. Presently large amounts of marble powder are generated in natural stone processing plants with an important impact on environment and humans. This project describes the feasibility of using the marble sludge powder in concrete production as partial replacement of cement. In India, the marble and granite stone processing is one of the most thriving industry the effects if varying marble powder contents on the physical and mechanical properties of fresh and hardened concrete have been investigated. Slump and air content of fresh concrete and absorption and compressive strength of hardened concrete were also investigated. Test results show that this industrial by product is capable of improving hardened concrete performance up to 10%, Enhancing fresh concrete behavior and can be used in architectural concrete mixtures containing white cement. The compressive strength of concrete was measured for 7 and 28 days. In order to evaluate the effects of marble powder on mechanical behavior, many different mortar mixes were tested.

#### **Use of Marble powder as replacement material in concrete**

In building industry, Marble has been commonly used as a building material since the ancient times. The disposal of the marble powder material, consisting of very fine powder, constitutes one of the environmental problems around the world. Marble blocks are cut into small blocks in order to give them the desired smooth shape. In India marble powder is settled by sedimentation and then dumped away which results in environmental pollution, in addition to forming powder in summer and threatening both agriculture and public health. Therefore, utilization of the marble powder in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. For instance, certain residues such as marble sludge from stony material manufacturing and cement kiln powder are characterized by an average diameter. This important characteristic makes them potentially candidates for use in the production of self-levelling mortars (SLMS) and self-compacting concrete (SCCS). They can be compacted under their

self weight, with no external action, providing a considerable saving in time and energy. The feasibility of the waste material recovery process is particularly influenced by the simultaneous satisfaction of the economic, technical and normative aspects for each field of use. Once the economic convenience has been assessed, the experimentation must verify that the physicochemical characteristics attained after treatment are suitable to the specific project solutions for which they are intended.

#### **Fiber reinforced concrete (FRC):**

Fiber reinforced concrete (FRC) may be defined as a composite materials made with Portland cement, aggregate, and incorporating discrete discontinuous fibers. Now, why would we wish to add such fibers to concrete. Plain, unreinforced concrete is a brittle material, with a low tensile strength and a low strain capacity. The role of randomly distributed discontinuous fibers is to bridge across the cracks that develop provides some post cracking "ductility". If the fibers are sufficiently strong, sufficiently bonded to material, and permit the FRC to carry significant stresses over a relatively large strain capacity in the post cracking stage. There are, of course, other (and probably cheaper) ways of increasing the strength of concrete.

The real contribution of the fibers is to increase the toughness of the concrete (defined as some function of the area under the load vs. deflection curve), under any type of loading. That is, the fibers tend to increase the strain at peak load, and provide a great deal of energy absorption in post-peak portion of the load vs. deflection curve. When the fiber reinforcement is in the form of short discrete fibers, they act effectively as rigid inclusions in the concrete matrix. Physically, they have thus the same order of magnitude as aggregate inclusions; steel fiber reinforcement cannot therefore be regarded as a direct replacement of longitudinal reinforcement in reinforced and prestressed structural members.

However, because of the inherent material properties of fiber concrete, the presence of fibers in the body of the concrete or the provision of a tensile skin of fiber concrete can be expected to improve the resistance of conventionally reinforced structural members to

cracking, deflection and other serviceability conditions. The fiber reinforcement may be used in the form of three dimensionally randomly distributed fibers throughout the structural member when the added advantages of the fiber to shear resistance and crack control can be further utilized. On the other hand, the fiber concrete may also be used as a tensile skin to cover the steel reinforcement when a more efficient two – dimensional orientation of the fibers could be obtained.

### Objectives of the study

The main objective of the proposed work is to study as to how by using mineral admixtures like silica fume and Marble powder in varying proportions.

1. The project deals with concrete grades M30.
2. To study Effects of Marble dust dosages and steel fiber on Compressive Strength and split tensile
3. To explain the change in properties of concrete, if any by explaining the microstructure.
4. To study the fresh and harden properties (i.e. compressive strength, workability test) partial replacement of cement by Silica fume and Marble powder in different percentage such , 0%SF+0%MP, 0.5%SF+10%MP, 1%SF+20%MP, 1.5%SF30%MP,2%SF+40%MP are evaluated.
5. After evaluating the mechanical properties for the various mix and it is compared with the best result.
6. Hence in the present investigation more emphasis is given to study the OPC marble powder so as to achieve better concrete composites and also to encourage the increased use of byproducts to maintain ecology.

## 2. LITERATURE STUDIES

**Rishi1, Dr. Vanita Aggarwal, et al., (2014)** Marble as a building material especially in palaces and monuments has been in use for ages many studies have been reported in literature on the performance of the concrete containing waste marble dust or waste marble aggregate. It can be seen that combination of marble dust and other ingredients has modulus or

compressive strength higher than alone for 7 days and 28 days respectively.

**Raman Kumar, Ankit, et al., (2016)** Marble is essential materials utilized as a part of the development business. Marble powder is created from handling plants amid the cleaning and sawing of marble squares and around 20 - 25% of the prepared marble is transform into powder structure. Devastating of the marble powder material from the marble business is one of the ecological issues overall today. This study is proposed to using Waste marble powder development industry itself as fine total in solid, substitution regular sand.

**Dr. Suji D, Krishna Kumar S, Perarasan M, Niranjani E, et al.,** It is found that the studies of concrete made of quarry rock dust and waste marble powder increases at 12.5%. Therefore the quarry dust and waste marble powder should be used in construction works, then the cost of construction would be saved significantly and the natural resources would be used efficiently.

**Brian et al.,** suggests that the resistance to acid attack is related to the impenetrability of the concrete rather than the particular cement type used. Requirements for resistance to acid attack are thus often expressed simply in terms of limitations on concrete composition such as minimum cement content or maximum free water–cement ratio. Resistance to other chemical attack is often only required in specialist applications such as chemical plants, or in contaminated land. The conditions may vary widely and most standards either do not address such issues or recommend the user to seek specialist advice.

## 3. MATERIALS AND MIX RATIOS USED

### OPC 53 Grade Cement

Ordinary Portland cement (OPC) of 53 Grade from a single lot was used throughout the course of the investigation. It was fresh and without any lumps. The physical properties of the cement are determined from various tests conforming to Indian Standard IS: 8112:1989 are listed in table below Cement is

carefully stored to prevent deterioration in its properties due to contact with moisture.



OPC 53 Grade

### Coarse aggregates

Those particles that are predominantly retained on the 4.75 mm (No. 4) sieve and will pass through 3-inch screen are called **coarse aggregate**. The coarser the aggregate, the more economical the mix. Larger pieces offer less surface area of the particles than an equivalent volume of small pieces. Use of the largest permissible maximum size of coarse aggregate permits a reduction in cement and water requirements. In this study coarse aggregate of nominal sizes of 20mm, 12mm are used.



20mm Size aggregates

### Fine aggregates

Those particles passing the 9.5 mm (3/8 in.) Sieve, almost entirely passing the 4.75 mm (No. 4) sieve, and predominantly retained on the 75 µm (No. 200) sieve are called fine aggregate.

For increased workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.



Fine aggregates

### Marble powder

Marble is a non-foliated metamorphic rock composed of re-crystallized carbonate minerals, most commonly calcite or dolomite. Geologists use the term "marble" to refer to metamorphosed limestone; however, stonemasons use the term more broadly to encompass un-metamorphosed limestone. Marble is a metamorphic rock resulting from the transformation of a pure limestone. The purity of the marble is responsible for its color and appearance: it is white if the limestone is composed solely of calcite (100%CaCO<sub>3</sub>). Marble is used for construction and decoration; marble is durable, has a noble appearance, and is consequently in great demand.



Marble dust

### Steel fibers

Mild steel fibers having 30mm thickness and 60mm length i.e. aspect ratio (l/d) 50 which are corrugated and obtained through cutting of steel wires have been used. The fibers have been cut by fiber cutting machine to an accurate size. Two different proportions 0.25%, 0.5% have been used.



Steel fibers

### Mix design of M30 Grade concrete used

Concrete Mix proportions for Trial Number 1

1. Cement = 438 kg/m<sup>3</sup>
2. Water = 197 kg/m<sup>3</sup>
3. Fine aggregates = 732 kg/m<sup>3</sup>
4. Coarse aggregate = 1177 kg/m<sup>3</sup>

Water-cement ratio = 0.45

Final trial mix for M30 grade concrete is 1:1.67:2.68 at w/c of 0.45

## 4. EXPERIMENTAL STUDY

### Mixing of concrete

Measured quantities of coarse aggregate, fine aggregate and cement were spread out over an impenetrable solid floor. Steel strands are included arbitrarily while blending the solid. The blend again and again until consistency of shading was accomplished the season of blending will be 10 15 minutes.



Concrete mixing

### Casting and curing of test specimens

The specimens of standard cubes (150mm x 150mm x 150mm) and standard cylinders (150mm diameter x 300mm height) were casted.

### Placing and compacting

The segments of shape were covered with form oil and a comparable covering of form oil was connected between the contact surfaces of the base of the molds and the base plate so as to guarantee that no water evades during the filling. At that point the solid is filled in the molds layer insightful by appropriate compaction. Lastly the molds are leveled once they completely filled. Utilization of slurry on the last solid surface makes solid surface plain by filling the voids. One thing must be noticed that compaction of cement ought to be done before the start of solid beginning settling time.

### Curing

The test example 3D shapes, crystals and chambers were put away in a spot, free from vibration, in most air at 90% relative mugginess and at a temperature of  $27 \pm 2c$  for 24 hours  $\pm \frac{1}{2}$  hour from the season of expansion of water to the dry fixings. At that point the solid 3D shapes, crystals and chambers are expelled from molds and put for restoring for 3 days, 7 days, and 28 days.



Test specimens kept for curing

### Tests to be conducted on concrete

#### Workability

#### Slump flow test

The concrete slump test is utilized for the estimation of a property of crisp cement. The test is an exact test that estimates the functionality of crisp cement. All the more explicitly, it gauges consistency between bunches.

#### Compaction factor test

Compaction factor test is the functionality test for cement directed in research facility. The compaction factor is the proportion of loads of mostly compacted to completely compacted cement. It was created by Road Research Laboratory in United Kingdom and is utilized to decide the usefulness of cement.

**Compressive strength of concrete**

This test was directed according to ([9] IS516-1959). The 3D shapes of standard size 150x150x150mm were utilized to locate the compressive quality of cement. Examples were set on the bearing surface of CTM, of limit 200T without whimsy and a uniform pace of stacking connected till the disap pointment of the 3D shape. The most extreme burden was noted and the compressive quality ([21] AS Alnuaimi,) was determined.



Compressive strength test machine

**Tensile strength of concrete**

This test was led according to IS516-1959. The chambers of standard size 150mmx300mm were utilized discover the quality of cement. Examples are set on the bearing surface of CTM, of limit 200T without flightiness and a uniform pace of stacking is connected till the disappointment of chamber. The most extreme burden was noted and the quality was determined. Split rigidity testing Procedure from IS5816-1999

**Durability of concrete**

Durability of concrete might be characterized as the capacity of cement to oppose enduring activity, compound assault, and scraped area while keeping up its ideal building properties.

Sturdiness is characterized as the ability of cement to oppose enduring activity, synthetic assault and scraped spot while keeping up its ideal building properties. It typically alludes to the term or life expectancy of inconvenience free execution. Various cements require various degrees of strength relying upon the presentation condition and properties wanted. For instance, concrete presented to tidal seawater will have unexpected prerequisites in comparison to indoor cement.

In the present investigation solidness of SCC was led because of impact of corrosive and sulfates



Mixing acid

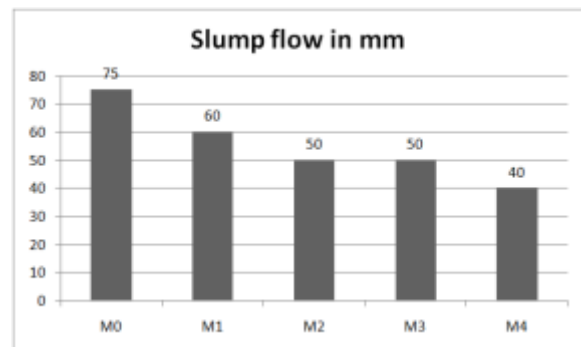


Specimen tested after acid attack

**5. RESULTS AND ANALYSIS**

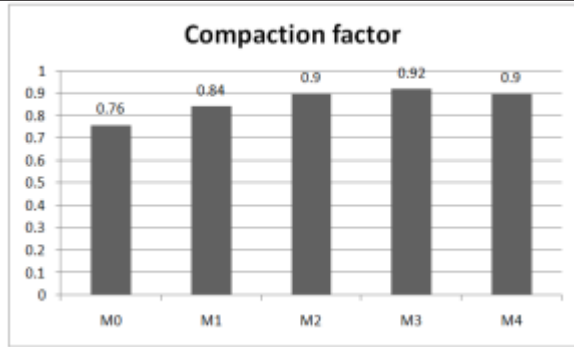
**Workability of concrete**

**Slump cone test**

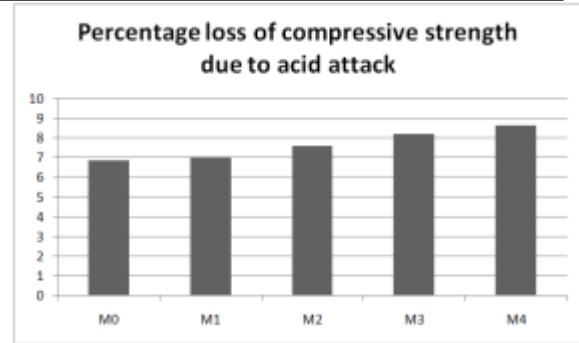


Comparison of slump cone test

**Compaction factor test**

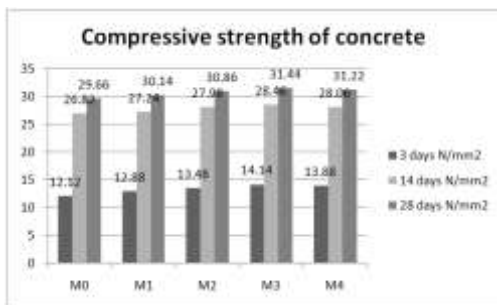


Comparison of compaction factor test

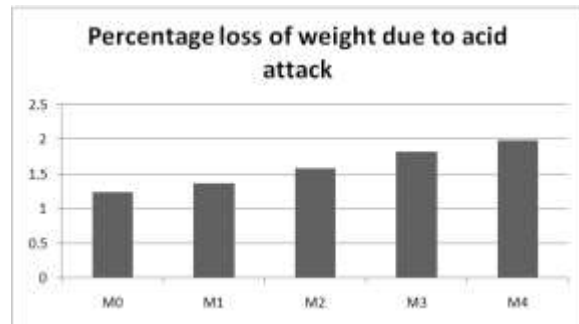


Percentage loss of compressive strength

**Compressive strength**

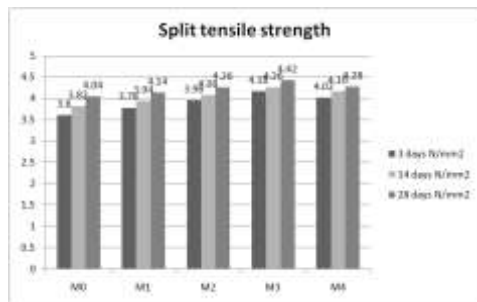


Comparison of compressive strength



Percentage loss of weight

**Split tensile strength**



Comparison of split tensile strength

**Acid resistance results**

**6. CONCLUSIONS**

From the above experimental study the following conclusions were made

- The value of slump decreases with increase in the percentage of marble powder from 0%SF+0%MP to 2.5%SF+40%MP.
- The value of compaction factor increases with increase in the percentage of marble powder from 0%SF+0%MP to 2.5%SF+40%MP.
- The optimal value (maximum value) of compressive strength was observed at 1.5%SF+30%MP for 3 days, 14days and 28 days.
- After 1.5%SF+30%MP the compressive strength of concrete decreases the compressive strength
- The optimal value (maximum value) of Split tensile strength was observed at 1.5%SF+30%MP for 3 days, 14days and 28 days. Similar to the compressive strength split tensile strength can be increased.
- The durability of concrete due to acid attack, alkaline attack, sulphate attack increases with increase in the percentage of Marble powder.

- Marble powder can be used as the replaced material for the cement for decrease in the cost of construction and increase in the strength.

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