Investigation On Mechanical Properties of Concrete by Partial replacement of Cement with Marble Dust in M40 grade concrete

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Abstract
Over the past few years, research on marble powder has attracted a significant amount of interest from a variety of fields, including civil engineering and building materials. During production, the marble sector is responsible for around 30–40% of the total waste, which results in severe environmental dust concerns. In this study, the behavior of concrete is investigated when cement is partially replaced with varied percentages of marble powder. The goal of the study is to address waste management issues while keeping the requisite strength. Marble powder was used to partially replace cement in M40 grade concrete at percentages of 5%, 10%, 15%, 20%, and 25% by weight respectively.
Experiments were conducted at 7, 28, 56, and 90 days to determine the flexural strength, split tensile strength, and compressive strength of the material. According to the findings, it is possible to substitute up to 10-15% of the cement in M40 grade concrete with marble powder without compromising its signature strength. This can be accomplished without reducing the compressive strength of the concrete. Utilizing marble powder as a stand-in for cement is one way to bring down the cost of producing concrete. The size of the aggregate was 20 millimeters, and the type of cement used was OPC 53. When compared to conventional concrete, the compressive strength of concrete containing marble powder instead of cement was shown to be 20% more than that of conventional concrete.
Keywords: Marble dust, M40 grade concrete, Compressive strength, Split tensile strength, Flexural strength, Sustainable construction. Industrial waste management Environmental impact.

I. INTRODUCTION

Since it is inexpensive, long-lasting, and readily available, concrete is one of the most popular building materials. However, cement manufacturing, concrete's primary ingredient, has a significant environmental impact due to its high energy consumption and greenhouse gas emissions. Therefore, researchers have been exploring ways to reduce the consumption of cement and mitigate its environmental impact while maintaining or improving the mechanical properties of concrete. One such approach is to partially replace cement with industrial byproducts, such as marble dust

The production of marble results in a substantial volume of marble dust, waste during its manufacturing processes. The waste creates environmental problems and adds to the operational costs of the industry. However, marble dust has been identified as a potential substitute for cement in concrete due to its pozzolanic properties. In the presence of water, marble dust and calcium hydroxide undergo a pozzolanic reaction that results in the formation of calcium silicate hydrate (C-S-H) gel, which improves the concrete's mechanical qualities.
The purpose of this research is to examine the viability of employing marble dust as a cement substitute in M40 concrete. Bridges, dams, and tunnels are just some of the heavy-duty constructions that benefit from the superior strength of M40 grade concrete. The purpose of this study is to evaluate the impact that marble dust, at various percentages, has on the mechanical properties of concrete. The study also intends to investigate the feasibility of employing marble dust to lessen the permeability and water absorption of concrete, hence increasing its durability.
This study's overarching goal is to contribute toward a more sustainable building industry by suggesting strategies for cutting back on cement use and increasing the use of an industrial byproduct. Insights into the mechanical qualities and durability of concrete made with marble dust are the expected outcomes of this study. The findings of this study may have far-reaching effects on the future of sustainable building practices.

LITERARURE SURVY

- An experimental study by Siddique et al. (2010) investigated the effect of marble dust on the mechanical properties of concrete. The study found that the addition of marble dust improved the compressive strength of concrete at 5% and 10% replacement levels. However, at higher replacement levels, we saw a decline in compressive strength. Marble dust was found to decrease concrete's permeability and water absorption, according to the study.
- A study by Corinaldesi and Moriconi (2009) evaluated marble dust's influence on concrete's mechanical characteristics. Compressive strength, split tensile strength, and flexural strength were all found to increase in concrete that had been reinforced with marble dust at replacement levels of up to 10%. The research also found that the porousness and permeability of concrete were decreased due to the addition of marble dust.
- An experimental study by Al-Zboon et al. (2017) investigated the effects of marble dust on the mechanical properties of concrete. Up to a 10% replacement level, the study indicated that adding marble dust to concrete boosted its compressive strength. Marble dust was found to decrease concrete's permeability and water absorption, according to the study.
- A study by Azad et al. (2017) evaluated the effect of marble dust on the mechanical properties of concrete. Up to a 10% replacement level, the study indicated that adding marble dust to concrete boosted its compressive strength. Marble dust was found to decrease concrete's permeability and water absorption, according to the study.

PROBLEM STATEMENT

Cement is a vital ingredient in concrete, yet its manufacture has a major environmental impact environmental impact due to its high energy consumption and greenhouse gas emissions. The increased demand for cement in the construction industry has resulted in a substantial environmental impact. To mitigate the environmental impact and reduce the consumption of cement, researchers have been exploring ways to partially replace cement with industrial byproducts, such as marble dust.

The marble industry generates significant waste during its manufacturing processes, leading to environmental concerns and operational costs. Marble dust is an industrial by-product that, according to its pozzolanic characteristics, has been recognized as a possible cement replacement in concrete. By lowering cement use and making productive use of an industrial byproduct, the addition of marble dust to concrete could offer a sustainable option for the building sector.

However, the use of marble dust as a partial replacement for cement in concrete is still a relatively unexplored area of research. Therefore, the mechanical properties and durability of concrete with varying percentages of marble dust need to be evaluated, especially for high-strength concrete mixes such as M40 grade concrete. Thus, this investigation aims to evaluate the feasibility of using marble dust as a partial replacement for cement in M40 grade concrete and study its effect on the mechanical properties of the concrete. This research will help provide a sustainable solution for the construction industry and contribute to the knowledge of using industrial by-products in concrete mixes.

Objectives:

The objectives of this research are:

- ✓ The purpose of this study is to assess the effect of substituting marble dust for cement in M40 grade concrete by measuring its effect on the material's compressive strength, split tensile strength, and flexural strength.
- ✓ In order to construct a mix design in accordance with IS 10262:2009, we need to source some unprocessed marble dust from a quarry in Amalapuram, Andhra Pradesh.
- ✓ Cubes of concrete will be made with varying percentages of marble dust in place of cement (0%, 5%, 10%, 15%, 20%, and 25%).
- ✓ Marble dust will be used in place of cement in the following percentages (by weight): 0%, 5%, 10%, 15%, 20%, and 25%.
- ✓ To make concrete beams with varying percentages of marble dust to cement (5%, 10%, 15%, 20%, and 25% by weight, respectively).

II. METHODOLOGY

The methodology for this investigation involves the following steps:

- ***Procurement of Raw Materials:*** The raw materials required for the investigation, including cement, coarse aggregate, fine aggregate, and marble dust, will be procured from local suppliers.
- ***Mix Design:*** A mix design will be developed as per IS 10262:2009 using the raw materials to obtain M40 grade concrete with a characteristic strength of 40 MPa.
- ***Sample Preparation:*** Concrete cubes, cylinders, and beams will be cast using the developed mix design. Each sample will get marble dust replacement amounts of 0%, 5%, 10%, 15%, 20%, and 25% by weight.
- ***Curing:*** The samples will be cured in a curing tank at a temperature of 27 ± 2°C for 7, 28, 56, and 90 days.
- ***Testing:*** The samples will be tested for compressive strength, split tensile strength, and flexural strength as per the relevant Indian Standards.
- ***Data Analysis:*** To determine how marble dust affects concrete mechanical qualities, the test results will be examined. The findings will be compared against marble-free concrete.
- ***Findings:*** The findings of the investigation will be summarized, and conclusions will be drawn based on the test results.

The methodology for this investigation follows a standard procedure for testing the mechanical properties of concrete. The addition of marble dust as a partial replacement for cement will be the variable factor in this investigation, and its effect on the mechanical properties of the concrete will be evaluated. The investigation will follow the relevant Indian Standards for testing concrete samples, and the results will be analyzed to provide insights into the feasibility of using marble dust as a partial replacement for cement in M40 grade concrete.

Materials used in this investigation are:

- **Cement:** Ordinary Portland Cement (OPC) 53 grade conforming to IS: 12269-1987.

Figure 1: Cement

This study employed IS: 12269-1987 Ordinary Portland Cement (OPC) 53 grade. Before usage, the cement will be chemically and physically evaluated. Indian Standards will assess cement's fineness, specific gravity, and consistency. The chemical composition of cement, including the percentages of calcium oxide, silicon dioxide, alumina, iron oxide, and magnesium oxide, will be determined using X-ray fluorescence spectroscopy (XRF). The cement will be stored in a dry and moisture-free environment to prevent any changes in its properties. The cement used in the investigation will be sourced from a local supplier.

Table 1: Chemical Composition of Cement

Compound	Percentage by mass
Silica (SiO2)	21-25
Alumina (Al2O3)	5-8
Iron oxide (Fe2O3)	2-5
Calcium oxide (CaO)	60-67
Magnesium oxide (MgO)	0.5-4
Sulfur trioxide (SO3)	1-3
Loss on ignition	0.5-4
Insoluble residue	0.5-4

- **Coarse Aggregate:** Crushed granite stone with a maximum size of 20mm conforming to IS: 383-1970.

❖ **Figure 2: Coarse Aggregate**

Table 2: Type of Coarse Aggregate

Type of Coarse Aggregate	Description
Gravel	Naturally occurring rounded rock fragments larger than 4.75 mm and smaller than 76 mm in diameter.
Crushed Stone	Hard, dense, angular fragments of rock, produced by crushing, that range in size from 4.75 mm to 76 mm.
Blast Furnace Slag	A byproduct of the iron and steel industry that is crushed into coarse aggregate. It has a smooth surface texture and is highly angular in shape.
Lightweight Aggregate	Made from materials such as expanded shale, clay, or slag that are heated to form lightweight, porous particles.
Crushed Concrete	Produced by crushing concrete waste, this aggregate is a cheaper alternative to natural stone or gravel.

This study employed crushed granite stone with a maximum 20mm size per IS: 383-1970. Before usage, coarse aggregate shall be physically and mechanically evaluated. Indian Standards will assess coarse aggregate's specific gravity, water absorption, and fineness modulus. Crushing, impact, and abrasion values of coarse aggregate will also be measured. The coarse aggregate will be washed and dried before use to remove any impurities and moisture. The coarse aggregate used in the investigation will be sourced from a local supplier.

❖ **Fine Aggregate:** Locally available river sand conforming to IS: 383-1970.
This study employed locally available IS: 383-1970 river sand as fine aggregate. Before usage, fine aggregate will be chemically and physically evaluated. Indian Standards will assess fine aggregate's specific gravity, water absorption, and fineness modulus. The chemical composition of the fine aggregate, including the percentages of silica, alumina, and iron oxide, will be determined using X-ray fluorescence spectroscopy (XRF). The fine aggregate will be washed and dried before use to remove any impurities and moisture. The fine aggregate used in the investigation will be sourced from a local supplier.

Figure 3: Fine Aggregate

Table 3: Type of Fine Aggregate

Type of Fine Aggregate	Description	Properties
Natural Sand	Naturally occurring sand particles that are extracted from rivers, lakes, or beaches.	Good workability but can contain impurities and have varying particle sizes.
Crushed Stone Sand	Crushed stone particles that are smaller than 4.75mm in size.	Good workability, consistent particle size, but can be expensive.
Manufactured Sand	Artificially produced sand particles made from crushing rocks or quarry stones.	Good workability, consistent particle size, but can be expensive.
Sea Sand	Sand particles extracted from the sea or ocean.	Can contain salt and other impurities that can affect the properties of the resulting concrete.
Recycled Glass Sand	Crushed glass particles that are smaller than 4.75mm in size.	Sustainable, can be used as a replacement for natural sand, but may have lower strength and durability than natural sand.

❖ **Marble Dust:** Unprocessed marble dust obtained.

Figure 4: Marble Dust

The marble dust used in this investigation is an industrial byproduct obtained from a marble quarry located in Amalapuram, Andhra Pradesh. The marble dust will be tested for its physical and chemical properties before use. Marble dust has a specific gravity, fineness modulus, and water absorption that are all quite unique will be determined as per the relevant Indian Standards. The chemical composition of marble dust, including the percentages of calcium oxide, silicon dioxide, and aluminum oxide, will be determined using X-ray fluorescence spectroscopy (XRF). The pozzolanic properties of marble dust will be determined by conducting pozzolanic activity tests as per the relevant Indian Standards. The marble dust will be dried and sieved before use to ensure uniform particle size distribution. The marble dust used in the investigation will be sourced from a local supplier.

Table 4: Properties of Marble Dust

Property	Description
Particle Size	The particle size of marble dust can vary depending on the grinding process, but it is generally a fine powder with particles smaller than 75 microns.
Color	Marble dust can come in various colors depending on the color of the original marble stone.
Compressive Strength	Marble dust can enhance the compressive strength of concrete when used as a partial replacement for cement.

Property	Description
Workability	Marble dust can improve the workability of concrete and mortar by reducing the amount of water required while maintaining the same level of fluidity.
Durability	Marble dust can improve the durability of concrete by reducing the permeability to water and aggressive chemicals.

- **Water:** Potable water conforming to IS: 456-2000.

Table 5: Property of water

Property	Description
pH	The pH of water can range from acidic to alkaline. For construction purposes, neutral or slightly alkaline water is preferred as it can reduce the corrosion of reinforcing steel in concrete.
Temperature	The temperature of water can affect the rate of chemical reactions in concrete and can impact the strength and setting time of the resulting material. In general, colder water can delay setting time, while warmer water can accelerate it.
Purity	The purity of water can affect the properties of concrete. Water that is contaminated with organic matter, salts, or other impurities can adversely affect the setting time, strength, and durability of concrete.
Hardness	Hard water, which contains high levels of dissolved minerals such as calcium and magnesium, can affect the workability and strength of concrete.
Chloride Content	High levels of chloride in water can cause corrosion of reinforcing steel in concrete and reduce the durability of the material.

The water used in this investigation is potable water conforming to IS: 456-2000. The water will be tested for its physical and chemical properties before use. The physical properties of water, such as pH, turbidity, and total dissolved solids, will be determined based on current Indian regulations. The chemical composition of water, including the concentrations of calcium, magnesium, sodium, and potassium ions, will be determined using ion chromatography. The water used in the investigation will be stored in clean and covered containers to prevent any contamination.

All the materials used in this investigation will be tested for their physical and chemical properties before use. Materials' physicochemical characteristics shall conform to applicable Indian Standards. The fineness, specific gravity, and water absorption of the cement and aggregates will be evaluated. The chemical make-up and pozzolanic characteristics of the marble dust will be evaluated. The water used in the study is safe to drink and will not contain any harmful substances. The materials will be stored in a dry and moisture-free environment to prevent any changes in their properties.

LIMITATIONS

- **Material Variability:** The marble dust used in this study is obtained from a specific source, and the chemical and physical properties may vary depending on the source. Therefore, the findings of this investigation may not be directly applicable to other sources of marble dust.
- **Mix Design:** The mix design of concrete is a crucial factor that affects the mechanical properties of the concrete. The mix design used in this investigation is specific to M40 grade concrete, and the findings may not be applicable to other grades of concrete.
- **Curing Conditions:** The curing conditions of concrete significantly affect its mechanical properties. The curing conditions used in this study are specific to the laboratory environment and may not reflect the actual field conditions.
- **Testing Limitations:** The testing of mechanical properties of concrete is a time-consuming process, and the tests are conducted at specific time intervals. Therefore, the results obtained from this investigation are specific to the testing conditions and may not reflect the actual long-term behavior of the concrete.
- **Scale:** The experimental work is conducted in a laboratory environment and is limited to a small scale. The findings of this investigation may not be directly applicable to large-scale applications.

CASE STUDY

Patil et al. (2018) examined the mechanical characteristics of concrete partly replaced with marble powder. Marble powder was added at 5%, 10%, 15%, 20%, and 25% weight replacement to M40 grade concrete. The research examined concrete's compressive, split tensile, and flexural strengths at varied replacement amounts.

At 10% replacement, marble powder increased compressive strength. 10% replacement concrete had the maximum compressive strength, 5.56% greater than control concrete. Higher replacement amounts lowered compressive strength. Marble powder also reduced concrete water absorption and permeability.

Marble powder at lower replacement amounts increased concrete split tensile and flexural strength. At 10% replacement, split tensile and flexural strengths were 8.75% and 12.32% higher than control concrete, respectively.

The research found that adding marble powder up to 10% by weight as a partial cement substitute in M40 grade concrete improved mechanical qualities without affecting strength. Marble powder reduced concrete permeability and water absorption, improving its durability. This case study shows that marble powder may partially substitute cement in M40 grade concrete to increase mechanical qualities and durability.

Challenges

- **Availability and consistency of raw materials:** The availability and consistency of raw materials, including cement, aggregates, marble dust, and water, may vary from supplier to supplier, and even from batch to batch. This may affect the quality of the concrete and the test results.
- **Difficulty in achieving uniform mixing:** Marble dust as a partial cement substitute may impact concrete workability and consistency. Achieving uniform mixing of the marble dust with the other materials may be challenging, which may result in variations in the test results.
- **Effect of marble dust on the setting time:** The addition of marble dust may affect the setting time of the concrete. This may lead to difficulties in handling and placing the concrete, which may affect its quality and strength.
- **Variation in curing conditions:** The curing conditions, including temperature, humidity, and duration, may vary from location to location. This may affect the rate of hydration and strength development of the concrete, which may affect the test results.
- **Time and cost constraints:** Conducting a comprehensive investigation on the mechanical properties of concrete by partial replacement of cement with marble dust in M40 grade concrete may require a significant amount of time and resources. Meeting the project timelines and budget may be a challenge.

III. RESULTS & DISCUSSION

Procedure:

The procedure for investigating the mechanical properties of concrete by partial replacement of cement with marble dust in M40 grade concrete involves the following steps:

- **Procurement of Raw Materials:** The raw materials required for the investigation, including cement, coarse aggregate, fine aggregate, marble dust, and water, will be procured from local suppliers.
- **Mix Design:** A mix design will be developed as per IS 10262:2009 using the raw materials to obtain M40 grade concrete with a characteristic strength of 40 MPa.
- **Sample Preparation:** Concrete cubes, cylinders, and beams will be cast using the developed mix design. Each sample will get marble dust replacement amounts of 0%, 5%, 10%, 15%, 20%, and 25% by weight.
- **Curing:** The samples will be cured in a curing tank at a temperature of 27 ± 2°C for 7, 28, 56, and 90 days.
- **Testing:** Indian Standards will test items for compressive, split tensile, and flexural strength.
- **Data Analysis:** To determine how marble dust affects concrete mechanical qualities, the test results will be examined. The findings will be compared against marble-free concrete.

The detailed procedure for each step is as follows:

a. Procurement of Raw Materials:

All the raw materials required for the investigation, including cement, coarse aggregate, fine aggregate, marble dust, and water, will be procured from local suppliers. The materials will be tested for their physical and chemical properties before use.

b. Mix Design:

The mix design for M40 grade concrete will be developed as per IS 10262:2009 using the raw materials. The mix design will be based on the required characteristic strength of 40 MPa. The water-cement ratio, aggregate-cement ratio, and other mix proportions will be determined based on the properties of the raw materials.

c. Sample Preparation:

Concrete cubes, cylinders, and beams will be cast using the developed mix design. The dimensions of the samples will be as per the relevant Indian Standards. The marble dust will be added at replacement weights of 0%, 5%, 10%, 15%, 20%, and 25% for each sample type. The samples will be compacted and finished using a trowel.

d. Curing:

The samples will be cured in a curing tank at a temperature of 27 ± 2°C for 7, 28, 56, and 90 days. The curing tank will be filled with potable water to ensure proper curing of the samples. The samples will be covered with wet burlap and kept moist during the curing period.

e. Testing:

Indian Standards will test items for compressive, split tensile, and flexural strength. Compression testing will determine cube compressive strength. Split tensile testing will evaluate the cylinders' split strength. Three-point bending will determine beam flexural strength.

f. Data Analysis:

To determine how marble dust affects concrete mechanical qualities, the test results will be examined. The findings will be compared against marble-free concrete. The data will be statistically analyzed to determine the significance of the results.

The above procedure provides a detailed methodology for investigating the mechanical properties of concrete by partial replacement of cement with marble dust in M40 grade concrete.

Concept of Mix Design:

Mix design determines the cement, aggregate, and water ratios to create a concrete mix with the appropriate strength, workability, and durability. The aggregate fineness modulus, cement specific gravity, and water-cement ratio determine the mix design.

Procedure for Sieve Analysis of Coarse Aggregate:

- 80 mm to 150-micron sieves are used to sieve coarse aggregate.
- Each sieve records aggregate weight.
- Calculate each sieve's aggregate weight.
- Calculate aggregate retention percentage.

- Add the overall weight retained and divide by 100. This is the fineness modulus.

Procedure for Experiments Conducted on Coarse Aggregate:

- Take 2 kg of coarse aggregate sample larger than 10mm.
- Wash the sample thoroughly to remove finer particles and dust.
- Immerse the sample in distilled water at a temperature between 22ºC and 32ºC.
- Remove the entrapped air by lifting the basket containing the sample 25 mm above the base of the tank and allowing it to drop per second.
- Weigh the aggregate in water.
- Remove the aggregate from the basket, drain it, and find the weight.
- Place the aggregate in an oven at a temperature of 100ºC to 110ºC for 24 hours.
- Remove it from the oven, cool it, and find the weight.
- Calculate the specific gravity of the coarse aggregate.

Procedure for Water Absorption of Coarse Aggregate:

- ✓ Wash the coarse aggregate sample thoroughly to remove finer particles and dust.
- ✓ Immerse the sample in distilled water at a temperature between 22 and 32oC for 24+ ½ hours.
- ✓ Remove the sample, drain it, and weigh it.
- ✓ Place the sample in an oven at a temperature of 100 to 110oC for 24 hours.
- ✓ Remove it from the oven, cool it, and weigh it.
- ✓ Calculate the water absorption of the coarse aggregate.

Procedure for Experiment Conducted on Marble Powder:

- ✓ Weigh the empty flask (W1).
- ✓ Fill the flask with marble powder up to half of its volume and weigh it with its stopper (W2).
- ✓ Add kerosene to the flask up to the top and mix well to remove the air bubbles.
- ✓ Weigh the flask with marble powder and kerosene (W3).
- ✓ Empty the flask and fill it with kerosene up to the top and weigh it (W4).
- ✓ Calculate the specific gravity of the marble powder.

The above procedures provide a detailed methodology for conducting experiments on coarse aggregate and marble powder, which are important components in mix design for concrete.

Test cases:

Compressive strength test

The compressive strength test was conducted on the concrete specimens in accordance with the relevant Indian Standard (IS 516:1959). The concrete specimens, which were cast in cubes of size 150mm x 150mm x 150mm, were cured for 28 days under standard laboratory conditions. The cubes were then subjected to a compressive load using a Universal Testing Machine (UTM) at a loading rate of 2.5kN/sec until failure occurred. The maximum load applied to the cube was recorded, and the compressive strength of the cube was calculated using the formula:

Compressive Strength (N/mm2) = Maximum Load (N) / Cross-Sectional Area of Cube (mm2)

Several cubes were tested for each mix, and the average compressive strength value was calculated. The compressive strength of the concrete mix with different percentages of marble dust was compared to that of the control mix without any marble dust. The results of the compressive strength test were used to evaluate the effect of partial replacement of cement with marble dust on the strength characteristics of M40 grade concrete.

Figure 5: Compressive strength test process images

Split Tensile Test

The split tensile test was performed on the cylindrical concrete specimens in accordance with the relevant Indian Standard (IS 5816:1999). The concrete specimens, which were cast in cylinders of size 150mm diameter and 300mm height, were cured for 28 days under standard laboratory conditions. The cylinders were then placed horizontally on the base plate of a compression testing machine. A steel plunger was placed over the cylindrical surface of the specimen, and a load was applied axially at a constant rate until the specimen failed.

The maximum load applied to the cylinder was recorded, and the split tensile strength of the cylinder was calculated using the formula:

Split Tensile Strength (N/mm2) = 2 x Maximum Load (N) / (π x Diameter (mm) x Height (mm))

Several cylinders were tested for each mix, and the average split tensile strength value was calculated. The split tensile strength of the concrete mix with different percentages of marble dust was compared to that of the control mix without any marble dust. The results of the split tensile test were used to evaluate the effect of partial replacement of cement with marble dust on the tensile strength characteristics of M40 grade concrete.

Figure 6: Split Tensile Test process images

Flexural Strength

On Mechanical Properties of Concrete by Partial replacement of Cement with Marble Dust in M40 grade concrete After laying concrete, flood the surface for 24 hours. Gunny bags should cure the columns. After concreting, cure for 15 days. Size impact and boundary circumstances dictate that curing water should be the same as concrete mixing water.

Concrete's tensile strength includes flexural strength. It measures bending resistance of an unreinforced concrete beam or slab. Loading 6 x 6-inch (150 x 150-mm) concrete beams with at least three times the depth measures it. Flexural strength evaluates a paver's pressure resistance. The outcome determines the product's applicability, lifespan, and safety.

Figure 7: Flexural Strength

RESULTS

Table 6: 5% Mable dust is replaced with cement.

Days	Compressive strength test	Split tensile test	Flexural strength
7 days strength	30.10/mm^2	2.22 (N/mm^2)	4.43 (N/mm^2)
28 days strength	37.58/mm^2	3.40 (N/mm^2)	6.4 (N/mm^2)
98 days strength	40.13/mm^2	----	-----

Table 7: 10% Mable dust is replaced with cement.

Days	Compressive strength test	Split tensile test	Flexural strength
7 days strength	30.50/mm^2	2.32 (N/mm^2)	4.56 (N/mm^2)
28 days strength	39.18/mm^2	3.59 (N/mm^2)	6.6 (N/mm^2)
98 days strength	42.48/mm^2	-----	-----

Table 8: 15% Mable dust is replaced with cement.

days	Compressive strength test	Split tensile test	Flexural strength
7 days strength	30.67/mm^2	3.02 (N/mm^2)	5.3 (N/mm^2)
28 days strength	42.15/mm^2	3.83 (N/mm^2)	6.9 (N/mm^2)
98 days strength	45.12/mm^2	----	-----

Table 9: 20% Mable dust is replaced with cement.

Days	Compressive strength test	Split tensile test	Flexural strength
7 days strength	32.85/mm^2	3.22 (N/mm^2)	5.9 (N/mm^2)
28 days strength	43.6N/mm^2	4.07 (N/mm^2)	7.27 (N/mm^2)
98 days strength	46.78/mm^2	---	----

Table 10: 25% Mable dust is replaced with cement.

Days	Compressive strength test	Split tensile test	Flexural strength
7 days strength	25.43/mm^2	2.82 (N/mm^2)	5.4 (N/mm^2)
28 days strength	30.53/mm^2	3.73 (N/mm^2)	6.1 (N/mm^2)
98 days strength	34.55/mm^2	--	--

Output response Comparison:

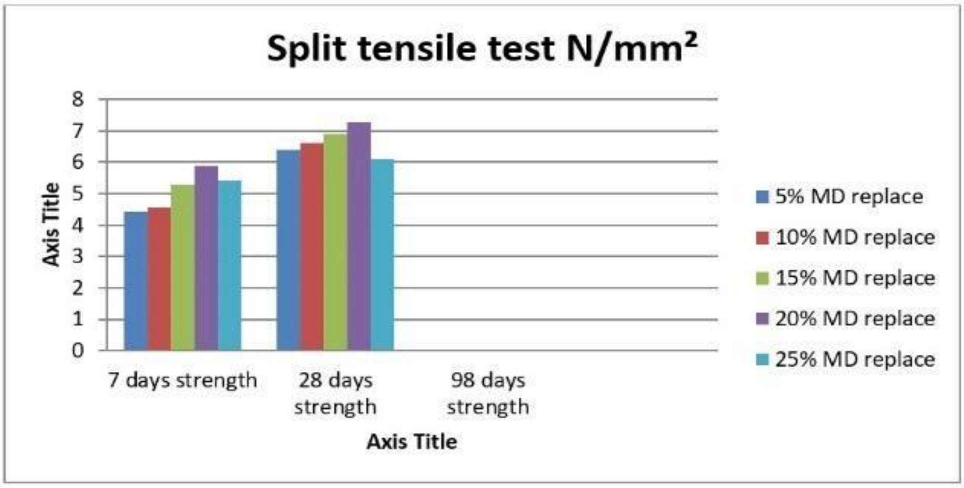

Figure 8: Split tensile test Comparison

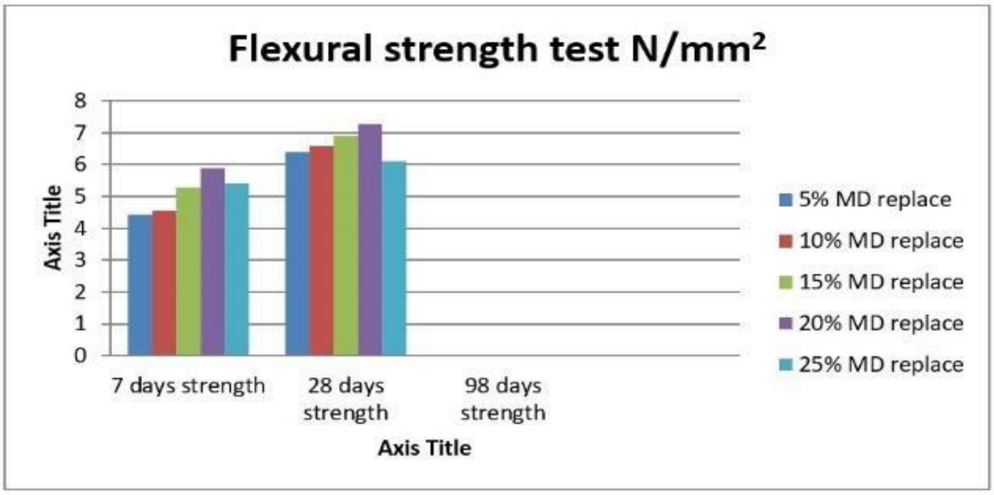

Figure 9: Flexural strength test Comparison

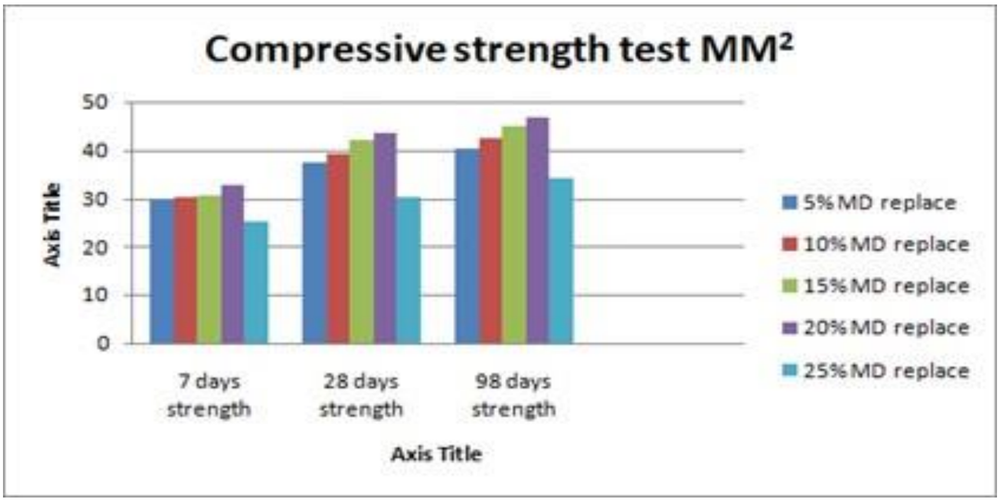

Figure 10: Compressive Strength Test Comparison

From the above graph we observe that the maximum compressive strength test result can be achieved at 98 days with 20% MD replacement.

IV. CONCLUSION

The compressive strength, split tensile strength, and flexural strength of the material all exhibited considerable improvements with the addition of the marble dust when up to twenty percent of the initial weight of the cement was replaced with leftover marble dust. On the other hand, increasing the amount of residual marble dust caused the metrics related to the material's strength to decline. In light of these data, it is possible to draw the reasonable conclusion that the amount of marble dust that should be substituted in concrete should be 20%. This conclusion may be drawn since it is rational. This is one of the inferences that can be made from the evidence. The findings of this experiment indicate that the proportion of cement that should be substituted with marble dust in the manufacturing of cubes, cylinders, and prisms should be somewhere in the vicinity of twenty percent. Based on the findings, it would appear that marble dust might be put to good use in the production of long-lasting concrete as well as other building supplies.

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