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# "Experimental Investigation in Concrete by Partial Replacement of Coarse Aggregate (Sand) with Marble Dust"

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ABSTRACT

*The Concrete is the most extensively used and adaptable building material which is generally used to counterattack compressive forces. Since the use of Sand and production of Sand creates much more environmental issues and is expensive also. The Sand is produced in a natural way. Mining of sand in Narmada River due to natural disasters there is a danger. In the coming time so we have to be ready to deal with this problem. So we are looking from marble dust. Marble Dust is a developing composite material that will allow the concrete industry to optimize materiel use, generate economic benefits and build structures that will be strong, durable and sensitive to the environment. The marble dust was replaced with coarse aggregate (Sand) at 0%, 5%, 10%, 15% and 20% by weight of sand in M20(1:1.5:3) grade concrete. Concrete mixes were experimentally tested and compared in terms of compressive strength of the conventional cement concrete at 7 days and 28 days for 150mmX150mmX150mm Sized cubes.*

***Key words: Waste Marble Powder, Partial Replacement, Durability, Cement Concrete, Compressive Strength, Flexural Strength, Split Tensile Strength, Workability***

## INTRODUCTION

Black Marble is obtained from the transformation of pure limestone. The purity of marble depends upon the color of the marble. Since the ancient times, marble is widely used in monuments and historical buildings for decorative purpose. The various types of constituents present in marble, some of which varies from origin to origin. There are some chemicals as well as mineral impurities which are associated with marble like quartz, muscovite, SiO2, limonite, Fe2O3. But some impurities like magnesia, phosphate, leads, zinc, alkalis and sulfides affect the properties of cement. In general, the large amount of marble powder dust is obtained during the cutting and forging process. In India, tons of waste have been produced from the industries. But there are some impurities present in the waste that cannot be easily disposed of. Such type of impurities mixed with soil and water. When they mix with soil, it reduces the porosity and permeability of the soil and also reduces the fertility of a soil. Also, if it mixes with water, it pollutes the water and make the water unfit for use. So, it is necessary to use the waste in functional manner. Usually, this type of waste can be utilized by using it as a raw material or as a constituent in a material because they had different chemicals present in it that causes a harmful effect on the environment.

Nowadays, concrete has a great advancement in concrete technology in which it can reduce the consumption of natural resources as well as the energy sources and that can further reduce the impact of pollutants on the surroundings. Due to hike in price, waste should be used in the constituents to decrease the cost and make the project cost effective.

In this experimental study, we had an experimental effect of marble dust powder on the concrete mix by partially replacing cement and sand with the marble powder dust. In this project, we check the effect on mechanical and physical properties of a concrete mix if varying marble powder dust is partially replaced in the concrete mix.

## Research Significance

In this experimental study, fine marble powder dust was collected from the nearby source for the investigation. Different concrete mixtures were prepared by using different percentages of marble powder like 0%, 10%, 10% and 20% as a partial replacement of cement and sand mix. The mechanical and physical properties were checked on the 7 & 28 days.

## NECESSITY OF STUDY

1. For requirement of substitute for Sand.
2. To overcome the material shortage of concrete.
3. To lessen the expense by making utilization of locally accessible & waste materials.
4. To check different properties of concrete with adding various percentages of Marble Dust.

## OBJECTIVE

1. Comparative study of the behavior of the concrete with & without Marble Dust.
2. To determine the compressive strength, split tensile strength & Bond strength of the Marble Dust used in concrete.
3. To study the behavior of concrete using Marble Dust in strength enhancement.
4. To find the optimum percentage of Marble Dust obtaining the maximum strength of concrete.
5. To prove the Marble Dust can be use as an economical civil engineering material.

## LITERATURE REVIEW

***Deepanshu Patel{1}*** : Investigation was done that there are several wastes being released from the industries which leads to many environmental and health problems and so it becomes necessary to find an appropriate solution to the emission of these wastes. Marble powder is an inert material which is procured as an industrial by-product during sawing, grinding, and polishing of marble is a cause to various environmental problems. These wastes can be used as the constituents of concrete by partially replacing the cement which makes it economical and also conserves our natural resources. The main objective of this research is to examine whether there is any possibility of utilizing marble powder in concrete production. This study includes different types of concrete mixes of M25 by replacing the cement with marble powder in various proportions (0%, 5%, 10% & 15%) by weight to determine the optimum percentage of replacement.
The testing for Compressive strength of these Concrete mixes is done at 7 and 28 days and the results are then compared with the Control Concrete. The results obtained after the research shows that marble powder can be used asa replacement for cement. From compressive strength tests it is concluded that the best proportion of marble powder is 10% with 28 days of curing. Use of marble powder in concrete does not affect the setting time of concrete.

***Devesh Meena {2}*** : The main objective of this research is to investigate the possibility of utilizing waste marble dust (MD) in cement and concrete production. In present study experimental investigation conducted on optimum marble dust replacement with sand. After cutting and sawing marbles, in large amount of marble slurry produce. This marble slurry disposed to open land area, it make land pollution and harmful to land. In road construction it can use as substitute of fine aggregate, it has good binding property and gives enough strength to concrete and due to this it is suitable to bear heavy load on rigid pavement. In present study compressive strength of concrete at 28 days was checked, and this concrete is prepared by mixing cement, aggregates, water and sand. In further study sand is replaced by marble dust, and then concrete was prepared. The replacement ratios which have been studied were 0.0%, 10%, 20%, 30%,40%, and 50% by weight. Water – cement ratio kept 0.55. Concrete made with marble dust as sand replacement achieved better performance compared to normal concrete. Experiment such as specific gravity test of sand and marble dust by pycnometer method, moisture content of marble dust and sand by oven drying method, specific gravity test of cement by Le-Chatelier flask method, normal consistency of cement, and initial setting time of cement, were performed to determine the physical property of concrete. On fresh concrete slump test was performed to check workability of concrete and after then compressive strength was checked. Thus marble dust is appropriate substitute of fine aggregates in concrete mix for construction. In present study experimental investigation conducted on optimum marble dust replacement with sand. After cutting and sawing marbles, in

large amount of marble slurry produce. This marble slurry disposed to open land area, it make land pollution and harmful to land. In road construction it can use as substitute of fine aggregate, it good binding property and give enough strength to concrete.

1. Specific gravity of sand 2.58 and marble dust's 3.06,thus specific gravity of marble dust is more than sand.
2. Sand has more water content then marble dust. So for preparing concrete mix marble dust require more water to add.
3. Initial setting time of cement was found 45-50 minute.
4. In slump test workability of marble dust-concrete was determined, as amount of marble dust increased slump value also decreased as compare tonormal cement concrete. For desired slump value for workability add more water added.
5. In compressive strength test on harden concrete cube, it was found as amount of marble dust increased compressive strength decrease but it has enough compressive strength as require for construction. Up to 50% fine aggregate can replaced with sand.

***Ramya Raju et al. {3}:*** This paper presents the study of concrete mix design using marble powder. The disposal of marble powder from the marble industry is one of the environmental problemsoday. The places where marble is used for various purposes, the use of marble powder can be included for construction purpose Marble powder is produced from processing plant during the sawing and polishing of marble blocks and about 20 – 25% of the processed marble is turned into powder form. Disposal of the marble powder material from the marble industry is one of the environmental problems worldwide today. The replacement is done partially in various proportions and its effect on properties of concrete is studied. The optimum percentage for replacement of marble powder to attain the maximum strength is 50% replacement where as in tensile strength the optimum strength is achieved by 10% replacement by cement. As the percentage replacement of marble powder increases the workability reduces. The use of marble powder reduces the cost of construction as it used in mixing with concrete for building of floors and other structures and it also reduces the proportion of water cement ratio. Based on the study the following conclusions are drawn:

a. The compressive strength is increases at 0.4 w/cratio, but decreases the tensile strength.
b. The partial replacement of cement by marble powder is used up to M25 grade concrete.
c. The strength decreases beyond the use of M 25 grade, but shall be improved on the addition of super plasticizer.

***Ranjan Kumar, Shyam Kishor Kumar {4}***: In this research work, the waste MDP passing through 90 microns, has used for investigating of hardened concrete properties. Furthermore, the effect of different percentage replacement of MDP on the compressive strength, splitting tensile strength (Indirect tensile strength) & flexural strength has been observed. In this experimental study, the effect of MDP in concrete on strength is presented. Five concrete mixtures containing 0%, 5%, 10%, and 20% MDP as cement replacement by weight basis has been prepared. Water/cement ratio (0.43) was kept constant, in all the concrete mixes. Compressive strength, split tensile strength & flexural strength of the concrete mixtures has been obtained at 7 and 28 days. The results of the laboratory work showed that replacement of cement with MDP increase, up to 10% for compressive strength, & up to 15% for split tensile strength & flexural strength of concrete. The usage of MDP in concrete improved its quality in terms of strength. The following conclusions were based on the study on the test result.

a. The Compressive strength of Concrete increasesup to 10% replacement of cement by MDP and further increasing of percentage of MDP leads todecrease in compressive strength of concrete.
b. The Split tensile strength of concrete increases upto 15% replacement of cement by MDP & furtherincreasing of percentage of MDP leads to decreasein Split tensile strength of concrete.
c. The Flexural strength increases up to 15% replacement of cement by MDP and further increases in the percentage of MDP leads to decrease in flexural strength.

***Vijaya Kumar YM et al. {5}:*** Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. Partial replacement of cement by varying percentage of marble dust Powder reveals that increased waste marble dust powder ratio result in increased workability and compressive strengths of the concrete Marble Dust Powder is settled by sedimentation and then dumped away, which results in environmental contamination, in addition to forming dust in summer and threatening both agriculture and public wellness.. In this research work, Marble Dust Powder has replaced the (OPC & PPC) cement accordingly in the reach of 0%, 5%, 10%, 15% 20%, & 25% by weight of M-20 grade concrete. Concrete mixtures were developed, tested and compared in terms of compressive strength to the conventional concrete. The purpose of the investigation is to analyze the behavior of concrete while replacing the Marble Dust Powder with Different proportions in concrete.

## EXPERIMENTAL METHODOLOGY & INVESTIGATION

### 2.1 Concrete Mix Constituents

| *Characteristics* | *Specified value as per IS:8112-1989* | *Experimental value* |
|---|---|---|
| Consistency of cement (%) | --- | 31.6 |
| Specific gravity | 3.15 | 3.02 |
| Initial setting time (minutes) | >30 | 40 |
| Final setting time (minutes) | <600 | 380 |
| Compressive strength ($N/mm^2$)<br>(i) 3 days<br>(ii) 7 days<br>(iii)28days | <br>>23<br>>33<br>>43 | <br>25.20<br>34<br>49 |
| Soundness (mm) | 10 | 1.2 |
| Fineness of Cement (gm) | 10 | 1.5 |

#### 2.1.1 Cement

The cement use for the experimental studies was 43 grade OPC conforming to the specifications of Indian Standard Code IS: 8112-1989 shows in table 1. It was fresh and without any lumps.

#### 2.1.2 Aggregate

Normal river sand which is locally available in the market and confirming to Zone II as per IS 383 1970 as shown in table 2 and specific gravity of fine sand is 2.614 and coarse aggregates were used in this experiment whose fineness modulus is 2.65. Coarse aggregate used as 20 mm downsize. The lumps of clay and other foreign materials were separated out carefully. Sand was washed and dried before testing. The coarse aggregates were washed to remove dirt, dust and then dried to surface dry conditions.

TABLE I CHARACTERISTICS PROPERTIES OF CEMENT

TABLE II PHYSICAL PROPERTIES OF FINE AND COARSE AGGREGATES

| *Sr.No* | *Physical Properties* | *Fine Aggregates* | *Coarse Aggregates* |
|---|---|---|---|
| 1 | Specific Gravity | 2.615 | 2.67 |
| 2 | Free Moisture Content | 2.1% | - |
| 3 | Water Absorption | 1.85% | 0.14% |
| 4. | Fineness Modulus | 2.85 | 2.64 |

TABLE III PHYSICAL PROPERTIES OF MARBLE POWDER

| *Sr.No* | *Physical Properties* | *Values* |
|---|---|---|
| 1 | Specific Gravity | 2.209 |
| 2 | Dry Moisture Content | 1.59% |
| 3 | Bulk Density($kg/m^3$) | 1117 |
| 4. | Fineness Modulus | 2.035 |

#### 2.1.3 Supplementary Cementitious Materials

The marble powder was obtained by crushing marble powder forms in a marble industry. The bulk density was 1117 $kg/m^3$ and fineness modulus is 2.035 and has a specific gravityof 2.209.

*2.1.4 Concrete Mixture Proportion*

In this experimental study, the mix design is taken as M25. Water binder ratio is taken as 0.43. Different mixes was prepared by using a different percentage of marble powder (0%, 10%, 10% and 20%) namely MX0, MX1, MX2& MX3 as a partial replacement in the cement sand mix, where MX0 is control mix with no marble powder dust, MX1with 10% marble powder as partial replacement of sand, MX2 with10% marble powder dust as partial replacement of cement and MX3 with 20% marble powder dust as partial replacement of cement and sand together.

**Fig. I WASTE MARBLE PIECES**

*2.1.5 Casting Detail*

The size of standard cubical moulds for the casting of aspecimen is 150mm x 150mm x 150mm were casted according to the mix proportion. The size of specimens of 150 mm diameter and 300 mm height of the cylinder size andthe size of prism 100 x 100 x 500 mm were also casted according to the mix proportion and also by partial replacing of cement and sand with marble powder in differentproportions.

*2.1.6 Curing of Specimen*

After the hardened of a specimen in about 24 hours then thecasted concrete specimens were cured under water which is free from chlorides and sulphates are placed for curing and tested after required curing.

**Fig. II CURING OF SPECIMEN**

*Testing the Specimen Details*

Concrete specimens were tested using compression testing machine (CTM) of capacity 200 tones and with a constant rate of load is 14 N/min for all specimens and were tested at different curing ages for 7days and 28 days. Split tensile strength was testing on the 200 tones capacity machine and constant rate of a load is 2.4 N/mm²/minute. Flexural strength testing was also conducted by using a 100kN capacity electrically operated flexural testing machine at a displacement rate of 0.05 mm/sec. Water absorption test was also conducted.

## EXPERIMENTAL TEST RESULT & DISCUSSION

*3.1 Workability*

Slump values of a concrete sample have been tested for a different sample of mix with different percentages of marble powder as replacement of cement and sand in a mix. The result showed that the workability of a concrete mix was decreases with increase in the marble powder dust content.

### 3.2 Strength

#### 3.2.1 Compressive Strength

It can be noted that when cement is partially replaced by the marble powder up to 10% then the compressive strength of the mix increased up to 8.9% and when partially replace it with sand then again compressive strength increased up to 9% but when marble powder dust is partially replaced by cement and sand together by 20%(10%+10%) then its compressive strength decreased up to 11%. Hence result shows that marble powder when mixed with sand and cement together has low compressive strength as compared to the replacement of marble waste in cement and sand individually.

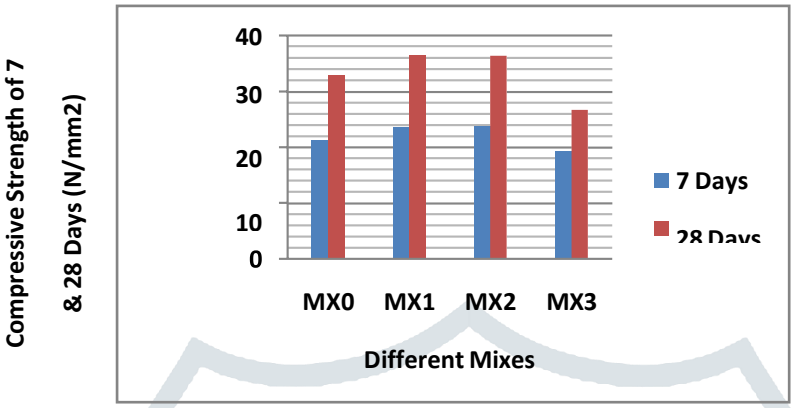


Fig. III GRAPH BETWEEN DIFFERENT MIXES AND COMPRESSIVESTRENGTH OF 7 & 28 DAYS

#### 3.2.2 Split Tensile Strength

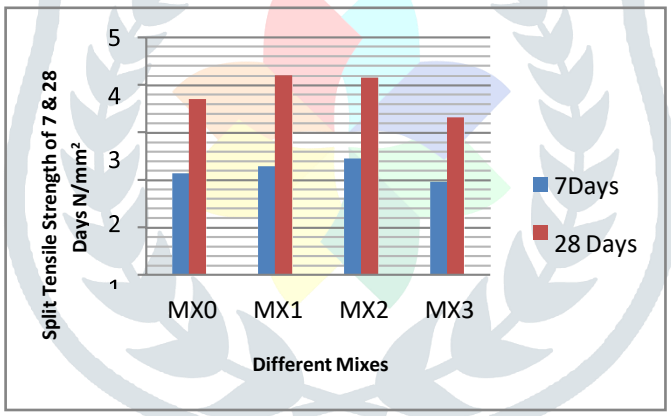


Fig. IV GRAPH BETWEEN DIFFERENT MIXES AND SPLIT TENSILESTRENGTH OF 7 & 28 DAYS

#### 3.2.3 Flexural Strength

It can be observed that the flexure strength for the concrete mix containing 10% of marble powder dust in cement got increased by the value of 9.2% and for 10% replacement withsand the flexure strength also got increased about 9.3% but it decreased when the mix contains 20% marble powder dust against cement (10%) and sand(10%) about 10%. Hence result shows that marble powder when mixed with sand and cement together has low flexural strength as compared to the replacement of marble waste in cement and sand individually.

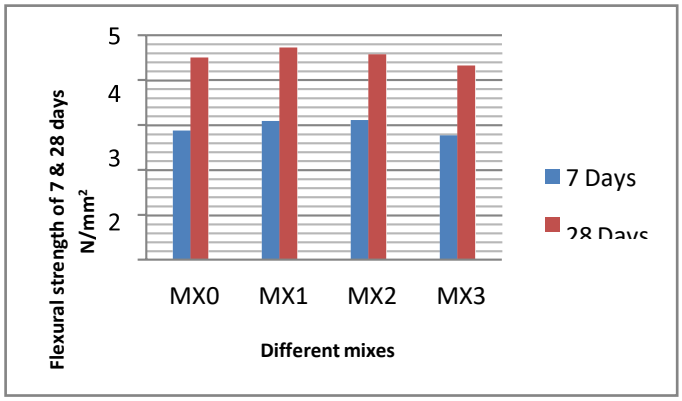

Fig. V GRAPH BETWEEN DIFFERENT MIXES AND FLEXURALSTRENGTH OF 7 & 28 DAYS

It can be noted that the split tensile strength for concrete mix increased with 8.7% when partially replaced by 10% marble powder dust against cement and also increased by 9.3% as in the partial replacement with sand having 10% marble dust powder. But the split tensile strength decreased for the mix which contains 20 % marble powder dust against cement (10%) and sand (10%) by 11%. Hence result shows thatmarble powder when mixed with sand and cement together has low split strength as compared to the replacement ofmarble waste in cement and sand individually. *Durability*

The result shows that marble powder when partial replaces with sand its durability decrease but when partial replaces with cement and cement sand mixture its durability comparatively increases. It can be noted that in all casesdurability is more as compared to the control mix.

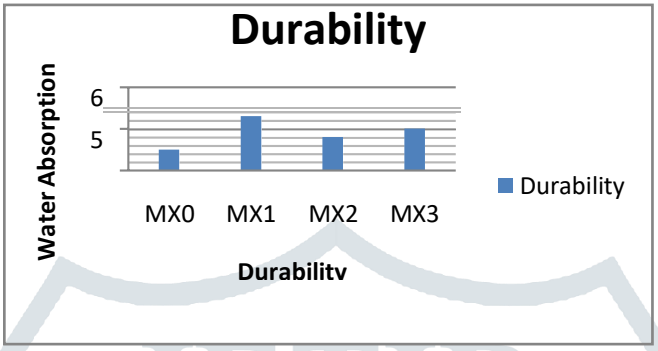


Fig. VI GRAPH BETWEEN DIFFERENT MIXES AND WATERABSORPTION OF 28 DAYS

## CONCLUSION

Experimental investigation showed the following conclusions:

a) When cement is replaced with marble powder up to 10% weight a high strength concrete was achieved.
b) Increasing the amount of marble powder decreases the workability of concrete.
c) Based on the experiment result it showed that replacement of cement and sand by marble powder up to 10% increases the compressive strength but above 10% content of marble powder decreases the compressive strength.
d) Split tensile strength increases with increase in marble powder dust.
e) Compared to the control concrete flexural strength is maximum when replace with fine aggregate up to 10%.
f) Durability increases with increase in marble content but in small amount.

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