# Experimental Study on Mechanical Properties of Concrete with Marble Dust and Quartz as Fine Aggregate

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***Abstract***- **Concrete is the blended material that typically constitute of cement as binding material, natural sand as fine aggregate & gravel as coarse aggregate. It may or may not constitute mineral or chemical admixtures. Aggregates consist of 50 to 80 percentage of a conventional concrete mixture. So, their selection is very important to produce ideal concrete strength, durability and workability. Thus, the stipulation for sand obtained from natural resources has increased over years, which has caused scarcity of natural river sand in several regions. Therefore, the need for an alternative for fine aggregate has been increased. On the other hand, ideal use of wastes and their by-products from industries as building materials brings greater significance in terms of cost effectiveness and also equally implies on the conservation of natural resources. So, in this paper an analysis is performed to explore the prospect of using a combination of marble dust powder and quartz in place of natural sand. The replacement ratios of marble dust and quartz are as 5%, 10%, 15%, 20% and 25% of marble dust and quartz by weight. Compression, tension and flexural strengths of concrete analyzed from waste marble dust and quartz has been analyzed in parallel with normal concrete of M25 grade.**

***Index terms***- **Concrete, Fine aggregate, Marble dust, Quartz powder, Compression, Flexural strength test, Split Tensile**

## I.INTRODUCTION

In past few decades, advancements in concrete technology and usage of new materials as replacements of typical cement, natural sand and gravels have been increased and led to the control of depletion of natural resources. Using marble dust powder is one such measure that would be a better replacement for natural river sand. Marble dust powder is a waste or slag produced in mass from marble manufacturing industries. Such waste can be harmful to the environment when dumped or disposed in other ways. Since it is a waste product and generated in tons, usage of such material in construction can be economically sound and profitable to use.

## II. OBJECTIVE

One of the key objectives of this work is to determine whether marble dust and quartz can be used as a replacement for sand. This also eventually leads to conservation of natural resources.

## III. LITERATURE SURVEY

After a detailed survey from the other papers, following points were derived.
Mostly, marble waste powder was used as a replacement for concrete and fine aggregate replacement was rare. Combination of two or more materials as a replacement for fine aggregate is also rarely done.
Marble dust and quartz powder was used as replacement separately but not used simultaneously.

## IV. MATERIALS USED

A. Cement
OPC - Ordinary Portland cement of grade 53 based on IS: 12269-1987 has been used in this experimental study. 3.12 is the specific gravity value of cement obtained.

B. Fine Aggregate
Manufactured sand - (M-Sand) obtained from granites have been was used in this work. Fineness modulus and the specific gravity value of fine aggregates is found out to be of 2.67 and 2.58 respectively.

C. Coarse Aggregate

Here, 12.5 mm sized gravels were used. Fineness modulus and the specific gravity values of coarse aggregates is found out to be 3.25 and 2.84 respectively.

D. Marble Dust Powder

Marble dust powder is obtained from local marble manufacturing industries. Metamorphic rock evolved from limestone transformation is knows as marble. The specific gravity of marble dust is found out to be 3.06.

E. Quartz

Quartz is mostly used in the high performance concrete HPC or UHPC. It is also a chemically inactive substance at normal environmental condition but is not entirely inactive and reacts at higher temperatures and for high pH values

| Mix % | W/ cratio | Water | Cement | FA | CA | MDP | Qua-rtz |
|---|---|---|---|---|---|---|---|
| 0 | 0.45 | 3.23 | 7.18 | 12.94 | 18.36 | 0 | 0 |
| 5 | 0.45 | 3.23 | 7.18 | 11.65 | 18.36 | 0.65 | 0.65 |
| 10 | 0.45 | 3.23 | 7.18 | 10.35 | 18.36 | 1.29 | 1.29 |
| 15 | 0.45 | 3.23 | 7.18 | 9.05 | 18.36 | 1.94 | 1.94 |
| 20 | 0.45 | 3.23 | 7.18 | 7.76 | 18.36 | 2.59 | 2.59 |
| 25 | 0.45 | 3.23 | 7.18 | 6.47 | 18.36 | 3.24 | 3.24 |

F. Water

Water is another fundamental component of concrete which undergoes the chemical reaction with the binding material cement actively. The pH of water is 6 –7 commonly that is suitable for the concrete mixture.

## V. METHODOLOGY

According to the Indian Standards IS: 10262 : 2019 and IS 456 : 2000 , mix design for M25 grade of concrete has been calculated by replacing partially the fine aggregate with various percentages of marble waste powder and quartz (0%, 10%, 20%, 30%, 40%, 50%) by weight. The concrete cubes of 150mm x150mm x150 mm in size, the concrete cylinders of 150mm x 300 mm in size and the concrete beams of 150 x150 x700 mm in size were casted. After curing for week, then fourteen days and followed by 28 days with water, the hardened models were put to testing for the compressive strengths, tensile and flexural strengths.

Table 1: Various percentages of Sand replacement with Marble Dust Powder and Quartz

| S. No. | Cement | M-Sand | MarbleDust | Quartz | CA |
|---|---|---|---|---|---|
| 1. | 100% | 100% | 0% | 0% | 100% |
| 2. | 100% | 90% | 5% | 5% | 100% |
| 3. | 100% | 80% | 10% | 10% | 100% |
| 4. | 100% | 70% | 15% | 15% | 100% |
| 5. | 100% | 60% | 20% | 20% | 100% |
| 6. | 100% | 50% | 25% | 25% | 100% |

Table 2: Concrete mix proportion (M25)

## VI. TEST DATA

The following basic test results were obtained from the tests done in the laboratory.

Table 3: Specific Gravity

| S. No | Material | Specific Gravity |
|---|---|---|
| 1 | Cement | 3.12 |
| 2 | FA | 2.58 |
| 3 | CA | 2.84 |
| 4 | MWP | 3.06 |
| 5 | Quartz | 2.65 |

Table 4: Slump values

| S. No | Marble dust | Quartz | Slump value |
|---|---|---|---|
| 1 | 0% | 0% | 50 |
| 2 | 5% | 5% | 48 |
| 3 | 10% | 10% | 45 |
| 4 | 15% | 15% | 40 |
| 5 | 20% | 20% | 30 |
| 6 | 25% | 25% | 30 |

## VII. TEST RESULTS

A. Compressive Strength

Compression test is one of the most important and common test carried out to check the compressive strength of a hardened concrete. This is a measure of its ability to resist static loading. As per IS: 516-1959, the compression test is carried out on cubical specimens. Table 5 and 6 shows the compressive strength containing varying percentage of marble dust powder and quartz. Figure 1 shows the bar graph of compressive strength results obtained for the same.

Table 5: Compressive strength results

| Marble Dust in % | Quartz in % | Values after 7 days strength (N/mm2 ) |
|---|---|---|
| 0 | 0 | 17 |
| 5 | 5 | 19 |
| 10 | 10 | 21 |
| 15 | 15 | 20 |
| 20 | 20 | 20 |
| 25 | 25 | 18 |

Table 6: Compressive strength results

| Marble dust and quartz in total % | Values after 14 days strength ($N/mm^2$) | Values after 28 days strength ($N/mm^2$) |
|---|---|---|
| 0 | 20 | 23 |
| 10 | 21 | 25 |
| 20 | 25 | 29 |
| 30 | 22 | 28 |
| 40 | 23 | 25 |
| 50 | 20 | 23 |

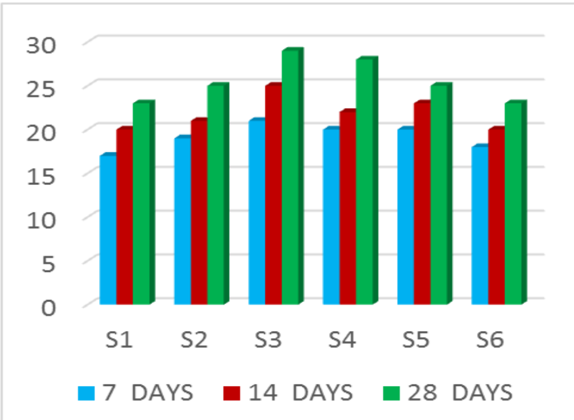


Figure 1. Graphical representation of Compressive strength test values (N/mm2)

B. Flexural Strength:

This test was made to obtain the flexural strength as per IS 516: 1959 in beam specimen. The specimens are tested for different percentage mix of marble dust powder and quartz after curing it for 4 weeks. Table below explains the test results and the following graph describes the flexural strength obtained.

Table 7: Flexural strength results (N/mm2)

| Marble dust in % | Quartz in % | 28 days $N/mm^2$ |
|---|---|---|
| 0 | 0 | 3.92 |
| 5 | 5 | 4.71 |
| 10 | 10 | 5.84 |
| 15 | 15 | 5.35 |
| 20 | 20 | 4.82 |
| 25 | 25 | 4.30 |

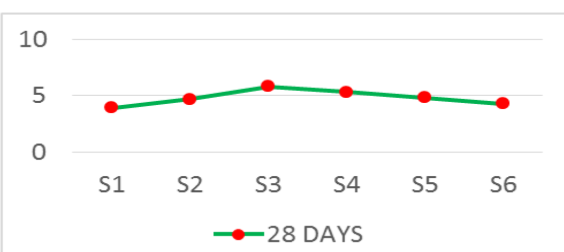


Figure 2. Graphical representation of flexural strength in N/mm2 (28th day)

C. Tensile Strength

A concrete cylindrical specimen of 150mm x 100 mm in size as per the IS code 5816 – 1999 is utilized to perform split tensile test. The specimens are tested for different percentage mix of marble dust powder and quartz after curing. Table 8 and 9 shows the flexural strength results and Figure 3 explains the bar graph of the tensile strength results obtained for the same.

Table 8: Tensile strength results (N/mm2)

| Marble dust in % | Quartz in % | Values after 7 days strength (N/mm2 ) |
|---|---|---|
| 0 | 0 | 2.45 |
| 5 | 5 | 2.32 |
| 10 | 10 | 2.14 |
| 15 | 15 | 2.10 |
| 20 | 20 | 1.80 |
| 25 | 25 | 1.52 |

Table 9: Tensile strength results (N/mm2)

| Marble dust and quartz in total % | Values after14 days strength ($N/mm^2$) | Values after 28 days strength ($N/mm^2$) |
|---|---|---|
| 0 | 2.58 | 2.62 |
| 10 | 2.47 | 2.50 |
| 20 | 2.43 | 2.47 |
| 30 | 2.33 | 2.41 |
| 40 | 2.28 | 2.35 |
| 50 | 2.25 | 2.30 |

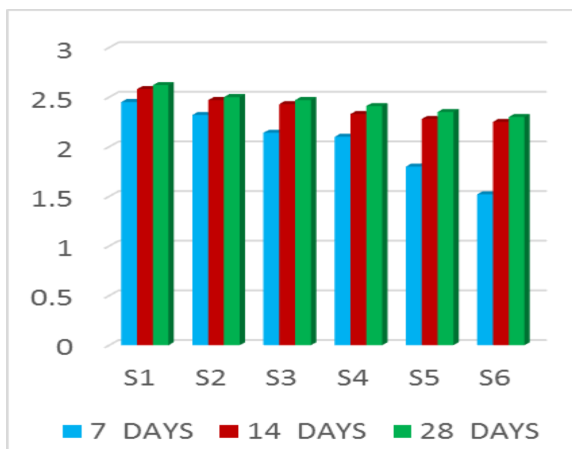


Figure 3. Bar graph showing the values of Tensile strength (N/mm2)

## VIII. CONCLUSION:

The below conclusions were made by considering the outcomes obtained from the above study.

Compressive strength of concrete is observed to be gradually high when compared to the conventional concrete by replacing some amount of fine aggregate with marble dust and quartz powder.

Ideal percentage of marble waste and quartz powder that can be used as an alternative for fine aggregate would be 5 to 15 percentage each. Optimal compressive strength after water curing for 28 days is 29 N/mm2 when the percentage mix is 10% of marble dust and quartz each.

Tensile strength is spotted to be decreasing with increased percentage of the replacement. However, at 5 percent of replacement of marble dust and quartz for fine aggregate is optimum.

Flexural strength is observed to be in increasing trend but decreases after 10 percent replacement. However, the decreasing values are established to be greater than that of the conventional concrete values. So, 5 to 15 percentages can be replaced with marble dust and quartz powder to attain optimal flexural strength.

From the results obtained above it is evident that the alternative natural sand with marble dust and quartz at 5 to 15 percentages is optimum and produces good results. Eventually, this leads to the better workability and durability of concrete.

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