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# Eco-Friendly & Cost effective High Performance Concrete by Using MarblePowder and Foundry Sand

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**Abstract -** *As construction in India and other developing countries increases, the consumption of energy and resources is also increasing in an alarming way. Most of the developing nations have reduced the usage of virgin materials in construction, due to consumption of energy and resources is increasing in an alarming way, so they focused on the environment and safeguarding of natural resources and recycling of wastes materials. Many industries produce lot of waste products which is disposed into landfills. This material can be used in construction industry as alternative to conventional materials. Such practice conserves natural resources and reduces the space required for the landfill disposal of these waste materials. Highperformance concrete appears to be a better choice for a strong and durable structure. In this project, investigations were carried out on strength properties such as compressive strength and flexural strength of M40 grade of HPC mixes with different replacement levels such as 05%, 10%, 15% and 20%, of marble powder with cement and 20%, 30%, 40%, 50%, and 60% of foundry sand with fine aggregate by adopting water-cement ratio of 0.42 and combined of both with different replacement levels such as (5%+20,30,40,50,60%),(10%+20,30,40,50%),(15%+20,30%). Conplast SP430 is based on can be used as a super plasticiser for better workability for high performance concrete. The HPC mix, grade M40 concrete is designed as per IS 10260-2009 Guide for selecting proportions for high strength concrete materials. Mechanical characteristics like Compressive strength and Flexural strength were examined. The result of these investigations demonstrates the strength characteristics of marble powder, foundry sand based concrete mixes*

***Key Words*: Marble powder, Foundry sand, Workability, Water-Cement ratio, Compressive strength,**

## 1.INTRODUCTION

A large number of researches have been directed towards the utilization of waste materialswhich are easy available and cheaper in cost. For the construction industry, the development and use of waste material is growing rapidly Construction industry need huge amount of construction material and continuous dependence on natural virgin material will lead scarcity of the construction material and increase in cost of material and construction. In recent times, many researches are going on for improving the properties of concrete with respect to strength, durability, and performance as a structural material. Toovercome such situation researchers introducing some substitution of material which is cheaper in cost and easily available use of industrial waste in concrete.

### 1.1 Material & Properties

**Cement:** OPC of grade 43 was used for casting all the specimens should be confirming to IS was used for the present experimental investigation. **Fine aggregate:** Clean and dry river sand available locally was used. Sand passing through IS 4.75 mm sieve was used for casting all the specimens. Specific gravity and fineness modulus is 2.55 and 3.45 respectively

**Coarse aggregate:** Coarse aggregate passing through 20 mm sieve as given in IS 383 – 1970 was used for all the specimens. In addition to cement paste- aggregate ratio, aggregate type has a great influence on concrete dimensional stability. Specific gravity and fineness modulus is 2.906 and 3.49 respectively.

**Foundry sand:** Foundry sand is high-quality uniform silica sand that is used to make moulds and cores for ferrous and nonferrous metal castings. Foundry sand is a by- product of the castings industry typicallycomprising uniformly sized sands with various additives and metals associated with the specific casting process. Foundry sand is the most essential raw material and its importance is sometimes forgotten amongst Foundry personnel. Foundry sand is as used by Foundries is desired for its thermal resistance and availability. Most metal casting sand (FS) is high quality silica sand with uniform physical characteristics. Specific gravity of foundry sand is 2.44and fineness modulus is 2.09

**Marble Powder:** Marble is a metamorphic rock resulting from the transformation of a pure limestone composed solely of calcite (100%$CaCO_3$). Chemically, marbles are crystalline rocks composed predominantly of calcite, dolomite or serpentine minerals. The main impurities in raw limestone (for cement) which can affect the properties of finished cement are magnesia, phosphate, leads, zinc, alkalis and sulphides. A large quantity of powder is generated during the cutting process. Leaving these waste materials to the environment directly can cause environmental problems. Using marble powder in concretes and results about strength and workability were compared

with control samples of conventional concrete. Marble powder can be used as filler in concrete and paving materials and helps to reduce total void content in concrete. Marble powder can be used as an admixture in concrete; so that strength of the concrete can be increased Marble powder can be used to improve the mechanical and physical properties of the conventionalconcrete.

**Water:** In this project, casting and curing of specimenswere done using potable water which shall be free from deleterious materials. Water plays an important role in concrete production (mix) in that it starts the reaction between the cement and the aggregates. It helps in the hydration of the mix.

### 1.2 Mix Design

In this investigation concrete mix design (M40) was designed based on IS10262-2009.This code presents a generally applicable method for selecting mixture proportion for high strength concrete and optimizing this mixture proportion on basis of trial batches. The method is limited to high strength concrete production using conventional materials and production techniques. Mix proportioning details are given belowin table 1

**Table 1 Mix Design**

| Unit ofbatch | cement | Fine aggregate | Course aggregate | Waterr | Admixture |
|---|---|---|---|---|---|
| Cube Meter content (kg) | 388 | 635 | 1307 | 163 | 3.88 |
| Ratio of Ingredients | 1 | 1.64 | 3.36 | 0.42 | 0.01 |

**Method of Experiment:** It is important that the constituent material of concrete remain uniformly distributed within the concrete mass during the various stages of handling and that full compaction is achieved, and making sure that the characteristics of concrete which affect full compaction like consistency,mobility and compatibility are in conformity with relevant codes of practice. The tests were carried out inaccordance with relevant IS Standards. The aggregates were tested for physical properties such as specific gravity and particle distribution test. The fresh concrete was subjected to the slump test followed by casting of concrete in moulds for further investigations. All the mixes were prepared by mixing the concrete in laboratory along with water and super plasticizer. For compressive strength studies cube specimens of size 150 mm x 150 mm x 150 mm, for flexural strength studies, beam specimens of size 150 mm x 150 mm x 700 mm studies were prepared. All the specimens were cast and cured for 28 days as per standard curing methods. are shown in tablefor the age of 28 days of the specimens

**Table 1 Test results of cube for compressive strength of M-40 grade concretewith Marble powder = 0%, Foundry sand= 0% (reference mix concrete) in 7 days**

| Stage | Batch | mixes | %age marble powder | %age foundry sand | Average Compressive strength (N/mm²) |
|---|---|---|---|---|---|
| 1 | 1 | M0,0 | 0 | 0 | 29.76 |

**Table 2 Test results of cube for compressive strength of M-40 grade concretewith Marble powder = 0%, Foundry sand= 0% (reference mix concrete) in 28 days.**

| Stage | Batch | Mixes | %ofMP | % ofFS | ompressive strength (n/mm²) |
|---|---|---|---|---|---|
| 1 | 1 | $M_{0,0}$ | 0 | 0 | 43.65 |

**Stage 2 Partial replacement of cement by marble powder** In this stage, samples were prepared by varying percentage 05, 10, 15, 20% of marble powder as a part of replacement of cement in mix design in the cube material then tested compressive strength. Tests are performed at the curing date of 28 days of the specimens.

**Table3 Test results of cube for compressive strength of M-40 grade concrete with Marble powder = 05, 10, 15, 20%, Foundry Sand =0% in28days.**

| Stages | Batches | Mixes | %age Marble powder | %age foundry sand | average compressive strength (n/mm²) |
|---|---|---|---|---|---|
| 2 | 2 | M05,0 | 05 | 0 | 30.04 |
| | | M05,0 | | | |
| | 3 | M10,0 | 10 | 0 | 37.28 |
| | | M10,0 | | | |
| | 4 | M15,0 | 15 | 0 | 38.46 |
| | | M15,0 | | | |
| | 5 | M20,0 | 20 | 0 | 27.59 |
| | | M20,0 | | | |

**Stage 3 Partial replacement of sand by foundry sand** In this stage, samples were prepared by varying percentage 20, 30, 40, 50, 60% of foundry sand as a part of replacement of fine aggregates in mix design in the cube material then tested compressive strength.

tests are performed at the curing date of 28 days of the specimens. The compressive strength tests results are shown in table for the age of 28 days of thespecimens.

**Table4.Test results of cube for compressive strength of M-40 grade concrete with Marblepowder=0%, Foundry Sand = 20, 30, 40, 50, 60% in 7days.**

| Stages | Batches | Mixes | %age Marble powder | %age foundry sand | average compressivestrength (N/mm²) |
|---|---|---|---|---|---|
| 3 | 6 | M0,20 | 0 | 20 | 33.47 |
| | | M0,20 | | | |
| | 7 | M0,30 | 0 | 30 | 34.05 |
| | | M0,30 | | | |
| | 8 | M0,40 | 0 | 40 | 35.35 |
| | | M0,40 | | | |
| | 9 | M0,50 | 0 | 50 | 35.61 |
| | | M0,50 | | | |
| | 10 | M0,60 | 0 | 60 | 26.54 |
| | | M0,60 | | | |

**Stage 4 Partial replacement of cement by marble powder and partial replacement of sand by foundry sand** In this stage, samples were prepared by varying percentage of foundry sand as a part of replacement of fine aggregates and percentage of marble powder as a part of replacement of cement in mix design in the cube material then tested compressive strength. Tests are performed at the curing date of 28 days of thespecimens

**Table 5 Test results of cube for compressive strength of M-40 grade concrete with Marblepowder=05%, Foundry Sand = 20, 30, 40, 50, 60% in 28days**

| Stages | Batches | Mixes | %age Marble powder | %age foundry sand | average compressive strength (n/mm²) |
|---|---|---|---|---|---|
| 4 | 11 | M05,20 | 05 | 20 | 45.84 |
| | | M05,20 | | | |
| | 12 | M0,530 | 05 | 30 | 46.21 |
| | | M05,30 | | | |
| | 13 | M05,40 | 05 | 40 | 47.94 |
| | | M05,40 | | | |
| | 14 | M05,50 | 05 | 50 | 47.96 |
| | | M05,50 | | | |
| | 15 | M05,60 | 05 | 60 | 41.11 |
| | | M05,60 | | | |

**Table6 Test results of cube for compressive strength of M-40 grade concrete with Marble powder=10%, Foundry Sand = 20, 30, 40, 50% in28days**

| Stages | Batches | Mixes | %of MP | %of FS | average compressive strength |
|---|---|---|---|---|---|
| 4 | 16 | $M_{10,20}$ | 10 | 20 | 44.92 |
| | 17 | $M_{10,30}$ | 10 | 30 | 45.15 |
| | 18 | $M_{10,40}$ | 10 | 40 | 45.72 |
| | 19 | $M_{10,50}$ | 10 | 50 | 42.08 |

**Table7 Test results of cube for compressive strength of M-40 grade concrete with Marble powder=15%, Foundry Sand = 20, 30, 40% in28days**

| Stages | Batches | Mixes | % of MP | %of FS | average compressive strength |
|---|---|---|---|---|---|
| 4 | 20 | $M_{15,20}$ | 15 | 20 | 43.04 |
| | 21 | $M_{15,30}$ | 15 | 30 | 41.13 |

## Flexural Strength Test:

**Stage1 Reference mix concrete** A minimum of two beams are casted in each batch for determining flexuralstrength. Flexural test are performed at the curing date of 28 days of the specimens.

**Table8 Test results of beam for Flexural strength of M-40 grade concrete referencemix concrete in 28days**

| Stage | Batch | Mixes | %ofMP | % ofFS | Average Flexural strength (n/mm²) |
|---|---|---|---|---|---|
| 1 | 1 | $M_{0,0}$ | 0 | 0 | 43.65 |

**Stage 2 Partial replacement of cement by marble powder** In this stage, samples were prepared by varying percentage 05, 10, 15, 20% of marble powder as a part of replacement of cement in the beam material then tested Flexural strength. Flexural test are performed at the curing date of 28 days of the specimens.

**Table9 Test results of beam for Flexural strength ofM-40 grade concrete with Marble powder = 05, 10, 15, 20%, Foundry Sand = 0% in 28days**

| Stages | Batches | Mixes | %ofMP | %ofFS | average flexural strength (n/mm²) |
|---|---|---|---|---|---|
| 2 | 2 | $M_{05,0}$ | 05 | 0 | 45.71 |
| | 3 | $M_{10,0}$ | 10 | 0 | 45.88 |
| | 4 | $M_{15,0}$ | 15 | 0 | 47.4 |
| | 5 | $M_{20,0}$ | 20 | 0 | 39.39 |

**Stage 3 Partial replacement of sand by foundry sand** In this stage, samples were prepared by varying percentage 20, 30, 40, 50, 60% of foundry sand as a part of replacement of fine aggregates in mix design in the beam material then tested Flexural strength.Flexural test are performed at the curing date of 28 days of the specimens. The Flexural strength tests results are shown in Table for the age of 28 days of the specimens.

**Table10 Test results of beam for Flexural strengthof M-40 grade concrete with Marble powder=0%,Foundry Sand = 20, 30, 40, 50, 60% in 28days**

| Stages | Batches | Mixes | %age Marble powder | %age foundry sand | average flexural strength (n/mm²) |
|---|---|---|---|---|---|
| 3 | 6 | $M_{0,20}$ | 0 | 20 | 7.8 |
| | | $M_{0,20}$ | | | |
| | 7 | $M_{0,30}$ | 0 | 30 | 8.22 |
| | | $M_{0,30}$ | | | |
| | 8 | $M_{0,40}$ | 0 | 40 | 8.61 |
| | | $M_{0,40}$ | | | |
| | 9 | $M_{0,50}$ | 0 | 50 | 7.20 |
| | | $M_{0,50}$ | | | |
| | 10 | $M_{0,60}$ | 0 | 60 | 6.87 |
| | | $M_{0,60}$ | | | |

**Stage 4 Partial replacement of cement by marble powder and partial replacement of sand by foundry sand** In this stage, samples were prepared by varying percentage of foundry sand as a part of replacement of fine aggregates and percentage of marble powder as a part of replacement of cement in mix design in the beam material then tested Flexural strength. Flexural test are performed at the curing date of 28 days of the specimens.

**Table11 Test results of beam for Flexural strength of M-40 grade concrete with Marble powder=05%,Foundry Sand = 20, 30, 40, 50, 60% in 28days**

| Stages | Batches | Mixes | %age Marble powder | %age foundry sand | average flexural strength |
|---|---|---|---|---|---|
| 4 | 11 | $M_{05,20}$ | 05 | 20 | 7.82 |
| | 12 | $M_{05,30}$ | 05 | 30 | 8.41 |
| | 13 | $M_{05,40}$ | 05 | 40 | 8.63 |
| | 14 | $M_{05,50}$ | 05 | 50 | 8.22 |
| | 15 | $M_{05,60}$ | 05 | 60 | 7.44 |

**Table12 Test results of beam for Flexural strength of M-40 grade concrete with Marble powder=10%,Foundry Sand = 20, 30, 40, 50% in 28days**

| Stages | Batches | Mixes | %of MP | %of FS | Average flexural strength |
|---|---|---|---|---|---|
| 4 | 16 | $M_{10,20}$ | 10 | 20 | 7.86 |
| | 17 | $M_{10,30}$ | 10 | 30 | 8.73 |
| | 18 | $M_{10,40}$ | 10 | 40 | 8.80 |
| | 19 | $M_{10,50}$ | 10 | 50 | 6.89 |

**Table13 Test results of beam for Flexural strength of M-40 grade concrete with Marble powder=15%,Foundry Sand = 20, 30% in 28days**

| Stages | Batches | Mixes | % of MP | %of FS | average flexural strength |
|---|---|---|---|---|---|
| 4 | 20 | $M_{15,30}$ | 15 | 20 | 6.68 |
| | 21 | $M_{15,30}$ | 15 | 30 | 6.02 |

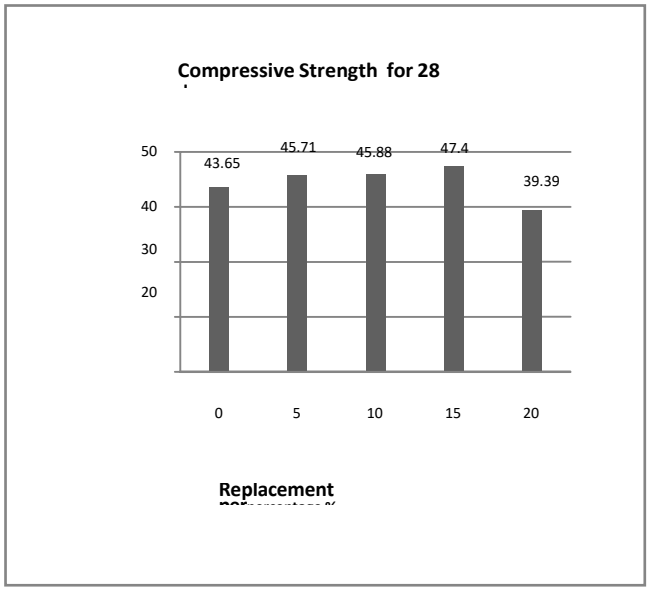
## Results & Discussion

As work is carried out in four stages, results of stages are presented in graphical form. Tests are performing on cubes & beams and their 28 days strengths have been calculate. A comparison based on strength of different mix proportions is carried out. A comparison of strengths for 28 days are also formulated.

**Stage-2** As explained before, cement is partially replaced by MP in this stage and 4 batches are been prepared. In each batch mix 4cubes and 4beams are casted on which 28 days strength tests are performed

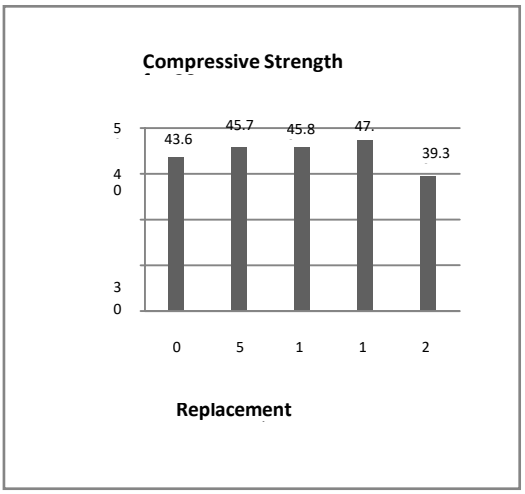
**Compressive Strength** Compressive strength test is performed on 2 cubes of each batch mix for 28 days. There are 4 batch mixes and each one having 4 cubes. Of these 4 cubes, 2 cubes are tested for 28 days each.

The graph shows the difference between compressive strength of the specimen with reference and various percentage replacements with cement




**Graph 1 Compressive Strength at 28 days with reference mix and various %replacements MP withcement**

**Flexural Strength** Flexural strength test is performed on 2 beams of each batch mix for 28 days. There are 4 batch mixes and each one having 4 beams. Of these 4 beams, 2 beams are tested for 28 days each.




**Graph 2 Flexural Strength at 28 days with reference mix and various %replacements MP with Cement(5,10,15,20%)**

**Stage-3** As explained before, sand is partially replacedby FS in this stage and 5 batches are been prepared. In

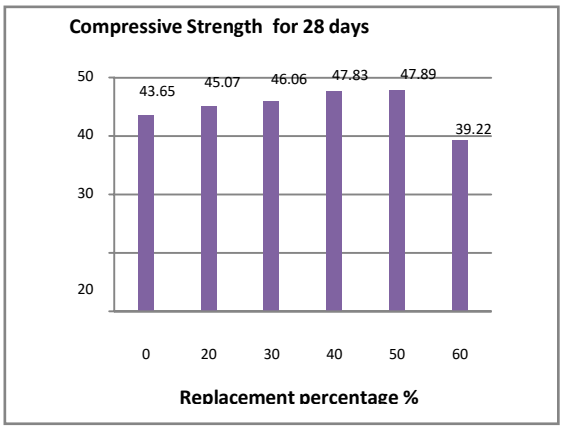
each batch mix 4cubes and 4beams are casted on

which 28 days strength tests are performed.

**Compressive Strength** Compressive strength test is performed on 2 cubes of each batch mix for 28 days.

There are 4 batch mixes and each one having 4 cubes.

Of these 4 cubes, 2 cubes are tested for 28 days each.




**Graph 3 Compressive Strength at 28 days with reference mix and various %replacements FS withsand. (20, 30, 40, 50, 60%)**

**Flexural Strength** Flexural strength test is performed on 2 beams of each batch mix for 28 days. There are 4 batch mixes and each one having 4 beams. Of these 4 beams, 2 beams are tested for 28 days each

**Graph 4 Flexural Strength at 28 days with**

**reference mix and various %replacements FS with sand.(20,30,40,50,60%)**

**Conclusion** The strength characteristics of concrete made with different type of waste materials are discussed in the present study. The possibility of using marble powder and foundry sand in concrete as a cement and fine aggregate replacement have been studied. The mixes of M40 grade concrete was prepared with cement sand aggregate, foundry sand, marble powder separately and combination of marble powder and foundry sand as a cement and fine aggregate. Additional super plasticizer by weight of cement. Based on the study discussed, the following conclusions are drawn:-

**Compressive Strength**

Due to MP, it prove to be effective in assure good cohesiveness of concrete. From the results, it is concluded that the MP can be used as replacement

material for cement and 15% replacement of MP gives an excellent result in strength aspect and quality aspectand it is better than the conventional concrete. 15% of the cement content by marble powder induced higher compressive strength

Foundry sand can be effectively used as fine aggregate in concrete. Replacement of fine aggregate with foundry sand gives good strength. As per our studies 50% replacement of sand gives maximum strength at the age of 28 days. The compressive strengths were increased with increase in the foundry sand in the concrete mix up to 50% and reduction in compressive strength of concrete specimen with replacement percentage beyond 50 % is attributed to binders present in foundry sand, composed of very fine powder of clay and carbon, which results in a weak bond between cement paste and aggregate. The replacement of natural sand with used foundry sand up to 50 % is desirable.

The maximum compressive strength was observed at combined replacement level of MP and FS is found to be (05+50%), (10+40%), (15+20%).

**Flexural strength**

The flexural strength of concrete for M40 grades of concrete increases with marble powder up to 15% replacement by weight of cement and further increases in the percentage of MP leads to decrease in flexural strength there was slight decrease in strength as compared to conventional concrete.

The maximum strength was observed for the replacement of foundry sand by 40% for 28 days strength and the 7 days strength. The result for 40% replacement of waste foundry sand shows that the concrete produce is an economical, sustainable and high strength concrete. The maximum compressive strength was observed at combined replacement level of MP and FS is found to be (05+40%), (10+40%), (15+20%).

Further, the cost of construction can be minimized withusage of marble powder and foundry sand which is freely or cheaply available and the environmental pollution can be reduced by using marble powder as replacement of cement and foundry sand as replacement of sand in concrete.

Use of these waste material leads to sustainable development in construction industry. It's an eco friendly building material. The problems of disposal and maintenance cost of land filling is reduced

The best possible way of disposal of waste material like marble powder and foundry sand can be by using it in concrete, which will reduce environmental burden

A better measure by an innovative construction material is formed also environmental effects from wastes and disposal problems of waste can be reduced through this research.

Making concrete using recycled materials (foundry sand and marble powder) saves energy and conserve primary resources and it is concluded that the more material was reused, the fewer resources were consumed which leads to a safe, sustainableenvironment

## References

**List of Reference bureau of Indian standard codes**

1. IS: 456–2000 Code of practice for plain and reinforced concrete (fourth revision).
2. BIS: 10262-2009. Recommended guidelinesfor concrete mix design. Bureau of Indian standards. New Delhi, India.
3. BIS: 516-1959. Indian standard code of practice-methods of test for strength of concrete. Bureau of Indian Standards. NewDelhi, India
4. IS: 9399 – 1979 Specification for apparatus for flexural testing of concrete
5. IS 4926-2003, Standard on Ready mixed concrete Code of Practice, BIS, New Delhi.
6. IS: 1130 1969(reaffirmed 2003) Specification for marble (blocks, slabs and tiles)

7. IS: SP: 23-1982 Hand book on concrete mixes

**List of Reference text books**:

1. "Design of Concrete Mixes",by N.Krishna Raju,CBS Publishers & Distributors,Delhi, 1993.

2. "Concrete Technology- theory and practice", by M S Shetty, S. Chand Company Ltd, Delhi, First multicolour illustrative revised edition, reprint 2015.

**List of Reference research papers**

1. Veena G Pathan and Md. Gulfam Pathan. Feasibilityand Need of use of Waste Marble Powder in ConcreteProduction, International Journal of EngineeringResearch and Applications April 2014.

2. D. Pradeep Kumar*, Dr. P. Eswaramoorthi**, Basil Baby International Journal of Engineering Research and Applications