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**Research Article**

# STUDY OF COMPRESSIVE STRENGTH OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH MARBLE DUST POWDER

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**ABSTRACT**

In recent years marble is considered one of the most important decorative building materials. Marble powder is one of the material which effects the environment, soil and heat problems. It is produced from sawing, Shaping and polishing process.

This research aim to study the effect of using marble powder as partially replace of cement on the properties of concrete. The main variable taken into consideration is the percentage of marble powder as partial replacement of cement content in concrete mixture. The experimental results shows that using definite amount of marble powder replacement of cement content increase the workability & compressive strength.

Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized.



## INTRODUCTION

Concrete has been the construction material used in the largest quantity from several decades. The reason for its popularity can be found in the excellent technical properties of concrete as well as in the economy of this material. It is also characteristic that the properties of concrete ingredient have a major influence on the fresh as well as hardened concrete.

Today the rate at which concrete is used is much higher than. It was 50 years ago. It is estimated that the present consumption of concrete in the world is of the order of 25 billion metric tonnes every year.

Recycling of industrial wastes has actually environmental, economical and technical benefits. These benefits can be seen from two different angles, one from the point of the waste producer and other from the user part. For the producer the benefits of recycling industrial wastes are economical and environmental for the users additional and technical benefits may be attained from recycling.

One of the greatest environmental concern is construction industry is the production of cement which emits large amount of $CO_2$ gas to the atmosphere. It is estimated that 1 tone clinker production releases 1 tone $CO_2$. Recycling marble waste powder in substitution of cement can reduce environmental problem related with cement production, the design of concrete ($M_2O$) was done with locally available material. Cement was replaced with replacement level of cement (0%, 10%, 15% & 20%). Three number of cubes of 150×150×150 were casted for each %age replacement.

Hence 36 number of cubes were casted for each compressive strength test. The compressive strength of concrete of all mixes was determined at the ages of 7, 14 and 28 days of curing for various replacement level of cement.

## METHODOLOGY

In this experimental work various experiments and various instruments are used. Summarized study of experimental setup and apparatus arc given below:

### *Sieve Analysis*

A sieve analysis (or gradation test) is a practice or procedure used (commonly used in civil engineering) to assess the particle size distribution (also called gradation) of a granular material. The size distribution is often of critical importance to the way the material performance in use. A sieve analysis can be performed on any type of nonorganic or organic granular materials including sands, crushed rock, clays, granite, feldspars, coal, and soil, a wide range of manufactured powders, grain and seeds, down to a minimum size depending

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on the exact method. Being such a simple technique of particle sizing, it is probably the most common.

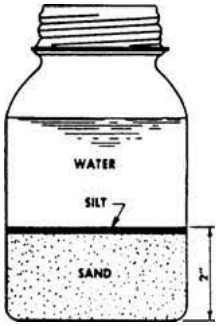
Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregate as per IS: 2386-1963 (Part2) [24]. In this we use different sieves as standardized by the IS code and then pass aggregates through them and thus collect different sized particles left over different sieves. Size of sieves are 80mm, 63mm, 40mm, 20mm, 16mm, 12.5mm, 10mm, 4.75mm, 2.36mm,1.18mm, 600µ,300µ,150µ,75µ,60µ,andpan.

### *Silt Content*

The pressure of dust, loam and clay materials with sand decreases the bond between the materials to be bound together there by decreases the strength of concrete besides decreasing the quality of concrete.

Before starting the nominal mix and concreting, silt content must been sure; To find the silt content in fine aggregate, put some amount of specimen into measuring cylinder up tone third (approx.) after that pour water into cylinder up to half the volume and shake well with closed mouth. And live this settlement, after an hour read the volume of the silt measuring cylinder which forms to player.(IS383:1970[25])

**Silt Content = (Volume of silt/Total volume of specimen)×100**




**Silt Content**

### *Specific Gravity*

Specific gravity is the ratio of the density of a substance to the density (mass of the same unit volume) of are ference substance. Apparent specific gravity is the ratio of the weigh to a volume of the substance to the weigh to fan equal volume of the reference substance.

Specific gravity is define as the ratio of the weight of a given volume of solid to the weight of an equivalent volume of water at 4 degree $C^0$. (IS2886PT3:1963) [26]

Pycnometer method is most accurate to finds specific gravity of fine aggregate. The specific gravity of solid sis determined using the relation:

$$G = (M_2-M_1)/\{(M_2-M_1)-(M_3-M_4)\}$$

Where,

$M_1$= mass of empty Pycnometer.

$M_2$= mass of the Pycno meter with dry soil.

$M_3$= mass of the Pycnometer and soil and water,

$M_4$= mass of Pycnometer filled with water only

G=Specific gravity of solids

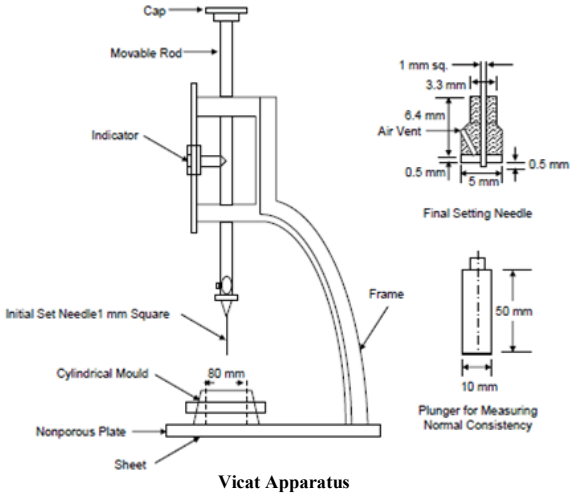
### *Consistency of cement*

Consistency is a general term to indicate the degree of fluidity or the degree of mobility. A concrete which has high consistency and which is more mobile, need not be of right workability for a particular job.

The quantity of water required to produce a paste of standard consistency to be used for determination of the water content for the compressive strength test and for the determination of soundness and setting time, shall be obtained by the method described in IS: 4031-1988(Part 4).

The basic aim is to find out the water content required to produce a cement paste of standard consistency as specified by the IS: 4031-1988(Part 4) [27].

The Principle is that standard consistency of cement is that consistency at which the Vicat Plunger penetrates to a point 5-7mm from bottom of Vicat mould (IS: 5513-1976)[28].




**Vicat Apparatus**

### *Setting time*

The stiffening of a cement paste is called setting. The time starling from the mixing of cement and water until the cement paste sets is called the setting time. Cement paste setting time is affected by a number of items including: cement fineness, water-cement ratio, chemical content (especially gypsum content) an admixtures. Setting tests are used to characterize how a particular cement paste sets. For construction purposes, the initial set must not be too soon and the final set must not be too late. Additionally, setting limes can give some indication of whether or not cement is under going normal hydration. Normally, two setting times are defined: Initial set occurs when the paste begins to stiffen considerably; final set occurs when the cement has hardened to the point at which it can sustain some load. These particular times are just arbitrary points used to characterize cement; they do not have any fundament alchemical significance. Both common setting time tests, the Vicat needle, define initial set and final set based on the time at which a needle of particular size and weight either penetrates cement paste sample to a given depth or fails to penetrate cement paste sample.

### *Initial Setting Time*

It's the time from which cement starts process after water added. Usually it is 30 min. It can be delayed or advanced using chemicals. We need to calculate the initial as per IS:

4031(Part5)-1988 [29]. To do so we need Vic at Apparatus conforming to IS: 55131976[28], Balance, whose permissible variation at a load of 1000g should be ±1.0g, Gauging trowel conforming to IS: 10086-1982.

***Final Settling Time***

Usually it is 500 min. It can be delayed or advanced using chemicals. We need to calculate the final as per IS: 4031 (Part5)-1988[29]. To do so we need Vic at Apparatus conforming to IS: 55131976[28], Balance, whose permissible variation at a load of l000g should be±1.0g, Gauging trowel conforming to IS: 10086-1982.

**Initial and Final Setting Needles**

***Work ability***

It is defined as the "ease with which concrete can be compacted hundred per cent having regard to mode of compaction and place of deposition".

Workability as the property determining the effort required to manipulate a freshly mixed quantity of concrete with minimum loss of homogeneity. The term "manipulate" includes the early age operations of placing, compacting and finishing. A workable concrete allows full compaction using are as on able amount of work. This helps in achieving maximum possible density (i.e. minimum possible voids) of concrete, which results in more strength and durability of concrete. The increase in fine aggregate to coarse aggregate ratio generally increases the water content required to produce a given work ability. If finer aggregate is substituted in a mixture, the water content typically must be increased to maintain the same workability. Lowering the cement content of concrete with given water content typically will lower work ability. An increase in cement fineness decreases work ability and produces excessive bleeding; a high fineness will cause a concrete mixture to lose workability of Cement more rapidly because of Cement replacing materials also affect workability.
Workability is measured by following test:

- Slump Test
- Compaction Factor Test
- Vce-bee Consistometer Test
- Flow Test

***Slump Test***

The slump test is a practical means of measuring the consistency of mix. Since changes in the values of slump obtained indicate material changes in the water content or proportions of the mix. It is therefore useful in controlling the quality of the mortar produced.

The apparatus consists of a steel mould 100mm diameter at the top, 200mm at the bottom and 300mm high, complete with a 16mmdia. Steel tamping rod 600mm long and rounded on one end. (Local standards may vary the size of the equipment.) The inside of the mould should be clean before each test, and the mould placed on a hard flat surface. The mould should be filled in four layers, each layer rodded 25 times with the tamping rod. After the to player has been rodded, the surface of the mortar is struck off level. Any leakage is leaned away from the base of the mould and the mould is lifted vertically from the mortar.

The slump is the difference between the height of the mix before and after removal of the mould. If any specimens hears off laterally or collapses, the test should be repeated. By using the correct mix and water/cement ratio prior to undertaking any casting, as a sample test(s) the average slump achieved from several tests w give the range of slump acceptable when the actual casting takes place. Because the mixisamortarmix, the slump can be exaggerated by a very little increase in the water/cement ratio. Therefore, it is a handy guide but should not be an over- riding conclusion when the practicalities of the construction and need for full impregnation of there in for cement are of priority during casting.

***Material Property***

***Sieve analysis***

**Table** Sieve analysis of fine aggregate

| ISSieve Size | Weight Retained | Cumulative weight | Cumulative% age wt Reatained | Cumulative % age Passing |
|---|---|---|---|---|
| 10 | 0 | 0 | 0 | 100 |
| 4.75 | 90 | 90 | 9 | 91 |
| 2.36 | 80 | 170 | 17 | 93 |
| 1.18 | 490 | 660 | 66 | 34 |
| 600µ | 190 | 850 | 85 | 15 |
| 300µ | 120 | 970 | 97 | 3 |
| 150µ | 20 | 990 | 99 | 1 |
| Pan | 10 | 1000 | 100 | 0 |

Total weight of fine aggregate= 1000gm
Fineness Modulus of sand-

$$= \frac{Sum\ of\ \%\ Retain\ on\ Sieve\ Size}{100}$$

$$= \frac{9 + 17 + 66 + 85 + 97 + 99}{100}$$

= 3.73

B-Sieve analysis of coarse aggregate
Total weight of coarse aggregate taken= 5kg

**Table** Sieve analysis of Coarse aggregate

| IS Sieve Size | Weight Retained | Cumula tive weight | Cumulative% age wt Reatained | Cumulati ve %age Passing |
|---|---|---|---|---|
| 40mm | 0 | 0 | 0 | 100 |
| 20mm | 1900 | 1900 | 38 | 62 |
| 10mm | 3090 | 4900 | 99.8 | 0.2 |
| 4.75mm | 10 | 5000 | 100 | 0 |
| 2.36mm | 0 | 0 | 100 | 0 |
| 1.18mm | 0 | 0 | 100 | 0 |
| 600µ | 0 | 0 | 100 | 0 |
| 300µ | 0 | 0 | 100 | 0 |
| 150µ | 0 | 0 | 100 | 0 |

Fine Modulus of coarse aggregate

$$= \frac{summation\ of\ \%\ retained\ sieve\ size\ (20mm,10mm,\ 4.75mm,2.36mm,1.18mm,600\mu,300\mu,150\mu)}{100}$$

$$= \frac{38+99.8+100\times6}{100}$$

=7.378

***Test for the silt content***

Silt content infine Aggregate Total weight of sand= 300gm Weight of silk= 75gm

% of silt = (wt ofsilt/ wt of sand) × 100

$$= \frac{7}{300} \times 100$$

= 2.33

***Test for specific gravity***

**A.** Specific Gravity of fine aggregate by Pycnometer,

$W_1$= Weight of Pyconometer= 642gm.

$W_2$= Weight of Pyconometer with dry sand= 1247gm

$W_3$= Weight of Pyconometer+ Weight of sand+ Weight of water = 1874.5gm

$W_4$= Weight of pyconometer+ Water only= 1518.0gm

SP. Gravity

$$G = \frac{W_2 - W_1}{(W_2 - W_1) - (W_3 - W_4)}$$

$$= \frac{1247 - 642}{(1247 - 642)(1874.5 - 1518.0)}$$

[G= 2.43]

**B.**Specific gravity coarse Aggregate:

Weight of empty pyconometer $W_1$= 496gm

Weight of aggregate+ pyconometer $W_2$= 860gm

Weight of sand+ pyconometer + water $W_3$= 1473gm

Weight of pyconometer+ water $W_4$= 1245gm

SP gravity of coarse aggregate $G = \frac{W_2 - W_1}{(W_2 - W_1) - (W_3 - W_4)}$

$$= \frac{860 - 496}{(860 - 496)(1473 - 1245)}$$

= 2.66

***Nominal Mix***

- Grade designation= M20
- Type of cement = PPC43
- Maximum nominal size of aggregate= 20mm
- Maximum W/c Ratio= 0.55(from tobee5IS456:2000)
- Method of concrete pealing= Hand pealing
- Degree of Supervision=Good
- Type of aggregate= crushed angular aggregate
- Specific gravity of PPC= 3.13
- Specific gravity of coarse aggregate= 2.66
- Specific gravity of fine aggregate= 2.43
- Mix proportion for M20grade= 1:15:3

***Details of Mix Proportions:*** Material Requirement [for 9cubes]

**Table** Mix Proportion

| S.No. | % Replacement of cement with marble dust | Cement (Kg) | Marble Powder | F.A.(Kg) | C.A. (Kg) | Water (Kg) |
|---|---|---|---|---|---|---|
| 1 | 0 | 13.09 | 0 | 19.63 | 39.27 | 7.2 |
| 2 | 10 | 11.781 | 1.309 | 19.63 | 39.27 | 6.48 |
| 3 | 15 | 11.126 | 1.964 | 19.63 | 39.27 | 6.11 |
| 4 | 20 | 10.472 | 2.618 | 19.63 | 39.27 | 5.76 |

***Preparation of specimen:*** The quantities of the constituents of the concrete were obtained from the Indian Standard Nominal design. The variation of strength of hardened concrete using Sandas Fine aggregate and using marble dust powder partial replacement of cement is studied by casting cubes. The concrete was prepared in the laboratory using machine mixing. The cement, fine-aggregate, and coarse aggregate were first mixed in dry state to obtain uniform colour and added amount of water and the while concrete was mixed for five minutes in wet state. Meanwhile the moulds are screwed lightly to avoid leakage; Oil was applied on inner surface of the moulds. The concrete after mixing was poured into moulds in three layers by poking with a tamping rod. The cast specimens were removed from moulds after 24 hours and the specimens were immersed in a clean water tank. After curing the specimens for a period of 28 days, the specimens were removed from the water tank and allowed to dry undershade.

***Compressive strength of concrete***

The compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. It can be measured by plotting applied force against deformation in a compressive at testing machine. Some material fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load. Compressive strength is a key value for design of structures.

Out of many test applied to the concrete, this is the most important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. For cube test-two types of specimens either cubes of 150mm ×ISOmm × 150mm or 100 mm × 100 mm×100mm depending upon the size of aggregate are used. For most of the works cubical moulds of size150mm × 150mm × 150mm are commonly used. This concrete is poured in the moulds and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimens should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen.

These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load at the failure divided by area of specimen gives the compressive strength of cement.

***Specimen for Compressive Strength***

To study the variation in compressive strength of conventional concrete and concrete with partial replacement of Cement by marble dust powder indifferent fraction for PPC (0%,10,15% &

20%). Three cub of size 150mm× 150mm×150mm is made for each set i.e. 0%, 10%,15% & 20% marble dust powder.

## RESULT AND DISCUSSION

The study is conducted to analyze the compressive strength of concrete when the base materials, i.e. cement is replaced with marble dust powder respectively. The marble dust powder replacement was kept at 0%, 10%, 15% & 20%. In all total 36 cubes of PPC (150mm×150mm×150mm) were tested and results were analyzed after curing 28 days. The results of all the tested specimen is given below.

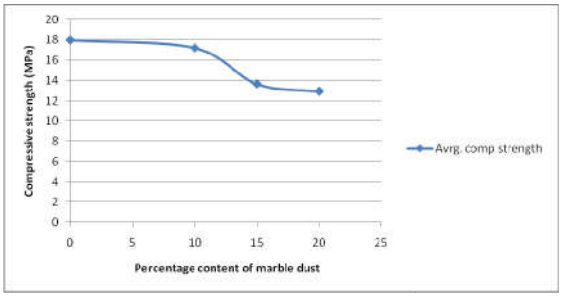
***Table for compressive strength for Portland Pozzolana Cement***

**For 0% Marble Dust Powder & 100% cement (PPC Conventional concrete)**

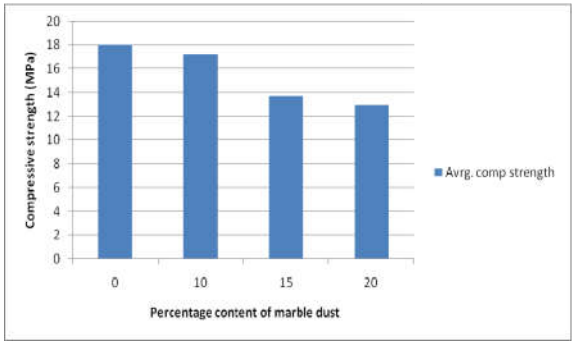
***Compressive Strength***

**Table 7** Compressive At 7 Days

| % Replacement of Marble Powder | Sample 1 | | Sample 2 | | Sample 3 | | Avg. C.S. MPa |
|---|---|---|---|---|---|---|---|
| | Load (Km) | Compression Strength MPa | Load (KM) | Compression Strength MPa | Load (KM) | Compression Strength MPa | |
| 0% | 400.2 | 17.78 | 410.5 | 18.24 | 4.3 | 17.91 | 17.97 |
| 10% | 390.8 | 17.33 | 385.2 | 17.11 | 386 | 17.15 | 17.19 |
| 15% | 397.4 | 13.2 | 315.2 | 14.00 | 309.3 | 13.74 | 13.64 |
| 25% | 271.2 | 12 | 290.3 | 12.90 | 312 | 13.85 | 12.91 |



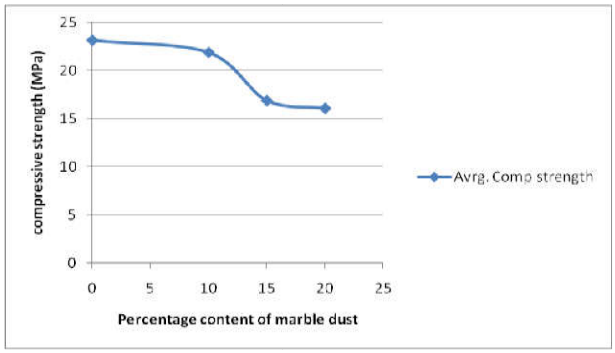

**Graph showing copressivestreng that 7days**



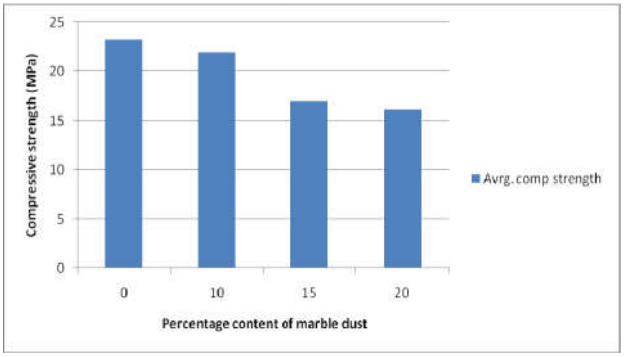

**Bar Chart Showing Compressive Strength at 7 Days**

**Table** Compressive At 14 Days

| % Replacement of Marble Powder | Sample 1 | | Sample 2 | | Sample 3 | | Avg. C.S. MPa |
|---|---|---|---|---|---|---|---|
| | Load (Km) | Compression Strength MPa | Load (KM) | Compression Strength MPa | Load (KM) | Compression Strength MPa | |
| 0% | 546.2 | 24.27 | 540.3 | 24.01 | 492.1 | 21.18 | 23.15 |
| 10% | 488.4 | 488.4 | 490 | 21.77 | 499.8 | 22.2 | 21.89 |
| 15% | 377.2 | 377.2 | 385.4 | 17.12 | 380 | 16.88 | 16.92 |
| 25% | 350.6 | 350.6 | 370.1 | 16.44 | 368 | 16.35 | 16.12 |



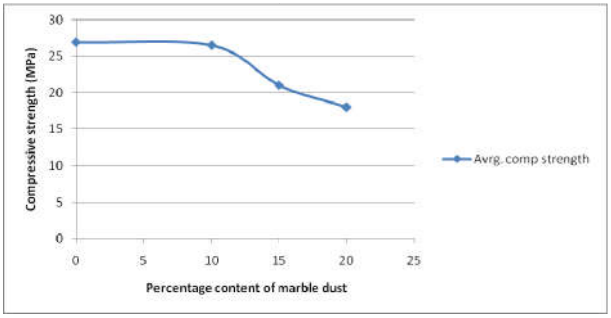

**Graph Showing Copressive Strength at 14 Days**

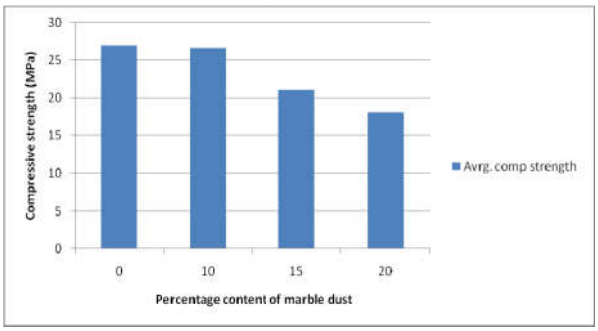



**Bar Chart Showing Compressive Strength at 7 Days**

**Table** Compressive At 28 Days

| % Replacement of Marble Powder | Sample 1 | | Sample 2 | | Sample 3 | | Avg. C.S. MPa |
|---|---|---|---|---|---|---|---|
| | Load (Km) | Compression Strength MPa | Load (KM) | Compression Strength MPa | Load (KM) | Compression Strength MPa | |
| 0% | 610.2 | 27.11 | 609.0 | 27.06 | 599.1 | 26.62 | 26.93 |
| 10% | 598.9 | 26.01 | 590.0 | 26.22 | 600.3 | 26.68 | 26.50 |
| 15% | 429.9 | 19.1 | 499.3 | 22.19 | 490.3 | 21.79 | 21.02 |
| 25% | 403.0 | 17.91 | 409 | 18.17 | 404.3 | 17.96 | 18.01 |




**Graph Showing Compressive Strength At 28 Bar Chart Showing Compressive Strength at 28 Days**

## CONCLUSIONS

1. The Compressive strength of cubes is gradually decreased with addition of marble dust powder by weight of cement.
2. The result shows that, we can replace the PPC only upto 10% by weight of cement with marble dust powder.
3. A simple step is forwarded to minimize the cost for construction with the usage of marble powder dust.
4. As being a civil engineer, we have also stepped into area lm of solving the environmental pollution by cement production.
5. Marble dust powder has a potential to provide an alternative to cement and helps in maintaining the environment as well as economical balance.
6. This project shows the hardened properties of concrete containing marble dust at 0%,10%,15% & 20% of PPC.

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