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# Experimental Analysis of Partial Replacement of Ordinary Portland Cement in Concrete with Super plasticizer and Marble Dust

**Rahul kumar[1], Neha Singh[2]**

[1]*Assistant Professor, Dept. of Civil Engineering, Sanskar College of Engineering & Technology, Ghaziabad U.P, India*
[2]*Assistant Professor, Dept. of Civil Engineering, Sanskar College of Engineering & Technology, Ghaziabad U.P, India*

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**Abstract -** Production of cement in cement industries causes hazardous impact over environment by emitting harmful gases like carbon dioxide, carbon monoxide, Sulphur dioxide & nitrogen oxide in environment. Therefore replacement of this material is an essential aspect to be worked out for preparing green concrete. Concrete prepared with industrial wastes such as marble dust, fly ash, ground granulated blast furnace slag and steel slag etc. can enhance the durability of reinforced concrete structures and reduce consumption of natural resources and environment pollution. The replacement of cement with Marble Dust Powder (MDP) provides a durable modification in compressive strength, making them compatible for the manufacturing of concrete. The replacement of materials offers cost reduction, energy savings and protection of environment. Marble dust is used as a replacement of fine aggregates in many literature works but this investigation discovers the feasibility of the substitution of marble waste for cement to achieve economy and environment friendly concrete. Water reducing admixtures (WRAs) also known as super plasticizers are most commonly used admixtures worldwide. Water reducing admixture, as its name suggests, reduces the water required to attain a given slump. In the present investigation optimum percentage of replacement of cement with marble dust in conjunction with super plasticizers for M20 grade of concrete has been evaluated. Parameters selected for investigation are compressive strength after 7 and 28 days and workability.

***Key Words*: Marble Dust, Super Plasticizer, Ordinary Portland Cement, Workability, Compressive Strength & Admixture**

## 1. INTRODUCTION

Cement is widely used in concrete for infrastructure development. The Ordinary Portland Cement (OPC) is one of the major ingredients used for the preparation of concrete and has no substitute in the civil construction industry. Unfortunately, production of cement leads to emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for greenhouse effect and the global warming, hence it is mandatory either to quest for another material or partly replace it by some other material. Higher concrete substance of High Strength Concrete altogether influences the quality at the solidified state because of shrinkage and more noteworthy assessment of warmth of hydration. Higher concrete substance of High Strength Concrete altogether influences the quality at the solidified state because of shrinkage and more noteworthy assessment of warmth of hydration. The expense of development moreover gets heightened further more leaving the waste materials to the environment straightforwardly can bring about natural issue. Henceforth the reuse of waste material has been referred.

## EFFECTS OF MARBLE DUST AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE

The advancement of concrete technology can decrease the application of natural resources and energy sources and lessen the charge of pollutants on the environment. Natural resources have become costlier. Natural stone processing plants produces large amount of stone dust with a vital impact over environment and humans. The use of the alternative materials provides reduction in cost, energy savings, superior products, and lesser hazards in the environment. Stone blocks are altered into smaller blocks in order to give them the desired shape and size. During the altering process of marbles, original marble mass is lost by 25% in the form of dust. Annually, 250-400 tons of Stone wastes are generated on site. The marble cutting plants are emitting the powder in any nearby pit or vacant spaces, near their unit although notified areas have been marked for disposing leading to serious environmental and dust pollution and covering vast area of land.

This project describes the feasibility of using the marble sludge dust in concrete production as partial replacement of cement The compressive Strength of concrete was measured for 7 and 28 days.

### 1.1 SUPER PLASTICIZERS AS ADMIXTURES

These are the materials which delivers very high workability with a remarkable decrease in water content (at least 20%). These can be added to concrete mix to produce high slump flowing concrete. The effect of super plasticizers lasts only for 30to 60 minutes, depending on composition and dosage and is followed by rapid loss in workability. One of the important factors that govern the issue water–cement ratio during the manufacture of

concrete, lower water-cement ratio leads to less capillary pores and also lower permeability and enhanced durability. Although Super plasticizer are essential to produce a truly high performance concrete (HPC) characterised by low water-cement ratio and workability level without high cement content. Concrete are being produced with w/c ratio of range 0.25 - 0.20, enables the production of highly durable high performance concrete. The workability also increases with an increase in the maximum size of aggregate. But smaller size aggregate provides larger surface area for bonding with the mortar matrix, which increases the compressive strength. For concrete with higher w/c ratio use of larger size aggregate is beneficial. High range super plasticizer was used in all the concrete mixes to achieve good workability. Super plasticizers are added to reduce the water requirement by 15 to 20% without affecting the workability leading to a high strength and dense concrete. To achieve the uniform workability, the admixture dosage was adjusted without changing the unit water content. This ensured the identical W/C ratio for a particular cementious content and the effect of pozzolanic material replacement can directly be studied on the various properties of concrete.

From composition point of view, there are four major categories of super plasticizers namely-

- Sulphonated melamine formaldehyde condensate (SMF),
- 6Sulphonated naphthalene formaldehyde condensate (SNF),
- Modified lignosulphonates (MLS)
- Polycarboxylate(PCE) based super plasticizers

### 1.2 MECHANISM OF SUPERPLASTICIZERS–

The basic mechanisms of water reduction are through dispersion of cement particles by electrostatic repulsion and/or steric hindrance. Fine particles such as cement grains have a tendency to flocculate when mixed with water. When they flocculate, a certain amount of water is often trapped inside agglomerates. Water reducing admixtures are used to deflocculate and to free the trapped water.

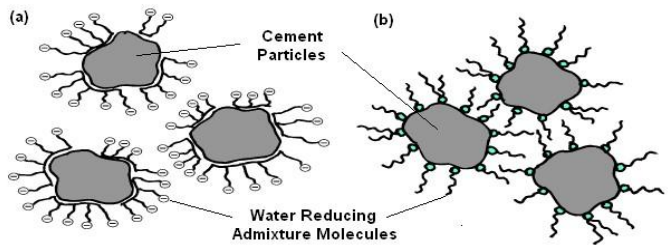


**Figure 1** MECHANISMS OF SUPER PLASTICIZERS

a) ELECTROSTATIC REPULSION

b) STERIC HINDRANCE

### 1.3. OBJECTIVE OF RESEARCH WORK

- To investigate the influence of partial replacement of cement with marble dust, along with addition of water reducing admixture i.e. super plasticizer.
- To check mechanical properties like slump value and compressive strength of concrete prepared by partial replacement of cement and addition of super plasticizer and to compare it with the corresponding properties of conventional M20 concrete.
- To find out optimum percentage of replacement of marble dust along with addition of super plasticizer after which the modified concrete will show degradation in its compressive strength.

## 2. LITERATURE REVIEW

From the literature survey it is observed that substantial amount of work has been carried out by few researchers on assessment of Previous study over marble dust& super plasticizers has been discussed under this chapter. Many experimental studies have been carried out over the behaviour and properties of concrete influenced by addition of marble dust and super plasticizers. Hence it is very important to study and discuss previous investigation as these studies provide direction& scope for future study & evolution of materials in construction industries.

Marble powder possessing cementious properties are being used as replacement of cement in production of concrete .It has been varied at different percentage for replacement of cement in different grades of concrete .Since marble powder is treated as waste product produced during sawing and cutting of marbles in industries, it can result in economical concrete production as cement is the costlier material used and also production of cement leads to environment pollution.

Super plasticizers are the chemical admixture added during mixing of concrete. The function of the super plasticizers is to impart high workability and strength to the concrete by reducing w/c ratio.

## 3. METHODOLOGY

### 3.1 INTRODUCTION OF MATERIALS:

Following materials were used in the experimental investigation

1. Cement (OPC 53)
2. Fine aggregate

3. Coarse aggregate
4. Waste marble dust
5. Super plasticizer
6. Water

**Table 1** Properties of OPC 53

| Properties | Result |
|---|---|
| Fineness | 7% |
| Specific gravity | 3.15 |
| Standard consistency | 31.5 |
| Initial setting time | 35min |
| Final setting time | 270min |

**Table 2** Properties of fine aggregates

| Properties | Result |
|---|---|
| Specific gravity | 2.62 |
| Water absorption | 1% |
| Bulk density | 1680 |
| Fineness modulus | 3 |
| Type of sand | Narmada river sand |

**Table 3** Properties of coarse aggregates

| Properties | Result |
|---|---|
| Specific gravity | 2.86 |
| Water absorption | 0.81% |
| *Impact value* | *13.56%* |
| *Los Angeles abrasion value* | *22.04%* |

**Table 4** CHEMICAL COMPOSITION OF MARBLE DUST

| Composition | Percentage |
|---|---|
| Silica $SiO_2$ | 28.36 |
| Alumina $Al_2O_3$ | 0.43 |
| Iron oxide $Fe_2O_3$ | 9.70 |
| Calcium oxide Cao | 40.44 |
| Magnesium | 16.26 |

Marble is a metamorphic rock formed from the transformation of a pure limestone. Marble used for construction and decoration is durable, has a noble appearance, and has great demand. Chemically marble consists of calcite, dolomite or serpentine minerals. Quartz, muscovite, tremolite, actinolite, micro line, talc, garnet, osterite and biotite are some of the major impurities whereas SiO2, limonite, Fe2O3, manganese, 3H2O and FeS2 (pyrite) are some of the chemical impurities associated with marble. A large quantity of marble powder is generated during the altering process resulting in the mass of marble waste which is 20% of total marble quarried has reached as high as millions of tons. Emitting these waste materials directly to the environment can cause environmental problems.

### 3.2 SUPER PLASTICIZERS:

Other than deflocculation of cement grains, phenomena that take place due to super plasticizers in concrete are:

- Induced electrostatic repulsions between particles
- Dispersions of cement grains & consequent release of water trapped within cement flocks
- Reduction in surface tension of water
- Formation of lubrication film between particles
- Change in morphology of hydration products
- Inducing steric hindrance that prevents particle to particle contact.

Super plasticizer used in this investigation is Sikament® 3070 NS. It is a dark brown liquid solution approved by IS 9103-1999, ASTM C494, IS 2645.Its chemical base consists of Modified Naphthalene Formaldehyde Sulphonate ,having Relative Density~1.15 kg/l at 25°C &pH Value≥ 6.


Figure 2 SUPER PLASTICIZER

### 3.3 EXPERIMENTAL INVESTIGATION:

Following test were conducted for investigation of properties of concrete:

Compressive strength test ,Slump cone test for workability

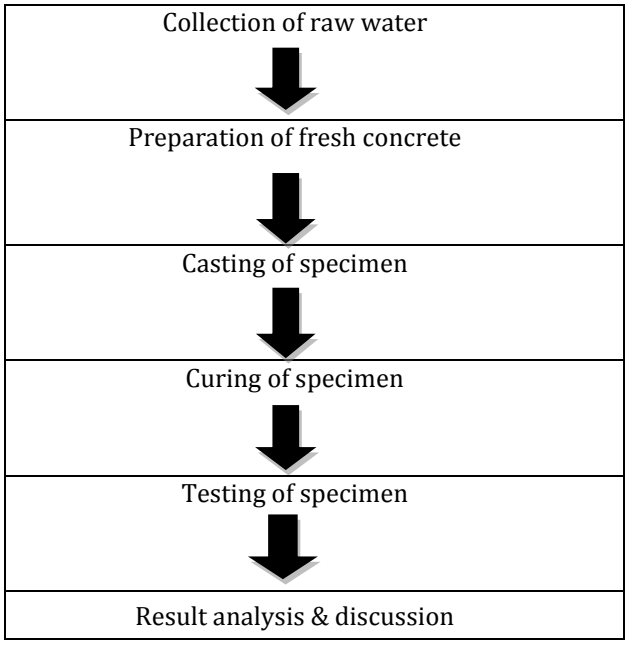


Figure 3 FLOW CHART OF METHODOLOGY

**Table 5** MIX PROPORTIONS (per m3 of concrete)

| Mix (%) Replace | Cement Kg/m³ | FA Kg/m³ | CA Kg/m³ | Water Kg/m³ | Marble Dust Kg/m³ | SP lit/m³ |
|---|---|---|---|---|---|---|
| 0% | 373.38 | 609.6 | 220.8 | 68.02 | 0 | 0 |
| 5% | 354.71 | 609.6 | 1220.8 | 168.02 | 18.669 | 6.44 |
| 10% | 336.04 | 609.6 | 1220.8 | 168.02 | 37.338 | 6.44 |
| 15% | 317.373 | 609.6 | 1220.8 | 168.02 | 56.007 | 6.44 |
| 20% | 298.70 | 609.6 | 1220.8 | 168.02 | 74.676 | 6.44 |

### 3.4 SLUMP CONE TEST:

This test is conducted to determine the workability of concrete. Its apparatus consists of a cone of 10cm top diameter, 20 cm bottom diameter, & 30 cm height as shown in fig.3-16. It has two handles for lifting purpose. Concrete to be tested for its workability is placed in the cone. Slump thus formed generally has either of the three slump pattern specified as shown in fig.3-15. An even slump is termed as true slump, if one half of the concrete cone slides down it is called shear slump & if entire concrete cone slides down it is termed as collapse slump.

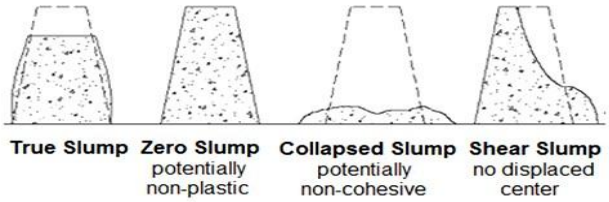


Figure 4 Slump Patterns

## 4.RESULT

Following Nomenclature was adopted for testing of different types of mixes prepared by replacement of cement by 5%, 10%, 15%, & 20% of marble dust by weight of cement& doping 1.5 % of super plasticizer by weight of cement.

**Table 6** TYPES OF MIXES

| Type Of Mix | % OF MARBLE DUST | SUPER PLASTICIZERS (% by weight of cement) |
|---|---|---|
| CC | 0%(CONVENTIONAL CONCRETE) | 0% |
| MD 1 | 5 %MARBLE DUST | 1.5% |
| MD 2 | 10%MARBLE DUST | 1.5% |
| MD 3 | 15%MARBLE DUST | 1.5% |
| MD4 | 20%MARBLE DUST | 1.5% |

**TABLE 7 COMPRESSIVE STRENGTH OF DIFFERENT MIXES**

| S.NO | TYPE OF MIX | COMPRESSIVE STRENGTH (N/mm²) | | AVERAGE COMPRESSIVE STRENGTH (N/mm²) | |
|---|---|---|---|---|---|
| | | 7 DAYS | 28 DAYS | 7 DAYS | 28 DAYS |
| 1 | CC | 14.02<br>13.86<br>14.22 | 12.4<br>27.11<br>26.75 | 14.03 | 26.75 |
| 2 | MD 1 | 19.91<br>19.64<br>18.62 | 33.33<br>27.28<br>28.88 | 19.37 | 29.83 |
| 3 | MD 2 | 19.91<br>21.84<br>21.5 | 27.51<br>30.17<br>32.48 | 21.10 | 31.05 |
| 4 | MD 3 | 21.73<br>21.75<br>22.01 | 33.95<br>34.75<br>32.44 | 22.83 | 33.71 |
| 5 | MD 4 | 18.31<br>17.34<br>17.60 | 26.08<br>28.35<br>26.22 | 17.74 | 26.88 |

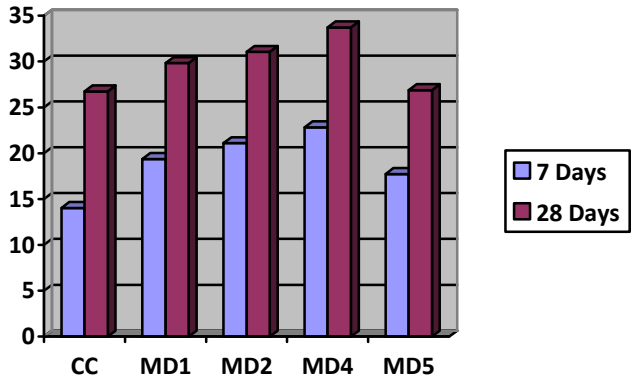


**Figure 5 BAR CHART FOR 7 DAYS COMPRESSIVE STRENGTH**

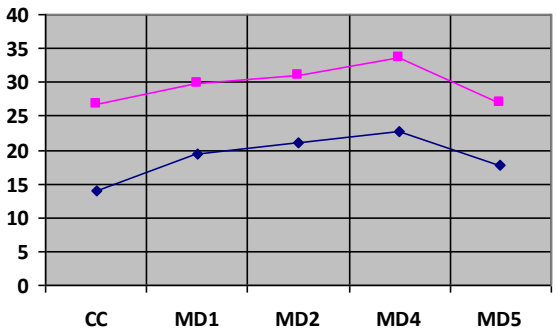


**Figure 6 GRAPH REPRESENTING 7 & 28 DAYS COMPRESSIVE STRENGTH**

## 5. CONCLUSIONS

From the above results of the experimental investigation usefulness of marble powder & super plasticizer as construction material was investigated. Various concrete cubes have been casted using these materials to investigate compressive strength. Slump values were also examined.

The above results shows that replacement of 15 % of cement with waste marble powder and doping of super plasticizer at 1.5 % of weight of cement shows maximum compressive strength in the experiment as compared to 5%, 10% & 20% replacement of cement .

Whereas; Slump values shows linear increment with increase in percentage replacement of cement. At 15 % replacement, a slump of 130 mm was obtained, which commits to obtain a concrete with enhanced workability.

### 5.1 SCOPE FOR FUTURE WORK

Suitability of other waste materials in conjunction with super plasticizers for replacement of cement can be experimentally determined in future. Other properties of concrete can also be identified by replacing of cement with waste marble dust in conjunction with different super plasticizers in same or other various proportions. More economical and environment friendly concrete can be produced by using waste material as replacement of cement in other different percentage

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