

**A COMPARATIVE STUDY OF MECHANICAL PROPERTIES OF THE HIGH  
STRENGTH CONCRETE(M50) BY PARTIAL REPLACEMENT OF CEMENT  
WITH METAKAOLIN AND MARBLE DUST POWDER**

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**Abstract**

Concrete is that the most normally used material for construction. Production of cement results in plenty of environmental pollution because it includes the emission of CO<sub>2</sub> gas. Supplementary cementitious materials like silicon oxide fumes, fly ash, slag, Rice Husk Ash and Metakaolin are utilized in recent years as cement alternative material for growing HSC with progressed workability, energy and durability with decreased permeability. Metakaolin is a dehydroxylated aluminum silicate from the recent analysis works exploitation Metakaolin, it's glaring that it is a completely effective pozzolanic cloth and it correctly complements the power parameters of concrete. In this study two trails are analyzed trail I as partial replacement of cement has been done in five different types of cases i.e. 0 %, 6 % 8 %,10%,12%,14% with MK(Metakaolin) and 0%, 10%, s MDP (Marble Dust Powder). with different combinations. Compressive as well as tensile strength of concrete made with MK-MD has been compared with conventional concrete of grade M50. Result shows that there is a gain of strength with the addition of MK and MD.

**Keywords:** Metakaolin, marble dust, strength, durability, compressive strength, split tensile strength and durability

**1.0 Introduction**

Concrete is one of the most widely used man-made construction material in the world. Metakaolin is a cementitious material used as an admixture to produce high strength concrete. Optimal quantity of Metakaolin for M50 grade concrete has been worked out, which can replace the cement to get better strength and durability. And, identification of the dry shrinkage and permeability characteristics of blended cement has been done. Jiping Bai studied that when Metakaolin is used as a partial replacement for Portland cement, tends to improve both the mechanical properties and the durability of concrete. The usage of pozzolana for growing concrete is taken under consideration budget friendly, because it lets in the reduction of the cement intake while growing the strength and sturdiness houses of the concrete. Metakaolin once used as a partial replacement substance for cement in concrete, it reacts with Ca (OH)<sub>2</sub> one in all the with the aid of products of affiliation reaction of cement and leads to further C-S-H gel which ends in amassed

electricity. Metakaolin is acquired by thermal activation of porcelain clay.

#### Uses of metakaolin:

- High performance, excessive power, and light-weight concrete
- Precast and poured-mold concrete
- Fiber cement and Ferro cement products
- Glass fiber bolstered concrete

#### 2.0 Literature review

**Abdullah Anwar et.al, (2014)**In this paper the authors represented that Marble Dust Powder has replaced the (OPC & PPC) cement of 0%, 5%, 10%, 15% 20%, & 25% by weight & M-20 grade concrete was used. Concrete is M30. 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.

**Sanjay N. Patil et, al.(2014)** The paper deals with the use of Metakaolin which is having good pozzolanic activity and is a good material to produce high strength concrete. Use of MK is getting popularity because of its positive effect on various properties of concrete. Literature Review shows that optimal performance is achieved by replacing 7% to 15% of the cement with Metakaolin and when use of MK is less than 10%, then the benefits are not fully realized so at least 10% Metakaolin should be used.

**J.M. Khatib et.al, (2012)**In the paper author studied the compressive strength, density and ultrasonic pulse velocity of mortar containing high volume of Metakaolin (MK) as partial substitution of cement. In this paper, up to 50% of MK was used to replace

cement in increment of 10. After De-molding, specimens were cured in water at 20°C for a total period of 28 days. The density seems to reduce with the increase of MK content especially at MK content above 30%.The strength increases as the MK content increases up to about 40% MK with a maximum strength occurring at 20% where the strength is 47% higher.

**P.A. Shiruleet.al, (2012)**The paper described the feasibility of using the marble sludge dust in concrete production as partial replacement of cement. The Compressive strength of Cubes & Split Tensile strength of Cylinders are increased with addition of waste marble powder up to 10% replaced by weight and it was also observed that 10% replacement gave optimum percentage of strength.

#### 3.0 Collection of materials

##### Cement:

Cement is a binder, a substance utilized in production that units and hardens and can bind other materials together. The maximum vital forms of cement are used as a issue inside the production of mortar in masonry, and of concrete- that is a aggregate of cement and an mixture to form a sturdy building material.

The normal Portland cement of 53 grades is used in accordance with IS: 12269-1987.

Properties of this cement had been tested and listed below.

- Fineness of cement = five%
- Specific gravity if cement = 3.02
- . Standard Consistency of cement = 33%
- Initial placing time = 50mins
- Final putting time = Not extra than 10 hours.

**Coarse aggregate:**

Crushed stone mixture of 20mm size is added from nearby quarry. Aggregates of length greater than 20mm size are separated by using sieving. Tests are carried which will find out the

- Specific gravity = 2.98
- Fineness modulus = 7.5

**Fine aggregate:**

Locally available sparkling sand, unfastened from natural count number is used. The result of sieve evaluation confirms it to Zone-II (in step with IS: 383-1970). The tests are carried out and results are shown below.

- Specific gravity = 2.3
- Fineness modulus = 3.06

**Metakaolin**

Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Stone that are wealthy in kaolinite are known as china clay or kaolin, historically used inside the manufacture of porcelain. The particle size of Metakaolin is smaller than cement particles, however not as best as silica fume.



**Figure 1: Metakaolin**

**Physical properties of metakaolin**

The following are some general physical properties of Metakaolin

Physical form is powder form

Fineness of Metakaolin is 700 to 900m<sup>2</sup>/kg.

Color of Metakaolin is white or Grey

Specific gravity is 2.50.

Specific surface is 8 to 15m<sup>2</sup>/g.

**Marble dust:**

Marble powder was collected from the dressing and processing unit in. It was initially in wet form (i.e. slurry); after that it is dried by exposing in the sun and finally sieved by IS-90 micron sieve before mixing in concrete.



**Figure: marble dust powder**

**Water:**

Generally potable water ought to be used. This is to make sure that the water is cheap unfastened from such impurities as suspended solids, organic depend and dissolved salts, which may additionally adversely affect the residences of the concrete, especially the placing, hardening, energy, sturdiness, pit fee, and many others.



**Figure: Adding water to cement mix**

### **Sample preparation and mix design of M 50:**

Concrete mix design is a procedure of selecting the suitable ingredients of concrete and their relative proportions with an objective to prepare concrete of certain minimum strength, desired workability and durability as economically (value engineered) as possible. As we decide to go for a concrete mix design, collect the following data before hand as few design stipulation are freezed on the basis of these data.

### **Impact test:**

The equipment used for figuring out aggregate effect value of coarse aggregates is Impact checking out machine conforming to IS: 2386 (Part IV)- 1963, IS Sieves of sizes – 12.5mm, 10mm and a pair of .36mm, A cylindrical metallic measure of 75mm dia. And 50mm intensity, A tamping rod of 10mm round move segment and 230mm period, rounded at one cease and Oven. Aggregate impact value =  $(B/A) \times 100\%$

### **Workability testing of concrete:**

The concrete slump take a look at is used for the measurement of a assets of sparkling concrete. The check is an empirical test that measures the workability of fresh concrete. More particularly, it measures consistency among batches. The test is popular due to the simplicity of kit used and simple manner.

### **Compaction factor test:**

The sample of concrete is placed gently in the top hopper, using trowel. The hopper is crammed stage with its brim and the entice-door is opened in order that the concrete falls into the lower hopper Immediately after

the concrete has come to rest , the lure-door of the lower hopper is opened, and the concrete is allowed to fall in to the cylinder The extra of concrete ultimate above the level of the top of the cylinder is then cut off by means of a trowel and the out of doors of the cylinder is then wiped clean The weight of the concrete within the cylinder is then determined to the closest 10g. That is known as the load of the partly compacted concrete.

### **Casting of cubes and cylinders:**

Casting of cubes and cylinders as achieved for M80 grade concrete, the mixture proportion is for which we're casting 50 cubes for ordinary concrete, with the partial alternative of concrete with metakaolin of 0%, 5%, 10%, 15%, 20%.

**Compaction:** Filling the Cube Moulds and Compacting the Concrete After the sample has been remixed, immediately fill the cube moulds and compact the concrete, either by way of hand or by vibration. Any air trapped inside the concrete will lessen the power of the cube. Hence, the cubes must be fully compacted. However, care must also be taken now not to over compact the concrete as this will reason segregation of the aggregates and cement paste inside the mix. This may additionally lessen the final compressive strength.

### **Compacting with compacting bar**

150 mm moulds must be crammed in 3 about equal layers (50 mm deep). A compacting bar is supplied for compacting the concrete. It is a 380 mm lengthy metal bar, weighs 1.Eight kg and has a 25 mm rectangular give up for ramming. During the compaction of every layer with the compacting bar, the strokes need to be dispensed in a uniform way over the floor of

the concrete and each layer ought to be compacted to its complete depth. During the compaction of the primary layer, the compacting bar has to not forcibly strike the lowest of the mould.

#### **Casting & testing:**

This take a look at changed into conducted as consistent with The cubes of popular size 150x150x150mm and cylinder of 150mm diameter 300mm height and prism of 150mmX150mmX700mm had been used to discover the compressive strength of concrete. Specimens had been located at the bearing surface of CTM, of capability 200T without eccentricity and a uniform fee of loading applied till the failure of the cube. The maximum load became mentioned and the compressive electricity (AS Alnuaimi,) turned into calculated.



**Figure : Casting of cubes**

#### **Results:**

##### **Compressive strength test:**

The bearing floor of the trying out system shall be wiped smooth and any unfastened sand are different fabric eliminated from the surface the specimen which might be to keep up a correspondence with the compression platens. In the case of cubes, the specimens will be placed inside the gadget in such a way that the load shall carried out two contrary sides of the cube as solid, that isn't always to the top and backside. The axis of the specimen shall be

carefully aligned with of thrust of the spherically seated platen.

##### **Split tensile strength of concrete**

This test was conducted as per IS516-1959. The cylinders of standard size 150mmx300mm were used find the strength of concrete. Specimens are placed on the bearing surface of CTM, of capacity 200T without eccentricity and a uniform rate of loading is applied till the failure of cylinder. The maximum load was noted and the strength was calculated. Split tensile strength testing

##### **Flexural strength test:**

The bearing surfaces of the supporting and loading rollers wiped clean, and any loose sand or other material removed from surface of the specimen where they are to may contact with the rollers. The specimen shall then be placed in the machine in such a manner that the load shall be applied to the uppermost surface as cast in the mould, along two line spaced 13.3cm apart the axis of the specimen shall be carefully aligned with the axis of loading devices. No packing shall be used between bearing surface of the specimen and rollers.

##### **Acid attack test:**

The concrete cube specimens of various concrete combos of size 150 mm had been forged and after 28 days of water curing, the specimens were eliminated from the curing tank and allowed to dry for sooner or later. The acid attack test on concrete dice turned into performed through immersing the cubes in the acid water for ninety days after 28 days of curing. Hydrochloric acid (HCL) with pH of about 2 at 10% weight of water became added to water in which the concrete cubes have been stored. The pH

turned into maintained all through the duration of ninety days. After 90 days of immersion, the concrete cubes were taken

out of acid water. Then, the specimens have been tested for compressive power.

**Table: Shape and Dimensions of Blocks**

| Type of test           | Shape of block | Length(m) | Breadth(m) | Height(m) | Diameter(m) | Volume of block (m <sup>3</sup> ) |
|------------------------|----------------|-----------|------------|-----------|-------------|-----------------------------------|
| Compressive strength   | Cube           | 0.15      | 0.15       | 0.15      | --          | 0.00375                           |
| Split tensile strength | Cylinder       | --        | --         | 0.30      | 0.15        | 0.00530                           |
| Flexural strength      | Square prism   | 0.1       | 0.1        | 0.7       | --          | 0.00700                           |

**Alkaline attack test:**

To decide the resistance of numerous concrete combos to alkaline assault, the residual compressive strength of concrete combos of cubes immersed in alkaline water having 10% of sodium hydroxide (NaOH) through weight of water turned into

discovered. The concrete cubes which had been cured in water for 28 days have been eliminated from the curing tank and allowed to dry for sooner or later. The weights of concrete dice specimen had been taken.

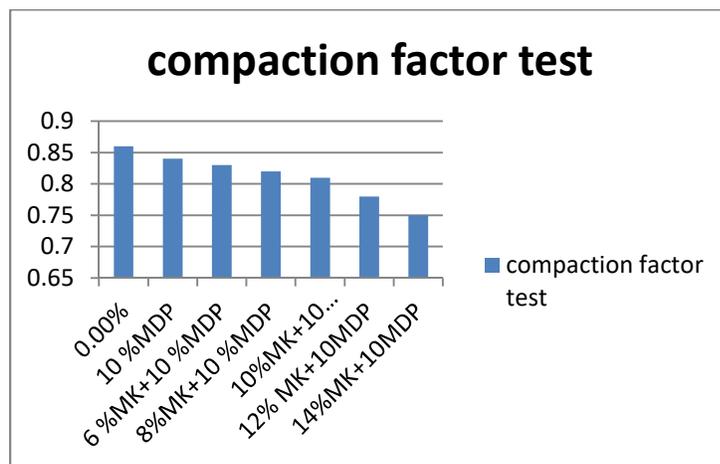
**Table: Test results on the cement**

| Sl.no | Test                           | Results              | IS code used | Acceptable limit                                 |
|-------|--------------------------------|----------------------|--------------|--|
| 1     | Specific gravity of cement     | 3.15                 | IS:2386:1963 | 3 to 3.2   |
| 2     | Standard consistency of cement | 6mm at 34% w/c       | IS:4031:1996 | w/c ratio 28%-35%                                |
| 3     | Initial and final setting time | 45 mins and 10 hours | IS:4031:1988 | Minimum 30mins and should not more than 10 hours |
| 4     | Fineness of cement             | 3.00%                | IS:4031:1988 | <10%   |

**Table: Slump test and compaction test results:**

| S.NO | Mix proportion | Slump | Compaction factor test |
|------|----------------|-------|------------------------|
| 1    | 0.00%          | 92    | 0.86                   |

|   |               |     |      |
|---|---------------|-----|------|
| 2 | 0%MK+10 %MDP  | 93  | 0.84 |
| 3 | 6 %MK+10 %MDP | 94  | 0.83 |
| 4 | 8%MK+10 %MDP  | 95  | 0.82 |
| 5 | 10%MK+10 %MDP | 96  | 0.81 |
| 6 | 12% MK+10MDP  | 99  | 0.78 |
| 7 | 14%MK+10MDP   | 100 | 0.75 |



**Figure: compaction factor test**

### Conclusions

From the above experimental program, the following conclusions were made. The material properties of the cement, fine aggregates and coarse aggregates are within the acceptable limits as per IS code recommendations, so I used the materials for research.

- Compaction factor value of metakaolin concrete decreases with increase in the percentage of metakaolin and the maximum values of compaction factor was observed at 6% of metakaolin with 10 % marble dust powder

- The compressive strength of concrete is maximum at 6% of Metakaolin with 10 % marble dust powder and is the optimum value for 7days curing, 28days curing, 56days curing.
- Split tensile strength for the cylindrical specimens is maximum at 6% of Metakaolin with 10 % marble dust powder for 28days curing, 56days curing.
- The flexural strength of copper slag concrete is also maximum at 6% of Metakaolin with 10 % marble dust powder for 28days curing, 56days curing.

- As per the durability calculations, the compressive strength is observed to be 58.5N/mm<sup>2</sup> per 0% replacement in cement. However, from the above data of results 6% of metakaolin and 10% of MDP is suggested from this analysis.
- So the replacement of 6% of metakaolin with 10 % marble dust powder is recommended for better strength values in M50 grade of concrete from my study.

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