# Study on Mechanical Properties of Concrete by Fractional Replacement of Cement with Metakaolin and Sand with M-Sand by Using M30 Grade

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**Abstract:** Metakaolin (MK) is a mineral admixture, various tests are carried out on the usage of Metakaolin for the development of high strength concrete. MK is a supplementary cementitious material derived from heat treatment of natural deposits of kaolin. Metakaolin exhibits high pozzolana reactivity due to their amorphous structure and high surface area. Concrete is the most commonly used material for development of infrastructure. As infrastructure is growing there arises problems in repairs. Due to manufacture of cement, $Co_2$gets emitted into environment. Researches started on working partial replacement of cement, which occur naturallyor manufactured. The different type of pozzolonic materials like metakaolin, silica fume, and fly ash etc, are the material have binding properties that of cement. The present study focuses on replacement cement with metakaolin by 0, 5, 10,15and 20% and fine aggregate with M-sand by 50%.

**Keywords:** Compressive strength, Metakaolin, M-Sand, Split tensile strength, Ultrasonic pulse velocity.

## 1. Introduction

By the development of technology and improved field of application of concrete, various properties of the ordinary concrete needed modification to make it more suitable for various situations, economical and eco-friendly. This has led to the use of cementitious materials such as M-sand and Metakaolin etc. which have contributed towards higher performance, energy conservation and economy. The use of M-sand and Metakaolin partially replacing the cement in concrete results in reduction of cement used, reduction in the emission of carbon dioxide, conservation of existing resources along with the enhancement in the strength and durability properties of concrete.

Metakaolin is a produce from kaolinite. It is a pozzolanic additive which provides many specific features plus reactivity. In general, Portland cement is partially replaced by metakaolin at 8-20% (by weight).

## 2. Objective

The experimental program was designed to investigate metakaolin as a partial replacement with cement.

i. To evaluate the mechanical properties by addition of Metakaolin at 5, 10,15 and 20%.

ii. To investigate the mechanical properties with addition of 50% M-Sand to Metakaolin in the production of M30 grade of concrete.

iii. To examine the property of cube strength by performing ultrasonic test.

## 3. Materials

### Metakaolin

The basic material used in the manufacture of Metakaolin is kaolin clay. Kaolin is used in the manufacture of porcelain. Dihydroxylation is a reaction of decomposition of kaolinite crystals to a partially disordered structure. The results of isothermal firing shows that the dihydroxylationbegins at 420°C.

### M-Sand

M-Sand is a replacement of river sand for concrete manfacture. Crushing of hard granite stone results in the formation of M-Sand. Shape of the resultant M-sand is cubical with grounded edges, washed and graded to as a construction material. The dimension of M-Sand is less than 4.75mm

**Coarse aggregate**

The aggregate which is retained on 4.75 mm is used in experimental investigation. The normal maximum size is 20 mm.

**Fine aggregate**

Gradation refers to the particle size distribution of aggregates. The aggregate which is passing through 4.75mm is used in this investigation. Zone –II sand is used.

## 4. Test Procedure

**Compressive Strength**

The compressive strength conducted in compression testing machine for the cast and cured specimens and the results are furnished in Table 1.

**Table 1. Compressive strength test results for 7 days and 28 days**

| S.No. | Mix id | Compressive strength N/mm$^2$ | |
|---|---|---|---|
| | | 7days | 28days |
| 1 | MS 0 + M0-C100 | 23.02 | 39.58 |
| 2 | MS 50 + M5-C95 | 25.35 | 42.05 |
| 3 | MS 50 + M10-C90 | 26.74 | 44.58 |
| 4 | MS 50 + M15-C85 | 30.21 | 50.35 |
| 5 | MS 50 + M20-C80 | 28.41 | 47.35 |

**Split Tensile Strength Results**

The split tensile strength conducted in flexural testing machine for the cast and cured specimens and the results are furnished in Table 2.

**Table 2. Split tensile strength test results**

| S.No. | Mix id | Split tensile strength, N/mm$^2$ | |
|---|---|---|---|
| | | 7days | 28 days |
| 1 | MS 0 + M0-C100 | 2.74 | 4.72 |
| 2 | MS 50 + M5-C95 | 2.92 | 4.81 |
| 3 | MS 50 + M10-C90 | 3.35 | 5.40 |
| 4 | MS 50 + M15-C85 | 3.62 | 5.63 |
| 5 | MS 50 + M20-C80 | 2.87 | 4.97 |

**Ultrasonic pulse velocity test**

The UPV test conducted before conducting the destructive tests to identify the properties of concrete and the results furnished in Table 3.

**Table 3.** UPV test results for 28 days

| S.No. | Mix Id | U.P.V |
|---|---|---|
| 1 | MS 0 + M0-C100 | 4344 m/s |
| 2 | MS 50 + M5-C95 | 4509 m/s |
| 3 | MS 50 + M10-C90 | 4591 m/s |
| 4 | MS 50 + M15-C85 | 4713 m/s |
| 5 | MS 50 + M20-C80 | 4635 m/s |

**Rebound hammer test**

The rebound hammer test conducted before conducting the destructive tests to identify the properties of concrete and the results furnished in Table 4.

**Table 4. Rebound hammer test results for 28 days**

| S.No. | Mix Id | Rebound hammer strength, $N/mm^2$ |
|---|---|---|
| 1 | MS 0 + M0-C100 | 31.26 |
| 2 | MS 50 + M5-C95 | 34.06 |
| 3 | MS 50 + M10-C90 | 34.99 |
| 4 | MS 50 + M15-C85 | 41.79 |
| 5 | MS 50 + M20-C80 | 38.82 |

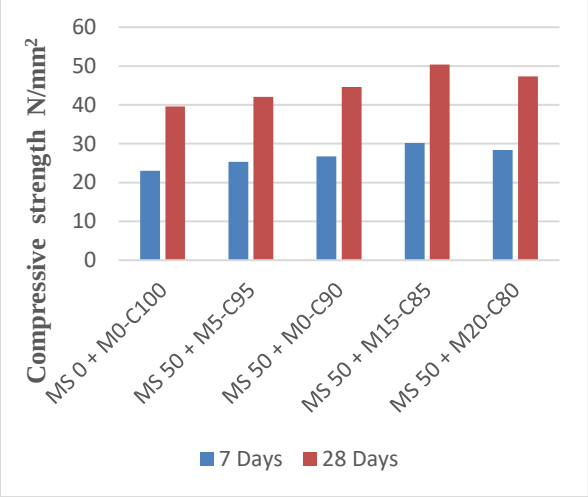


**Figure 1.** Compressive strength test results for 7 days and 28 days

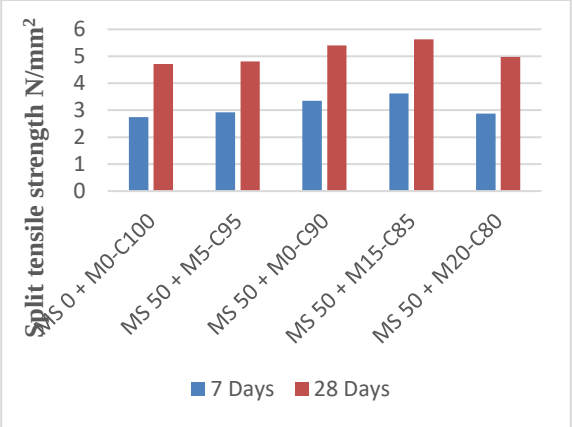


**Figure 2.** Split tensile strength test results for 7 days and 28 days

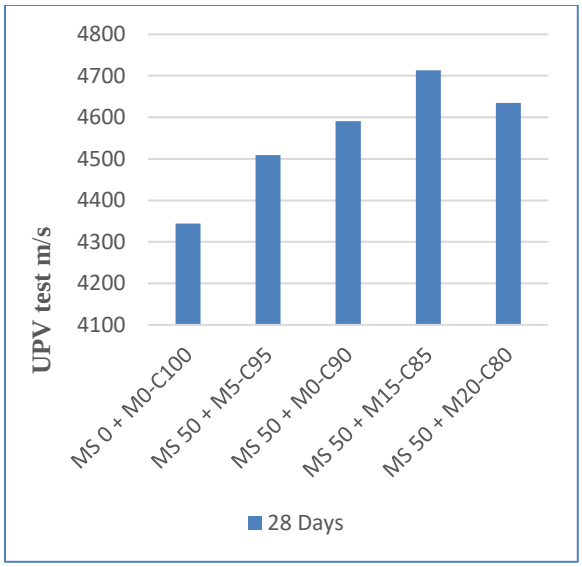


**Figure 3.** UPV test results for 28 days

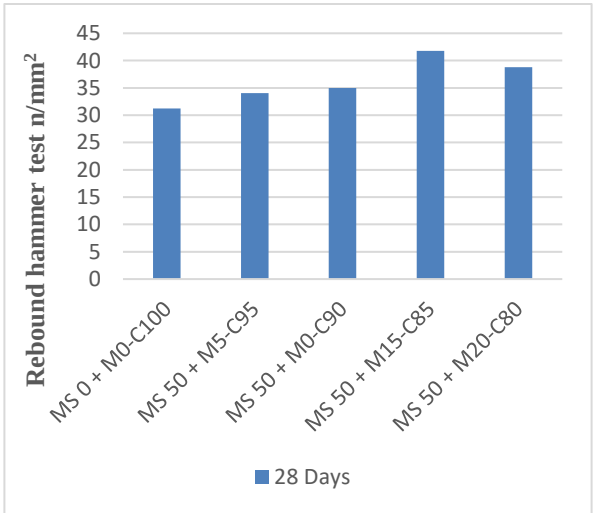


**Figure 4.** Rebound hammer test results for 28 days

## 5. Conclusion

i. The compressive strength for M30 grade conventional concrete at 7 and 28 days are 23.02 and 39.58 N/mm$^2$.

ii. The compressive strength for M30 grade concrete by using 15% MK and 50% M-sand at 7 and 28 days are 30.21 and 50.35 N/mm$^2$.

iii. The split tensile strength for M30 grade conventional concrete at 7 and 28 days is 2.74 and 4.72 N/mm$^2$.

iv. The split tensile strength for M30 grade concrete by using 15% MK and 50% M-sand at 28 days is 3.62 and 5.63 N/mm$^2$.

v. The percentage increase of compressive strength for 15% MK and 50% M-sand compared to conventional concrete at 28 days is 27.21.

vi. The percentage increase of split tensile strength for 15% MK and 50% M-sand compared to conventional concrete at 28 days is 19.27.

vii. The ultrasonic pulse velocity test results for conventional concrete and addition of 15% MK and 50% M-sandare 4344 and 4713m/sec.

viii. The rebound hammer test results for conventional concrete addition of 15% MK and 50% M-sandare31.26and 41.79N/mm

ix. The percentage increase of UPV for 15% MK and 50% M-sand compared to conventional concrete at 28 days is 8.49.

x. The percentage increase of rebound hammer test for 15% MK and 50% M-sand compared to conventional concrete at 28 days is 33.68.

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