# STRENGTH AND DURABILITY PROPERTIES OF CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT WITH METAKAOLIN AND MARBLE DUST

**RANDER SARVESHWAR**
Student, Dept of Civil (Structural) Engineering, Shri Shirdi Sai Institute of Science and Engineering, India
randersarveshwar@gmail.com

**P. NAVEEN KUMAR**
Assistant professor Dept of Civil (Structural) Engineering, Shri Shirdi Sai Institute of Science and Engineering, India

## ABSTRACT

*In this study partial replacement of cement has been done at 0%,3%,5%,9%,12%,13% with MK(Metakaolin) and 0%,10%(constant) with MP (Marble Powder). Compressive as well as tensile strength of concrete made with MK-MP has been compared with conventional concrete of grade M30. Durability of concrete was also analysed with RCMT (Rapid chloride Migration Test). Result shows that there is a gain of strength with the addition of MK and MP. The optimized strength value of concrete was achieved for both compressive as well as split tensile strength at 9%MK and 10%MP. RCMT shows that with the increase of addition of Metakaolin and Marble powder, there is a decrease in rate of penetration of chloride ions, hence good durability as compared to standard concrete In construction Industry, consumption of cement is increasing day by day as well as cost is also increasing so to reduce the consumption of cement, partial replacement with Metakaolin and Marble powder was done in this study. Metakaolin is a calcified clay and easily available in Gujarat, Maharashtra & Bombay etc. It is a Dehydroxylated form of the clay mineral Kaolinite. Stone having higher percentage of Kaolinite are known as china clay or kaolin, was traditionally used in the manufacture of porcelain i.e. ceramic material. The particle size of Metakaolin is smaller than cement particles. Marble dust is obtained from cutting and manufacturing industries of marble. In India near about 3500 metric tons of marble dust slurry per day is generated. So, Marble dust is very easily available with very less cost. Some of industries used to wash out this marble powder with water in natural streams which cause water pollution and is harmful for our environment. So, it is advisory to use marble dust as partial replacement with cement as it has properties similar to cement and one of good pozzolanas. Similarly use of MK leads to Green concrete, because during production of MK there is no emission of carbon dioxide, also MK is good admixture for high early age strength, known as HPC etc. Since there is large emission of carbon dioxide in manufacturing of cement and clinker, results in 3-5% increase in greenhouse gasses and global warming.*

***Keywords:*** *Metakaolin; marble dust; strength; durability; Modulus of Elasticity*

## 1.0 INTRODUCTION

In construction Industry, consumption of cement is increasing day by day as well as cost is also increasing so to reduce the consumption of cement, partial replacement with Metakaolin and Marble powder was done in this study. Metakaolin is a calcinied clay and easily available in Gujarat, Maharashtra & Bombay etc. It is a Dehydroxylated form of the clay mineral Kaolinite. Stone having higher percentage of Kaolinite are known as china clay or kaolin was traditionally used in the manufacture of porcelain i.e. ceramic material. The particle size of Metakaolin is smaller than cement particles. Marble dust is obtained from cutting and manufacturing industries of marble. In India near about 3500 metric tons of marble dust slurry per day is generated. So, Marble dust is very easily available with very less cost. Some of industries used to wash out this marble powder with water in natural streams

which cause water pollution and is harmful for our environment. So, it is advisory to use marble dust as partial replacement with cement as it has properties similar to cement and one of good pozzolanas. Similarly use of Metakaolin leads to Green concrete, because during production of Metakaolin concrete there is no emission of carbon dioxide since there is large emission of carbon dioxide in manufacturing of cement and clinker, results in 3-5% increase in greenhouse gasses and global warming.

**Construction Waste**

Environmental Protection Agency (EPA) defines construction and demolition (C&D) waste as waste materials consist of the debris generated during the construction, renovation, and demolition of buildings, roads, and bridges. C&D materials often contain materials that include: concrete, asphalt, wood, metals, gypsum, plastics and salvaged building components. It is a challenging task to handle C&D waste because it is bulky, heavy and inert and also mixture of various materials of different characteristics. It is also difficult to choose any suitable disposal method, for example, it cannot be incinerated due to its high density and inertness.

**Scope of the Work**

The aim of the present study is to use naturally available and low cost Metakaolin and marble dust as a partial replacement to cement in concrete and to recycle the Construction waste materials so that to reduce environmental pollution.

**Objectives of the Research**

Objectives of the study as follows:

To study mechanical properties such as compressive strength at the end of 7, 28 and 90 days of curing by partially replacing cement with Metakaolin and marble powder under normal curing.

- To reduce environmental Pollution
- To study the properties of fresh pollution by utilizing waste material in concrete.
- To make Eco-friendly concrete
- Concrete this is cast by using metakaolin and marble dust
- To study the properties of fresh concrete this is cast by using Metakaolin and marble dust.

**2.0 LITERATURE REVIEW**

**Abdullah Anwar et.al (2014)** In this paper the authors represented that Marble Dust Powderhas 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 for the production of high strength concrete. Use of MK is getting popularity because of its positive effect on various properties of concrete.

**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.

**Shirule et.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 METHODS AND MATERIALS

The main constituents of the concrete are Cement, fine aggregate, coarse aggregate, water, Metakaolin and Marble powder were procured from various places. Natural fine aggregate and coarse aggregate is procured from local area. MK and MP material was procured from the dumping yard of Electrical department (SPDCL office), Hyderabad. Local drinking water was used for mixing and curing. The properties of ingredients of concrete, cement, sand, coarse aggregate and water were analyzed based on standard experimental procedures laid down in IS codes. The standard experimental procedures were adopted for the determination of workability, normal consistency, initial and final setting times and compressive strength of cement. Tests were conducted on coarse aggregate and fine aggregate to find the water absorption, specific gravity and bulk density. Slump test was conducted on fresh concrete and also test is were conducted on hardened concrete to find compressive strength.

### CEMENT

Cement is a fine mineral powder manufactured with very precise processes. Mixed with water, this powder transforms into a paste that binds and hardens when submerged in water. Because the composition and fineness of the powder may vary, Cement has different properties depending upon its makeup. Cement is the main constituent of Concrete. It's an economical, high-quality construction material used in construction projects worldwide.

### FINE AGGREGATE

Sand shall be hard, durable, clean and free form adherent coatings and organic matter and shall not contain any appreciable amount of clay. Sand shall not contain harmful impurities such as Iron, Pyrites, Coal particles, Lignite, Mica shale or similar laminated material, alkali, and organic impurities in such form or quantities as to affect the strength or durability of concrete or mortar.

### Metakaolin

Metakaolin is a pozzolanic probably the most effective pozzolanic material for use in concrete. It is a product that is manufactured for use rather than a by-product and is formed when china clay, the mineral kaolin, is heated to a temperature between 600 and 800ºC

**Figure-3.1: Metakaolin powder**

### Marble dust

It is an essential component of igneous and metamorphic rocks. The size varies from specimens weighing a metric ton to minute particles that sparkle in rock surfaces. The crushed marble powder used in the experiments is in a form of white powdered, which replaces fine aggregate from the conventional concrete. The particle size used ranges from 10 to 45µm

**Figure: 3.2 Marble dust waste from construction Industry**

**CONCRETE MIX DESIGN:**

Concrete is an extremely versatile building material because, it can be designed for strength ranging from $M_{10}$ (10MPa) to $M_{100}$ (100MPa) and workability ranging from 0 mm slump to 150mm slump Concrete mixture is special equipment used to mix all the required quantities of concrete like cement, natural sand, coarse aggregate, ceramic material and water, calculated as according to the design as per IS 10262:2009. Fig: 4.1 shows the concrete mixture.

**Figure 3.3 Concrete Mixture**

**CONCRETE MIX PREPARATION**

It is defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the objective of producing concrete of required strength and durability as economically as possible. The design of concrete mix is not a simple task on account of widely varying properties of the constituent's materials. Design of concrete mix requires complete knowledge of various properties of the constituent materials, the complications, in case of changes on these conditions at the site. Initially the ingredients such as cement, sand are mixed to which coarse aggregates and ceramic waste were added and thoroughly mixed. Water content to be required was measured exactly. Then it was added to the dry mix and it was thoroughly mixed until a mixture of uniform color and consistency was achieved which was then ready for casting. Prior to casting workability was measured in accordance with IS code 1199-1959 and determined by slump cone test.

## 4.0 RESULTS AND DISCUSSION

The results of the experimental investigation are presented in this chapter. In order to facilitate the interpretation of the result, the analysis was carried out at each phase of experimental work. The significance of the results were assessed with the reference to relevant IS codes. The properties of concrete mixes are obtained for conventional concrete and partial replacement of Fine aggregate with ceramic waste material

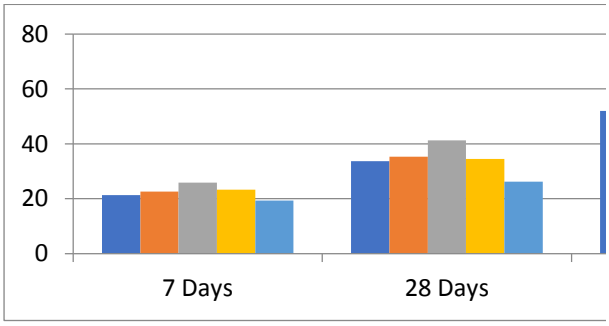
**COMPRESSIVE STRENGTH TEST**

Compression test is the most common test conducted on hardened concrete, partly because most of desirable characteristics properties of concrete are quantitatively related to its compressive strength. The compression test is carried out on specimens cubical or cylindrical in shape. Prism is also sometimes used, but it is not common in our country. Sometimes, the compressive strength of concrete is

determined using parts of the beam tested in flexure.

**Table 4.1 Compressive strength of cubes of size 15x15x15cm is tested after 7, 28, 90 days**

| S NO | NO OF DAYS | CONVENTIONAL CONCRETE | MK 5% + MP 5% | MK 10% + MP10% | MK 15% + MP15% |
|---|---|---|---|---|---|
| 1 | 7 | 21.26 | 22.663 | 25.83 | 23.31 |
| 2 | 28 | 33.67 | 35.34 | 41.28 | 34.52 |
| 3 | 90 | 52.00 | 53.50 | 63.28 | 56.23 |



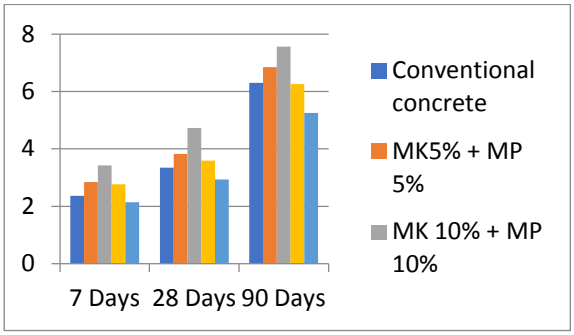

**Graph: concrete replaced with Metakaolin and Marble dust 10%+10% has given more strength**

**SPLIT TENSILE STRENGTH TEST**

This test is conducted in a 200 tones capacity of the compression testing machine by placing the cylindrical specimen of the concrete, so that its axis is horizontal between the plates of the testing machine.

**Table: 4.2 Split tensile test results of concrete cylinders for 7, 28, 90 days**

| S NO | No. of Days | Conventional concrete | MK(5%)+ MP(5%) | MK(10%)+ MP(10%) | MK (15%) + MP (15%) | MK (20%)+ MP (20%) |
|---|---|---|---|---|---|---|
| 1 | 7 | 2.36 | 2.84 | 3.42 | 2.77 | 2.14 |
| 2 | 28 | 3.35 | 3.82 | 4.73 | 3.59 | 2.93 |
| 3 | 90 | 6.30 | 6.85 | 7.56 | 6.25 | 5.25 |



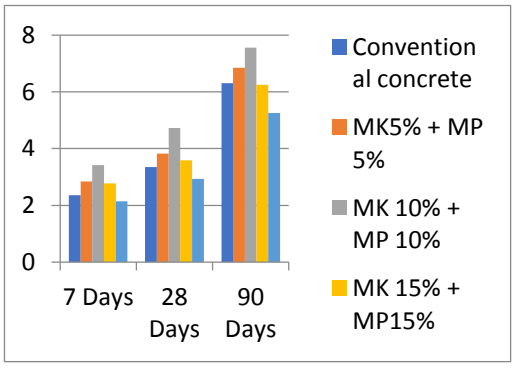

**Graph: 4.2 concrete replaced with Metakaolin and Marble dust 10%+10% has given more strength**

**FLEXURAL STRENGTH TEST**

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam to resist failure in bending. The flexural strength can be determined by standard test method of third point of loading or center point loading. In this study, three beams of size 100mm x 100mm x 500mm were used to find flexural strength

**Table: 4.2 Flexural tensile test results of concrete cylinders for 7, 28, 90 days**

| S NO | No .of Days | Conventional concrete | MK(5%)+ MP(5%) | MK(10%)+ MP(10%) | MK(15%)+ MP(15%) | MK(20%)+ MP(20%) |
|---|---|---|---|---|---|---|
| 1 | 7 | 1.07 | 1.14 | 1.21 | 1.05 | 0.98 |
| 2 | 28 | 1.41 | 1.55 | 1.65 | 1.48 | 1.33 |
| 3 | 90 | 2.36 | 2.85 | 3.02 | 2.65 | 2.30 |




**Graph: concrete replaced with Metakaolin and Marble dust 10%+10% has given more strength**

**CONCLUSION:**

The present experimental investigation was aimed to design a high grade concrete with partial replacement of Metakaolin and Marble dust to cement analysing the same on various parameters to obtain replacement percentage of metakaolin in production of concrete. Some of the broad conclusions The following conclusions may be drawn based on the experimentations conducted on the behavior of concrete with partial replacement of cement by Metakaolin and Marble dust the addition of Metakaolin along with cement has increased the compressive strength of the concrete when compared to the conventional concrete.

- From the Test results we find that Metakaolin and marble dust can be used for partial replacement in concrete.
- The compressive strength of concrete is more at 10%+10% replacement of Metakaolin and marble dust. Has given maximum strength is 41.28 N/mm2
- The Split tensile strength of concrete Cylinder strength of concrete is more at 10%+10% replacement of Metakaolin and marble dust. Has given maximum strength is 4.73 KN/M2
- Flexural strength of concrete replaced with Metakaolin and Marble dust 10% + 10 % has given Maximum strength which is 4.73 N/mm2
- Workability of concrete is also reducing due to increase in percentage of Metakaolin and marble dust.
- Strength and durability of concrete is increase
- Eco-friendly by reducing of CO2

By replacing the cement and sand with Metakaolin and Marble powder the reduction in the consumption of cement can be achieved. By reducing the consumption of cement. The ecology of the earth can be improved enormously and the air pollution due to the production of cement can also be reduced. Comparative analysis for beam is done.

**FUTURE SCOPE**

The present experimental investigation was confined to the strength evaluation of concrete using Metakaolin and Marble dust combination with the cement. The investigation can be extended in future to incorporate some of the following aspects which have not been covered in the present study:

- Tests for mix design of higher grade of concrete can be considered
- Permeability tests of the above combinations may be undertaken
- Metakaolin replacement accelerates the rate of gain of strength in concrete and is predominant at early age

**REFERENCES**

1. *Abdullah Anwar et.al (2014): Study of Compressive Strength of Concrete by Partial Replacement of Cement with Marble Dust Powder. Ird Indian ISSN (Print*
2. *Sanjay N. Patil et.al (2014): Metakaolin-Pozzolanic Material For Cement in High Strength Concrete. (IOSR-JMCE) ISSN: 2278- 1684, PP: 46-4.*
3. *J.M. Khatib et.al (2012): High Volume Metakaolin as Cement Replacement in Mortar. World Journal of Chemistry, ISSN 1817- 3128, © IDOSI Publications, 10.5829/idosi.wjc.2012.7.1.251.*
4. *Prof. P.A. Shirule et.al (2012) Partial Replacement of Cement with Marble Dust Powder. International Journal of Advanced Engineering Research and*

*Studies E-ISSN2249–8974 IJAERS/Vol. I/ Issue III/April-June, 2012/175-177.*

5. *B.B.Sabir et.al (2001)Metakaolin and calcined clays as pozzolanas for concrete:a review.Cement & concrete composites 23(2001) 441-45*
6. *Hassan A. Mohamadien et.al (2012) The Effect of marble powder and silica fume as partial replacement for cement on mortar. ISSN 0976 – 4399, PP 418-428.*
7. *V. M. Sounthararajan and A. Sivakumar (2013) Effect of the lime content in marble powder for producing high strength concrete .ISSN 1819-6608.PP 260-264*