Towards Sustainable Concrete: Partial Replacement of Cement Using Eco-Friendly Pozzolanic Materials

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ABSTRACT
Rapid industrialization and urbanization have led to extensive infrastructure development across the country. This growth has also created challenges that must be addressed, including a severe shortage of construction materials and an increase in waste generation. Although M40 concrete is commonly used for construction, this project investigates M30 concrete incorporating metakaolin and marble powder. The study evaluates the workability and strength of concrete mixtures containing different proportions of metakaolin (MK) and marble dust (MD): 0% MK + 0% MD, 5% MK + 5% MD, 10% MK + 10% MD, 15% MK + 15% MD, and 20% MK + 20% MD. Compressive, split tensile, and flexural strengths are compared after 7, 14, and 28 days of curing.

Key words: concrete, strength, workability, metakolin, marble dust.

I. 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.

The growing concern of resource depletion and global pollution has challenged many researchers to seek and develop new materials relying on renewable resources. These include the use of by-products and waste materials for building construction. The high cost of conventional building materials is a major factor affecting construction in India. In developing countries where abundant agricultural and industrial wastes are discharged, these wastes can be used for various purposes in construction industry. This will have double the advantages, reduction in the cost of construction material and also as a means of disposal of wastes. Thus the approach is logical, worthy and attributable. Therefore an attempt has been made in this study to utilize the metakaoline and waste marble powder is used as a partial replacement of cement in the development of low cost concrete. So a study on various strength and durability properties of these materials is carried out. Also suitable measures have to be adopted for attaining the target strength**.**

1.1 Objectives of the study
The following are the major objectives considered for this study

1. To study mechanical properties such as compressive strength at the end of 7, 14 and 28 days of curing by partially replacing cement with metakaoline and marble powder under normal curing.
2. To reduce environmental Pollution

3. To study the properties of fresh pollution by utilizing waste material in concrete.
4. To make Eco-friendly concrete
5. Concrete this is cast by using metakaolin and marble dust
6. To study the properties of fresh concrete this is cast by using metakaoline and marble dust.

II. LITERATURE STUDIES

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%, and 25% by weight M-20grade concrete was used. The result obtained for 28-day compressive strength confirms that the optimal percentage for replacement of cement with marble dust powder is about 10% for (PPC) and (OPC).

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 MKisgettingpopularitybecauseofitspositiveeffectonvariouspropertiesofconcrete.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. Values of compressive strength of concrete with Metakaolin after 28 days can be higher by 20%. Dosage of 15% of Metakaolin causes decrease of workability.

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.

III. MATERIALS USED FOR THE STUDY AND MIX DESIGN

3.1 Cement

cement is a binding material invented by Joseph Aspdin in 1824. It is manufactured from calcareous materials, such as limestone or chalk, and argillaceous material such as shale and clay.



Figure1: OPC 53 Grade cement

3.2 Coarse Aggregate

If the size of aggregate is bigger than 4. 75 mm, then the aggregate is considered as coarse aggregate.

Stone, ballast, gravel, brick ballast are some examples of coarse aggregates.



Figure 2: Coarse aggregates sample

3.3 Fine Aggregate

According to IS 383, most of the aggregate which will pass through 4. 75 mm IS sieve and entirely retained on 75 µ sieve is considered as fine aggregate.

Sand crushed stone, ash or cinder are some examples of fine aggregates.



Figure 3: Fine aggregates sample

3.4 Water

water is the main ingredient used to mix all t he contents. Potable water is used as usage of any other water may contain salts and cause decrease in strength of concrete.

3.5 Metakaolin

Metakaoline 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 4: Metakolin powder

3.6 Marble powder

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 marble flour, which replaces fine aggregate from the conventional concrete. The particle size used ranges from 10 to45µm



Figure 5 : Marble powder

3.7 Final trial mix of M40 Grade

Mix Proportions used for M40 conventional concrete

Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (lit)
492.5	671.574	1079.73	197
1	1.36	2.19	0.4

IV. EXPERIMENTAL INVESTIGATION

4.1 Mix Trials Used for concrete

For the current project 5 mix trials are used which are shown below.

1. Mix 1 -0%MK+0%MD
2. Mix 2-5%MK+5%MD
3. Mix 3-10%MK+10%MD
4. Mix 4-15%MK+15%MD
5. Mix 5-20%MK+20%MD

4.2 Workability

4.2.1 Slump cone test

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete.

The below figure shows the slump cone test method for various percentages of metakolin and marble dust.



Figure6: Slump cone test

4.2.2 Compaction factor test

The compaction factor test is designed primarily for use in the laboratory. It is more precise and sensitive than the slump test and is mostly useful for very low workability concrete mixes.

4.3 Strength of concrete

4.3.1 Compressive strength

Compression test is the most common test conducted on hardened concrete because most of the desirable characteristic properties are qualitatively related to its compressive strength. The compression test is carried out on specimens cubical or cylindrical in shape. The cube specimen is of the size 150×150× 150mm. The test is conducted on Universal Testing Machine.

The below figure shows the failure of test specimen under compressive load.



Figure7: Compressive strength for 5%MK+5%MD mix

4.3.2 Split tensile strength

This test method consists of applying a diametric compressive force along the length of a cylindrical concrete specimen at a rate that is within a prescribed range until failure occurs. This loading induces tensile stresses on the plane containing the applied load and relatively high compressive stresses in the area immediately around the applied load. Tensile failure occurs rather than compressive failure because the areas of load application are in a state of tri axial compression, thereby allowing them to withstand much higher compressive stresses than would be indicated by a axial compressive strength test result. The size of the specimen will be 150 mm diameter and 300mm long.

Split tensile strength for 15%MK+15%MD mix is shown in below figure.



Figure8: Split tensile strength for 15%MK+15%MD

4.3.3 Flexural strength

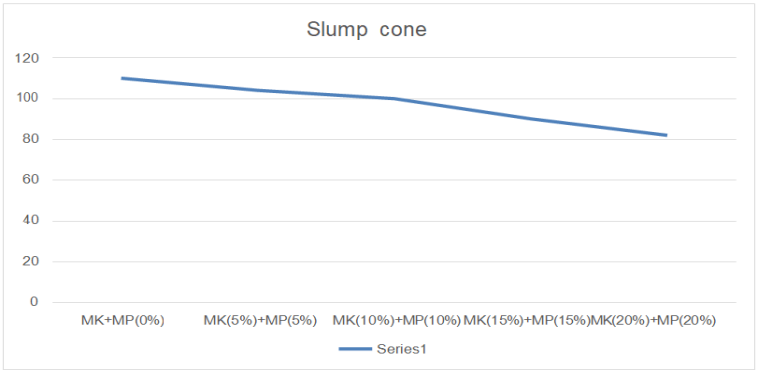
The flexural strength of concrete prism was determined based on IS: 516 –1959. Place the specimen in the machine in such a manner that the load is applied to the upper most surface as cast in the mould along two lines spaced 13.3cm a part. Apply load without shock and increase continuously at a rate of 180kg/min and it is increased until the sample fails. Measure the distance between the line of fracture and nearest support.



Figure9: Flexural strength for 15%MK+15%MD mix

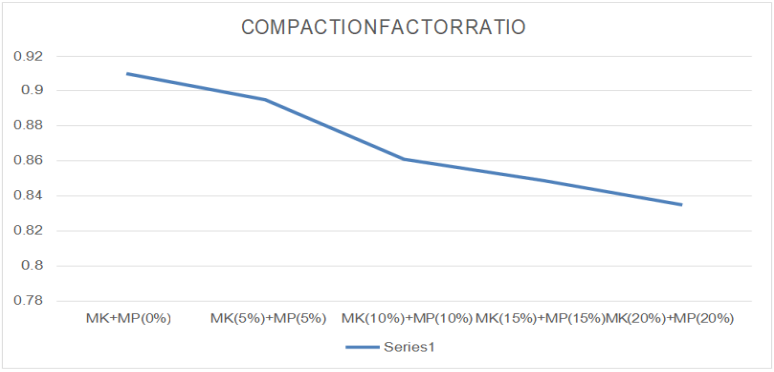
V. RESULST AND ANALYSIS

5.1Slump cone test



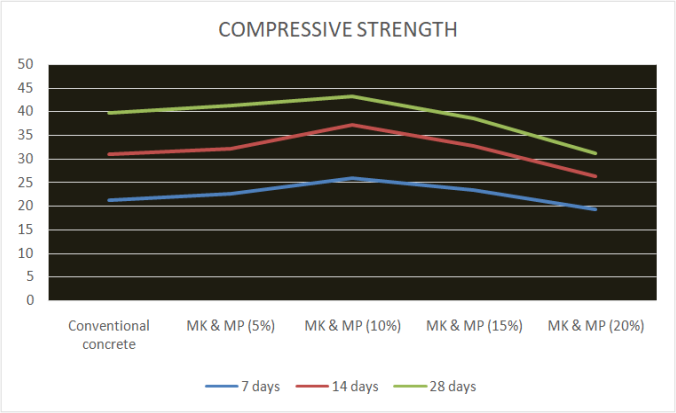
Graph 1: Comparison of Slump cone test results

5.2 Compaction factor test



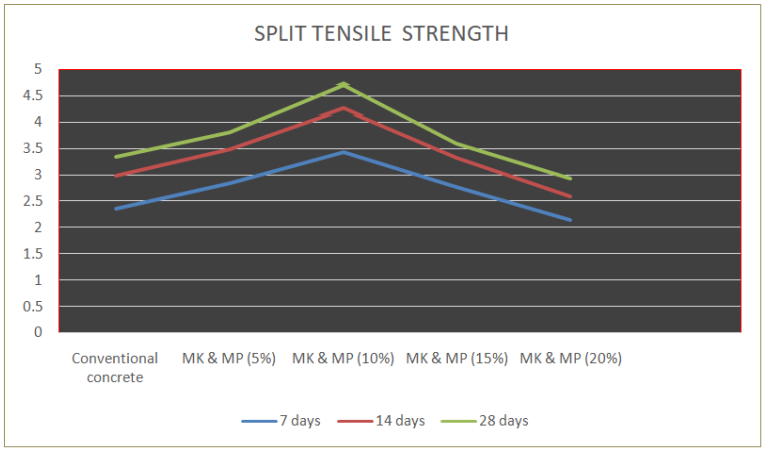
Graph2: Comparison of compaction factor ratio test

5.3 Compressive strength



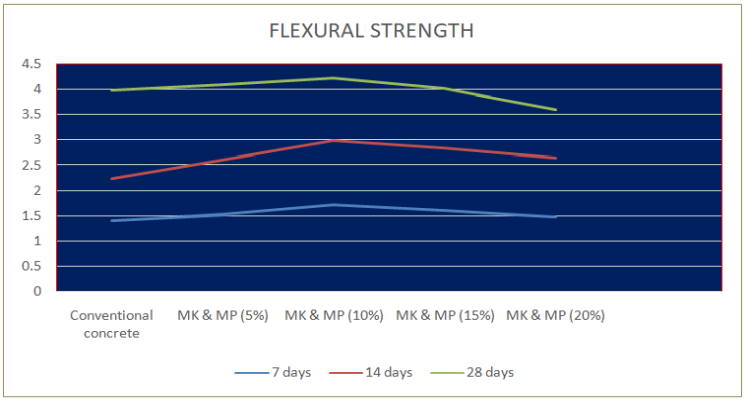
Graph 3: Comparison of compressive strength of concrete

5.4 Split tensile strength



Graph 4: Comparison of split tensile strength of concrete

5.5 Flexural strength



Graph 5: Comparison of flexural strength of concrete

VI. CONCLUSIONS

The present experimental investigation was aimed to design a high grade concrete with partial replacement of Metakaolin and Marble powder to cement analyzing 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 powder The addition of Metakaolin along with cement has increased the compressive strength of the concrete when compared to the conventional concrete.

1. From the Test results we find that metakaoline and marble powder can be use for partial replacement in concrete.
2. The compressive strength of concrete is more at 10%+10% replacement of metakaoline and marble powder. Has give maximum strength is 43.28KN/M2.
3. The Split tensile strength of concrete Cylinder strength of concrete is more at 10%+10% replacement of metakaoline and marble powder. Has give maximum strength is 4.73KN/M2
4. Flexural strength of concrete replaced with Metakaoline and Marble powder10% + 10% has given Maximum strength which is 4.23 KN/M2
5. Workability of concrete is also reducing due o increase in percentage of metakaoline and marble powder.
6. Strength and durability of concrete is increase
7. Eco-friendly by reducing of CO2
8. 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.

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