Experimental Study on Cement Concrete with METAKAOLIN

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Abstract— Metakaolin is a dehydroxylated form of clay mineral kaolinite. Rocks that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacturing of porcelain and effectively used as a replacement for cement in conventional concrete. It highly efficient in increasing the strength without affecting it's properties in fresh and hardened state. Even though, cement includes metakaolin at manufacturing process, it can be added further to increase the workability, strength and to reduce the cost of cement based concrete property. In this project, the cement is replaced by metakaolin as 0%, 10%, 13.5%, 15%, 17.5%, .M60 grade mix is adopted for concrete. This project covers the workability and strength properties of concrete with metakaolin. Cubes, Cylinders, Prism are cast and cured to conduct compressive strength and split tensile strength on 7 and 28 days.

Keywords: Metakaolin, Cement Concrete

I. INTRODUCTION

Concrete is far the most versatile and most widely used construction material worldwide. It can be engineered to satisfy a wide range of performance specification, unlike other building materials such as natural stone or steel, which generally have to be used because the tensile strength of concrete is much lower than its compressive strength, it is typically reinforced with steel bars, in which case it is known as reinforced concrete.

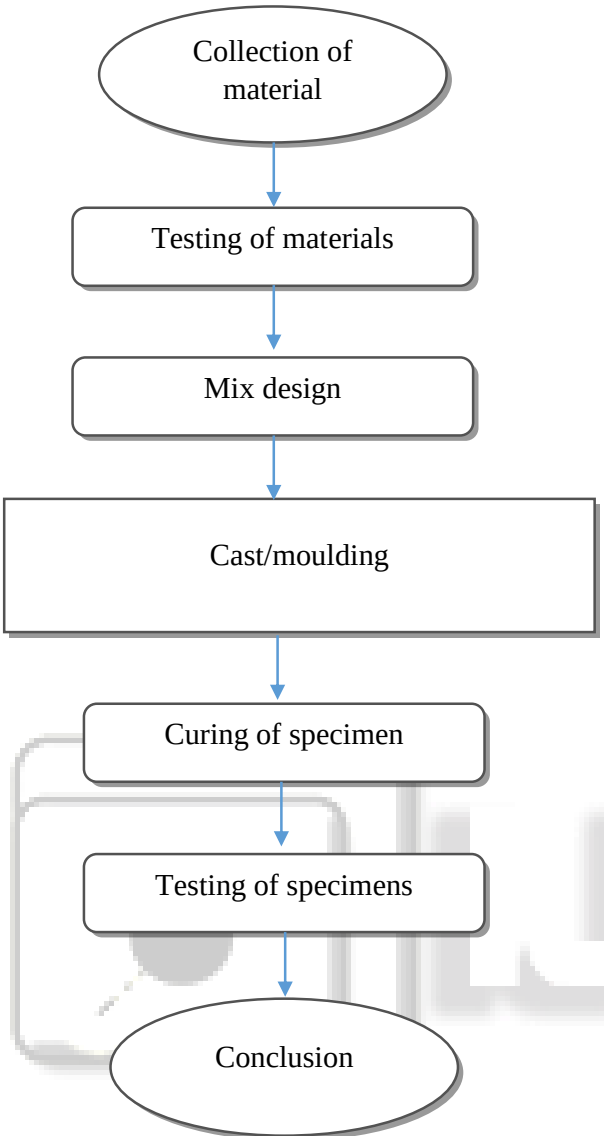
In fresh state of concrete, metakaolin eliminates or minimizes the bleeding, reduces segregation and improves workability. On hardening such concrete they provide greater compression strength, increase resistance to sulphate attack, freeze- thaw action, the resistance to corrosion, resistance to chloride ion penetration prevent and water permeability. They also studied the relationship between the concrete made using this type of materials; environmentally friendly concrete and green building rating systems.

Penetrationprevent and water Besides the above advantages mostly the addition of mineral admixture reduces the rate of gain of early strength of concrete. In the present day construction time is more valuable factor for projects to be economical and competitive, it becomes the setback.

II. LITERATURE REVIEW

1) Arka Saha [1] et al. (2014) conducted a study on "Strength development characteristics of high strength concrete incorporating an Indian fly ash". The study generally focuses on the feasibility of using fly ash as a replacement material in the concrete production. In this paper the cement is replaced by fly ash and it ranges between 0 - 40 %. The investigation was done in such a way that the water cement ratio lies between 0.27 to 0.42 and the cement content varies from 430 to 550 kg/m3. Compressive strength of the concrete was determined for 7, 28 and 90 days curing. From the studies they reached to the conclusion that increase of the fly ash upto a certain limit decreases the strength of the concrete and the optimum percentage found was 10.
2) Barbhuiya S [2] et al. (2015) in the paper "Microstructure, hydration and nanomechanical properties of concrete containing metakaolin" presents the results of an experimental investigation carried out to evaluate the properties of concrete containing metakaolin. The properties of concrete containing metakaolin at 0%, 5%, 10% and 15% by mass of cement were studied for their compressive strength, sorptivity and carbonation resistance at two different water–binder ratios. It was found that 10% of the Portland cement could be beneficially replaced with the metakaolin to improve the sorptivity and carbonation resistance of concrete. To better understanding the properties various analytical techniques such as XRD, MIP and nanoindentation studies were carried on cement paste samples (with and without 10% MK).
3) Bhaskara Teja Chavali [3] et al. (2016) in his paper "Effect of varying quantities of Metakaolin and fly ash on strength characteristics of concrete" studies the effect of adding Metakaolin along with fly ash in the concrete on its performance. The replacement was done in a pattern of 0% of Metakaolin and fly ash replacement, 15% of Metakaolin to cement and 30% of fly ash to cement separately and afterwards the combined effect of 15% Metakaolin and 30% of fly ash to cement were calculated. Concrete mix of M40 grade was used for the experimental investigation. The cubes, cylinders and prisms were tested for compressive strength, split tensile strength and flexural strength respectively. The tests are performed after 7 days and 28 days curing of the specimens.
4) Guneyisi E [4] et al. (2014) in the paper "Combined effect of steel fiber and metakaolin incorporation on mechanical properties of concrete" reports the results of an experimental study on mechanical properties of plain and metakaolin (MK) concretes with and without steel fiber. To develop the metakaolin included steel fiber reinforced concrete mixtures, Portland cement was partially replaced with metakaolin as 10% by weight of the total binder content.
5) Mirmoghtadaei R [7] et al. (2015) in the paper "The impact of surface preparation on the bond strength of repaired concrete by metakaolin containing concrete" studies the influence of various types of surface preparation on bond strength of repaired concrete is evaluated. Six different surface textures are studied: as-cast; wire brushed; acid etched; grooved; grooved-wire brushed; grooved-acid etched.

III. METHODOLOGY



IV. MATERIAL PROPERTIES

A. *Cement:*

Portland cement are calcareous material as a, such as limestone or chalk, and argillaceous material such as shale or clay. The chemical composition of cement as properly added. It posses the high compressive strength.

It is a corrosion resistance material and atmospheric agent has no appreciable effect on it. It hardens with age the process of hardening continues for a long time after the concrete has attained sufficient strength. It is this property of cement concrete which gives it a distinct place among building materials.

Chemical Properties	Value
Calcium oxide	60-67 %
Silicon dioxide	17-25 %
Aluminium oxide	3-8%
Iron oxide	0.5-0.6 %
Magnesium oxide	0.1-4 %
Alkalies	0.4-1.3 %
Sulfur trioxide	1.3-3 %

Physical Properties	Value
Retain on 90micron sieve %	6.25
Unit weight kg/m^3	1440
Specific gravity	3.15

Table 1:Properties of cement

B. *M-Sand*

M-Sand is a by-product of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In quarrying activities, the rock as the Crushed into varies sizes during the process the dust generated is waste.

Properties	Value
Textural composition (% by weight)	
Coarse (4.75-2.00 mm)	28.1
Medium(2.00-0.425 mm)	44.8
Fine(0.425-0.075 mm)	27.1
Specific gravity	2.2
Bulk density	15.1
p^H	10.11

Table 2: Properties of M-sand

C. *Coarse Aggreagte*

Coarse aggregate are irregular broken stone or naturally occurring rounded gravel used for making concrete. Materials which are large to be retained on 4.7mm sieve size are called coarse aggregate, and its maximum size can be up to 63mm.

- Specific gravity of coarse aggregate is 2.76
- Water absorption is 0.4

D. *Metekaolin*

Metakaolin is a dehydroxylated from of the clay mineral kaolinite. Rocks that are rich in kaolinite are known as china clay or kaolin, traditionally used in manufacture of porcelain. The particle size of metakaolin is smaller than cement particles, but not as fine as silica fume

V. FINENESS MODULUS TEST FOR METAKAOLIN

100g of the Metakaolin is weighted accurately and is placed on IS 90 micron sieve and is sieved continuously for 15 minutes by circular and vertical motion. The underside of the sieve is lightly brushed with the given brush after every 5 minutes of sieving. The weight of the residue is found accurately and thus the fineness of the Metakaolin is found out by the ratio of weight of residue and weight of sample taken which is expressed in percentage. The experiment is repeated with fresh sample and result are tabulated

VI. MIX DESIGN

Mix design is the process of selecting suitable ingredient if concrete and determines their relative proportions with the object of certain minimum strength and durability as economically as possible.

The objectives of concrete mix design as follow:

1) To achieve the stipulated minimum strength.
2) To make the concrete in this most economical manner.

Concrete mix design for M20 grade in this experiment was designed as per the guidelines specified in

I.S. 10262 – 1982. The table 4 shows mix proportion of concrete.

A. Design Mix

1. Characteristic compressive strength = 20N/mm^2 (Required in the field at 28 days)
2. Maximum size of aggregate = 20mm (angular)
3. Degree of workability = 0.90
4. Degree of quality control = Good
5. Type of exposure = Mild

B. Test Data For Materials

1. Specific gravity of cement = 3.12
2. Specific gravity of coarse aggregate = 2.97
3. Specific gravity of fine aggregate = 2.62
4. Water absorption: fine aggregate = 0.9%
5. Sieve analysis of fine aggregate = Conforming to grading Zone III (with reference of IS 383-1970)

C. Mix proportioning

Water	191.6 ml	0.5
Cement	383 Kg	1
Fine Aggregate	549 Kg	1.43
Coarse Aggregate	1184 Kg	3.09

VII. Experimental Results

A. Compressive Strength

In the compressive strength test, the size of cube specimens used for testing is 150mm x 150mm x 150mm. the 150mm cubes were casted for compressive strength test at various dosage of concrete specimen such as 5%, 10%. 15% and the test was carried out on 7. 14. And 28 days of curing were done, the cubes are removed from water and made it dry.

Compressive strength = P/A

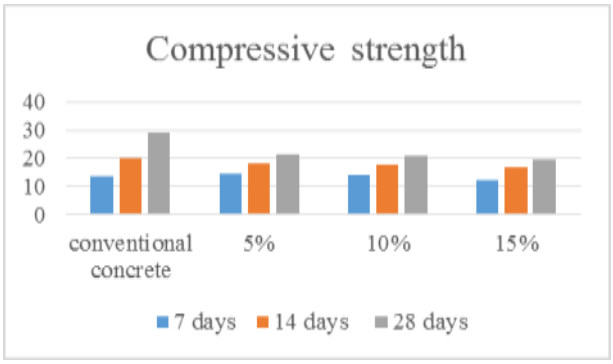
Compressive strength of conventional concrete

Type of concrete	Compressive Strength N/mm^2		
Conventional concrete	7 days	14 days	28 days
	13.46	19.92	29.02

COMPRESSIVE STRENGTH OF (N/mm^2)

Compressive strength of Concrete

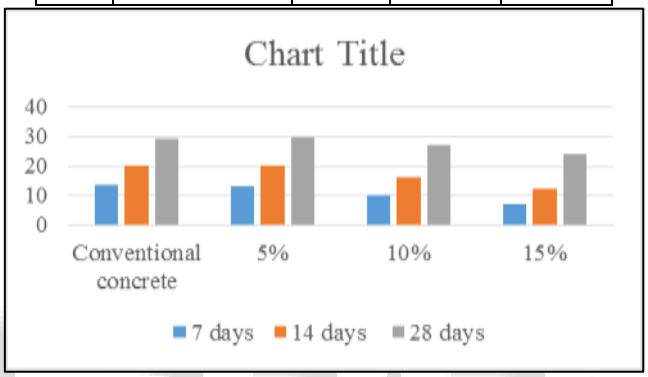
S.no	% CSA	7 days	14 days	28 days
1.	5%	14.30	18.15	21.45
2.	10%	13.83	17.78	20.75
3.	15%	12.11	16.77	19.63



COMPRESSIVE STRENGTH CONCRETE (N/mm^2)

Compressive strength of Metakoalin Concrete

S.no	% Metakaolin	7 days	14 days	28 days
1.	5%	13.02	19.07	29.50
2.	10%	10.27	16.19	27.10
3.	15%	7.18	12.46	23.80



VIII. Conclusion

- Metakaolin is a suitable material for replacement of cement in concrete.
- Basic test for cement, fine aggregate, coarse aggregate and metakaolin were conducted and results were tabulated.
- The concrete was prepared for the M20 grade concrete with partial replacement of cement by metakaolin with various percentages of 5%, 10% and 15%.
- The specimen were casted for 7 days, 14 days and 28 days then tested.
- Replacement of metakaolin by 5% show an increase in strength than conventional concrete.
- Replacement of metakaolin cement reduces the cost of making concrete and reduces the consumption of cement.
- Generally it is concluded that metakaolin can be used as partial replacement of cement to produce concrete with good strength.

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