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PARTIAL REPLACEMENT OF CEMENT WITH METAKAOLIN

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ABSTRACT: The overall objective of the present study is to determine the optimum content of metakaolin in replacement of cement and to study its performance. For this Mix proportions of OPC concrete for M25 by IS method was determined. The mix proportion was calculated for conventional concrete and cement was replaced by 5%, 10%, 15%, 20% and 25% of metakaolin. The concrete specimens such as cubes and cylinders for M_{25} grade concrete was prepared and cured for 7days and 28 days. The compressive strength of concrete increased when cement is replaced by 15% of metakaolin. The split tensile strength of concrete is also increased when cement is replaced with 15% of Metakaolin.

KEYWORDS – Metakaolin, compressive strength, split tensile strength.

I. INTRODUCTION

Concrete is the most widely used material for various constructional activities. The main ingredient in conventional concrete is Portland cement. The amount of cement production is approximately equal to the emission of carbon dioxide in atmosphere and consumes certain natural resources. To overcome such ill effects, the advent of admixtures and construction techniques are coming way. In recent times, the use of supplementary materials such as fly ash, ground granulated blast furnace slag, silica fume has been utilized as a partial replacement for cement provided as these materials can improve the strength and durability characteristics of concrete in comparison with concrete made of ordinary Portland cement alone.

One such mineral admixture is metakaolin which is obtained from thermally activated ordinary clay and kaolinite clay that enhances the properties of ordinary concrete. This is quite advantageous compared to other pozzolonas due to the fact that it can increase the durability of cement paste or mortar if proper curing is adopted. The calcium hydroxide produced by the cement hydration reacts with the pozzolonas and produces additional gel which has a pore blocking effect and therefore alters the pore structure and the strength. In addition, there is a reduction in calcium hydroxide (CH) which leads to improved sulphate attack and alkali-silica reaction.

1. Metakaolin

Metakaolin is a cementitious material produced by burning kaolin at 600- 800°C. In experiments, metakaolin having composition less than 90 microns is used. When cement is partially replaced with metakaolin, it reacts with calcium hydroxide and results in C-S-H gel which is the sole cause of strength development in cement based concrete.This C-S-H gel binds together the cement particles into a cohesive whole. The physical and chemical properties of metakaolin are given below.

Chemical composition of metakaolin

Chemical properties of Metakaolin are as follows, Silica (SiO2): 51-53% Al2O3: 42-44% CaO: <20%

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II. EXPERIMENTAL SETUP

Introduction

On arriving the mix proportions for various replacements, the concrete cubes were cast in our college. The concrete cubes are cast with proper care and done systematically by following codal specifications and procedures.

Phases of Casting

Production of good quality concrete cubes requires meticulous care exercised at every stage of manufacturing. The following are the various stages to manufacture concrete cubes.

- Batching
- Mixing
- Casting
- Compaction
- Curing

Batching

The measurement of materials for making concrete cubes is known as batching. There are two methods of batching

- Volume batching
- Weigh batching

Volume batching is not a good method for proportioning the material because of the difficulty that it measures granular material in terms of volume. Weigh batching is the correct method of measuring the materials. Use of weigh system in batching facilitates accuracy, flexibility and simplicity.

Different types of weigh batchers are available. The particular type to be used depends upon the nature of the job. Weigh batching is adopted for casting the cubes with a weighing machine having an accuracy of 0.01 kg. Measurement of water and Superplasticizer is done by volume basis since the mix proportioning is on weigh basis, it is converted into the volume in terms of litres and superplasticizer is also measured by the same way in terms of litres.

Mixing

Thorough mixing of the materials is essential for the production of uniform casting of concrete cubes. The mixing should ensure that the mass becomes homogeneous, uniform colour and consistency, there are two methods adopted

For casting cubes.

- Hand mixing
- Machine mixing

Machine Mixing

Mixing of concrete almost invariable carried out by machine, for medium and large scale mass concrete works. Machine mixing is not only efficient, but also economical, when the quantity of concrete to be produced is large.

Hand mixing

Mixing of concrete using hand is suitable for small quantity of works. The quality can be assured in this case. In this project hand mix is adopted as the quantity of materials is small and the resin may stick in the circumference of the mixer which leads to troubles since the quantity is less. The measured quantity of materials like cement, fine aggregate, water, coarse aggregate and the superplasticizer is added with water. The cement and fine aggregate is mixed dry initially and water is added slowly, coarse aggregate is added further and superplasticizer mixed with water is added to the mix.

Dry mix

The concrete cubes are casted in the size of 150 x 150 x 150 mm. Moulds are cleaned and oil is applied inside the cubes to demould easily. For each trial 3 cubes were casted. It is ensured that the nuts and bolts are tightened so that it may not loosen while vibrating.

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Compaction

Compaction of concrete is the process adopted for expelling the entrapped from the concrete. In the process of mixing, transporting and placing of air is likely to get entrapped in the concrete. The lower the workability,
Concrete higher percentage the amount of air entrapped. In other words, stiff concrete mix has high of entrapped air and, therefore, would need higher compacting efforts than high workable mixes.
There are two major methods of compaction

- Hand compaction
- Compaction by vibration

Hand Compaction of concrete is adopted in case of unimportant work of small magnitude. Sometimes, this method is also applied in such situation, where a large quantity of reinforcement is used, which cannot be normally compacted by mechanical means.
Compaction by vibration: It is pointed out that the compaction by hand, if property carried out on concrete with sufficient workability, gives satisfactory results, but the strength of the hand compacted concrete will be necessarily low because of higher water cement ratio required for full compaction. Where high strength is required, it is necessary that stiff concrete, with low water cement ratio compact such concrete, mechanically operated vibratory be used. To equipment, in by layers must be used.
This project, Platform vibrator is used for the compaction. The cubes are filled s and it is vibrated for 15-20 seconds. The cubes are finished and noted with the trail numbers for identification.

Curing

The cubes are demoulded after 24 hours and then it is allowed to curing tank .Then it is sorted for compressive strength test.

III. RESULT AND DISCUSSION

Slump Test

The ease with which one can work with concrete is called workability. Slump cone test is used to determine the workability or consistency of concrete mix. It is done with a metallic cone of 30 cm height having diameter of 20 cm at the base and 10 cm at the top, a tamping rod, non- porous base plate and a measuring scale. Inside of the mould is moistened to reduce surface friction.

After filling the metallic cone with concrete and smoothening the top surface, it is gradually lifted up without jerking immediately. The concrete mix is yet in the form of paste and it will not stand to its original height. It undergoes some subsidence which is called slump before it becomes stable. The following table shows the workability of different concrete mix which used metakaolin as a partial replacement of cement in increments of 5%.

Table 1: Workability of Concrete

MIX DESIGNATION	% REPLACEMENT OF CEMENT BY METAKAOLIN	SLUMP (mm)
A	0	102
B	5	93
C	10	84
D	15	65
E	20	55
F	25	40

Determination of Dry Density
The density of concrete is a measure of its unit weight and it depends upon the amount of density of aggregates, the cement and water content. The following table shows the dry density of Concrete.

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Table 2: Dry density of Concrete

MIX DESIGNATION	% REPLACEMENT OF CEMENT BY METAKAOLIN	DRY DENSITY IN Kg/m^3
A	0	2418
B	5	2409
C	10	2379
D	15	2376
E	20	2341
F	25	2334

The dry densities of various mix proportion of metakaolin concrete vary by more or less 50 kg/m^3. The slight reduction in the densities of metakaolin concrete was due to the lower specific gravity of metakaolin compared to cement alone.

Determination of Compressive Strength

Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size. It is calculated by the load applied at the point of failure to the cross section area of the face on which load was applied. The specimens are tested by compression testing machine after 7 days curing and 28 days curing. Following table shows the compressive strength for concrete specimens of different mixes containing metakaolin in an increment of 5% at age of 7 days and 28 days.

Table 3: Compressive strength of Concrete

MIX DESIGNATION	% REPLACEMENT OF CEMENT BY METAKAOLIN	7 DAYS COMPRESSIVE STRENGHT (Mpa)	28 DAYS COMPRESSIVE STRENGHT (Mpa)
A	0	23.54	31.72
B	5	24.74	32.22
C	10	28.59	37.17
D	15	35.11	45.54
E	20	29.18	37.93
F	25	28.44	39.47

Determination of Split Tensile Strength

The cylinders were taken out from the curing tank and tensile strength of concrete specimens of different proportions was determined which are tabulated as below.

Table 4: Split tensile strength of Concrete

MIX DESIGNATION	% REPLACEMENT OF CEMENT BY METAKAOLIN	TENSILE STRENGHT (Mpa)
A	0	1.98
B	5	2.12
C	10	2.68
D	15	2.82
E	20	2.54
F	25	2.40

IV. CONCLUSION

The following conclusions were made from the results of various tests performed on the concrete where cement is partially replaced with metakaolin:

> Workability of concrete decreases with the increase in metakaolin replacement level.
> 15% of replacement of metakaolin shows the optimum replacement level.
> The strength of all metakaolin concrete mixes over shoot the strength of control mix.

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> The Compressive strength and split tensile strength of conventional concrete and concrete with metakaolin as partial replacement are compared and observed and concluded that the strength of the metakaolin concrete is higher than the conventional concrete.

The compressive strength results show that when cement is replaced by 15% of metakaolin, the compressive strength and Split Tensile strength has increased compared to other proportions.

> At the optimum level, the compressive strength attained was 43.56% more than the adopted grade of concrete.

> The results encourage the use of Metakaolin, as a pozzolanic material for partial replacement in producing high strength concrete.

REFERENCES

1) Eva Vejmelkova and Milena Pavlikova (2010) "High performance concrete with Czech metakaolin: Experimental analysis of strength, toughness and durability characteristics" Construction and Building Materials 24 (2010) 1404-1411

2) Jirawat Suwanpruk, Suvimol Sujjavanich & Jaroenwut Punyanusornkit (2003) "Impact of Low Sulphate Metakaolin on Strength and Chloride Resistance of Cement Mortar and High Strength Concrete". Fourth Regional Symposium on Infrastructure Development in Civil Engineering (RSID4), Bangkok, Thailand,
2003.

3) Dinakar P.(2011) "High reactive metakaolin for high strength and high performance concrete" The Indian Concrete Journal APRIL 2011.

4) Khatib and S.Wild (1993) "Pore size distribution of Metakaolin paste" in cement and concrete research, ICJ Vol 26 No. 10, 1996, pp 1545-1553.

5) Khatib and Wild (1998) "Sulphate Resistance of Metakaolin Mortar". Cement and Concrete Research, ICJ Vol .28. No. 1, 1998, pp. 83-92

6) Kinuthia, J. M., Bai, J., Wild andS., Sabir, B. B. (1999), "Workability of Concrete Incorporating Pulverized Fuel Ash and Metakaolin", Magazine of Concrete Research, V. 51, No. 3, p.207-216.

7) Kimberly E. Kurtis (2011) "Benefits of Metakaolin in HPC" HPC Bridge Views Issue 67 May/June 2011.