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# Strength Characteristics of Concrete with Partial Replacement of Cement with fly-Ash & Metakaolin

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**ABSTRACT:**The most expensive and energy-intensive component of concrete is cement. By partially substituting fly-ash and metakaolin for cement, the unit cost of concrete can be as low as possible. Therefore, reuse should be the subject of scientific research, both in terms of experimental testing and actual implementation. The clay mineral kaolinite has been de-hydroxylated to generate metakaolin. Metakaolin can be made from both primary and secondary sources that contain kaolinite, including high purity kaolin deposits, lower purity kaolinite deposits or tropical soils, waste paper sludge that contains kaolinite, and oil sand tailings. It has been established from the foregoing observations that using the waste product Metakaolin boosted compressive and flexural strengths and increased durability. Utilizing metakaolin promotes excellent strength and performance in concrete. Without changing the cement, M25 grade reference concrete was made for the current study. 20% of fly-ash and 0%, 5%, 10%, and 15% of metakaolin in cement were used to partially replace the same grade. On specimens that had been curing for 7, 28, and 90 days, research was done on the properties of newly-poured concrete and those of hardened concrete.

**KEYWORDS:** Metakaolin, fly-ash.

## I. INTRODUCTION

Ordinary Due to demand and the global expansion of the construction industry, Portland cement and water continue to be the most widely utilised building materials worldwide. The protection of the environment and providing for the infrastructure needs of our expanding population present the concrete building sector with their two most serious challenges. Metakaolin is widely used in the concrete industry all over the world. Metakaolin has several tangible performance advantages in terms of mechanical and durability qualities, as well as environmental advantages. While portland cement manufacture is linked to significant CO<sub>2</sub> emissions. The clay mineral kaolinite has been dehydroxylated to generate metakaolin. Metakaolin can be made from both primary and secondary sources that contain kaolinite, including high purity kaolin deposits, lower purity kaolinite deposits or tropical soils, waste paper sludge that contains kaolinite, and oil sand tailings. It has been established from the foregoing observations that using the waste product Metakaolin boosted compressive and flexural strengths and increased durability. Utilizing metakaolin promotes excellent strength and performance in concrete.

The finely divided mineral waste known as fly ash is produced when ground or powdered coal is burned in a thermal power station to produce electricity. A useful mineral additive for concrete is fly ash. Numerous characteristics of fresh and hardened concrete are affected by it. Additionally, using waste materials in the cement and concrete industry lessens power plant environmental issues and lowers.

The price of producing power. Concrete's permeability and the density of calcium silicate hydrate are both decreased by fly ash-infused cement. (C-S-H). According to research, both the fresh and hardened phases of concrete will benefit from the partial replacement of cement with fly ash. The workability of the fly ash is enhanced when it is fresh.

### Project's main goal

1. Developing mix designs for concrete that are applicable to IS: 10262-2009 is one of the goals of this experimental project study.
2. To investigate the workability and strength characteristics of concrete of grade M25. To investigate the impact of concrete when fly ash and metakaolin are used as a partial replacement for cement..



### Scope of the present study

The following elements are included in the study's scope:

Cement, fine aggregate, coarse aggregate, fly ash, metakaolin, and water were all tested in the lab. Using the IS: 10262-2009 as a guide, a mix design for concrete M25 was created, replacing some of the cement with fly-ash (20% replacement) and metakaolin (0%, 5%, 10%, and 15% replacement). Trial mixes were then made to test the concrete's workability and goal mean compressive strength. Specimens were examined after 7 days, 28 days, and 90 days of water curing.

The slump cone test and the compaction factor test were used to evaluate the properties of fresh concrete. Concrete samples were tested for their hardened properties after 7, 28, and 90 days of water curing.

## II.LITERATURE REVIEW

**V.S. Sai Kumar and B. Krishna Rao**The strength of concrete with partial cement replacement with quarry dust and metakaolin has been examined by Concrete is a composite material comprised of cement, water, fine aggregate, and coarse aggregate. The topic of the current study is the partial substitution of cement with metakaolin and quarry dust, both of which include silica and are used as admixtures in concrete. According to their claims, concrete can benefit from using quarry dust up to 25% of the time in place of cement without the cement losing any of its strength. The impact of quarry and metakaolin on concrete has also been studied, and experiments using 25% quarry dust and 2.5%, 5.0%, 7.5%, 10.0%, and 12.5% metakaolin as a partial replacement for cement have been conducted. Results showed that quarry dust and metakaolin might be used to partially replace cement.

**B. Patil1, P. D. Kumbhar**The current paper deals with the study of properties, namely workability, compressive strength, and durability of M60 grade HPC mixes incorporating different percentages of high reactivity metakaolin by weight of cement along with some suitable super plasticizer. B. Patil1, P. D. Kumbhar examined that "Strength and Durability Properties of High Performance Concrete incorporating High Reactivity Metakaolin." According to the study's findings, adding HRM to HPC mixtures up to an acceptable cement level of 7.5% by weight enhanced their workability and strength. Additionally, HPC mixes have shown improved resilience to chemical assaults from sulphates and chlorides when the HPC mixes were exposed to these chemicals for a period of 180 days.

**Beulah M. Asst Professor and Prahallada M. C. Professor**Effect of Cement Replacement With Metakalion On The Properties Of High Performance Concrete Subjected To Hydrochloric Acid Attack by. This study includes an experimental inquiry into the effects of partial cement replacement with metakalion in high performance concrete when it is attacked by hydrochloric acid in various percentages (0, 10, 20, and 30%). The outcomes were contrasted with the reference mixture. According to test results, using Metakalion's replacement cement in HPC has increased concrete performance by up to 10%.

## III.MATERIAL PROPERTIES

Materials characteristics and concrete mix design calculations for M30 grade concrete were described in detail in this chapter. This chapter covers the mix design description for the M30 under investigation. The following are the raw ingredients needed to make the concrete used in this project: cement, aggregates, fly ash, water, and mineral additive. Fly ash is a large-scale industrial waste product from thermal power plants. With more power plants, it is predicted that annual fly ash production will reach roughly 90 million tons, of which 13% is used for profitable purposes. Mechanical collectors or electrostatic precipitators are used to remove fly ash. 20% of the ash particles produced in a boiler using pulverised fuel agglomerate into larger particles by fusion and are deposited as fly ash.



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Fig. 1 Fly-ash

Highly pozzolanic substance is metakaolin. It is made by calcining Algerian kaolin for seven hours at 700 °C. It is made from high purity kaolin clay that has been calcined. The item is then ground to a size of 1 to 2 m. (about 10 times finer than cement). The metakaolin's active silica and alumina react with free lime to produce C-S-H and alumina-silicates, which significantly increase the strength.



Fig.2 Metakaolin

#### IV. MIX DESIGN

The cost of concrete is made up of the cost of the material, plant, and labour. The variation in the cost of the material arises from the fact that the cement is several times more expensive than the aggregates, so the aim is to produce as much concrete as possible.

The following mix calculations must be made for each concrete volume unit:

$$\begin{aligned}
 \text{a) Volume of concrete} &= 1 \text{ m}^3 \\
 \text{b) Volume of cement} &= \frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1000} \\
 &= \frac{424.4186}{3.13} \times \frac{1}{1000} \\
 &= 0.1355 \text{ m}^3 \\
 \text{c) Volume of water} &= \frac{\text{Mass of water}}{\text{Specific gravity of water}} \times \frac{1}{1000} \\
 &= \frac{182.466}{1} \times \frac{1}{1000} \\
 &= 0.18256 \text{ m}^3
 \end{aligned}$$





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- d) Volume of all in aggregate = (a-b+c)  
 =(1-0.1355+0.1824)  
 =0.682m<sup>3</sup>
- e) Mass of coarse aggregate = dx volume of CA x Specific gravity  
 Coarse aggregate x 1000  
 =0.682x0.634x2.78x1000  
 =1202kg
- f) Mass of fine aggregate = fx volume of fine aggregate x Specific Gravity of FA x 1000  
 =0.681x0.366x2.57x1000  
 = 641kg

**Mix proportions for trail:**

- Cement =424.41kg/ m<sup>3</sup>
- Water =182.5litre
- Fine aggregate: =641kg
- Coarse aggregate =1202kg
- WaterCement ratio =0.43

**IV.RESULTS & DISCUSSIONS**

The experimental findings that were addressed are reported in this chapter. In relation to fresh concrete, observations of slump and compaction factor are made. The test findings for hardened concrete of M25 grade replacement of cement with 20% of fly-ash and 0%, 5%, 10%, and 15% proportions of metakaolin mixes at the ages of 7, 28, and 90 days are given, including the compressive strength, split tensile strength, and flexural strength.

S.No	MixId	Compressive strength(N/mm <sup>2</sup> )		
		7days	28days	90days
1	NCC	21.35	32.62	37.21
2	F-M0	23.42	42.6	45.80
3	F-M5	30.13	44.25	46.23
4	F-M10	35.34	47.58	49.26
5	F-M15	30.8	44.6	46.17

S.No	MixId	Flexural strength(N/mm <sup>2</sup> )		
		7days	28days	90days
1	NCC	4.1	5.05	6.08
2	F-M0	4.63	6.28	7.23
3	F-M5	5.02	6.50	7.54
4	F-M10	5.34	6.93	7.85
5	F-M15	5.21	6.70	7.62



S.No	MixId	Splittensilestrength(N/mm <sup>2</sup> )		
		7days	28days	90days
1	NCC	1.45	2.0	2.23
2	F-M0	2.0	2.4	2.9
3	F-M5	2.3	2.8	3.01
4	F-M10	2.9	3.03	3.3
5	F-M15	2.4	2.9	3.02

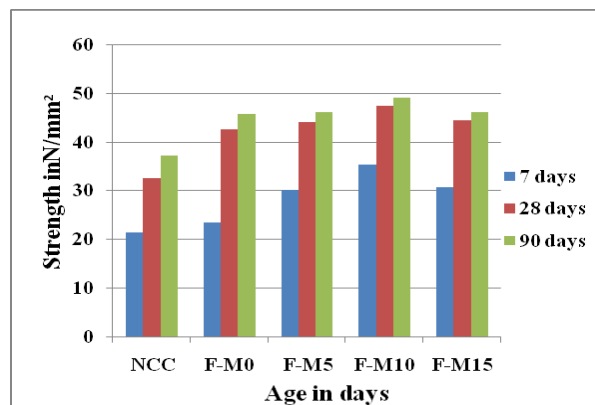


Fig no-3 Compressive strength Vs Age

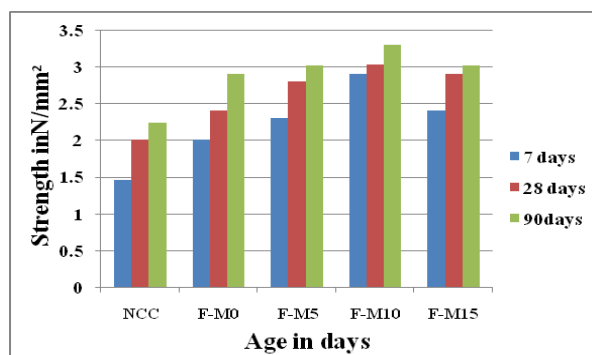


Fig no-4 Tensile strength Vs Age

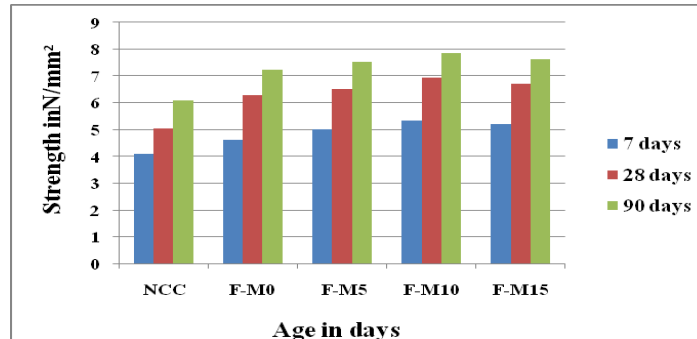


Fig no-5 Flexural strength Vs Age

## VI.CONCLUSIONS

The study's findings could lead to the conclusions listed below.

1. The compressive strength of F-M5, F-M10, and F-M15 at the age of 28 days had met its intended mean strength, although it had grown by 30%, 36%, 45%, and 36.7%, respectively, in comparison to NCC.
2. At the age of 28 days, it was found that the compressive strength of F-M15 had decreased by 6% in comparison to F-M10.
3. When compared to mix NCC, the flexural strength of F-M0, F-M5, F-M10, and F-M15 has risen by 24%, 28%, 37%, and 32%, respectively, at 28 days.
4. When compared to mix F-M0, the flexural strength of NCC at 28 days has decreased by 24%. Flexural strength (At 28 days) of mix F-M5, F-M10 and F-M15 has increased by 3%, 10% and 6% respectively when compared with mix F-M0.
5. When compared to mix F-M10, the flexural strength (at 28 days) has decreased by 6%.
6. When compared to mix NCC, the split tensile strength of mixes F-M0, F-M5, F-M10, and F-M15 rose by 20%, 40%, 51%, and 45%, respectively, at 28 days.
7. When compared to F-M0, the split tensile strength of mix NCC has decreased by 20%.
8. When compared to mix F-M0, the split tensile strength of mixes F-M5, F-M10, and F-M15 rose by 16%, 26%, and 20%, respectively, at 28 days.
9. When compared to mix F-M10, the Split tensile strength of mix F-M15 has decreased by 4%.
10. Up to 10% of cement can be replaced with metakaolin without suffering a significant loss in compressive strength, but at 15% cement replacement with metakaolin, compressive strength started to decline noticeably.

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