International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 05, May-2019

"EXPERIMENTAL STUDY ON FLYASH AND METAKOALIN AS PARTIAL REPLACEMENTOF CEMENT IN CONCRETE"

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ABSTRACT: ***As the impact of resource declines and greenhouse gas emissions become clearer, it is becoming increasingly important to minimize the environmental impacts and energy and carbon dioxide intensities of concrete used in construction. The approach was to create alternatives that would reduce environmental, energy and CO2 impacts. This can be achieved by partially replacing the cement with a large amount of fly ash and metakaolin. Fly ash is a by-product of coal combustion and metakaolin (MK) is produced by calcined kaolinite clay at high temperatures***

In this study investigates the mechanical properties of cement has been replaced with fixed percentage of fly ash and variable percentage of metakaolin. Four basic concrete mixes have considered. These are (1) Conventional mix with no material substitutions, (2) 30% replacement of cement with fly ash and 5% replacement of cement with metakaolin, (3) 30% replacement of cement with fly ash and 10% replacement of cement with metakaolin, (4) 30% replacement of cement with flyash and 15% replacement of cement with metakaolin. M30 grade concrete used to get maximum strength. Cubes are tested at 7 days and 28 days of curing period for compressive strength test. Cylinders are tested at 7 days and 28 days of curing period for split tensile test. Beams are tested at 7 days and 28 days of curing period for flexural strength test.The obtained test results are compared with conventional concrete.

Key words: ***Fly ash, Metakaolin, Compressive Strength, Tensile Strength, Flexural strength, Slump Cone Test.***

1. INTRODUCTION

Concrete has played an important role in infrastructure development. Concrete has many advantages over other building materials, including low cost, applicability in various conditions, adaptability of cement, use and production, and increasingly the leading cause of global ecological problems in over-exploitation of non-renewable natural resources ranging from high-temperature production processes to fossil fuel combustion and raw material extraction.In order to overcome this effect, O-cement (C-SH), which converts formalin, which produces hydric cementitious material in the presence of lime, to calcium silicate hydrate (C-SH) which reacts with the lime and gives strength to the concrete, maintain durability.

Low calcium fly ash (ASTM Class F) and metakaolin are readily available at low cost compared to silica fume used as pozzolanic material to replace OPC in concrete that reduces the amount of cement and reduces carbon dioxide emissions. All of these materials are fine and the particles are glassy, which reduces the amount of water and improves workability. We use this mineral admixture to reduce the cost of concrete and develop environmentally friendly concrete.

Low calcium fly ash is widely used to replace cement in regular and high strength concrete. In moderate strength concrete, the replacement level can be more than 50%, but in high strength concrete, the replacement level is usually limited to 15 to 25%. The main purpose of using fly ash in concrete is to reduce heat generation and obtain better durability

Fly ash is a fine powder that is a by-product of burning pulverized coal in a power plant. Fly ash is pozzolanic material that contains alumina and siliceous materials that form cement in the presence of water. When lime and water are mixed, fly ash forms a compound similar to Portland cement

Metakaolin is refined kaolin clay that is fired (calcined) under carefully controlled conditions to make reactive amorphous alumino silicates in concrete. Like other pozzolans, meta-kaolin reacts with the calcium hydroxide (lime) by-products produced in the cement hydration process. MK had a dry uncompressed powdery white color.

2. OBJECTIVES OF THE PRESENT PROJECT:

- To study the influence in properties of concrete due to use of fly ash and metakaolin.
- To promote the utilization of fly ash and metakaolin in concrete for creating a possibility of sustainable construction.
- To motivate engineers and contractors regarding use industrial waste products in construction thereby paving path for greener environment.
- To find out variation in compressive, tensile and flexural strength of fly ash and metakaolin concrete with conventional concrete.

3. EXPERIMENTAL METHODOLOGY:

Many research paper and journal studies were carried on the experimental study on flyash and metakoalin as a partial replacement of cement in concrete and properties and materials were focused for consideration. Therefore, in this study, M30 mix design is prepared as per IS10262:2009. Flyash is added at fixed proportion of 30% and metakoalin is added at a variable proportions of 0%,5%,10%,15% as partial replacement of cement by weight of M30mix. Total of specimens of cubes, cylinders, beams were casted for compressive strength, split tensile strength, flexural strength tests respectively for testing after curing of 7 and 28 days.

4. MATERIAL CHARACTERIZATION

a) Cement:

The Ordinary Portland Cement "**PENNA**" of 53 grade is used specifying all the properties from IS12269-1987.

TABLE 1: PHYSICAL AND MECHANICAL PROPERTIES OF CEMENT

S. NO.	PARTICULARS OF TEST	TEST RESULTS
1.	Specific gravity	3.156
2.	Fineness	5.3
3.	Normal Consistency	32%
4.	Initial setting time	55 min.
5.	Final setting time	210 min.

b) Coarse Aggregate:

20 mm and 16 mm rough aggregates are selected by passing them through 20 mm and 16 mm sieves, respectively. The grain shape of the two aggregates forms an angle. Other tests such as specific gravity, fineness, and water absorption should be performed. Rough aggregates have no dust and no surface moisture.

TABLE 2: PROPERTIES OF COARSE AGGREGATE

S. NO.	PARTICULARS OF TEST	VALUE
1.	Specific gravity	2.64
2.	Fineness modulus	8.64
3	Flakiness Index	13.25%
4.	Elongation Index	47.35%

(c) Fine Aggregate:

In fine aggregate, natural sand is best one and it selected. From 4.75mm sieve sand is sieved and also washed to reduce the silt content. For natural sand, the water demand is slightly less, hence more preferable. The tests to be conducted on Natural sand are specific gravity, fineness modulus and water absorption.

TABLE 3: PROPERTIES OF FINE AGGREGATE

S. NO.	PARTICULARS OF TEST	VALUE
1.	Specific gravity	2.62
2.	Fineness modulus	2.94
3.	Zone	II

(d) FLYASH:

Fly ash can be a cost-effective alternative to Portland cement in many markets. Fly ash is recognized as an eco-friendly material because it is a by-product and has low specific energy to measure how much energy is consumed to produce and ship building materials

Table 4: PROPERTIES OF FLYASH

Specific gravity	2.288
Average particle sizes	6.92 µm
Surface area	15 m^2/gm
Moisture	3.14
Bulk desity	0.994 g/cm^2
Color	Whitish grey

(e)Water:
For mixing and curing of concrete potable water is used which can be available in laboratory. Unwanted substances and chemical oxides free containing water must be used.

(f)Metakaolin:

Considered to have twice the reactivity of most other pozzolans, metakaolin is a valuable admixture for concrete/cement applications. Replacing portland cement with 8–20% (by weight) metakaolin produces a concrete mix that exhibits favourable engineeringproperties, including the filler effect,the acceleration of OPC ihydration,and the pozzolanic reaction.

TABLE 6: PROPERTIES OF METAKOALIN

1.	Specific gravity	2.60
2.	Effective sizes D_{10} D_{50} D_{90}	 <2.0 μm <4.5 µm <25 µm
3.	Brightness	79-82
4.	Surface area	15 m^2/gm
5.	Bulk density	0.03 ≅ 0.4 g/cm^2
6.	Color	White

5. TESTS, GRAPHS & RESULTS.

i. **Slump cone test:** The settlement test is carried out using the concrete mix prepared according to the proportions of the mixing design carried out. After the fresh concrete is prepared, it is compacted into a settlement cone using tamping bars and then the settlement test is performed. It was found that the depression was 100 mm, which means that the concrete has a high workability. The drop values are listed below for the different mixing proportions

TABLE 7:OBSERVATIONS FOR SLUMP TEST VALUES

Sl. No.	MIX	SLUMP
1	0%	90
2	5%	100
3	10%	85
4	15%	82

ii. Compressive Strength Test:
The compressive strength of the concrete was casted on 150 x 150 x 150 mm cubes. The average value of the 3 specimens is reported as the strength at that particular age.

TABLE 8: COMPRESSIVE STRENGTH TEST RESULT

S.No.	%OF FLYASH	%OF METAKOALIN	Average compressive strength (N/mm^2)	
	%	(%)	7Days	28Days
1	0%	0%	26.55	43.81
2	30%	5%	28.02	47.61
3	30%	10%	30.08	49.02
4	30%	15%	26.70	46.22

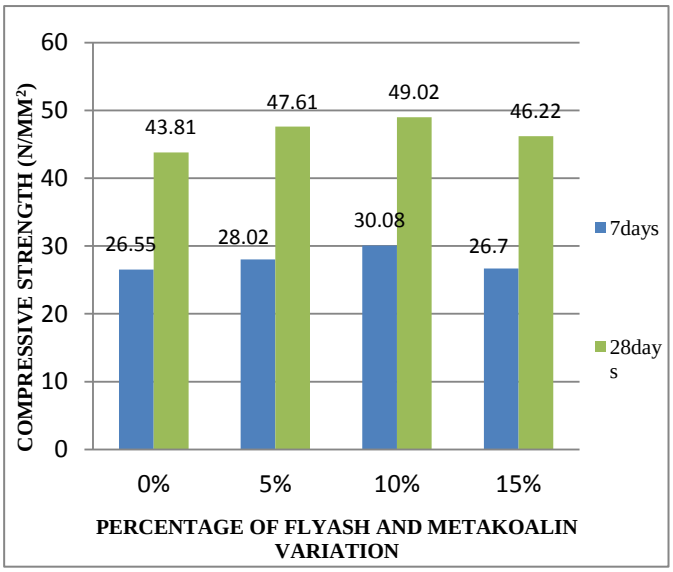

Figure1: Graphical representation of Compressive strength.

iii. Split Tensile Strength:

Standard cylinder specimen of length 300 mm and diameter 150 mm. A total of 24 cylinders were cast for the four mixes. i.e., for each mix 6 cubes were prepared. Testing of the specimens was done at 7 days and 28 days, at the rate of three cylinders for each mix on that particular day. The average value of the 3 specimens is reported as the strength at that particular age.

TABLE 9: SPLIT TENSILE STRENGTH TEST RESULTS

S.No.	%OF FLYASH	%OF METAKOALIN	Average split tensile strength (N/mm^2)	
	(%)	(%)	7Days	28Days
1	0%	0%	2.35	3.13
2	30%	5%	2.61	3.42
3	30%	10%	3.01	4.10
4	30%	15%	2.44	3.32

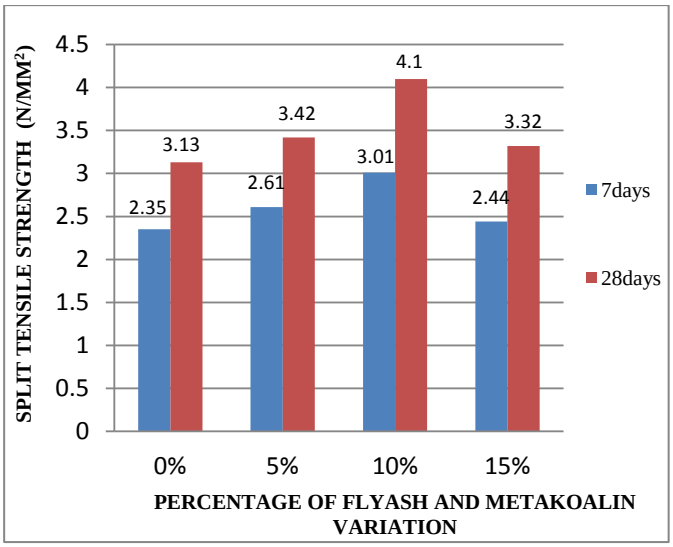

Figure2:Graphical representation of split tensile strength.

iv. Flexural Strength Test:

Standard beam samples of length 500 mm, width 100 mm and depth 100 mm were moulded and analyzed to determine the flexural strength with different percentages of fly ash and metakaolin for 7 days and 28 days respectively. These samples were analyzed and values for each proportion of fly ash and metakaolin were found and an average flexural strength was obtained.

Table 10: FLEXURAL STRENGTH TEST RESULTS

S.No.	%OF FLY ASH	%OF METAKOALIN	Average flexural strength (N/mm^2)	
	(%)	(%)	7Days	28Days
1	0%	0%	3.53	4.02
2	30%	5%	3.90	4.95
3	30%	10%	4.23	5.76
4	30%	15%	3.73	4.63

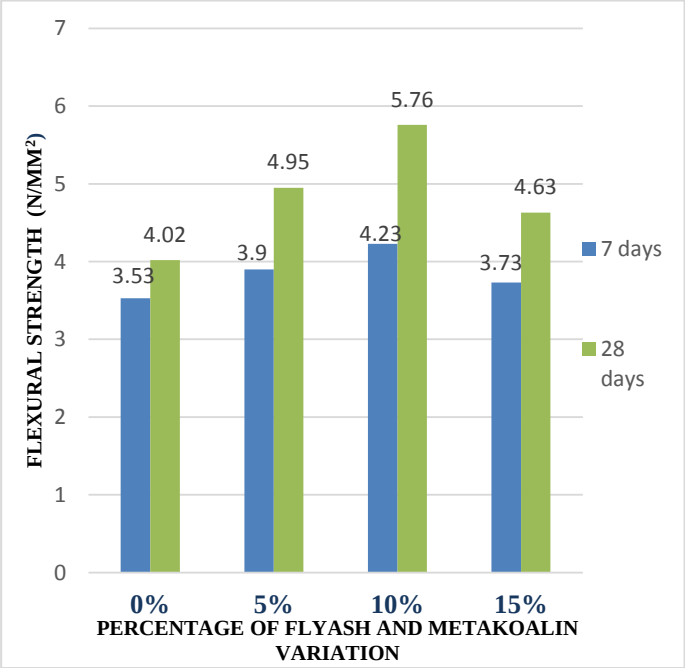

Figure3. Graphical representation of flexural strength.

6. CONCLUSION

All the experimental data shows that the mixing of fly ash and metakaolin in concrete is far better in physical and mechanical properties than the normal concrete. So, it can play a vital role in construction field in coming days.
Based on the investigation conducted following conclusions can be arrived at.

1. Replacement of fly ash and metakaolin with cement increases the workability of concrete.
2. At 30% of fly ash and 10% of metakaolin replaced with cement of 0.45 water cement ratio, yields the better compressive strength results. we know that pozzolanic materials increases the compressive strength of concrete at optimum proportions replaced with cement because of, siliceous material that develops any hydraulic cementitious properties in the presence of lime is added into OPC cement which reacts with free lime and convert in to calcium silicate hydrate which gives strength to concrete.
3. Replacement of 30% fly ash and 10% of metakaolin with cement compressive strength of concrete for, 7 days is 30.08 N/mm^2 and 28 days is 49.02 N/mm^2 which is more than the conventional mixes i.e. increases by, 3.53 N/mm^2 for 7 days and 5.21 N/mm^2 for 28 days than the conventional mixes respectively.
4. Replacement of 30% fly ash and 10% of metakaolin with cement split tensile strength of concrete for, 7 days is 3.01 N/mm^2 and 28 days is 4.10 N/mm^2 which is more than the conventional mixes i.e. increases by, 0.66 N/mm^2 for 7 days and 0.97 N/mm^2 for 28 days than the conventional mixes respectively.
5. Replacement of 30% fly ash and 10% of metakaolin with cement flexural strength of concrete for, 7 days is 4.23 N/mm^2 and 28 days is 5.76 N/mm^2 which is more than the conventional mixes i.e. increases by, 0.7 N/mm^2 for 7 days and 1.74 N/mm^2 for 28 days than the conventional mixes respectively.
6. Better cost economic due to its strength gaining properties which is highly favorable life cost economic.
7. Fly ash and metakaolin particles are finer and glassy which help to better finishing of concrete.

7. SCOPE FOR FUTURE WORK:

In regard to the project "EXPERIMENTAL STUDY ON FLYASH AND METAKAOLIN AS A PARTIAL REPACEMENT OF CEMENT IN CONCRETE",

Following things can be taken in consideration in the future:

- There is a scope to alter the Mix Proportions of concrete which may reduce the stripping time of concrete and faster strength gain.
- Mix designs which can offer much compressive strengths for precast concrete elements can be designed to withstand heavy loading conditions.
- Effective curing methods can be used with the help of different admixtures which could reduce shrinkage and creep and also to maintain good quality control throughout the precast concrete element.
- Similarly, different water cement ratio other than applied in this project can be tested.

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