

## ***Experimental Investigation on Strength of Concrete by Using Metakaolin and Flyash***

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### ***Abstract***

*Concrete is the most commonly used for construction. The need of high Strength concrete is increasing day by day. The test carried out on concrete specimens with 0,6,12,18% replacement of cement by Metakaolin and FlyAsh together. Concrete is very strong in compression but very weak in tension. However it is reported that tensile and bending strength of concrete is 10 to 15% of the compressive strength respectively. The addition of different types of pozzolonic material in concrete have significantly improves its compressive as well as tensile strength. In the present study Metakaolin and FlyAsh are used in the concrete mixes and compressive of the specimens to be tested. A total of (4+4) mixes are to be prepared by varying the percentages of Metakaolin and FlyAsh on M 40 and M20 grade of concrete mix. Certain properties such as workability, later age strength development and few durability characteristics due to the addition of fly ash in concrete improves. Concrete is the high volume of fly ash and metakaolin as a partial replacement of ordinary Portland cement. The conventional concrete M40 and M20 are made with the mixture of metakaolin and fly ash in order to evaluate different properties based on concrete and compare with conventional mix .From the optimization 18% cement replacement by metakaolin and flyash superior than all the mixes.*

**Keywords:** *Metakaolin, Flyash, Compressive Strength & Design Mix*

## **I. INTRODUCTION**

When we talk about Construction considering the modern Infrastructure, Concrete plays a very important role. Concrete is a composite material in which cement is used on a large scale. Due to different circumstances on the construction site such as cost issue, early days strength pozzolonas are preferred in order to enhance the properties of Concrete.

The most important pozzolanic materials are fly ash, silica fume, and metakaolin whose use in cement and concrete is thus likely to be a significant achievement in the development of concrete technology in coming few decades. The benefits of using metakaolin or fly ash separately in concrete as partial replacement for Portland cement are fairly well-established, especially for fly ash. However, because the cost of metakaolin is about 4-5 times the cost of ordinary Portland cement, thus using metakaolin alone as a supplementary cementitious material (SCM) may not be cost effective. On the other hand, the slow reaction rate of fly ash can make its use impractical when rapid early strength development is required. However, use of these materials

in combination – as a ternary blend – has the potential to overcome the higher cost associated with metakaolin concrete and the slower strength development associated with fly ash concrete.

In this modern age, civil engineering constructions have their own structural and durability requirements, every structure has its own intended purpose and hence to meet this purpose, modification in traditional cement concrete has become mandatory. It has been found that different type of pozzolonic materials are added in specific percentage to concrete improves the mechanical properties, durability and serviceability of the structure.

These pozzolonic materials can be used in many large projects involving the construction of industrial floors, pavements, highway-overlays.

## **2. OBJECTIVES AND SCOPE OF THE STUDY**

The main objective of the project is to know the behaviour of the mixture of Metakaolin and Flyash with various proportion as replacement of cement in M20 and M40.

Also the purpose of adding Metakaolin and Flyash together in concrete is to find solution on the slow reaction rate of flyash and early strength of Metakaolin. Also the cost of Metakaolin is high so it can't be use alone hence Flyash is added to it in order to save the money.

### 3. EXPERIMENTAL WORK

#### 3.1 Material used

The materials used for preparing a concrete mix were described below:-

##### 3.1.1 Cement & Water

Ordinary Portland cement of grade 43 is used to prepare the mix design of M-20 and M40 grade. The cement used was fresh and without any lumps Water – cement ratio is 0.45 for this mix design using IS 456:2007.

##### 3.1.2 Fine Aggregate

Aggregate of maximum Size 4.75 mm are used as a fine aggregate the Experimental program was locally procured And

conformed to grading zone 3 as per IS: 383-1970.

##### 3.1.3 Coarse Aggregate

The coarse aggregates are locally available was used having maximum size of 20 mm.

##### 3.1.4 FlyAsh

Fly ash is the ash removed from the exhaust gas of burning coal at power plants to generate electricity. The ash is removed from the exhaust by air pollution control equipment such as electrostatic precipitators before the exhaust is emitted through stacks or chimneys into the atmosphere

##### 3.1.5 Metakaolin

The Metakaolin is obtained From the 20 MICRONS LIMITED Company at Balanagar in Hyderabad. The specific gravity of Metakaolin is 2.4. The metakaolin is in conformity with the general requirement of Pozzolona.

**Table 1: Physical properties of ordinary Portland cement**

S.NO.	PROPERTY	VALUE
1	Fineness of cement	4.52 %
2	Specific gravity	3.05
3	Normal consistency	33 %

4	Setting time	40 Mins
	<ul style="list-style-type: none"> <li>i. Initial</li> <li>ii. Final</li> </ul>	6 Hours
5	Compressive strength at	44.8N/mm <sup>2</sup>
	<ul style="list-style-type: none"> <li>i. 7 days</li> <li>ii. 28 days</li> </ul>	59 N/mm <sup>2</sup>

**Table 2: Physical properties of Fine Aggregate**

S.NO.	PROPERTY	VALUE
1	Specific Gravity	2.60
2	Fineness Modulus	3.77
3	Bulk Density	
	Loose	14.67 KN/m <sup>3</sup>
	Compacted	16.04 KN/m <sup>3</sup>
4	Grading	Zone II

**Table 3: Physical properties of Coarse Aggregate**

S.NO.	PROPERTY	VALUE
1	Specific Gravity	2.65
2	Bulk Density	
	<ul style="list-style-type: none"> <li>i. Loose</li> <li>ii. Compacted</li> </ul>	13.29 N/mm <sup>2</sup> 15.00 N/mm <sup>2</sup>
3	Water Absorption	0.7%
4	Flakiness Index	10.22 %

5	Elongation Index	11.54 %
6	Crushing Value	21.43 %
7	Impact Value	15.50 %

**Table 4: Physical properties of Flyash**

S.NO	CONSTITUENTS	PERCENTAGE (%)
1	Silica, SiO <sub>2</sub>	60.9
2	Alumina, Al <sub>2</sub> O <sub>3</sub>	31.01
3	Iron Oxide, Fe <sub>2</sub> O <sub>3</sub>	3.99
4	Lime, CaO	0.7
5	Magnesia, MgO	1.50
6	Sulphur Trioxide, SO <sub>3</sub>	0.85
7	Loss on ignition	0.2
8	Surface Area m <sup>2</sup> /kg	236
9	Drying Shrinkage	0.012
10	Bulk Density	1.25

**Table 5: Physical properties of Metakaolin**

S.NO.	PROPERTY	VALUE
1	Specific Gravity	2.54
2	Accelerated pozzolanic active index, % of control	89
3	Residue on 45 micron sieve, %	1.31
	Chemical analysis	
4	Loss on Ignition	0.70

5	Silica (SiO <sub>2</sub> )	52.24
6	Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> )	0.60
7	Aluminum (Al <sub>2</sub> O <sub>3</sub> )	43.18
8	Calcium Oxide (CaO)	1.03
9	Magnesium Oxide (MgO)	0.61

### 3.2 Design Mix

The concrete mix design was proposed according to Indian standard code 10262-2009 for control concrete. The grade was M-20 & M40 and water - cement ratio is 0.45 which is constant for all mix design. Natural coarse and fine aggregate were used. The replacement proportions of cement were kept as- 3% MK + 3% FA, 6%MK + 6% FA & 9% MK & 9% FA.

## 4. TEST PERFORMED

### 4.1 Compression test

The test is carried out on the cube specimen 150mm X 150mm X 150mm. Cast iron moulds are used to cast the cubes having leak proof metal base plate. For the compression test, the cubes were placed in machine in such a way that the load was applied on the faces perpendicular to the direction of cast. The top surface of machine is fixed and load is applied on the bottom surface of specimen. The rate of loading was gradual

and Failure (crushing) load was noted and the failure pattern was also precisely observed. The compressive strength of cube can be calculated by using following formula-

$$SC = P/A$$

Where,

SC = Compressive strength of cube in MPa.

P = Load at failure in N.

A = Loaded area of cube in mm<sup>2</sup>

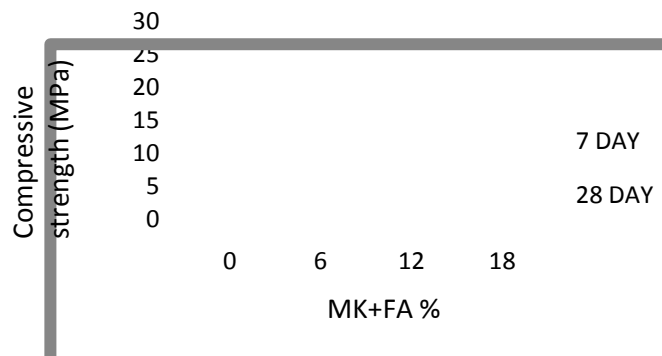
## 5. RESULTS

### 5.1 Compression test

Compressive strength was measured at 7 and 28 day of testing. The test results are shown in table 6

**Table 6: Compressive strength values for M20**

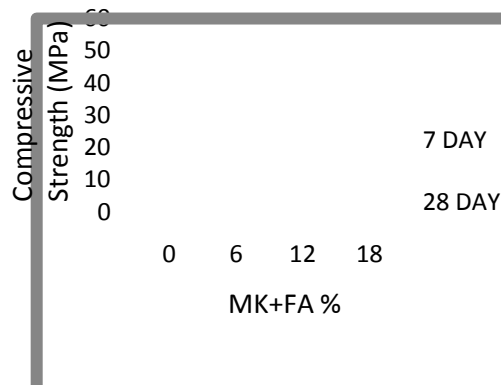
SR.NO.	MK+FA+ CEMENT %	COMPRESSIVE STRENGTH ( MPa)	
		7 DAYS	28 DAYS
1.	0+0+100	13.46	26.35
2.	3+3+94	14.06	27.03
3.	6+6+88	14.52	27.74
4.	9+9+82	14.84	28.41



**Fig.1 Compressive strength of M20**

**Table 7: Compressive strength values for M40**

SR.NO.	MK+FA+ CEMENT %	COMPRESSIVE STRENGTH ( MPa)	
		7 DAYS	28 DAYS
1.	0+0+100	26.85	49
2.	3+3+94	28.1	49.30
3.	6+6+88	28.765	51.16
4.	9+9+82	29.58	53.09



**Fig.2 Compressive Strength for M40**

## CONCLUSION

- 1) Ternary blending by Metakaolin in combination with Fly Ash was found leading to further technical improvements to concrete strength. Especially, blended concrete mixtures with Metakaolin / Fly Ash -ratio to 50/50 by weight revealed higher efficiency for improving strength at older ages.
- 2) The 28-days compressive strength of concrete was improved by partial replacements of OPC by metakaolin in the range up to 9% by weight. The highest 28-days strength improvement of concrete can be expected at partial replacements in the 10-15% range.
- 3) Metakaolin is an effective pozzolona and results in enhanced early strength and ultimate strength of concrete.
- 4) The compressive strength of young concrete, i.e., 7 days is improved by blending the OPC with 9% of metakaolin by weight.
- 5) The 9% replacement with metakaolin is the most optimum replacement, enhancing the concrete's compressive strength at all ages.
- 6) Addition of flyash results in economy of the mix because of low cost of fly ash.

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