METAKAOLIN BASED GEOPOLYMER CONCRETE

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Abstract **- Day by day the emission of CO_2 gas is increased in this world. In the case of production and consumption of cement, 7% greenhouse gas is being emitted into atmosphere per year. To reduce that emission, one of the alternative choice is using Geo Polymer Concrete (GPC).This paper presents the report on the use of Metakaolin based Geo Polymer Concrete containing with Alkaline Activators. The Metakaolin was replaced by Fly Ash as a percentage of 10%, 20% and 30%. The specimens were casted and the compressive and split tensile test was carried out for 7 and 28 days. From the result, the 30% replacement of Metakaolin gave greater compressive and split tensile strength.**

Keywords: Flyash (FA), Metakaolin (MK), Alkaline Activators

1.INTRODUCTION

Concrete is a widely used as construction material for various types of structures due to its durability. For a long time it was considered to be very durable material requiring a little or no maintenance. So the use of concrete is unavoidable. At the same time the scarcity of aggregates and the pollution contributed by the production of cement by the emission of greenhouse gases such as CO_2 has become a major issue during past decade.

For the past many years, by products such as fly ash, silica fume, ferrous and non-ferrous slag were considered as waste materials from so many industries. They have been successfully used in the construction industry for partial or full replacement for fine and coarse aggregates.

It is suggested that consumption of cement and aggregates could be reduced by the following ways

- ✓ Through economical mix design
- ✓ By replacing cement by using other supplementary cementitious materials
- ✓ By utilizing the waste materials from industries for partial or full replacement for fine and coarse aggregates
- ✓ By using alternate binding materials for concrete.

II. MATERIALS USED

A. Fly ash

Low-calcium (ASTM Class F) fly ash-based Geopolymer is used asthe binder, instead of Portland or other hydraulic cement paste, to produce concrete. The fly ash based Geopolymer paste binds the loose coarse aggregates,fine aggregates and other un-reacted materials together to form the Geopolymer concrete, with or without the presence of admixtures. This fly ash has siliceous or siliceous and aluminous material, which itself possesses little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperature to form cementitious compounds. Progress of the pozzolanic reaction of class F fly ash is slow.

B. Metakaolin

Metakaolin is a pozzolanic material which is manufactured from selected kaolin, after refinement and calcinations under specific conditions. It is a highly efficient pozzolana and reacts rapidly with the excess calcium hydroxide resulting from OPC hydration, via a pozzolanic reaction, to produce calcium silicate hydrates and calcium aluminosilicatehydrates.

Fig.1 Metakaolin

Oxides	%flyash	Metakaolin %
Silica	52.8	55.9
Alumina	22.3	37.2
Lime	Trace	0.11
Iron	9.2	1.7
Sulphur	0.7	0.18
Magnesia	0.5	0.24
Alkaline	0.2	0.27
Loss on ignition	3.7	0.8

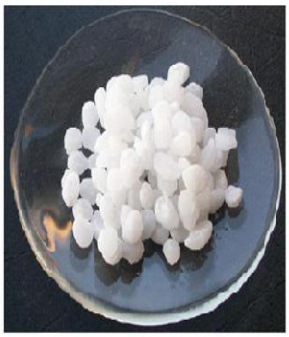



Fig.2 Alkaline Activators

Compound	Percentage of mass
Na_2O	14.7
SiO_2	29.4
H_2O	55.9

Table I Chemical composition of FlyAsh

C. Alkaline Liquid

A combination of sodium silicate solution and sodium hydroxide solution was chosen as the alkaline liquid. Sodium based solutions were chosen because they were cheaper than Potassium-based solutions. The sodium hydroxide solids were either a technical grade flakes form (3 mm) or a commercial grade in pellets form with 97% purity. The sodium hydroxide (NaOH) solution was prepared by dissolving either the flakes or the pellets in water

E. Coarse Aggregate

The material whose particles are of size as are retained on retained on I.S. sieve no. 4.75 mm is termed as coarse aggregate. The size of coarse aggregate depends upon the nature of the work. The coarse aggregate used in this experimental investigation is 20mm size, crushed and angular in shape.

F. Water

Water is used in the mix was tap water that was free from all types of harmful chemicals, Organic material, Oil, chloride, silt and suspension, confirming to IS 456-2000.

G. Super Plasticizer

Also super plasticizers enable savings in cement for given strength. The super plasticizer of brand name CONPLAST-SP430 was used in this work. It is based on sulphated naphthalene formaldehyde condensate and conforming to IS: 9103-1999 and ASTM C- 494.

III. EXPERIMENTAL INVESTIGATIONS

A.MIX PROPORTION

The basic mixture proportions used for the majority of the trial mixtures was based upon previous research on

D. Fine Aggregate

The size of the fine aggregate is below 4.75mm, natural sand used as the fine aggregate in concrete mix. Sand may be obtained from rivers, lakes but when used in concrete mix, it should be properly washed and tested to ascertain that total percentage of clay silt, silt and other organic matters does not exceed the specified limit.

the geo polymer mixture proportions and is detailed in Table. These mixture proportions are characterized by an alkaline liquid toto total mass proportion of approximately 75% with the nominal fly ash by mass of 0.35 and aggregate strengths, as shown in table, and elevated temperature curing in a steam room at 60^0C for 24 hours.

Materials	Quantity of materials / m^3 of concrete
Fly ash	404 kg/m^3
Coarse aggregate	641 kg/m^3
Fine aggregate	549 kg/m^3
Sodium silicate solution	41 l/m^3
Sodium hydroxide solution	102 l/m^3
Superplastizicer	6 l/m^3
Water	25.5 l/m^3

***B.*TESTING OF SPECIMEN**

The study the workability of fresh concrete and slump test is used.This experimental program was carried out using 30 cube and 24 cylindrical specimens were investigated. Generally the fine aggregate,coarse aggregate and fly ash areweighed to the required quantities and then they are mixed indry condition for 2-3 minutesand then the alkaline solutionsprepared(combination of sodium hydroxide and sodiumsilicate) are to be taken to required quantity in addition to thesuper plasticizer and this solution is added to the dry mix.Thismixing is done for 5-7 minutes in the mixer for properbonding of all the materials.

IV.RESULTS AND DISCUSSION

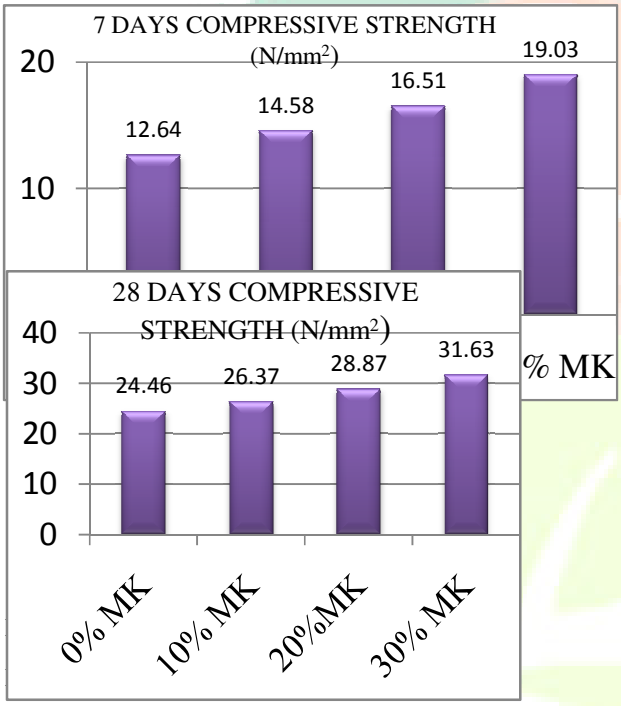
A.Compressive Strength Test

The compressive strength of hardened Fly ash-based Geopolymer concrete was performed on a 1000KN capacity compression testing machine as per IS 516. The cube specimens of size 150mm x 150mm x150mm were tested for cube compression testing at 7 days and 28days. Geopolymer cubes of 12M and 10M were cast. The specimens were wrapped by plastic sheet to prevent loss of moisture and placed in an oven.

MIX PROPORTION	COMPRESSIVE STRENGTH (N/mm^2)	
	At 7 days	At 28 days
100% Flyash	12.64	24.46
GPC (90% FA + 10 % MK)	14.58	26.37
GPC (80% FA + 20 % MK)	16.51	28.87
GPC (70% FA + 30 % MK)	19.03	31.63

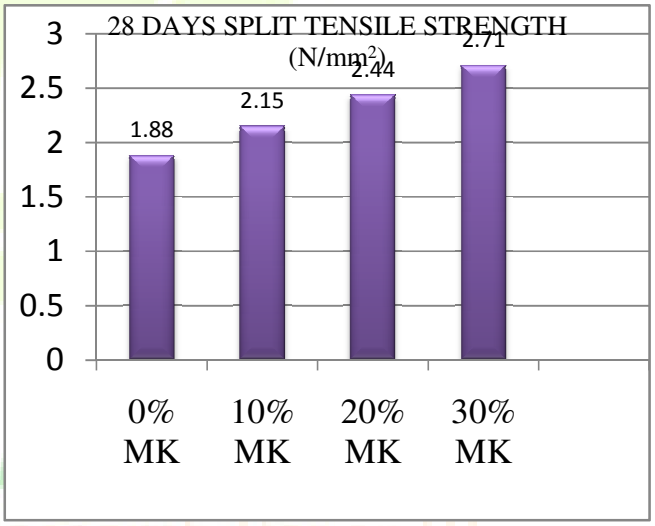
Table 2: Compressive Strength of GPC

Fig.1 Compressive Strength at 7 days



Split tensile test was carried out as per ASTM C496-90. Concrete cylinders of size 100 mm diameter and 150 mm height were cast. The test is performed on a 1000KN capacity compression testing machine. The Geopolymer specimens were wrapped by plastic sheet to prevent the loss of moisture and placed for curing 60^0C.The average split tensile strength values were recorded.

MIX PROPORTION	SPLIT TENSILE STRENGTH (N/mm^2)	
	At 7^{th} days	At 28^{th} days
100% Fly Ash	1.63	1.88
GPC (90% FA + 10 % MK)	1.98	2.15
GPC (80% FA + 20 % MK)	2.23	2.44
GPC (70% FA + 30 % MK)	2.46	2.71



V. CONCLUSION

The following conclusions are derived on the use of Fly Ash and Metakaolin combination in concrete making.

- From the above study we conclude that the compressive strength of the concrete cubes has gradually increased up to addition of 10% of Metakaolin.
- Mix with 70% of Fly Ash and 30% of Metakaolin seems to have better compressive strength than other mixes. This may be due to increase in

alkaline reaction between Fly Ash particles and calcium in Metakaolin.

- Whereas comparing to control mix concrete, compressive strength of 30% has been increased.
- The gain compressive strength is improved depending upon the replacement of Fly Ash by Metakaolin.

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