International Journal of Research
Available at https://journals.pen2print.org/index.php/ijr/
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 07
March 2018

A STUDY ON MECHANICAL PROPERTIES OF FLY ASH BASED GEOPOLYMER CONCRETE FOR DIFFERENT MIX PROPORTIONS

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ABSTRACT*:*Present days in research field the geopolymer is getting more prominent than cement. In the research area from past 30 years the geopolymer is getting major role then cement. Some researcher and their studies conformed that the geopolymer is getting good engineering properties like mechanical properties and durability properties compared to conventional concrete. Geopolymer is getting good mechanical properties like compressive strength, flexural strength, split tensile strength and modulus of elasticity. In present study the study includes total aggregate content, proportion of fine aggregate to total aggregate content, proportion of alkali to fly ash, proportion of sodium silicate to sodium hydroxide, making of sodium hydroxide solution, molarity of sodium hydroxide, curing at different curing conditions like oven temperature curing, air curing, curing period like 7 days and 28 days. Engineering properties like compressive strength, flexural strength, split tensile strength and modulus of elasticity of geopolymer and OPC concrete were found. The 7 days compressive strength at 12M of NaOH at 90^0c temperature curing is getting maximum strength; at 28 days, the 12M of NaOH at 90^0c temperature curing is getting maximum strength.

*Keywords***:** **geopolymer concrete, fly ash, alkali solution, molarity elevated temperatures**

Abbreviations: TA (total aggregate), FA (fine aggregate)

I. INTRODUCTION

1.1 GENERAL

The overall utilization of concrete is accepted to rise exponentially mainly used in the infrastructural construction mainly in China and India. Production of Cement increased throughout the years in developing and developed countries. World Statistics shows that nearly more than 4 billion tons of cement production capacity, India was the second-biggest cement producer on the planet in the year 2017.It is an important binder in concrete and now it is important to find the new binder in replacement of cement,Davidovits of France initially said about the alternative material for cement is Geopolymer concrete and recommended that an alkaline liquid that could be utilized to respond with the silica (Si) and the Alumina (Al) in the main material of ecological origin point or in by-product materials, for example, rice husk ash, fly ash and Ggbs to create binders.When concrete is exposed to elevated temperatures just like fire accident, thermal power plant, nuclear power plant, chimneys, etc., how the concrete is reacting to the elevated temperature and understanding the behavior of concrete structure is very important. As we know the behavior of conventional concrete at different elevated temperatures but no idea of behavior of geopolymer concrete at different elevated temperature.

2.1 LITERATURE REVIEW

RM Andrew (2018) [1]

He organizes official information and outflow factors, including assessments submitted to the UNFCCC in addition to new gauges for China and India, to show another examination of the worldwide procedure from concrete generation. We demonstrate that worldwide procedure discharges in 2016 were 1.45 ± 0.20 gigatonnes CO2, equal to around 4 % of outflows from non-renewable energy sources. Total discharges from 1930 to 2016 were 39.3 ± 2.4 gigatons CO2, 66 % of which have happened since 1990.China is the biggest maker of concrete, representing near 60% of worldwide generation, trailed by India at 7%.

Kong et al (2008) [2]

The geopolymers showed strength increments by about 53% after elevated temperature exposure. In any case, a geopolymer/aggregate composite with indistinguishable geopolymer decreases in strength by up to 65% after a similar exposure. Test information from dilatometer readings of geopolymers and aggregates gives clarification to this conduct. The tests results demonstrate that the aggregate consistently increases with temperature, up to about 1.5–2.5% development at 800°C. Correspondingly, the geopolymer matrix experiences undergo contraction of about 1% somewhere in the range of 200°C and 300°Cand a further 0.6% between 700°Cand 800°C. This examination exhibits the consequences of 15 distinctive geopolymer mixes (for specimens, mixture proportions, curing, and period) and 4 distinct aggregates.

3.1 EXPERIMENTAL PROGRAMME

The geopolymer is a mixture of fly ash, fine aggregate, coarse aggregate, alkaline activators, and super plasticizers.

The mechanical properties of geopolymer concrete are mainly compressive strength, split tensile strength and flexural strength.

The size of the cube which is used for the compressive strength is 0.15mX 0.15mX0.15m. The size of cylinder is 0.3m X 0.15mwhich is used to find the split tensile strength, and the size of beam is 0.5m X 0.1m X 0.1 is used to determine the flexural strength.

3.1.1 MIX DESIGN

Specific gravity of fly ash

: 2.42

Specific gravity sodium hydroxide NaOH

: 1.47

Specific gravity of sodium silicate Na2Sio3

: 1.39

Specific gravity of Conplast sp 430

: 1.18

Unit weight of geopolymer concrete

: 2400kg/m3

Total aggregate content

: 70% = 0.72

: 0.7 x 2400 =1680 kg/m3

Ratio of fine aggregate to total aggregate

: 30%

Coarse aggregate: 70% and fine aggregate

: 30% of total aggregate

70% of coarse aggregate

: 0.7 x 1680 = 1176 kg/m3

30% of fine aggregate

: 0.3 x 1680 = 504 kg/m3

Alkaline to fly ash ratio

: 0.6

Mass of fly ash and liquid

: 2400-1680 = 720 kg/m3

Mass of fly ash

: 720/ (1+0.6) = 450 kg/m3

Mass of alkaline liquid

: 720-450 = 270 kg/m3

sodium hydroxide / sodium silicate

: 3

Mass of NaOH

: 270/ (1+3) = 67.5 kg/m3

Mass of sodium silicate

: 270-67.5 = 202.7 kg/m3

For molarity

NaOH

% of NaOH flakes

12M

36.9

For 12 M NaOH

: 36.09 % x 67.5 = 24.36 kg/m3

Weight of water in sodium hydroxide
: 67.5 - 24.36 = 40.14 kg/m3

Weight of water in sodium silicate solution
: 202.7 x 0.5= 101.35 Kg/m3

Weight of Sodium silicate solid
: 202.7-101.35= 101.35Kg/m3

Ratio of Weight of water to weight of total geopolymer solid : (40.14+101.35) / (24.36+101.35+450) = 0.24

4. RESULTS & DISCUSSION

4.1.1 Compaction factor test:

It could be seen from Fig. 4.1 that the compacting factor increases almost linearly with the ratio of TA to FA up to 0.30 and then decreases with increases with ratio of TA to FA. Further, as expected, the compacting factor is higher for a higher alkali to fly ash ratio.

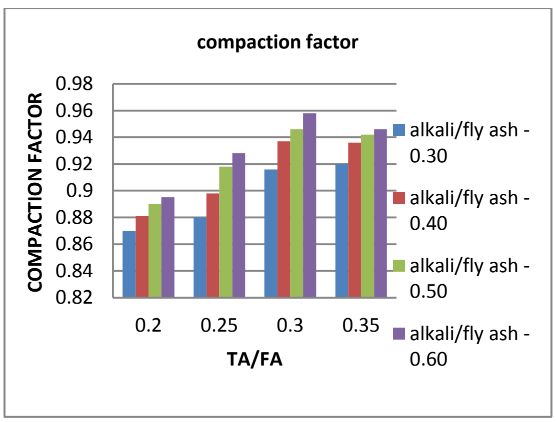

Fig : 4.1 compaction factor test of different alkali /fly ash content

From the past studies, the alkali/fly ash ranges from 0.3 to 0.7 and Na2SiO3/NaOH ranges from 0.2 to 3. It was seen from the past studies, the proportion of Na2SiO3/NaOH as 3 and alkali to fly ash as 0.6, and curing temperature of 100°C yields great strength properties in geopolymer concrete. Consequently, to begin with, by keeping the above qualities consistent in the A1 group of the mix. The aggregate substance differed from 60% to 75% of the volume of concrete. The proportion of the mass of fine aggregate to add up to aggregate has fluctuated from 0.2 to 0.4 for every vale of the aggregate substance.

4.1.2 COMPRESSIVE STRENGTH:

It tends to be seen from Fig4.4 that, not at all like (OPC FA/TA-0.30) concrete the rate of strength improvement of geopolymer concrete past seventh day is minimum. The consistent parameters considered in these figures have been chosen dependent on a mixture design. It could be seen from Fig. 4.4 that, up to the value of 70% the compressive strength of geopolymer concrete increases with increment in total aggregate substance and afterward it start decreasing.While Fig. 4.4 demonstrates the impact of aggregate substance on compressive strength, Fig 4.4 demonstrates the variety of the proportion of total aggregate on28 days compressive strength of geopolymer concrete. For all the values of fine aggregate to total aggregate proportion and the values are consider (0.20-0.40). From Fig. 4.4 for an incentive up to 0.30 it could be seen that the compressive strength of geopolymer concrete increases with an increase in the proportion of fine aggregate to total aggregate and after that it start decreasing. This wonder is valid for every one of the values of the aggregate substance in the mixture considered (60%– 75% by volume).The compressive strength of geopolymer concrete is increasing with increasing of total aggregate content up to 70% and then decreasing. The compressive strength at 75% of total aggregate is less compared to 7% of total aggregate. Keeping the Fine aggregate to total aggregate is constant because the compressive strength is more at that ratio compared to other ratios. At G3 the 7 days compressive strength is more compared to all other ratios. At G3 max compressive strength at 7 days is 41.02 MPa and at 28 days the compressive strength is 49.25MPa. The percentage of compressive strength increases for seven days and 28 days for G3 mix is 20%.But the percentage increases is more for G2 mix compared to G3 mix.

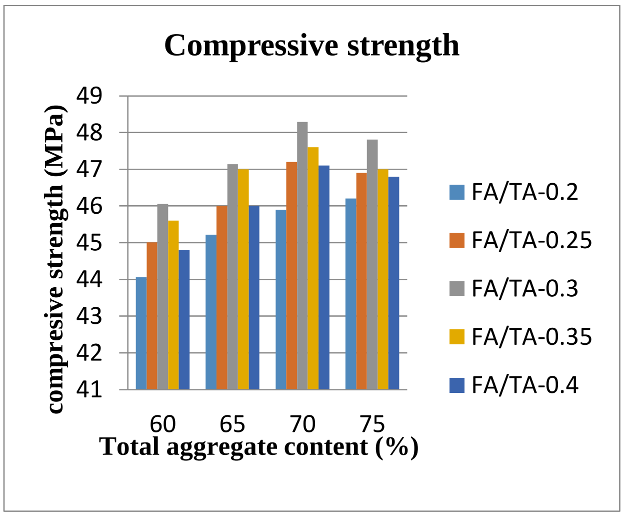

Fig: 4.2 Variation of 7 days compressive strength with the total aggregate content

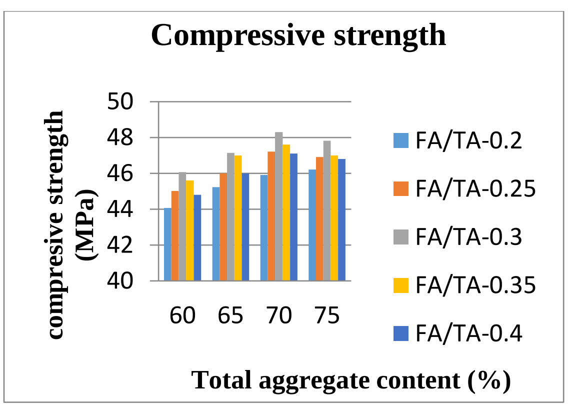

Fig: 4.3 Variation of 28days compressive strength with the total aggregate content

Curing temperature: 90 ºC; Curing period
: 24 h;
Ratio of alkali to fly ash
: 0.6;
Ratio of Na2SiO3 to NaOH
: 3;
Ratio of fine aggregate to total aggregate(R0.30)
: 0.3

G1 = Mix A1 Total Aggregate (60% volume)

G2 = Mix A1 Total Aggregate (65% volume)

G3 = Mix A1 Total Aggregate (70% volume)

G4 = Mix A1 Total Aggregate (75% volume)

OPC1 =Mix A1 Total Aggregate (70% volume)

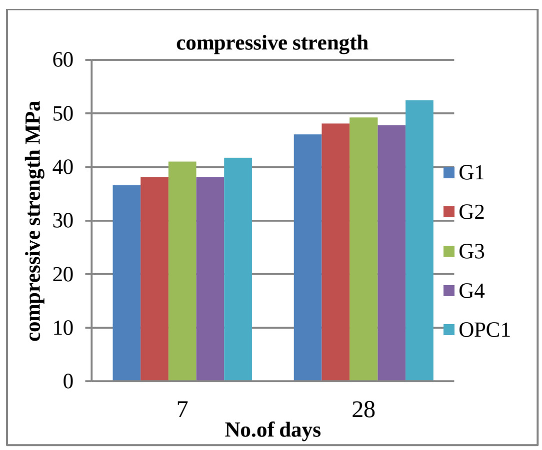

Fig -4.4 Compressive strength at 7 and 28 days

4.1.3 SPLIT TENSILE STRENGTH RESULTS

The peak split-tensile strength of GPC mixed with G3 was compared to the other mixes (G1, G2, and

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 07
March 2018

G4). The split tensile strength is 2.48 MPa in the 7 days for G3 and 3.46 MPa for 28 days. In comparison with OPC1, geopolymer concrete has less split tensile strength. The tensile division force for OPC1 concrete is 2.08 MPa for 7 days and 3.80 MPa for divides for 28 days. At seven days, GPC has split tensile strength than normal cement concrete. At a maximum strength of 28 days, OPC1 is achieved in comparison with geopolymer intensity as shown in the fig 4.5.

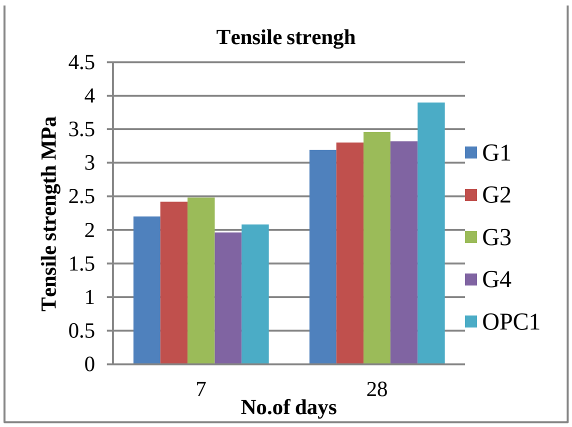

Fig -4.5 Split tensile strength at 7 and 28 days

4.1.4 FLEXURAL STRENGTH

Geopolymer concrete with G3 mix got the maximum split tensile strength compared to remaining mix (G1, G2, & G4). At 7days for G3 mix, the flexural strength is 3.45 MPa & for 28 days maximum flexural strength is 4.38 MPa. Compared to OPC1 the flexural strength is less for geopolymer concrete. For the OPC1 concrete at 7 days, flexural strength is 3.21 MPa and at 28 days, the split tensile strength is 4.92 MPa.

The percentage increase for G3 mix at 7 days to 28 days is 27% and for OPC is 53% but flexural strength increases at G3 is more compared to all other mixes (G1, G2, and G4).

(i) At 7days the geopolymer cement becomes stronger than normal cement in Portland.

(ii) At 28days OPC1 concrete is getting maximum strength compared to geopolymer strength.

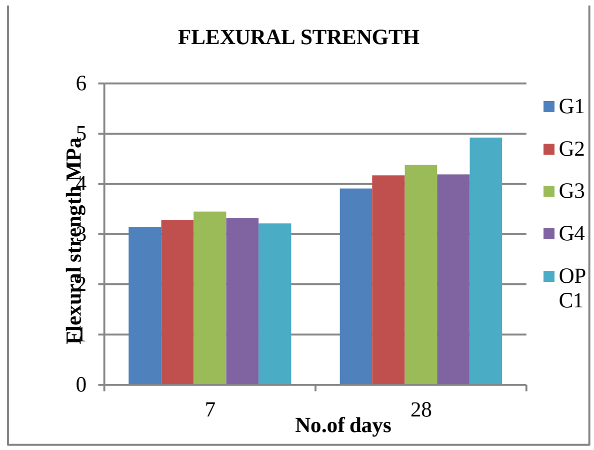

Fig -4.6 Flexural strength at 7 and 28 days

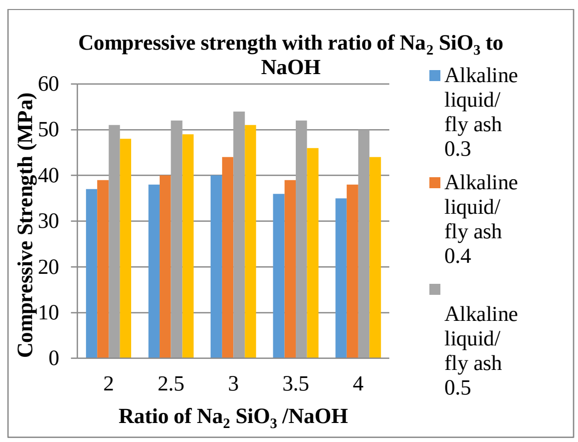

Fig 4.7: 7th day cube compressive strength with ratio of sodium silicate to sodium hydroxide

5. CONCLUSIONS

- Based on the present investigation the compaction factor value is maximum at the water to geopolymer ratio at 0.3 and alkaline to fly ash ratio at 0.6.

- Based on the present examination, it is seen that a geopolymer concrete with the total aggregate substance of 70% by volume, the proportion of fine aggregate to a total aggregate of 0.30, NaOH molarity12, Na2SiO3/NaOH proportion of 3 and soluble base to fly ash proportion of 0.6 gives most extreme compressive strength. At different percentages of the total aggregate substance by volume, we got the maximum strength at 70%of total aggregate content.

- The curing temperature of 90 °C yields the extreme compressive strength for the geopolymer concrete with the total aggregate substance of 70% by volume, the proportion of fine aggregate to a total aggregate of 0.30, NaOH molarity12, Na2SiO3/NaOH proportion of 3 and soluble base to fly ash proportion of 0.6.

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- The curing temperature of 90 °C yields the extreme split tensile strength and flexural strength for the geopolymer concrete with the total aggregate substance of 70% by volume, the proportion of fine aggregate to a total aggregate of 0.30, NaOH molarity12, Na2SiO3/NaOH proportion of 3 and soluble base to fly ash proportion of 0.6.

- Early strength advancement in geopolymer concrete could be accomplished by the best possible choice of curing temperature and the time of curing. With 24 hours of curing at 90°C, 80% of the 28th-day cube compressive strength could be able to get in 7 days in the present investigation.

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- Early strength advancement in geopolymer concrete could be accomplished by the best possible choice of curing temperature and the time of curing. With 24 hours of curing at 90°C, 57% of the 28th-day cube flexural strength could be accomplished in 7 days in the present investigation.

- Thetotal aggregate substance of 70% by volume and the ratio of fine aggregate to total aggregate content at 0.3 got maximum passion ratio compared to all other ratios, and same passion ratio as opc concrete.

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