Compressive Strength and Ultrasonic Pulse Velocity Tests on Fly Ash Based Geopolymer Concrete with Robo Sand

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Abstract

The use of construction is increasing day to day as the growth rate of population is increasing. Geo polymer concrete is eco-friendly. This paper presents the experimental investigation on geo polymer concrete using Destructive and NDT tests like Compressive Strength and Ultrasonic Pulse Velocity test (UPV). These tests are conducted on the cube specimens of dimensions 150mmX150mmX150mm at differet age's i.e. 7 and 28 days. Proportions considered for geo polymer concrete metakaiolin- fly ash is taken in proportions of (100-0%, 80-20%, 60-40% and 50-50%). Alkaline activators such as sodium silicate and sodium hydroxide with molarity 12M are used in preparing geo-polymer concrete. The main objective of this investigation is to check the quality of Fly ash based geo polymer concrete with robo sand and its respective compressive strength.

Keywords—Fly ash, robo sand, metakaiolin, compressive strength, ultrasonic pulse velocity.

I. INTRODUCTION

In present conditions the usage of the natural resources are very high and alsoconstruction is increasing day by day with high advanced technology. Hence, the requirement of the cement is also increasing. The preparation process of conventional concrete releases carbon dioxide content environment. A study shows that the production of Co_2 content contributes to 7% of the global carbon dioxide emissions. Geopolymer concrete is an eco-friendly material &it is used in construction process. A special concrete was proposed by the Davidovits named as "Geopolymer". The strength of the concrete is increases by the addition of metakaiolin and it depends upon the colour and quality parameters of the metakaiolin. In this project work robo sand is used as a replacement of the river sand. Alkaline activators such as sodium hydroxide and sodium silicates are used and which are plays crucial role in geopolymer concrete.

The measurement of strength of concrete through UPV was initiated in the USA in the mid-1940s and later adopted everywhere as NDT on concrete. Ultrasonic Pulse Velocity (UPV) is one of the non-destructive methods used for testing of the quality of concrete, homogeneity and compressive strength by the regression equation. UPV methods basically consist of transmitting the mechanically generated pulses (in the frequency ranges of 20-150/s) through concrete with the help of electro-acoustic transducers for measuring the velocity of the longitudinal waves generated by the applied pulse. UPV is correlated to much desirable information pertaining to concrete, such as: Elastic modulus, strength, and uniformity of concrete Layer thickness, cracking, honeycombing and deterioration of concrete.

The compressive strength of the concrete may vary from 17Mpa for residential concrete to 28Mpaand in commercial structures it exceeds up to 70Mpa. The compressive strength of the concrete depends on the w/c ratio, cement strength, quality of concrete, etc. Compressive strength is calculated from failure load divided by the cross-sectional area resisting the load and it is expressed in Mpa or psi. The guide lines given by ASTM C 31and C 39 provides procedure for field-cured specimens and cylindrical concrete specimens. The results of the test should not differ more than 13% of the average of the two results. Strength test results from cast cylinders used for quality control, acceptance of concrete and foe evaluating the concrete strength in a structure.

II. MATERIALS

A. FLY ASH:

Fly ash is produced at thermal power stations by burning coal and lignite. It consists of fine particles collected from boilers with flue gases. The particle size of fly ash is ranges in diameter from 1to 150 microns. Fly ash used in this project work is taken from the thermal power plant at Kondapalli, Krishna district, Andhra Pradesh, India. Properties of Fly ash were presented in Table 1.

B. ROBO SAND**:**
Robo sand is a waste product obtained by the crushing stone, gravel and slag in crushes. The fineness modulus of Robo sand is 3.62 and is conforming to Zone III as per IS: 383-1970. Robo sand which is used for construction should be passed through the less than 4.75 mm sieves. It is also called M-sand or artificial sand.

C. COARSE AGGREGATE**:**
Coarse aggregate is obtained from quarry site. The aggregates of 20mm and 10 mm are used in this experiment conforming to Zone III as per 102622009. In this experiment, we are using 60% of 20mm and 40% of 10mm aggregates.

D. METAKAIOLIN:
The dehydroxylated form of clay mineral kaolinite is called metakaolin. The particle size of metakaiolin is smaller than cement particles. It gives high strength to the concrete the disordered kaolinite and ordered kaolinites are converted into dehydroxylated at temperatures of 530-5700C, 570-6300C. A light Pinkish metakaolin is used in the present study. The specific gravity of metakaolin is 2.45.

E. ALKALINE ACTIVATORS:
Sodium hydroxide and sodium silicate are the chemicals used in the preparation of geopolymer concrete. Alkaline liquid plays an important role in the polymerization process.
Sodium hydroxide: Generally, sodium hydroxide (NaOH) is available in flakes and pellets. Sodium hydroxide flakes are used in this experiment.
Sodium silicate: Sodium silicate is also named as water glass or liquid glass. Generally, these are available in the liquid state (gel form).

- ***Methodoloy***

Solution preparation: Sodium Hydroxide (NaOH) solution is prepared 24- 48 hours prior to the use in concrete. As it is in the form of flakes, it is dissolved in water to prepare sodium hydroxide solution. In this experiment 12M (12 Molarity) is considered. So, for preparing a 12M solution 480 grams of sodium hydroxide flakes are to be dissolved in water to make one litre of sodium hydroxide solution. When sodium hydroxide and sodium silicate solutions are mixed, heat is liberated. So, they must be mixed separately.

Molarity=moles of solute/litre of solution

12M=12 molarity

=2 x molecular weight

=12 x40

=480 gm.

i. TEST PROCEDURE

a) MIXING AND CASTING:

Geopolymer concrete is similar to conventional concrete. Initially a dry mixture is prepared consists of coarse aggregate, Robo sand, fly ash and metakaiolin is mixed in types of different proportions. After that sodium hydroxide and sodium silicates are added to the dry mix separately. Proper mixing is done for 5-7 min to attain good bond between these constituents. Then the mix is filled into 150mm x150mm x 150mm moulds and casting is done by placing concrete in three layers. Each layer is tampered 25 times by using a tamping rod compaction is done at the rate of 25blows for 3 layers. As the setting time is very slow, the cubes are allowed to rest in the mould for 1 or 2 days. Then the cubes are removed from the moulds for curing.

b) CURING:

The Curing process of concrete cubes is done in 2 stages. In the first stage, the cubes are kept in the oven for 24-48 hours at 600°c. In the second stage, the cubes are allowed to be cured in open atmosphere called" ambient curing"

c) TESTING PROCEURE**:**

The cubes are tested for 7 & 28 days after curing of concrete. By using ultrasonic pulse velocity test procedure we will get the time and velocity values at ages of 7 days and 28 days. The compressive strength value can be obtained by subjecting the cubes after desirable curing period to gradual loading under a compressive testing machine which has a capacity of subjecting 1000KN load.

C. Testing: i. Ultrasonic pulse velocity test procedure:[9] The principle of ultrasonic pulse velocity test is to measure the pulse of longitudinal vibrations passing through the concrete. For the measuring of travel time of wave through concrete. From the experiments, the velocity depends on the elastic property and geometry of the material. The recommendations for the use of this method are given BS-4408 part-5; ASTM C 597-71 and BIS 13311 part -1-1992. In this procedure, the direct method is used for testing the specimens. For homogeneous concrete, the compression wave velocity is given by $V = \sqrt{(kEd/\rho)}$ (1) Where $k = (1-\gamma) / [(1+\gamma)(1-2\gamma)]$ (2) Ed= dynamic modulus of elasticity ρ = dynamic poisons ratio The velocity of an ultrasonic pulse is influenced by properties such as elastic stiffness and mechanical strength. The pulse velocity values may vary with the variations in the state of concrete under test. According to the obtained velocity values calibration charts must be established to evaluate the compressive strength and quality of concrete

Table no:1
Various types of mix proportions for GPC

MIX NO	MIX PROPORTION
1.	100%MK+0%FA
2.	80%MK+20%FA

3.	60%MK+40%FA
4	50%MK+50%FA

Table no:2
Compressive strenghth values for GPC

CONCRETE MIX	Compressive strength	
	7 days	28 days
MIX 1	0.34	0.6
MIX 2	2.61	4.31
MIX 3	9.98	15.6
MIX 4	8.52	12.75

Table no:3
UPV values for GPC

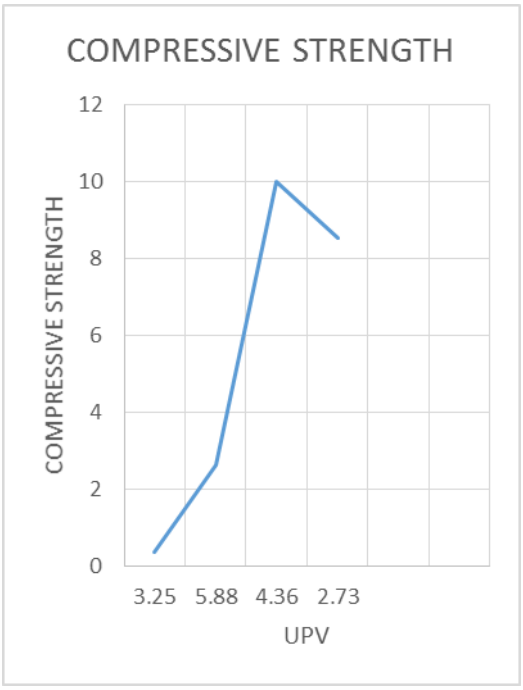
CONCRETE MIX	VELOCITY	
	7 days	28 days
MIX 1	3.25	4.58
MIX 2	5.88	6.34
MIX 3	4.36	5.47
MIX 4	2.73	4.24

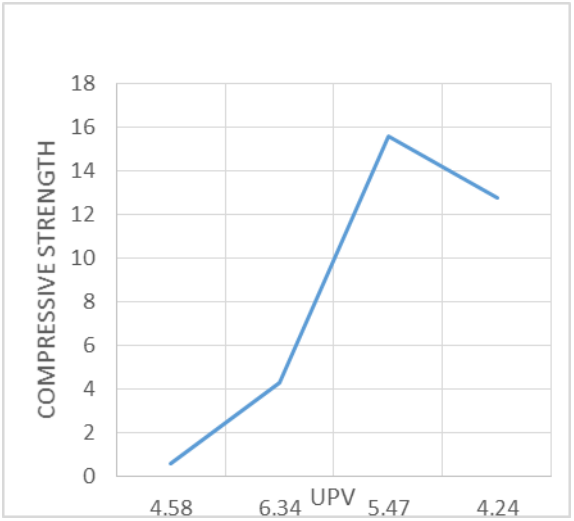
Table no:4
Quality of GPC under ultrasonic pulse velocity with respect to age

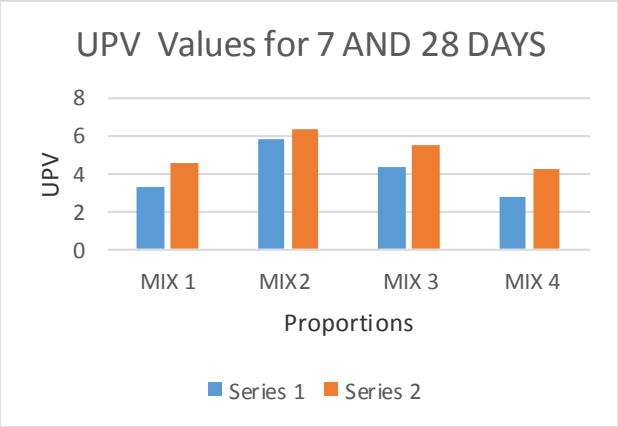
TIME (Days)	Quality of concrete			
	MIX1	MIX 2	MIX3	MIX4
7	M	E	G	P
28	E	E	E	G

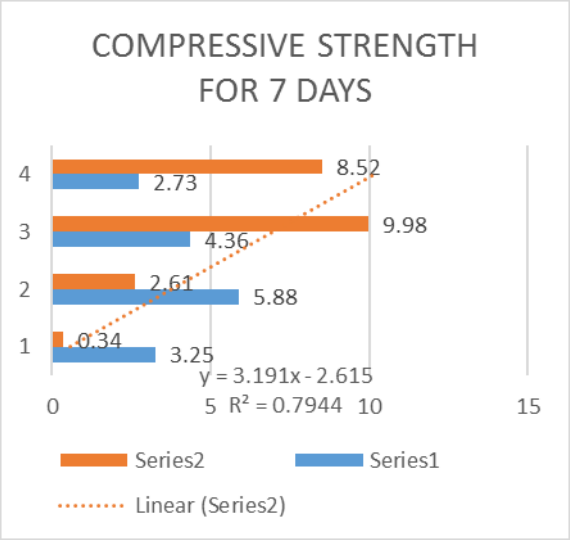
Where
E= Excellent
G=Good
M=Medium
P=POOR

Pulse velocity (Km/sec)	Quality of concrete
Above 4.5	Excellent (E)
3.5 – 4.5	Good (G)
3-3.5	Medium (M)
Below 3	Poor (P)









III. CONCLUSION

1) For this present experimental study we have determined an equation for UPV & compressive strength.
2) The UPV & compressive strength va;ues increases in the curing period.
3) There is an increase in compressive strength of FA concrete.
4) For mix 4, the UPV & compressive strength values decreases when compared to the remaining proportions.
5) Low compressive strength and UPV values are resulted due to the use of light buff coloured metakolin ash
6) For every 20% addition of fly ash increase the UPV values for GPC and increase the quality of concrete.

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