© 2017 IJSRST | Volume 3 | Issue 4 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Study on Strength Parameters of In-Situ Fly Ash Based GEO Polymer Concrete with Nitobond PVA

Aravinthan. K*, Sivakumar. N, Rajeshwaran. K, Sundaram. S. P, Praveen Kumar. G
Civil Department, EASA College of Engineering and Technology, Coimbatore, Tamilnadu, India

ABSTRACT

Geo-polymer is an eco-friendly binding material alternative to ordinary Portland cement. Geo-polymer concrete is obtained by mixing the ingredients such as sodium hydroxide solution, sodium silicate solution, fly ash, and, fine aggregate (m-sand) and coarse aggregate. But in most of the literature they have carried out stream curing for initial and final strength. We are interested to know when the geo-polymer concrete is not steam cured or oven dried. Because due to less prefabricated structure in developing and underdeveloped country. Our aim is to research an alternative solution for 100% cement replaced, in-situ geo-polymer concrete. So, here we propose a research on 100% replacement of cement to fly ash and replace 100% river sand to M-sand. For achieving the binding property of geo-polymer concrete most of the literatures suggest to add sodium silicate and sodium hydroxide solution. We are adding the Nitobond PVA solution in addition to sodium silicate and sodium hydroxide solution to increase the strength of concrete. The samples are casted with Nitobond PVA agent in that we mix 2%, 4%, & 6% and cured by sunlight curing. Compressive strength, Tensile strength and young's modulus test are carried out to evaluate the behaviour of in-situ geo-polymer concrete.

Keywords: Geo-polymer concrete, Sodium silicate and sodium hydroxide solution, Strength test, Nitobond PVA solution

I. INTRODUCTION

A new study about geo-polymer concrete with Nitobond PVA solution is proposed in this project. The utilization of cement causes pollution to the environment and reduction of raw material (limestone). The usage of OPC is on the increase to meet infrastructure developments. The world-wide demand for OPC would increase further in the future. On the other hand, coal burning power generation plants produce huge quantities of fly ash. geopolymer concrete had been introduced to reduce the above problem. Geopolymer concrete also showed good properties such as high compressive strength, low creep, good acid resistance and low shrinkage. In fly ash-based geopolymer concrete, the silica and the alumina present in the source materials are first induced by alkaline activators to form a gel known as alumino-silicate. The role of binder in geopolymer concrete is replaced by fly ash which also possesses pozzolanic properties as OPC and rich with alumina and silicate.A significant advance in the usage of fly ash in concrete is the development of high volume fly ash (HVFA) concrete, which partially replaces the use of Portland cement in concrete (up to 60%), while maintaining excellent mechanical properties with enhanced durability performance. Longer curing time improved the polymerization process resulting in higher compressive strength. The results indicate that a longer curing time at 60 °C does not produce weaker material. However, the increase in strength for curing periods beyond 48 h is not significant. M.w. Ferdous, et.al. (2013) proposed a method for selecting the mix proportions of geo-polymer concrete which may be suitable for concrete containing fly ash to be used as a cementitious material. The relative ratios of Fly ash: Fine aggregate: Coarse aggregate are 1: 1.59: 3.71 where the aggregates are considered in oven dry conditions in result should be determine compressive strength to water-to-geo-polymer solid ratio. If compressive strength is 60 Mpa and water-to-geo-polymer solid is 0.38 and alkaline liquid to fly ash ratio is 0.55. The geo-polymer concrete achieved 87% of its 28-day strength in 7 days while OPC concrete achieved only 67%.

Mohamed aquib javeed, et.al. (2015) studied Geo-polymer is an eco-friendly binding material alternative to ordinary Portland cement. About 60%of M-sand and 40% of pond ash as sand replacement is found to be the optimum amount in order to get a favorable strength in 40.14. The compressive strength of concrete increases with increasing the concentration of sodium hydroxide. The compaction factor is 0.61 and the maximum compressive strength is 40.41 as the test results S Ganesh Kumar et.al. (2012) found out an optimum mix for the Geo-polymer concrete. They are used in four different trial mixes are Trial mix - I (1 : 1.3 : 3.10), Trial Mix - II (1 : 1.4 : 3.20), Trial Mix - III (1 : 1.5 : 3.3), Trial Mix - IV (1 : 1.6 : 3.4).If compressive strength in 7 days is 38,41,48,39.8 Mpa respectively, If compressive strength in 28 days is 42.66,48,53,48.88 Mpa respectively. They are taken the good result for Trial Mix - III (1 : 1.5 : 3.3), If compressive strength in 7 days is 48Mpa. The compressive strength in 28 days is 53Mpa.

The review of a number of literatures shows the importance of this field of research. The results show the improved characteristics of the blended concrete in terms of compressive, tensile and flexural strength. Apart from that the permeability of the specimen can also be decreased by adding a small percentage of the sodium silicate. Sodium Hydroxide and Nitobond PVA. But in most of the literature they conclude with by using the materials and cured by stream curing. In that we replaced 100% cement to fly ash and replaced 100% sea sand to M-sand. We newly added the nitobond pva solution along with sodium hydroxide and sodium silicate. Nitobond is a bonding agent in that we mix 2%, 4%, & 6% and cured by sunlight curing. Compressive strength can be tested for 2%, 4%, & 6% is 20,30&50 KN\m^2 For 21 days.

II. METHODS AND MATERIAL

The materials used to design the mix for M20 grade of concrete are, Fly ash, Fine aggregate , Coarse aggregate, Water, Sodium silicate, Sodium hydroxide, Nitobond PVA, Super plasticizer.

A. Properties of Cement

The ordinary Portland cement of 43 grade conforming to IS: 455-1989 is used for preparing concrete specimens. The properties of cement used are given in the Table 1.

TABLE I

INITIAL TEST FOR CEMENT AND FLY ASH

DESCRIPTION	SPECIFIC GRAVITY	SETTING TIME		NORMAL CONSISTENCY (%)
		INITIAL (min)	FINAL (hr)	
Cement	3.15	29.10	9.45	56
Fly ash	1.6-2.6	5	120-192	38

The following tables provide general range of physical, chemical, geo-technical properties, available major, secondary, micro-nutrients and trace / heavy metals and radio-activity levels in fly ash and soil (source: Fly Ash India 2005 - International Congress).

TABLE III

PHYSICAL PROPERTIES OF FLY ASH

Parameters	Fly Ash
Bulk Density (gm/cc)	0.9-1.3
Plasticity	Lower or non-plastic
Shrinkage Limit (Vol stability)	Higher
Grain size	Major fine sand / silt and small per cent of clay size particles
Clay (per cen)	Negligible
Free Swell Index	Very low
Classification (Texture)	Sandy silt to silty loam
Water Holding Capacity (WHC) (per cent)	40-60
Porosity (per cent)	30-65
Surface Area (m2 / kg)	500-5000
Lime reactivity (MPa)	1-8

TABLE IIII

CHEMICAL PROPERTIES OF FLY ASH

Minerals %	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O

Fly ash (F)	54.90	25.90	6.90	8.70	1.80	0.60	0.60	0.60
Cement OPC	22	5	3.20	63	2	1.5	0.3	1.9

B. Aggregate

The three different sizes of coarse aggregates (14 mm, 10 mm and 7 mm) obtained in crushed rock form and fine aggregate in uncrushed form were used to prepare concrete in the laboratory. The specific gravity of aggregate was measured according to relevant ASTM standard.

C. Properties of fine and coarse aggregate.

The M- Sand is added as fine aggregates and collected from locally available quarry. The sieve analysis of the samples is done. It is found that the sand collected is conforming to IS: 383-1970. For coarse aggregate, the parent concrete is crushed through mini jaw crusher. During crushing it is tried to maintain to produce the maximum size of aggregate in between 20mm to 4.75mm. The coarse aggregate particle size distribution curve is presented. The physical properties of both fine aggregate and recycled coarse aggregate are evaluated as per IS: 2386 (Part III)-1963 and given. The tests are conducted for coarse aggregate.

TABLE IV

PROPERTIES OF COARSE AGGREGATE AND FINE AGGREGATE

Property	Coarse Aggregate	Fine Aggregate
Specific Gravity	2.48	2.79
Sieve analysis	Satisfy the IS383:1970	Satisfy the IS383:1970
Flakiness & Elongation (%)	100%	–
Water Absorption (%)	0.9%	
Impact Value (%)	14%	

D. Sodium Hydroxide

Generally the sodium hydroxides are available in solid state by means of pellets and flakes. The cost of the sodium hydroxide is mainly varied according to the purity of the substance. Since our geo-polymer concrete is homogenous material and its main process to activate the sodium silicate, so it is recommended to use the lowest cost i.e. up to 94% to 96% purity. In this investigation the sodium hydroxide pellets were used.

Specific gravity = 1.47

TABLE V

PHYSICAL PROPERTIES OF SODIUM HYDROXIDE.

Property	Information
Molecular weight	39.997 g/mol
Appearance	White crystalline substance
Transparent	Only in liquid form
Odour	None
Density	2.13 g/cm3
Boiling point	1390 C
Melting point	318 C
Freezing point	14 C
Vapour pressure(0.2 kpa,20)	1.5 mmHg
Specific gravity	1.52 g/mol
Flammable	No

TABLE VI

CHEMICAL PROPERTIES OF SODIUM HYDROXIDE.

Property	Information
Chemical formula	NaOH
Acidity	Very low (13-14 pH)
Basic type	caustic metallic base
Corrosive	High
Reactivity	medium
Hygroscopic	Yes
Solubility	1110 g/lit

E. Sodium Silicate

Sodium silicate is also known as water glass or liquid glass, available in liquid (gel) form. In present investigation sodium silicate 2.0 (ratio between Na2O to SiO_2) is used. As per the manufacture, silicates were supplied to the detergent company and textile industry as bonding agent. Same sodium silicate is used for the making of geo-polymer concrete.

TABLE VII

PROPERTIES OF SODIUM SILICATE

Property	Information
Molar mass	122.06 g/mol
Appearance	Colorless solid
Density and phase	2.4 g/cm
Solubility in water	soluble
Melting point	1088 C

F. Super-Plasticiser

A super-plasticizer was used to improve the workability of fresh geo-polymer concrete. A carboxylic ether polymer-based super-plasticizer under the brand name conplast SP 430 was applied in the mix. The Conplast SP430 has been used as a super plasticizer in this experiment. It has the specific gravity 1.225. It doesn't have the presence of chloride content as mentioned by IS456 and its main advantage is reduction of water & early strength is increased up to 20%.

G. Nitobond PVA

Prepare and seal surface as required, apply priming coat of 1 part Nitobond PVA to 1 part water and allow to become tacky. Using the same sand or fine aggregate as in the concrete to be repaired, prepare a stiff cement/sand mix in the proportions 1:2 (or leaner) gauged with 1 part Nitobond PVA to 3 parts clean water.

Advantages

Single component liquid, gauged as required, Bonds most common construction materials , Improves the durability of mortars and renders, Excellent as a dust proofer and sealer , Easily applied by brush roller or spray, Contains no chloride admixtures, Self-Life Of Nitobond PVA = 12 Month.

H. Preparation of Test Specimen

Totally 48 specimens are casted (cube, cylinder, prism) for various proportions and also 7 days and 28 days are listed in table Cubes of size (150 x 150 x150) mm, cylinder(150 x 300) mm, prism (500x10 x10) mm are casted In hand mixing and compacted well after successful casting, the concrete specimens are de-moulded after 3 days and sunlight heated for 7 days and 28 days maintaining. Fig.1 shows some concrete specimen casted in laboratory.

III EXPERIMENTAL PROOF AND ANALYSIS

A. Compressive Strength Test

The compressive strength test for control mix is 24.4Mpa and when comparing to other samples without heating in hot air oven or steam curing the compressive strength largely decrease up to 18.3 times the control mix. This is mainly because due to the calcium content is 8.7% in geo-polymer concrete. When heating them it gains initial strength and binds due to the sodium silicate solution. The alumino- silicate reactions are formed while heating gains initial and final strength. The samples are found to be wet after the compressive strength test. During de-molding process the geo-polymer concrete is found to be unstable and the shape and structure can be easily damaged this is one of the drawback which was found while geo-polymer concrete.

B. Young's Modulus Test

The Young's Modulus of specimens is determined by using Extensometer after 7 and 21 days of curing with surface dried condition as per Indian Standard IS: 516-1959. Two specimens are tested for typical category and the mean Young's modulus strength of two specimens is considered as the Young's modulus of the specified category Fig. 6 shows compressive strength test results for specimen for 7 days, Fig 7 shows compressive strength test results for specimen for 21 days. The young's modulus of 7 days control concrete and samples are 24720Mpa and 5773.5Mpa, 4714.05Mpa, 4714.05Mpa respectively. The young's modulus is 4.28 times lesser than control mix. This is due to the absence of calcium content in geo-polymer concrete which gives initial strength in more the 3 hours to the concrete.

C. Flexural Strength Test

The tensile strength of geo-polymer concrete is reduced 3 times the control concrete as shown in chart. The final setting time takes more than two days and the fly ash gains strength in longer periods i.e., more than 27 days. Otherwise we can cure under the sun or to remove the moisture content in geo-polymer concrete by artificial heating.

Figure 1: Casting of specimen

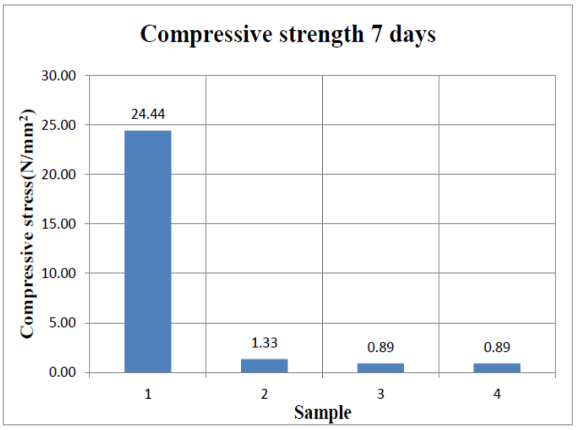

Figure 2: Compressive strength Test -7 days

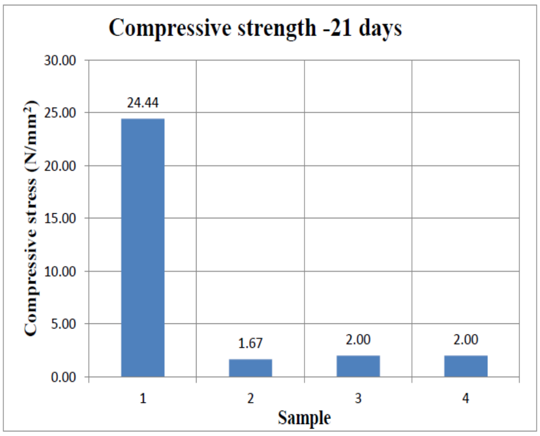

Figure 3: Compressive strength Test -21 days

Figure 5: Young's Modulus Test

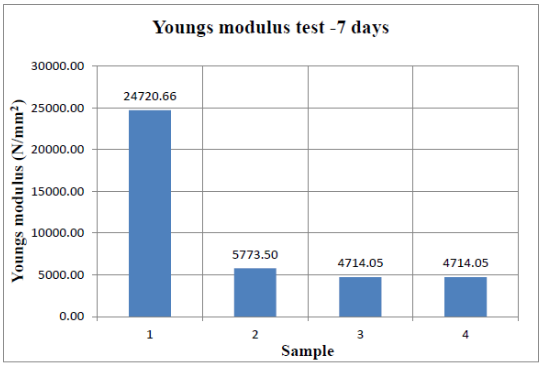

Figure 6: Young's Modulus Test 7 days

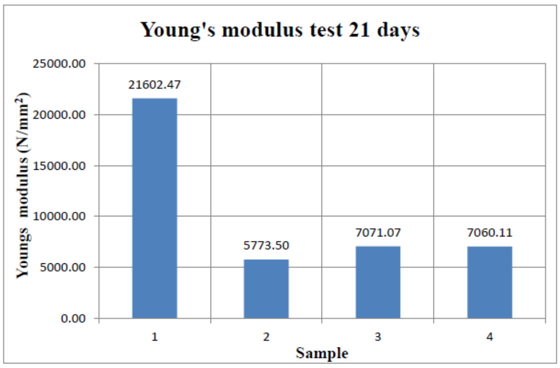

Figure 7: Young's Modulus Test 21 days

Figure 8: Flexural strength test before breaking due to self-weight.

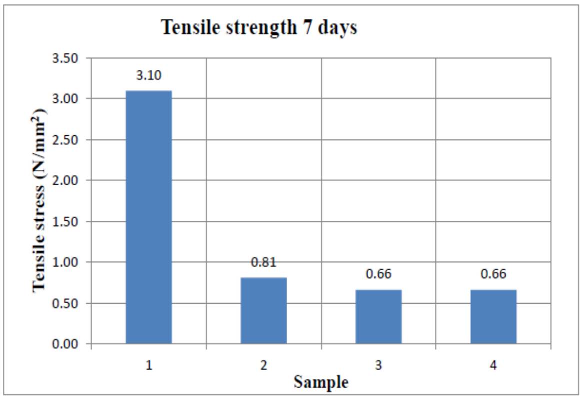

Figure 9: Tensile Strength Test 7 Days.

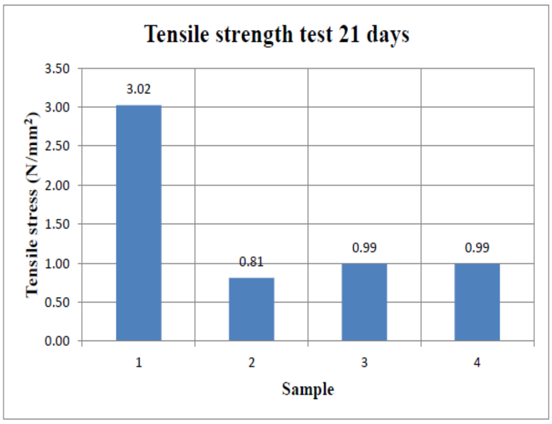

Figure 10: Tensile Strength Test 21 Days.

IV CONCLUSION

Geo-polymer concrete is well known for its promising mechanical properties, acid resistance and fire resistance and therefore is a potential alternative construction material with comparable properties to OPC concrete. Geo-polymer emit approximately 80% less Co_2 than OPC during production, making it a more environmental friendly building material. Like OPC concrete, geo-polymer concrete as a brittle failure. The combination of fly ash, sodium silicate, sodium hydroxide with Nitobond PVA solution as a 100% replacement for cement has been investigated in this study. The sodium silicate was used in quantities of 25% and sodium hydroxide was used 10%, and Nitobond PVA was used 2, 4, & 6% along with fly ash. Due to direct sunlight curing process the bonding take more time than the conventional concrete. The strength are reducing because the sodium silicate and sodium hydroxide solution dose not form CHS gel which cause early attainment of strength in conventional concrete. The Nitobond PVA solution is even though a good binding material which is used in many retrofitted structure does not produce strength when it is used as a concrete admixture. Further this research can be done with calcium oriented mineral admixtures instead of sodium silicate sodium hydroxide solution to improve the strength parameter of in-situ concrete.

V. REFERENCES

[1] M.W.Ferdous,O.Kayali, (2013) "A Detailed Procedure of Mix Design For Fly ash Based Geopolymer Concrete" Fourth Asia-Pacific Conference on FRP in Structures,

[2] Ankush khadwal (2015) "A Brief Review On Geo-polymer Concrete" International Journal Of Advanced Research (ijaret), Vol.2, Issue3. July - Sept.

[3] 4. Mohamed Aquib Javeed, Veerendra Kumar.M, Dr. H.Narendra, (2015) "Studies on Mix Design of Sustainable Geo-Polymer Concrete", International Journal of Innovative Research in Engineering & Management (IJIREM) ISSN: 2350-0557, Volume-2, Issue-4, July 2015.

[4] S Ganesh Kumar, Dr. MI Abdul Aleem, S Dinesh (2012), "Optimum Mix for the geo-polymer concrete", Indian journal of science and technology, vol. 5 no. 3, mar.

[5] Abhishek c. ayachit pranav b. nikam , siddharth n. pise , akash d. shah , vinayak h. pawar (2016) "Mix Design Of Fly-Ash Based Geo-polymer Concrete," International Journal Of Scientific And Research Publications", Volume 6, Issue 2.

[6] Shri N. G.Bhagavan, R.Kumutha. (2016) "Development of Low Strength and Geo-Polymer Concrete Mix Utilizing Demolished Aggregate". International Journal of Advanced Research, Volume 4, Issue 4, pp. 1168-1179.

[7] S Ganesh Kumar, Dr. MI Abdul Aleem, S Dinesh (mar 2012) "Optimum Mix for the geo-polymer concrete" Indian journal of science and technology, vol. 5 no. 3.

[8] IS: 2386-1963 (Part-III). Methods of Test for aggregates for concrete Part III specific gravity, density, voids, absorption and bulking. Bureau of Indian Standards.

[9] IS: 383-1970. Specification for coarse aggregate and fine aggregate from natural sources for concrete. Bureau of Indian Standards.

[10] IS: 456-2000. Plain and Reinforced concrete- code of practice (Fourth Revision). Bureau of Indian Standards.