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Geopolymer Concrete: An Experimental Investigation of Workability and Compressive Strength of Geopolymer Concrete with PPC

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Abstract: The Romans constructed the Colosseum from a primitive form of concrete. It was made by using concrete using lime, which was burned to create quicklime, water and volcanic ash. The volcanic ash served as the aggregate and is likely the reason Roman concrete, which was 10 times weaker than the concrete used presently, but it lived even after almost 2,000 years. Moreover Pyramids were possibly made of this long lasting material the Pyramids are still in good shape, which demonstrates the excellent durability of geopolymer. This era have witnessed a lot more varieties of construction and concrete. This paper is an exploration of "Geopolymer Concrete" which offers the "greenery" construction as well as to reduce the air pollution and consumption of Cement. The Ordinary Portland Cement (OPC) is most widely used construction material, approximately for every tone of cement production 1 tone of CO_2 emitted by cement factory. The Cement production is responsible for approximately 5% emission of Co_2 of world. Geopolymer Concrete results from high silica rich material. A research undertaken included study of Geopolymer Concrete mix design, Workability, Compressive and Tensile strength of concrete. A low calcium fly Ash was used with both Sodium silicate solution and Sodium hydroxide solution in mix. Sodium hydroxide solution with 5M, 8 M, 10 M and 12 M concentration, Sodium silicate to sodium hydroxide ratio is 2.0 was used .The ratio of Alkaline liquid to fly ash 0.49, heat curing was adopted at 60 $\pm$ 5°C for 24 h and room temperature curing at 23 $\pm$ 2°C.

Keywords: Chemical, Composition, Fly Ash, PPC, OPC.

I INTRODUCTION

The term Geopolymer was first initiated by Davidovits (1991). Geopolymer concrete does not use any Ordinary Portland Cement (OPC), rather the binding material is produced by reaction of alkaline liquid with source material rich in silica and alumina (N. A.Lloyd2010). Due to large production of Ordinary Portland Cement (OPC) , global warming is increases by continuous emission of CO2 .The using of Geopolymer concrete is an effort to reduce the growth of Portland Cement consumption and use alternative pozzolanic materials such as Fly ash, Slag, Silica fume, Meta kaolin, Pond ash, Palm oil fuel ash, and rice husk ash. So many research and development has done in the field of "Geopolymer technology" with hopes to promote geopolymer concrete as an ultimate sustainable construction material for the future (Hardjito et al. 2004; Wallah and Rangan 2006, Sumajouw and Rangan 2006, Kong and Sanjayan 2010).Low calcium fly ash was used for making the mix due to showing the similar mechanical property like concrete (Hardjito and Rangan 2005). Previous research showing that a high Calcium fly ash posse's good results. The workability and setting property of Geopolymer concrete is affected by alkaline liquid to fly ash ratio, NaOH concentration, and ratio of alkaline solutions, curing conditions, and admixtures (Sathonsaowaphak et al. 2009). Varying ratio of sodium silicate to sodium hydroxide primarily affected the consistency of the geopolymer mixture.

II EXPERIMENTAL INVESTIGATION

1. Material: F class fly ash obtained from coal burning power station .Low calcium fly ash has successfully used to manufacture the Geopolymer concrete with the silica and aluminium constitute about 80 % by mass.

2. Mixing, Sample preparation and Curing:

Sodium silicate and sodium hydroxide solution of desired quantity mix together before 24 hours at room temperature. The sodium silicate solution was used with ratio of SiO2 to Na2O by mass approximately 2.0. Sodium should be dissolved in water and

prepared a required concentration of solution vary from 5M to 12 M .Course and fine aggregate with dry surface mix with binder (Fly Ash) for 3 to 5 minute thoroughly in mixing pan . The premix alkaline solution was added in mix. A concrete cube mold with size 150 mm X 150 mm X150 mm was filled by geopolymer concrete in two layers by using vibrating table.

Table 1 Chemical Composition of Fly Ash

Sample	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	P_2O_5	TiO_2	LOI
Fly ash	53.71	27.20	11.17	1.90	-	0.36	0.54	0.30	0.71	1.62	0.68

Table 2 Details of Geopolymer Concrete Mix (Kg/m3)

Designation	PPC	Fly Ash	CA	FA	Water	NaOH Solution	Na_2Sio_3 Solution	Admixture
M 0	0 %	400	1190.09	619.76	9.6	56	140	8
M 5	5%	380	1190.09	619.76	9.6	56	140	8
M 10	10%	360	1190.09	619.76	9.6	56	140	8

III EXPERIMENT

The workability of Geopolymer concrete was measured by slump test. Which was reported 162 mm ,158 mm , 157 mm .Compressive strength and flexural strength test was conducted at 7, 14 and 28 days. The paste was prepared by mixing the binders and the alkaline solutions manually in mixing.

Figure 1: Concrete mix and cube filling

RESULTS AND DISCUSSION

Three mix of Geopolymer Concrete were tested for each number of partial replacements of fly ash by Portland Pozzolans Cement (PPC) after 7, 14 and 28 days. All the mixture of Geopolymer concrete was designed with small amount of water with alkaline solution. To improve workability, extra water or superplasticizer can be added, however this is likely to affect the mechanical properties of the hardened concrete.

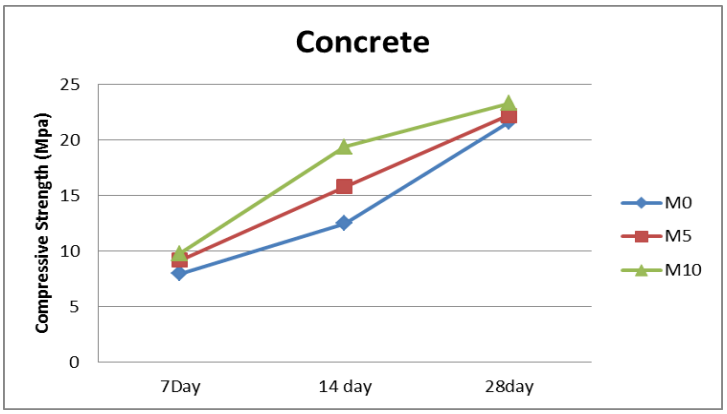

Figure 2: Compressive Strength Test

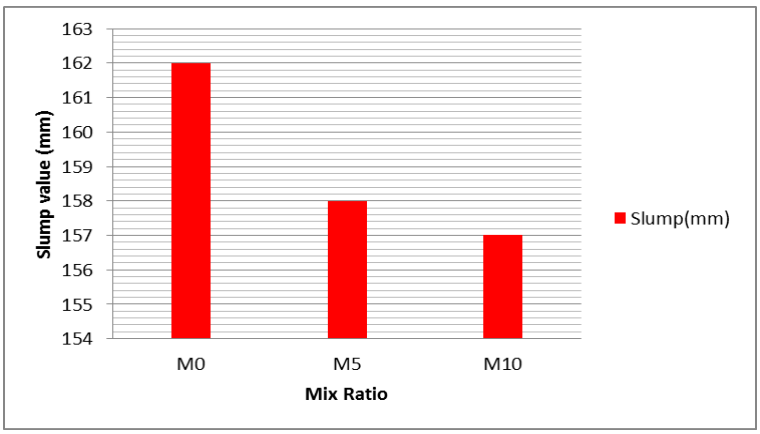

Figure 3: Slump Test Results

CONCLUSIONS

Three Geopolymer concrete mix were designed by using of low calcium fly ash and tested at 7days, 14 days and 28 days. The results were found satisfactory. Compressive strength of geopolymer concrete is affected by heat of curing at temperature 60 ^{0}C. Concrete samples cured without heat strength gradually over the age, while samples cured in 60 ^{0}C for 1 day achieved high early strength which increased negligibly over the age. By using this method we can increase the consumption of flyash, which is the waste product.

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