To Study The Properties of Geopolymer Concrete using Fly Ash and Slaked Lime

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***Abstract* :- In this project the experimental investigation is done on geopolymer concrete. The project aim is to use fly ash and slaked lime in place of OPC and compare its properties with the normal concrete .The Slaked lime is in ancient time in making the lime mortar which act as the binder material.**

In this project fly ash, slaked lime , sodium hydroxide, sodium silicate, coarse sand and coarse aggregate are used as the ingredient. The fly ash react with sodium hydroxide and sodium silicate to form sodium alimino silicate and slaked lime react with coarse sand to form calcium silicate.

Thus this sodium alumino silicate and calcium silicate act as binder and bind the coarse sand and coarse aggregate. Thus this reaction is exothermic liberating large amount of heat.

I. INTRODUCTION

In the production of cement the limestone and clay is heated to a high temperature of 1500 degree celcius in a kiln then these materials fused and form clinker which further crushed to form cement. Thus this processs is very costly and emit large amount of fly ash and carbon dioxide to the environment. Thus in geopolymer concrete the use of fly ash and slaked lime as the binder replaces the cement thus it is a key for the sustainable development.

Geopolymer concretes which are ideal for building and repairing infrastructures and for casting units, because they attain high early strength and their setting times can be controlled by adding superplasticizer.

The geopolymer can attain high early strength, and have low shrinkage, freeze-thaw resistance, sulphate resistance and corrosion resistance.

II. EXPERIMENT PROGRAMME

In this experiment the fly ash and slaked lime is used as the binder in place of cement in concrete. The fly ash and slaked lime react with the bases and form sodium alumino silicate and calcium silicate which act as the binder to the coarse sand and coarse aggregate.

The variation in the amount of sodium hydroxide and sodium silicate is done in concrete and their effect on compressive strength and tensile strength is noted down.

The manufacture of geopolymer concrete is carried out using the usual concrete technology methods as in the case of OPC concrete in Concrete laboratory of Integral University, Lucknow.

III. MATERIAL USED

A. Fly ash

Fly ash is defined as ‘the finely divided residue that results from the combustion of ground or powdered coal and that is transported by flue gasses from the combustion zone to the
particle removal system’. Fly ash is removed from the combustion gases by the dust collection system, either mechanically or by using electrostatic precipitators, before they are discharged to the atmosphere. Fly ash particles are typically spherical, finer than Portland cement and lime, ranging in diameter from less than 1 µm to no more than 150 µm.

The types and relative amounts of incombustible matter in the coal determine the chemical composition of fly ash. The chemical composition is mainly composed of the oxides of silicon (SiO2), aluminium (Al2O3), iron (Fe2O3), and calcium (CaO), whereas magnesium, potassium, sodium, titanium, and sulphur are also present in a lesser amount. The major influence on the fly ash chemical composition comes from the type of coal.

The physical and chemical properties vary to a great extent as shown in table

Physical properties of Fly ash

Characteristics	Observed values
Specific Gravity	2.12
Unit weight, (KN/m^2)	14.39
Liquid limit (%)	24
Loss on ignition, percent by mass	0.40

Chemical properties of Fly ash

Characteristics	Observed values (%)	Range specified for Class C Fly Ash (as per ASTM C-618)
Silicon dioxide (SiO_2)	59.00	46-60
Alumina (Al_2O_3)	27.00	21-28
Iron oxide (Fe_2O_3)	4.50	5-9
Calcium oxide (CaO)	1.80	0.5-6
Magnesium oxide (MgO)	0.70	0.2-4
Sulphur trioxide (SO_3)	0.10	0-0.4
Sodium oxide (Na_2O)	0.28	0-0.3
Potassium oxide (K_2O)	1.44	0-0.2

The locally available fly ash which was collected from Harduaganj thermal power station was used in the present study.

B. Coarse sand

The most common constituent of sand is silica, usually in the form of quartz, which is chemical inert and hard. Hence used as a coarse sand in concrete.

Properties of Coarse sand**:**

Properties Results Obtained are as follows

Specific Gravity	2.65
Water absorption	0.6%
Fineness Modulus	2.47

Coarse aggregate

The coarse aggregate are used are crushed stone ranging from 10mm to 20mm.Thus it is necessary to do the sieve analysis.

Physical Properties	**Observed values**		**Recommended values**
	10mm aggregate	**20mm aggregate**	
Fineness Modulus	6.07	8.17	-
Specific Gravity	2.635	2.623	2.6-2.8
Water Absorption(%)	0.4	0.2	0.5-1%
Dry Rodded density(kg/m^3)	1574.10	1618	-
Aggregate crushing value(%)	17.63	19.5	Not more than 45%
Aggregate impact value(%)	24	20.2	Not more than 45%

Natural coarse aggregate (20mm and 10mm)

C. Quick lime

Calcium oxide is formed by the thermal decomposition of limestone, to temperature of 825 °C to liberate a molecule of carbon dioxide (CO_2)and leaving quicklime .And when water is added to quick lime slaked lime is produced.

$$CaO\ (s) + H_2O\ (l) \rightleftharpoons Ca(OH)_2\ (aq)\ (\Delta H_r = -63.7\ kJ/mol\ of\ CaO)$$

Sodium hydroxide and Sodium silicate are commercially available in market in pellets form. In all forms, sodium hydroxide is highly corrosive and reactive. Sodium hydroxide solution reacts readily with metals such as aluminum, magnesium, zinc, tin, chromium, bronze, brass, copper, and tantalum. . It reacts with most animal tissue, including leather, human skin, and eyes. It also reacts readily with various reducing sugars (i.e., fructose, galactose, maltose, dry whey solids) to produce carbon monoxide.

Sodium silicate is stable in neutral and alkaline solutions. In acidic solutions, the silicate ion reacts with hydrogen ions to form silicic acid, which when heated and roasted forms silica gel, a hard, glassy substance.

The sodium hydroxide and sodium silicate solution is prepared one day before the casting are shown in the images.

The ratio of sodium hydroxide solution to sodium silicate solution is taken 2.5.And the quantity of sodium hydroxide in solution is calculated by multiplying the molecular mass with the number of moles of solution. That means if solution is 10 molar then molecular mass of sodium hydroxide that is 40 is multiplied by the 10 and the quantity of sodium hydroxide will be 400 gram in the solution

Mixture proportion

The volume of concrete is given in tabular form for 3 cubes= .0101 cubic meter

Geopolymer concrete using fly ash and slaked lime

NaOH	Sodium Silicate	fly sh	Slaked Lime	coarse sand	Agg 10 mm	agg 20 mm	Molarity
337 m	1 kg	6.5kg	2kg	7.76	6.68kg	10kg	8M
405gm	1 kg	6.5kg	2kg	7.76	6.68kg	10kg	10 M
480gm	1 kg	6.5kg	2kg	7.76	6.68kg	10kg	12M
560gm	1 kg	6.5kg	2kg	7.76	6.68kg	10kg	14 M


Casting of concrete

In the laboratory fly ash, coarse sand and coarse are mixed in a concrete mixer and then dry mixing is done for three minutes and then slaked lime and bases are added to the mixture. The mixing is done till homogenous slurry is fomed. Then mixture is taken to a pan where slump is mearsured.


Observation and Result

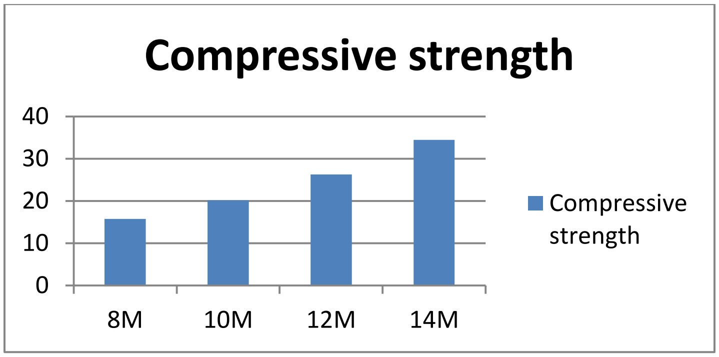
Slump
The result indicates that the value of slump will remain constant on varying the molarity of geopolymer concrete and thus collapse slump is formed.

Slump = 18.3 cm

Compressive Strength

Compressive strength test was performed according to ASTM C 39.Cubes of specimen of size 150 mm x 150 mm x 150 mm were prepared for each mix. After 24 hours the specimens were de molded and cured in water for 28 days until testing. For specimens with uneven surfaces, capping was used to minimize the effect of stress concentration. The compressive strength reported is the average of three results obtained from three identical cube

Variation in the molarity of NaOH				
	8M	10M	12M	14M
Comp.	16.24	19.81	26.02	34.18
Strength	15.13	18.38	26.33	31.6
(Mpa)	15.8	22.11	26.42	37.48
Mean value	15.72	20.1	26.25	34.42
(Mpa)				



Split Tensile Test

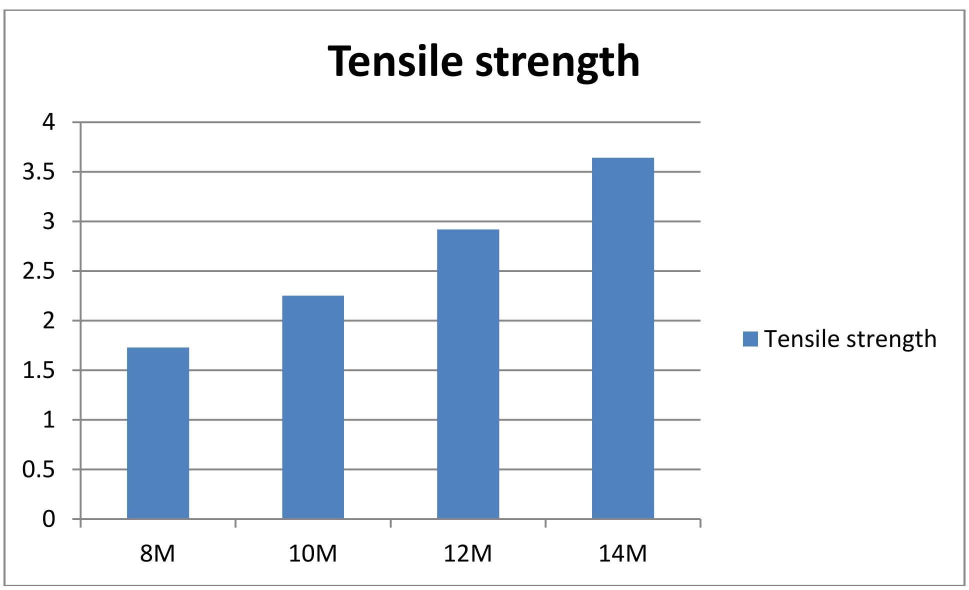
Splitting tensile strength, T = 2P/ pi DL

where,

P= load in Newton
l= length of cylinder in mm i.e 300mm

d= diameter of cylinder in mm i.e 150mm

Variation in the molarity of NaOH				
	8M	10M	12M	14M
Tensile	1.63	2.19	2.616	3.45
Strength	1.822	2.176	3.036	3.6
(Mpa)	1.76	2.398	3.13	3.87
Mean value	1.73	2.25	2.92	3.64
(Mpa)				



Conclusion

1. The increase in the content of bases increase both compressive as well as tensile strength.
2. The setting time is very short so it is necessary to add superplasticizer to delay the setting time.
3. The bases are very harmful they can cause blindness.

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4. It is long working life before stiffening.
5. It is impermeable and higher resistance to heat and resist all inorganic solvents.
6. If steam curing of geopolymer concrete is done then its increases the strength of concrete.
7. The geopolymer concrete also shows excellent resistance to sulfate attack, good acid resistance, undergoes low creep, and suffers very little drying shrinkage.

General Suggestion

In this work we have used fly ash which is a waste product from iron industries and it is very cheaper and its cost is 1200 rupees per metric tonne. And its composition is near about similar to cement . So we can easily replaces the cement in concrete. But the problem is that fly ash is having very short setting time and its sets quickly while placing into the moulds. As we increase the morality of bases the liberation of heat is increased due to which polymerization process started and concrete sets quickly.

The modification that can be done is that we can use ggbs ,rice husk ash in place of fly ash as they also rich in alumina and silica content and react with the bases and form calcium alumino silicate.

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