

**EXPERIMENTAL INVESTIGATION ON GEOPOLYMER
CONCRETE IN REPLACEMENT OF CEMENT BY
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Abstract — Concrete is the most abundant manmade material in the world. One of the main ingredients in a normal concrete mixture is Portland cement. However, the production of cement is responsible for approximately 7% of the world's carbon dioxide emissions. In order to create a more sustainable world, engineers and scientists must develop and put into use a greener building material. This paper will discuss the use of geo polymer concrete as well as consider its ethical issues. Additionally, this paper will explore the areas in which geo polymer concrete out performs ordinary concrete. Geo polymer concrete uses fly ash, a byproduct created from the burning of coal. Currently, the majority of fly ash is dumped into landfills, causing environmental problems.

The production of geo polymer concrete allows fly ash to be recycled and eliminated from landfills. Geo polymer concrete is also more resistant to damage than standard concrete. For example, geo polymer concrete is stronger under tension and compression than its cement based counterpart. It is also more resistant to salts, acids, sea water corrosion, and fire. There are some disadvantages of geo polymer concrete that must be overcome before its incorporation into the construction industry, many of which will be discussed. Presently, it is difficult to create geo polymer concrete outside of a laboratory setting as it is still being researched by engineers and scientists. However, if this material can be readily and safely produced at low costs it will revolutionize the construction industry.

Keywords-Geopolymer concrete, Sugarcane ash, Chemical properties.

INTRODUCTION

The concrete is the most commonly used construction material. Its usage by the communities across the globe second only to water. Customarily concrete is produced by using the OPC as the binder. The usage of OPC is on the increase to meet infrastructure developments the main component of concrete structure is cement. It is change the climate due to global warming. The global warming is caused by the emission of greenhouse gases such as carbon dioxide, methane, chloro fluoro carbon, hydro fluoro carbon, and water vapour etc.

The cement industry is responsible for about 6% of all CO₂ emissions and the global cement industry contributes around 1.3 billion tons of the greenhouse gas emission annually 7% of the total manmade greenhouse gas emission to the earth atmosphere in years of 1987. Every one ton of concrete loads to CO₂ emissions which vary between 0.05 to 0.13 tons about 95% of all CO₂ emissions from a cubic yards of concrete are from cement librates about one ton of CO₂ as the results of de-carbonation of limestone during manufacturing of cement and combustion of fossil fuels. There fore any direct or attempts to reduce greenhouse gas emission would be encouraged.

In order to produce environmental friendly green concrete reduce use of natural resources, technology consuming less amount of energy and producing lower CO₂ emission is suggested. The present study attempts to explore the possibility of using fly ash in the development of binding material with alkalis like sodium hydroxide and sodium silicate and thus in the manufacture of concrete.

GEOPOLYMER

Geopolymers which refers to an amorphous inorganic polymer formed through the ionic bonding reaction between an alumina silicate (Al-Si) material and a strong alkaline solution. Geo polymers are able to be synthesized from

a variety of alumina silicate sources such as poly silicates, zeolites, kaolinite, metakaolin, calcium, rocks, silica, fly-ash, blast furnace slag, phosphate and organic minerals.

GEOPOLYMER CONCRETE

Geopolymer concrete is a high strength and lightweight inorganic polymer that can be used in place of normal concrete. The main difference between normal concrete and Geopolymer concrete is that normal concrete uses ordinary Portland cement (OPC) as a binder whereas Geopolymer concrete uses a chemical and fly ash mixture as a binder. Geo polymer concrete has multiple benefits; unfortunately, it has seen very little application in the construction industry so far. Geo polymer concrete is becoming increasingly popular as the demand for a green and sustainable building material increases each year.

OBJECTIVES

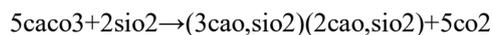
The project aims at making and studying the different properties of Geopolymer concrete using the fly ash and other ingredients locally available in. Sodium hydroxide and sodium silicate were used as alkaline activators in different mix preparations. The actual compressive strength of the concrete depends on various parameters such as the ratio of the activator solution to fly ash, morality of the alkaline solution, ratio of the activators chemicals, curing temperature, curing time, curing methods, water cement ratio etc.

The following parameters are to be studied.

1. Compressive strength of cube.
2. Split tensile strength of cylinders.

CO₂ EMISSION DURING MANUFACTURE:

The manufacture of Portland cement clinker involves the calcination of calcium carbonate according to the reaction:



To simplify: 1 T of Portland cement = 0.95 of carbon dioxide On the opposite geo polymer cements don not rely on calcium carbonate and generate much less co2 during manufacture , ie .a reduction in the range of 40./ to 80-90./.

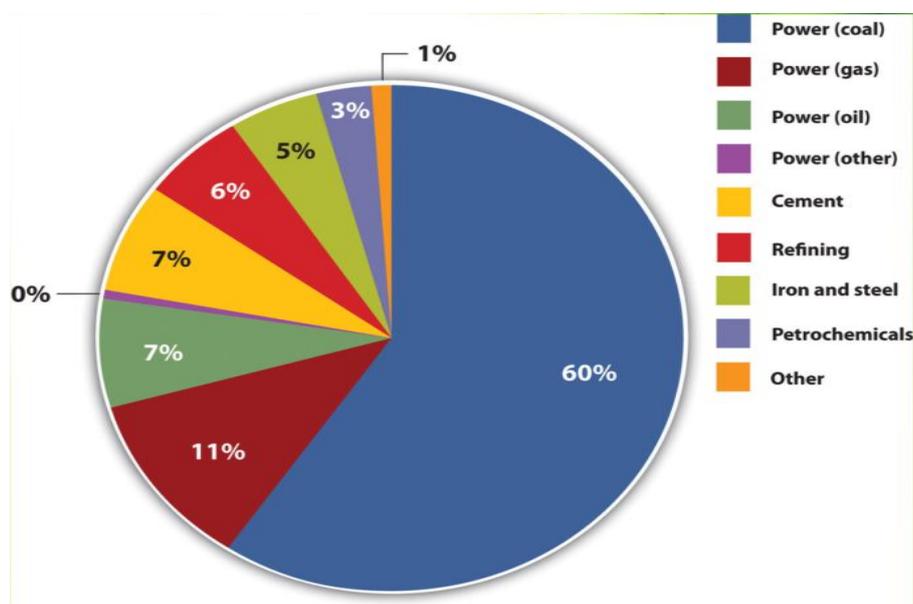


Fig.1 Co₂ emission by industry

METHODOLOGY

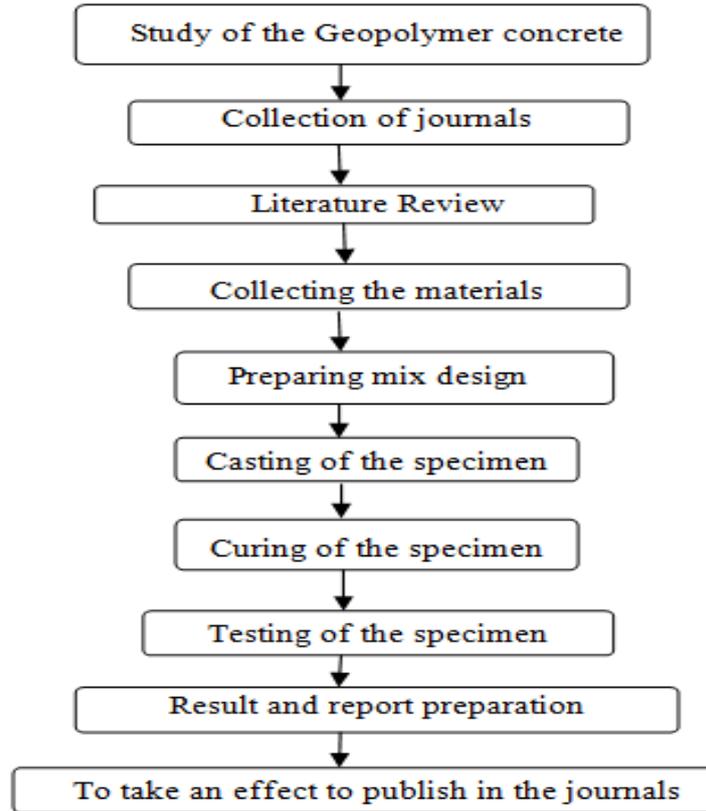


Fig.2 Methodology for the work

CASTING DETAILS

The number of specimens in normal concrete is 27 nos. The number of specimens in geopolymer concrete is 54 nos. The mix ratio is $M_{20} = 1:1.5:3$. The density of aggregate are 1872 kg/m^3 . The density of fly ash is are 377 kg/m^3 . The density of sodium silicate are 108 kg/m^3 . The density of sodium hydroxide are 43 kg/m^3 . The size of cube are $150 \times 150 \text{ mm}$, cylinder size are 150 mm dia, 300 mm height and prism size are 450mm length, 150 mm breadth, 150 mm height.

SAMPLE COLLECTION

FLY ASH

Fly ash is a by-product of coal fired electric generating plant. Fly ash can be used in Portland cement concrete to enhance the performance of the concrete.

Table.1 Properties of fly ash

S.No	Test Particulars	Result
1	Specific gravity	2.00 to 2.05
2	Bulk density	750 to 1800 (kg/m3)
3	Colour	Grey
4	Physical	Powder

ALKALINE LIQUID:

The sodium hydroxide (NaOH) solution was prepared by dissolving either the flakes or the pellets in water. terms of molarity 8M and 10M there adding $\text{Na}_2\text{O} = 14.7\%$, $\text{SiO}_2 = 29.2\%$ water 55.9% by mass.

FINE AGGREGATE:

Fine aggregate should consist of natural sand or crushed stone sand. The fine aggregate is various of type river sand, Specific gravity 2.50, Moisture content 0.16, Net water absorption 0.86, Fineness modulus 2.81.



Fig.3 Materials used

COARSE AGGREGATE:

Coarse aggregate are a broad category particulate inert materials used in construction. Hard stones are crushed to the required size and are used as coarse aggregate. The material that is retained on as IS Sieve of size 4.75 mm is called coarse aggregate. The size of coarse aggregates is 7mm, 14mm, 20mm. The aggregates are taken as 77% of mass of concrete in the preparation. The coarse aggregate is various of type crushed, maximum size 20mm, Specific gravity 2.76, Fineness modulus 7.23

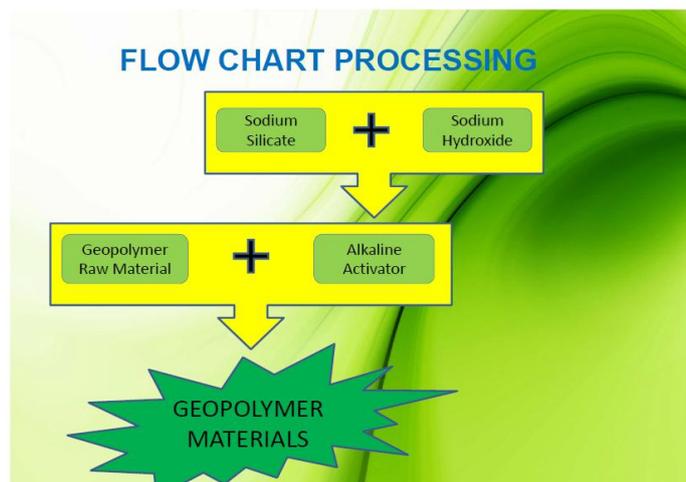


Fig.4 Ingredients of Geopolymer

MIX PROPORTIONS:

The following ranges were selected for the constitutions of the mixtures used.

Fly ash , Alkaline liquid , Ratio of sodium silicate solution to sodium hydroxide solution, by mass of 0.4 to 2.5. This ratio was fixed at 2.5 for most of the mixtures because the sodium silicate solution is considerably cheaper than the sodium hydroxide solution. Molarity of sodium hydroxide (NaOH) solution in the range of 8M to 16M Ratio of activator solution to fly ash by mass ratio of 0.3 and 0.4. Coarse and fine aggregates of approximately 75% to 80% of the entire mixture by mass. This value is similar to that used in OPC concrete. Extra water, when added, in mass.



Fig.5 oven curing

COMPRESION TEST

The determination of compressive strength has received a large amount of attention because the concrete is primarily designed to withstand compressive stresses. Compression test was done conforming to IS 516-1959(reaffirmed-1999). All the concrete specimens were tested in 2000KN capacity of the compression the testing machine. After curing, The maximum load applied specimen was recorded and the failure load was divided by the area of the specimen ton obtain the compressive strength of concrete. In the ultimate load, the cube get cracked that load was taken for calculating the compressive strength.



Fig.6 Compression Test on cubes



Fig.7 Testing on cylinder

RESULT

Compressive strength of control concrete and geopolymer concrete .For the compressive strength values are shown in Table.2 and split tensile strength values are shown in Table.3

Table.2 Compressive strength of cubes (N/mm²)

S.NO	7days	14days	28days
Control concrete	16.01	18.75	21.33
GPC (Air curing)	16.9	18.84	22.00
GPC (oven curing)	17.5	19.3	23.00

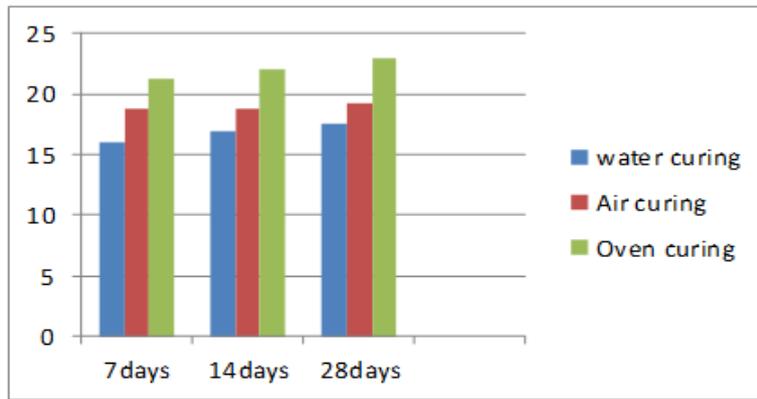


Fig.8 Compressive strength of cubes

Table.3 Split tensile strength of cylinders (N/mm²)

S.NO	7days	14days	28days
Water curing	1.70	1.92	2.15
Air curing	2.20	2.58	2.92
Oven curing	2.41	2.75	3.1

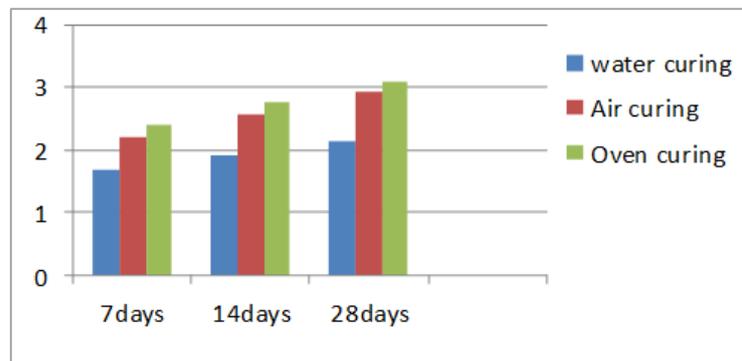


Fig.9 Split tensile strength of cylinders (N/mm²)

CONCLUSION

Based on the experimental work reported in this study, the following conclusions are drawn:

1. Polymerization process contributes the strength.

2. The compressive strength of geopolymer concrete does not vary with the age of concrete.
3. Longer curing time improves the polymerization process resulting in higher compressive strength.
4. The geo polymer concrete is resistant to the corrosive environment.
5. Therefore the fly ash based geo polymer concrete makes better compressive strength and replacement of binder material (cement). Also it provides cost reduction in project and eco-friendly green concrete.
6. An increase in the curing temperature increases the concrete compressive strength, especially up to 75°C.

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