EXPERIMENTAL STUDY ON GEOPOLYMER CONCRETE

P.Prashanth [1] , M.Prasanna Lakshmi [2], , Dr. G.Manohar [3],
[1]Assistant Professor, [2]Graduate student , [3]Professor,
Civil Engineering Department , Matrusri Engineering College, Hyderabad

ABSTRACT: The objective of this research work was to produce a carbon dioxide emission free cementitious material. The geopolymer concrete is such a vital and promising one. In this present study the cement is replaced by GGBS(Ground Granulated Blast Furnace Slag) and Fly Ash .The Alkaline liquids used in this study for the polymerization process are the solutions of sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3). A 10 Molarity solution was taken to prepare the mix. The cube compressive strength was calculated for 10 M solution for different mix Id i.e. $G_{10}F_{90}$, $G_{20}F_{80}$, $G_{30}F_{70}$, and $G_{40}F_{60}$ (Where F and G are, respectively, Fly Ash and GGBS and the numerical value indicates the percentage of replacement of cement by fly ash and GGBS). The cube specimens are taken of size 150 mm x 150 mm x 150 mm. Ambient curing of concrete at a temperature of 35-40^{0}c was adopted. In total 6 cubes and 3 beams were cast for different mix Id and the cube and beam specimens are tested for their compressive strength at age of 7 days, 14 day and 28 days respectively. The result shows that geopolymer concrete gains strength with increase in the GGBS content without water curing at ambient temperature. Also the strength of Geopolymer concrete was increased with increase in period of curing.

INTRODUCTION

Geopolymer concrete is an innovative and ecofriendly construction material and an alternative to Portland cement concrete. Use of geopolymer reduces the demand of Portland cement which is responsible for high CO_2 emission.

Geopolymer was the name given by Daidovits in 1978 to materials which are characterized by chains or networks or inorganic molecules. In 1978, Davidovits proposed that binders could be produced by a polymeric reaction of alkaline liquids with the silicon and the aluminium in source materials of geological origin or by-product materials such as fly ash. He termed these binders as geopolymers. Two main constituents of geopolymers are source materials and alkaline liquids. The source materials of alumino-silicate should be rich in silicon (Si) and aluminium (Al). Geopolymer cement concrete is made from utilization of waste materials such as fly ash and ground granulated blast furnace slag(GGBS). Fly ash is the waste product generated from thermal power plant and ground granulate blast furnace slag is generated as waste material in steel plant.

The threat of climate change is considered to be one of the major environmental challenges for the society. The production of cement contributes to the emission of CO2 through the decarbonization of limestone. Cement is one of the most important building materials used worldwide for the production of concrete. The cement industry is a major source of carbon emissions and deserves attention in the assessment of carbon emission reduction options. It is responsible for about 6% of all CO_2 emissions, because the production of one ton of Portland cement emits approximately one ton of CO_2 into the atmosphere. The contribution of Ordinary Portland Cement (OPC) production worldwide to greenhouse gas emissions is estimated to be approximately 1.35 billion tons annually or approximately 7% of the total green house gas emission to the earth's atmosphere. This research aims at 100% replacement of cement with fly ash as an alternative binding material.

METHODOLOGY

MATERIALS USED

GGBS(*GROUND GRANULATED BLAST FURNACE SLAG****)***

Ground granulated blast furnace slag (GGBS) is a by-product from the blast-furnaces used to make iron.

FLY ASH

Fly ash (FA) is a by-product of the combustion of pulverized coal in thermal power plants. It is a fine grained, powdery and glassy particulate material that is collected from the exhaust gases by electrostatic precipitators or bag filters.

ALKALINE SOLUTIONS

The solutions of sodium silicate and sodium hydroxide are used as alkaline solutions in the present work. Sodium hydroxide in pellets form and sodium silicate solution are used.

Fly ash was taken from thermal power plant, Ramagundam, karimnagar, Telangana .GGBS slag was obtained from JSW suppliers, Hyderabad. Locally available river sand having a specific gravity 2.65 was used. Crushed granite coarsed aggregate of 20 mm maximum size having a specific gravity of 2.56 was used. Distilled water was used in a concrete mix.

PREPARATION OF SOLUTIONS

In this work the strength of Geopolymer concrete is examined for the mixes of 10 molarity of sodium hydroxide. Molecular weight of sodium hydroxide is 40. To prepare 10 Molarity 400 g of sodium hydroxide flakes are weighed and they can be dissolved in distilled water to form litre solution. Volumetric flask of 1 itre capacity is taken, sodium hydroxide flakes are added slowly to distilled water to prepare 1 litre solution.

MIX PROPORTIONS

As there are no provisions for the mix design of geopolymer concrete, the design is done according to IS 10262 provisions. The alkaline liquid to fly ash and GGBS ratio is kept as 0.4. The ratio of sodium hydroxide to sodium silicate is kept as 2.5. The conventional method used in the making of normal concrete is adopted to prepare geopolymer concrete.

CASTING AND CURING

Firstly, the fine aggregates and coarse aggregates, fly ash and GGBS are mixed in dry condition for 3-4 minutes and then the alkaline solution which is a combination of sodium hydroxide solution and sodium silicate solution. Water is taken as 10% of the cementious material(fly ash GGBS). The mixing is done for about 6-8 mins. For proper bomding of all the materials. After mixing is done, cubes are casted by giving proper compaction in three layers.

The demoulded specimen are kept at a temperature of 35-40^{0}c for air curing until testing. Water is not involved in the chemical reaction of Geopolymer concrete and instead water is expelled during curing and subsequent drying. This is in contrast to the hydration reactions that occur when Portland cement is mixed with water, which produce the primary hydration products calcium silicate hydrate and calcium hydroxide

MATERIALS REQUIRED FOR 1 M3

Fly ash+GGBS	Sodium hydroxide	Sodium silicate	Fine aggregate	Coarse aggregate
478.95 kg/m^3	136.825 kg/m^3	54.73 kg/m^3	475.05 kg/m^3	1113.88 kg/m^3
Distilled water: 10% of the total cementitious material				

TEST RESULTS

The cubes are tested in compression and flexure testing machines to determine their compressive strength and flexural strength at the age of 1 day, 7 day and 28 days of curing. The results are shown in the following table.

COMPRESSIVE STRENGTH(N/mm2)

Mix	curing period					
	7 days		14 days		28 days	
A $G_{10}F_{90}$	11.56	11.11	12	13.33	11.11	12
B $G_{20}F_{80}$	24.44	24.889	25.33	27.11	32	32
C $G_{30}F_{70}$	29.78	30.22	24.44	26.67	33.33	37.78
D $G_{40}F_{60}$	28.89	26.22	27.556	32	33.33	33.78

FLEXURAL STRENGTH(N/mm2)

Mix	**curing period**		
	7 days	**14 days**	**28 days**
A $G_{10}F_{90}$	3.214	2.69	3.32
B $G_{20}F_{80}$	3.629	4.25	4.35
C $G_{30}F_{70}$	3.629	3.111	3.73
D $G_{40}F_{60}$	3.733	3.007	4.25

A $G_{10}F_{90}$- GGBS 10% FLYASH 90%
B $G_{20}F_{80}$- GGBS 20% FLYASH 80%
C $G_{30}F_{70}$- GGBS 30% FLYASH 70%
D $G_{40}F_{60}$- GGBS 40% FLYASH 60%


Casting **failure of cube**




casting of cubes **failure of beam**

Compression testing machine

Solution of NaOH and Sodium Silicate

CONCLUSION

User-friendly geopolymer concrete can be used under conditions similar to those suitable for ordinary portland cement concrete. Replacement of 100% of cement with GGBS is made possible without compromise in compressive strength.

GGBS was effectively used as a mineral admixture in modifying the microstructure of geopolymer concrete and also in the polymerisation process. It also developed very good binding property with alkaline liquids to yield a better strength and alkali activation process. These constituents of Geopolymer Concrete shall be capable of being mixed with a relatively low-alkali activating solution and must be curable in a reasonable time under ambient conditions

From the limited experiments conducted, it was found that,

- With the increase in the GGBS content from 10% - 40% of cement there is slight increase in the compression and flexural strengths of the member.
- With the increase in the period of curing there is slight increase in the strengths.

- This type of geopolymer concrete not only serves to replace the cement to a greater extent and also for making use of industrial waste products to minimize its disposal problem.

REFRENCES

1. IS : 10262 – 2009, "Concrete Mix Proportioning-Guidelines".
2. IS SP : 23-1982, "Hand Book On Concrete Mixes".
3. "GEOPOLYMER CONCRETE- A REVIEW", *International Journal of Engineering Sciences and Emerging Technologies*.
4. Journal on "Geopolymer Concrete an Eco-friendly Construction Material", *International Journal of Research in Engineering and Technology*.
5. Journal on "30 Years of Success and Failures in Geopolymer Applications", Prof. Dr. Joseph Davidovits,Geopolymer Institute, France
6. "Geopolymer concrete-Green Concrete for the Future-A Review", *International Journal of Civil Engineering Research.*
7. "Mechanical Properties of Fly Ash Based Geopolymer Concrete with Addition of GGBS as Smart Material", Dr. V.Bhikshma**.**
8. "A Brief Review on Geopolymer Concrete", *International Journal of Advanced Research.*
9. "Compressive Strength Of Thermal Cured Ggbfs Based Geopolymer Concrete", *Asian Journal Of Civil Engineering*, Vol. 17.
10. "Strength Characteristics Of Low Calcium Fly Ash Based Geopolymer Concrete", *IOSR Journal of Engineering*.
11. A Technical Paper on "Geopolymer Concrete For Environmental Protection" *The Indian Concrete Journal.*
12. "Geopolymer Concrete Using Different Source Materials", International Journal of Emerging Technology and Advanced Engineering.
13. "A Brief Review on Geopolymer Concrete", *International Journal of Advanced Research in Eduation Technology.*
14. https://www.researchgate.net/publication/Geopolymer Concrete For Ambient Curing Condition
15. N. Krishna Raju, "Design of Concrete Mixes", CBS Publishers and Distributors.
16. M.S. Shetty, "Concrete Technology".