STUDY ON PERFORMANCE OF GLASS FIBER REINFORCED GEOPOLYMERCONCRETEWITH COARSE AGGREGATES BY QUARRY DUST AND CERAMSITE

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Abstract: *Demand for concrete as construction material is on the increase and so is the production of cement. The production of one ton of cement liberates about one ton of CO_2 toatmosphere. In order to address environmental effects associated with Portland cement, there is need to develop alternative binders to make concrete. Recent years have seen a great development in new types of inorganic cement binders called ''geo- polymeric cement'' This prompted its use in concrete, which improves the greenness of ordinary concrete. Efforts have been made to replace the cement based binder in the current fibre reinforced cement concrete with ''geo-polymeric'' binder resulting in Fiber Reinforced Geo-polymer Composites (FRGCs). The present work deals with study of fresh properties, strength and durability of fly ash based fiber reinforced geo-polymer concrete.*

Keywords : *Geo-polymer Composites (FRGCs), geo-polymeric cement, geo-polymer, CO2 to atmosphere*

1- INTRODUCTION

The climate change due to global warming is one of the greatest environmental issues during the lastdecade. The global warming is caused by the emission of greenhouse gases, such as CO2, to the atmosphere by human activities. Among the greenhouse gases, CO2 contributes about 65% of global warming .The cement industry is responsible for about 6% of all CO2 emissions, because the production of one ton of Portland cement emitsapproximately one ton of CO2 into the atmosphere. In order to reduce the usage of Ordinary Portland Cement (OPC) in concrete, recent environmental awareness in construction industries promote the useof supplementary cement materials (SCM) such as fly ash, silica fume, granulated blast furnace slag (GGBS), rice-husk ash(RHA) and Metakaolin (MK).

Geo-polymer consists of silicon and aluminum atoms bonded via oxygen into a polymer network. Unlike ordinary Portland/pozzolanic cements, geo- polymer do not form calcium-silicate-hydrates (CSHs) for matrix formation and strength, but utilize the poly condensation of silica and alumina precursors to attain structural strength. Two main constituents of geo-polymer are: source materials and alkaline liquids. Any material that is rich in Si and Al in amorphous form such as fly ash, RHA, GGBS, Silica fume etc. can be a possible source material for geo-polymer binder. Fly ash is considered to be advantageous due to its high reactivity that comes from its finer particle size than slag. Moreover, low- calcium fly ash is more desirable than slag for geopolymer source material.

Geo polymerization involves the chemical reaction of alumino silicate oxides with alkali poly silicates yielding polymeric Si – O – Al bonds. Water is expelled from the mixture during the curing process. A critical feature is that water is present only to facilitate workability and does not become a part of the resulting geopolymer structure.

Concrete exhibits brittle behavior due to its low tensile strength. The addition of fibers, either short orcontinuous, changes its brittle behavior to ductile with significant improvement in tensile strength, tensile strain, toughness and energy absorption

capacities. Earlier studies show that addition of different types of fibres improves the mechanical properties of geopolymer concrete. Efforts have been made to replace the cement based binder in the current fibre reinforced cement concrete with ''geo polymeric'' binder resulting in Fiber Reinforced Geopolymer Composites (FRGCs), which is greenerthan the former one.

Durability is another important aspect of concrete. Earlier studies revealed that geopolymer concrete composites have performed better than Portland cement composites in durability related tests such as Sulphate, acid and corrosion resistance. This is mainly due to polymeric nature of geopolymer matrix without presence of free lime. Present study investigates the strength and durability aspects of fiber reinforced geopolymer concrete based on compressive strength, flexural strength, sulphate resistance test, sulphuric acid test and bulk diffusiontest.

COMPOSITION

Following materials are required to produce this concrete: Fly ash – A byproduct of thermal power plant GGBS – A byproduct of steel plant Fine aggregates and coarse aggregates as required for normal concrete.

Alkaline activator solution for GPCC as explained above. Catalytic liquid system is used as alkaline activator solution. It is a combination of solutions of alkali silicates and hydroxides, besides distilled water. The role of alkaline activator solution is to activate the geopolymer source materials containing Si and Al such as fly ash and GGBS.

3- MECHANICAL PROPERTIES

Compressive strength of geopolymer concrete has been found up to 70 MPa (N/mm^2). The concrete gains its compressive strength rapidly and faster than ordinary Portland cement concrete.

The concrete strength after 24 hours has been found to be more than 25 MPa. Compressive strength after 28 days has been found to be 60 to 70 MPa. - Ref. Paper by – James Aldred and John Day and Test results by SERC Chennai.

4 – OTHER PROPERTIES

The drying shrinkage of is much less compared to cement concrete. This makes it well suited for thick and heavily restrained concrete structural members.

It has low heat of hydration in comparison withcement concrete.

The fire resistance is considerably better than OPC based concrete – Reference – Paper by – JamesAldred and John Day.

This concrete jas chloride permeability rating of 'low' to 'very low' as per ASTM 1202C. It offers better protection to reinforcement steel from corrosion as compared to traditional cement concrete.

This concrete is found to possess very high acid resistance when tested under exposure to 2% and 10% sulphuric acids.

5 – APPLICATIONS

The applications are same as cement concrete. However, this material has not yet been popularly used for various applications.

This concrete has been used for construction of pavements, retaining walls, water tanks, precast bridge decks.

Recently world's first building Structural Building, The University of Queensland's Global Change Institute (GCI) has been constructed with the use of geopolymer concrete. It is a four story high buildingfor public use.

6 - DESCRIPTION AND LOAD CALCULATIONS

EXPERIMENTAL

Materials General In the review of literature various materials and the

conclusions were discussed in detail. From the above literatures the materials chosen for the present works are materials used.

- Fly Ash – (Class F)
- Chemical
  - Sodium Hydroxide.
  - Sodium Silicate.
- Super Plasticizer
- Aggregates
  - Fine Aggregate
  - Coarse Aggregate

Fly Ash

In Geo polymerization process, fly ash is one of the important ingredients in the creation of GC. It is a fine powder of spherical glass particles having pozzolanic properties consists of reactive silicon dioxide (SiO2), aluminum oxide (Al2O3), iron III oxide (Fe2O8) and other oxides.

It can be obtained by electrostatic (or) mechanical precipitation of dust like particles from the flue gases of power station furnaces fired with pulverized bituminous (or) other hard coal. There are two types of fly ash are exists, that in class C fly ash and class F fly ash having its own unique properties. The Specific gravity of Fly ash 2.13. The chemical composition of fly ash is shown in Table 1.

Table shows composition of Fly Ash

S. No.	Oxides	Percentage
1	SiO_2	58.70
2	Al_2O_3	30.35
3	Fe_2O_3	4.20
4	CaO	1.80
5	Na_2O	0.09
6	MgO	0.82
7	Mn_2O_3	0.09
8	TiO_2	1.88
9	SO3	0.30
10	Others	2.25
11	LOI	2.03

Alkaline Liquids

In Geo polymerization process, an alkaline solution is mainly used to activate the source materials. The main alkaline activate used for the Geo polymerization process are combination of Sodium or potassium hydroxide and sodium or potassium Silicate. Sodium based solutions were selected due to cheaper cost than potassium based solutions.

Chemicals

The alkaline activator solutions are main constituent for the geo polymerization process. Hence Sodium silicate and sodium hydroxide liquids are obtained from local suppliers in Chennai.

Sodium Hydroxide

Normally sodium hydroxide (Noah) is available in solid state either flakes (or) pellets form obtained from local suppliers. According to the purity of Noah, the cost will be varied. The Noah solution was prepared by dissolving the pellets in water. Depending upon the concentration of solution, the mass of Noah solids in a solution varied in terms of molar. For instance sodium hydroxide solution with concentration of 16M consists of 16 x 40 = 640 grams of sodium hydroxide solids (in pellet form) per liter of the solution. Where 40 is the molecular weight of sodium hydroxide.

Sodium Silicate

Sodium Silicate (Na_2SiO_3) is also known as water glass or liquid glass available in liquid gel form obtained from local suppliers. The mixture of sodium silicate solution and sodium hydroxide solution forms the alkaline liquid.

Super Plasticizer

Generally in fresh state, the GC has a stuff consistency. To achieve the adequacy in the Geopolymer concrete, super plasticizer is added. Depending on the solid content of the mixture a dosage of 1 to 2 percent by

weight of fly ash is advisable. In this present investigation a super plasticizer namely Master Glenium SKY8233 has been added for obtaining workable concrete.

Aggregates

Generally aggregate are the main material in the concrete. Based on aggregates the strength density and other properties of the concrete are varied. Fine aggregate and coarse aggregate are the main important aggregate in the concrete mix.

Fine Aggregate

The Fine aggregate which is used for the project is mainly M-Sand with the replacement of river sand obtained from local suppliers. Manufactured sand is defined as a purpose- made crushed fine aggregate produced from a suitable source material. Production generally involves crushing, screening and possibly washing. Separation into discrete fractions, recombining and blending may be necessary. In this M sand was used to replace the river sand like 0%, 20%, 40%, 60%, 80% & 100%. Properties of fine aggregates (M-sand and River sand) are tabulated below in Table2.

Properties of M-Sand and River Sand

Characteristics Values			Values
S.No		(M-Sand)	(Natural sand)
1	Type	Crushed	Uncrushed
2	Specific gravity	2.57	2.59
3	Bulk density	16571.27(kg/m3)	1564.64 (kg/m3)
4	Finess modulus	2.47	3.09
5	Grading zone	Zone II	Zone II

Coarse Aggregate

Grading of combined coarse aggregates having the sizes of 8mm, 10mm and 20mm were used and obtained from local suppliers. The properties of coarse aggregate are tabulated in Table below

7 - EXPERIMENTAL INVESTIGATION

Introduction

The Experimental investigation was carried out on the test specimen based on the mix design and variation of M-Sand to study the strength related properties of Geopolymer concrete. The experimental test for strength properties of concrete are compressive strength and split tensile strength test of concrete

Mix Proportion of Geopolymer Concrete

Student have studied and given that modified guidelines for Geopolymer concrete. Based on the ratio between alkaline liquid and fly ash have been taken as 0.60, the ratio between Na_2SiO_3 to Noah have been taken as 2.5 and fly ash content to compressive strength have been taken.

Preparation of Alkaline Activator Solution

The alkaline activator solutions are a combination of sodium hydroxide and sodium silicate solutions. To prepare sodium hydroxide solution of 16 Molarities (16 x 40) 640 g of sodium hydroxide pellets are dissolved in one liter of water. The mass of Noah solids in the solution varies depending on the concentration requirement. The prepared Noah solution was added with Na_2SiO_3 solution according to the mix, 24 hrs before casting.

Geo Polymer Mix Design

The aggregates occupy the largest volume by mass in geopolymer concrete. The alkaline activator solution is mainly used to activate the silicon and aluminum in the fly ash. The mix proportion values shown below in table.

Constituents	Density (kg/m3)
Coarse aggregate	1295
Fine aggregate	555
Fly ash	345
Sodium silicate	146.43
Sodium hydroxide	58.57
Super plasticizer	6.9

In the above trial mix design the fine aggregate of natural river sand has been replaced by M-Sand in the proportions of 0%, 20%, 40%, 60%, 80% & 100%.

Results and Discussion

The compressive strength and split tensile strength tests have been carried out for the Geopolymer concrete with the replacement of M-Sand.

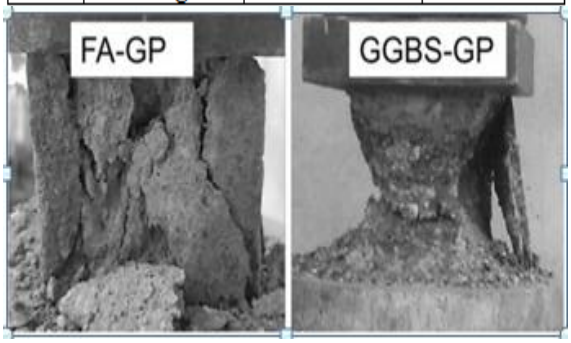
Test specimens

The test specimens for compressive strength testwere carried out in the cubes of having size of 100 mm x 100 mm x 100 mm for each replacement percentage of M-Sand, the three numbers of cubes were cast ,oven dried for 24 hours and tested at 60°C the age of 7 days and 28 days. The test specimens for split tensile strength test were carried out in the cylinders of having a size of 100 mm diameters and 200 mm high cast iron moulds were used. For each replacement percentage of M-Sand, the three number of cylinders were cast, oven From the above test results obtained for the compressive strength shows that there is increase in strength when manufactured sand is fully replaced by river sand.

Tensile Strength

The variation of Tensile strength at the age of 7^{th} and 28^{th} days by varying the percentage of M-sand like 0%, 20%, dried for 24 hrs @ 60°C and tested at the age of 7 days and 28 days. The details of test specimens are tabulated below.

S.No	Name of test	Size of Specimen (mm)	No of Specimens
1	Compressive strength	100X100X100	36
2	Spilt tensile strength	100X200	6



Compressive Strength Test

The variation of compressive strength at the age of 7^{th} and 28^{th} days by varying the percentage of M-sand like 0%, 20%, 40%,60%, 80%,100% for river sand. Results are tabulated below in Table below.

	Cube Strength (N/mm^2)	
	7Days	28Days
M1	21.98	31.28
M2	22.40	31.60
M3	22.90	33.00
M4	23.45	33.45
M5	23.92	33.45
M6	25.10	35.25

40%,60%, 80%,100% for river sand. Results are tabulated below in table.

	Tensile Strength (N/mm^2)	
	7Days	28Days
M1	1.37	2.38
M2	1.42	2.48
M3	1.43	2.50
M4	1.48	2.58
M5	1.50	2.62
M6	1.54	2.69

8 – SUGGESTIONS FOR FUTURE WORK

- Flexural strength of the Geopolymer concrete beams shall be studied.
- Durability property of the Geopolymer concretewith M-sand shall be carried out.
- Geopolymer concrete beam reinforced concrete beams & columns, Reinforced concrete beams and columns wrapped or strengthened by FRP have to be investigated.

9 – CONCLUSIONS

Based on the experimental investigation the following conclusions are below. From the above test results obtained, the compressive strength and Split tensile strength of the Geopolymer concrete increases when quarry sand isfully replaced the river sand.

Hence it proves that Geopolymer concrete using M- sand is an alternative to Ordinary Portland Cement. Since no cement is used in Geopolymer concrete; a lot of energy can be saved. The waste material of Flyash helps to reduce the atmospheric pollution.

Fibers increased compressive and flexural strength, ceramsite decreasing the compressive and flexural strength but ceramsite decreased the weight of concrete compare to ordinary concrete.

10 – REFERENCES

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