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Study on Properties of Geo-Polymer Concrete Using Steel Fibers

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Abstract:- There is rapid development in construction industry, which is also one of the important sources of there venue of the country. Construction industry provides a great source of employment opportunity, and also improves living standard of the people in the country. There is a lot of benefit from the construction industry, but there is a little disadvantage because of excess usage of cement in the construction. As the cement is a key element in the construction it emits some toxic gases like CO2 in the excess amount during Manufacture of cement To overcome this problem scientist has done a lot of research on it and finally a French scientist Davidovits found a compete cement replacing agent called GEO-POLYMER concrete. Geo-polymer is a concrete which is used instead of cement and is a binded mixture of elements fly ash and GGBS. Fly ash which is residue from the coal manufacturing industry and blast furnace slag are the key constituents for preparing geo-polymer concrete. Fine aggregates, coarse aggregates are mixed to it and finally water is added to prepare Geopolymer concrete. So in this study an attempt is made to know the strength of geo-polymer concrete by adding holed steel bars in the mix. By making 3 mixes with varying proportion of fly ash and GGBS like 1st mix with 70% fly and 30% GGBS, 2nd mix with 50% fly ash and 50% GGBS and finally 60% fly ash and 40% GGBS. For all the 3 mixes hooked steel fiber were added and from this cubes of size 150mm x 150mm x 150mm and 21 in number were casted. And 21 cylinders with size 150mm dia and 300mm height and beams of size 100mm x 100mm x 400mm 21 in number were casted. And all the test specimens were tested for compression test, flexural test and split tensile test. And finally strength of geopolymer concrete with steel fibers is determined.

Keywords:- *Geopolymers, fly ash, Alkaline Liquids, GGBS, Steel fibers,*

I. INTRODUCTION

Concrete is the most widely used contraction material. Cement is the main component for making concrete. It is estimated that production of cement is increase 3% annually, in this process it is observed that production of 1 ton cement produce 1 ton of CO2 gas. Among the greenhouse gas CO2 contributes about 65% of global warming further it has been reported that the durability of ordinary Portland cement concrete is under examination, as many concrete structures are specially build in corrosive environment to start to deteriorate after 20 to 30 years even though they have been designed for more than 50 years of service life. It is time to apply new technology materials like Geopolymers that offer waste utilization and emission reduction.

On the other scenario huge quantity of fly ash generated around the world from the thermal power plant and leads to waste management problem. Alternative binder system within fly ash to produce concrete eliminating cement is called "Geopolymer concrete". Geopolymer is a type of amorphous alumina- silicate product that exhibit the properties of rock forming element i.e. hardness of chemical stability and longevity.

Geopolymer binder are used together with aggregate to produce Geopolymer concrete which is ideal for building and repairing infrastructure and for pre-casting unit. The properties of Geopolymer include high early strength, weak in shrinkage and resistance to freeze-thaw, sulphates and corrosion resistance. This material can save up to 80% of CO2 emission which is released in the process of making cement and aggregate industries.The global use of concrete is second only to water.How much demand incerases for concrete as a construction material, so also increases the demand for Portland cement. It is observed that the production of cement increased by 1.5 billion to 2.2 billion tons from 1995 to 2010 (Malhotra, 1999).

On the other hand, global warming became a major concern due to the climate change.. The global warming is caused by the emission of greenhouse gases, such as carbon dioxide (CO2), to the atmosphere by human activities. Among all the greenhouse gases, CO2 contributes about 65% of global warming. The cement industry is held a major responsible factor for some of the CO2 emissions, because the production of one ton Portland cement emits approximately one ton of CO2 into the atmosphere. Several efforts are in progress to supplement the use of Portland cement in concrete to control the global warming issues. The supplement for Portland cement should include the utilization of supplementary cementing materials such as fly ash, silica fume, granulated blast furnace slag, rice-husk ash and metakaolin.

In this respect, the geopolymer technology shows considerable promise for application in concrete industry as

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an alternative binder to the Portland cement (Duxson et al, 2007). In terms of global warming, the geopolymer technology could significantly reduce the CO2 emission to the atmosphere caused by the cement industries as shown by the detailed analyses of Gartner (2004).

A. Properties of Geo-polymer concrete (GPC)

- Higher compressive, Tensile and flexural strength
- Elasticity modulus
- Higher durability
- Bleeding free and non-toxic
- Impermeable
- Higher resistant to all inorganic chemicals and heat
- Higher resistance against chemical attack
- Substantially higher fire resistance (up to 2400°F)
- Rapid strength gain and lower shrinkage
- Greater corrosion resistance

Fiber reinforced concrete with the supplement of steel fibers is commonly applied to make industrial floors as well as road and airport runways.Fibre-reinforced concrete is also used to make machine foundations and other elements exposed to dynamic loads .so hooked end steel fibers are used in this mix .

II. MATERIAL USED

A. Fly ash

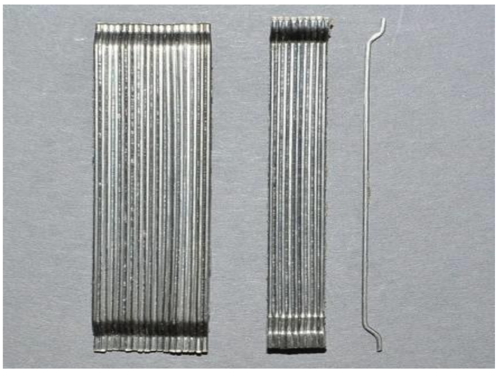
For this case study, the main material (fly ash) is collected from power plant KTPS Palvancha, Badradri Kothagudem district. The chemical and physical composition of main material (fly ash) was determined as per IS: 3812 Table2. It is classified into 2 classes:
Class F- fly ash: it has good puzzolonic properties and it produced by burning of bituminous coal and it as less than 5% of calcium oxide.
Class C- fly ash: it is produced by burning of lignite/ sub standards of bituminous coal. This type of Fly ash may have calcium oxide content in excess of 10% addition to its puzzolonic and concreteous properties.

B. Ground granulated blast furnace Ash (GGBS)

GGBS is a by product of the Iron and steel making in the molten stage. Slag is essentially comprised of silica (35%), alumina (13%), calcium oxide (40%), and magnesia (8%). Different components like manganese, iron, sulphur, and follow measures of different components make up about other 5% of slag. Slag is precisely amassing components somewhat depending on where and how the slag is created. Around 30% by mass of binder was replaced with GGBS. The GGBS which is used in this work is brought from cement plant, Vizag. Ground Granulated Blast Furnace Ash is partially replaced with concrete in geo polymer concrete. GGBS gives better workability without increase in water content, and decreases heat of hydration. After concrete get hardens durability, its ultimate strength will increase. The tests on granulated blast furnace slag were carried out as per (IS: 383-1970).

C. Fiber

Hooked-end steel fibers are made with low carbon steel which has a length of 15mm and a Dia of 0.3 mm thus giving an Aspect ratio of 50 were used and they are shown in Figure. These fibers have a density of 3925 kg/m3, modulus of elasticity of 2 x10^5 MPa and yield strength of 650 MPa



C. Alkaline Liquid

In this study, Sodium hydroxide (NaOH) and sodium silicate combine to prepare Alkaline liquid. Sodium solutions are used because they are more economical than potassium solutions. For this study we are using concentration of 8M of alkaline liquid. Sodium hydroxide pellets and flakes are available in market.

D. Selection of suitable mix proportion

As discussed from the beginning geopolymer concrete is the mixture of fly ash, GGBS, 70% of aggregates and water which is complete replacement of ordinary Portland cement . In this research geopolymer concrete mix is prepared with different percentages of both Fly ash and GGBS as these two are key elements in the concrete. Firstly 3 combinations of different percentage of fly ash and GGBS are takes like 1st combination 70% of fly ash with 30% ofGGBS, and 2nd combination where both fly ash and GGBS are taken equally that is 50% - 50%, and finally the third combination where fly ash is used is 60 and GGBS is 40%. With these 3 combinations of geopolymer mix hooked steel fibers were added. When the hooked steel fibers were added.in ordinary concrete the 1.5% showed the best results so the same percentage can be used in the geoploymer concrete as well.

After the geopolymer concrete mix prepared with 1.5% of hooked steel fibres test specimens were casted like cubes of size 150mm x 150mm x 150mm in size, and cylinders with length 300mm and diameter 150mm, and finally beams ofsize 100 x 100mm x 400mm each specimens that is cubes, cylinders and beams each of 24 in number were casted. After that the test specimens were kept for ambient curing and different tests like compressive test, tensile test and split test were carried for a period of 7days and 28 days.

III. LITERATURE REVIEW

A. Davidovits Joseph on "Properties of Geopolymer Cements".

In this paper he analyses the Geopolymer cement as high alkali (K-Ca)-Poly (sialate-siloxo) cement, results from an inorganic polycondensation reaction, so-called Geopolymerisation yielding three dimensional zeoliticpolycondensation frameworks. This high tech Geopolymer K-poly (sialatesiloxo) binder whether use pure, with filler or reinforced. Geopolymer cement hardens rapidly at room temperature and provides compressive strength in the range of 20 MPa. Final 28 day compressive strength was in the range of 70-100 MPa. X-ray diffraction results showed that polycondensation of various alkali-alumino-silicates present in Geopolymer binder, are actually amorphous material which are difficult characteristic. The X-ray diffraction pattern suggest however that (Na-K)-PSS, (Ca-K)-PSS and K-PSS consist of disordered framework of short-range order materials with structure similar to those feldspatic glass or crystalline zeolites.

B. Hardijito, D., Wallah, S.E., Sumajouw, D.M.J and Rangan[12]., on "Development of fly ash based Geopolymer concrete."

Hardijito et al.Investigated the effect of various synthesizing parameter on fly ash based Geopolymer concrete prepared by low calcium class „F fly ash with sodium hydroxide and sodium silicate activated solution. Four type of local available aggregate of size 20 and 14 and 7 mm and fine sand. Mixture was casted using 100 x200 mm steel cylinder mould with 30-60 min rest period. The compressive strength test specimen was performed to find the influence of various Geopolymer synthesizing parameters such as (a) Concentration of sodium hydroxide (b) Sodium silicate to sodium hydroxide liquid ratio (c) Curing time and curing temperature, (d) adding of High range water reducing admixture (e) Handling time (f) Water content in the mixture. Results revealed that the higher concentration of sodium hydroxide solution result in a higher strength of Geopolymer concrete. Higher ratio of sodium silicate to sodium silicate by mass increases the compressive strength. Curing temperature in the range of 30 to 900C and Curing time 6 to 96 Hours produce large amount of compressive strength. Fresh Geopolymer concrete easily handle up to 120 min without any setting. It was also observed that a little drying shrinkage and low creep with high resistance against sodium sulfate.

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D. Thakur Ravindra N. and GhoshSomnath[41]on "Performance of Fly Ash based Geopolymer composite at elevated temperature."

Thakur et al. investigation on Physico-mechanical and microstructure characteristic of Fly ash based Geopolymer Composite expose to elevated temperature. Bulk density apparent porosity, compressive strength, Weight loss and Microstructure of Geopolymer paste and Mortar Specimen were studied after expose up to 900^0C.The apparent porosity and bulk density of the Geopolymer matrix increase corresponding with Si: Al Ratio and decrease with increase with expose temperature. Thermo gravimetric analysis revealed that specimen loss it weight at elevated temperature due to dehydration, Dehydroxylation and densification process occurred during transient heating from room temperature to 900^0C.

IV. STEEL FIBRES

Use of hooked end steel fibres of aspect ratio 60 is used. For Geopolymer concrete mix we have crimped stainless steel fibres. & mild steel fibres. The use of fibres in conceret has the property to resistance against cracking & crack propagation. The fiber composite pronounced post cracking ductility which is unheard in ordinary concrete .The transformation from a brittle to ductile type of material would increase substantially the energy absorption characteristics of the fiber composite. These fibres are short, discrete lengths having an aspect ratio in the range of 20-100.

A. Properties of Hook end Steel fibres

Length	30 mm
Diameter	0.5 mm
Aspect Ratio	60
Specific Gravity	-----
Water absorption	0
Shape	Hook end type

V. PROPERTIES OF FLY ASH (taken from K.T.P.S paloncha) :

SL NO	PARAMETETS	UNITS	RESULTS
I	**Physical properties**		
1	**Fineness**	**Sq/kg**	**324**
2	**Bulk density**	**Gm/cc**	**2.23**
II	**CHEMICAL PRPPERTIES**		
1	**Silica as Sio_2**	**%**	**62,74**
2	**Aluminium as al_2o_3**	**%**	**12.90**
3	**Iron as Fe_2o_3**	**%**	**2.24**
4	**Iron as Feo**	**%**	**0.19**
5	**Calcium as Cao**	**%**	**6.75**
6	**Magnesium as Mgo**	**%**	**1.28**
7	**Sodium as Na_2o**	**%**	**0.96**
8	**Potasium as K_20**	**%**	**0.20**
9	**Sulphate as SO_4**	**%**	**2.01**
10	**Loss on Ignition**	**%**	**2.20**
11	**Titanium as TIO_2**	**%**	**0.77**
12	**P^H(5% solution)**	**%**	**6.85**

A. Mix proportion per cubic meter

Combined aggregate	782.3529kg
Fine aggregate	518kg
Coarse aggregate	1100kg
NaOH	63.8655kg
Sodium silicate	159.6639kg
Fly ash	558.8235kg
GGBS(30% of fly ash)	167.646
Hooked Steel Fiber	118

VI. EXPERIMENTAL RESULTS

This chapter will present the results of the carried out experimental program on these reinforced Conventional concrete along with reinforced geopolymer concrete. This behavior of load characteristics is presented in this chapter.

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A. Compressive strength

Without steel fibres :	
For 7 days	32 N/mm^2
For 14 days	39.5 N/mm^2
With Hooked end steel fibres :	
For 7 days	36 N/mm^2
For 14 days	42.1 N/mm^2

B. Advantages

- Reduces co_2 emission
- Utilization of by product(fly ash)
- Durable
- Economically sustainable
- Fire proof
- Chemical resistance
- High tensile and compression strength

C. Disadvantages

- Difficult to create
- Pre-mix only
- Geopolymerization process is sensitive

D. Applications

- Precast concrete products like railway sleepers, parking tiles, and geopolymer concrete blocks.
- In marine structures due to chemical attacks.
- Where the fire resistance material is required.
- In road construction.

VII. CONCLUSION

❖ The influences of GGBS on strength of geopolymer concrete mixes were studied. It has been observed that the increasing the quantity of GGBS and compressive strength of geopolymer increases.

❖ Compressive strength of geopolymer concrete without fibres has increased by 10.63% then conventional concrete.

❖ Compressive strength of geopolymer concrete with fibres has increased by 10.70% then conventional concrete.

❖ Geopolymer concrete produces a substances that is comparable to or better than traditional cements their properties.

❖ Fly ash based geopolymer concrete has excellent compressive strength and is suitable for structural applications.

❖

❖ Due to geopolymer concrete the consumption of cement, emission of carbon di-oxide and greenhouse effect are reduced.

❖ The Geopolymer concrete mixes were produced easily using equipment similar to those used for production of conventional concrete.

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