STRENGTH OF GEOPOLYMER CONCRETE- A REVIEW

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Abstract: Concrete industries and environment has a very strong bond. Concrete demands OPC in large amount for building several huge and mega structures. The CO2 emission from Portland cement industries harms a lot to the environment. It is necessary to find alternate low emission binding solution for Portland cement. Geopolymer concrete is polymer material which utilizes the by products from coal and steel industries like fly ash, ground granulated blast furnace slag and also metakaoline etc. along with the alkaline activators. This paper reviews the strength parameters for class F fly ash based GPC and metakaoline based GPC. The geopolymer concrete is really a green solution for concrete to reduce CO2 emission.

Index Terms **– Alkaline Activators, fly Ash, Geopolymer concrete, Metakoaline.**

I. INTRODUCTION

Construction sector plays a vital role in the urbanization and globalization. Many unexpected dreams comes true because of building mega structures worldwide. Beside all the advantages construction industry is also responsible for global pollution. In global energy related emissions, around 38% of total amount comes from building and construction sector. In advance construction system, CO2 emission due to ordinary Portland cement has become a global issue. Worldwide many being taken by construction sector to reduce environmental damage for example adaptation of green buildings etc. As a part of 10th annual world green building week, world green building council has issued bold new vision for how building and infrastructures around world can reach 40% less embodied CO2 emission by 2030 and 100% net zero emissions buildings by 2050.

To overcome this difficulty many researchers are continuously working on alternative solution of OPC. This research work reveals that geopolymer concrete is proper and green alternative for reducing CO2 emission. In the same manner recycled raw materials and for demolished concrete is also going on. This paper reviews all the important properties of geopolymer concrete. It is an eco-friendly alternative for OPC, as it uses waste products from mainly coal and steel (thermal power plant and steel plant). It has composition of fly ash and ground granulated blast furnace slag. By using these two materials vast stock of waste materials will reduce and also the CO2 emission. Alkaline silicates and alkaline hydroxide are the activators used in concrete along with the super plasticizer. In India, geopolymer concrete is not been used so much for mega structures. It can be fly ash based type, GGBFS based type and also metakaoline based geopolymer concrete.

II. POLYMERIZATION PROCESS

Polymerization process involves dissolution of alumino-silcate and condensation of free silicates and aluminates to form three dimensional silico-aluminate structure. For the process alkaline activator solution is needed.

III. MATERIAL STUDY

Geopolymer concrete consists of two main materials- source materials and alkaline activators. Source materials should be rich in Al and Si. Such materials can be natural like kaolinite and clay or the byproduct like fly ash, GGBFS, rice husk ash etc. [11].

3.1Fly Ash

It is also called as fuel ash or pulverized fuel ash. PFA is a combustion product of coal industry, obtain in the form of particulates which are thrown out of coal-fired boilers together with fuel gases. All fly ash includes amount of silicon dioxide (SiO2), Aluminum oxide (Al2O3) and calcium oxide (CaO) etc. Depending on the chemical composition and presence of cementitious materials in it, PFA can be partially or fully used as replacement of Portland cement.

Class F- this type is pozzolanic in nature, less than 7% lime, can form geopolymer.

Class C- In this type in addition to having pozzolanic properties, is has self-cementing properties too.

Fig.1 fly ash

3.2 Ground Granulated Blast Furnace Slag

Ground granulated blast furnace slag, which is GGBS or GGBFS, is a byproduct of iron and steel making industry. GGBFS is highly cementitious and contain high calcium silicate hydrate CSH, which makes GGBS to be used in concrete. Composition of GGBS helps to improve strength, durability and appearance of concrete.

Fig.2 ggbfs

3.3 Metakaoline

It is anhydrous calcined form of clay mineral kaolinite. Metakaoline properties mainly depend on the properties of kaolinite.

3.4 Activators

Alkaline solution like NaOH, KOH –alkaline hydroxides and Na2SiO3, K2SiO3 – alkaline silicates required to bind the polymer material like fly ash and GGBFS.

Fig.3 alkaline activators

3.5 Super Plasticizer

The admixtures like retarders, accelerators, plasticizers are chemical agents that added to concrete to enhance the properties and make it workable in different environmental conditions. Super plasticizers are the chemical additives which helps to reduce water content. It is a higher version plasticizer and allow reduction in water content by more than 30%.

IV. STRENGTH PROPERTIES OF GPC

Geopolymer concrete concept was first introduced by Joseph Davidovits. As the GPC mainly requires source materials and the alkaline activators, it has different curing methods than conventional concrete.

4.1 Properties of fly ash based GPC

4.1.1 Effect of molarity of alkaline solution on compressive strength

Raijiwala D.B. et.al.studied different properties of low calcium fly ash ASTM class F with potassium hydroxide and sodium hydroxide solution of desired molarity. They concluded that the GPC has 1.5 times greater compressive strength than conventional concrete [3]. Also Mr.G.Hemanaag et.al.studied GPC properties with alkaline solution as sodium silicate and sodium hydroxide with molarity varying from 2M to 8M. Study was based on comparison of fly ash and metakaoline based GPC and results of fly ash based GPC having 8M shows higher results up to 520 N/mm2 [1].Prakash R. Vora et.al.explained increase in concentration of NaOH in terms of molarity will increase the compressive strength of GPC [9].

4.1.2 Effect of additive on strength of GPC

Dhavamani Doss Sakhtidoss et.al.casted a high strength GPC with river and M-sand. They got better results in terms of compressive strength in case of HSGPC with M-sand up to 71.46 N/mm2 compared to HSGPC with river sand. Manufacturing sand will also be the best possible alternative for river sand [7]. A.Supriya Prakash have used cylindrical steel fibers with hooked ends and added in the 0.5%, 1% and 1.5% by volume of concrete. They got 5% increase in compressive strength for 1% fibers [4]. Xin Ren et.al.used recycled aggregates for casting GPC and got the better results than NA. Demolished concrete lumps can also act as a better additive for GPC [2].

4.1.3 Flexural strength of GPC

Raijiwala D.B. tested the specimens for flexural strength. Over controlled concrete GPC shows 1.6 times increase in flexural strength. [3].

4.1.4 Split tensile strength of GPC

Steel fibers when used in GPC showed 5% increase in split tensile strength. [4].

4.2 Metakaoline based GPC

4.2.1 Effect of metakaoline on compressive strength

M. Muthuanand et.al studied and used metakaoline in partial replacement of fly ash in 10%, 20% and 30% to prepare geopolymer concrete. Metakaoline can be prepared by selected kaoline and this material is also an effective to produce HSGPC. 30% replacement of metakaoline increases strength of GPC up to 31.63 N/mm2 as compared to conventional concrete. The study also includes the comparison of compressive and split tensile strength of both conventional concrete and fly ash based GPC and also GPC with partial replacement of fly ash with metakaoline. 30% metakaoline replacement showed higher results for strength [6]. The study of Mr. G.Hemanaag compared the metakaoline based GPC with fly ash based GPC and concluded that as compared to fly ash metakaoline based GPC is better and showed the strength 566.66N/mm2 for 8M alkaline solution [1].

V. CURING METHOD FOR GPC

Geopolymer concrete go through the polymerization process during curing. Alkaline activators helped for this process. For class C fly ash based GPC these activators need not to add in to the GPC, as it has self-activating properties. Polymerization process requires high temperature than normal. Geopolymer concrete cannot be cured in water like conventional concrete. The methods like oven curing, membrane curing, steam curing, ambient curing, etc. adopted [11]. Research for effect of curing temperature and curing time has carried out by many researchers. Oven curing is adopted by many laboratories for GPC. Prakash R.Vora casted the GPC specimens and allowed them to heat cured in oven for 24-48 hours up to 750 C curing temperature. After this the specimens were left in molds to avoid changes in concrete. After demolding they were allowed to rest at normal room temperature up to the test day [9]. The curing time may affect the strength properties of GPC. In the work of Mr.G. Hemanaag the specimens were cured in oven for 12 hours at 600C and after demolding they were allowed to cool at room temperature for 3,7,28 days [1]. For practical application the curing time should not be more than 24 hours [11].

CONCLUSION

Effective alternative for OPC will be the geopolymer concrete. From the review it can be concluded that metakaoline based GPC will give higher strength results than fly ash based GPC. But as compared to fly ash metakaoline is costly so fly can be used as the better solution for concrete industries for future.

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