International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 08 | Aug-2016 www.irjet.net p-ISSN: 2395-0072

REVIEW PAPER ON GEOPOLYMER CONCRETE BY USING GGBS

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Abstract-*Geopolymer concrete technology has the potential to reduce globally the carbon emission and lead to a sustainable development and growth of the concrete industry. The influence of alkaline activators on the strength and durability properties has been studied and environmental investigation has been undergone in addition with GGBS (Ground Granulated Blast Furnace Slag). Sodium Hydroxide is available in plenty and Sodium hydroxides. These binders have been reported to achieve high early strength and better durability as compared to Ordinary Portland cement based counterparts.*

Sodium hydroxides were added by the 1:2.5 ratio as alkaline activators along with sodium silicate at varying temperature in the preparation of geopolymer concrete. Fly ash was procured from a local thermal power station. Compression and Durability test were performed. The results indicate that the combination of the above constituents at 60°C has a positive impact on the strength and durability properties of geopolymer concrete.

Key words: Geo polymer concrete, F-fly ash, GGBS, Alkaline solution, Super plasticizer, Durability test.

1. INTRODUCTION

Portland cement is the most used material in the worldwide construction industry and has a high level of CO2 (1 ton of cement generates 1 ton of CO2) and also its use tends to become less competitive compared to alternative ecological new binders like geopolymers. Although research in this field has been published as "alkali-activated cement, or "alkaline cement" the term "geopolymer" is the generally accepted name for this technology.

Hardjito.D et al (2005), explains Geopolymerisation involves a chemical reaction between various aluminosilicate oxides with silicates under highly alkaline conditions, yielding polymeric Si–O–Al–O bonds indicating that any Si–Al materials could become sources of geopolymerization. Geopolymer binders are used together with aggregates to produce geopolymer concrete which are ideal for building and repairing infrastructures and for precasting units, because they have very high early strength, their setting times can be controlled and they remain intact for very long time without any need for repair.

Fernando Torgal,et al(2008) investigated the properties of geopolymer include high early strength, low shrinkage, freeze-thaw resistance, sulphate resistance and corrosion resistance. These high-alkali binders do not generate any alkaline aggregate reaction. The geopolymer binder is a low-CO2 cementious material. It does not rely on the Calcination of limestone that generates CO2.

1.1 GGBS as a binder replacement in concrete

Debabrata Dutta et al (2014) experimentally found the detail of Ground Granulated Blast Furnace Slag (GGBS) is obtained during the steel making process, when the slag is quenched to form granules. Granulated Blast furnace Slag (GGBS) is the byproduct obtained in the manufacture of pig Iron in blast furnaces at around 1400° to 1500°C in the molten form. The slag is obtained by rapidly chilling the molten ash from the furnace by means of chilled water and is ground about 400 m^2/kg of fineness by using state of the art grinding mill to make GGBS. It is a non-metallic product consisting essential of glass containing silicates and alumino Silicates of lime

1.2 CHARACTERS OF GGBS

Fernando Torgal,et al(2008) reported the charters of GPC as follows

- Reduction in heat of hydration and minimization of Thermal cracks.

- Permeability and surplus lime liberated during the hydration of Portland cement are the root causes for deleterious effect on the concrete.
- Absorption of surplus lime released out of OPC to form in to secondary hydratedmineralogy.
- Pore refinement and grain refinement due to the secondary hydrated mineralogy, thus contributing for impermeability and enrichment of transition zones.

2. Materials

Anuar.K.A, et al (2007) concluded the materials needed to manufacture the fly ash-based geopolymer concrete are the same as those for making Portland cement concrete, except for the Portland cement. Low calcium (class F) dry fly ash obtained from a local power station was used as the source material.

For the alkaline activator, a combination of sodium hydroxide solution and sodium silicate solution was used. The sodium hydroxide solution was prepared by dissolving the sodium hydroxide solids, either in the form of pellets or flakes, in water. Extra water and Naphthalene Sulphonate-based super plasticizer were also added to improve the workability of the fresh fly ash-based geopolymer concrete. The sodium silicate solution used contained Na2O=14.7%, SiO2=29.4%, and 55.9% of water by mass. All the liquids were mixed together before adding to the solids.

2.1 F-Fly ash

For this research purpose low calcium ash was collected from METTUR THERMAL PLANT, India. It had chemical composition as given in Table1.

TABLE 1

CHEMICAL COMPOSITION	FLYASH(%MASS)
SiO_2	57.79
Al_2O_3	20.18
Fe_2O_3	7.04
TiO_2	1.03
CaO	2.97
MgO	1.98
P_2O_5	0.26
SO_3	0.84
Alkaline	3.69
LOI	4.22

2.2 Alkaline Liquid

Hardjito.D, et al (2005), briefly explains the alkaline liquid used was from a combination of sodium silicate solution and sodium hydroxide solution. The sodium silicate solution (Grade A53) comprised 14.7% of Na2O, 29.4% of SiO2, and 55.9% of water by mass. The sodium hydroxide solution was prepared by mixing 98% pure flakes in water. Both the solutions were mixed together at least 24 hours before use .the ratio of sodium hydroxide to sodium silicate solution is 1:2.5.

Table-2

MOLARITY	MASS OF Sodium Hydroxide (NaOH)(gms)
8M	360
10M	310
12M	361
14M	404
16M	444

2.3. Aggregates

Aggregates currently used by the all constructions are used. Both coarse and fine aggregates were wet. The moisture contents of the aggregates over and above the saturated-surface-dry (SSD) condition were determined by tests. The specific gravity is also determined by the tests.

i) Fine aggregate

Ordinary sand available in Tiruppur, Tamilnadu (noyyal river sand) having the following characteristics has been used.

Specific gravity: 2.67
Fineness modulus: 2.60
Unit weight: 1.674 gm/cc
Water absorption: 0.44%
Bulking: 25%

ii) Coarse aggregate

Locally available black crushed stone in Tamilnadu with maximum nominal size of 20 mm and 10 mm have been used as coarse aggregate. The physical properties for the coarse aggregate as found through laboratory test according to IS 2386-1963 is resulted as:

Aggregate crushing value = 24%
Aggregate impact value = 29%
Specific gravity = 2.74
Water absorption = 0.94%
Unit weight = 1.60gm/cc
Fineness Modulus = 6.15

2.4. Super plasticizer

To improve the workability of the fresh geopolymer concrete, a high range water reducing (Naphthalene sulphonate- based) super plasticizer, supplied by BASF Construction Chemical Company Mumbai was used in the mixtures at the rate 1.5% of fly ash.

3. Preparation of specimens

Fernando Torgal et al (2008) undergone the experiment in Fly ash without blast furnace slag was mixed with predetermined quantity of activator solution for 5 minutes .The geopolymers mix exhibited a thick sticky nature with low workability. The mix was then transferred into 150x150x150mm^3 steel cubes by in M25 ratio. Table vibration was provided for 2 minutes to expel any entrapped air. After 60 minutes, the cubes were cured in an oven for a period of 24 hours at 60°C and then allowed to cool inside the oven. Specimens were demoulded and stored at room temperature at a dry place before testing.

The geopolymer specimens were immersed in 10% magnesium sulphate solution for 28days after 3 days from casting. Specimens were tested for physical changes, weight changes and compressive strength changes at regular intervals. Unexposed specimens were subjected to water absorption, apparent porosity and compressive strength tests as well, to assess the pore characteristics

3.1 Mixing and Compacting

Debabrata Dutta, et al (2014) concluded the mixing of aggregates in saturated surface dry condition and the dry fly ash were mixed in a pan mixer for 3-4 minutes. At the end of this mixing, the liquid component of the geopolymer concrete mixture, i.e. the combination of the alkaline solution, the superplasticiser and the extra water, was added to the solids, and the mixing continued for a specified period of time. In this study, the wet mixing period was designated as the 'mixing time'.

The fresh concrete had a stiff consistency and was glossy in appearance. The fresh concrete was then cast in moulds. Compaction was performed using the usual practice, either by applying strokes or using vibration or a combination of both. After casting, the concrete samples were cured at an elevated temperature for a specified period of time.

3.2 Curing

In this study, curing was carried out at a specified elevated temperature, either in an oven (dry curing) or in a steam chamber. At the end of the curing period, the test specimens were left in the mold for about six hours. The samples were then removed from the molds, and left to air dry in the room temperature before testing at a specified age.

Deposit has been also reported by some authors. Here the product has been tested through SEM .The Scanning Electron Microscopy depicts the presence of regular structure on the surface of deposits which supports the crystal nature. This indicates the existence of Magnesium, Silicon and Aluminum in this outcome.

4. TESTS CONDUCTED

4.1 Durability test

i) Sulphate attack test
ii) Chloride attack test
iii) Acceleration corrosion test

4.1.1 Sulphate attack test

a. Visual observation

Fernando Torgal et al (2008) experimented the sulphate attack test by Optical microscope, accuracy .02mm, Zoom capacity of 10X has been used to monitor the physical appearance of geopolymer specimens after exposure to magnesium sulphate solution. Geopolymer paste specimen without blast furnace slag got white crystal deposits after exposure which were very soft but with time being it became harder. Specimen containing blast furnace slag in no case got white deposits. The white reaction product may be magnesium aluminosilicate. This white sulphate solution into the specimens. No further increase was shown for blended specimens after the initial rise. Weight gain continued gradually for 50 days in specimen GP1 (without blast furnace slag).It indicates continuous penetration of sulphate.Solution in addition to formation of reaction products due to interaction of geopolymer material with the exposure solution.

Weights of specimens were remaining almost constant up to the end of test where the specimens without supplementary blast furnace slag began to decrease beyond 50 days of exposure.The drop in weight could be due to migration of alkalis from the specimens into the solution and also due to breakdown and dissolution of some reaction products. Final weight for all the samples was higher than initial one. This newly built reaction product within the internal voids is accused for weight gaining.fig1

FIG- 1: Direct contact of specimen with 10% Magnesium sulphate.

b. Weight changes

Anuar.K.A, et al(2011) explains the Weights for exposed specimens were measured at regular intervals in saturated surface dry condition after washing and removal of surface deposits. Specimens are cleaned in running cold water for around five minutes and wiped dry with clean lint free cloth and then blown with clean dry air for around 5 minutes. Speedy increases in weight took place for all paste specimens up to 1 week of exposure.

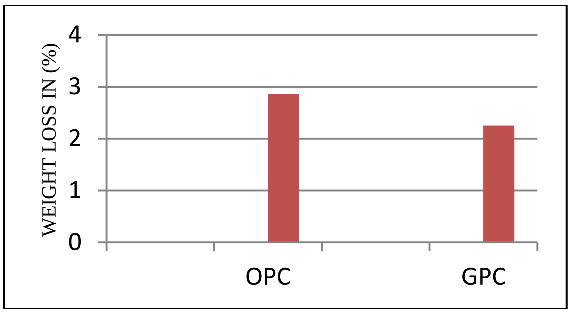

Fig2. Weight loss in percentage

4.1.2 Chloride attack test

As like sulphate attack in chloride attack also there will change in appearance and weight. Results obtained as follows

4.1.3 Accelerated corrosion test

Hardjito.D ,et al (2005),done experiment in the Specimen for this test prepared is cylinder of size diameter 150mm and height 300, while casting 20mm TMT bar is placed above representation. The results are then noted. The resistive characteristic strength is high when compared to conventional concrete.in the center of the cylinder and then thespecimen is kept as like the fig 2

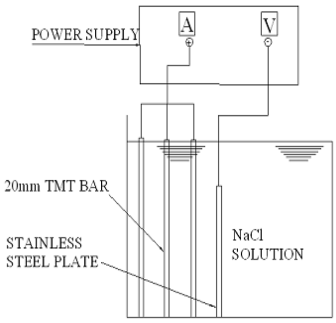

Fig 2. Circuit diagram of acceleration corrosion test

5. Conclusion

The primary focus of this investigation has been to experimentally evaluate the durability of fly ash based geopolymer concrete in the marine environment, compared to ordinary Portland cement concrete (OPC). The key outcome expected is the better corrosion-resistant performance of GPC. Therefore, by analyzing and comparing the behavior and properties of both types of concrete, it was observed that the geopolymerization product of low calcium fly ash-based concrete is more homogeneous and well-bonded to the aggregate, than ordinary Portland cement concrete. Consequently, better crack resistance and long-term durability are obtained with GPC concrete. The electrical resistivity and permeability of the low calcium fly ash-based GPC were not significantly affected by the severe marine environment in view of reduced cracking.

6. REFERENCE

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