Production of FlyAsh Based Dry Geo-Polymer Binder Powder

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Abstract- *The manufacturing of cement demand burning of huge quantities of fuel as well as significant emissions of CO2 resulting from the decomposition of limestone that consequently resulted in severe environmental impact that is estimated by one ton of CO2 per ton of cement. Geopolymerization technology is an effective method for converting wastes (containing alumina and silica) into useful products. It can reduce CO2 emissions significantly from the cement industry. The geopolymerization process usually starts with source materials based on alumina/silicate in addition to alkaline liquids.*

Geopolymer concrete (GPC) can be produced by chemical activation of industrial by-products and processed natural minerals that contain aluminosilicate. The compressive strength, setting time, and workability of the final product depends mainly on the type and proportions of the precursors, the type and strength of the activator, the mixing and curing conditions. The structural performance of a geopolymer is similar to that of ordinary Portland cement (OPC). Therefore, geopolymer can replace OPC, and thus decreasing the energy consumption, reducing the cost of the building materials, and minimizing the environmental impacts of the cement industry In this experimental study,fly ash and the alkaline activators are sodium silicate and sodium hydroxide taken with molarity .Three ratios of solution to fly ash are used and for each ratio consider four parameters of sodium silicate to sodium hydroxide. The e tests including workability in the form of water absorption, compressive strength at the age of 28 days with oven curing at 70℃ were studied. It will found that dry geo-polymer concrete with temperature curing will give the better or similar strength as of conventional concrete.

Keywords- Geopolymer; Geopolymerization process; Cement industry, CO2 reduction; Environmental impact; Sustainability.

I. INTRODUCTION

With the rapid development of urban construction, concretes with different functions have been widely used. Commonly used concretes include self-consolidating concrete, reinforced concrete, prestressed concrete etc. . Sequentially, the demand for basic building materials, such as cement, is increasing. At the same time, the amount of CO2 emissions continuously rises year by year because of the production of ordinary Portland cement (OPC) [1]. Hence, it is urgent to use green building materials instead of traditional materials, which cause critical environmental pollution.

Geopolymer concrete (GPC), the commercial name of alkali-activated concrete (AAC), which usually result from the chemical reaction between aluminosilicate waste materials and alkaline activators, are currently regarded as greener alternatives to Portland cements concrete (PCC) [2]. Geopolymers/ alkali-activated binders are deemed as an environmentally friendly binding material. The three pillars of sustainable development are economic and environmental protection as well as social development. It is known though that the Earth's capacity to support people is determined by natural constraint and human priorities. The theoretical basis of geo polymerization as a major reaction mechanism of cement less concrete was established for the first time by the French researcher Davidovits in 1978[3] who used kaolinite and alkaline activators. Geopolymerisation has definitely a good potential for the production of “green” concrete and construction materials with lower carbon footprint. In order to accurately assess this potential the environmental impact of geopolymers has to be quantified by considering also the impact of the byproducts (or wastes) used through Life Cycle Assessment studies. The limited literature so far shows that the production of most standard types of geopolymer concrete has lower impact on global warming than standard OPC concrete .This study shows that geopolymer concrete made from fly ash and GBFS results in lower CO^2emissions than OPC concrete[4]. The environmental impact of geopolymer concrete is related with the use of sodium silicate solution as activator that results in pollution transfer within all other environmental impact categories. Today, the production of sodium silicate utilizes pure glass cullet but discarded glass cullet could be easily used as alternative silicate source. The best way for the concrete industry to reach its current CO^2 objectives, would be to produce geopolymer concrete from raw material with a suitable Si/Al molar ratio which is recognised as industrial waste and does not have an allocation impact. In fact, geopolymer technology allows the use of waste instead of a by-product from an LCA point of view. Magnesium-iron and ferronickel slags cannot be utilized with the blended cement technology, but can be used as geopolymeric binders. Slag based geopolymer concrete only requires small amount of sodium silicate and therefore has low environmental impact . Furthermore, the use of these wastes reduces environmental impacts associated with their disposal and subsequent generation of hazardous leachates. Efforts were exerted to develop this geopolymer type as a concrete repairagent because it can rapidly increase the compressive strength. This was proven by the experiments (i.e., the compressive strength could achieve 60% of the 28days strength after 1d of curing)[5]. Due to the diversity of raw materials, additives and mix proportions of geopolymer/alkali-activated concrete. By using the proposed method GPC can be produced for a specific strength by employing the corresponding AAS/FA ratio obtained from the modified ACI strength vs. w/c ratio curve[6].

II. EXPERIMENTAL PROGRAM

As design code does not exist for the mix design of geopolymer concrete. In the case of Portland cement concrete the density is in the range between 2200 to 2600 kg/m3. The density of geopolymer concrete 2150 kg/m3 was considered for 1m3 fly ash based geopolymer concrete. The fly ash 400 gm was considered for fly ash based geopolymer concrete. The solution of sodium silicate (Na2SiO3) with Na2O = 32.25%, SiO2 =67.40% and water 0.35% by mass was used and sodium hydroxide (NaOH) with 14M was used. Solution to fly ash ratio was used 0.3,0.4& 0.5 by mass. The sodium silicate to sodium hydroxide ratio was 1:1,1:2,1:3,&1:4 by mass. The water was 80 gm adopted. For each mix cubes specimens were cast.

III. MATERIALS AND THEIR PROPERTIES

1. Constituent materials of GPC

Generally, Plain Concrete is not required in the production process of GPC. The two key constituents of GPC are: (1) alkaline solutions such as sodium silicate (Na2SiO3), sodium hydroxide (NaOH), and (2) Alumino-silicate sources of byproduct materials such as Fly ash and standard sand.

2. Fly ash

GPC may be formed by using low-calcium fly obtained from coal-combustion binder stations as a by-product of bituminous or anthracite coal combustion . Fly is identified as “pulverised fuel ash,” and it is a byproduct of coal combustion which comprises fine particles that have been blown out of the boiler along with flue gases .Fly ash is often used as a substitute to ordinary Plain Concrete (OPC) in concrete production Compared with traditional concrete, fly ash concrete has a higher strength and durability can be poured readily, has lesser permeability, and resists the alkali–silica reaction more efficiently; thereby, extending its service life and lowering its cost . For example, the low-calcium fly ash has been positively used to produce GPC when the aluminum and silicon oxides constitute about 80% by weight, with the Si:Al ratio of 2. The iron oxide content is typically varied between 10 and 20% by weight, while the calcium oxide content is lower than 5% by weight. The fly ash carbon content, as designated by the loss on ignition by weight, is below 2%. Reportedly, the distribution of fly ash particle size is about 80% of the FA particles which are less than 50 μm. FA can be 20% to 60% cheaper than OPC in some countries, but in some cases, OPC can be more than twice as expensive as fly ash . However, fly ash is rarely shipped at long distances and is more expensive than local OPC because some concrete durability requirements can only be fulfilled by using fly ash . This material can also positively affect the environment due to the conservation of the landfill spaces, reduction of water and energy consumption, and minimization of greenhouse gas emissions.

3. Standard sand

This Indian standard sand IS 650 is made of local natural silica sand (silica content 99 %), having a water content lower than 0.1 %. Its average density is 2630 kg/m^3The constituent grains of this sand are uncrushed and of rounded form. The sand is used for the testing of hydraulic cement.

We produce Grade I; II; III:

- in bag of 25 kg,
- in separate part,

or mixt of I 33% grad II 33% grad III 33%.

4. .Source of by-product materials

Geopolymer is a patchy silicate-alumino cementing material that is produced by poly condensation reaction of alkali and polysilicatesgeopolymeric precursor known as the geopolymerization process. Geopolymerization is an advanced process capable of converting several silicate-alumino materials into valuable products named inorganic polymers or geopolymers. Geopolymerization includes an inhomogeneous chemical reaction between alkali solutions and silicate-alumino oxides at mild temperatures. A GPC with ultrahigh strength and increased durability is expected to be developed in the near future.

5. Importance of activators in geopolymerization process

The commonly alkaline activators used in production of geopolymer are a mixture of sodium hydroxide and sodium silicate. The aim of adding the latter is to improve the formation of geopolymer precursors. It contains partially polymerized silicon, which facilitates the reaction. And fasten the geopolymerization .

The kind of alkali activators affects the solubility of the precursors and determines the pore size of the final product. The composition, structure, microstructure, and properties of the polymers formed in the alkali activation of fly ash depend on the concentration, volume and type of activator used .The increase in mass and the concentration of the alkaline solution strengthen the bond between the sand and the binder resulting in high stiffness in the matrix. Other researchers found that the compressive strength of the geopolymer increased when the molarity of NaOH solution increased.

6.1 SODIUM HYDROXIDE

- Sodium hydroxide in flakes form purchased from Samarth chemical industry khamgaon. During this preparation sodium hydroxide is blend by tamping rod and passing through 90micron sieve.

6.2 SODIUM SILICATE

Sodium silicate is naturally in glass form purchased from Samarth chemical industry khamgaon. During Fly ash based Geopolymer concrete mixed by adopting the traditional techniques used in the mixed of alkaline activators in concrete. In the laboratory, the fly ash and the standard sand were first mixed together by hand mixing for 3 to 4 minutes. The alkaline activators was ,then added to the dry materials and the mixing continued for further about 3 to 5 minutes to

- preparation it grinds on aggregate impact test machine and passing through 150mm micron sieve.
- Chemical composition
- Na2o:32.25%
- Sio2 :67.40%
- Water:0.35%

7. Water

Water content is very important in geopolymerization. Potable water was used. The presence of excessive water may compromise the compressive strength of geopolymer concrete.

IV. MIXING, CASTING AND CURING OF FLY ASH BASED GEOPOLYMER MORTAR SPECIEMENS

Fly ash based Geopolymer concrete mixed by adopting the traditional techniques used in the mixed of alkaline activators in concrete. In the laboratory, the fly ash and the standard sand were first mixed together by hand mixing for 3 to 4 minutes. The alkaline activators was ,then added to the dry materials and the mixing continued for further about 3 to 5 minutes to manufacture the fresh concrete. The fresh concrete was cast into the moulds immediately after mixing in three layers for cubical specimens of size 70 X 70 X70 mm each layer was given 25 to 30 manual strokes using a temping rod. After 24 hours from casting fly ash based geopolymer concrete specimens were cured by oven curing. The specimens were cured at 70℃ for 24 Hours and specimens were allowed to cool up to room temperature then specimens were removed from mould and kept in room temperature up to testing..

Fig1 -: Mixing of GPC materials

V. TESTING AND RESULTS

1 Compressive strength

compressive strength is affected by wet-mixing time, curing time, curing temperature, particles size and addition of typical. The impact of these additives on the compressive strength of fly ash-based GPC exhibits a steady reduction in their original compressive strength at elevated temperatures of up to 400 °C regardless of their molarity and standard sand. The compressive strength of GPC also reduces considerably when the amount of extra water exceeds 12% of the fly ash mass Such compressive strength reaches its peak when a mixture of water-glass and NaOH is adopted as the activator but decreases when the alkaline solution content increases from 35% to 45% of the total binder .

Table1 -: EFFECT OF SOLUTION TO FLY ASH RATIO ON COMPRESSIVE STRENGTH

Of 28 days

SS/SH	S/FA Ratio wise Compressive strength N/mm²		
	0.3	0.4	0.5
1:1	20.13	26.21	33.56
1:2	22.33	28.96	37.85
1:3	25.17	34.85	47.53
1:4	27.68	43.98	56.96

Fig2 -: Compressive Strength Test

2. Water Absorption Test

The cured fly ash based geopolymer concrete specimens initially weighed for weight W1 kg. The specimens kept in oven at temperature of 100℃ for a period of 24 hours. The specimen removed from oven and allowed to cool to room temperature and weighed for weight W2. The oven dried specimen immersed in water bath and kept undisturbed for 24 hours allowing the water to fill all the voids with in the specimen. The specimen removes from water bath and allowed for surface dry condition. The specimen at saturated surface dry condition and weighed for weight W3. The % water absorption can be calculated by formula.

% water absorption = [(W3-W2)/ W2] *100

For water absorption three sample for each parameter were casted and water absorption test was performed at the age of 28days.

Table 2 -: WaterAbsorptionResults

Sr. No	Solution o FA Ratio	Water Absorption(%)
1	0.3	1.7
2	0.4	2.0
3	0.5	2.45

Sr. No.	Materials	Details
1	Fly Ash	400 gm
2	Sand	600 gm
3	Na2SiO3	350.42 gm
4	NaOH	123.41 gm
5	Water	80 gm
6	Rest Period	1 day
7	Curing Temp.	80⁰c
8	Curing Duration	24 hr

Fig3 -: GPC Specimen

VI. CONCLUSION

The following conclusions are drawn based on the experimental results.

- GPC is an inventive construction material that provides an alternative to OPC, and it is made by the chemical activity of inorganic particles of waste materials. GPC has become more common in past decades due to being more environmentally friendly as opposed to conventional OPC.
- The workability of fly ash based geopolymer concrete in fresh state increases with increasing percentage of sodium silicate .
- The stability of GPC production depends on numerous factors such as temperature curing , setting and curing time, molarity of alkaline activator and mix ratio.
- Dry geopolymer binder powder is produced gives a good fresh and hardened properties for GPC.

- It will found that dry GPC with temperature curing will give the better or similar strength as of conventional method of production of geopolymer.
- GPC exhibits high early strength and has been effectively utilized in precast industries. This is demonstrated by its ability to produce large-scale GPC structure within a short duration with minimal tendency to breakage during transportation.
- The activator solution prepared before 1day produce the same strength as solution prepared at the time of mixing.
- The solution to fly ash ratio 0.5 gives the ultimate strength to mortar for all ratios of sodium silicates to sodium hydroxide..

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