Analytical Review of Geopolymer Mortar

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Abstract— Mortar is one of the most widely used construction material; it is usually associated with Portland cement as the main binder. Portland cement production is under critical review due to high amount of carbon dioxide gas released to the atm. The use of Portland cement is still unavoidable in the future; efforts are made to reduce use of Portland cement in concrete. These efforts include utilization of supplementary materials such as fly-ash, silica flumes, granulated blast furnace slag, rice husk ash and metakaolin as alternative binders to Portland cement. In this respect, Geopolymer Technology show considerable promise for application in the concrete industry as an alternative binder to Portland cement. GEOPOLYMER MORTAR is new that doesn't require use of Portland cement as a binder. Instead, the sources of materials such as fly-ash that are rich in silicon, aluminum, are activated by liquids to produce the binder. Hence mortar with no Portland cement. This paper covers constituents of Geopolymer mortar, casting procedure, curing methods, advantages, limitation and Economical benefits of Geopolymer mortar.

Key words: Geopolymer Mortar, Metakaolin

I. INTRODUCTION

Mortar is most widely used man-made construction material in the world. It is usually associated with Portland cement as the main component for making mortar. It is obtained by mixing cementitious materials, water and aggregates in required proportions. Use of Portland cement is still unavoidable in the foreseeable future; efforts are made to reduce use of Portland cement in mortar. These efforts include utilization of supplementary cementing materials such as fly ash, silica fume, granulated blast furnace slag, rice-husk ash and metakaolin as alternative binders to Portland cement.

In this respect, Geopolymer Technology shows considerable promise for application in mortar industry as an alternative binder to Portland cement. GEOPOLYMER MORTAR is new material that doesn't need use of Portland cement as a binder. Instead, the sources of materials such as fly ash, that are rich in silicon and aluminum, are, activated by alkaline liquids to produce the binder. Hence mortar with no cement.

Fly ash is an industrial waste normally used to replace Portland cement for making mortar. Geopolymer is usually made of fly ash activated with alkaline solution at low temperature and it is sometimes called alkali-activated fly ash.

Geopolymer with good mechanical properties viz., high compressive strength and stability at temperature upto 1300-1400 degree centigrade can be synthesized at low temperature using similar technique to that of zeolite.

A. Need of Geopolymer Concrete:

It is evident from the present scenario that ordinary Portland cement is causing much the environmental hazards such as

- Increasing greenhouse gases.
- Enormous consumption of power for manufacturing of cement.
- Restricted use of natural resources.

Considering all the above points there is a need to find some alternative material. Any material which contains silicon in amorphous state can be a source of binding material, and fly ash which contains this is considered to be a waste product which can be utilized effectively to overcome the effects caused by ordinary Portland cement.

II. CONSTITUENTS OF GEOPOLYMER MORTAR

A. Fly Ash:

Fly ash used in this experimental work.

B. Aggregates:

The type of Coarse and Fine aggregates used. Maximum sizes of fine aggregates used are 4.75 mm down. It constitutes 75-80 % of the mass of GPC and the aggregate are in saturated surface dry condition.

C. Water:

The water content in Geopolymer concrete is the combined water present in the alkaline solution.

D. Alkaline Solution:

Alkaline solution used for experimental study is a combination of sodium silicate and sodium hydroxide soliution. Geopolymer materials exhibit better zeolite properties with Sodium hydroxide solution rather dioxide solution with Potassium hydroxide solution. Addition of Sodium silicate solution to Sodium hydroxide solution enhances the reaction rate between source material and alkaline solution. Sodium hydroxide with 97-98% purity is in the pellets or flakes form.

E. Superplastizer

To handle the mix easily workability of the mix should be good. Hence to increase the workability of the mix a Superplastizer called CONPLAST SP 430 is added with the range of 1.5% by mass of fly ash.

III. CASTING PROCEDURE

A. Casting Procedure of Geopolymer Mortar (without Superplastizer)

- Geopolymer mortar can be manufactured by adopting conventional techniques used in the manufacture of Portland cement mortar.
- The alkaline solution must be prepare a day before the casting process.

- Geopolymer mortar is mixed manually.
- In the laboratory, on a pan fine aggregate, coarse aggregate and fly ash was added and dry mixing was carried out.
- Liquid components of the mixtures i.e. firstly required amount of water was added then, gradually alkaline solution was then added.
- Mixing of total mass was continued until the binding paste covered all the aggregate and mixtures become homogenous and uniform in color.
- The fresh mortar was cast and compacted by usual methods used in the case of Portland cement mortar.

B. Casting Procedure of Geopolymer mortar (with Superplastizer)

- Geopolymer mortar can be manufactured by adopting conventional techniques used in the manufacture of Portland cement mortar.
- The alkaline solution must be prepare a day before the casting process.
- Geopolymer mortar is mixed manually.
- In the laboratory, on a pan fine aggregate, coarse aggregate and fly ash was added and dry mixing was carried out.
- At the time of casting, the required amount of Superplastizer is added in the alkaline solution. While mixing firstly required amount of water was added then, gradually mixtures of alkaline solution and Superplastizer was then added.
- Mixing of total mass was continued until the binding paste covered all the aggregates and mixtures become homogenous and uniform in color.

IV. CURING METHODS FOR GEOPOLYMER MORTAR

A. Steam Curing:

A Steam boiler system with digital temperature control and thermocouple can be used to deliver steam and maintain the temperature inside the steam curing chamber. Steam can be automatically delivered through the solenoid valve controlled by the digital controller to obtain the desired temperature set.

B. Oven Curing:

Compressive strength of Geopolymer mortar is tested after keeping the casted 12 mortar cube specimen under supervised conditions. The Geopolymer mortar cubes after casting kept in open atmosphere 24 hours and after 24 hours cubes were molded and then kept in oven for accelerated curing at a temperature of 80degree centigrade there are two methods adopted while curing of the specimen cubes which are as follows.

- 48 hours or one day heated oven curing
- 72 hours or three days heated oven curing.

V. USE OF SUPER PLASTIZER IN GEOPOLYMER MORTAR

To handle the mix easily workability of the mix should be good. Hence, to increase the workability of the mix a Superplastizer called CONPLAST SP 430 is added.

VI. EFFECT OF WATER IN GEOPOLYMER MORTAR

Previous research by Barhosa et al. on Geopolymer pastes showed that water contents in the mix played an important role on the properties of Geopolymer binders.

In order to study the effect of water content on the compressive strength of Geopolymer mortar, several tests were performed. Other details of mixes same as those used in the earlier part of this report. The percentage of the super plasticizer to the mass of fly ash was 1.5 % the delay time was 30 minutes, and there was no rest period. In order to quantify water content in Geopolymer mortar mix, the ratio of water (H_2O)-to-sodium oxide (Na_2O) was calculated in terms of molar ratio of the oxides. Note that both H_2O and Na_2O are identified in both the activator liquids used in this study,i.e the sodium silicate is composed of H_2O and Na_2O .also, the sodium hydroxide flake (NaOH),which was dissolved in water, can be expressed as $2NaOH \rightarrow Na_2O + H_2O$.

VII. ADVANTAGES

- It is ecofriendly because as cement is absent, heavy pollution during cement manufacturing is avoided.
- As less water is required for preparing the mortar, bleeding is avoided and water is also saved.
- Fly-ash is used, which is a waste from thermal power plant.
- Precast product can be economically by using fly ash based Geopolymer mortar, e.g.:-Prefabricated slabs, Beams, Lintels, Windows & Door Frames, casting of Paving Blocks, Mortar Blocks etc.

VIII. LIMITATIONS

- Transportation cost for bringing the base material fly ash to the required site.
- High cost for alkaline solution.
- Safety risk associated with the high alkalinity of the activating solution.
- Practical difficulties in applying Steam curing / high temperature curing process.
- There is safety risk associated with the high alkalinity of the activating solution, high alkalinity also requires more processing, resulting in increased energy consumption and greenhouse gas generation.

IX. ECONOMIC BENEFITS OF GEOPOLYMER MORTAR

Heat –cured low –calcium fly-ash –based Geopolymer mortar offers several economic benefits over Portland cement mortar. The price of one ton of fly ash is only a small fraction of the price of one ton of Portland cement. Therefore, after allowing for the price of alkaline liquids needed to make the Geopolymer mortar, price of fly-ash –based Geopolymer mortar is estimated to be about 10% to 30% cheaper than that of Portland cement mortar. In addition, the appropriate usage of one ton of fly ash earns approximately one carbon –credit that has a significant redemption value. One ton low-calcium fly ash can be utilized to manufacture approximately three cubic meters of high quality fly ash-based Geopolymer mortar, and hence earn monetary benefits through carbon-credit trade.

Furthermore, the very little drying shrinkage, low creep, excellent resistance to sulphate attack, and good acid resistance offered by the heat-cured low-calcium fly ash based Geopolymer mortar may yield additional economic benefits when it is utilized in infrastructural applications.

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