Blended Geopolymer Composite for Checking Strength and Durability

[1]Madhur, [2]Rishabh Sharma

[1]M.Tech. Scholar, [2]*Assistant P*rofessor

Department of CE

BRCM College of Engineering and Technology, Bahal (Bhiwani) India

ABSTRACT

Due to growing industrial production, the generation of wastes has been increased many folds with time and disposition is a challenging problem. On the other hand, carbon dioxide emission has increased to a great extent causing global warming. There is scarcity of ore also.Under this circumstances fruitful application of the (like slag, fly ash etc.) are made in cement manufacturing but major portion is used in road construction or for any filling purpose. This may create ground water contamination problem due to leaching of toxic and heavy metals, ultimately reachingto underground water reservoir. Joseph Davidovits introduced geopolymer as a synthetic material primarily. Later on it is observed that geopolymer may be developed from the waste materials ina, in an alkaline environment. metakaolin, slag, silica fumes etc. are considered as the prime base material to make waste based polymer. Geopolymer is imported from the geo-synthesis of polymeric aluminosilicate and alkali silicates which results a tetrahedral structure of SiO4 and AlO4 [72]. Geopolymer is stated to retain better strength and durability [73] and geopolymer may be substitute of cement

INTRODUCTION

Geopolymerization is a geo-synthesis which includes naturally arising silico-aluminates [56]. Any type of pozzolanic compound has the possibility to act pecies in alkali solution [137]. In geopolymerization process the geopolymer is usually amalgamated through the triggering of an aluminosilicate waste sources like fly ash, slag etc.in resence of activator (generally, an alkali hydroxide or a base material. Usually, highly soluble silicate concentrations are often used as an activating solution to produce geopolymers in a way to achieve better setting and mechanical properties [132]. The rate of geopolymerization and the leaching of alkali may be influenced by the cationanion pair theory. It may be identified by this fact affect differently only use of dissimilar size. In this connection, the smaller sized cations emphasize the ion-pair reactivity in presence of small sized silicate oligomers like monomers, dimers and trimmers [55, 91 and 121]. Earlier research shows that the On the contrary, larger silicate oligomers increase considerably with theaddition of more silicate solution which is [137]. Literally geopolymer file contains an amorphous aluminosilicate complex, where the alkali-cations balance the charges of tetrahedral aluminium [20].

Contrivance of geopolymers comprises the poly-condensation of geopolymeric precursors, which produces Si–O–Al link ultimately [28, 54, 99, and 128].

REGRESSION ANALYSIS USE OF ACTIVATORS IN GEOPOLYMER

Selection of activator is highly dependent on several parameters like types/chemical composition of base material, supplementary materials, silicate content etc. Major drawbacks of geopolymer is correlated with the wrong choice of activator. The rheological characteristics of geopolymer is interfered mainly by the viscosity of alkali activator [100]. Choice of activator is again important in this context. Like fly ash in activation with highly concentrated sodium hydroxide plus silicate solvent, generates cracks with aging in some cases [30]. This is mainly because of the development of pore pressure within the hardened composite by the late precipitated alkali compound [30]. Though at the infancy level ofdevelopment, it exhibits sequential rising in strength [30]. Use of alternative hydroxide to bring the stable structure is a subject of interest in this connection. The size of cations has great impact on the ion-pair reaction which in fact determine the differential performance of alkali in activation of a particular base material under defined ambience [55], [91], [121]. Again, the concentration of silicate solution has major impact on the choice of alkali hydroxide for better dissolution and stabilization of geopolymer [137]. As already discussed that the higher presence of monomer and dimer which exist during dissolution of Al-Si, supports sodium hydroxide for better stabilization [137]. Whereas, potassium hydroxide is favored as alkali activator for larger silicate oligomers in the sense of better co-ordination of geopolymer framework [137]. So, the choice of alkali hydroxide is subjected to the concentration of reactive silica (available from silicate solution, base material and supplementary materials) in the mixture. Again, the role of alkali cation is to balance the charges of aluminium indeed. Hence, the presence of supplementary cation like calcium (available from calcium supplement) minimize the requirement of alkali cation in activator or claims lower concentration of alkali hydroxide. Therefore, choice of alkali for different mixture, is extremely important to have best performance of the activated product. Drawbacks in Alkali activated Fly ash based Geopolymer

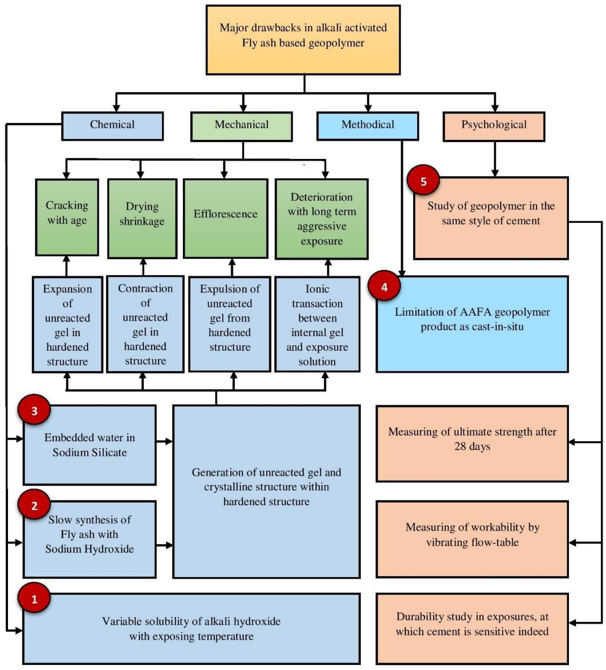

Figure 1.1 Schematic Diagram of Drawbacks in Fly ash Geopolymer

The major drawbacks associated with alkali activated fly ash based geopolymer is depicted schematically in Figure 1.1. The major drawbacks have been categorized by four types like chemical, mechanical, methodical and psychological drawbacks. All above mentioned drawbacks were taken care while framing scope of work as discussed below.

SCOPE OF WORK

Research indicated some noticeable drawbacks of fly ash based geopolymer like hardening characteristics, cracking with age, efflorescence, low reactivity level etc. Studies on the water cured fly ash based geopolymers, has not received proper attention in the past. Some more drawbacks may be noted here. It is observed that dissolution of sodium hydroxide in lower ambient temperature (in winter) is very low. The optimization of temperature level of activator prior mixing is essential to overcome this problem and have a considerably better geopolymer. Again, the rate of poly-condensation is dependent on the choice of oxide/combination of oxides in activator solution for different base and supplementary material/additives. Slow synthesis may provide an amorphous structure but partly crystalline. The sequential development of crystallized compound within the pores affects the product performance. An investigation program may be designed to investigate the pre-mixing and post-mixing performance of different combination of activators. It may be noted here that the silicate solution consists of more than 65% of water which is mainly responsible for porous character and semi crystalline phases in geopolymer. But this reactive silica is also essential to initiate the primary poly-condensation. The scope of supplementary reactive silica (like silica fume) as an alternative of sodium silicate may be investigated. Most of the research is confined with the effect of supplements added to the base material, concerning strength and durability properties. The parametric study on blended fly ash based geopolymer considering the influence of silicate modulus, oxide/combination of oxides in activator solution, curing regime on synthesis etc. needs systematic study. Fly ash may be blended with Calcium / Silicon intensive supplementary materials like lime stone dust, blast furnace slag, silica fumesetc.

Workability and strength are the most important aspects. Breed of geopolymer is completely different from conventional cement based products and therefore new measurement procedure need to be used. It is again a big challenge to have non heat cured fly ash based geopolymer, as the polymeric reaction mostly takes place at a temperature of 60-90^{0}C. In alkali activated mixture, the accretion reveals better solution compared to conventional cement based products. However, it is observed that weight and strength decreases with more time, might be due to the ionic transaction between the geopolymer structure and exposure environment. A systematic study is required to evaluate performance of blended geopolymer with less permeable pores in severe exposure to assess long term performance.

Present study was inclined towards of geopolymer, optimization, suitable parameter for measuring workability, choice of supplementary materials, choice of oxide/combination of oxides in activator solution, choice of curing profile etc. Present research deals with the incorporation of supplementary materials Base material used is fly ash / fly ash blended with lime stone dust, blast furnace slag, silica fumes. The entire research work may be divided into three different aspects. Firstly, use of oxide/combination of oxides in activator solution, to study the performance of fly ash based non blended/ blended geopolymer. Secondly, the impact of supplementary materials on the performance non blended/ blended geopolymer at fresh and hardened state. Lastly,. Performance of potassium hydroxide, sodium hydroxide or combination ofoxides in activator solution, was examined with non-blended (only fly ash) and blended base material. Optimum temperature of alkali activator prior mixing and its effect on the performance of geopolymer, was studied. Preheating of alkali activator was made to arrive at a particular temperature. Choice of alkali with respect to base material, has been evaluated. Silica fume as an alternative of silicate solution and its impact on strength and durability of the improved geopolymer, were evaluated. Incorporation of Borax and Murram as tertiary input to compensate the lack in source alumina was studied and briefed. The incorporation of supplementary materials (calcium based compound) and its positive effect on workability, strength, curing type, curing regime and durability, were investigated. New parameter like 'Area factor' for measuring workability, has been introduced. Long term strengthoptimization, long term exposure in cyclic freezing-thawing in sulfate exposure etc., have been introduced and new findings were presented.

The following combinations of non-blended and blended geopolymer have been studied

1. Fly ash + KOH + Na_2SiO_3
2. Fly ash + NaOH + Na_2SiO_3
3. Fly ash + NaOH + Na_2SiO_3 + supplementary material (Lime stone dust)
4. Fly ash + NaOH + Na_2SiO_3 + supplementary material (Blast furnace slag)
5. Fly ash + KOH + Na_2SiO_3 + supplementary material (Silica fume and Borax)
6. Fly ash + KOH + Na_2SiO_3 + supplementary material (Silica fume and Murram)

For all the studies, the mechanical performance of geopolymer was carried out and typical microstructural studies like SEM, XRD, MIP, FESEM, EDAX, TG/DTA etc., were made for proper scientific interpretations. This research provides new information based on systematic. New areas of research have been explored to assess workability. Newly introduced workability parameter added new dimension in understanding the performance of fresh geopolymer. This research has provided pathway to produce high performance fly ash based non blended and blended geopolymers in different forms overcoming present drawbacks as discussed earlier.

RESULT AND DISCUSSION

PREAMBLE

Experimental investigation was conducted to understand the comparativ. At the very outset parameters likepremixing temperature of activator was investigated. This result was crucial in a way to fixup the manufacturing process of fly ash based geopolymer in different seasons. Different alkali combinations were tried and the selection of alkali combination was made judiciously. Then the investigation was made to study the impact of blending which compensate some remarkable properties in fly ash geopolymer i.e. instability of strength, lack of control on workability, lack of control on strength, heat curing etc. The performance and character of blended geopolymer in fresh and hardened state along with its microstructural changes was simultaneously analyzed. Parameter like workability, strength, sorptivity, were studied. Again, mineralogical and micro-structural changes and its comparison with non-blended fly ash based geopolymer was also studied. Result of the water cured blended geopolymer with varying rest period was observed. Durability study on blended geopolymer exposed to magnesium sulfate solution also under freezing-thawing cycle was studied. Different combinations of source materials were studied non-blended composites. The parameters like alkali concentration, curing profile, curing type etc. were considered. All the results was presented in graphical / tabular form. Discussions were based on scientific interpretations and broadly divided into three phases:

ACTIVATOR AND ITS IMPACT ON NON-BLENDED FLY ASH BASED GEOPOLYMER

At the very early stage, includes the review on fundamental chemistry of non- blended control parameters, like processing of raw materials, mix proportion, activator combination, mixing and curing regime etc. But before finding the effect of the blending of supplements with base material (fly ash), it is essential to fix up the general controlling parameters of the activator. Controlling parameters of activatorsimply the parameters of the activator itself which impact directly on the potentiality of the activator and the performance of the activated product. This phase of investigation was focused out the optimal like imposing temperature (by pre- heating) on activator prior use to manufacturing geopolymer. Furthermore, the existence of dual oxide in activator and its impact product was also examined.

FLY ASH BASED GEOPOLYMER BLENDED WITH SUPPLEMENTARY CALCIUM COMPOUND

In the second stage of investigation, the research includes the concept of calcium blending to overcome drawbacks of fly ash geopolymer as indicated in earlier chapters. Blending of various supplementary materials like lime stone dust, performance of alkali activated products, both in green and hardened state, have been experimentally studied. Parameters like alkali concentration, alkali oxide combination, curing types, curing factors in connection with physical, mechanical and microstructural and mineralogical features. Again, this research was focused towards the durability performance of blended geopolymer subjected to saline exposure, freezing thawing for short and long period. Study was made for both the heat cured and water cured blended geopolymer.

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