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MAKING GEOPOLYMER WITH THE HELP OF BLENDED MIXTURE WITH HEAT CURING: A REVIEW

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ABSTRACT

However, the result is reversed in absence of water glass. Other authors [12] noticed that prolonged exposure of alkali-activated slag in higher curing temperature gradually lowers the strength with time though initially it tends to the strength-gaining. Again it has been observed

that the solubility of slag is increased with curing temperature [46]. But, other authors consider that the drop in strength is resulted from the development of new hydrated product which creates barrier around the slag grains and makes obstacle towards further hydration [117]. According to some studies [118], the generation of unreacted material is emphasized with raised curing temperature. Some researchers [84] observed the successive drop in compressive strength with prolonged heat curing. Sanjayan et. al. [23, 24] investigated on slag activated with water glass (powder) under heat curing. Some authors [102] also spotted to the requirement of the separation of the toughened samples in a manner to resist evaporation of water. Higher strength in compare to non-isolated water and air curing was observed for the same with isolation. Criado [2

REVIEW OF EXISTING LITERATURE

Past literature were reviewed with the aim to collect specific information on the research area to identify the

drawbacks indicated in the earlier chapters and also to develop a pathway to resolve drawbacks to have a high performance fly ash based geopolymer. Testing methods are also reviewed to understand their shortcomings and to develop a better one to appreciate the performance of the product in a more scientific way. Literature in this regard is very limited. Literature on the experience of using supplementary materials were collected. Most of the available literatures on geopolymer with supplements dealt with mostly strength. But literature on the synthesizing parameters like optimization of curing temperature, curing duration, alkali concentration, possibility of water curing etc. is limited. Comparative analysis in view of pore morphology, microstructure and durability study on blended geopolymer is very limited. Review aimed at to stretch the research from single phase composites to multiphase primarily, by blending supplementary materials with fly ash to develop new geopolymer and its parametric trend. Lot of works have been done on geopolymer from MK-Fly ash-based geopolymers and MK-rock-forming minerals [4], [5], [53], [129], [137]. It is well known that strength and durability of geopolymeric binders is better compared to conventional cement binders in general [71], [125]. The polymeric reaction product and their proportion should be monitored to satisfy some important properties e.g. durability, porosity, strength and stability which are expected from a high performance binder. Aconcept of blended geopolymer for the betterment in connection with improved structural performance may be drawn in a manner to compensate the major drawbacks of fly ash based geopolymer. In this chapter a review on previous studies mainly related to blended geopolymer and their properties have been done. Again, considering the structural stability as the prime concern, the review has been also focused towards the study related to the basic chemistry of activators, reactivity of precursors with the variation of base materials, methodology concerning curing types and profile, phase generation or transformation or deterioration of activated product with time in ambient and aggressive exposure. The entire review is divided into four sections (i) Instability of Geopolymer with Aging (ii) Reactivity ofprecursors with variation of Base material and Alkali (iii) Parametric

Instability of Geopolymer with Aging

Carsten Kuenzel. et.al. (2012) [146] focused on the instability of geopolymer over time. Drying shrinkage is observed at normal environment with low moisture for geopolymer pastes prepared from metakaolin. This research tried to correlate the impact of mixing composition like water content, silica alumina ratio, sodium to aluminium ratio, sodium ions and potassium ions on drying shrinkage at normal temperature. The study suggested the reduction of gel contraction and successive drying shrinkage with the possible reduction in structural water content. The study reveals the consequence of the whole quantity of cations, density of ionic charge, the relative measures and permanencies of cation, presence of aluminate combines in the mixing on shrinkage with aging. It is quite enough to understand that the existence of excessive water in the polymeric product which ascends by means of improper control on mixing parameters, choice of alkali and lack of chemical understanding, may bring the instability of geopolymer with time.

REACTIVITY OF PRECURSORS WITH VARIATION OF BASE MATERIAL AND ALKALI

Van Jaarsveld. et.al. (2002) [131] examined that the fundamental research on geopolymerization process is under demand, due to extreme exposure of the marketable application. In fact, differential reactiveness of base material affects the final characteristicsof the material indeed. Apropos the same it matters a lot on the typical level of synthesis. These pragmatic deviations in measureable characteristics take place owing to the inadequate suspension of those waste solids. Several parameter including water to solid ratio, percentage ash of kaolinite, category of silicate involved, keep considerable influence on the ultimate characteristics of the product. The specific work exhibits that two important elements basically control the performance of the developed geopolymer. One is the thermal account of the base material and the second one is the curing profile. Again the investigation suggests to consider these major elements before scheming this product for particular tender. Also an inter-relationship exists amid the numerous parameters which influence developed structure and characteristics of geopolymers. The clay content lies a great impact on the hardened characteristics. The clay gets abided into the formation but some portion of the clay may not react in the same manner which creates inconvenience like water retaining nature. Heatcuring at higher magnitude and intensity may bring in humid environment exhibits cracking. Whereas, the same under moderate intensity of heat curing appears with better compound. Present research has revealed that cautious attention on the mixing procedure, heat curing profile, environmental moisture content is required for manufacturing geopolymer composite to meet categorical needs.

J G S Jaarsveld. et.al. (2003) [78] proposed in this research work that not every waste material is dissolved in alkali solution. Because of that the author mentioned that original structure of some waste particles remain intact and contribute to either quicken or toughen those developed frameworks. In this research, distinctive parameters like dissolution behavior, reactivity, mechanical performances through XRD and FTIR techniques. Author recognized the degree of crystalinity of the geopolymer is the prime influencing parameter for strength perspective. Again, the presence of calcium in fly ash and its role towards strength development has been found out. The extent of particle, calcium contamination, metals in alkaline medium and base material category directly influence initial synthesis and the final product.

M N Qureshi. et.al. (2013) [94] first time introduced blast furnace slag as a base material activated by the term flow diameter in a manner to evaluate workability and setting times were maintained. The typical parameters like liquid to solid ratio, alkaline medium, amount of silicate solvent, basematerial to activating solution, and silicate solvent to metal hydroxide. Again, the typical characteristic like consistency, setting behaviour were broadly investigated. Research outcome shows, consistency and setting behaviour of activated GGBS depend mainly on the feature of the activating solvent indeed. In this research, the verification of the potentiality of blast furnace slag as source material was exercised.

P Rovnaník (2010) [109] observed the metakaolin-based geopolymer properties which are not directly resulted by the use of primary source material metakaolin and its constituent. It is also subjected to specific surface area, configuration and comparative extent of activator. It is also hinged upon the primary level of circumstances. The author also explained the upshot of the curing intensity and duration (varied from 10 to 80^0C) on the typical physical performance and its correlation in micro level. It is resulted though the handling mix at raised heat curing which speeds up the strengths improvement. It was examined that mechanical performance were declined after 28 days of heat exposure. Whereas, mixes which waspreserved at moderate or room temperature performed well enough. Impact of raising in curing temperature on geopolymer was tested in micro structurally including MIP. An inclination towards higher value of pore size and volume was observed parallel to the increment of curing intensity, which was again confirmed through mechanical enactment.

R N Thakur. et.al. (2009) [106] experimented on the growth of macro and microstructure of geopolymer with or without introducing sand. It was organized by thermal activation of fly ash in alkaline medium. Author again studied on the chief amalgamation factors like (Na_2O/Al_2O_3), (SiO_2/Al_2O_3), water to ash ratio, percentage of sand, heat curing profile and its impact on the change of the typical characteristics at micro and macro level. The compressivestrength was optimized at a curing regime of 85^0 C for 2 days. Establishment of a novel amorphous aluminosilicate part, which affects the improvement of the strength was found out through typical micro level analysis like (SEM), (XRD). The study results that alkali metal, silicon and water level of mixture has a noteworthy impact on the hardened properties. Author found that water in mixture plays a significant role throughout several stages like suspension, poly-condensation and toughening of geopolymerisation. Again, research depicts the strength under compression is improved along the reduction of the presence of external water in the mix. The research was inclined towards the optimization of strength considering heat curing profile including the temperature regime and time extent. As per the researcher, hotness crosses stimulation blockade and enriches the rate of dissolving of the source material. Raising strength was visualized with the application of heat influx in the system. Here amorphous phase with partly water phases was observed under high resolution microscopy. The existence like aluminosilicate part (s) like hydroxysodalite, herschelite etc. was confirmed through mineralogical studying equipment, such as X-ray diffractometer. The investigation ensures 1:1 ash to sand ratio is best for having good strength indeed. In certain industrial applications, the geopolymer binders are considered as future eco-friendly alternative to Portland cement.

S Thokchom. et.al. (2009) [115] correlated durability with apparent porosity and sorptivity for mortar specimens. By activating a Class F fly ash with a mixture ofNaOH and Na_2SiO_3, geopolymer mortar specimens were manufactured. This mixture ofNaOH and Na_2SiO_3 was consisted of Na_2O immersion of geopolymer mortar specimens, Nitric acid solution was used and the evaluation was performed to predict durability. This was executed Higher apparent porosity and water sorptivity were found for specimens containing lesser Na_2O. In Nitric acid solution, even after 24 weeks, substantial compressive strength was retained by he performance of geopolymer mortars in Nitric acid is influenced by porosity and sorptivityof geopolymer mortar specimens.

PARAMETRIC STUDY ON THE PERFORMANCE OF BLENDED GEOPOLYMER

2.1.1 Geopolymer Blended with Supplementary Calcium compound

J Temuujin. et.al. (2009) [67] minutely observed the impact of calcium supplements on the characteristics of geopolymer prepared from ash. In this present research, Calcium supplements was replaced to ash from 1 to 3 wt. (%). Again, the research was focused to the development of polymer structure at heat & ambient curing (20^0C to 70^0C). This research briefly indicates that calcium supplements is highly beneficial towards the enhancement of typical characteristics at green and harden condition. For Calcium Oxide and Calcium Hydroxide as supplements in weight 3% within the mix of fly ash geopolymer inaugurate better strength characteristics. The author indicates calcium hydroxide as a beneficial additive than calcium oxide. In this experimental program it was resulted that addition of Calcium compound developed secondary input as generation of CSH and others hydrates associated with Alumina, Silicon and Calcium. In the same way, increment of suspension of ashes comprising silica in activator along with higher poly-condensation reactivity was observed. Again the author suggested that the sudden drop or degradation of the characteristics of polymer exposed in raising temperature might be due to the inadequate formation of 3D network. The efflorescence made on the geopolymer synthesized from collie ash was confirmed as hydrate comprising Na and P, as decided from mineral analysis.

CAST-IN-SITU GEOPOLYMER

Hu Mingyu. et.al. (2009) [57] investigated on the synthesis of geopolymer at ambient temperature. For this purpose, author introduced fly ash and bentonite as base material and supplementary material. A combination of NaOH and CaO was used. Reactivity of metakaolin was found better in compare to fly ash. This low reactivity is basically responsible for the poor rate of reaction at ambient temperature at the time of geopolymerization. In this research methodology the supplementary material was introduced in a way to have better rate of geopolymerization which enhance the properties of fly ash based geopolymer as well. This research explored the differential nature between fly ash and geopolymer made by the same. The comparison was carried out through X-ray spectra. The spectra were almost similar for every case except the pics of $CaCO_3$. From the result the author indicated that geopolymerization reaction did not allow the formation of new crystalline phases indeed. Secondary electron image proves the existence of zeolite in the matrix. Again, some unreacted fly ash particles were visualised even after sixty days ofcuring in ambient temperature. Some networked outcome was also observed microscopically at the top surface of fly ash particles which was arbitrarily dispersed. Due to the presence of these products over fly ash the structure exhibited lesser porosity. The author found bentonite as the prime cause behind this phenomenon. The durability exposure tests observed the better performance for the geopolymer comprising zeolites. Lower weight loss was observed after sixty days of emersion in magnesium sulfate. At the end of the research the author suggested that geopolymer comprising zeolite was much imtact under aggressive environment and exhibited no fracture as confirmed by short term (two months) sulfate exposure.

GEOPOLYMER BLENDED WITH SUPPLEMENTARY SILICA COMPOUND

Prud'homme. et.al. (2010) [36] . Dehydroxylated kaolinite and alkaline hydroxide pellets solution (dissolved in potassium silicate) were used to prepare the materials. After that, the constituents were transmitted to a polyethylene mold sealed with a top. Then the materials were employed to oven at 70^0C for 24 hours. FTIR-ATR spectroscopy studied that a polycondensation reaction was used in the formation of the amorphous solid for all thermal measurement having a 0.22 W m^{-1} K^{-1} value.

Again, TGA-MS experiments confirmed that there was a synthesization of. For the applications in building materials, this substance had potentiality as an insulating material.

OBJECTIVES OF THE PRESENT RESEARCH

The objective of the present research is to develop blended geopolymer by eliminating the major drawbacks discussed in earlier chapters. There are three major aspects. Firstly, the investigation on the optimal parameters of activator prior mixing and its impact on non- blended fly ash. Secondly, the effect of supplementary material on the properties of geopolymer at green and hardened state. Thirdly, to develop water cured blended geopolymer as a cast-in-situ product. Finally, the resolved aspects will be useful to align in a way to compensate the major drawbacks of Alkali activated fly ash based geopolymer. The study is aimed to develop a new stable blended geopolymer in connection with physical, mechanical, microstructural performance in ambient and aggressive environment.

The scope of studies comprised of (i) optimization of temperature level of activator solution prior mixing. (ii) incorporation of combination of oxides in activator solution (iii) supplementation of external calcium based material (lime stone dust, silica fumes and blast furnace slag) in fly ash geopolymer. (iv) parallel study on alkali activated fly ash blended with calcium subjected to water curing (v) Silica fume blending with flyash to compensatethe role of sodium silicate. (vi) new approach to assess workability and durability. For all the studies physical, mechanical, microstructural and mineralogical studies were made separately to appreciate the non-blended and blended geopolymer characteristics clearly. Considering the major aspects, the entire research can divided into three parts.

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