Experimental Investigation On Flexural Behavior Of Reinforced Geo-Polymer Concrete Under Day-Light Curing

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Abstract - Environmental pollution is the biggest menace to the human race on this planet today. In the construction industry, mainly the production of Portland cement will cause the emission of pollutants. Nearly 120 million tone of fly ash get accumulated every year at the thermal power stations in India. In order to reduce the effect of above problems by increasing the usage of industrial by-products in our construction industry. In the present study, Geopolymer concrete is one in which the Portland cement is fully replaced with fly ash and alkaline solution are used as binding materials. Generally, geopolymer are adopted in precast construction which requires heat curing. But it is not possible in cast-in-situ. Hence Daylight curing is adopted for to overcome these difficulties. This paper presents the experimental investigation on flexural behavior of reinforced Geo-Polymer Concrete under Day-Light Curing. Geopolymer Concrete is an innovative method which is produced by the fully replacement of cement by fly ash with the combination of alkaline solution. The specimens are casted for M-25 grade under the molarity of 12M. The specimens of size 150x150x150mm cubes, 300mm height and 150mm diameter cylinders and 1200x150x200mm beams were cast and cured in the open atmosphere. The workability of fresh concrete, compressive strength, split tensile strength, flexural behavior of beam are investigated. The geopolymer acts as good resistance to chloride penetration, sulphate attack and more workable, posses more strength than conventional concrete.

INTRODUCTION

Ordinary Portland Cement (OPC) becomes an important material in the production of concrete which act as its binder to bind all the aggregate together. However, the utilization of cement causes pollution to the environment and reduction of raw material (limestone). The manufacturing of OPC requires the burning of large quantities of fuel and decomposition of limestone, resulting in significant emissions of carbon dioxide. Geopolymer concrete had been introduced to reduce the above problem. In1978, J. Davidovits initiated inorganic polymeric material that can be used to react with another source material to form a binder. The application of this binder is recently being focused to replace Ordinary Portland Cement (OPC) portion in concrete. The environmental issues resulted from OPC production has taken the progress of polymer researches further nowadays. The encouragement to produce the eco-friendly concrete can be achieved by limiting the utilization of raw materials and decreasing the rate of pollutant from respective OPC production, and diminishing the cement portion in concrete. Employment of waste material like fly ash, rice husk ash, and other cement replacement material (CRM) can only replace cement portion until certain percentage. Geopolymer, named after the reaction between polymer and geological origin source material, is proposed to replace all cement portions in concrete as the main binder.

The main constituents of geopolymer are alkaline liquid and source material. Alkaline liquid is usually a combination of sodium hydroxide or potassium hydroxide with sodium silicate or potassium silicate. The use of only alkaline hydroxide activator will result in low rate reaction compared to those containing soluble silicate. The addition of sodium silicate solution to sodium hydroxide solution will enhance the reaction rate between alkaline liquid and source material. Source materials used in this research are combination of fly ash. These materials have specification for calcium content, which is low in calcium. High calcium content in source material is not recommended since it can obstruct the polymerization process.

Experimental set up on geopolymer concrete has been conducted by several researchers. However the curing method has developed into some limitations to the geopolymer concrete applications. Heat requirement in the curing process can only be supplied by electrical instruments; hence geopolymer concrete currently can only be applied in precast concrete industry. Therefore this research is focused in the curing method to obtain geopolymer concrete that suitable with cast in-situ application. The primary difference between geopolymer concrete and Portland cement concrete is the binder. The silicon and aluminium oxides in the low-calcium fly ash reacts with the alkaline liquid to form the geopolymer paste that binds the loose coarse aggregates, fine aggregates, and other un-reacted materials together to form the geopolymer concrete. As in the case of Portland cement concrete, the coarse and fine aggregates occupy about 75 to 80% of the mass of geopolymer concrete. The influence of aggregates such as grading, angularity and strength are considered to be the same as in the case of Portland cement concrete [Lloyd and Rangan, 2009]. Therefore, this component of geopolymer concrete mixtures can be designed using the tools currently available for Portland cement concrete.

PREVIOUS STUDIES

ALI ALLAHVERDI, FRANTISEK SKVARA (2005) **[2]**discusses "**S**ulfuric acid attack on hardened paste of geopolymer cements". The mechanism of corrosion of the hardened paste of geopolymer cements at relatively high concentrations of sulphuric acid (pH≈1) consists of two subsequent steps. The first step starts by an ion exchange reaction between the charge compensating cations of the framework, i.e. sodium and calcium, and H+ or H3O+ ions from the solution along with an electrophilic attack by acid protons on polymeric Si–O–Al bonds. The electrophilic attack of acid protons results in the ejection of tetrahedral aluminium from the alumina silicate framework. In the second step, the exchanged calcium ions diffusing toward the acid solution react with counter-diffusing sulphate anions resulting in the formation and deposition of gypsum crystals inside corroding layer. Deposition of gypsum crystals inside corroding matrix provides a protective effect inhibiting the total process of deterioration. TheSiO_2/Na_2O ratio (silica modulus, Ms) of the alkali-activatorwas adjusted to 0.6 by adding enough NaOH towater glass which itself had a modulus of 1.68. At the age of 28 days, the specimens wereimmersed in three different solutions of sulphuric acid at pH values of 1±0.01, 2±0.03, and 3±0.05. All the solutionswere prepared by adding concentrated acid to tapwater. All solutions were renewedmonthly and the temperature of the solutions was keptconstantly at 20°C.

Hardjito, Djwantoro and VijayaRangan (2005)[7]investigated the "Development and properties of strength properties of low calcium fly ash based geopolymer concrete" by kept the ratio of Sodium Silicate to Sodium Hydroxide as 2.5 and the ratio of activator solution to fly ash by mass is 0.35. Sodium hydroxide of 8M with sodium silicate was used as alkaline activators. In this test compression strength and split tensile strength were studied at 7 days, 21 days and 28 days. The test specimens were cured under steam curing at 30ºC, 45ºC, 60ºC, 75ºC, 90ºC. The compression strength was high for geopolymer concrete specimens having maximum replacement of fly ash. It was observed that there was 25% loss in compression strength for specimens exposed to high temperature. Higher concentration of NaOH results in higher compressive strength and when Curing temperature (range of 30-90ºC) increases, the strength also increases. The density of geopolymer concrete was found to be same as conventional concrete.

CHI SUN POON, DIXON CHAN (2008)[4]conducted study on "Influence of fly ash as a cement addition on the hardened properties of recycled aggregate concrete". In this study, four series of concrete mixtures were prepared with water-to-cement (w/c) ratios of 0.55, 0.50, 0.45 and 0.40. The recycled aggregate was used as 0%, 20%, 50% and 100% replacements of coarse natural aggregate. Furthermore, fly ash was employed as 0% and 25% addition of cement. Although the use of recycled aggregate had a negative effect on the mechanical properties of concrete, it was found that the addition of fly ash was able to mitigate this detrimental effect. Also, the addition of fly ash reduced the drying shrinkage and enhanced the resistance to chloride ion penetration of concrete prepared with recycled aggregate.The specimens were cured in a water-curing tank at 27 ± 1°C until the age of testing. Moreover, it was found that the drying shrinkage and chloride ion penetration decreased as the compressive strength increased. Compared with the results of our previous study, the present study has quantified the advantages of using fly ash as an additional cementitious material in recycled aggregate concrete over the use of fly use as a replacement of cement.

Prabir Kumar Sarker (2010)[15]deals **"**Bond strength of reinforcing steel embedded in fly ash-based geopolymer concrete**".** The bond strengths of the conventional concrete and geopolymer concrete were compared. The compressive strength of geopolymer concrete varied from 25 to 39 MPa. The other test parameters were concrete cover and bar diameter. The reinforcing steel was 20 mm and 24 mm diameter 500 MPa steel deformed bars. The concrete cover to bar diameter ratio varied from 1.71 to 3.62. Failure occurred with the splitting of concrete in the region bonded with the steel bar, in both geopolymer and OPC concrete specimens. Comparison of the test results shows that geopolymer concrete has higher bond strength than OPC concrete. This is because of the higher splitting tensile strength of geopolymer concrete than of OPC concrete of the same compressive strength. A comparison between the splitting tensile strengths of OPC and geopolymer concrete of compressive strengths ranging from 25 to 89MPa shows that geopolymer concrete has higher splitting tensile strength than OPC concrete.

M.F. Nuruddin, A. Kusbiantoro (2011)[14]investigates **"**Development of geopolymer concrete with different curing conditions**".**Geopolymer is a part of inorganic polymer material that has similar bonding function like cement in concrete. It consists of alkaline solutions and geological source material. Alkaline liquids used in this research are 8 M sodium hydroxide (NaOH) solution and sodium silicate (Na_2SiO_3) solutions, while source materials are fly ash and microwave incinerated rice husk ash (MIRHA). Hardened Concrete samples were tested for their compressive strength on 3, 7, 28, and 56 days for all curing regime. Three different curing regimes, namely hot gunny curing, ambient curing, and external exposure curing, oven curing of 400°c were applied to obtain suitable method that was suitable with cast in situ application. Geopolymer concrete samples were tested on their compressive strength and microstructure properties. It was found that external exposure curing had the highest compressive strength compared to other two curing methods. Scanning electron microscopy analysis also showed better improvement in interfacial transition zone for concrete sample with external exposure curing.

FAREED AHMED MEMON (2012) [6] discusses "Effect of sodium hydroxide concentration on fresh properties and compressive strength of self-compacting geopolymer concrete". The experiments were conducted by varying the concentration of sodium hydroxide from 8 M to 14 M. Test methods such as Slump flow, V-Funnel, L-box and J-Ring were used to assess the workability characteristics of SCGC. The test specimens were cured at 70°C for a period of 48 hours and then kept in room temperature until the day of testing. Compressive strength test was carried out at the ages of 1, 3, 7 and 28 days. Test results indicate that concentration variation of sodium hydroxide had least effect on the fresh properties of SCGC. With the increase in sodium hydroxide concentration, the workability of fresh concrete was slightly reduced; Concrete samples with sodium hydroxide concentration of 12 M produced maximum compressive strength.

CONCLUSION

Geopolymer concrete attains the strength without hydro-curing or steam curing. In practical, oven curing is not suitable during construction and is uneconomical. To overcome these difficulties, we prefer the daylight curing.

While Compared to the hot air oven curing and steam curing, the GPC specimens attains the expected strength under daylight curing and it is more economical. The M25 grade geopolymer concrete attains its target strength within 14 days of daylight curing with full elimination of cement and water curing.

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