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Reviews of GGBS and Fly Ash Concrete in Concrete Pavement

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Abstract

Highway and pavement design plays an important role in the growth of any country. The satisfactory performance of the pavement will result in higher savings in terms of vehicle operating costs and travel time, which has a bearing on the overall economic feasibility of the project. Concrete is the most widely used construction material in civil engineering industry be-cause of its high structural strength and stability. The concrete industry is con-stantly looking for supplementary cementi-tious material with the objective of reducing the solid waste disposal problem. Geopolymer concrete known as new con-struction material similar to conventional concrete where the presence of Portland cement as a binder is not needed. The materials like fly ash and GGBS which are rich in Silicon (Si) and Aluminium (Al), are activated by using the alkaline solu-tions to produce the binder for concrete in Geopolymer concrete.Geopolymer concrete can be one of the solution to global warming causing due to rapid modernization. Today the waste generated from industriesis the major concern for the envi-ronment and health. Recycling of such wastes materials and their utilization as construction materials appears to be a bet-ter solution to the environment pollution and an economical option in construction sector The present paper reviews vari-ous developments and methodologies adopted for making Geo polymer Concrete, in view of industrial waste utiliza-tion in Geo polymer Concrete. The Strength properties of Geo polymer Concrete made of different waste materials is reviewed.

Keywords: *Geopolymer concrete(GPC); Fly-ash(FA);GGBS (ground granulated blast furnace slag);Alkaline so-lution, waste material (WM)..*

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1. Introduction

The transportation by road is the only road which could give maximum service to one all. This mode has also the maximum flexibility for travel with reference to route, direction, time and sped of travel. It is possible to provide door to door service only by road transport .Concrete pavement a large number of advantages such as

long life span negligible maintenance, user and environment friendly and lower cost. For con-crete pavement the basic material is cement for binding purpose so here we can use geopolymer concrete instead of conventional concrete. Concrete made using Portland cement has full-fledged everywhere in recent years.The demand for con-crete as a construction material has increased due to enhancement of infrastructure demands. However, production of Portland cement concrete generates problems such as CO2 emission, global warming etc. The CO2 emission from the concrete production is directly proportional to the cement content used in the con-crete mix; approxi-mately 900kg of CO2are produced from manufacturing of every ton of cement [1]. It is also predicted, that there would be considerable shortfall in availability of various natural building materials. As per the study(TIFAC 2000), there would be considerable short-fall in the production of bricks to upto25 billion bricks on an estimated demand of 100 billion bricks per year in India by end of the century[2]

Human activities on earth produce in considerable quantities of wastes including industrial and agricultural wastes from urban and rural socie-ties. This is creating serious problems to the environment, health and disposal difficulties. In present scenariothe concrete is mostly used manmade material in the world. Approximately 400 million tons of concrete and also a relative amount of mortar is consumed by Indian in-dustries every year [17]. Therefor the demand of the concrete and the required raw materials are very high. This causes the hike in the costs of cement, fine and coarse aggregates. The shortage of these materials also occurs sometimes. Geopolymers are binding materials, developed by J.Davidovits in1970's.Geopolymer is a type of amorphous alumina- silicate bind-ing material that shows the behaviours like cement concrete. J. Davidovitsproposed that an alkaline solution could be used to react with silicon (Si) and the aluminum(Al) in a geological originsource materi-al [7]. In past years Fly-ash geopolymers have been prepared as geopolymer pastes, mortars and the concretes. The source materials and the alkaline solutions are the two main constituents of Geopolymer paste. The materials that are rich in silicon and aluminium are the source mate-rials for Geopolymers. The alkaline liquid sodium or potassium based known to be activator solutions. The most common alkaline solution used in geopolymerisation is a combination of so-dium hydroxide (NaOH) and sodium silicate (Na2SiO3). Geopolymer paste is a result of polymerization reaction between material containing alumina -silicate (source materials) and alkaline solutions.

2. Review of Previous Research on Making Geo Polymer Concrete Using Various Waste Materials

2.1 Prof. M. A. Bhosale et al. (2012) has studied the process of activation of Fly ash (only solid material used as binder) using alkaline solutions and reported on the study of the processing of geo polymer using fly ash and alkaline activator solution. The factors causing the early age compressive strength of geopolymer concrete like concentration of sodium hydroxide (NaOH) have been studied. They studied about the comparison of the ratios of Na_2Si0_3&NaOHsolutions of 0.39 & 2.51. The geopolymer concrete samples were cured at 60°C inside an oven for 1 day and kept at room temperature until the testing days and result showed that the geopolymer paste with NaOH concentration, compressive strength increase with molarities increases and revealed with preparation of test sam-ples of fly ash with geopolymers of different composition in the ratio of 0.39 & 2.51. The samples were prepared with the different molarities of NaOHsuch as 8,10,12,14.

Case-1: For ratio Na_2SiO_3 to NaOH of 2.51, results in higher compressive strength of fly ash based geopolymer concrete.

Case-2:For ratio $Na_2SiO_3$to NaOH of 0.39, It is observed that, whenNa_2SiO_3 to NaOH is reversed by mass, compressive strength increased. For both cases that is 1 & 2 compressive strength is more curing in oven at high temperatures as compare to specimen left in ambient temperature,**[8].**

2.2 B. Rajini et al. (2014)the aim of this work was to study behaviour of GGBS and Fly ash at different replacement levels (FA0-GGBS100, FA25-GGBS75, FA50-GGBS50; FA75-GGBS25, FA100, GGBS0). The compressive strength and split tensile strength of geopolymer concrete respectively 54.29 N/mm^2 and 2.46 N/mm^{2}ismaximum for the FA0-GGBS100 irrespective of curing period. Here specimens were cured at ambient temperature which was possible through using GGBS with Fly Ash in concrete. The rate of gain in compressive strength and split tensile strength of geo polymer concrete is very fast at early stage of one week and the rate reduces with age, [9].

2.3 J.Thaarrini et al. (2016) has studied Economic feasibility of Geopolymer Concrete. The production cost of 1m^{3}of GPC and OPC were determined as per the market rates of the ingredients and compared for socio-economic feasibility. Based on the cost calculations, it was seen that for higher grades the cost of production of OPC concrete is on higher side than the cost of production of GPC. For M30 grade of GPC concrete the cost of production is marginally (1.7%) higher than OPC concrete of the same strength, but for M50 grade, the cost of production of OPC concrete is higher than GPC of same grade. It can be concluded from here that savings in cost can be attained in the production of Geopolymer concretes of higher grades, [10].

3. Review of Various Parameters of Geo Polymer Concrete

Review of various papers leading to the effect of fineness of source materials, concentration and ratio of alkali activator solutions used, methods of curing are discussed below

3.1 Effect of type of Binding Materials

Muhammad N.S. Hadi, Nabeel A. Farhan, M. Neaz Sheikh (5) studied about the design of optimum mix proportions for geopolymer concrete using ground granulated blast furnace slag (GGBS) and GGBS was partly replaced by Fly-ash, metakaolin and silica fume in different proportions. All the specimens were cured Ambiently. Results shows that the decrease in calcium content in the source material delays the polymerization reaction. It was also concluded that decrease in calcium content also reduces the compressive strength of concrete.

3.2 Various binding materials which can be used as per Indian conditions are as below;

Fly Ash & GGBS:

In geopolymer concrete pulverized silicious fly ash obtained from National steel Power Corporation (NSPCL), Bhilai, India, and low calcium, ground granulated blast furnace slag (GGBS) obtained from the, Bhilai Steel

plant(BSP), India can used as the binder material after required modifications. Coarse aggregate locally available crushed angular granite metal of 20 mm size and for fine aggregate local river sand can be used.

Alkaline Activator Solutions:

According to Prof. J. Davidovits (1st person who discovered Geopolymer Concrete) the alkaline liquid should be made at least one day before mixing because at the time of mixing of Na_2SiO_3 solution with NaOH solution huge amount of heat is generated which will create difficulty if made on the spot and the polymerization takes place by reacting with one another, which will act as a binder in the geo polymer concrete. Common activators include NaOH, Na_2SO_4, waterglass, Na_2CO_3 , K_2CO_3 , KOH, K_2SO_4 and cement clinker, the most utilized alkaline activators are a mixture of sodium or potassium hydroxides (NaOH, KOH) and sodium waterglass ($nSiO_2Na_2O$) or potassium waterglass($nSiO_2K_2O$). Molarity of NaOH can be calculated by multiplying the molecular mass of NaOH(23+16+1=40) with the molarity required per liter of the solution. For making the NaOH solution, NaOH flakes should be mixed with distilled water and stirred until all the flakes were completely dissolved. The solution was made approximately 24 hours before the scheduled casting of concrete

Figure1: Fly Ash

Figure2: GGBS

Figure3: Alkaline solution

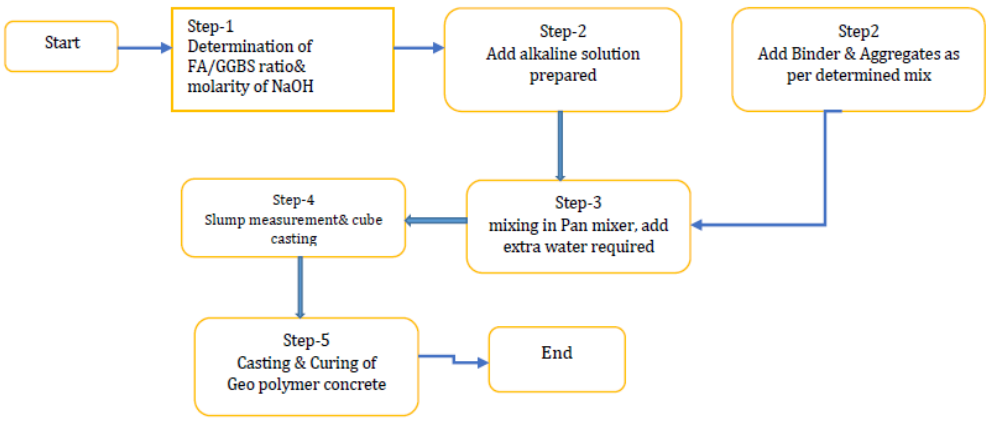

Figure1. Flow chart for the application of the mix design procedure.

Effect of Curing type and Curing Period

V. Supraja and M. Kanta Rao[13] studied the influence of curing method in the strength of Geopolymer Concrete. Alkaline liquid to GGBS ratio taken as 0.30. Molarity of Sodium hydroxide (NaOH) was taken from 3M, 5M, 7M, and 9M. Cubes were casted to calculate the compressive strength. Two regimes of curing were carried out by exposure to sunlight for some specimens and Oven curing at 50°C was done for few specimens. Results showed that oven dried curing have no significant increase in the strength after 3 days of oven curing but rate of gain of strength was more than curing by exposure to sunlight.

A.Iftiqar Ahmed[14] studied the influence of curing methods in the compressive strength of Geopolymer concrete for the mixes of differentconcentration of Sodium hydroxide of8M, 12M, and 16M. Compressive strength test was conducted on cubes. Curing was done by using an oven for specimens of one batch and curing by direct sunlight exposer for specimen specimen of another batch. Oven cured specimens shows higher compressive strength but sunlight curing was good as per the construction suitability

4. Conclusion

The Literature review based on Using Industrial waste in Geopolymer concrete concluded that by using various Industrial waste materials as a partial or complete substitute of fine aggregate, coarse aggregate, cement and sand of design mix in Geo polymer concrete, following conclu-sions can be drawn

1) It can reduce the disposal problems of Industrial waste materials and also consume the cement used for making of Geo polymer concrete.

2) Different tests have been conducted as per the standards on the Geopolymer concrete. The common parameter calculated by various re-searchers is compressive strength.

3) It is seen that waste materials like fly ash, GGBS, Micro silica were used extensively and sufficient research have been done on them, by using GGBS the curing of geopolymer concrete can be done at ambient temperature leading to its wider on site applicability.

4) When cement is replaced by various industrial waste compressive strength, flexural strength and split tensile strength of Geo polymer con-crete for various mixes is depends upon the type of Industrial waste materials and activator solution used for making of Geo polymer con-crete.

5) The study in turn is useful for various resource persons involved in using industrial or agricultural waste material to develop sustainable construction material.

6) A proper mix design process of Geopolymer concrete is also required to be developed as per Indian Conditions which would be of great help to a lay man.

Based on the above discussion's geo polymer could be effectively used as a construction material by opti-mizing the various factors that control their performance. GGBS could be incorporated with flyash for better gain of strength under ambient curing. This is also found to yield better compressive strength than flyash based geopolymer concrete. Addition of GGBS also provides better durability prop-erties and increases the unit weight o geopolymer concrete.

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