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Experimental Investigation Flyash Based Light Weight Geopolymer Concrete Using Expanded Polystyrene (EPS) : A Review

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A B S T R A C T

The main objective is to produce lightweight geopolymer concrete using expanded polystyrene (EPS) beads as partial replacement of the fine aggregates for building components. The selection of EPS bead aggregate was made mainly due to its low density, closed cellular structure, hydrophobic and energy absorbing characteristics. Also, to study the strength characteristics of light weight geopolymer concrete using different combinations. Previously, several studies were conducted on mix details, strength properties, drying shrinkage, compaction and finishing etc. of the geopolymer concretes .A new material that has been introduced in the construction field called Geopolymer concrete in which cement is totally replaced by Fly ash rich in Aluminium (Al) and Silicon (Si). When the polymerisation process of highly alkaline liquids is activated, the materials start to bind with aggregates in concrete. Expanded Polystyrene (EPS) is a lightweight material that is used in various Engineering, industrial, commercial as well as household applications. It has density that is about a couple of hundredth of that of soil. It has compressive strength comparable to medium clay and has good thermal insulation properties with stiffness. It is mainly use to reduce settlement below embankments, reducing lateral pressure on sub-structures, reducing stresses on rigid buried conduits and related applications, sound and vibration damping. EPS is very light in weight and has grainy form which is used as aggregate to create a light weight structural concrete. It has unit weight varying from 1200 to 2000 kg per m³. As polystyrene aggregate is light weight and high density, concrete can be created by partially replacing sand (fine aggregate) in the normal weightconcrete mixtures with equal volume of the chemically coated crushed polystyrene granules.

Keywords: Lightweight Geopolymer concrete, Geopolymer, Expanded polystyrene (EPS) , Fly Ash, Polymerisation

1. Introduction

Concrete, as a major construction material, is being used at an ever increasing rate all around the world. Almost all of this concrete is currently made using OPC, leading to a massive global cement industry. Every year the production of Portland cement is increasing with the increasing demand of construction The survey shows the total production of fly ash in the world is about 780 million tons per year after 2010. In India more than 100 million tons of fly ash is produced annually, out of which 17 – 20 % fly ash is utilized either in concrete as a part replacement of cement or workability improving admixtures or in stabilization of soil. There are environmental benefits in reducing the use of Portland cement in concrete, and using a byproduct cementations material, such as fly ash, silica fume, ground granulated blast furnace slag, rise husk ash, etc. as a partial substitute. With silicon and aluminum as the main constituents, fly ash has great potential as a cement replacing material in concrete.

Geopolymer concrete is a new material in which cement is totally replaced by the pozzolanic materials that is rich in Silicon (Si) and Aluminum (Al) like fly ash. It is activated by highly alkaline liquids to produce the binder which binds the aggregates in concrete when subjected to elevated temperature. Geopolymers were developed as a result of research into heat resistant materials after a series of catastrophic fires. The research yielded non-flammable and non-combustible geopolymer resins and binders. Geopolymers can be synthesized using waste materials like industrial slag, fly ash, volcanic ash and along-with alkali activators. These materials have excellent compressive strength, ranging from 30MPa to 120 MPa, depending on the starting materials, method of preparation and the added aggregates. Such properties make these materials a very attractive choice for a range of potential applications. Currently, geopolymer can be considered as the materials still in their embryonic stage, but these materials are developing very fast. Although the geopolymer technology wasdeveloped more than 30 years ago, patents and licences closely guarded it. Also, Geopolymeric materials were developed as technology rather than science; hence there is a very little fundamental understanding of these materials.Geopolymerization is the process of combining many small molecules known as oligomers into a covalently bonded network.The geo-chemical syntheses are carried out through oligomers which provide the actual unit structures of the three dimensional macromolecular edifice.

2. Literature Review

In recent years, many studies were conducted by various researchers on geopolymer concrete. The goal that expected from the paper is to compile the recent innovations in lightweight geopolymer concrete Using Expanded Polystyrene (EPS), study their effect on the properties of concrete and establish an international benchmarking for further research work in this regard.

Palomo. A.et.al (1999), Concluded that alkali-activated fly ashes, is cement for the future. For the production of geopolymer concrete, an alkaline solution containing NaOH and sodium silicate (Na_2O=32%.SiO_2=5%, and H_2O=63%) were used. Concrete specimens were cast with solutions to fly ash ratio of 0.50. After casting the moulds in three layers, the sample were kept in an oven and cured for 20 hours at 85°C. It was observed that the concrete give good mechanical strength with in a very short period. [1]

V. Gurusaktivel, et.al (April 2016), Concluded that the shear capacity of section and moment capacity of section has the same value due to which combined shear and flexural crack has occurred during the testing of beam. The major conclusions and the economic benefits of using low calcium fly ash based geopolymer concrete. Geopolymer concrete has the potential to substantially curb CO emissions. Produce a more durable infrastructure capable of design life measured in hundreds of year. Greenhouse gas reduction potential as much as 90 percent when compared with ordinary Portland cement. Shear and flexural strength of geopolymer concrete increase with increase in concentration of KOH from 10M to 14M. The higher the ratio of silicate to potassium hydroxide liquid ratio by mass, higher isthe strength of geopolymer concrete. [2]

Ning Liu, et.al (2016), studied on influence of EPS particle size on mechanical properties of EPS light weight concrete. Expanded polystyrene (EPS) concrete is a new lightweight building material that exhibits good mechanical properties that are suitable for construction[3]

Ling I.H., et.al (2011), concluded that properties of EPS RHA lightweight concrete bricks under different curing conditions. Potential use of waste rice husk ash (RHA) and expanded polystyrene (EPS) beads in producing lightweight concrete bricks. The RHA was used as a cementations material since it is a lightweight reactive pozzolanic material.RHA was used as partial cement replacement, while the EPS was used as partial aggregate replacement in the mixes. [4]

S. V. Patankar, et.al (Dec. 2014), Studied and prepared a mix design steps for the preparation of geopolymer concrete. The steps are designed by considering all the important parameters such as fineness of flyash, wet density of concrete, solid content of alkaline solution, concentration of alkaline solution, alkaline solution ratio, quantity of water, fine and coarse aggregate content geopolymer binder to water ratio, etc. [5]

Anwar Hosan, et.al (2016), studied and compared the behaviour of sodium and potassium based flyash geopolymer at elevated temperature.The geopolymer pastes containing Na-based activator exhibited higher compressive strength at ambient temperature and higher compressive strength at elevated temperatures up to 400^{o}C than its K-based counterpart. At600^{o}C the compressive strength of geopolymer containing K-based activator is slightly higher than its Na-based counterpart. The geopolymer paste containing K-based activator exhibited higher residual compressive strengths at all elevated temperatures compared to ambient temperature than its Na-based counterpart. The geopolymer paste containing K-based activator with K_2SiO_3/KOH ratio of 3 exhibited the highest residual compressive strengths at all elevated temperatures compared to ambient temperature than its Na-based counterpart. The volume stability and mass loss of geopolymer paste containing K-based activator is higher and lower, respectively than its Na-based system. The geopolymer pastes containing K-based activator exhibited fewer surface cracks than that of Na-based activator. [6]

Andi Arham et.al (2014), studied the effect of temperature and duration of curing on the strength of fly ash based geopolymer mortar. The temperature and duration of heat curing plays a major role for the strength development of fly ash based geopolymer mortar. The optimum heat curing regime in this study was at 120° for 20 hours. [7]

Kamlesh Patidar et.al (dec 2014), The main ingredients of geopolymer were the source materials and the alkaline liquids. Alumina-Silicate which is rich in Silicon and Aluminium forms the source materials for the Geopolymer. They were great examples for natural minerals i.e., kaolinite, clays, etc. Fly ash, silica fume, slag, rice husk can be used as a cause materials. The cause materials can be choosed placed on the characteristics like availability, cost, type of application and user demands. Sodium/ potassium based alkali metals constitute the alkali liquids. The combination of Sodium hydroxide/potassium hydroxide with sodium silicate or potassium silicate results in a alkaline liquid that was majorly utilized in geopolymerization. The other way of creating the geopolymer concrete was by using flyash as binding agent instead of cement. It is generally categorized as cement free concrete. A gel was formed as a result of chemical return between fly ash, alkaline solution and potassium silicate which helps to hold fine and coarse materials together. [8]

3. Conclusion

From above Literature survey, we have studied that there is no any precise code for designing of geopolymer Concrete. So we are going to do the experimental model on trial and error basis and comparing the same with conventional model.

The Light Weight Geopolymer concrete containing Potassium (K)-based activator gave highest compressive strength of 67.71 N per mm2 for 5% EPS content at oven curing Temperature 120oC.The compressive strength of K-based activator geopolymer concrete is higher than Na- based activator geopolymer concrete at ambient temperature and oven curing temperatures of 90oC and 120oC.Na-based activator geopolymer concrete gave higher compressive strength than K- based activator at ambient temperature for 20% EPS content and alkaline ratio 1.The compressive strength of all the combination of Na-based specimens having alkaline ratio as 2 is less than that of 1.5 and 1.The Compressive strength of all the combination of Na-based specimens having alkaline ratio as 3 is less than that of 2, 1.5 and 1.

It is observed that specimens with Na2SiO3 to NaOH or K2SiO3 to KOH ratio as 1.5 gave higher compressive strength than that of ratio as 1.The compressive strength of Na-based lightweight geopolymer concrete having 5%, 10%, 15% and 20% EPS is reduced by 3.33%, 9.67%, 32.35% and 48.84% and K- based lightweight geopolymer concrete is reduced by 4.64%, 11.76%, 26.14% and 49.04% as compared to normal geopolymer concrete.The compressive strength of geopolymer concrete is 1.5 times greater than conventional concrete.The overall density of geopolymer concrete is reduced from 2400 kg per m3 to 2100 kg per m3 by using EPS beads.The density for 20% EPS obtained was 2138 kg per m3 and density for 5% EPS was 2290 kg per m3.

The density of light weight geopolymer concrete compared to normal geopolymer concrete is reduced by 4.58%, 6.83%, 8.08% and 10.91% for 5% EPS, 10% EPS, 15% EPS and 20% EPS respectively.The light weight geopolymer concrete specimens with Na-based activator exhibited more surface cracks than that of K-based activator.Results indicate that lightweight geopolymer concrete having 10% EPS can be effectively used as part replacement of fine aggregates in making lightweight geopolymer concrete.From cost analysis, it is observed that Na-based activator light weight geopolymer concrete is less costly than that of K-based activator concrete.The results were experimentally compared and it shows that for 5% EPS there was 25.7% increase in the value of modulus of elasticity for ambient curing. Similarly for 90oC and 120oC the percentage increase in the value of modulus of elasticity was observed to be 32.07% and 25.53%, respectively.The result obtain by NDT test using rebound hammer was 60 N/mm2, 56N/mm2, 48N/mm2, 34N/mm2 for 5% EPS , 10%EPS, 15%EPS and 20% EPS, respectivelyThe floating and segregation of EPS beads can be minimized by using low slump of mix and fast setting of geopolymer with hardener.

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