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GEOPOLYMER CONCRETE AN ECO-FRIENDLY CONSTRUCTION MATERIAL

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Abstract: Portland cement concrete industry has grown universally in recent years. The demand for concrete as a construction material has increased due to increase of infrastructure. However, Portland cement concrete generates problems such as durability and carbon dioxide emission. There are many ways to reduce environmental pollution (carbon dioxide) caused by the production of Portland cement and by the increasing of waste material. Around 120 million tonnes of fly ash get assembled every year at the thermal power stations in India. It becomes a serious problem due to inadequacy of land disposal. Cement is totally replaced by the pozzolanic material that is rich in Silicon and Aluminium like fly ash referred to as “Geopolymer concrete” which is a contemporary material. Geopolymer concrete was actually manufactured by reusing and recycling of industrial solid wastes and by products. Fly Ash, a byproduct of coal obtained from the thermal power plant is plenty available worldwide. Fly ash is used as ingredients in concrete which enhance the properties of concrete and utilization of fly ash is helpful for consumption. This paper presents a brief history and review of geopolymer technology with the aim of introducing the technology and the vast categories of materials that may be synthesized by alkali activation of alumino silicates.

Keywords: Fly ash, GGBS, Alkaline Solution, strength, durability, utilization

INTRODUCTION

Concrete is one of the most widely used construction material. It is usually associated with Portland cement as the main component for making concrete. Ordinary Portland cement (OPC) is conventionally used as the primary binder to produce concrete. Production of Portland cement is currently exceeding 2.6 billion tons per year worldwide and growing at 5 percent annually. Five to eight percent of all human-generated atmospheric carbon-di-oxide worldwide comes from the concrete industry. Among the greenhouse gases, carbon-di-oxide contributes about 65% of global warming. Although the use of Portland cement is still unavoidable until the foreseeable future, many efforts are being made in order to reduce the use of Portland cement in concrete. On the other hand, a huge volume of fly ash is generated around the world. Most of the fly ash is not effectively used, and a large part of it is disposed in landfills which affects aquifers and surface bodies of fresh water. Fibre reinforced cement or concrete is a relatively new composite material in which fibres are introduced in the matrix as micro reinforcement, so as to improve the tensile, cracking and other properties of concrete. Glass Fiber Reinforced Concrete (GFRC) is a type of fiber reinforced concrete which are mainly used in exterior building facade panels and as architectural precast concrete. The term “ geopolymer” was first introduced by Davidovits in 1978 to describe a family of mineral binders with chemical composition similar to zeolite but with an amorphous microstructure. So, one of the ways to produce environmentally friendly concrete is to reduce the use of Ordinary Portland Cement by replacing cement with by-product materials such as fly ash. One of the efforts to produce more environmentally friendly concrete is to replace the Portland cement in concrete with by-product materials such as fly ash. An effort to make environmentally friendly concrete is the development of inorganic alumina-silicate polymer, such as fly ash that are rich in silicon and aluminum called Geopolymer, synthesized from materials of geological origin or by-product materials such as Fly ash that are rich in Silicon and Aluminum. GGBS (Ground Granulated Blast Slag) is a waste material Generated in iron or Slag Industries have significant impact on Strength and Durability of Geopolymer Concrete.

LITERATURE REVIEW

Pratap Kishanrao et al studied the Performance of Geopolymer concrete mixes at elevated temperatures. It is an established fact that the green house gas emissions are reduced by 80% in Geopolymer concrete vis-a-vis the conventional Portland cement manufacturing, as it does not involve carbonate burns etc. Thus Geopolymer based Concrete is highly environment friendly and the same time it can be made a high-performance concrete. In the present study, fly ash, blast furnace slag and catalytic liquids have been used to prepare Geopolymer concrete mixes. This study is continued to investigate the behaviour of such Geopolymer concrete under high temperatures ranging from 100°C to 500°C. Cubes of size 100mm × 100mm × 100 mm are tested for their residual compressive strengths after subjecting them to these high temperatures.

D.B. Raijiwala et al studied about the geopolymer concrete. This paper presents the progress of the research on making Geopolymer concrete using the Thermal Power Plant fly ash, (Ukai) Gujarat, India. The project aims at making and studying the different properties of Geopolymer concrete using this fly ash and the other ingredients locally available in Gujarat. Potassium Hydroxide and sodium Hydroxide solution were used as alkali activators in different mix proportions. The actual compressive strength of the concrete depends on various parameters such as the ratio of the activator solution to fly ash, morality of the alkaline solution, ratio of the activator chemicals, curing temperature etc.

S.Subburaj et al studied the Strength and Durability characteristics of Geopolymer concrete using GGBS and RHA. In this study GGBS used as a base material for geopolymer concrete and it is replaced upto 30% by BRHA. The strength characteristic of GGBS and BRHA based geopolymer concrete has been studied. The suitable compressive strength test is performed. The result shows that the replacement of BRHA decreases the compressive strength of geopolymer concrete, because of the unburnt carbon content present in the BRHA. In order to improve the workability of fresh concrete, high-range water-reducing naphthalene based super plasticizer was used.

Anurag et al investigated results of an experimental study on the strength and absorption characteristics of Geopolymer concrete. In this experiment Total nine mixes were prepared with NaoH concentration as 8M, 12M, 16M and curing time as 24hrs, 48hrs, and 72hrs. Compressive strength, water absorption and tensile strengths tests were conducted on each of the nine mixes. Results of the investigation indicated that there was an increase in compressive strength with increase in NaoH concentration. Strength was also increased with increase in curing time, although the increase in compressive strength after 48hrs curing time was not significant. Compressive strength up to 46 MPa was obtained with curing at 600 C. The results of water absorption test indicated that % water absorption of cubes decreased with increase in NaoH concentration and curing time**.**

Parthiban et al investigate the Chemical Admixture does not show any impact on Compressive Strength but shows considerable increase in the workability of the concrete. The Specimens have been cured in ambient temperature condition to check the suitability of Geopolymer concrete for cast-in-situ conditions. 7 day strength was found to be 70% of its 28 days strength, the 28 days strength is higher compared to OPC.

Ganapati et al investigate replacement of Fly ash for 5 different GGBS content (upto 40%) and 8M NAOH solution and NA2SIO3/NAOH ratio was 2.5 taken and the result indicates that with the increase of Slag content, the compressive Strength of 31.85 at 3 days achieved. From the paper it is also concluded that there is no necessity of Exposing Geopolymer Concrete to Higher temperature to attain maximum Strength if minimum 9% of flyash is replaced by GGBS. 90% of compressive Strength was achieved in 14 days and the average density of Geopolymer. Concrete was equal to that of OPC concrete.

Partha et al investigated that the GGBS added to (0 to 20%) of total binder, significant increase in Strength and some decrease in workability observed on Geopolymer concrete. The addition of GGBFS enhanced setting of the concrete at ambient temperature. The strength gain slowed down after the age of 28 days and continues to increase at a slower rate until 180 days. The effect of mixture variables on the development of tensile strength was similar to that on the development of compressive strength.

Supraja et al investigated that in order to produce GGBS added Geopolymer concrete different Molarities 3M, 5M, 7M and 9M are taken to prepare different mixes. The Cube Specimens are taken of 100mm*100mm*100mm.Two different curing is carried oven curing at 50C and Direct Sunlight Curing. The Result shows that there is no significant increase in strength of oven cured specimens after 3 days of Geopolymer concrete and the strength of Geopolymer concrete is increasing with the increase of the morality of Sodium Hydroxide. Sunlight curing is more convenient for practical conditions

Madheshwaran et al investigated the variation of GGBFS in concrete has been studied and Longer curing time improved the Polymerization process and results in compressive Strength. Higher the Molar Ratio (7 M) with Higher GGBS (100%)results in the Higher Compressive Strength and Split tensile strength .By this compressive Strength in the range of 45Mpa to 60 Mpa is achieved and Highest is for 100% GGBS. Apart from energy intensiveness, the GPCs utilize the industrial waste for producing the binding system in concrete; there are both environment and Economical Benefits of Using Fly ash and GGBS. The addition of Naphthalene based Super Plasticizer content more than 2% slightly reduce the Compressive Strength.

Vijai et al conducted tests on Geopolymer concrete cubes, cylinders and prism specimens by using fly ash and aggregates and also using the ordinary Portland cement along with the fly ash and aggregates. It was inferred that the density of GPC ranges from 2336 to 2413 kg/m3 and density of GPCC ranges from 2356 to 2424 kg/m3. They also reported that Geopolymer Concrete has two limitations such as delay in setting time and necessity of heat curing to gain strength.

Vijaya Rangan et al studied the behavior of fly ash-based Geopolymer concrete and informed that the geopolymer concrete had an excellent compressive strength and is suitable for the structural applications. The elastic properties of the hardened concrete, as well as the behaviour and strength of the reinforced structural members were similar to those of Portland cement concrete. Therefore, the design provisions present in the current standards and codes can be used to design the reinforced fly ash-based geopolymer concrete structural members.

Limitations

- Geopolymer concrete did not harden immediately at room temperature as in conventional concrete.
- Geopolymer concrete specimens took a minimum of 3 days for complete setting without leaving a nail impression on the hardened surface.

These two limitations of geopolymer concrete mix was eliminated by replacing 10% of fly ash by OPC on mass basis with alkaline liquids resulted in Geopolymer Concrete Composite and are considered as drawbacks of this concrete to be used for practical application.

CONCLUSION

From the past research studies, it can be sequel that: The reduced CO2 emissions of Geopolymer cements build them a good alternative to Ordinary Portland Cement. Geopolymer cement produces a substance that is comparable to or better than traditional cements with respect to most properties. Higher concentration of sodium hydroxide solution results in higher compressive strength of geopolymer concrete. Geopolymer concrete has excellent properties within both acid and salt environments. Low calcium fly ash based geopolymer concrete has excellent compressive strength, exposure to aggressive environment, workability, exposure to high temperature and is suitable for structural applications.

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