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# APPLICATION OF GEOPOLYMER CONCRETE IN CONSTRUCTION OF GREEN BUILDING

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**ABSTRACT:-** *Rapid infrastructure development taking place nowadays, Portland cement concrete is the most popular and widely used building material. However, due to the restriction of the manufacturing process and the raw materials there are two major drawbacks with respect to sustainability. About 1.5 tons of raw materials are needed in the production of every ton of Portland cement, at the same time about one ton of carbon dioxide (CO2) is released into the environment during this production. The coal-fired thermal power plants generate solid waste in the form of fly ash and pond ash. The rice mill industry produces rice husk ash. Disposal of these wastes is a major engineering challenge. Today research has combined sustainability with waste management leading to a wonderful product called geopolymer concrete. Modern-day geopolymer concrete are mostly made from low calcium fly ash and rice husk ash and other waste materials activated by alkaline solutions using (NaOH or KOH with Na2SiO3 or K2SiO3). However it should be noted that with the variation in the parameters such as Na2SiO3/NaOH ratio, Molarity of NaOH curing temperature and curing time leads to changes in the strength. Geopolymer materials represent an innovative technology that is generating considerable interest in the construction industry, particularly in light of the ongoing emphasis on sustainability.*

***Key Words: Geopolymer concrete, Fly ash, Rice husk ash, Sodium hydroxide, Sodium silicate.***

## INTRODUCTION

Sustainable development is a concept that declares that today's generation should not compromise the ability of future generations to meet their needs. The three pillars of sustainable development are economic and environmental protection as well as social development. A sustainable city should provide a high quality of life for its inhabitants without affecting human conditions in neighboring regions. Climate change, energy insecurity, low carbon economy through technological innovation and behavioral transition are some of the issues that should be seriously considered in future sustainable cities. Buildings are energy-consuming structures that have a large impact on global climate change and other energy-related environmental issues. Buildings are responsible for almost 40 percent of the total primary energy consumption and 70 percent of electricity consumption. About 40 percent of CO2, 50 percent of SO2, and 20 percent of NOx emissions are produced in the US as a result of building-related energy consumption. Today there is a growing trend in most countries towards the design and construction of green buildings. A green building should have certain unique features and during its entire life cycle should contribute to the conservation of resources (energy, land, water and materials), reduction of pollution, improvement in indoor environmental quality and protection of the environment. Portland cement is the most widely used binder material for concrete. However, it is a very energy-intensive material resulting in the production and release of global warming greenhouse gas CO2, besides causing degradation of the earth due to mining activities for limestone. This necessitates the development of eco-friendly binder material and geopolymer concrete is one such potential material. Environmental issue has become a crucial issue in the concrete industry. This is mostly because of the emission of greenhouse gasses from the production of Portland cement, a primary binder in making concrete. Many efforts have been made to reduce the use of Portland cement in concrete that in turn will reduce the greenhouse gas emission. Those efforts include the use of supplementary cementing materials and finding alternatives for Portland cement. The disposal of fly ash, rice husk ash and other waste materials generated by the industries have become a serious environmental problem. A huge amount of fly ash is generated by the thermal power plant industry while 55kg of rice husk ash is generated during the production of 1000kg of paddy. This has created the necessity for developing a new eco-friendly concrete where a large quantity of fly ash and rice husk ash are used.

The following are some of the problems that are solved when fly ash, rice husk ash, and other waste materials are used in large proportions:

1. It reduces the usage of Portland cement.

2. It reduces the emission of CO2.

3. The natural materials/resources like limestone, clay etc., can be conserved, which are used during the cement manufacturing.

**LITERATURE REVIEW**

**Thaarrini J (2019)**

The growing concern in the Reuse and Recycling of wastes has provoked research interests in exploring ways for the transformation of industrial wastes into useful building materials. This work aims to characterize and study the feasibility of using the Cotton textile effluent from the Mercerizing process for developing Geopolymer concrete blocks. The cotton mercerizing process uses large quantities of caustic soda (NaOH) solution which is then disposed of into agricultural lands, landfills or nearby rivers. This effluent from the mercerizing process is used as a partial replacement of the alkaline activator solution of Geopolymer concrete in the manufacture of blocks. Effluent from the various processes was collected and was checked for the molar ratio which ranged from 0.015 to 0.751. The effluent from the mercerizing process with molar ratio ($SiO_2/Na_2O$) of 0.54 was chosen and replaced with the alkaline activator solution in varying percentages of 0,25,50,75 and 100.The preliminary investigations were conducted on geopolymer mortar and the optimum replacement of textile effluent was found to be 50% with a molarity of 6M with alkaline Liquid to Binder ratio as 0.4 and 0.5. With the optimum parameters geopolymer concrete blocks were manufactured and tested for their mechanical properties. The results show that the cotton mercerizing effluent can be used as a partial replacement for the alkaline activator solution of Geopolymer Concrete.

**Dr.R.Kumutha, S.Aarthy and Dr.K.Vijai, 2018**

Portland cement is the most widely used binder material for concrete and also it generates a large amount of carbon dioxide ($CO_2$) which is responsible for global warming. The other major engineering problem is the disposal of solid waste from coal-fired thermal power plants namely fly ash. Geopolymer concrete is prepared without using conventional cement and it can be self-cured. The industrial by-products like fly ash and Ground Granulated Blast furnace Slag (GGBS) can be activated using alkaline solutions to get a cementitious binder. This paper aims to develop the double-layered geopolymer concrete paver blocks by the activation of fly ash and GGBS by adding polyester fibres in the top half-thickness of paver blocks. In this experimental investigation properties like density, compressive strength, split tensile strength, flexural strength, water absorption, and abrasion resistance of paver blocks were determined by adding polyester fibres in proportions of 0%, 0.1%, 0.2%, 0.3%, 0.4% and 0.5% by volume of concrete. The paver blocks developed were tested as per IS 15658:2006. Test results indicated that the addition of polyester fibres in paver blocks has significant advantages with respect to flexural strength and abrasion resistance.

**Abhay Tawalare, Rupali Kejkar and Mahesh Kumar, 2018**

An approximate 400-500 million metric tons of fly ash is generated annually from the thermal power plant. The maximum use of fly ash is necessary for sustainable development. In this research, it attempted to develop a method for the manufacture of paver block using fly ash-based geopolymer technology. The influence of the ratio of alkaline solution and fly ash on geopolymer paver block studied. The fly ash, fine aggregate, coarse aggregate mixed with an alkaline solution of 14 molar concentration of NaOH and cured at 90°C temperature. The paver blocks cast for different Na2SiO3/NaOH ratio using natural aggregate and recycled aggregate as fine aggregate and slag as coarse aggregate. Paver blocks tested for compressive strength, flexural strength, water absorption, abrasion resistance. Results compared against geopolymer paver block using natural aggregate and recycled aggregate as fine aggregate and slag as coarse aggregate. The geopolymer paver block with recycled aggregates having mix proportion as GPC4 showed all the test results within the limit as per IS15658, hence it can be used in residential driveways, light vehicles/public pedestrian and light vehicle paths.

**D.V. Karunarathne, K. Arulolipavan and K.M.L.A. Udamulla, 2017**

The coal-fired thermal power plants generate solid waste in the form of fly ash and pond ash. Disposal of these wastes is a major engineering challenge. Since a large amount of raw materials is needed in the production of every tonne of Portland cement and at the same time about one tonne of carbon dioxide ($CO_2$) is released into the environment during this production, the research attempts to see whether this solid waste Fly ash can be used in geopolymer concrete paving blocks, so that it will mitigate the adverse effects on the environment due to disposal while reducing the carbon footprint. In this research

geopolymer concrete paving blocks were made from low calcium fly ash activated by alkaline solutions (NaOH or KOH) to liberate silicon and aluminium with an additional source of silica to assess whether these could satisfactorily be used in Sri Lankan roads satisfying Sri Lanka Standard(SLS) requirements. Geopolymer concrete blocks with a concentration of NaOH of 12M and 16M was prepared for three different strength classes, namely 30MPa,40MPa,50MPa.One set of series was cured in 80ºC for 48hrsand the other series was cured in ambient temperature. The compressive strength, slip/skid resistance and water absorption of GPC paving blocks were determined and were compared with SLS 1425 part 1and 2.GPC paving blocks for all strength classes which is cured in 80 ºC ambient temperature is found to satisfy all SLS specifications while compressive strength of geopolymer concrete paving bocks cured in ambient temperature is found to be less than the design strength.

**G. Gayathri,V.S. Ramya,T.Yasotha and M. Dheenedhayalan, 2016**

The major problem the world is facing today is environmental pollution. Mainly in the construction industry, the production of Portland cement causes the emission of pollutants that causes a serious threat to the environment. The pollution effects on the environment can be reduced by increasing the usage of industrial by-products in our construction industry. Geopolymer concrete in the present study, to produce the geo-polymer concrete the Portland cement is fully replaced by fly ash and GGBS (Ground granulated blast furnace slag). The alkaline liquids are used for the activation of these materials. The alkaline liquids used in this study are the solutions of sodium hydroxide (NaOH) and sodium silicate (Na2SiO3). Molarity of sodium hydroxide (8M) is considered. Fly ash and GGBS were used in this study such as 90% fly ash and 10% GGBS. The rapid growth of technology and a high rate of obsolescence in the electronics industry have led to one of the fastest-growing waste streams in the world, simply called as E-waste. Improper disposal of E-waste can cause serious threats to human health and the environment. The present study covers the use of E-Waste as a partial replacement in fine aggregate in geopolymer concrete. The main aim of this study is to investigate the change in mechanical properties of geopolymer concrete with E-Waste in concrete. And also to reduce as far as possible the accumulation of used and discarded electronic and electrical equipment, this investigation were made with replacement of sand by using e-waste are 0%,10%,20%,30%,40% and 50%. Further, the strength characteristics of cubes, beams and cylinder of geopolymer concrete with E-waste of varying mix ratios can be carried out.

**GEOPOLYMER CONCRETE**

There are mainly two constituents of geopolymers, such as the source materials and the alkaline liquids. The source materials for geopolymer concrete may be fly ash, rice husk ash, kaolinite, GGBS, clay etc simply saying by-products or the combinations of the above. The choice of the source materials for making geopolymers depends on factors such as availability, cost, type of application, and specific demand of the end-users.

The alkaline liquids are from soluble alkali metals that are usually Sodium or Potassium based. The most common alkaline liquid used in geopolymer concrete is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate. The alkaline liquid and the source materials are used with fine aggregate and coarse aggregate for making geopolymer concrete. The ratio of alkaline activator solution to the source material is chosen based on the workability and strength requirement.

**MATERIALS USED IN THE STUDY**

Rice husk ash generated by rice mill industry, fly ash generally available as low calcium fly ash obtained as by-product of burning anthracite, commercial-grade sodium hydroxide pellets, sodium silicate solution, fine aggregate and coarse aggregate.


**SCOPE OF STUDY**

1. The main objective of this present study is producing Geopolymer fly ash and RHA based concrete.
2. Since there is no provision for mix design of geopolymer concrete so, mix design of ordinary Portland cement is taken as reference and M25 grade mix is produced using locally available fine and coarse aggregate using fly ash and RHA as a binder material.
3. Commercially available chemicals (sodium hydroxide + sodium silicate) will be used for preparing alkali solutions for activation of fly ash and RHA to act as binder material. The alkaline activator solution should be prepared a day before use.

**METHODOLOGY**

Formulation of alkaline solutions, source materials and other ingredients, the source materials are fly ash and rice husk ash. Characterization of ingredients, such as chemical compositions and particle size are examined. Formulation of geopolymer concrete at ambient temperature, i.e. different geopolymer concrete specimens have been casted based on the different combinations of source materials as well as alkaline solutions, and different ratios of alkali-activated solution to the source material are taken based on the workability conditions such as 0.40, 0.45, 0.50.

Compressive strength test and flexural strength test was analyzed and compared with ordinary Portland cement of the same mix and based on the data different applications are seen.

**PROCEDURE ADOPTED IN FORMULATING THE MIXTURES**

Unlike conventional cement concrete geopolymer concretes are a new class of construction materials and therefore no standard mix design approaches are available for geopolymer concretes. M25 grade mix is considered for manufacturing geopolymer concrete as we have specific mix design for OPC concrete, so geopolymer concrete was casted for testing of compressive strength at the end of 14 days and 28 days. The ratio of alkali-activated solution to geopolymer solids was used suitably and is taken as 0.5. The primary objective for performing the experiment is to obtain good compressive strength at the end of 28 days. The secondary objective was to obtain a good cohesive mix with good workability. The proportions of source material, i.e, a suitable combination of fly ash and rice husk ash is taken. (rice husk ash is taken 15% and 20% of fly ash by weight and it should not be more than 25%).

**PREPARATION OF TEST SPECIMENS AND CURING**

In this experimental work, Rice husk ash that was obtained from India Glycols Limited Gida Gorakhpur and low-calcium Class 'F' dry fly ash obtained from a local market were used that buys the fly ash from NTPC Tanda as the source material. Analytical

grade sodium hydroxide (NaOH with 98% purity) flakes dissolved in water and sodium silicate solution ($Na_2O$=14.7%, $SiO_2$=29.4% and water=55.9% by mass) were used. Both the liquids were mixed together and the activator solution was prepared one day prior to its use. The aggregates and fly ash and RHA were mixed in a pan mixer for about 3 minutes. Then added with the activator solution, the fresh geopolymer concrete had a stiff consistency and glossy appearance. The specimens were placed at the ambient temperature, for curing to the desired periods. For precast beams or the structures where high strength is required ambient curing is not sufficient so curing at a high temperature range of $80^0$c to $100^0$c.

**APPLICATIONS**

PAVEMENTS

For protection against drying aliphatic alcohol-based spray are used, no chances for bleeding of water above the surface and also geopolymer concrete based pavements are light in weight.

WATER TANK

Leaking in the tank is prevented due to gel swelling mechanism and in geopolymer concrete, there are less chances of generation of calcium hydroxide and also are more durable as GPC shows more resistance against chemical attacks.

PRECAST BEAMS

Nowadays DMRC uses the geopolymer concrete based precast beams and also GPC beams formed three suspended floor levels of buildings, for temperature-controlled hydraulic heating of building spaces above and below water pipes were placed inside them.

**CONCLUSIONS**

- The major problem today is the disposal of solid waste. Coal-fired thermal power plants generate solid waste in the form of fly ash and pond ash, And rice husk ash generated by rice mill industry. Disposal of these wastes is a major engineering challenge so utilization of these waste materials was necessary.
- Geopolymer concrete is a promising construction material due to its low carbon dioxide emission
- Widespread applications in precast industries due to

-its high production in short duration

-less breakage during transportation

- Enhanced research along with acceptance required to make it a great advantage to the industry
- Using RHA enhances the basic properties of Geopolymer concrete in addition to its resistance to various chemical attacks.

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