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A Study on Geopolymer Concrete

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ABSTRACT: Geopolymer concrete is a new form of concrete made up of organic molecules that react chemically. The by-product of coal-fired power plants, fly-ash, is widely available in the world. Since fly ash is high in silica, it forms an alumina silicate gel when it interacts with an alkaline solution, which behaves in the same way as a silicate gel. Fly-ash is being used to replace 50% of the fly-ash in the beams and cubes. GGBS is being used to replace 50% of the GGBS. The opposite of an acidic solution is an alkaline solution. In the casting process, sodium hydroxide and sodium silicate solutions are used. Fly-ash and GGBS have completely replaced cement in this factory. Three key factors affect Dowel action, shear reinforcement part and shear span to effective depth ratio contribute to shear strength.

KEYWORDS: Geopolymer Concrete, Fly-Ash, GGBS, Properties of Concrete, Strength Tests.

I. INTRODUCTION

Via process technology, the cement industry has made substantial progress in lowering CO₂ emissions. And process efficiency changes since CO₂ output is inherent in the basic calcination of limestone. However, there isn't anything else that can be done. Geopolymer concrete is free of cement, water, and curing. The main aim is to minimize the amount of ordinary Portland cement used while increasing the number of waste materials (GGBS and FLYASH). Geo-polymer concrete is made of GGBS and fly ash. Cement is the second most commonly used substance on the planet, after water. Because of its versatility and power, concrete is the most frequently used material in the modern world. OPC is a form of cement widely used in concrete production. Binding aggregates have unique properties, but the use of cement in polluting the atmosphere is not. Factors like availability, cost, type of application, and end-user demand influence the source materials used to produce geopolymers. Alkaline liquids are made up of alkali metals soluble in water, such as sodium or potassium. A mixture of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate is the most common alkaline liquid used in geopolymerization. Cement production has long been linked to environmental concerns. Carbon dioxide emissions from limestone calcination and fossil fuel combustion during cement production are based on one ton per tons of cement produced. As a result, seeking an alternative to Portland cement, which is currently the most expensive and resource-intensive, is essential. OPC is commonly used in India due to its low cost and widespread availability. In light of a growing awareness of the adverse effects of over-exploitation of natural resources, eco-friendly strategies for effective resource management are introduced. In terms of global use, concrete is only second to water. Cement has historically been used as the primary binder in concrete. On the other hand, it affects the environment and has a variety of negative consequences. Among these efforts is the use of Additional cementing materials such as fly ash, silica fume, granulated blast furnace slag, rice husk ash, and met kaolin and the hunt for alternative binders to Portland cement. Geopolymer technology holds a lot of promise in the concrete industry as a binder alternative to Portland cement. In terms of reducing CO₂ emissions from the cement and aggregates industries, geopolymer technology can reduce CO₂ emissions by about 80%. Excellent compressive strength, minimal drying shrinkage and creep, high sulphate resistance, and good acid resistance are all properties of low-calcium fly ash-based geopolymer concrete that has been heat-cured. It can be used for a wide range of infrastructure purposes.



II. LITERATURE REVIEW

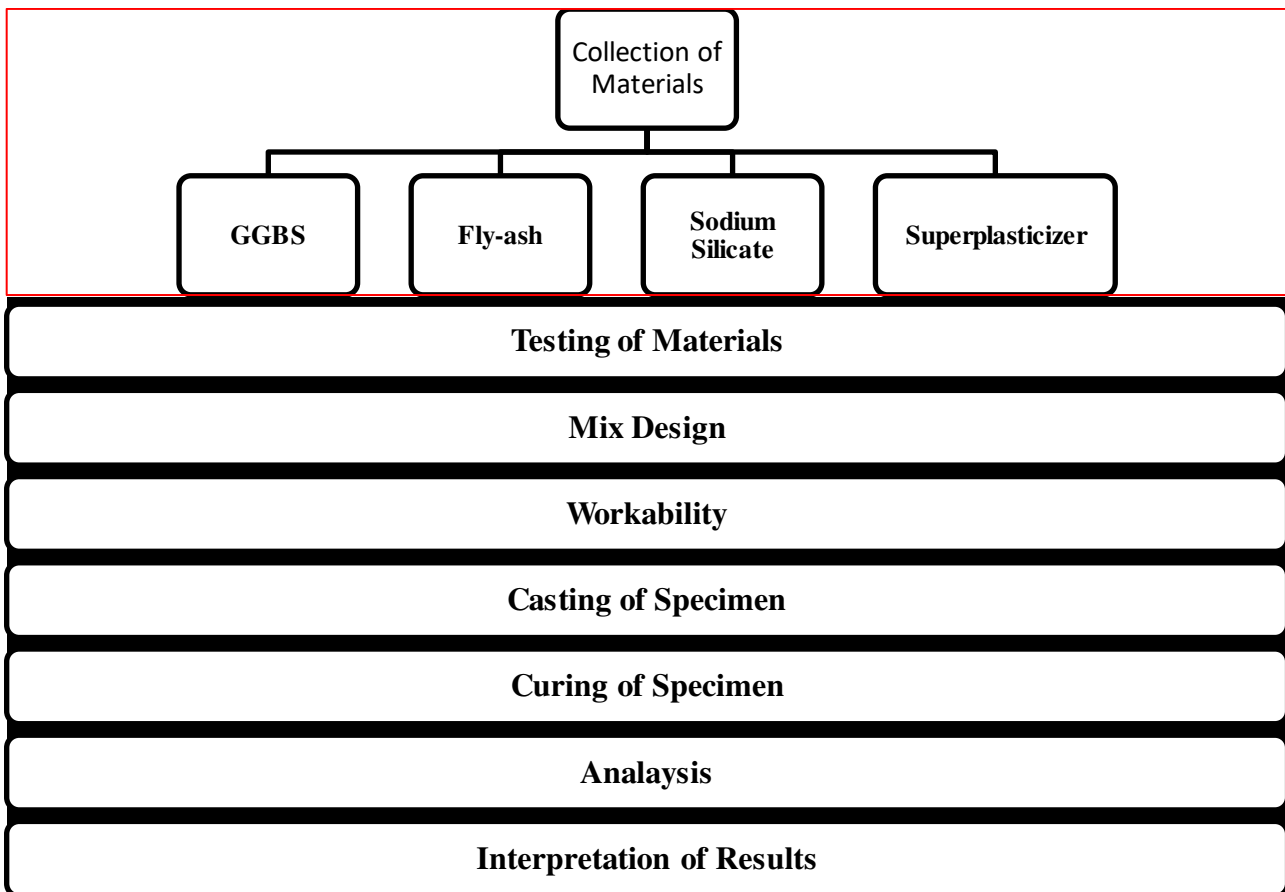
Antony 2014 et al.

The author of this research paper spoke about geopolymer concrete and how it flexes. During the production of Ordinary Portland Cement, CO₂ is released into the atmosphere (OPC). Fly ash, a coal industry by-product, is used to replace OPC in concrete. To make solid concrete, it contains a lot of silicate gel and is mixed with an alkaline solution. Fly ash's compressive strength increases as fineness increases and porosity decreases. This paper compares the M 40 Geopolymer Concrete (GPC) beams flexural conduct to control cement concrete beams. GGBS is applied to the fly ash used in GPC at a rate of 25% to achieve the necessary compressive strength.

Kumaravel 2013 et al.

The author of this Research Paper addresses geopolymer concrete and the flexure behaviour of beams. CO₂ emissions Pollution of the atmosphere results from the manufacture of Ordinary Portland Cement (OPC). As a result, a new material to replace OPC in concrete has been created. Deficiency in calcium Fly ash is a coal industry by-product that is commonly available around the world. Since fly ash is high in silicate and alumina, it interacts with an alkaline solution to form an alumina silicate gel that binds the aggregate and results in good concrete. The porosity of fly ash decreases as the fineness of the ash increases, resulting in increased compressive strength. Geopolymer concrete (GPC) and control cement concrete (CCC) beams are compared and contrasted in flexural behaviour. Geopolymer concrete beams and control beams have their load-displacement responses calculated and compared to theoretical predictions. According to the results, the geopolymer concrete beams have a higher flexural strength. At different stages, such as duty load and peak load, GPC beams have higher deflections.

III. METHODOLOGY





GGBS

The GGBS is a waste product from the iron industry. The most popular components of blast furnace slag are CaO and MgO. The compressive strength of slag increases as the CaO content rises. Up to 11 per cent and 15 per cent, respectively, the MgO and Al₂O₃ materials follow the same trend, after which no further changes are necessary. Many compositional ratios or so-called hydraulic indices are used; the latter is typically expressed as the binder compressive force.

FLY-ASH

Fly-ash is a coal combustion by-product that is used in industry. The scale of fly ash particles ranges from 0.5 to 300 micrometres, and they are spherical. Because of the rapid cooling, only a few minerals crystallize, resulting in primarily amorphous, quenched glass. In pulverized coal, however, some refractory phases do not melt (completely) and remain crystalline. Fly ash is a heterogeneous material as a result of this. SiO₂, Al₂O₃, Fe₂O₃, and, on rare occasions, CaO are the most significant chemical components contained in fly ashes. Fly ashes have a wide range of mineralogy. Glass, quartz, mullite, and the iron oxides hematite and magnetite are the most commonly used expressions. The two types of fly ash that are available are Class F and Class C. The most significant difference between these classes is the amount of calcium, silica, alumina, and iron in the ash. The chemical composition of coal combustion influences the chemical properties of fly ash.

SODIUM SILICATE

The goods come in two forms: aqueous solution and solid. Water glass or liquid glass are other names for sodium silicate. Colourless glassy or crystalline solids, or white powders, are sodium silicate. They are water-soluble, except for the silicon-rich ones, and produce alkaline solutions. In both neutral and alkaline solutions, sodium silicates are stable.

SUPERPLASTICIZER

Superplasticizers, also known as high-range water reducers, are additives used in high-strength concrete manufacturing. Plasticizers are chemical compounds that reduce the amount of water used in concrete production by around 15%. Superplasticizers can minimize the amount of water in a product by up to 30%.

IV. APPLICATIONS & OBJECTIVES

APPLICATIONS

Geopolymer concrete has a wide range of uses in building projects, mainly in the former Soviet Union, China, and other countries. There are some of the applications:

- Concrete structural elements
- Pavements Made of Concrete
- Block made of masonry.
- Refractory concrete

OBJECTIVES

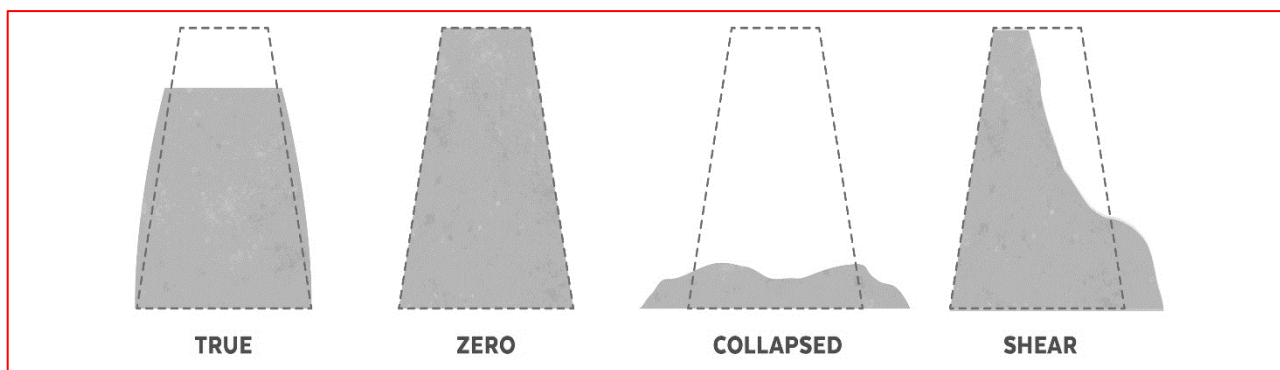
- To determine the shear response of geopolymer concrete with longitudinal and shear reinforcement under flexural loading.
- Investigate the anatomy of the cracks. The following are the study's goals:
- Determine the mechanical properties of geopolymer concrete
- Reduce the use of ordinary Portland cement and increase factory-made cement (GGBS and FLY ASH).
- Create a geopolymer concrete mix design.
- To figure out how geopolymer concrete behaves in shear.



V. TESTS AND RESULTS

SLUMP TEST

The slump test does not account for all factors that affect concrete's workability, but it is beneficial for detecting differences in a mix's uniformity. The cone is slowly lifted after filling, and the unsupported concrete will slump, hence the term "slump test." When unsupported concrete is used for the first time, it can flow to the sides and drop in height, a process known as a slump. Slump is a metric that indicates the workability of fresh cement concrete and the water/cement ratio needed for various applications.



COMPRESSIVE STRENGTH TEST

Outdoor cured specimens of cubes were subjected to a 28-day compressive strength test. The cube specimens will be tested in a 3000KN compression measuring unit. Until testing, the bearing surface of the cubing machine and the surface of the cubes should be wiped clean. The loading faces should be parallel to the loading wall, and the cube specimen should be 150mm x 150mm x 150mm, with the axis of specimen carefully aligned at the loading frame's middle. The load applied will be gradually increased, and if the specimen or load applied fails, the failure should be registered. Compressive strength = load/area N/mm² is the formula for calculating concrete's compressive strength.



Fig. Compressive Strength Machine



SPLIT TENSILE STRENGTH TEST

Aside from the flexure measure, the other methods for determining the tensile strength of concrete can be divided into direct and indirect ways. The natural techniques face various challenges, including properly keeping the specimen in the testing machine without adding stress concentration and applying a uni-axial tensile load to the sample free of eccentricity. Bending and even a slight eccentricity of load induces axial force conditions and tensile power. Since performing a direct tension test is complex, several indirect methods for determining tensile strength have been established. A compressive force is applied to the concrete in these experiments. The specimen in such a way that tensile stresses are caused in the sample, causing it to fail. The strength of concrete is the stress under which failure occurs—the splitting tests, also known as the splitting tensile strength of concrete. According to a plastic analysis, a concrete cylinder located horizontally between the platens is used to add compressive line loads to the opposite generators. The specimen eventually fails due to this tensile stress by splitting along the loaded diameter, and the tensile strength can be measured by knowing P at failure. At the end of a line, avoid hyphenation. Symbols should denote vectors and matrices in bold form. Italics are usually used to express scalar variable names. SI units can be used to express weights and scales. When non-standard abbreviations or symbols are first listed, they must be specified, or a glossary must be given.



Fig. Tensile Strength Machine

TYPES OF FAILURES

Various types of failures
Diagonal Tension Failure: This form of loss occurs when shear reinforcement is insufficient. At 45 degrees, a diagonal shear crack forms in the member and spreads quickly, causing failure.
Shear Compression Failure: Diagonal compression failure occurs when the a/d ratio is between 1 and 2.5. The beam carries a ten-tons load. Concrete is crushed at the tip of the inclined crack in the compression field. This is due to a lack of concrete ability.
Failure Due to Shear Tension A diagonal crack propagates horizontally and longitudinal tensile reinforcement, causing this failure. This happens as a result of insufficient reinforcement anchorage. The experimental and analytically predicted deflection values were in good agreement, suggesting the applicability of OPC analytical methods to GPC. The geopolymer concrete was found to be adequate as structural components and could be seen as a possible replacement material for OPCC. Geopolymer concrete is both environmentally and economically friendly, and it can replace traditional cement concrete in a variety of applications, including precast units.



The beam is being loaded with a 90-tonne load on its two points, with simple bending occurring in the middle region of the beam. However, the malfunction occurred when the load was applied in large amounts. Shear compression failure is the cause of the failure. Both a/d ratios of 1.5 and 2 GPC beams had crack patterns identical to the OPCCs beams. The failure patterns of all the beam specimens were discovered to be the same. During the early load stages, flexural cracks developed in the central portion of the structure and gradually spread to the supports. In the compression mode, all of the beams failed in the flexural mode due to reinforcement yielding and concrete crushing.

VI. CONCLUSION

- The findings reached as a result of the current study's experimental investigation are as follows.
- In comparison to traditional concrete, the strength of GPC is exceptionally high.
- Early age strength of geopolymer concrete is very high.
- Is the geopolymer concrete made with water and cement or without them?
- NaOH Concentration affects the consistency of the superplasticizer.
- The shear period is an essential factor to remember. It was discovered that the effective depth ratio (ad)
- every beam A diagonal crack ran from the support to the nearest loading point, causing the structure to fail.
- As the ad ratio fell, the shared strength of beams increased.

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