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Experimental Investigation on Microscopic and Strength Characteristics of Geo Polymer Concrete

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Abstract: In this project introduced geopolymers concrete it is made by fly ash, sodium silicate and sodium hydroxide, fine aggregate and coarse aggregate. Flyash and alkaline solution combination act as a cement. Sodium silicate and sodium hydroxide pH level obtained above 7 so it is called alkaline solution. In this innovative concrete fully replaced portland cement so it is called green concrete. The flyash is one of the industrial waste products it is store above land filled and it is initiated land pollution. In this research to control land pollution and green house effects. The flyash product collect from mettur thermal power plant.

The title of our project is "microscopic and strength characteristics of GPC" Through this project we have calculated the strength of GPC and also to find suitable alternate for cement to reduce the pollution (emission of greenhouse gases like CO₂ to the atmosphere) due to the production of cement. To increase the utilization of fly ash. To study the factors that affecting the strength parameters of geopolymers concrete. Besides, in this project, SEM analysis also conducted. The experiment was conducted on strength basis (i.e. compressive strength) for different trial mixes. By this the strength comparisons of various mixes are done. The results shows 76% of combine aggregate mix (MixD) geopolymers concrete obtained dense structure compare to the Mix-A. so this reason Mix-D specimens achieved higher compressive and split tensile strength.

I. Introduction

Geopolymer Concrete (GPC) has emerged as a promising alternative to conventional Portland cement concrete. In GPC, the cementitious binder can be produced by activating aluminosilicate-rich materials such as fly ash, ground-granulated blast-furnace slag (GGBS), metakaolin, rice husk ash and other industrial by-products using alkaline activating solutions. Common alkaline activators include sodium hydroxide (NaOH), potassium hydroxide (KOH), sodium silicate (Na₂SiO₃) and potassium silicate. The reaction between the aluminosilicate source material and the alkaline solution network that acts as the binding phase in concrete.

II. Literature Review

This literature review examines existing studies on replacement fine aggregate replaced with WFS. This review aims to synthesize existing findings, identify gaps in knowledge, and provide a foundation for future research.

2.1 Utilisation Of Fly Ash In A Geopolymeric Material, J.C. Swanepoel, C.A. Strydom

Finding means of utilizing waste products is a very important field of research at the moment. In this study, fly ash, a waste product of the electricity and petrochemical industries, was investigated as a basic ingredient of a new geopolymeric material. The similarity of fly ash to natural pozzolans has encouraged the use of this waste product in the synthesis of geopolymers, which, in turn, can best be viewed as consisting of a polymeric Si-O-Al

framework. Manufacturing of the geopolymers was conducted by mixing fly ash, kaolinite, sodium silicate solution, NaOH and water.

The samples were cured at 40, 50, 60 and 70°C for different time intervals (6, 24, 48 and 72 h). The optimum condition was found to be at 60°C for a period of 48 h. Compressive strength measurements show a maximum strength of almost 8 MPa after 28 days.

2.2 Recent Research Geopolymer Concrete, Nguyen Van Chanh¹, Bui Dang Trung, Dang Van Tuan

Geopolymer Is A Type Of Amorphous Alumino-Silicate Cementitious Material. Geopolymer Can Be Synthesized By Polycondensation Reaction Of Geopolymeric Precursor, And Alkali Poly Silicates. Comparing To Portland Cement, The Production Of Geopolymers Has A Relative Higher Strength, Excellent Volume Stability, Better Durability. Geopolymer Concrete Based On Pozzolana Is A New Material That Does Not Need The Presence of Portland Cement As A Binder. This Paper Presents The Results Of Studying Materials, Mixture Composite, Microstructure Of Geopolymer, And Parameters Affecting Properties Of Geopolymer Concrete.

2.3 Influence Of Naoh Solution On The Synthesis Of Fly Ash Geopolymer, Ubollukrattanasak, Prinyachindaprasit

A Study Was Conducted On Leaching Of Fly Ash Mixed With

Naoh Solution And On Mixing Procedure For Preparing Geopolymer. Leaching Of SiO_2 And Al_2O_3 Was Investigated By Mixing Fly Ash With Naoh Solution For Different Time Intervals And Leachates Were Analyzed In Terms Of Silica And Alumina Contents. To Make Geopolymer Paste, Separate Mixing And Normal Mixing Were Used. For Separate Mixing, Naoh Solution Was Mixed With Fly Ash For The First 10 Min; Subsequently Sodium Silicate Solution Was Added Into The Mixture. For Normal Mixing, Fly Ash, Sodium Hydroxide And Sodium

Silicate Solution Were Incorporated And Mixed At The Same Time. Geopolymers Were Cured At 65 C For 48 H. Microstructure Of Paste And Compressive Strength Of Mortar Were Investigated. Results Revealed That Solubility Of Fly Ash Depended On Concentration Of Naoh And Duration Of Mixing With Naoh. For Mixing Procedure, Separate Mixing Gave Slightly Better Strength Mortar Than Normal Mixing. High Strength Geopolymer Mortar Up To 70.0 Mpa Was Obtained When The Mixture Was Formulated With 10 M Naoh And Sodium Silicate To Naoh Ratio Of 1.0, And The Separate Mixing Sequence Was Used.

III. Methodology

The methodology adopted for the project involves a systematic study of fly ash-based geopolymer concrete, beginning with an extensive literature survey to understand previous research, material characteristics, mix proportions, and strength development. The required materials, including fly ash, fine aggregate, coarse aggregate, and alkaline activator solution, are then selected and their physical and chemical properties are evaluated. Based on the material properties and relevant guidelines, suitable trial mix proportions are designed and different mixes are prepared. Concrete specimens are cast and subjected to the required curing conditions, followed by experimental investigations to determine properties such as workability, compressive strength and angular in shape. The coarse aggregate is also washed to remove any dirt or impurities. The size of the aggregates used here is 20mm, with a specific gravity of 2.8.



IV. Trail Mix Design

Table 1: Trail mix design

Sl. no	Materials	Mix-A 70%	Mix-B 72%	Mix-C 74%	Mix-D 76%	Mix-E 78%
1.	Coarse aggregate (70%-20mm)	1176	1209.6	1243.2	1276.8	1310.4
2.	Fine aggregate (4.75mm-30 %)	504	518.4	532.8	547.2	561.6
3.	Fly ash	533.3	497.7	462.2	426.6	391.1
4.	Sodium Silicate	133.28	124.42	115.47	106.72	97.68
5.	Sodium Hydroxide	53.31		49.7		39.11

V. Materials and Methods

In view of the proposed experimental study, materials such as ordinary Portland cement, M-sand, coarse aggregate and Flyash are used. Before casting the specimen various tests of materials has been conducted.

1. Cement

A cement is a binder, a substance used for construction that sets and hardens. To other materials together. Cement is seldom used on its own, but rather to find sand and gravel together. Cement with fine aggregate produces mortar for masonry, or sand and gravel produces concrete.

2. Fine Aggregate

Aggregate is the granular material used to produce concrete or mortar. When the particles of the granular material are so fine that they pass through a 4.75mm sieve ,it is called fine aggregate.

3. Coarse Aggregate

The coarse aggregates used for the current study are the aggregates used here is 20mm, with a specific gravity of 2.8.

4. Water

Water is a crucial component in concrete, facilitating the hydration of cement to form a strong binding matrix. Only clean, potable water

split tensile strength, and flexural strength.

should be used. The water-cement ratio is critical - excess water weakens concrete, while insufficient water reduces workability.

VI. Preparation of the specimen

1. Mould

The mould is used to prepare the concrete cubes to test their compressive strength. The most common size is 150mm ×

150mm × 150mm. The moulds consists of a main body, base plate and side clamps or bolts to ensure a tight leak-proof assembly. The mould must be cleaned after each use, oiled to prevent rusting, and stored in a dry environment.

2. Mixing

Mixing is the process of combining cement, fine aggregate, coarse aggregate, water and admixtures to achieve a uniform and workable mixture. Over-mixing can reduce workability, under-mixing leads to weak concrete.

3. Casting

Casting is the process of placing the freshly prepared concrete into moulds to achieve the desired shape and strength. The interior surface of the mould should be filled with crude oil before casting for easy demoulding. The concrete should be placed within the setting time of the concrete. It should be placed layer by layer.

4. Compaction

Compaction is the process of removing entrapped air to achieve a dense, strong and durable structure. Compaction can be done using tamping rods or rammers. Proper compaction enhances strength, durability and impermeability preventing cracks.

5. Curing

Curing is the process of maintaining adequate moisture, temperature and time to ensure proper hydration of cement and achieve the desired strength and durability. Common curing method include water curing. The curing period of concrete is 7 days, 14 days and 28 days.

VII. Results and Discussion

7.1 Compressive Strength Test Results

The compressive strength of concrete is determined at the age of 1 days using cubes. The test was carried out on 150mm x 150mm x 150mm size cube as per IS: 516-1959. A 2000kN capacity standard compression testing machine was used to conduct the test. For the studies on compressive strength, cubes are tested with a replacement of 100% of mass of cement with fly ash. Two cubes are cast for each proportion.

Compressive strength=crushing load/ area in N/mm²

Table 2: Flyash based geopolymer concrete compressive strength test

Sl.No	Specimen Description	24 hrs (MPa)
1	Mix-A	23.56
2	Mix-B	25.33
3	Mix-C	24.44
4	Mix-D	29.33
5	Mix-E	24
6	Mix-F	20

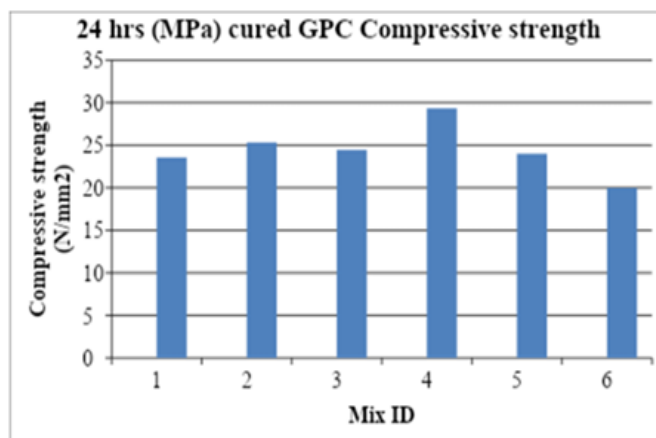


Figure 1: showing the compressive strengths of GPC for various mixes

7.2 Split Tensile Strength Test Results

Table 3: Flyash based geopolymer concrete split tensile strength test

Sl.No	Specimen Description	24 hrs (MPa)
1	Mix-A	2.24
2	Mix-B	2.41
3	Mix-C	2.33
4	Mix-D	2.79
5	Mix-E	2.29
6	Mix-F	1.90

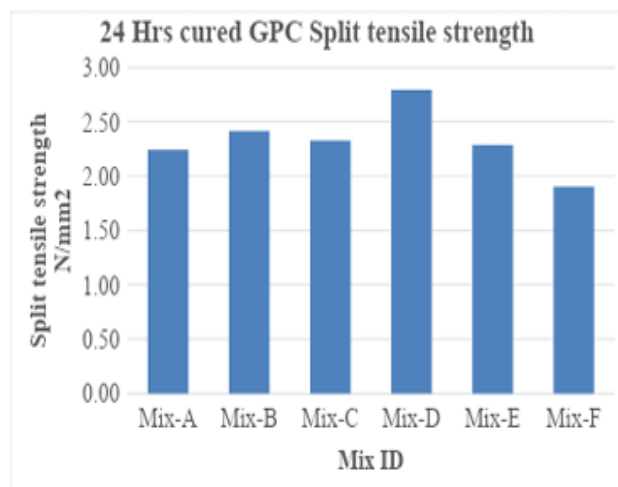


Figure 2: Flyash based geopolymer concrete split tensile strength test

7.3 Sem Analysis

The experimental analysis is shows Mix-A specimen obtained lower mechanical strength and Mix-D specimen obtained good mechanical performance compared to the other mixes. So both Mix-A and Mix-D specimens adopted for SEM analysis.

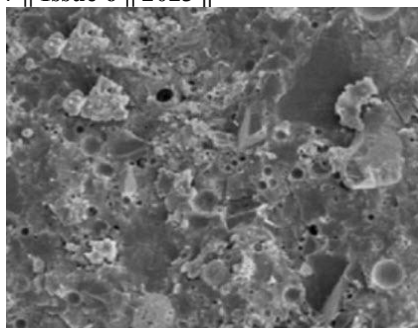


Figure 3: Mix-A Specimen SEM image

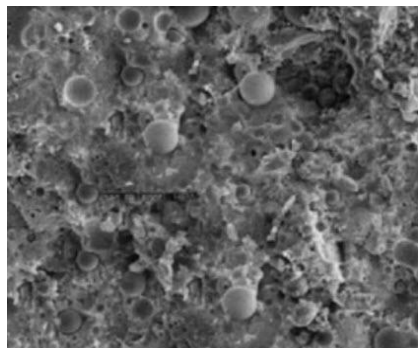


Figure 4: Mix-D Specimen SEM image

Mix-A and Mix-D specimen samples are analyzed by scanning electron microscopy. Mix-A specimen SEM image shows larger size caps and air voids presented compare to the Mix-D. Mix-D geopolymer concrete dense structure compare to the Mix-A. so this reason Mix-D specimens achieved higher compressive and split tensile strength. The large voids cause Mix-A specimens achieved poor mechanical performance.

VIII. Conclusion

- The maximum strength was attained for the mix
- Higher the ratio of sodium silicate-to-sodium hydroxide ratio by mass, higher is the compressive strength of fly ash-based geopolymer concrete.
- Shorter curing time in warm temperature, produces higher compressive strength of fly ash-based geopolymer concrete.
- The slump value of the fresh fly-ash-based geopolymer concrete increases with the increase of extra water.
- Mass of combined aggregate 70% to 80% increased similarly slump value decreased.
- The fresh fly ash-based geopolymer concrete is easily handled up to 120 minutes without any sign of setting and without any degradation in the compressive strength.
- As the H₂O-to-Na₂O molar ratio increases, the compressive strength of fly ash-based geopolymer concrete decreases.
- As the ratio of water-to-geopolymer solids by mass increases, the compressive strength of fly ash-based geopolymer concrete decreases.
- Mix-A specimen SEM image shows larger size caps and air voids presented compare to the Mix-D.
- Mix-D geopolymer concrete dense structure compare to

the Mix-A. so this reason Mix-D specimens achieved higher compressive and split tensile strength.

- 76% combined aggregate based geopolymer concrete obtained dense structure and less air voids and also greater mechanical performance.

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