A Research on Geopolymer Concrete

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Abstract— Geopolymer is a kind of cementitious substance that is amorphous and composed of alumino-silicate. The creation of geopolymer can be achieved through the polycondensation process involving an alkali polysilicates and a geopolymeric precursor. In comparison to Portland cement, geopolymer production exhibits superior strength, exceptional volume stability, and enhanced durability. Pozzolana-based geopolymer concrete is an innovative material that eliminates the need for Portland cement as a binding agent. This document showcases the findings from the examination of materials, composite mixtures, Geopolymer microstructure, and factors influencing the characteristics of geopolymer concrete.

Keywords— Geopolymer, mixture composite, microstructure, properties of concrete.

1. Introduction

Portland cement serves as a crucial component in traditional concrete. Roughly one ton of carbon dioxide is released into the atmosphere for every ton of cement produced. Portland cement accounts for approximately 85% of the energy consumption and 90% of the carbon dioxide emissions associated with typical ready-mixed concrete. Geopolymer concrete relies on fly ash, a byproduct of industrial processes. Fly ash is readily available worldwide as it is generated from industrial waste. A significant portion of fly ash goes underutilized, with much of it ending up in landfills instead of being effectively. Taking this into account, it becomes evident that geopolymer concrete offers both economic benefits and environmental friendliness. In the present era, this technology finds extensive application in the Australia, United States and Europe. Geopolymer concrete finds extensive application across diverse sectors, including railway infrastructure for sleepers, electricity distribution for power poles, road construction for pavements, building industry for cement mortar, maritime engineering for marine structures, and waste management for containment purposes.Researchers are currently exploring geopolymer systems that yield a low embodied energy and low carbon dioxide binder, while still exhibiting properties comparable to those of Portland cement. Additionally, there is a current focus in research on the advancement of user-friendly geopolymer concrete formulations. The incorporation of geopolymer concrete in construction endeavors presents a dual advantage, both in terms of economic efficiency and environmental responsibility. This advanced building material not only offers cost-effective solutions but also significantly diminishes pollution and minimizes ecological harm. Geopolymer concrete has already found application in the Delhi Metro Project in India. Hence, it can be inferred that the extensive utilization of geopolymer concrete, as a substitute for Portland cement, holds immense potential in the Indian context. This project delves into the exploration of geopolymer concrete, highlighting its various advantages. Geopolymer concrete, known for its superior durability and sustainability, offers several benefits over traditional Portland cement concrete. By utilizing industrial by-products such as fly ash and slag, geopolymer concrete reduces carbon emissions and promotes the recycling of waste materials, contributing to environmental conservation efforts.

1.1 Objective of the study

The objective of geopolymers is to provide a sustainable and high-performance alternative to traditional construction materials by leveraging industrial byproducts and natural minerals, thereby reducing environmental impact while enhancing structural durability and strength for large-scale applications. Their exceptional robustness and resilience make them perfect for applications such as domestic dwellings, impermeable infrastructures, and marine-based projects.

This combination of environmental and performance benefits positions geopolymers as a promising alternative to conventional construction materials, supporting the development of more sustainable and resilient infrastructure.

1.2 Scope of Study

As the OPC emits CO, in the atmosphere, this is the primary cause that leads to the phenomenon of global warming but the Geopolymeric building materials emits almost no CO_2.

The concrete industry’s coarse and fine aggregates are appropriate for the production of geopolymer concrete. In the field of construction, 38% of fly ash is being utilized. The residual fly ash, which is not utilized, is stored in ponds and contributes to the environmental pollution in the area. Hence, it is essential to conduct studies on the structural characteristics of fly ash.

Geopolymer concrete will help to consume industrial waste materials along with replacement of Portland cement which will significantly help in reducing global warming.

2. MATERIALS

2.1 Fly Ash

Fly ash is a fine brown powder that is a by-product of pulverized bituminous coal fired in a fire furnace. Whose electricity is produced in thermal power stations.
Specific gravity Fly Ash = 2.24.
Fineness of the Fly Ash = 365 m²/kg.

Fig. 1 (FLY Ash)

2.2 Aggregate

The concrete industry's coarse and fine aggregates are appropriate for the production of geopolymer concrete.

The aggregates test are listed below:

- Specific gravity of Fine Aggregate = 2.61
- Specific gravity of Coarse Aggregate = 2.69
- Fineness modulus = 2.73
- Fine Aggregate is confirmed to zone-II (IS: 383 – 1970)
- Fineness Modulus = 2.25 (coarse aggregate of size ranging from 12.5 to 5mm)

Fig. 2 (Coarse Aggregate)

Fig. 3 (Fine Aggregate)

2.3 Alkine Liquid

The alkaline liquid is prepared by mixing sodium silicate and sodium hydroxide solutions together at least 24 hours prior to use for thorough mixing and reaction. Sodium silicate solution comes in various grades that are readily accessible in the market. The sodium silicate solution with sodium hydroxide ratio by mass of 2.5 is used. The sodium hydroxide with 97-98% purity in pellet form is commercially available. The solids dissolved in water to make solution with the required concentration. The concentrations of sodium hydroxide solution are kept as 8 Mole. The mass of NaOH solids in a solution varies depending on the concentration of the solution**.**

2.4 GGBS

Ground-grained fluorine-fired (GGBS) blasting produces a glass-dried granular product, which is then heated to form a fluorine-fired fluorine or steam oven and dried to a powdery state for one month. yes. The base-granulate blasting oven is a highly cementitious and high-quality (low-liquid silicate hydroates) compound that improves the strength, stability and presence of the concrete. The GGBs used for this study were obtained from good jamul, durg.

2.5 Admixture

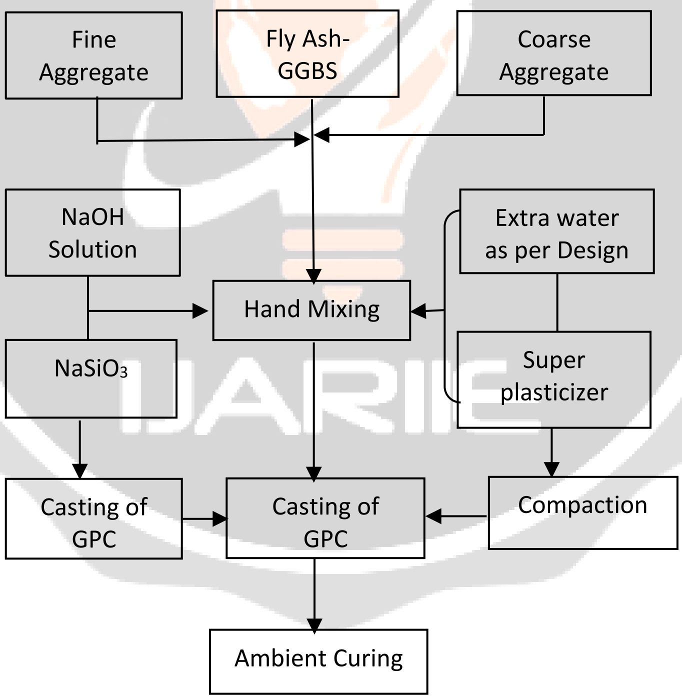
Sulfonated naphthalene is a high grade water working mixture for formaldehyde concrete. It is also called naphthalene super plasticizer or eseneph super plasticizer. It has the benefits of high water, low temperature, no mandate and no air penetration, and strong adaptability. Therefore, sulphated A53 naphthalene can greatly improve the workability of concrete and can reduce the consumption of water for mixing and can increase the strength of concrete considerably. The Admixture used for this study was purchased from India mart.


Fig. 4 (Alkaline Liquid)


Fig. 5 (GGBS)

3. METHODOLOGY & RESULT

Flow chart of mixing and Casting of Geopolymer concrete



3.1 Geopolymer Concrete Mix Design as Per IS10262-2019

Moreover, contemporary studies are concentrating on the advancement of geopolymer concrete that is more accessible and convenient for users.

Indeed, there is no designated Indian Standard (IS) code or universally accepted standard code specifically for the mix design of geopolymer concrete and therefore we have used IS10262-2019 for mix design.

Cementitious Material (70% Fly Ash + 30% GGBS)	-	436 kg / m3
Na_2SiO_3 / NaOH	-	2.5
(Na_2SiO_3 + NaOH) / Cementitious Material	-	0.45
NaOH solid	-	17.94 kg / m3
Water with added solid NaOH.	-	38.12 kg/m3
Na_2Sio_3 solution	-	140.14 kg / m3
Coarse aggregate	-	1308 kg / m3
Fine aggregate	-	654 kg / m3
Molarity	-	8 Mol

3.2 COMPRESSIVE STRENGTH TEST

COMPRESSION STRENGTH (N/mm2)						
MIX	07 DAY	AVG	14 DAY	AVG	28 DAY	AVG
CONVENTIONAL CONCRETE	16.39		18.99		29.14	
	16.63	**16.67**	22.5	**21.63**	32.3	**31.7**
	16.99		23.4		33.66	
GEOPOLYMER CONCRETE	24.99		29.75		36.31	
	25.89	**25.33**	32.63	**31.04**	38.77	**37.41**
	25.11		30.74		37.15	

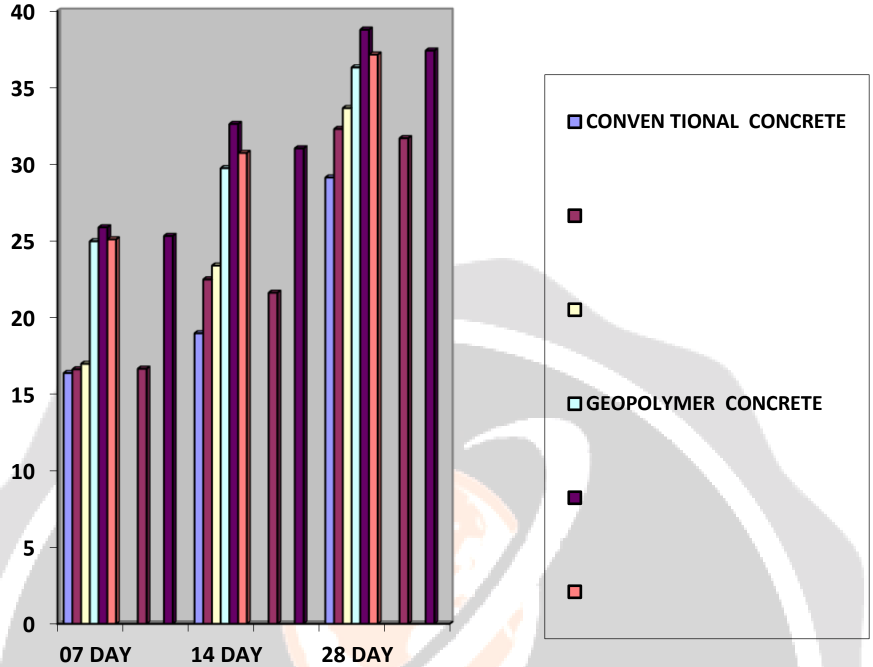


Fig.6 (Graph of Compressive strength)

Fig.7 **(**GPC Casting Cubes)

4.CONCLUSIONS

1. The increase in compressive strength over time for geopolymer concrete has been found to surpass that of traditional concrete composed of ordinary Portland cement.
2. Furthermore, it's been found that the highest compressive strength of geopolymer concrete closely parallels that of traditional concrete that utilizes ordinary Portland cement.
3. Compared to conventional concrete, lightweight concrete exhibits lower water absorption properties. This characteristic makes it advantageous for various applications, including construction of lightweight structures, insulation panels, and precast elements. By subjecting the concrete to different curing conditions, the resultant material demonstrates robust mechanical properties similar to those of conventional concrete mixes. This method not only encourages the utilization of eco-friendly resources, but it also highlights the versatility of fly ash-GGBS concrete in diverse environmental conditions.
4. Achieving comparable strengths through this curing method highlights a promising avenue for widespread adoption of eco-friendly concrete solutions in construction practices.
5. In simpler terms, when using bottom ash and GGBS (Ground Granulated Blast Furnace Slag) to create geopolymer concrete, the resulting strength tends to be low. This could be because of the relatively large particle size of these materials.
6. By optimizing the curing conditions, engineers can achieve the desired mechanical properties while utilizing sustainable materials. The combination of fly ash and GGBS enhances the material's durability, reduces its environmental impact, and contributes to the overall performance of the concrete.

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