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Original Article

Renovating the Potholes on the Road Using Geopolymer Concrte

Mr. S.Hari[1], Dr.M. Shahul Hameed[2]
[1]*Department of Civil Engineering, P.S.R Engineering College, Sivakasi, Tamil Nadu, India.*
[2]*Department of Civil Engineering, P.S.R Engineering College, Sivakasi, Tamil Nadu, India.*

Abstract: *Road potholes are a major issue affecting transportation safety, vehicle efficiency, and maintenance costs. Conventional repair methods using Ordinary Portland Cement (OPC) concrete often fail due to low durability, poor bonding, and slow strength development. In recent years, geopolymer concrete has emerged as a sustainable alternative to conventional concrete, as it utilizes industrial by-products such as fly ash and ground granulated blast furnace slag (GGBS) and reduces carbon dioxide emissions.*

This project focuses on the use of geopolymer concrete for the renovation of road potholes. Geopolymer concrete is produced by activating alumino-silicate materials with alkaline solutions such as sodium hydroxide and sodium silicate, resulting in a strong and durable binder. The study involves the preparation of geopolymer concrete mixes and evaluation of their mechanical properties, including compressive strength and flexural strength.

An experimental investigation is carried out to assess the suitability of geopolymer concrete for pothole repair applications. The performance of geopolymer concrete is compared with conventional cement concrete in terms of strength, durability, and early strength gain. The results are expected to demonstrate that geopolymer concrete provides better performance, faster setting, and enhanced durability.

Keywords: *Geopolymer Concrete, Pothole Repair, Fly Ash, GGBS, Alkaline Activation, Compressive Strength, Flexural Strength, Durability, Sustainable Construction, Road Maintenance.*

I. INTRODUCTION

Road transportation plays a vital role in the development of any country, but the formation of potholes remains a major issue affecting road safety, vehicle performance, and maintenance costs. Potholes are mainly caused by water infiltration, repeated traffic loading, and poor quality repair materials. Conventional repair methods using Ordinary Portland Cement (OPC) concrete often fail due to slow strength development, poor bonding with the existing surface, and low durability. In addition to performance issues, the production of cement contributes significantly to environmental pollution by releasing large amounts of carbon dioxide.

In recent years, geopolymer concrete has emerged as a sustainable alternative to conventional concrete. It is produced by activating industrial by-products such as fly ash and ground granulated blast furnace slag (GGBS) using alkaline solutions like sodium hydroxide and sodium silicate. This process forms a strong and durable binder without the use of cement, thereby reducing environmental impact. Geopolymer concrete exhibits high early strength, low permeability, and excellent resistance to chemical attack, making it highly suitable for repair applications.

In addition to its mechanical advantages, geopolymer concrete also contributes to environmental sustainability by reducing the use of cement and utilizing industrial waste materials. This not only reduces carbon emissions but also helps in effective waste management. Due to its high early strength, geopolymer concrete allows faster repair and reopening of roads, which minimizes traffic disruption and improves the efficiency of maintenance works. These properties make it highly suitable for repair and rehabilitation works, particularly for road pothole renovation.

II. LITERATURE REVIEW

Several researchers have studied the development and application of geopolymer concrete as a sustainable alternative to conventional cement concrete. Davidovits first introduced the concept of geopolymers, explaining that alumino-silicate materials such as fly ash can be activated using alkaline solutions to form a strong and durable binder. Subsequent studies by Hardjito and Rangan demonstrated that fly ash–based geopolymer concrete exhibits high compressive strength and improved durability compared to Ordinary Portland Cement (OPC) concrete. It was also observed that factors such as the concentration of alkaline activators, curing temperature, and the ratio of sodium silicate to sodium hydroxide significantly influence the strength and performance of geopolymer concrete.

Further research by Sofi et al. highlighted that geopolymer concrete possesses superior resistance to chemical attack, lower permeability, and better bonding characteristics due to its dense microstructure. Studies have also shown that the inclusion of ground granulated blast furnace slag (GGBS) enhances early strength development and allows curing at ambient temperatures, making geopolymer concrete more suitable for field applications. In addition, researchers have reported that geopolymer concrete demonstrates excellent resistance to sulphate and acid attack, making it ideal for aggressive environmental conditions.

Recent literature emphasizes the potential use of geopolymer concrete in infrastructure applications, particularly in pavement and repair works. Its high early strength and durability make it suitable for rapid repair of road potholes, reducing traffic disruption and maintenance frequency. Moreover, the use of industrial by-products such as fly ash contributes to environmental sustainability by reducing carbon emissions and promoting waste utilization. However, despite these advantages, limited studies have focused specifically on the application of geopolymer concrete for pothole renovation. Therefore, this project aims to experimentally investigate its suitability for this purpose and compare its performance with conventional repair materials.

III. METHODOLOGY

Selection and testing of materials such as fly ash, GGBS, aggregates, and preparation of alkaline solution using sodium hydroxide and sodium silicate. Preparation of geopolymer concrete mix with required proportions and casting of specimens (cubes, cylinders, beams) for strength testing. Creation of an artificial pothole model and application of geopolymer concrete for repair under controlled conditions.Curing of specimens and evaluation of mechanical properties, followed by comparison with conventional concrete to assess performance.

Figure 1: Compressive Testing Equipment

IV. RESULTS AND DISCUSSION

The compressive strength of geopolymer concrete specimens was determined using cube samples under standard testing conditions. The results indicate that geopolymer concrete achieved significant strength at early ages compared to conventional concrete**.**

Mix Number	Molarity	Strength at 7 Days(N/mm^2)	Strength at 14 Days(N/mm^2)
1	10	21.0	24.5
2	11	23.0	28.0
3	12	23.5	30.0

A. Pothole Repair Performance

Strong bonding with existing surface, No visible cracks after curing ,Fast setting observed ,Withstood applied loads without failure. Geopolymer concrete performed effectively under load conditions.

B. Durability Performance

Low permeability observed, Resistant to water penetration, No deterioration under wet conditions, Good chemical resistance.Enhanced durability compared to conventional concrete.

V. CONCLUSION

The experimental investigation on the use of geopolymer concrete for pothole repair demonstrates that it is an effective and sustainable alternative to conventional repair materials. The study confirms that geopolymer concrete exhibits high early strength, good bonding characteristics, and excellent durability properties.

From the results, it is observed that geopolymer concrete can withstand significant load and shows steady strength development over time. The material also demonstrated good resistance to water penetration and chemical attack, which are critical factors in road repair applications. The fast setting nature of geopolymer concrete allows quicker repair and reopening of roads, thereby reducing traffic disruption.

The performance of geopolymer concrete in the pothole model indicates strong adhesion with the existing surface and no visible cracks under loading conditions. Compared to conventional concrete, it provides better durability, reduced maintenance, and longer service life.

Although the initial preparation involves careful handling of alkaline solutions, the overall benefits such as environmental sustainability, utilization of industrial waste materials, and reduced carbon emissions make geopolymer concrete a promising material for future infrastructure development.

Overall, geopolymer concrete is a reliable, eco-friendly, and cost-effective solution for pothole renovation and can be effectively used in road maintenance applications

VI. REFERENCES

[1] IS 456:2000 – Plain and Reinforced Concrete
[2] IS 10262:2019 – Concrete Mix Design
[3] IS 516:1959 – Testing of Concrete
[4] Davidovits, J., *Geopolymers: Inorganic Polymeric New Materials*, Journal of Thermal Analysis, France, (1991).
[5] Hardjito, D., Rangan, B.V., *Development and Properties of Low-Calcium Fly Ash-Based Geopolymer Concrete*, Curtin University of Technology, Australia, (2005).
[6] Sofi, M., van Deventer, J.S.J., Mendis, P.A., Lukey, G.C., *Engineering Properties of Inorganic Polymer Concretes*, Cement and Concrete Research, (2007).
[7] Lloyd, N.A., Rangan, B.V., *Geopolymer Concrete: A Review of Development and Opportunities*, Curtin University, Australia, (2010).
[8] Abdul Aleem, M.I., Arumairaj, P.D., *Geopolymer Concrete – A Review*, International Journal of Engineering Sciences, (2012).
[9] Patil, S.G., Panth, R., *Geopolymer Concrete – A Brief Review*, International Journal of Engineering Research & Technology, (2014).
[10] Nath, P., Sarker, P.K., *Effect of GGBS on Setting and Early Strength of Geopolymer Concrete*, Construction and Building Materials, (2014).
[11] Ganesh, A.C., Muthukannan, M., *A Review of Recent Developments in Geopolymer Concrete*, International Journal of Engineering and Technology, (2018).
[12] Jaf, D., Ismael, P., Aziz, S.Q., *Geopolymer Concrete: Properties, Durability and Applications – Review*, Materials Today Proceedings, (2022).
[13] Meskhi, B., Beskopylny, A.N., *Analytical Review of Geopolymer Concrete: Retrospective and Current Issues*, Materials, (2023).
[14] IS 456:2000 – Plain and Reinforced Concrete – Code of Practice, Bureau of Indian Standards, New Delhi, India.
[15] IS 10262:2019 – Concrete Mix Proportioning Guidelines, Bureau of Indian Standards, New Delhi, India.
[16] IS 516:1959 – Methods of Tests for Strength of Concrete, Bureau of Indian Standards, New Delhi, India.