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Original Article

Low Cost Geopolymer Paver Using Industrial Waste & E-Waste

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Abstract: *Geopolymer concrete has emerged as a sustainable alternative to conventional cement concrete due to its reduced environmental impact and utilization of industrial waste materials. In this study, low-cost geopolymer paver blocks are developed using fly ash as the primary binder and electronic waste (E-waste) as a partial replacement for aggregates. The alkaline activators used include sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3), which facilitate the geopolymerization process. The experimental investigation focuses on evaluating the mechanical properties such as compressive strength and durability of the paver blocks. The results indicate that the inclusion of E-waste improves sustainability while maintaining adequate strength up to an optimum percentage. The developed geopolymer paver blocks exhibit good performance, reduced cost, and lower carbon footprint compared to conventional paver blocks.*

Keywords: *Geopolymer Concrete, Fly Ash, E-Waste, Alkaline Activators, Paver Blocks, Compressive Strength, Sustainable Construction.*

I. INTRODUCTION

Geopolymer concrete is an eco-friendly alternative to conventional cement concrete, developed to reduce environmental impact caused by cement production. It utilizes industrial waste materials such as fly ash as the primary binder, eliminating the need for Ordinary Portland Cement (OPC). The geopolymerization process involves the reaction of alumino-silicate materials with alkaline activators like sodium hydroxide and sodium silicate to form a strong binding matrix. In addition to industrial waste, electronic waste (E-waste) can be used as a partial replacement for aggregates to promote sustainable waste management. Paver blocks made using geopolymer concrete offer advantages such as reduced carbon emissions, lower cost, and adequate strength. This study focuses on developing low-cost geopolymer paver blocks and evaluating their mechanical performance and feasibility

II. LITERATURE REVIEW

Previous studies indicate that geopolymer concrete is an effective alternative to conventional concrete due to its eco-friendly nature and use of industrial waste materials. Research shows that fly ash-based geopolymer concrete provides high compressive strength, early strength gain, and excellent resistance to chemical attack. The strength of geopolymer concrete increases with higher molarity of sodium hydroxide and higher sodium silicate to sodium hydroxide ratio. Studies also reveal that the incorporation of waste materials such as quarry dust, marble powder, plastic waste, and E-waste improves sustainability and reduces cost. The use of E-waste as partial aggregate replacement enhances performance up to an optimum level (around 20%), beyond which strength decreases due to poor bonding. Additionally, the use of superplasticizers improves workability, while heat curing enhances strength development.

III. METHODOLOGY

- Material Preparation and Mix Design: Collection of fly ash, aggregates, E-waste, and alkaline solutions, followed by preparation of geopolymer mix with suitable proportions.
- Casting, Curing and Testing: Casting of paver blocks, curing under required conditions, and testing for compressive strength and durability.

IV. RESULTS AND DISCUSSION

A. Compressive Strength Test

The compressive strength test was conducted to evaluate the load-carrying capacity of geopolymer paver blocks. The test results indicate that the strength increases with the addition of E-waste up to an optimum level. Beyond this limit, a reduction in strength is observed due to weaker bonding between E-waste particles and the geopolymer matrix.

Figure 1: Compressive strength test

The geopolymer paver blocks exhibited higher early strength compared to conventional concrete blocks. The optimum replacement level of E-waste was found to be around 20%, which provided adequate compressive strength suitable for pavement applications.number of Test required to specimen failure has shown in Table 1.

Table 1: Compressive Strength Test Result For Added E-Waste

Sample	E-Waste Content	Compressive Strength (MPa)
1	3%	26
2	4%	28
3	5%	30
4	10%	27

Table 2: Compressive Strength Test Result For Added Marble Powder

Sample	Marble Powder Content	Compressive Strength (MPa)
1	5%	27
2	10%	29
3	15%	30
4	20%	28

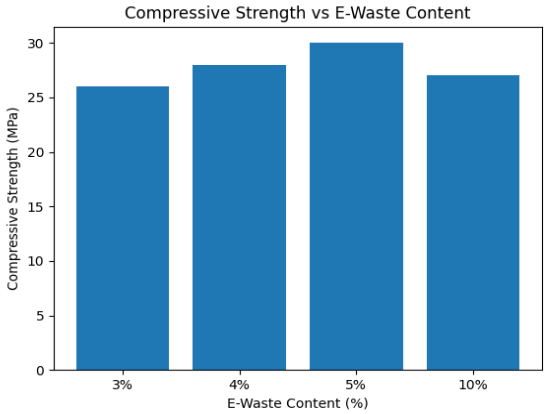

Figure 2: Bar Chart of Compressive Strength at E-Waste Content Added

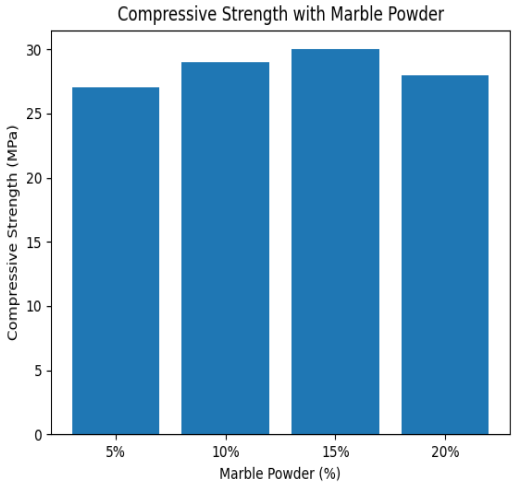

Figure 3: Bar Chart of Compressive Strength at Marble Powder Content Added

B. Durability Performance

Durability characteristics such as water absorption were studied to assess the long-term performance of the paver blocks. The results show that geopolymer paver blocks have low water absorption values, indicating good resistance to moisture penetration.

The inclusion of E-waste slightly reduces density and improves resistance to environmental effects. Overall, geopolymer paver blocks demonstrated better durability and performance compared to conventional paver blocks, making them suitable for sustainable construction applications.

Table 3: Water Absorption Test

Sample	Material Type	Percentage (%)	Water Absorption (%)
1	E-Waste	3%	6.2
2		4%	5.8
3		5%	5.5
4		10%	6.5
1	Marble Powder	5%	5.9
2		10%	5.6
3		15%	5.3
4		20%	6.1

The inclusion of E-waste and marble powder slightly reduces the density of the mix while improving resistance to environmental conditions. It is observed that the optimum percentage of waste materials provides better durability, whereas higher percentages may lead to increased voids and reduced performance.

V. CONCLUSION

The study demonstrates that geopolymer paver blocks can be effectively produced using fly ash as a binder and E-waste and marble powder as partial replacement materials. The experimental results indicate that the compressive strength increases with the addition of waste materials up to an optimum level, achieving a maximum strength of 30 MPa. The optimum percentages were found to be 5% for E-waste and 15% for marble powder.

Durability studies show that geopolymer paver blocks have low water absorption and good resistance to environmental effects. The incorporation of waste materials improves sustainability while maintaining adequate mechanical performance. Beyond the optimum level, the strength and durability decrease due to weaker bonding and increased voids. Overall, geopolymer paver blocks are eco-friendly, cost-effective, and suitable for pavement applications. The use of industrial and electronic waste materials reduces environmental pollution and promotes sustainable construction practices.

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