An Experimental Investigation on The Use of Waste Glass Powder and Fly Ash Powder in Paver Blocks

BHARANIDHARAN K[1], SRI GAYATHRI S[1], NAVEENPRASATH K A[1], Dr KAVIMANI V[2]
[1]*UG Students,* [2]*Professor*
Civil Engineering, Tamilnadu College of Engineering, Coimbatore, India.

Abstract- **This research project focuses on the development of eco- friendly paver blocks by partially replacing conventional materials with waste glass powder and fly ash. The main objective is to promote sustainability in the construction industry by reducing dependency on natural resources, lowering carbon emissions, and encouraging effective waste management through recycling. The study explores the potential of these industrial by-products as alternative raw materials to produce high-performance paver blocks. Various mix proportions are tested to assess their impact on the mechanical properties, such as compressive strength, flexural strength, and durability. Additionally, the long-term performance and economic feasibility of the modified paver blocks are evaluated and compared with conventional blocks. The results aim to demonstrate that using glass powder and fly ash can lead to a more sustainable and cost-effective solution for modern construction needs.**

I. INTRODUCTION

Paver blocks, also commonly known as paving stones or bricks, are modular construction units extensively used for creating aesthetically pleasing and highly functional paved surfaces. These surfaces include driveways, patios, garden paths, sidewalks, and walkways. Paver blocks are typically manufactured using materials such as concrete, clay, or natural stone. Their interlocking design not only enhances the visual appeal of the surface but also ensures superior strength, durability, and load-bearing capacity. Due to their modular nature, they are easy to install, maintain, and replace, making them a sustainable and cost-effective solution for a variety of outdoor applications. In addition to their practical benefits, paver blocks offer a wide range of colors, textures, and patterns, allowing for creative design flexibility. Their resistance to weathering and wear further increases their demand in modern landscaping and construction projects.

II. EXPERIMENTAL INVESTIGATIONS

This study focuses on investigating the feasibility and effectiveness of using waste glass powder and fly ash (Class F) as partial replacements in the manufacturing of paver blocks. The experimental work has been conducted in three main phases: material selection and characterization, mix design, and casting and curing of paver blocks. Each phase is crucial to ensure the durability, strength, and sustainability of the final product.

2.1 MATERIALS

In this study, three primary materials were used for the production of sustainable paver blocks: Fly Ash (Class F), Waste Glass Powder, and Fine Aggregate (M Sand). Each material plays a vital role in enhancing the physical, mechanical, and environmental performance of the paver blocks.

1. Fly Ash (Class F)

Fig 1 Fly ash(class F)

Fly ash is a by-product obtained from coal combustion in thermal power plants. Class F fly ash, which contains less than 10% lime (CaO), was chosen for this study due to its pozzolanic nature. It reacts with calcium hydroxide in the presence of water to form compounds possessing cementitious properties. The required specific gravity for Class F fly ash typically ranges from 2.1 to 2.4, and the obtained value in this experiment was 2.1, indicating its suitability for use in concrete mixtures. Its use helps in reducing the cement content, thereby minimizing carbon emissions and utilizing industrial waste effectively.

Table-1: Chemical Composition of Fly ash (Class-F)

Chemical composition of Fly ash	Weight in %
Silica	55-65
Aluminium oxide	22-25
Iron oxide	5-7
Calcium oxide	5-7
Magnesium oxide	<1
Titanium oxide	<1
Phosphorous	<1
Sulphates	0.1
Alkali oxide	<1
Loss of ignition	1-1.5

2. Waste Glass Powder

Fig 2 Waste Glass Powder

Waste glass powder was produced by crushing and grinding discarded glass into fine particles. This material is rich in silica and exhibits pozzolanic behavior when finely ground. It helps improve the strength and durability of paver blocks while also providing a method for glass waste disposal. The required specific gravity range for glass powder is 2.4 to 2.7, and the value obtained during testing was 2.5, confirming its appropriateness for inclusion in the mix. Additionally, it enhances the aesthetic appearance and reduces the environmental burden of glass waste.

3. Fine Aggregate (M Sand)

Manufactured sand (M Sand) was used as the fine aggregate, replacing natural river sand. M Sand is produced by crushing hard stones and is environmentally more sustainable. The standard specific gravity range for fine aggregates is 2.5 to 2.7, but the obtained value was 2.9, which is slightly higher. This may indicate denser particles, which can affect mix design, but still can be adjusted to achieve the required strength and durability.

2.2 MIX DESIGN

The mix design for paver blocks plays a vital role in determining their strength, durability, and cost-effectiveness. For this study, a number of trial mixes were prepared using different proportions of cement, fly ash, waste glass powder, and M-Sand.

The mix design was based on the IS 15658:2006 code for precast concrete blocks and pavers. Cement was partially replaced with fly ash and glass powder in varying percentages, such as 10%, 15%, and 20%, to observe the effects on the mechanical properties.

A typical mix proportion used was:

- Cement: 5%
- Fly Ash: 45%
- Glass Powder: 45%
- Fine Aggregate (M-Sand): 5% (as per weight of binder)
- Water-Cement Ratio: 0.40 to 0.45

Superplasticizers were added in small quantities (0.5–1%) to improve workability. The water-cement ratio was carefully controlled to avoid excessive bleeding and segregation.

Each mix was tested for workability, compressive strength, and setting time. The optimal mix was selected based on the best balance of strength and sustainability.

Category	Material	Description
Binder Selection A	Fly Ash (Class F)	Main aluminosilicate source for geopolymerization
Binder Selection B	Waste Glass Powder	Provides silica and enhances early strength and durability
Aggregate	M-Sand	Clean and well-graded for optimal compaction and strength

2.3 CASTING AND CURING OF PAVER BLOCKS

Casting Process

Once the mix proportions were finalized, the casting of paver blocks was carried out using standard molds. The molds were made of cast iron and were cleaned and oiled before use to ensure easy demolding. The dry mix of cement, fly ash, glass powder, and M-Sand was first prepared and then water and admixtures were added gradually. The materials were thoroughly mixed using a pan mixer to achieve uniform consistency.

The concrete mix was then placed in the molds in two layers:

1. Top Wearing Layer – This was about 10-15 mm thick and made of fine, rich concrete to ensure a smooth surface finish.
2. Base Layer – This formed the rest of the paver block and contained the main structural components.

The mix was compacted using a vibrating table to remove air voids and ensure dense packing. The paver blocks were left to set in the molds for 24 hours.

Fig 3 Mixing casting of Paver Blocks

Fig 4 Paver blocks

Demolding and Curing

After 24 hours, the paver blocks were demolded carefully and transferred to a curing tank. Curing is an essential step in the concrete production process as it ensures the hydration of cementitious materials, which is critical for strength development. The blocks were cured under water for 7, 14, and 28 days, and samples were taken at each interval for mechanical testing. Water curing helps in maintaining moisture content and enhances durability. For comparison, a few samples were also subjected to air curing and wet gunny bag curing to evaluate the best curing method. It was found that water curing produced the best results in terms of compressive strength and surface finish.

Testing

After the curing period, the paver blocks were tested for:

- Compressive strength
- Flexural strength
- Water absorption

The test results were analyzed to determine the impact of fly ash and glass powder replacement on the mechanical performance of the blocks. Blocks with 15% fly ash and 15% glass powder showed the most promising results in terms of strength and sustainability.

Fig 5.Flexural strength

Fig 6. Compression Testing on Paver blocks

MIX PROPORTION

Mix Type	Cement (%)	WGP (%)	Fly Ash (%)	Fine Aggregate (%) (WGP Replacement %)	Coarse Aggregate (%)	Remarks

Mix 1 (High Strength)	75	15	10	70	30	High compressive strength due to lower replacement levels
Mix 2 (Balanced Performance)	70	20	10	65	35	Balanced strength and durability, cost-effective
Mix 3 (Cost Effective)	65	25	10	60	40	Higher WGP reduces cost but maintains adequate strength

III. RESULT

MIX TYPE	7-DAY STRENGTH(Mpa)	14-DAY STRENGTH(Mpa)	28-day strength(Mpa)
Cement mortar(control)	16.5	22.5	26.5
10% waste glass powder + fly ash	17.5	24.0	30.0
25% waste glass powder + fly ash	15.5	22.0	28.0
50% waste glass powder + fly ash	14.3	20.4	26.0
75% waste glass powder + fly ash	13.6	18.6	25.1
100% waste glass powder + fly ash	12.4	17.3	23.9

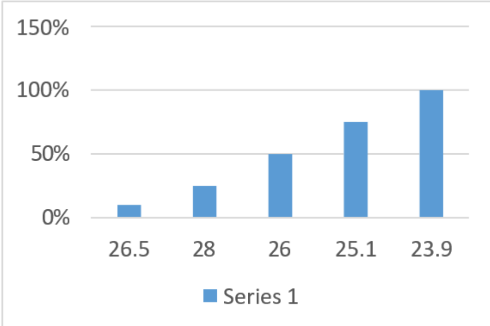

Fig Comparision of normal paver block and WGP and FAP paver blocks

IV. CONCLUSION

The experimental study on paver blocks incorporating Fly Ash Powder (FAP) and Waste Glass Powder (WGP) highlights a sustainable and effective alternative to traditional concrete paver blocks. The partial replacement of cement with these industrial and municipal waste materials not only contributes to reducing the environmental burden but also improves the overall performance of the paver blocks.

The results indicate that the inclusion of fly ash and glass powder enhances key mechanical properties such as compressive strength and flexural strength. Additionally, durability aspects such as lower water absorption and increased resistance to chemical attacks were observed, indicating long-term performance benefits.

This preliminary investigation confirms that waste glass powder, in particular, holds great potential as a partial cement substitute, offering significant economic and environmental advantages. Therefore, the integration of such waste materials in construction pavers represents a viable step toward sustainable development.

REFERENCES

[1] Siddique, R., & Klaus, J. (2009). Influence of waste glass powder addition on the durability properties of concrete. Construction and Building Materials, 23(2), 818–825.

[2] Topçu, İ. B., & Canbaz, M. (2004). Properties of

concrete containing waste glass. Cement and Concrete Research, 34(2), 267–274.
[3] Naik, T. R., Kraus, R. N., & Kumar, R. (2003). Use of recycled materials in concrete. Concrete International, 25(6), 50–54.
[4] Mehta, P. K., & Monteiro, P. J. M. (2014). Concrete: Microstructure, Properties, and Materials (4th ed.). McGraw- Hill Education.
[5] ASTM C618-19. (2019). Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete. ASTM International.