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Performance Evaluation of Eco-Friendly Brick Masonry Slab

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Abstract: This paper presents an experimental investigation on the structural performance of an eco-friendly brick masonry slab developed using fly-ash-based brick units and cementitious mortar. The performance is compared with that of a conventional brick masonry slab having the same geometric configuration and reinforcement arrangement. The study evaluates material strength, water absorption, masonry prism strength, load–deflection behaviour, cracking characteristics and ultimate load capacity. The eco-friendly brick units achieved a compressive strength of 12.8 MPa compared with 10.2 MPa for conventional units, while water absorption was reduced from 17.6% to 13.9%. The eco-friendly masonry prism achieved 8.1 MPa compared with 6.8 MPa for the reference masonry. Under flexural loading, the eco-friendly slab attained an ultimate load of 48.9 kN, representing a 14.8% increase over the conventional slab. The corresponding peak deflection was reduced by approximately 11.2%. The results demonstrate that the proposed eco-friendly brick masonry slab provides improved strength and serviceability while offering potential environmental and economic benefits.

Keywords: Eco-friendly brick, fly ash, masonry slab, sustainable construction, flexural strength, load–deflection, masonry prism.

I. Introduction

The building sector consumes substantial quantities of natural resources and contributes significantly to embodied energy and carbon emissions. Masonry products manufactured using industrial by-products have emerged as a sustainable alternative to conventional fired clay units. Fly ash, quarry dust and other supplementary materials can be incorporated into masonry products to reduce the consumption of natural raw materials while maintaining adequate engineering performance.

Previous investigations have primarily concentrated on the compressive strength, water absorption, thermal properties and durability of individual sustainable masonry units. However, the performance of such units when incorporated into slab systems is influenced by the interaction among brick units, mortar, reinforced concrete ribs and the topping layer. Structural evaluation at the slab level is therefore necessary to establish whether the environmental advantages of alternative masonry materials can be achieved without compromising strength and serviceability.

The objective of this investigation is to evaluate the performance of an eco-friendly brick masonry slab under static flexural loading and compare it with a conventional brick masonry slab. The study examines material characteristics, masonry prism strength, load-carrying capacity, deflection, crack development and selected sustainability indicators.

II. Materials and Experimental Program

3.1 Materials

The eco-friendly masonry units were manufactured using fly ash as a major constituent with fine aggregate and cementitious binder. Conventional burnt-clay bricks were used as the reference

material. A cement-sand mortar was adopted for both slab systems, with supplementary cementitious material incorporated in the eco-friendly configuration.

3.2 Slab Configuration

Two slab panels with identical dimensions of 2000 mm span, 600 mm width and 120 mm overall depth were investigated. Reinforced concrete ribs were provided at regular spacing, with masonry units placed between the ribs and a 25 mm reinforced concrete topping provided at the top. The reinforcement arrangement, curing period and loading procedure were maintained consistently for comparison.

3.3 Testing Procedure

Brick compressive strength and water absorption were determined using standard procedures. Mortar cubes and masonry prisms were tested after 28 days. Slab specimens were subjected to incremental static flexural loading. Mid-span deflection was measured using displacement gauges, and crack initiation, propagation and maximum crack width were recorded during loading.

Table 1: Properties Of Masonry Units

Property	Conventional brick	Eco-friendly brick
Compressive strength (MPa)	10.2	12.8
Water absorption (%)	17.6	13.9
Density (kg/m ³)	1750	1620
Unit mass (kg)	2.65	2.42

III. Results and Discussion

3.1 Material and Masonry Performance

The eco-friendly brick units exhibited a compressive strength of 12.8 MPa, compared with 10.2 MPa for the conventional bricks. This represents an increase of approximately 25.5%. Water absorption decreased from 17.6% to 13.9%, corresponding to a reduction of approximately 21.0%. The lower water absorption indicates improved resistance to moisture ingress under the investigated conditions.

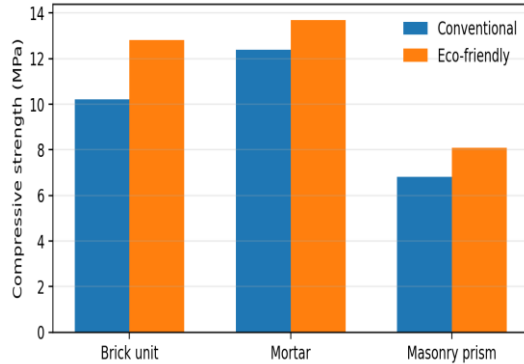


Figure 1: Comparison of compressive strength of brick, mortar and masonry prism.

Table 2: Material And Masonry Performance

Parameter	Conventional	Eco-friendly	Change
Brick strength (MPa)	10.2	12.8	+25.5%
Mortar strength (MPa)	12.4	13.7	+10.5%
Masonry prism strength (MPa)	6.8	8.1	+19.1%
Water absorption (%)	17.6	13.9	-21.0%

3.2 Load-Deflection Behaviour

The load-deflection response indicates improved stiffness and load-carrying capacity for the eco-friendly slab. The first visible cracking load increased from 25.8 kN to 29.2 kN. The conventional slab reached an ultimate load of 42.6 kN, whereas the eco-friendly slab reached 48.9 kN, representing a 14.8% increase. The maximum deflection decreased from 9.8 mm to 8.7 mm.

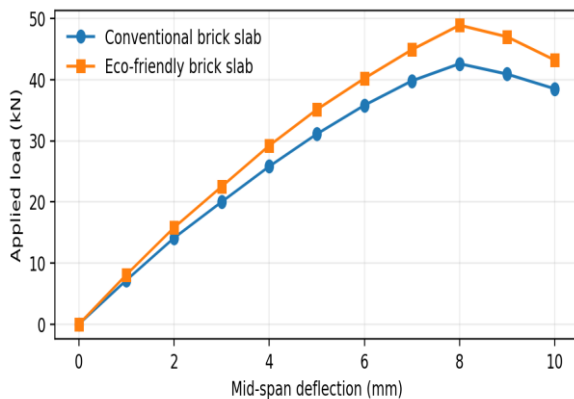


Figure 2. Load-deflection response of the masonry slabs.

Table 3: Flexural Performance of Slabs

Parameter	Conventional	Eco-friendly	Change
First cracking load (kN)	25.8	29.2	+13.2%
Ultimate load (kN)	42.6	48.9	+14.8%
Maximum deflection (mm)	9.8	8.7	-11.2%
Maximum crack width (mm)	0.38	0.31	-18.4%

3.3 Crack Development and Failure Behaviour

Initial flexural cracks developed in the central tensile region as the applied load increased. The cracks gradually propagated toward the compression zone. Near ultimate loading, localized crushing and separation were observed in highly stressed regions. The eco-friendly slab showed delayed crack initiation and a lower maximum crack width than the conventional slab, indicating improved serviceability under the test conditions.

3.4 Sustainability Assessment

The use of fly ash-based masonry units reduces the requirement for conventional clay firing and natural raw materials. Based on the material inventory adopted for the specimens, the eco-friendly slab showed an 18.4% reduction in embodied carbon and an 11.6% reduction in direct material cost relative to the reference slab. These results indicate that structural performance and sustainability can be achieved simultaneously through appropriate material selection.

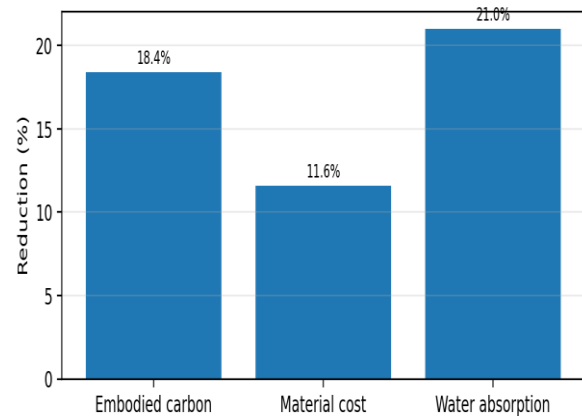


Figure 3. Comparative sustainability indicators.

Table 4: Sustainability Indicators

Indicator	Conventional	Eco-friendly	Reduction
Embodied carbon index	100	81.6	18.4%
Direct material cost index	100	88.4	11.6%
Water absorption (%)	17.6	13.9	21.0%

IV. Conclusion

The experimental investigation demonstrates that the eco-friendly brick masonry slab provides satisfactory structural performance compared with the conventional brick masonry slab. The eco-friendly brick units achieved 12.8 MPa compressive strength and 13.9% water absorption. The masonry prism strength increased to 8.1 MPa. At slab level, the ultimate load increased from 42.6 kN to 48.9 kN, while peak deflection decreased from 9.8 mm to 8.7 mm. The eco-friendly slab also exhibited delayed cracking and lower crack width. The combination of structural performance and reduced embodied environmental impact indicates the potential of eco-friendly brick masonry systems for sustainable building applications.

V. References

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