

Development of Nonconventional First-Class Fly Ash Bricks Using Silica Fume and Alkali Activators

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Abstract- This study focuses on developing eco-friendly fly ash bricks using silica fume and alkali activators (NaOH and Na₂SiO₃) as a sustainable alternative to traditional clay bricks. The objective is to utilize industrial waste effectively while reducing environmental degradation caused by clay brick production. Fly ash was used as the primary material, with silica fume added to enhance mechanical strength and alkaline chemicals to initiate geopolymerization. Bricks were prepared by mixing materials, molding, and proper curing. Tests including compressive strength, water absorption, and visual inspection were conducted. Results indicate that alkali-activated fly ash bricks with silica fume exhibit superior strength and durability compared to conventional clay bricks. This approach promotes waste utilization, low pollution, and energy-efficient construction, offering a promising solution for sustainable building practices.

Keywords: Fly Ash Bricks, Silica Fume, Alkali Activators, Geopolymer, Sustainable Construction, Compressive Strength.

I. INTRODUCTION

Fly ash bricks are an eco-friendly construction material made from fly ash—a byproduct of thermal power plants—along with lime, gypsum, and sand. They require less energy to produce, save agricultural land, and offer advantages such as lightweight, high strength, uniform size, and good thermal insulation. Conventionally, fly ash bricks are produced using hydraulic press and molding processes with approximately 60–70% fly ash, sand or stone dust, and 8–10% cement or lime.

However, traditional cement-based fly ash bricks still rely on cement, whose production emits significant CO₂. This study replaces cement with alkali activators (sodium hydroxide and sodium silicate) and incorporates silica fume to improve strength. The need for this research arises from environmental hazards posed by fly ash disposal and the potential for its beneficial reuse. Using

fly ash reduces waste, conserves natural resources, decreases energy consumption, and improves material performance.

II. METHODS AND MATERIAL

A. Materials Used

Fly Ash (Class F): Used in varying proportions (65%, 60%, 55%, 50%) as the primary binder.

Silica Fume: A fine amorphous SiO₂ powder added to improve mechanical strength.

Alkali Activators: NaOH (sodium hydroxide) and Na₂SiO₃ (sodium silicate) were used to initiate geopolymerization, forming a strong N-A-S-H gel.



Silica Fume & Alkali Activator (NaOH, Na₂SiO₃)

Sand: River sand (Zone 2) used as fine aggregate. Cement (OPC 43 grade): Used only in control mix (Type A) for comparison.

B. Mix Proportions

Five brick types (A to E) were prepared with dimensions 230mm × 110mm × 80mm.

Type	Fly Ash	Sand	Silica Fume	Activators	Cement
A	65%	27%	0%	0%	15%
B	65%	27%	4%	2%	0%
C	60%	27%	8%	2%	0%
D	55%	27%	12%	2%	0%
E	50%	27%	16%	2%	0%

C. Testing Procedures

Compressive strength tests were conducted at 7, 14, and 28 days as per IS standards. Sieve analysis, normal consistency, and water absorption tests were also performed.

III. RESULTS AND DISCUSSION

A. Basic Material Tests

Cement fineness (90 μ sieve) was 6–8%, normal consistency 30%. Sand fineness modulus was 2.44 (Zone 2).

B. Compressive Strength Results

Type 7 Days (MPa) 14 Days (MPa) 28 Days (MPa)

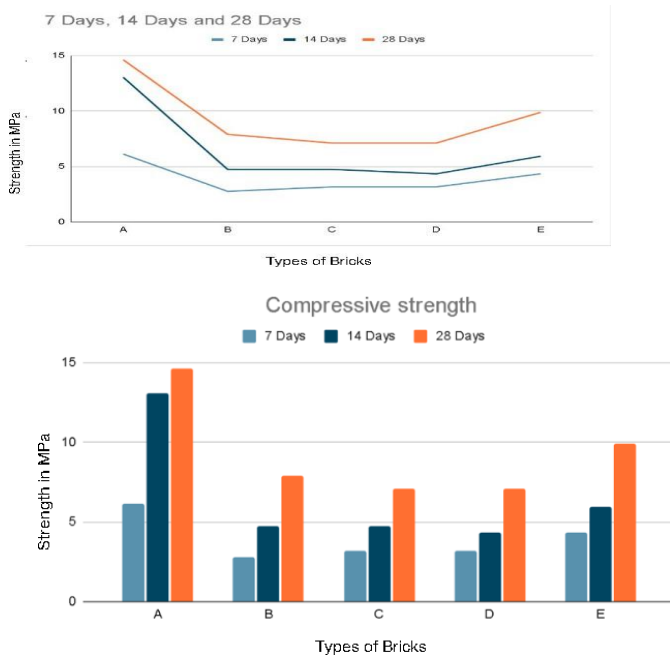
A 6.12 13.04 14.62

B 2.76 4.74 7.90

C 3.16 4.74 7.11

D 3.16 4.34 7.11

E 4.34 5.92 9.88



Type	7 Days	14 Days	28 Days
A	6.12	13.04	14.62
B	2.76	4.74	7.9
C	3.16	4.74	7.11
D	3.16	4.34	7.11
E	4.34	5.92	9.88

Fig. 1: Compressive strength comparison at 7, 14, and 28 days in N/mm²

C. Discussion

Type A (cement-based control) achieved the highest 28-day strength (14.62 MPa), but its production involves cement, which has a high carbon footprint. Among alkali-activated mixes (Types B–E), Type E (50% fly ash, 16% silica fume) showed the best performance at 28 days (9.88 MPa), followed by Type B (7.90 MPa). Strength increased steadily from 7 to 28 days due to continuous geopolymerization. Silica fume contributed to denser microstructure and improved bonding. Workability was enhanced due to fine particles, though setting time increased slightly—an acceptable trade-off for higher ultimate strength.

These results demonstrate that alkali-activated fly ash-silica fume bricks can achieve compressive strengths comparable to or exceeding conventional clay bricks (typically 3.5–7.5 MPa), making them a viable sustainable alternative.

IV. CONCLUSION

The following conclusions are drawn from this study:

1. The compressive strength of alkali-activated fly ash bricks increases with the addition of silica fume, with Type E (16% silica fume) achieving 9.88 MPa at 28 days.
2. Replacing cement with alkali activators (NaOH and Na₂SiO₃) is feasible and produces bricks with adequate structural performance while eliminating cement-related CO₂ emissions.
3. Workability improves due to fine particle packing of fly ash and silica fume, making the mix easier to mold.
4. Strength development continues beyond 7 days due to ongoing geopolymerization, with significant gains up to 28 days.
5. The developed bricks achieve 7-day strengths of 4–6 MPa, 14-day strengths of 5–13 MPa, and 28-day strengths of 7–15 MPa, meeting or exceeding conventional brick standards.
6. Alkali-activated fly ash bricks offer a strong, durable, and environmentally friendly alternative to clay bricks, supporting sustainable construction.

REFERENCES

1. Ganesh Prabhu, Parivallal Kumar, Binitha, Sahadevan, "Investigating the thermal properties and structural integrity of fly ash bricks with varying rice straw proportion for sustainable construction," 2025.
2. Meagamat Tahaaziz Bhayat, "Development and assessment of fly ash and metakaolin blended geopolymer concrete incorporating expanded vermiculite for masonry unit," 2025.
3. Pramod Sankar, Ravi Kumar MS, "Evaluation of strength and durability of fly ash - lime - quarry dust bricks," 2025.

4. Ashkhan Sardar, "Investigating the properties and microstructure of high-performance cement composites with nano-silica, silica fume and ultra-fine TiO₂," 2024.
5. Pramod Sankar, M. S. Ravikumar, "Bricks Made with Fly Ash - A Review of Recent Developments," 2023.
6. Anil Soharu, Naveen BP, Arjun Sil, "Fly ash bricks development using concrete waste debris and self healing bacteria," 2022.
7. Behl, V. Dahiya, "Comparison of Fly Ash Based (AAC) Block and Clay Bricks for Structure and Strength Properties," 2021.
8. Tomas Hulan, Ondruska, Anton Trnık, "The Influence of Fly Ash on Mechanical Properties of Clay-Based Ceramics," 2020.