

# A Study to Evaluate Granite and Glass Waste as Fly-Ash Replacements in Brick Production

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**Abstract-** This literature survey reviews published research on using granite waste (sawing/processing powder, quarry fines) and waste glass (powder or cullet) as partial replacements for fly ash in brick production. The review covers (1) material characteristics and chemical behaviour, (2) manufacturing routes for bricks (clay-fired, cement/fly-ash bricks, geopolymer/unburnt fly-ash bricks, autoclaved products), (3) effects on mechanical, durability and thermal properties, (4) optimum replacement ranges reported, and (5) gaps and recommendations for future experimental work. The weight of evidence shows both granite and glass wastes are promising as constituents in sustainable bricks, but behaviour depends strongly on particle size, glass chemistry, processing route, and mix design — so research must be standardized to identify robust, scalable recipes.

## I. BACKGROUND AND MOTIVATION

Global mineral-processing (granite/quarrying) and glass consumption produce large quantities of fine wastes that are difficult and expensive to landfill. Valorizing these wastes into bricks reduces raw-material extraction, landfill pressure and embodied carbon.

Fly ash has been widely used in brick products (e.g., fly-ash bricks, geopolymer bricks). However, fly ash availability and variability, together with circular-economy targets, motivate partial substitution of fly ash with other wastes that can contribute filler, pozzolanic behavior, or vitrification.

## II. BRICK PRODUCTION ROUTES WHERE SUBSTITUTIONS ARE USED

Brief overview of routes found in literature:

Burnt clay bricks[8] — clay partially replaced with granite powder[6] or glass (then fired). Granite/glass act mainly as inert filler or flux (glass reduces melting temperature)[1].

Fly-ash / cement-stabilized bricks (pressed, cured) — conventional fly-ash bricks use fly ash, lime/cement

and water. Glass or granite powders may be added to the mix as additional fines or pozzolanic components. Geopolymer / alkali-activated bricks — fly ash is activated with alkali; waste glass can serve as additional reactive silica (after fine grinding) and reduce porosity; granite waste (rich in silica and alumina depending on type) can be partially incorporated.

Autoclaved or steam-cured products — applicable when reactive silica (e.g., glass powder) can form tobermorite-like phases under hydrothermal conditions. Several studies explore glass in autoclaved blocks.

## III. GRANITE WASTE IN BRICKS — SUMMARY OF EVIDENCE

### 3.1 Material & chemistry

Granite waste / sawing powder / quarry fines: mainly silica (SiO<sub>2</sub>), feldspars (aluminosilicates), and inert rock fragments; chemical reactivity is generally low unless the material has fine particle size and some amorphous content. Several reviews and experimental studies show granite waste can replace clay or sand/filler in bricks and concrete.

### 3.2 Effects on brick properties (from experimental studies)

Compressive strength: Many studies report that granite powder[6] can be used up to moderate percentages (commonly 10–30% replacement of clay or sand) without significant loss of strength, and in geopolymer formulations it can even enhance compressive[4] strength when particle packing and alkali activation are optimised. Exact increases/decreases depend on particle fineness and mix.

Water absorption & porosity: Granite fines tend to reduce porosity when well-graded (acting as filler), but if coarse or poorly graded they can increase pores and water absorption. Proper grinding and grading help.

3.3 Workability & firing behavior (for clay-fired bricks): granite powders[6] act largely as non-plastic filler; high contents may reduce green strength and change shrinkage/firing shrinkage. Additives or adjustment of forming pressure/drying may be needed.

#### 3.4 Representative studies

Reviews and experimental papers (IJAEM, IJRET, ResearchTrend etc.) document successful use of granite sawing powder in clay or fly-ash bricks, often recommending pre-treatment (drying, sieving, fining) and upper limits ~20–30% depending on route.

### IV. WASTE GLASS IN BRICKS — SUMMARY OF EVIDENCE

#### 4.1 Material & chemistry

Waste glass (soda-lime, borosilicate, cullet) — primarily amorphous silica and alkali oxides ( $\text{Na}_2\text{O}$ ,  $\text{CaO}$ ). When finely ground, glass exhibits pozzolanic reactivity (silica dissolution) in alkaline or high-temperature environments and acts as a flux during firing. Particle size and glass chemistry crucially determine role.

#### 4.2 Effects on brick properties

Compressive strength: Many studies report that finely ground glass powder added to fly-ash bricks or geopolymer matrices tends to increase compressive strength up to an optimum (commonly reported 10–30% of binder or filler) after which strength may drop due to excess glass causing brittleness or poor bonding. For example, some experimental works found optimums near 20–30% glass powder in fly-ash bricks.

4.3 Water absorption & density: Glass lowers water absorption and apparent porosity in several fly-ash/geopolymer matrices by densifying the microstructure (glass acts as micro-filler and, when reactive, forms additional binding phases).

4.4 Durability & fire resistance: Glass-containing geopolymer composites showed reduced porosity and improved fire resistance in some studies (denser matrix). However, alkali–silica reaction (ASR) is a potential concern when glass is present with reactive aggregates in cementitious systems; finely ground glass tends to reduce ASR risk versus large cullet.

#### 4.5. Representative studies

Feasibility studies and experimental papers show practical compressive strengths (often meeting common masonry standards) for fly-ash-based bricks with glass powder replacements (e.g., 10–30% glass powder). Results vary with glass type (soda-lime vs borosilicate), grinding fineness, and curing method.

### V. USING GRANITE AND GLASS TOGETHER AS FLY-ASH REPLACEMENTS — WHAT LITERATURE INFORM US

Complementary roles: Glass supplies reactive silica and fluxing action (when fine), while granite waste [5] supplies inert/fine aluminosilicate filler and improves particle packing. Several works examine combined wastes (e.g., glass + copper slag + fly ash) with optimum blend designs producing higher compressive strength than single-waste mixes.

Geopolymer advantage: In alkali-activated systems, adding glass powder often reduces porosity and improves early strength, while granite fines can contribute bulk and, if sufficiently fine, some reactivity under activation. This makes geopolymer bricks a promising route for combined substitution.

### VI. TYPICAL EXPERIMENTAL METHODS USED ACROSS STUDIES

Common characterisation and testing methods you should include in any experimental study (standardised where possible):

Raw material characterisation: XRD (mineral phases), XRF (chemical composition), particle size distribution (laser diffraction / sieving), BET/surface area, SEM for morphology.

Mix design variables: replacement percentages (by mass) of fly ash with granite powder[6] and/or glass powder (typical ranges explored: 0–50%), binder ratio, water/binder or activator concentration (for geopolymer), use of cement/lime/alkali activator.

Manufacturing: mixing, moulding or pressing (static or hydraulic), curing regimes (ambient curing, steam/autoclave, or oven curing), firing schedules if clay-fired (temperatures[2], soak times).

Tests on bricks: compressive strength (typically 28-day and/or after firing), water absorption, apparent

porosity, bulk density, efflorescence, thermal conductivity (if relevant), and durability tests (freeze-thaw, acid/alkali resistance).

#### VII. REPORTED OPTIMUM RANGES AND PRACTICAL RECOMMENDATIONS

Synthesised from surveyed studies — reported optimums vary with route and material

Waste glass powder[7]: Many studies report 10–30 wt.% replacement (of binder or fine fraction) as optimum for strength and reduced water absorption in fly-ash/geopolymer bricks; some studies find 20–30% optimal. Monitor for brittleness or excessive shrinkage at higher contents.

Granite waste[5]/sawdust powder: Replacements of 10–30 wt.% of clay or sand are common without severe property loss; in geopolymer mixes granite fines up to similar levels can be used if particle grading is controlled.

Combined use: Blends where glass provides reactive silica (10–30%) and granite supplies filler (10–30%) show promise — but experiments must optimise particle size distribution, activator dosage (for geopolymer), and curing.

#### VIII. ENVIRONMENTAL AND ECONOMIC CONSIDERATIONS

Environmental: Using granite and glass wastes reduces landfill and virgin resource extraction; geopolymer routes can lower CO<sub>2</sub> versus fired-clay bricks[3] and OPC-stabilized bricks. However, life-cycle impacts depend on grinding energy (especially for glass powder) and transport distances.

Economic: Savings come from lower raw-material costs and possible disposal-cost avoidance; however, additional processing (grinding, sieving) and quality control add cost. Pilot-scale studies and local supply-chain analysis required for feasibility.

#### IX. GAPS IN THE LITERATURE AND RECOMMENDED RESEARCH AGENDA

Standardised protocols: Many papers use ad-hoc mix designs and curing; cross-study comparisons are difficult. A standard test matrix (fixed particle-size

classes, replacement levels, and curing regimes) is needed.

Long-term durability: Limited data on long-term durability (weathering, freeze–thaw, efflorescence, alkali–silica reactions) for combined waste mixes — particularly important for glass-containing mixes. More accelerated ageing studies required.

Scale-up and industrial trials: Most studies are lab-scale; industrial pressing/firing/geopolymer plant trials and economic assessments are sparse.

Optimising grinding vs performance trade-offs: Finely ground glass performs better but costs more energy to produce; life-cycle and techno-economic optimization is required.

Local raw-material characterisation: Granite and glass wastes vary widely by source. Local characterisation must precede mix design.

#### X. SUGGESTED EXPERIMENTAL PLAN (CONCISE, ACTIONABLE)

Raw materials: collect representative samples of fly ash, granite sawdust/quarry fines, and waste glass cullet (document origin). Run XRF, XRD, PSD and BET.

Prepare glass powder[9] and granite fines: produce two fineness classes for glass (e.g., <75 μm and <45 μm) and one fine granite class (<75 μm).

Mix design matrix (example):

Control: fly-ash brick mix (baseline from local standard).

Replace fly ash (by mass) with glass powder at 0%, 10%, 20%, 30% (keeping other constituents constant).

Replace fly ash with granite powder[6] at 0%, 10%, 20%, 30%.

Combined mixes: glass 10% + granite 10%, glass 20% + granite 10%, etc.

Manufacturing: prepare specimens using the intended route (pressed and cured for fly-ash bricks; also a set for geopolymer activation if exploring both). Record workability, green strength, drying/cracking.

Curing & testing: 7, 28, 90-day compressive strength; water absorption; apparent porosity; bulk density; thermal conductivity (optional); accelerated durability tests (soaking, wet-dry, efflorescence, acid resistance).

Microstructure: SEM/EDX and XRD on selected mixes to identify new phases/bonding.

## XI. CONCLUSIONS

Both granite waste[5] and waste glass are viable candidates to partially replace fly ash[10] in brick production. Glass (when finely ground) contributes reactive silica and densifies matrices (often improving strength and lowering water absorption), while granite fines act as effective fillers and reduce raw-clay/sand demand.

Optimisation is essential: particle size, chemical composition, and production route determine whether substitution improves or degrades performance; many studies show optimums typically in the 10–30% range for each waste, but local verification is necessary.

Research priorities: standardised comparative studies, durability/long-term performance, life-cycle and techno-economic analyses, and pilot-scale trials to demonstrate commercial feasibility.

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