

A Experimental Study on utilizing coalmine overburden and industrial flash into eco – friendly building bricks

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ABSTRACT

Industrial waste is increasing day by day these leads to search for efficient alternatives for construction sector which will help in management of industrial waste. This study investigates the potential of manufacturing of solid bricks according to IS: 12894 standards by using two major industrial waste: coal mine overburden (OB) and industrial fly ash (IFA). In these quantities of sludge lime and cement are kept constant which will be used as binders. A detailed physio- chemical characterization will be conducted for raw materials and bricks samples. The testing focus includes key performance metrics such as compressive strength, water absorption, efflorescence, and bulk density. To ensure methodological rigor, OB and IFA will be characterized for particle size distribution, chemical composition, mineral phases, and moisture content prior to mixing. Mortar proportions will be adjusted to maintain proper workability and curing conditions for all mixes. For each formulation, bricks will be molded under standardized pressure and cured under controlled temperature and humidity to minimize variability in brick samples. Compressive strength tests will be performed on brick samples after 7, 14, and 28 days of curing to check early and late strength development of bricks, while water absorption will be decided according to proper standards to rate porosity and durability. Efflorescence potential will be checked qualitatively and, if possible, quantified using standardized scoring methods.

Bulk density will be measured to determine unit weight and packing efficiency. Statistical analysis will be employed to determine the influence of OB and IFA contents on the measured properties, and optimization techniques will be used to identify mix proportions that maximize strength and minimize water absorption and efflorescence without compromising environmental and economic benefits. This will offer improved sustainability profiles, due to reduced cement demand and effective utilization of industrial waste. This research could provide a way for proper use of OB and IFA in the brick manufacturing industry, which will be contributing to waste minimization and supporting sustainable construction practices.

Keywords: - Sustainable bricks, Coal mine overburden (OB), Industrial fly ash (IFA), and circularity goals

1. INTRODUCTION

Coal is still India's main energy source—it's basically a type of sedimentary rock deposit. We dig it up using two big methods: opencast (or surface) mining and underground mining. Opencast is by far the most common, handling over 90% of the country's total coal production.

In surface mining, the first step is stripping away the overburden—that's all the waste rock sitting on top—to reach the coal seam underneath. Once the coal's mined out, they usually shove that overburden back into the hole to fill it up. But there's often about 20% extra that won't fit, so it ends up in huge piles called external dumps, right near the mine's edges.

The ratio of “over budern (OB) to be removed” to “the mineral to be produced” during the whole project life. Suppose in an opencast mine, 20 lakh CuM OB will be removed during the life time (suppose 15 years) against the production of 10 lakh Te of coal, the standard stripping ratio will be 2.1 [1]

These external dumps are a real headache—they gobble up precious land and create big risks for the environment and mine safety. On top of that, the amount of waste rock keeps piling up year after year from all sorts of reasons, putting even more pressure on available land and safety measures.

Fly ash is that super-fine, powdery stuff left over when coal gets burned in power plants. It's made up of silica, alumina, iron oxide, and a few other elements. Builders love mixing it into concrete as a partial swap for Portland cement—it boosts strength, durability, and how easy it is to work with.

If fly ash leaks into rivers or lakes, it can be pretty toxic, but government initiatives are promoting clever ways to reuse it, which is sparking new business opportunities. The market divides fly ash into two main types: Class F and Class C. Back in 2024, Class F dominated with about 58.2% of the share.

Class F usually wins out over Class C thanks to its superior chemistry and rock-solid long-term strength. It has low calcium (less than 10%) but loads of silica, alumina, and iron oxide, giving it killer pozzolanic powers—it reacts with lime or cement to create super-strong bonds like natural cement.

That makes Class F awesome for resisting sulphate attacks and alkali-silica reactions, perfect for concrete in harsh environments. Class C, on the other hand, packs more calcium oxide (20-30% or higher), so it can set and gain strength on its own pretty fast. But its higher alkalis and sulphates make it trickier in aggressive conditions, and that quick self-hardening can make concrete mixes less workable, especially for jobs needing ultimate long-haul toughness.

Special features of fly ash cement bricks as follows:

- Fly ash cement bricks offer high dimensional uniformity achieved through precision machine finishing.
- They require approximately 20-25% less bedding and jointing mortar demonstrate superior strength and durability compared to Class-I burnt clay units.
- The bricks' smooth texture and low water absorption minimize or eliminate the need for exterior plastering.
- They exhibit high resistance to efflorescence and chemical degradation (salinity tolerance).
- Their lower unit density reduces both the structural dead load and associated logistics costs.
- Environmentally, the manufacturing process is non-fired, mitigating atmospheric pollution, and it preserves agricultural topsoil.
- Crucially, the formulation effectively utilizes 80-82% fly ash, significantly reducing industrial waste disposal impact.

2. LITERATURE REVIEW

This section provides a synthesized evaluation of previous research concerning the fundamental properties and parameters of fly ash. It explores established academic literature regarding the chemical mechanisms behind coal mine overburden and cement-fly ash hydration processes. Additionally, it examines how the integration of fly ash alters the performance of concrete, with a specific focus on critical fresh and hardened properties such as workability and compressive strength.

Stone waste is a big polluter because it's super alkaline. This research [2] shows how to turn stone sludge waste into fly ash bricks. As you add more stone waste, the bricks' compressive strength goes up to a peak, then drops off. The sweet spot for max strength is swapping out 30% of Class F fly ash with stone waste. It offers a fresh way to use Class F fly ash, which has less than 20% lime. This approach cuts down on the environmental damage from these wastes and solves disposal headaches.

In this author [3] looks at different ways to make bricks and finds the best mix of fly ash with stuff like lime, cement, and clay. For each mix, they tested replacing 50% to 80% of the main material with fly ash, in 10% steps. The top performers for compressive strength were fly ash + lime, and fly ash + lime + stone dust. In the fly ash + lime mix, strength builds slowly at first but picks up speed later on. Fly ash + cement gives a quick early strength boost, but it slows down over time. Clay bricks are strong, but they're not eco-friendly and gobble up fertile soil. Lime pairs perfectly with fly ash to boost the brick's durability. Adding fly ash cuts the overall cost of making bricks.

Researcher tries to introduce [4] ironite into fly ash bricks. Ironite is waste from iron ore processing. They made bricks using cement, sand, fly ash, and ironite, and lab tests showed solid results for putting this waste to good use. In the experiments, they added small amounts of ironite—0%, 2%, 4%, or 6%—to different ratios of cement, sand, and fly ash. Adding ironite boosts the bricks' compressive strength. The highest strength comes from a 1:1:3.5 ratio (cement : sand : fly ash + ironite) with 6% ironite. The 1:1:4.5 ratio strikes the best balance of strength and low cost. These bricks qualify as first-class, with water absorption under 16%.

This paper [5] explores using waste rock from surface coal mines to make bricks and blocks, as an alternative to traditional clay bricks. These can go into building construction or as pavement material near coal mines. Overburden bricks outperform regular burnt clay bricks in compressive strength, efflorescence and weathering tests, water absorption, and more. Their specific gravity is a bit higher than conventional bricks. That's not a big downside, especially for affordable housing, boundaries, or low-rise structures around mining areas.

In this study, [6] we looked at experiments mixing different amounts of laterite soil and fly ash with either 5% or 10% cement. The main motive is to find the percentage of fly ash to blend with soil and cement as a stabilizer, so we can make low-cost bricks. Key takeaways from the results: Cost analysis shows these laterite-cement bricks cut wall construction costs by 50% compared to regular laterite stone. The fly ash-laced laterite-cement bricks hit a compressive strength of 9.5 N/mm²—that's 4.5 times stronger than plain laterite stone. Thanks to that extra toughness, they work great for load-bearing walls. In the interlocking wall system, these bricks snap together without any mortar, letting you build walls way faster than with laterite stone and slashing construction

time. No need for plastering either—their clean, interlocking design looks sharp on its own. Using fly ash makes the whole brick eco-friendly. They soak up less water too, which means better durability than laterite stones.

This study [7] checks out how silica fume affects fly ash-cement bricks. We ran experiments in two phases to track changes in key properties like compressive strength, density, and water absorption. **Phase 1:** Kept fly ash and stone dust amounts fixed, but swapped out cement for silica fume in varying proportions. **Phase 2:** Added silica fume as an extra ingredient (admixture) at the same weight proportions relative to the cement.

The bricks were tested after 7, 14, and 28 days of curing in the institute's concrete testing lab.

Key findings: Water absorption gets worse when replacing cement with silica fume, but improves when you just add it to the mix. Dry density drops if you replace cement with silica fume; it rises when added instead—with the best balance in mix S-II-2. Compressive strength takes a hit from cement replacement, but gets a boost when silica fume is added as an extra. Bottom line: Silica fume isn't great as a cement substitute, but it shines as an additive, enhancing the bricks' overall performance.

Researchers [8] tried a fresh approach to brick-making by using industrial leftovers like Class F fly ash, granite dust, and sludge lime as the main ingredients. The highest compressive strength came with 55% fly ash and 25% granite dust, whether bricks were partially cured or fully immersed in water. Bricks fully dunked in water for curing ended up stronger than those only partially cured. These bricks soak up less water compared to traditional clay bricks. Overall, fly ash-granite dust bricks are energy-efficient, cheaper to make, and a step toward greener, eco-friendly construction. This method also helps cut down on the hazards and headaches of disposing industrial waste.

This paper explores [9] how fly ash bricks perform with different mixes of fly ash, cement, lime, gypsum, and sand. They tested three versions: ones with 3% cement, 5% cement, and no cement at all. From the experiments, here's what they found: Fly ash bricks with 0% cement are 27% stronger (in compressive strength) than standard Class I conventional bricks. Add 3% cement, and they jump to 51.8% stronger than conventional. With 5% cement, they're over 63% stronger. Water absorption is way better too: 27% less than conventional bricks with no cement, 42% less with 3% cement, and 48% less with 5% cement. Overall, these fly ash bricks are three times tougher than traditional burnt clay bricks.

Researchers [10] tested brick-making with a mix of materials like fly ash, lime, sand, Kheda dust, and glass fiber. They tried adding glass fiber in different amounts: 0.2%, 0.4%, 0.6%, 0.8%, and 1.0% to create fiber-reinforced fly ash bricks. Key findings from the experiments: As compressive strength goes up, water absorption goes down. The best results after 21 days. A max strength of 5.86 N/mm² with just 12.32% water absorption (the lowest). More glass fiber means stronger bricks, but it also bumps up the cost—the toughest ones run about 11.4 rupees per brick.

Sure, these bricks cost more upfront, but they're a smart swap for PCC (plain cement concrete), BBCC (brick bat cement concrete), or RCC (reinforced cement concrete) at the plinth level or in load-bearing spots. Using them actually cuts the overall cost of those concrete elements.

The main goal here [11] is to spotlight fly ash's chemical properties and show how it can be used in construction just like traditional burnt clay bricks.

Geopolymer fly ash bricks are tougher—you can tell by scratching them by hand; they hold up better than clay bricks. They make a sharp, clear ringing sound when tapped, even crisper than regular bricks. No structural defects showed up in fly ash bricks during testing. They absorb less moisture than clay bricks, with an average of 10.42% for fly ash vs. 13.16% for clay. Fly ash bricks pack more than twice the punch of burnt clay bricks.

3. OBJECTIVES OF RESEARCH WORK

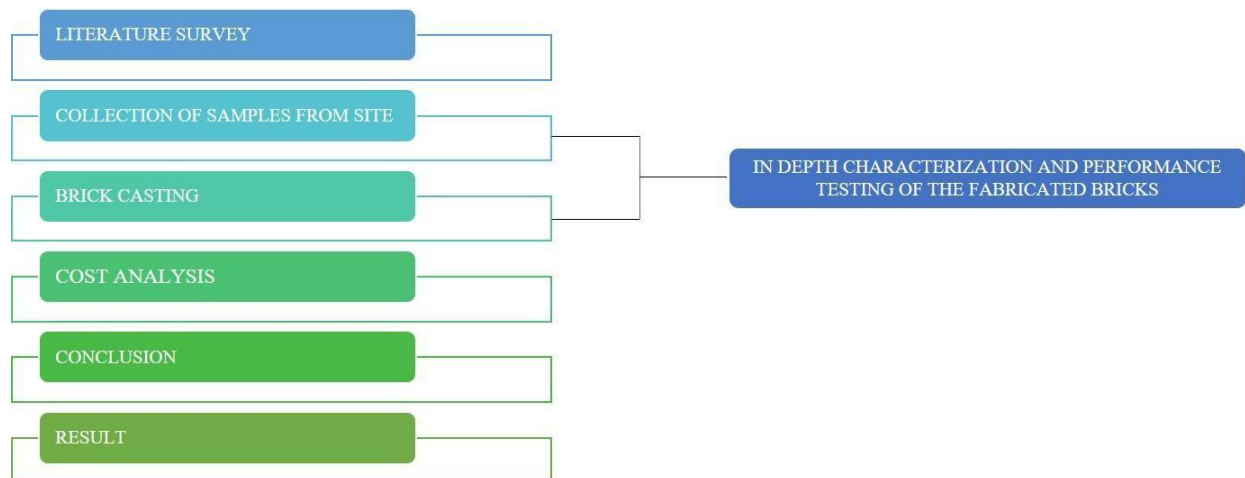
- To explore the feasibility of utilizing coalmine overburden waste and fly ash as primary raw materials for sustainable brick production.
- To conduct comprehensive physio-chemical and mineralogical characterization (including XRD, SEM, and EDAX analysis) of the coalmine overburden, fly ash and produced bricks to determine their material properties. To design, fabricate, and test bricks with different mix design of cement overburden waste, industrial fly ash, and cement, following IS: 12894 standards.
- To assess the mechanical and durability properties (water absorption, bulk density, efflorescence) of the developed bricks.
- To compare the economic viability of the newly developed bricks with conventional fired clay bricks and other commercial alternatives

4. PROBLEM STATEMENT

Coal mine waste piles up like crazy, eating up land and creating big environmental and safety headaches. Add in all the fly ash from power plants, and you've got even more industrial trash problems. This study mixes that mine overburden with fly ash to make bricks—helping cut down waste, free up land, and build cheap, eco-

friendly materials

5.METHODOLOGY



6.CONCLUSION

Based on the review of the above paper, the following conclusions have been drawn:

- Fly ash cement bricks weigh less but pack more compressive strength than regular clay bricks.
- The exact mix of fly ash and other materials changes both their strength and overall cost—get the proportions wrong, and performance suffers. Each mix also needs its own curing time to hit peak strength.
- Plus, fly ash bricks have sharper, more uniform edges than lime or clay bricks, and they're tough—their surface won't scratch with a fingernail like traditional clay ones do.

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