Final Year Project Showcase Batch 2021
Year 2024

	Department: Civil Engineering TIET Programme: B.E.(Civil)
1	**Project Title** **Utilization of Thar Coal Fly Ash in Manufacturing of Clay Bricks**
2	**Project Idea** The project is concerned with the area of sustainable construction materials in the domain of civil engineering or in other words how to develop as well as produce environmentally friendly clay bricks. It directly concerns the issue of industrial by-product reuse in construction with the Thar Coal Fly Ash and lime being used as a partial substitute to natural clay in the brick making process. The product also belongs to the scope of environmental engineering and material science in which the task is to support the material performance and work through the environmental issues like waste management and the depletion of the raw material. These features of fly ash as pozzolanic materials and stabilization ability of lime is exploited to produce low cost, durable and thermally efficient building bricks. It is part of the general trend of green building practices, sustainable solutions to infrastructure development, and the technologies developing the concept of circular economy. The developed product can be mostly applied in the process of manufacturing environment-friendly fired clay bricks serving the purposes of non-load-bearing masonry construction that can be used in residential (shown in Figure 1) and public infrastructure building at a relatively low price.
3	**Process** Fly ash-clay bricks are produced in the following manner as shown in Figure 2: **1. Collection and Sorting** Raw clay was taken at the site of NAUKOT whereas it took fly ash at the coal power plants of Thar. Lime was obtained in local markets. Visual inspection of the materials was carried to eliminate large debris, rocks, and organic productions. **2. Drying and Crushing** The fresh clay was sun dried further and manually pulverized by hammer bin empowered with a fine particle that was suitable to blend. Fly ash and lime were already available in fine powder form and did not need much pre-processing. **3. Mixing and Proportioning** The materials got blended in three proportions: Mix1: fly ash 5 %, lime 1 % and Clay 94 % Mix 2: 2 percent lime + 10 percent fly ash + 88 percent clay

	Mix 3: 15% fly ash, 3% lime and 82% clay Water was also added slowly till a consistency was reached that was easy to work with. It was mixed manually on a flat surface. **4. Molding** The mixture was poured into standard sized brick wooden molds. The bricks were hand pressed and surplus was chopped out to obtain even surface. **5. Drying** The moulded bricks were left to be dried in the sun, 5 to 6 days to get rid of any moisture content so that the bricks might not crack during firing. **6. Firing in Kiln** The drying bricks were refired in a customary clamp kiln to 1000-1100 Degrees Celsius over a 48-72 hours firing, this produced sufficient vitrification. **7. Cooling and Finishing** Bricks were allowed to cool themselves in a kiln and then they were examined by identifying the defects. There was minor surface finishing to eliminate irregularities as shown in Figure 3.
4	**Outcome** In order to explore a sustainable solution for waste material management and construction material improvement, a comprehensive experimental study on the utilization of Thar Coal Fly Ash in the manufacturing of clay bricks has been carried out. Three different mix designs: 5% fly ash with 1% lime, 10% fly ash with 2% lime, and 15% fly ash with 3% lime, while a set of control bricks without any fly ash have been used. These bricks were tested for compressive strength, dry density, and water absorption to evaluate their mechanical and durability characteristics. The product offered benefits in terms of lightweight construction. The results demonstrated a steady increase in water absorption with the fly ash content. Dimensional analysis showed that all brick samples maintained acceptable shape and size consistency, with only minor deviations, indicating that fly ash addition did not significantly affect the molding or drying process. Overall, bricks with 5% fly ash and 1% lime provided the most balanced performance among the fly ash blends, showing potential for use in non-load-bearing applications such as partition walls, infill panels, and boundary structures. This study highlights the dual benefit of utilizing an industrial by-product to reduce

	environmental burden while developing alternative building materials.The successful reuse of fly ash in this context represents a step forward toward sustainable construction practices and resource conservation in Pakistan.
5	**Evidence (Theoretical Basis)** Pakistan's energy sector produces millions of tons of fly ash annually, much of which ends up in landfills. Concurrently, the construction industry heavily uses clay bricks, which deplete valuable agricultural soil. Utilizing industrial waste like fly ash in brick production offers a sustainable solution, reducing both environmental degradation and raw material demand. Prior studies support its use, but local feasibility, especially for Thar coal ash, needed to be experimentally validated. The uncontrolled disposal of coal fly ash from Thar-based power plants presents significant environmental and waste management challenges. At the same time, conventional clay brick production consumes fertile topsoil and contributes to air pollution. This project addresses both issues by investigating the use of Thar Coal Fly Ash as a partial replacement for clay in brick manufacturing, aiming to develop eco-friendly, cost-effective building materials. The project followed a structured methodology comprising literature review, material characterization, experimental design, specimen preparation, and testing. Bricks were produced using three fly ash–lime–clay mixes (5% FA + 1% lime, 10% FA + 2% lime, and 15% FA + 3% lime) and compared against control bricks. Tests included compressive strength, water absorption, dry density, efflorescence, and dimensional accuracy, following ASTM standards. The results showed that increasing fly ash content led to reduced compressive strength and increased water absorption, while dry density decreased marginally. The 5% fly ash mix performed best among the alternatives, offering moderate strength and acceptable durability. Dimensional tolerance and appearance remained within usable construction standards. Although none of the fly ash bricks exceeded the control sample in performance, they showed potential for low-cost, non-load-bearing applications. This study confirms the partial viability of using Thar Coal Fly Ash in brick production, particularly at lower replacement levels. The approach offers a promising solution to fly ash waste and promotes sustainable material use in construction. While further optimization is necessary for structural-grade applications, this work lays the foundation for environmentally responsible brick manufacturing and highlights the broader potential of industrial waste valorization in civil engineering.

6	**Impact on Sustainability of Urban Regions or SDG-11 "Sustainable Cities and Communities"** The developed product is very probable to a sustainable world in many ways since it can solve various environmental and industrial problems. The unregulated dumping or disposal of coal fly ash especially that used by Thar based power plants has resulted in very serious environmental risks such as degradation of soil, water pollution and health challenges. This product converts that waste into a useful raw material in construction sector lessening the requirement of the land fill space and neutralizing the adverse consequences of the by-products of industries. Also, the conventional production of bricks requires huge quantities of the topsoil, resulting in the loss of agricultural land and environmental imbalance. The product decreases the topsoil usage and promotes the preservation of natural resources since topsoil use is partially substituted with fly ash. Lime use also boosts the structural qualities of bricks and it also promotes pozzolanic reactions which reduces firing temperatures and thereby indirectly reduces energy consumption thus generating less greenhouse gases per tonne of products produced. The advantages follow global competencies in the battle against climate change and the green infrastructure. Also, the invention facilitates the adoption of a number of the United Nations Sustainable Development Goals, among which are climate action, sustainable cities and communities, and decent work and economic growth. Overall, the proposed undertaking is an environmentally friendly solution to the construction sector with a reasonable degree of scalability that leads to a more sustainable development and a circular economy business model.
7	**Competitive Advantage or Unique Selling Proposition** (Cost Reduction, Process improvement, Attainment of any SDG (Sustainable Development Goal), increase of market share or capturing new market or having superior performance over a competitor. In summary, any striking aspect of the project that compels the industry to invest in FYP or purchase it. Some detailed description is required in terms of how, why when what. You can select one or more from the following dropdown and delete the rest of them). Please keep relevant options, delete the rest of them, and correct the sequence The product can be mostly applied in the process of manufacturing environment-friendly fired clay bricks serving the purposes of non-load-bearing masonry construction that can be used in residential (shown in Figure 1) and public infrastructure building at a relatively low price. **a) Application in Non-Load-Bearing Masonry and Partition Walls:** The invention can be applied in making bricks applicable in the non-load bearing structures like that of partition walls and internal partitions. These bricks provide adequate strength and light weight properties and also they provide the dimensional accuracy. They are very easy to install and are durable, thus suited to use in the residential and commercial sphere of the interior. **b) Use in Low-Cost and Affordable Housing Projects:** Fly ash bricks can be used in low cost as well as affordable housing schemes particularly in those areas

	where income is low or the location is remote. These bricks are cheaper to construct using local fly ash, and they also require less energy to make. They fit well in rural dwelling programs, and they are aided by government or non-profit bodies. **c) Implementation in Public Infrastructure and Government Projects:** Innovation may be implemented into work with the infrastructures of the community and community buildings together with school and clinic facilities. The projects are also good in the use of green materials in the project design due to the government green procurement policies. The bricks are also fair to the environment by offering a green substitute that does not concede on structural necessities. **d) Integration into Green Building and Sustainable Architecture Initiatives:** Bricks also aid in green building requirements such as reuse of material and energy efficiency. They contribute in reducing the amount of energy used in buildings through their thermal insulation capabilities. This qualifies them to architects who want to satisfy LEED or other green architecture requirements. **e) Application Near Coal Power Plant Zones for Localized Resource Utilization:** The invention encourages location of brick production around the power plants through the utilization of fly ash at the site. This helps to minimize the waste disposal difficulties and saves the transportation costs. It promotes circular economy activities and sponsors industrial regions sustainability. **f) Association with the UN SDGs:** The product, environment-friendly fired clay bricks made using fly ash, can be associated with several United Nations Sustainable Development Goals (UN SDGs) No. 9, 11, 12 and 13.
a	**Attainment of any SDG** (e.g. How it is achieved and why it is necessary for the region) The product, environment-friendly fired clay bricks made using fly ash, can be associated with several United Nations Sustainable Development Goals (UN SDGs) No. 9, 11, 12 and 13. ■ **Goal 9:** Industry, Innovation and Infrastructure: The use of fly ash bricks promotes sustainable construction practices, innovation in building materials, and efficient use of resources. ■ **Goal 11:** Sustainable Cities and Communities: By utilizing environmentally friendly bricks in construction, cities can become more sustainable, reducing environmental impacts while meeting housing and infrastructure needs. ■ **Goal 12:** Responsible Consumption and Production: Fly ash bricks encourage the reuse of industrial waste (fly ash), reducing waste disposal issues and promoting responsible production and consumption patterns.

	■ **Goal 13:** Climate Action: The bricks contribute to reducing energy usage in buildings through thermal insulation, aligning with efforts to mitigate climate change. Key aspects of the product aligning with these SDGs include: ■ Sustainable Construction: Environment-friendly bricks support sustainable building practices. ■ Resource Efficiency: Utilization of fly ash reduces waste and conserves natural resources. ■ Affordable Housing: Fly ash bricks can contribute to low-cost housing solutions. ■ Reduced Environmental Impact: By using industrial waste and offering thermal insulation, these bricks minimize environmental footprint. By contributing to these SDGs, the product supports broader goals of sustainability, resource efficiency, and reduced environmental impact in the construction sector.
b	**Environmental Aspect** (e.g. carbon reduction, energy-efficient, etc.) **Application Near Coal Power Plant Zones for Localized Resource Utilization:** The product encourages location of brick production around the power plants through the utilization of fly ash at the site. This helps to minimize the waste disposal difficulties and saves the transportation costs. It promotes circular economy activities and sponsors industrial regions sustainability.
c	**Cost Reduction of Existing Product** Bricks also aid in green building requirements such as reuse of material and energy efficiency. They contribute in reducing the amount of energy used in buildings through their thermal insulation capabilities. This qualifies them to architects who want to satisfy LEED or other green architecture requirements. All this results in money saving in terms of reduced cost of bricks as well as saving of the cost incurred on dumping of fly ash in landfills.
d	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process** (e.g. What is the issue is current process and what improvement you suggests) The two issues of waste management and sustainable construction are solved by the current product development that seeks to solve, namely, by establishing a proposal of a new brick formulation that will introduce a partial replacement of clay with fly ash and lime. It presents a solution to the current problem of industrial waste going straight to the landfills, dependence on the natural clay, and the opportunity to create bricks that can be utilized in the non-load bearing construction with a satisfactory durability and dimensional stability.
e	**Expanding of Market share** (e.g. how it expand and what is the problem with the current market The product, environment-friendly fired clay bricks made using fly ash, can contribute to market share in several ways: ■ - Cost-Effectiveness ■ Sustainability and Green Building ■ Localized Production ■ Diverse Applications

	■ Compliance with Government Policies By targeting these areas, the product can capture a share of the market for sustainable, cost-effective building materials.	
f	**Capture New Market** (e.g. Niche market or unaddressed segment) The product, environment-friendly fired clay bricks made using fly ash, can capture new markets through several strategies. Potential new markets include: ■ Green Building and Sustainable Architecture: Architects and builders focusing on LEED or similar certifications. ■ Government and Public Infrastructure Projects: Projects prioritizing sustainable materials and green procurement. ■ Affordable Housing Initiatives: Low-cost housing schemes in low-income or remote areas. ■ Industrial Regions Near Coal Power Plants: Utilizing local fly ash for brick production. By targeting these markets and highlighting the product's benefits, the environment-friendly fired clay bricks can capture new market segments.	
g	**Any Other Aspect (Please tag it like above options)**	
8	**Target Market** (Industries, Groups, Individuals, Families, Students, etc) Please provide some detail about the end-user of the product, process, or service The target market for environment-friendly fired clay bricks made using fly ash includes: ■ Industries: Construction companies focusing on sustainable building practices; and Manufacturers of building materials looking for eco-friendly alternatives. ■ Groups: ✓ Government agencies involved in public infrastructure and affordable housing projects. ✓ Non-profit organizations working on low-cost housing or sustainable development initiatives. ✓ Architects and designers prioritizing green building and LEED certifications. ■ Individuals: Builders and contractors seeking cost-effective, sustainable materials for residential and commercial projects as well as homeowners interested in eco-friendly construction for new builds or renovations. ■ Families: Those living in low-income or remote areas benefiting from affordable housing initiatives. ■ Students and Educators: In fields like architecture, engineering, and environmental science, where sustainable building practices are of interest.	
9	**Team Members** (Names along with email address	Abdul Raqeeb (raqeeb4410502@cloud.neduet.edu.pk) Sharjeel Ahmed (ahmed4402703@cloud.neduet.edu.pk) Sher Afzal (afzal4402272@cloud.neduet.edu.pk) Sagar Ali (ali4409148@cloud.neduet.edu.pk)
10	**Supervisor Name** (along with email address)	**Dr. Muhammad Aslam Bhutto (mabhutto@cloud.neduet.edu.pk)**

11	**Video (If any)**	You may please provide the link of the video to be accessible

Pictures (If any)

Figure 1: Use of fly ash-clay bricks in non-load bearing wall including partition wall, boundary wall and low cost housing

Figure 2: Graphical display of the process of making a brick using Thar Coal Fly Ash as a partial replacement of clay and lime.

Figure 3: Standard bricks in their molded form (in a rectangular shape) after firing in a traditional clamp kiln.

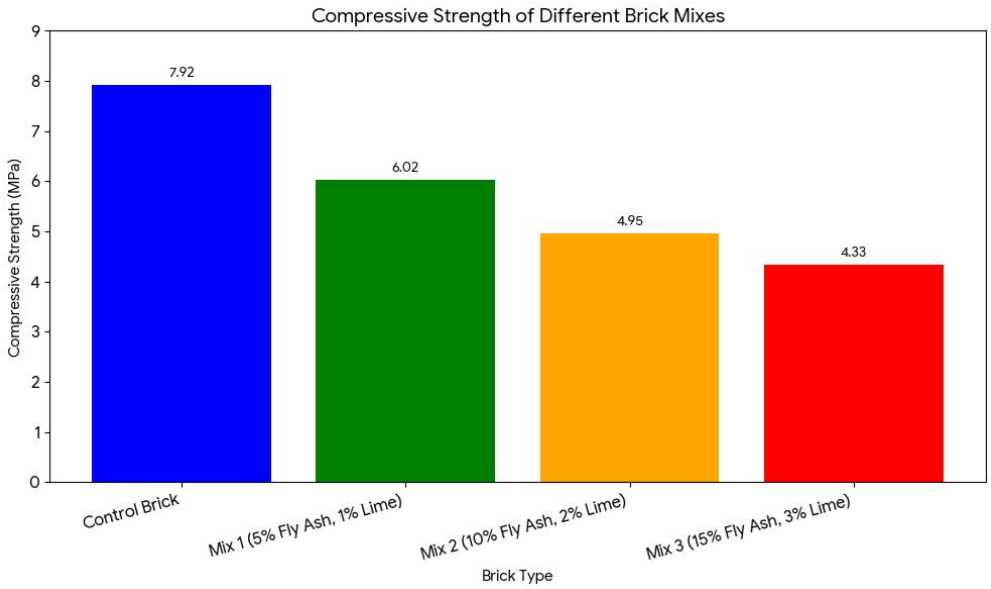

Figure 4: Comparative compressive strength results of clay bricks and fly ash-lime bricks samples.

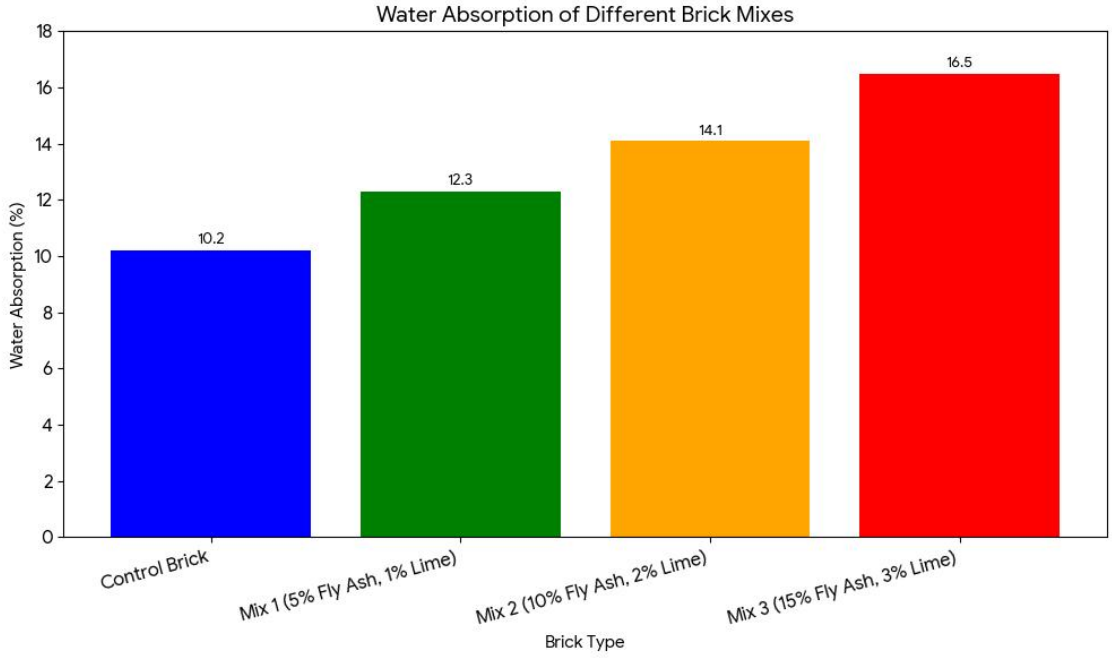

Figure 5: Water absorption of bricks of different concentrations (5 cm, 10 cm, 15 cm) and control.

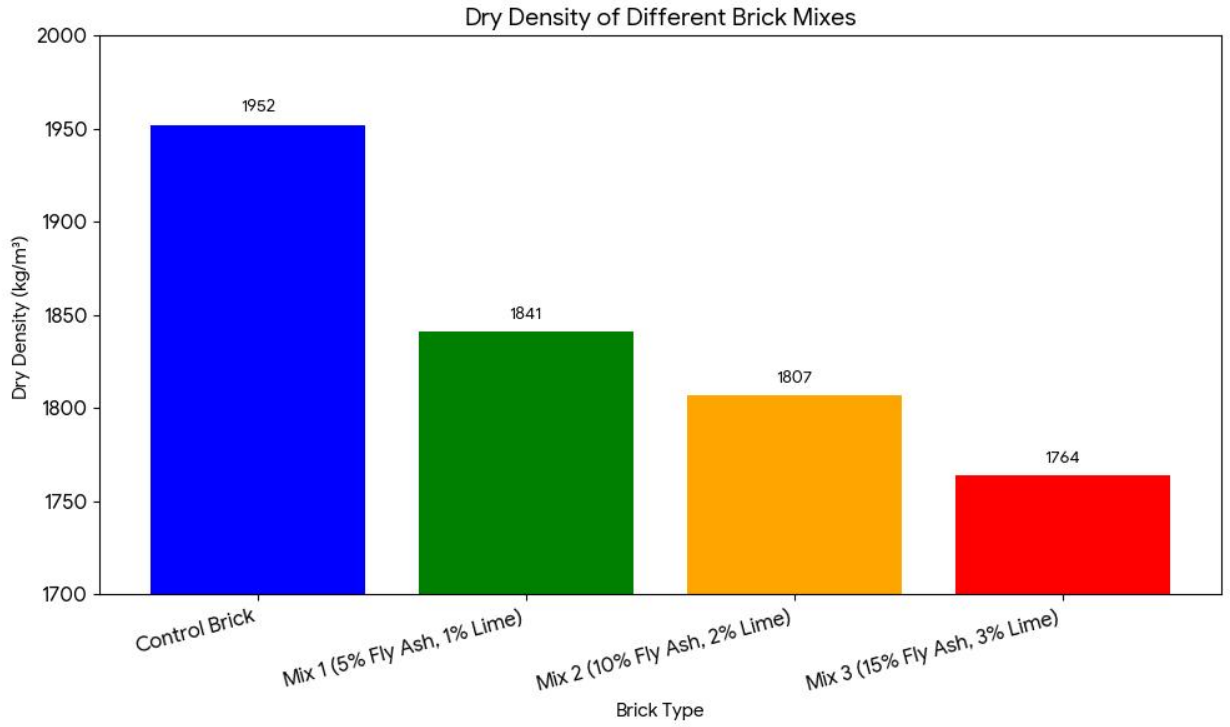

Figure 6: Comparison of dry density of developed bricks and conventional clay bricks.

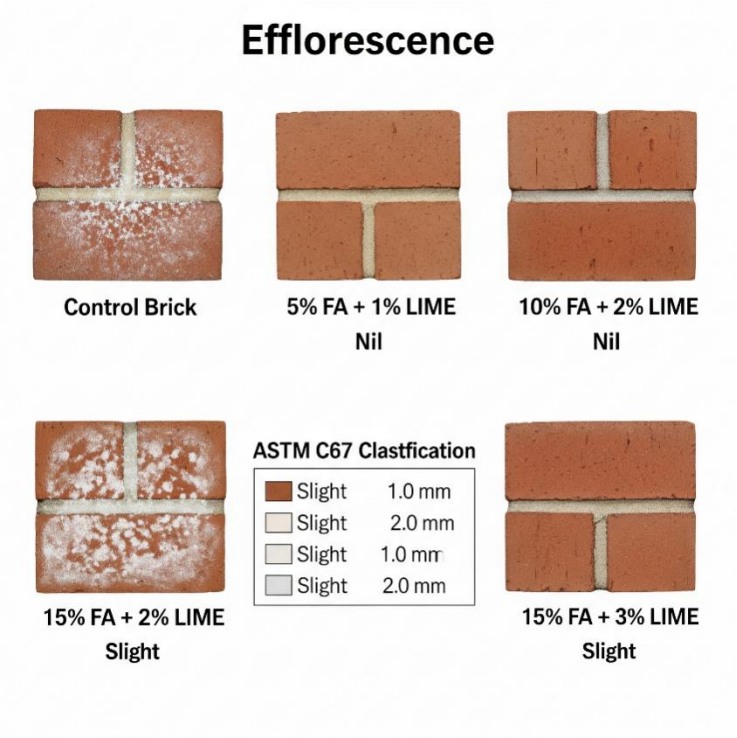

Figure 7: Illustration of efflorescence coming out and classification of brick samples in respect to ASTM standards.