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Study on Stabilized Block Using Fly Ash, Construction & Demolition Waste

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Abstract: This study investigates the development of sustainable stabilized blocks using sandy soil, fly ash, cement, and crushed roof tile waste obtained from construction and demolition activities. The primary objective is to reduce the environmental impact and construction cost associated with traditional masonry units while utilizing industrial and construction waste effectively. Different mix proportions were prepared and tested for compressive strength, water absorption, and density after curing periods of 14, 21, and 28 days. The results showed that the mix M1 containing 40% fly ash and 15% crushed roof tile waste achieved the highest compressive strength of 8.16 N/mm² after 28 days. Water absorption values remained below the permissible limit, confirming good durability. The study concludes that fly ash and roof tile waste can be effectively utilized in stabilized blocks to produce low-cost, eco-friendly, and sustainable construction materials.

Keywords: Fly ash, stabilized blocks, Construction and Demolition Waste, sustainable construction, compressive strength

I. INTRODUCTION

The rapid growth of the construction industry has led to increased consumption of natural resources and environmental degradation. Conventional materials such as burnt clay bricks require high energy and contribute to pollution and resource depletion. Therefore, there is a growing need for sustainable and eco-friendly alternatives in construction. Stabilized mud blocks (SMBs) have gained importance as a low-cost and environmentally friendly building material. These blocks can be produced using locally available soil along with industrial and construction waste materials. Fly ash, a by-product of thermal power plants, is widely available but underutilized, while construction and demolition (C&D) waste creates disposal challenges. This study aims to utilize fly ash and crushed roof tile waste in the production of stabilized blocks and to evaluate their performance in terms of compressive strength, water absorption, and density.

II. MATERIALS AND METHODS

A. Material Used

The materials used for the preparation of stabilized mud blocks are sandy soil, class C fly ash, Crushed roof tile waste, Cement and water

1) Sandy soil

Sandy soil is used as the primary material for block preparation. It has good compaction characteristics and low plasticity, which makes it suitable for forming stabilized blocks. The soil used in this study was obtained from a nearby location and was free from organic impurities.

2) Class C fly ash

Fly ash is an industrial by-product obtained from thermal power plants. In this study, Class C fly ash was used due to its self-cementing and pozzolanic properties. It reacts with water to form cementitious compounds, which improve the strength and durability of the blocks.

3) Crushed roof tile waste

Crushed roof tile waste was collected from construction and demolition activities. It was used as a partial replacement material to improve particle size distribution and reduce voids. The inclusion of tile waste also helps in reducing environmental waste and enhances the density of the blocks.

4) *Cement*

Cement was added in a small quantity (5%) as a stabilizing agent. It helps in improving early strength and provides better bonding between the materials. The presence of cement accelerates the strength gain of the blocks during curing.

5) *Water*

Potable water was used for mixing all materials. Clean water ensures proper hydration of cement and fly ash, leading to better strength development. The amount of water added was controlled to achieve optimum moisture content.

B. *Mix Proportions*

Mix proportion adopted for this study are given below in TABLE 1:

TABLE I MIX PROPORTIONS

MIX	SOIL (%)	FLY ASH (%)	TILE WASTE (%)	CEMENT (%)
M1	40	40	15	5
M2	40	35	20	5
M3	40	30	25	5

C. *Block Preparation*

The preparation of stabilized blocks was carried out through dry mixing, wet mixing, and casting. Initially, sandy soil, fly ash, and crushed roof tile waste were dry mixed thoroughly to obtain a uniform mixture. Cement was then added and mixed uniformly. Water was added gradually to achieve an optimum moisture content of approximately 16%, ensuring proper compaction. The mixture was thoroughly mixed to form a consistent mass. The prepared mix was then placed into cube moulds of size 70 mm × 70 mm × 70 mm and compacted adequately to eliminate air voids. The specimens were then removed from the moulds and prepared for curing. FIG shows the casting of cubes with dimension 70 mm × 70 mm × 70 mm.



Fig. 1. Casting of cubes

D. *Curing*

After casting, the blocks were cured for 7 to 28 days by regular water sprinkling. During curing, hydration of cement and pozzolanic reactions of fly ash occur, leading to the formation of cementitious compounds such as calcium silicate hydrate (C-S-H) and calcium aluminate hydrate (C-A-H). These compounds enhance the strength, bonding, and durability of the stabilized blocks.

III. TESTING OF BLOCKS

A. *Compressive Strength Test*

Compressive strength is the most important property for evaluating the performance of stabilized blocks. This test determines the load-bearing capacity of the block. Strength increases with proper curing and compaction. Fig 2 shows the compression strength testing of stabilized mud block in Universal testing machine (UTM).



Fig. 2. Compression strength testing in UTM

B. Water Absorption Test

This test measures the amount of water absorbed by the blocks, which indicates durability. Lower water absorption implies better resistance to moisture and longer service life.

C. Density Test

Density is calculated as mass per unit volume. Higher density indicates better compaction and improved strength of the blocks.

IV. RESULTS AND DISCUSSION

The performance of stabilized mud blocks was evaluated based on compressive strength, water absorption, and density. The experimental results obtained for different mix proportions are presented and discussed below.

TABLE II COMPRESSIVE STRENGTH RESULTS

Mix	14Days(MPa)	21Days(MPa)	28Days(MPa)
M1	3.16	4.73	8.16
M2	2.65	4.61	7.14
M3	2.14	3.81	6.12

The results indicate that the compressive strength of stabilized mud blocks increases consistently with curing time for all mix proportions. At 14 days, Mix M1 shows the highest strength (3.16 MPa), followed by M2 (2.65 MPa) and M3 (2.14 MPa). A similar trend is observed at 21 days and 28 days, where M1 achieves 4.73 MPa and 8.16 MPa respectively, which are higher than the corresponding values of M2 and M3. The increase in strength with curing period is attributed to the continuous hydration of cement and pozzolanic reaction of fly ash, leading to the formation of cementitious compounds such as calcium silicate hydrate (C-S-H), which enhances bonding between particles. Among the mixes, M1 exhibits the highest compressive strength at all curing periods, indicating better compaction and an optimum combination of soil, fly ash, and tile waste. Mix M2 also shows good strength development but remains slightly lower than M1. Mix M3 records the lowest strength due to its higher tile waste content, which reduces cohesion and increases voids within the matrix.

TABLE III WATER ABSORPTION RESULTS

Mix	Water Absorption (%)
M1	13.47
M2	13.62
M3	16.31

The water absorption results indicate that Mix M1 shows the lowest water absorption, followed closely by M2, while M3 exhibits the highest value. Lower water absorption indicates better resistance to moisture and improved durability. The increase in water absorption for M3 is due to higher tile waste content, which leads to increased porosity. The presence of fly ash and proper compaction in M1 and M2 helps in reducing voids and improving resistance to water penetration.

TABLE IV DENSITY RESULTS

Mix	7 Days(kg/m ³)	14 Days(kg/m ³)	28 Days(kg/m ³)
M1	1557	1644	1860
M2	1516	1626	1831
M3	1510.2	1615	1761

The density results show that Mix M1 exhibits the highest density, followed by M2, while M3 has the lowest density. Higher density indicates better compaction and improved structural integrity. The decrease in density in M3 is due to the higher proportion of tile waste, which affects the compactness of the mix.

The results clearly demonstrate that the inclusion of fly ash and crushed roof tile waste significantly influences the properties of stabilized blocks. Compressive strength increases with curing time due to hydration and pozzolanic reactions, while water absorption is affected by porosity and compaction. Among the mixes, M1 provides the best overall balance between strength, durability, and material efficiency, making it the most suitable mix for stabilized block production.

V. CONCLUSIONS

The present study demonstrates that stabilized mud blocks incorporating fly ash and crushed roof tile waste can be effectively used as a sustainable alternative to conventional building materials. The experimental results clearly indicate that compressive strength increases with curing time due to continuous hydration and pozzolanic reactions, while water absorption is influenced by the porosity and compaction of the mix. Among the different mix proportions, Mix M1 exhibited the highest compressive strength (8.16 MPa at 28 days) and maximum density, indicating superior load-bearing capacity and compaction characteristics. However, Mix M2 showed a more balanced performance with adequate strength (7.14 MPa), relatively low water absorption (13.62%), and efficient utilization of materials. The results also reveal that increasing crushed roof tile content beyond an optimum level (as in M3) leads to a reduction in strength and density due to increased porosity and reduced cohesion. The inclusion of fly ash significantly contributed to strength development through pozzolanic reactions, while crushed tile waste improved particle packing up to an optimum limit. Therefore, considering overall performance, material efficiency, and sustainability, Mix M1 can be considered the optimum mix, more suitable for applications requiring higher strength. Overall, the study confirms that the utilization of industrial and construction waste materials in stabilized mud blocks not only enhances engineering properties but also promotes eco-friendly, cost-effective, and sustainable construction practices.

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