Modification of Brick from Polyethne

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***Abstract*—The construction industry grapples with persistent challenges concerning environmental sustainability and waste management. This research delves into a pioneering approach aimed at augmenting the attributes of conventional clay bricks by incorporating discarded polyethylene waste. As a prevalent plastic material, polyethylene significantly contributes to the burgeoning global plastic waste crisis. By harnessing this waste as a modifier in brick production, the study endeavors to tackle waste reduction and enhance material properties concurrently.**

The investigation centers on gauging the impact of varied polyethylene content on brick characteristics, encompassing compressive strength, thermal insulation, water absorption, and durability. Rigorous laboratory experiments entail blending diverse percentages of polyethylene waste with clay during the brick manufacturing process. The resultant bricks undergo mechanical strength assessments under both compression and flexural load conditions, while their thermal traits are evaluated using thermal conductivity measurements. Complementing these tests are evaluations of water absorption and accelerated weathering simulations to discern the modified bricks' longevity.

Initial findings hint at the potential for polyethylene inclusion to elevate brick thermal insulation, potentially bolstering energy efficiency within structures. However, the mechanical robustness and long-term endurance of these modified bricks warrant meticulous attention due to the presence of plastic components. This underscores the imperative of optimizing polyethylene content to strike a harmonious equilibrium between desired property enhancement and structural soundness.

The research's ramifications are multifaceted, holding the potential to curtail plastic waste by ingeniously reutilizing polyethylene while concurrently heightening brick attributes. These outcomes contribute substantively to the broader dialogue on sustainable construction materials and their capacity to positively reshape environmental dynamics. Further exploration is imperative to refine manufacturing techniques, mitigate mechanical impediments, and assess extended performance, ultimately clearing the path for the emergence of more ecologically responsible and resilient building materials.

***Index Terms*—FROG, ASTM C216, ASTM C652**

I. INTRODUCTION

Bricks, a fundamental construction material, find extensive application in the creation of walls, pavements, and various architectural components. Crafted from dried clay, sand, lime, and assorted additives, these synthetic units exhibit versatile utility. They primarily serve the purpose of erecting walls, boundary structures, and more. The fired clay bricks exhibit a color spectrum influenced by the chemical composition of the raw materials, firing temperatures, and kiln atmospheres. Bricks may take the form of solid entities or incorporate perforations to economize on material consumption. Additionally, a characteristic feature known as a 'frog,' an indentation present on one or two surfaces, holds significance. During bricklaying, these frogs necessitate mortar filling to preserve the structural integrity and acoustic performance of constructed walls. To ensure optimal results, it is recommended to orient bricks with the frog facing upwards, facilitating convenient mortar application. In cases of dual frogs, the larger indentation should be positioned facing upwards for optimal performance.

A "frog" is an indentation found on one or two surfaces of a brick. The term "frog" is believed to be derived from the Dutch word "kikker," referring to a device placed at the bottom of traditional wooden brick-making boxes. This device, resembling a kicker, exerted outward pressure on the clay material during brick formation. The frog in a brick must be filled with mortar during bricklaying, as neglecting to do so can adversely affect the structural integrity, thermal insulation, and acoustic performance of the resulting wall. Therefore, the recommended practice is to orient bricks with the frog facing upwards, facilitating easy mortar application, especially when there are two frogs on the brick's surface.

Actual brick dimensions represent the final measurements of bricks upon leaving the manufacturing facility. These dimensions adhere to specified size tolerances outlined in ASTM C216 (Standard Specification for Facing Brick) and ASTM C652 (Standard Specification for Hollow Brick). Tolerances vary depending on brick type and size but remain minimal, typically not impacting architectural design. Those seeking more comprehensive information about tolerances can consult the Brick Industry Association Technical Notes 9A.

Nominal brick dimensions are employed in modular construction and encompass the specified size along with the width of the mortar joint. These nominal sizes are designed to fit into a 4" grid, aligning with other building materials like doors, windows, and wooden components. In construction, the predominant mortar joint width is 3/8". This specification is frequently referenced in the International Building Codes, drawing from TMS 602 Specification for Masonry Structures. While this 3/8" mortar joint serves as a primary reference point for architects and engineers, it's advised to confirm the specified size of the chosen brick. Brick grades indicate a brick's durability when exposed to moisture and freezing conditions. Three factors—compressive strength, water absorption, and the saturation coefficient—contribute to determining brick durability. The urgency to create bricks from plastic waste is driven by the escalating plastic waste situation in India. Plastics' widespread usage is attributed to their functional convenience and cost-effectiveness. However, their prevalence has disrupted traditional industries and fostered a disposable culture. Bottled water, fast food, and soft drinks have contributed to India's mounting plastic waste problem. Inadequate end-of-life management exacerbates the environmental, social, and economic challenges posed by this waste.

Bricks are in high demand as both filler and structural materials. Incorporating plastic waste into bricks offers an effective solution for waste utilization, mitigating environmental impact and reducing brick manufacturing costs.

A. Preparation Methodology:

Compressive strength is a vital property of bricks, tailored to specific tasks. Evaluating the compressive strength corresponding to brick grades is crucial. The initial phase involves introducing approximately 4 to 5 kgs of waste soft plastic (polythene bags, crisp bags) into a brick mold with dimensions 1999 cms. The mold is then sealed to prevent the escape of viscous plastic. After filling, the mold is compressed using a tamping rod until complete and subsequently sealed with a metal plate. The prepared brick mold is placed in a heating oven and subjected to temperatures of 175 to 200ºC for one and a half to two hours. Upon carefully removing the mold from the oven, rapid cooling is facilitated by spraying a jet of water. The outcome is a plastic brick, achieved through mechanical processes.

Fig.1 Poly-Brick with Mould

B. Material

The materials utilized in the experimental program consist of waste polythene and single-use plastic. Additionally, manufactured river sand is procured from a local supplier. The specific gravity of the sand measures 2.6, while its fineness modulus stands at 3.7.

C. Specimen Preparation

The gathered waste polythene and single-use plastic undergo a cleansing process, achieved either by utilizing a brush or, alternatively, through water. The objective is to eliminate any dirt or impurities. Subsequently, the plastic is cut into smaller pieces to facilitate effective heating. A combination of plastic and sand in a 1:1.5 ratio (1-part plastic to 1.5 parts sand) by weight is heated separately in dedicated containers, each maintained at approximately 200°C.

Once heated, the materials are transferred into cube molds. After allowing for a 10-hour cooling period within the molds, the specimens are demoulded and immersed in water for a duration of 24 hours prior to conducting tests.

D. Specimen Testing

The collected samples are subjected to various tests including water absorption, bulk density, apparent porosity, and compressive strength assessments. Furthermore, as part of the comparative analysis, traditionally manufactured clay bricks and cement block bricks sourced from a nearby local factory are also tested alongside the plastic brick specimens.

II. RESULTS AND DISCUSSION

A. Water Absorption Test:

The acceptable range for water absorption in clay bricks lies between 12% and 20%. In the case of engineering bricks, a value closer to 12% yields better results. The permissible water absorption for cement block or concrete block should not exceed 10%. In the course of our research, various mix ratios (1:2, 1:3, and 1:4, plastic:sand) were employed, yielding water absorption rates as low as 0.95% to 4.5%.

B. Bulk Density:

The Bulk Density or Unit Weight of solid concrete blocks typically falls around 2150 kg/m³ or 134 lbs/ft³. Bricks are mandated to have a density not less than 2.5 g/cm³. To determine bulk density, bricks are subjected to drying in a well-ventilated oven at a temperature ranging from 105°C to 115°C until a substantially constant mass is achieved. Upon analysis, the average values reveal that BK4 exhibits the highest maximum bulk density at 19.71 kN/m³, while BK1 possesses the minimum value of 16.43 kN/m³. This innovative process involves blending plastic waste with sand and heating it, resulting in bricks that exhibit an impressive strength five to seven times greater than that of concrete.

C. Compressive Strength:

For medium weight concrete blocks, whether load-bearing, hollow, or solid, their compressive strength tends to hover around 12.5 N/mm² or 125 kg/cm². In the case of normal brick units, the compressive strength varies from 4.3 to 6.9 MPa, with an average of 5.7 MPa. Initial researchers concluded that the highest compressive strength was achieved at plastic proportions of 5% and 15%, resulting in values of 11.618 N/mm² and 20 N/mm² respectively. A third study found the brick's compressive strength to be 5.56 N/mm², surpassing Malaysia's 5.2 N/mm² standards.

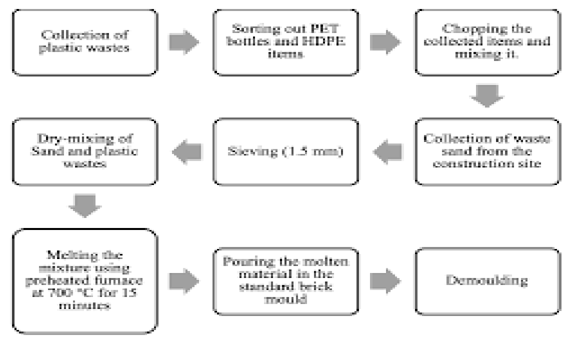

Fig.2 Process Flow Chart

III. CONCLUSION

The utilization of waste materials for brick production holds significant potential as a sustainable approach. The creation of plastic sand bricks not only presents an opportunity to mitigate environmental pollution but also contributes to a cleaner and healthier environment. By diminishing the reliance on clay for brick manufacturing, these bricks offer a viable alternative to consumers at affordable rates.

Remarkably, the water absorption rate of these bricks approaches zero percent, rendering them highly resistant to environmental influences. Additionally, their extended lifespan surpasses that of conventionally manufactured clay bricks. These innovative bricks boast lightweight and slender attributes, coupled with exceptional heat insulation properties, while retaining the robustness of traditional stone counterparts. The resulting ecobricks exhibit exceptional durability, positioning them as valuable building materials.

Furthermore, construction expenses can be curtailed through the elimination of mortar usage during construction, achieved by incorporating recyclable bricks and floor interlocks. Rather than contributing to landfills or incineration, waste materials find purpose as construction resources, substantially reducing costs after undergoing targeted processing.

This study contributes significantly to the resolution of plastic waste disposal predicaments by harnessing waste materials in their most refined form and transforming them into practical construction elements. The ultimate output in the form of these bricks showcases heightened strength compared to conventional alternatives, thus fostering a sustainable and resource-efficient construction paradigm.

IV. FUTURE SCOPE

The future scope of bricks from polyethylene is multifaceted, encompassing advancements in material composition, production processes, performance evaluation, and sustainable construction practices. Embracing these opportunities will not only contribute to waste reduction and environmental preservation but also pave the way for more resilient, energy-efficient, and eco-friendly building solutions.

The exploration of using polyethylene waste in brick production presents a promising avenue for sustainable construction materials. As we look ahead, several areas of future research and development emerge to further enhance the utilization and benefits of these innovative bricks:

Optimization of Polyethylene Ratios: Continued investigation into the ideal proportions of polyethylene and other components within the brick matrix can lead to bricks with improved properties. Fine-tuning these ratios can result in enhanced strength, durability, and thermal performance.

A. Mechanical Reinforcement:

Exploring methods to incorporate reinforcing agents, such as natural fibers or polymers, into the polyethylene-brick matrix could elevate the mechanical strength and structural integrity of these bricks, allowing them to withstand higher loads and stress.

B. Long-Term Durability Studies:

Conducting extensive studies to evaluate the long-term durability of these bricks in various environmental conditions, such as exposure to extreme temperatures, moisture, and UV radiation, will provide insights into their performance over extended periods.

C. Compatibility with Mortars:

Investigating the compatibility of polyethylene-based bricks with different types of mortars can help develop optimal bonding techniques, ensuring strong connections between bricks in masonry structures.

D. Life Cycle Assessment (LCA):

Conducting comprehensive life cycle assessments of these bricks will offer a holistic view of their environmental impact, helping to quantify their benefits in terms of energy savings, reduced carbon footprint, and waste reduction.

E. Architectural Applications:

Exploring innovative architectural designs that leverage the unique properties of polyethylene-based bricks, such as their insulation capabilities and aesthetic appeal, could open new avenues for sustainable and creative building design.

F. Waste Management Strategies:

Integrating these bricks into waste management strategies can offer a practical solution for plastic waste recycling. Developing efficient collection and processing systems for polyethylene waste can contribute to cleaner environments.

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