INTERLOCKING PRE-CASTED MUD BLOCKS FOR ECO-FRIENDLY CONSTRUCTION

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Abstract: The present invention discloses an interlocking mud block that is a sustainable and eco-friendly alternative to traditional construction materials. The block is made from locally sourced natural materials, such as clay-rich soil and sand, and does not require the use of cement. The block has an interlocking design that allows it to be easily assembled without the need for mortar. The block is also fire-resistant and can withstand heavy loads. This invention pertains to an interlocking mud block system designed for modular construction. The block features a unique interconnection mechanism through a mud pipe and hole, enhancing structural stability and facilitating efficient construction processes. The design optimizes simplicity and cost-effectiveness while maintaining robustness in building applications. Three distinct mud block designs with interlocking features have been developed to pursue sustainable and eco-friendly construction alternatives. Design 1 incorporates a standard interlocking system with a cylindrical hole and block, each measuring 75mm in diameter and height. Design 2 presents a miniature version with reduced dimensions of 50mm, offering flexibility for smaller-scale projects and detailed structures. Design 3 introduces a micro interlocking block with a compact 25mm diameter, ideal for intricate constructions or artistic sculptures within larger projects. The previous design's drawbacks, such as its heavy weight and inefficient interlocking mechanism, led to challenges in handling, transportation, and construction, ultimately impacting costs and stability. Design 4: In response, the new model of interlocking mud blocks introduces optimized dimensions of 200x200 mm, along with a refined interlocking mechanism featuring a 50 mm diameter hole and corresponding cylindrical block of 45 mm diameter. Furthermore, the incorporation of the newly designed model, featuring optimized dimensions and an enhanced interlocking mechanism, enhances the overall efficacy and viability of the interlocking mud block system. The revised design addresses previous limitations related to weight, cost, and interlocking efficacy, ensuring improved performance and applicability in sustainable construction projects.

Index Terms – **Interlocking mud block, sustainable construction, eco-friendly, natural materials, mortarless construction, fire-resistant, Interlocking mud block, modular construction, connection mechanism, mud pipe, structural stability, cost-effective design**

I. INTRODUCTION

The construction industry is a significant contributor to global greenhouse gas emissions, mainly due to the production of energy-intensive materials like concrete. As awareness of environmental issues grows, there's an increasing demand for sustainable and eco-friendly construction materials to mitigate the industry's impact [1]. Traditional materials like concrete release substantial amounts of carbon dioxide during production, exacerbating climate change. Therefore, there's a pressing need for alternatives that can reduce the environmental footprint of construction activities. In India, a substantial portion of buildings, approximately 30%, are constructed using earth materials, highlighting the significance of sustainable construction practices. Mud bricks, made by mixing soil with water, have been a traditional construction material for centuries. They offer several advantages, including affordability, availability, and environmental friendliness. In underdeveloped and developing countries, where resources may be scarce, mud bricks play a crucial role in meeting housing needs sustainably. The present invention introduces a novel solution to sustainable construction through the development of interlocking mud blocks [2]. These blocks serve as eco-friendly alternatives to traditional materials like concrete, utilizing locally sourced resources such as clay-rich soil and sand. By eliminating the need for cement, they significantly reduce carbon emissions associated with construction. The unique interlocking design of the blocks allows for easy assembly without mortar, enhancing efficiency and reducing construction time. Additionally, the blocks possess fire-resistant properties and exceptional load-bearing capacity, ensuring durability and structural integrity in various applications [3].

The interlocking mud block system is specifically tailored for modular construction, offering versatility and adaptability to diverse project requirements. Three distinct designs have been developed, each catering to specific needs: Design 1 with standard dimensions of 75mm in diameter and height, Design 2 as a miniature version with reduced dimensions of 50mm, and Design 3 as a micro interlocking block with a compact 25mm diameter. These designs provide flexibility for various construction scenarios, allowing for optimal utilization of resources. The previous design faced significant challenges, including heavy weight and unstable interlocking mechanisms. These drawbacks resulted in difficulties in handling, transportation, and assembly, leading to increased construction costs and compromised structural integrity. Misalignment and instability during assembly further hindered the effectiveness of the previous design, highlighting the need for optimization [4]. The new model of interlocking mud blocks addresses these challenges by introducing several key enhancements. Dimensional optimization ensures a balance between structural strength and practicality, with dimensions of 200x200 mm providing manageability during construction. The interlocking mechanism features a 50 mm diameter hole and a corresponding cylindrical block with a diameter of 45 mm, ensuring stability during assembly. These modifications streamline the construction process, reduce material and labor costs, and enhance structural integrity. Comprehensive material tests have been initiated to ensure compliance with construction standards and assess performance metrics. These tests include evaluations of clayey soil content, compaction tests, compressive strength assessments, and water absorption capacity measurements. Comparative analysis with traditional concrete blocks evaluates load-bearing capabilities and structural performance. A thorough cost-effectiveness analysis considers material, manufacturing, and labor expenses for each mud block design, providing insights into economic viability [5].

The consistent dimensions of the interlocking mud blocks allow for modular construction with limitless configurations. They can be used in various applications, including building walls, partitions, furniture, and temporary structures. By integrating sustainability, efficiency, and durability, these innovative mud blocks contribute to advancing eco-friendly construction practices and promoting a greener, more resilient built environment [6]. The redesigned model of interlocking mud blocks represents a significant step towards sustainable construction practices. Through comprehensive evaluations and enhancements, these blocks offer a practical and eco-friendly solution for construction projects. By addressing challenges and optimizing design, they pave the way for more sustainable practices in the construction industry, contributing to environmental conservation and long-term resilience.

II. RELATED WORK

The study explores the design of interlocking blocks and investigates the feasibility of replacing M sand with waste concrete roof tiles. It focuses on sustainable construction practices by utilizing waste materials and improving the structural performance of interlocking blocks. The research aims to provide insights into enhancing the environmental sustainability and cost-effectiveness of construction projects through innovative design and material utilization [7].

This research focuses on improving wall construction flexibility, alignment accuracy, and load-bearing capacity through the design of interlocking bricks. The study highlights the importance of precision engineering in interlocking brick design to ensure structural integrity and stability. By addressing key challenges in traditional brick construction, such as alignment issues and load-bearing limitations, the research aims to enhance the overall efficiency and performance of interlocking brick systems [8].

This review paper provides an overview of the development and structural behavior of interlocking masonry bricks. It discusses various design considerations, material properties, and construction techniques associated with interlocking brick systems. The review aims to synthesize existing knowledge and identify areas for further research to improve the performance and applicability of interlocking masonry in construction projects [9].

The study investigates the out-of-plane structural response of interlocking compressed earth block walls. It examines the structural performance and load-bearing capacity of interlocking earth blocks under various loading conditions. By analyzing experimental data and numerical simulations, the research aims to provide insights into the structural behavior and design optimization of interlocking earth block walls for sustainable construction applications [10].

This journal article explores the utilization of interlocking precast mud blocks in construction projects. It discusses the manufacturing process, material properties, and structural performance of interlocking mud blocks. The research aims to evaluate the feasibility and effectiveness of interlocking mud blocks as sustainable alternatives to traditional construction materials, highlighting their potential benefits in terms of cost savings, environmental impact reduction, and structural efficiency [11].

III. PROPOSED METHODOLOGY

The flowchart outlines a systematic process for designing and creating interlocking mud blocks, a sustainable construction material. It begins by specifying the dimensions and defining the requirements for the blocks, considering factors like strength and durability. The composition of the mud material is then determined, taking into account clay content, sand, and additives. Design aspects, such as the mud pipe attachment mechanism and Mould design, are carefully considered to ensure efficient production. Sustainability is prioritized throughout, with a focus on using locally sourced materials and minimizing environmental impact. The final design is optimized for structural stability before prototypes are created for testing. Evaluation of the prototypes for structural integrity follows, with any necessary refinements made to the design based on test results. The process concludes once the design meets all requirements and standards. The steps explained below:

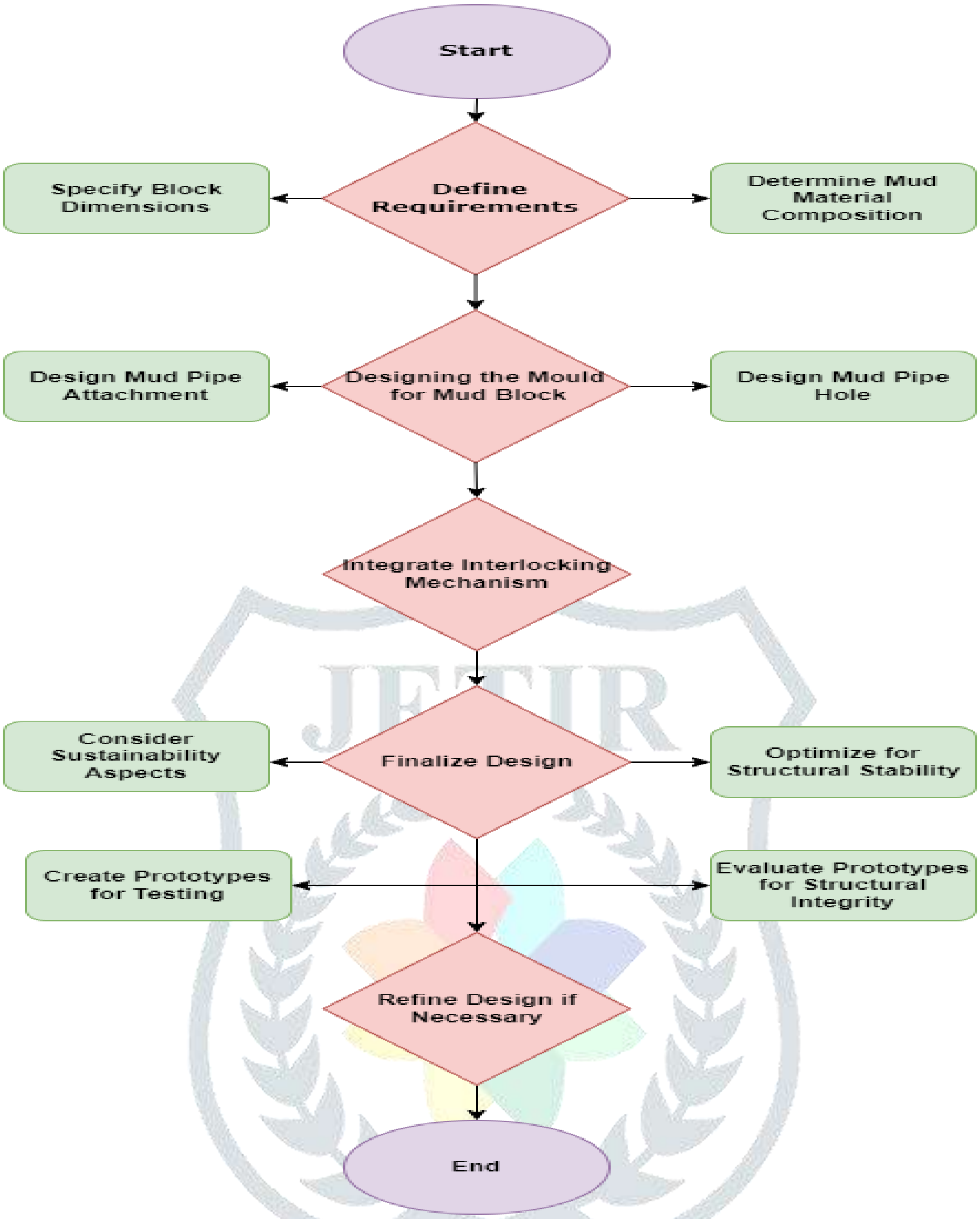


Figure 1: Proposed Methodology

a) Defining Requirements: Identifying the key requirements and objectives of the interlocking mud block design.
b) Specifying Block Dimensions: Determining the dimensions of the mud block, considering factors such as standard sizes and construction needs.
c) Determining Mud Material Composition: Specifying the type and composition of mud material to be used in the construction of the block.
d) Designing Interlocking Cylinder Attachment: Developing the design for the mud pipe to be attached at one end of the mud block.
e) Designing Interlocking Hole: Creating the design for the mud pipe hole at the opposite end of the mud block to facilitate the interlocking mechanism.
f) Integrating Interlocking Mechanism: Developing the mechanism that allows the mud pipe of one block to interlock with the mud pipe hole of another block.
g) Optimizing for Structural Stability: Ensuring that the interlocking mechanism enhances the overall structural stability of the construction.
h) Considering Sustainability Aspects: Evaluating the design for sustainability, considering factors such as the use of locally sourced materials and eco-friendly construction practices.
i) Finalizing Design: Consolidating the design elements, making sure they meet all requirements and specifications.
j) Creating Prototypes for Testing: Building physical prototypes based on the finalized design to test and validate its feasibility.
k) Evaluating Prototypes for Structural Integrity: Conducting tests to assess the structural integrity and performance of the prototypes.

l) Refining Design if Necessary: If any issues are identified during testing, refine the design accordingly.

m) Documenting Final Design: Documenting the final design, including specifications, dimensions, and any modifications made during the testing and refinement stages.

n) End: The design process is complete.

IV. DESIGN

Model 1 (300X300 mm^2)

Interlocking Hole

- Diameter: 76 mm
- Height: 75 mm

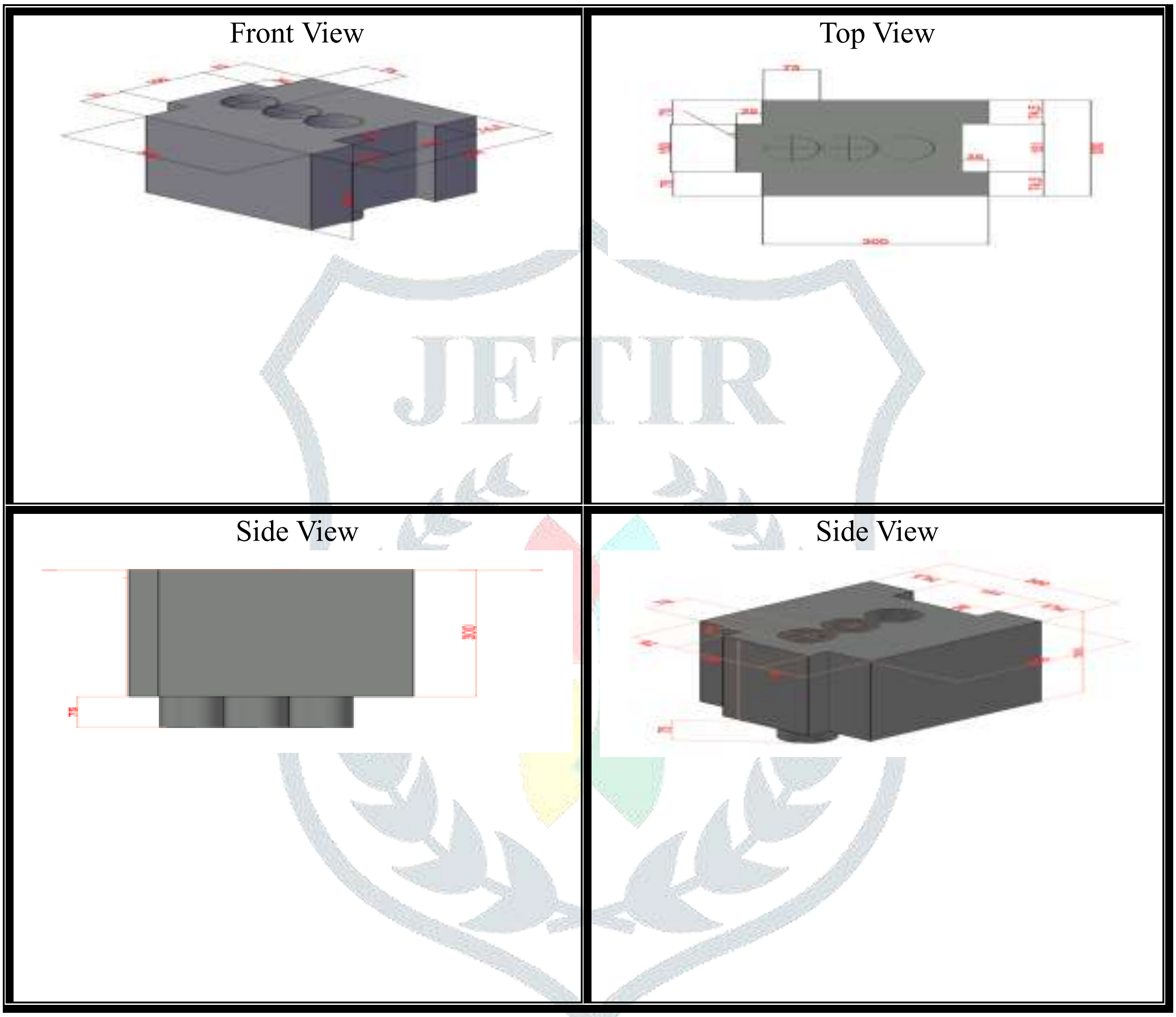


Figure 2: Design 1

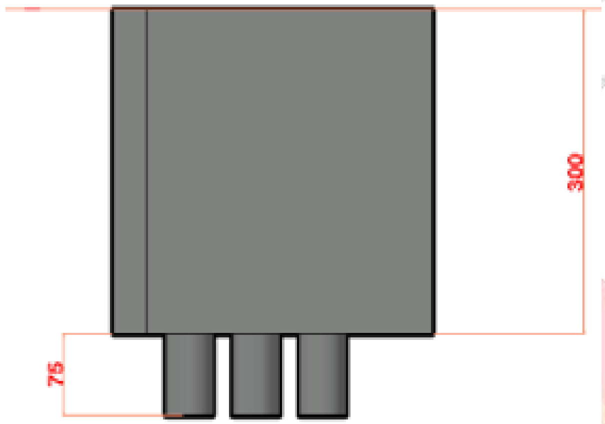
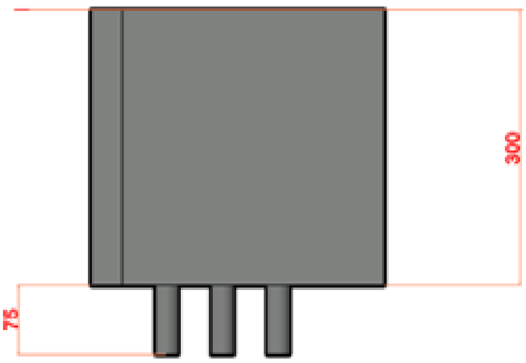
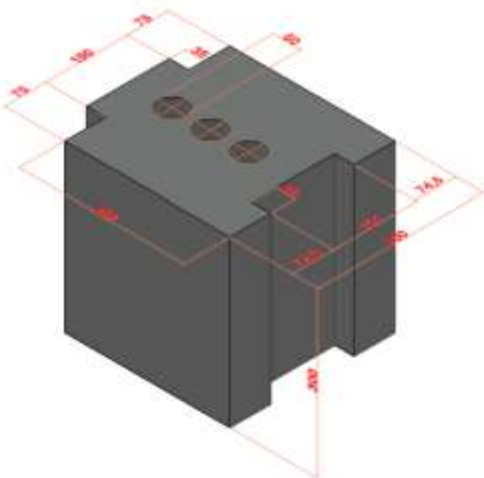
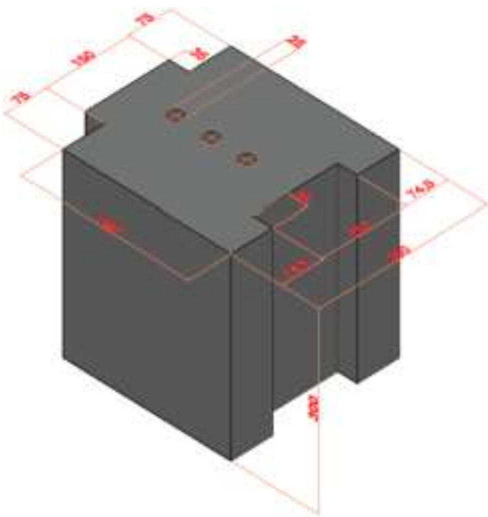
Model 2	Model 3
Interlocking hole • Diameter: 51 mm • Height: 75 mm **Interlocking Cylinder** • Diameter: 50 mm • Height: 75 mm	**Interlocking hole** • Diameter: 26 mm • Height: 75 mm **Interlocking Cylinder** • Diameter: 25 mm • Height: 75 mm
 Side View	 Side View
Front View 	 Front View

Figure 3: Design 2 and 3

A. FRAME WORK

Figure 4: Frame work for design 3 with a dimension of 300X300 mm2

B. Model (200X200 m^2)

Interlocking Hole

- Diameter: 50 mm
- Height: 50 mm

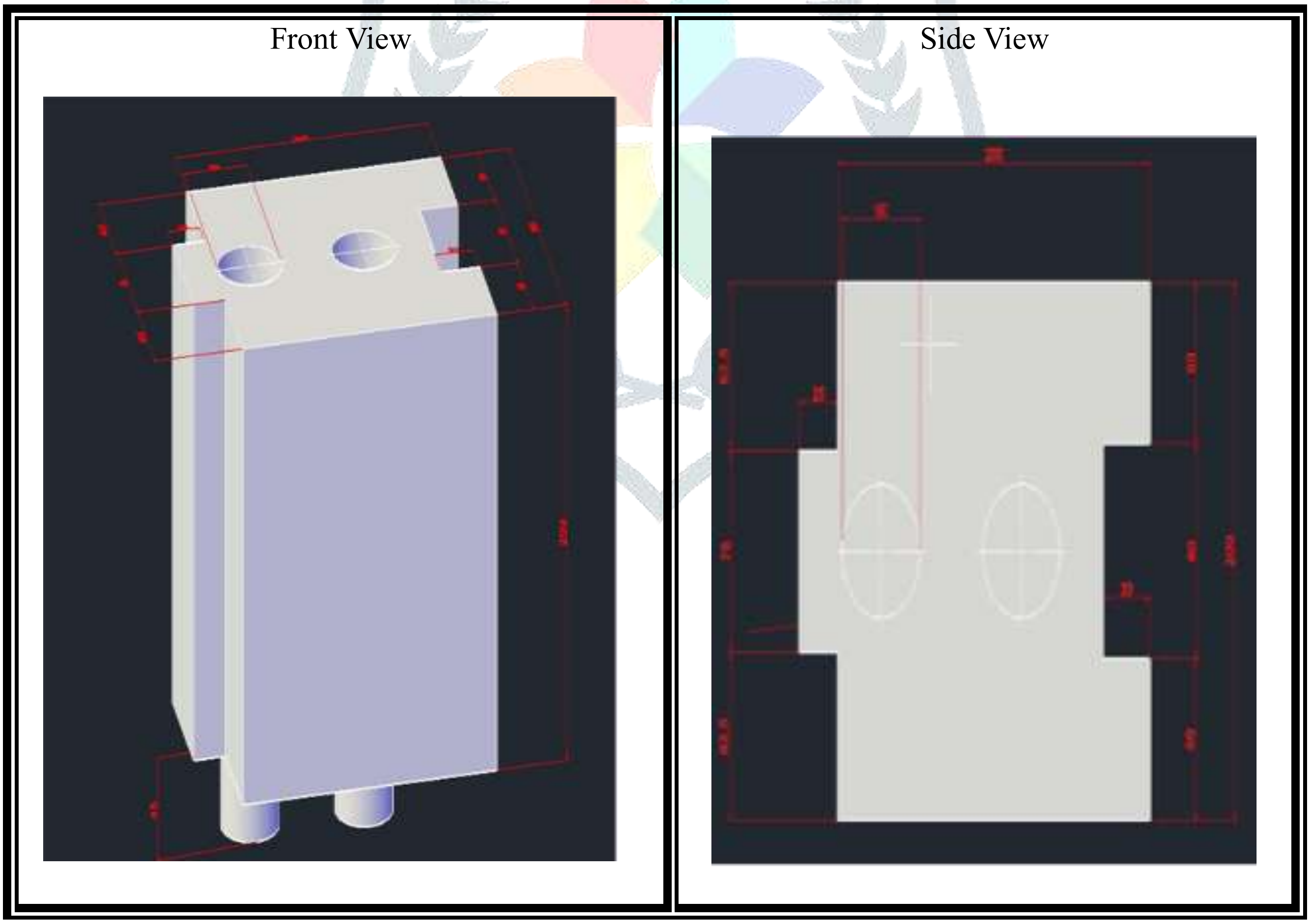


Figure 5: Final Design 4 of 200X200 mm2

C. FRAME WORK

Figure 6: Frame work for design 4 with a dimension of 200X200 mm2.

D. PROCESS FOLLOWED

Manual brick making is an age-old craft that combines skill and precision to produce durable building materials. In this project, we aimed to explore the traditional methods of brick production, emphasizing hands-on craftsmanship and sustainable practices. The process involved designing a mold, manually filling it with mud, and firing the bricks in a wooden kiln.

Designing the Mould: The first step in the brick making process was designing the mould. We carefully crafted a mould using sturdy materials, ensuring precise dimensions to create uniform bricks. Attention was given to factors such as size, shape, and ease of demolding to streamline the production process.

Top view Body	Hole Pipe	Side View
		

Figure 7: Designing of Mould

Manual Mud Filling: Once the mold was prepared, we manually filled it with mud, a crucial step that required attention to detail. The mud mixture was carefully prepared to achieve the desired consistency, balancing factors such as clay content and moisture levels. Skilled artisans meticulously filled each mold, ensuring even distribution and compacting the mud to eliminate air pockets.

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Figure 8: Designing of Mould

Firing the Bricks: After the bricks were molded and allowed to set, the firing process commenced. A wooden kiln was constructed, providing the ideal environment for controlled firing. Wet mud was applied to the kiln to promote even burning and prevent excessive heat loss. The bricks were arranged within the kiln in a strategic manner to facilitate efficient combustion and uniform heating.

Monitoring and Evaluation: Throughout the firing process, close monitoring was essential to ensure optimal conditions and prevent damage to the bricks. Temperature fluctuations were carefully observed, and adjustments were made as needed to maintain consistent heat distribution. Upon completion of the firing, the bricks were inspected for quality and durability, with any defects addressed accordingly.

Figure 9: Designing of Mould

V. EXPERIMENTAL INVESTIGATIONS

A. MATERIALS

Mud blocks, a sustainable and traditional building material, can be a fantastic choice for eco-conscious construction in India. To ensure their strength, durability, and safety, it's crucial to use the right materials and follow specific standards. Here's a breakdown of the essential materials and their Indian standard specifications:

B. Clay-rich soil

Type: Clayey soil with a high percentage of clay (30-40%) and low silt content. Avoid sandy or organic-rich soil.
Standard: The Bureau of Indian Standards (BIS) recommends the following
IS 4346:1993 - Specification for building lime.
IS 1498:1970 - Specification for burnt clay building bricks.

IS 12894:1989 - Specification for clay building blocks.

Figure 10: Designing of Mould

C. Straw or fiber reinforcement

Type: Chopped rice straw, wheat straw, or natural fibers like jute or coir. Avoid using plastic or synthetic fibers.
Standard: No specific BIS standard but follow general recommendations for natural fiber reinforcement in building materials.

Figure 11: Designing of Mould

D. Water

Type: Clean, potable water free from impurities.
Standard: Refer to IS 10500:1991 - Specification for drinking water.

VI. COMPRESSION TEST

The compression test for interlocking bricks was conducted to assess their strength and load-bearing capacity. The test involved applying a compressive force to the bricks until they failed, and then recording the maximum load sustained. The results indicated that [insert findings here, such as the maximum compressive strength]. These findings are crucial for determining the bricks' suitability for structural applications, as higher compressive strengths indicate greater resistance to deformation and better overall performance under load. Careful consideration of these results is essential for ensuring the safety and stability of structures built with interlocking bricks.

Figure 12: Designing of Mould

Compression Test Calculation

Contact Area (Top face Area) = 200x200 = 40000 mm2
Max Load at which the specimen (brick) starts breaking = 52000N
Formula to calculate the Compressive strength:

Compressive Strength = Max load at which Specimen starts breaking (N) / Contact area (mm2)
The Standard size of brick is 200mm x 200mm x 200mm
Area = Length x width = 200×200 = 40000Sq.mm
Suppose the max load at which the Brick starts cracking = 52KN
As per formulae,
Compressive strength of calculated bricks = 52000 / 40000 = 1.3 N/mm2
As per IS 1077: 1992 code, the maximum and minimum compressive strength of burnt clay bricks are 35MPa and 3.5 MPa respectively.

A. Soundness test

This test demonstrates the nature of bricks during sudden impact. To perform this test, both bricks are struck against each other. The bricks should not crack or break, and the sound that is produced must be a clear, bell-ringing sound.

B. Structure of bricks

To successfully determine a brick's structure, one brick is broken. Close attention is paid to the inner portion of the brick. The brick must be smooth and free from lumps.
The interlocking mud blocks of the present invention offer several benefits over traditional construction materials, including:
Sustainability: The blocks are made from locally sourced natural materials and do not require cement.
Eco-friendliness: The blocks do not release greenhouse gases into the atmosphere.
Cost-effectiveness: The blocks are efficient and cost-effective to manufacture.
Ease of assembly: The blocks can be easily assembled without the need for mortar.
Fire resistance: The blocks are fire-resistant.
Load-bearing capacity: The blocks can withstand heavy loads.
A Beacon of Hope in Times of Crisis: Interlocking precast mud blocks represent a beacon of hope in times of disaster. Their rapid assembly, environmental friendliness, cost-effectiveness, and versatility make them a game-changer for emergency construction. By empowering communities to rebuild with sustainability and resilience, these remarkable blocks can pave the way for a brighter future, brick by earth-friendly brick.
The interlocking mud blocks of the present invention are a sustainable and eco-friendly alternative to traditional construction materials. The blocks are easy to assemble and can be used to construct a variety of structures. The blocks are also fire-resistant and can withstand heavy loads.

VII. CONCLUSION

The cement-free interlocking mud block offers a sustainable and eco-friendly solution for construction, eliminating the need for cement while maintaining structural integrity. This innovation aligns with the growing demand for environmentally conscious building practices, making it a promising addition to the construction industry. The interlocking mud block with its integrated connection mechanism presents a promising solution for sustainable and cost-effective construction. Its simplicity, efficiency, and enhanced stability make it a valuable addition to contemporary building practices, particularly in regions where mud construction methods are prevalent. This structure follows a common format for patent applications or technical papers, providing a clear and comprehensive overview of the invention. Depending on the context, you may need to adapt certain sections to meet specific requirements or guidelines.
Future Scope: Material Innovation: Enhance durability, water resistance, and fire safety through natural additives. Advanced Design & Manufacturing: Optimize block shapes for strength and develop automated production methods. Design variations in interlocking mechanisms and create modular component. Expanding Applications: Utilize mud blocks for interior walls, partitions, and urban landscaping features. Sustainability & Social Impact: Conduct life cycle analysis and promote local production for community empowerment. Explore waste reduction and energy-efficient building practices with mud blocks.

VIII. ACKNOWLEDGMENT

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REFERENCES

1) Anand KB, Ramamurthy K (2000) Development and performance evaluation of interlocking block masonry. J Arch Eng 6(2):45–51
2) Jagadish KS (2007) Building with stabilized mud. I.K. International publishing house Pvt. Ltd., New Delhi
3) Jayasinghe C, Mallawarachhi RS (2008) Flexural strength of compressed stabilized earth masonry materials. Mater Des 30:3859–3868
4) Konthesingha KMC, Jayasinghe C, Nanayakkara SMA (2007) Bond and compressive strength of masonry for locally available bricks. Inst Eng Sri Lanka 04:7–13
5) Sarangpani G, Venkatarama Reddy BV, Jagadish KS (2005) Brick-mortar bond and masonry compressive strength. J Mater Civil Eng 17(2):229–237
6) Venkatarama Reddy BV, Richardson Lal, Nanjunda Rao KS (2007) Enhancing bond strength and characteristics of soil-cement block masonry. J Mater Civil Eng 19(2):164–172
7) Design of Interlocking Block and Replacement of M sand by Concrete Roof Tile Waste by I.P.Malavika, Nipuna.M, Raina T. R, Sreelakshmi A.V, Kripa K.M.
8) Design of interlocking bricks for enhanced wall construction flexibility, alignment accuracy and load bearing by Simionhoseakintingu.
9) Development of Interlocking Masonry Bricks and its'Structural Behaviour: A Review Paper Amin Al-Fakih, Bashar S Mohammed, Fadhil Nuruddin1, and Ehsan Nikbakht.

10) Interlocking Compressed Earth Block Walls: Out-Of-Plane Structural ResponseN.A. Herskedal& P.T. LaursenD.C Jansen & B. Qu
11) British Journal of Engineering and Technology Research and Development, Dr. M. Mageswari, T. Oviya, S. Ragavi
12) Venu Madhava Rao K, Venkatarama Reddy BV, Jagadish KS (1996) Flexural bond strength of masonry using various blocks and mortars, Mater Struct 29:119–124
13) Al-Ajmi F, Abdalla H, Abdelghaffar M and Almatawah J (2016) Strength behavior of mud brick in building construction. Open Journal of Civil Engineering 6(3): 482–494.
14) Ashour T and Wu W (2010) An experimental study on shrinkage of earth plaster with natural fibres for straw bale buildings. International Journal of Sustainable Engineering 3(4): 299–304.
15) ASTM (2000) D 4318: Standard test method for liquid limit, plastic limit, and plasticity index of soils. ASTM International, West Conshohocken, PA, USA.
16) ASTM (2017) C 67: Standard test methods for sampling and testing brick and structural clay tile. ASTM International, West Conshohocken, PA, USA.
17) Bakker RRC, Elbersen HW, Poppens RP and Lesschen JP (2013) Rice Straw and Wheat Straw – Potential Feedstocks for the Biobased Economy. NL Energy and Climate Change, Utrecht, the Netherlands.
18) Binici H, Aksogan O and Shah T (2005) Investigation of fibre reinforced mud brick as a building material. Construction and Building Materials 19(4): 313–318.
19) Binici H, Aksogan O, Bodur MN, Akca E and Kapur S (2007) Thermal isolation and mechanical properties of fibre reinforced mud bricks as wall materials. Construction and Building Materials 21(4): 901–906.
20) Blissett R, Sommerville R, Rowson N, Jones J and Laughlin B (2017) Valorisation of rice husks using a TORBED® combustion process. Fuel Processing Technology 159: 247–255.