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Review Article

Analysing Stability and Strength of Masonry Bricks: A Comprehensive Review and Simulation Study

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Abstract *- Soil is a naturally plentiful raw material utilized in design; earth-based construction methods have been employed for over 400 years. Its capacity for block manufacture has not yet been completely used. The outlook for stabilized earth construction is similarly encouraging internationally. The soil properties are probably the most critical factor for both hard and durable. Therefore, one solution to this issue might involve fixing the soil using industrial wastes and by-products and constructing a block. This research uses a simulation tool to investigate a literature review on compression, flexural, thermal, and shear stress analysis of masonry brick's performance. Using simulation tools reduces the cost of experimental analysis over many specimens, which does not tend to produce the necessary stability. Thus, the review of prior software-based strength analysis work gives an insight into various pros and cons of the study. Thus, this study explains masonry brick with multiple constituents, performance, and future scope.*

Keywords *- Soil-based construction technologies, Earth building, Compression behaviour, Flexural behaviour, Thermal stress analysis, Shear stress analysis.*

1. Introduction

The quest for innovative, sustainable, and aesthetically pleasing architectural solutions has led to the evolution of modern construction materials and techniques [1]. Among these advancements, Masonry brick, a form of brickwork that exudes elegance and charm while maintaining structural integrity, has garnered substantial attention from architects, engineers, and enthusiasts alike.

This review delves into the intricate world of Masonry brick design, exploring its unique characteristics, advantages, and challenges in contemporary construction practices. A thorough analysis of Masonry brick's performance using a state-of-the-art finite element analysis software simulation tool to evaluate its mechanical properties and structural behaviour under varying conditions [2].

Masonry brick design is an artful juxtaposition of traditional brick masonry and contemporary architectural sensibilities [3]. Its distinctive arrangement, featuring an assortment of brick sizes, shapes, colours, and textures, results in captivating facades that elevate the visual appeal of buildings. Besides its captivating aesthetics, Masonry brickwork offers numerous practical benefits, such as increased thermal efficiency, reduced maintenance, and enhanced durability [4]. This review analyses the structural aspects of Masonry brickwork, including its shear deformation, tensile stress, compressive forces, and thermal stability. Powerful engineering simulation tools are used to simulate and understand the intricate behaviour of Masonry brick structures under static and dynamic conditions [5]. Despite its widespread appeal and proven benefits, Masonry brickwork remains underexplored in several critical aspects. There are limited quantitative studies on stress distribution, deformation patterns, and failure modes in Masonry brick structures under diverse loading conditions.

Additionally, understanding material properties, mortar compatibility, and construction techniques for varied architectural applications is insufficient. Furthermore, there is a notable lack of simulation-based frameworks to optimize Masonry brick designs for dynamic and static conditions. These gaps highlight the need for an integrated approach that combines advanced engineering tools and traditional craftsmanship to understand and fully optimize Masonry brickwork. Addressing these challenges is essential to meet the demands of modern construction practices, including sustainability, structural reliability, and material efficiency.

Integrating software tools into this analysis allows us to gain invaluable insights into Masonry brick designs' stress distribution, deformation patterns, and failure modes [6]. Engineers and architects can better comprehend the design's performance through this simulation-driven approach and make informed decisions to optimize its structural integrity and safety [7]. Moreover, this review will shed light on the challenges of Masonry brickwork, such as material selection, mortar compatibility, and construction techniques. By addressing these challenges, a more seamless integration of Masonry brick into contemporary building practices, expanding its application to a wider range of projects and architectural styles [8].

In conclusion, combining traditional craftsmanship and cutting-edge engineering through Masonry brick design opens possibilities for creating visually stunning and structurally robust buildings. By leveraging the power of software tools for analysis, this review aims to foster a deeper understanding of Masonry brickwork, encouraging further innovation and advancements in sustainable architectural practices. As the discussion progresses, readers are invited to explore the multifaceted world of Masonry brick, unlocking its potential to redefine the landscape of modern architecture.

1.1. Influence of Soil Properties on Masonry Brick Performance

The manufacturing of masonry bricks is greatly influenced by the soil, which directly affects the masonry bricks' stability, strength, and durability. Important ingredients for brick performance include clay, sand, silt, and organic matter, each contributing specific characteristics. For instance, clay provides binding properties, while sand enhances stability by reducing shrinkage. The presence of minerals such as feldspar, quartz, and kaolinite further enhances structural integrity and heat resistance. Various soil types, such as lateritic, clayey, sandy, and loamy soils, offer differing suitability for brickmaking due to their unique compositions.

To optimize soil performance, stabilization techniques like thermal procedures, chemical additives (e.g., lime or cement), and the inclusion of industrial wastes (e.g., fly ash or slag) have proven effective. These methods improve compressive strength, reduce shrinkage, and enhance durability, making soil-based masonry bricks more reliable for diverse applications. Simulation tools provide critical insights into soil-based masonry bricks' compressive, flexural, and thermal behavior by offering cost-effective alternatives to extensive experimental testing.

These tools allow for precise performance predictions under various conditions, reducing resource consumption and testing time. By comprehending and enhancing soil characteristics through such techniques, the performance of masonry bricks can be significantly improved, paving the way for innovative designs and real-world implementation.

2. Literature Survey

A Mechanical test on masonry bricks assesses their strength and load-bearing capacity. This test is crucial in determining whether the masonry bricks meet the required standards for construction purposes. Here is an overview of how the compression test is conducted through experiment:

- Sample Selection: Random samples of masonry bricks are selected from the batch or lot. Engineered blocks of materials like clay or stabilized soil are used in construction for load-bearing and aesthetic purposes. The masonry bricks should represent the entire lot to ensure accurate results.
- Conditioning: The masonry bricks must be conditioned in a controlled environment to ensure consistency before testing. This typically involves soaking the bricks in water for a specified period to achieve a certain moisture content level. Conditioning helps replicate real-world scenarios where masonry bricks can come into contact with moisture during construction.
- Testing Machine: The test is usually conducted using a Mechanical testing machine (Universal Testing Machine). This machine applies a steadily increasing load on the brick until it fails. The load is applied vertically to the brick, and the machine measures the force required to crush the brick.
- Testing Procedure: A brick is placed on the testing machine's lower plate. The upper platen descends constantly, applying a compressive force on the brick. The load and deformation (strain) are recorded throughout the test.
- Failure Criteria: The test continues until the brick fails, usually by crushing or cracking. The maximum load the brick can withstand before failure is recorded. The load-deformation curve can also provide valuable information about the brick's underload behaviour.
- Calculations: From the recorded data, engineers can calculate the compressive strength of brick. The compressive strength is usually expressed in units of pressure, such as megapascals (Mpa) or pounds per square inch (psi). It is the maximum compressive stress a material, such as a masonry brick, can withstand before failing.
- Interpretation: The results are compared with the specified standards or requirements for the specific application. The masonry bricks should meet the minimum compressive strength standards to be considered suitable for construction.

Performing a Mechanical test on masonry bricks using ANSYS (a finite element analysis software) allows for a virtual simulation of the physical test. Advanced FEA software tools simulate materials and structures' mechanical and thermal behaviour.

This simulation can provide valuable insights into the behaviour of the masonry bricks under compression without the need for physical testing of each brick. Here is a general outline of how you can simulate a compression test on masonry bricks using ANSYS:

- Model Creation: Create a 3D model of the masonry brick in ANSYS. You can use the software's built-in modelling tools to design the brick geometry or import a pre-existing CAD model.
- Material Properties: Define the material properties of the brick within ANSYS. For masonry bricks, you can typically use the material properties for the type of brick you are testing. Important properties include elastic modulus, Poisson's ratio, and compressive strength.
- Boundary Conditions: Implement the required boundary criteria for the framework to represent the compression test. In this case, you would fix the bottom face of the brick to simulate the constraint provided by the testing machine and then apply a vertical downward force on the top face to simulate the compression load.
- Meshing: Generate a mesh for the model. A fine mesh is often necessary for accurate results, especially around stress concentration areas.
- Solver Settings: Set up the solver settings in ANSYS to run the Mechanical test simulation. Choose the appropriate analysis type (static structural analysis) and specify any other necessary parameters.
- Run the Simulation: Run the simulation and allow ANSYS to calculate the response of the masonry brick under the applied load.
- Post-Processing: After the simulation, analyze the results using ANSYS's post-processing tools. You can examine stress distribution, deformation, and other relevant data.
- Results and Interpretation: Evaluate the simulation results to determine the maximum load the brick can withstand before failure. Compare the results to the desired compressive strength requirements for masonry bricks.

2.1. Survey on Compression Behaviour on Masonry Brick

In recent years, various studies have focused on enhancing the performance of masonry materials through different reinforcement techniques and innovative materials. The following summarizes key research findings in the field, examining different materials and methods to improve the compressive and flexural strength of masonry bricks:

Ozigi, P.B. et al. [9] evaluated the flexural strength of APA-reinforced stabilized lateritic soil beams. Wood was used as reinforcement, leveraging its local availability, low cost, and abundant nature. The study demonstrated that APA-reinforced lateritic soil beams showed slightly higher flexural strength (0.763 N/mm²) than steel-reinforced beams, especially at a 4% reinforcement area. The research suggests that APA reinforcement can be a sustainable alternative to steel for improving load-bearing capacities in masonry applications.

Ogunkeye et al. [10] explored the effect of molten plastic in plastic interlocking masonry bricks. Using response surface methodology and finite element analysis (FEM) software ANSYS, they found that the use of molten plastic significantly increased the compressive strength of interlocking masonry bricks from 10.5 N/mm² to 14.0 N/mm² after 7 days of curing. This approach introduces a sustainable alternative to traditional brick materials, with the potential to reduce plastic waste.

Pereasamy Palanisamy et al. [11] investigated geo-polymer earth masonry bricks from fly ash, ground Granulated Blast-Furnace Slag (GGBS), soil, and quarry dust. The mix improved compressive strength (5.93 MPa) and flexural strength (3.43 MPa) while also providing resistance against acid and sulfate attacks. Using these materials is a step towards more durable and sustainable alternatives to traditional clay masonry bricks, with the potential for widespread use in earth construction.

Raghavendra Prasad et al. [12] examined the effect of nanomaterials, including carbon nanotubes (MWCNT), titanium dioxide (TiO_2), and copper oxide (CuO), on the strength and durability of concrete. After 28 days of curing, the mixture with 0.5% of these nanomaterials demonstrated significantly reduced water sorptivity and absorption, essential for producing concrete under harsh environmental conditions. The study opens avenues for improving the durability of masonry structures.

Amin Al-Fakih et al. [13] studied Rubberized Concrete Interlocking Bricks (RCIBs) for masonry construction without mortar. Using ANSYS software for finite element analysis, they found that the results of the compressive strength, stiffness, and failure mechanisms were 90% in agreement with the experimental results. This reinforces the potential of RCIBs as an alternative material in masonry systems, highlighting their effectiveness and resilience in construction.

Bawar Othman et al. [14] employed micro-modeling and macro-modeling techniques to analyze stresses under in-plane loads in solid, unreinforced masonry and textile-strengthened masonry walls using ANSYS software. The study found that the micro-modelling technique was particularly effective in examining fracture propagation and material behaviour. This research offers a better understanding of the mechanical performance of masonry walls under stress, with potential applications in earthquake-resistant design.

Miss Vindhyashree et al. [15] focused on simulating masonry prism tests using ANSYS and ABAQUS software. The study found that the compressive strength predicted by ANSYS was in reasonable agreement with experimental values, with crack patterns observed in the simulation resembling those seen in experiments. This highlights the importance of accurate simulation techniques for predicting masonry behaviour.

Hasim Ali Khan et al. [16] investigated the out-of-plane flexural rigidity of masonry walls reinforced with geotextile. The study demonstrated that geosynthetics significantly improved the strength and performance of masonry walls, making them more resilient to out-of-plane bending, especially in earthquake-prone areas. Geosynthetics offer a cost-effective and widely available solution for enhancing masonry structures. Tingwei Shi et al. [17] studied interlocking masonry bricks with large shear keys, examining their mechanical properties through laboratory compression tests and numerical modelling using ABAQUS. The research found that the compressive strength of masonry constructed with these interlocking masonry bricks is heavily influenced by the number of masonry bricks used in the construction. This provides valuable insights into designing interlocking brick systems for improved load-bearing capacities.

N Afanador Garcia et al. [18] analyzed solid masonry bricks and masonry prisms baked in artisanal ovens in Colombia. Their study focused on developing computational methods to predict uniaxial compressive strength, providing a more efficient approach to design and analysis. This is particularly useful for regions where traditional brick-making methods are common, enabling the optimization of masonry designs with minimal experimental testing. The Systematic survey on compression behaviour is shown in Table 1.

Table 1. Systematic survey on compression behaviour

Ref no	Author	Material /Technique	Significance	Limitation/future scope
9	Ozigi, P.B.	APA-reinforced stabilized lateritic soil beams	APA-reinforced beams showed higher flexural strength (0.763 N/mm²) than steel reinforcement.	Further studies can investigate the long-term durability and environmental impacts of APA-reinforced materials.
10	Ogunkeye	Molten plastic interlocking bricks	Significant increase in compressive strength (10.5 N/mm² to 14.0 N/mm²).	Investigate the scalability of molten plastic masonry bricks for large-scale construction and their environmental impact.
11	Pereasamy Palanisamy	Geo-polymer earth masonry bricks with Fly Ash, GGBS, Quarry Dust	Improved strength (compressive: 5.93 MPa, flexural: 3.43 MPa) and resistance to acid and sulfate.	Further research on the impact of geo-polymer masonry bricks in extreme weather conditions and their environmental benefits.
12	Raghavendra Prasad	Nanomaterial concrete	The 0.5% Carbon Nano Tubes, TiO2, and CuO combination demonstrated lower water absorption and sorptivity, making it suitable for demanding concrete manufacturing circumstances.	Long-term durability tests on nanomaterial concrete in real-world conditions are needed.
13	Amin Al-Fakih	Rubberized Concrete Interlocking Bricks (RCIBs)	The results were 90% in agreement with the experimental findings and significantly impacted compressive strength, stiffness, and failure mechanism.	Further investigation on the long-term behaviour and cost-effectiveness of RCIBs in construction.
14	Bawar Othman	Solid and textile-strengthened masonry walls	Micro-modeling showed good agreement with experimental results in terms of fracture propagation.	Further research on scaling these results to larger masonry structures and different material combinations.
15	Miss Vindhyashree	Masonry Prism Tests	The value projected by ANSYS is closer to the experimental finding than the value predicted by ABAQUS.	Broader application of simulation methods in diverse masonry materials and real-world conditions.
16	Hasim Ali Khan	Geotextile-reinforced masonry wallets	Geosynthetic is frequently employed to brace masonry structures against out-of-plane bending after an earthquake	Explore the economic feasibility of geosynthetic reinforcement in low-cost construction.

			because of its low cost, ease of supply, and high strength.	
17	Tingwei Shi	Interlocking bricks with big shear keys	Compressive strength is influenced by brick quantity and shear key design.	Investigate design variables like brick size and material to optimize interlocking brick systems.
18	N Afanador Garca	Solid masonry bricks baked in artisanal ovens	The framework's efficacy enables the prediction of the uniaxial compressive strength of masonry prisms in solid masonry bricks produced in artisan ovens.	Extend predictive models to incorporate different curing methods and geographical regions.

2.1.1. Summary of Compressive Behaviour

The compression behaviour of masonry brick is an essential aspect to study in order to understand the structural performance and stability of masonry structures. In this regard, the finite element analysis software ANSYS has been utilized to investigate masonry bricks' compression behaviour. Using ANSYS, engineers and researchers can create realistic numerical models of masonry bricks and simulate their behaviour under compressive loads. The software allows for accurate predictions of the brick's stress distribution, deformation, and failure patterns, providing valuable insights into its mechanical response. One of the key advantages of using ANSYS to study the compression behaviour of masonry bricks is the ability to account for material nonlinearity. Masonry bricks exhibit nonlinear behaviour due to their heterogeneous and discontinuous nature, which cannot be accurately represented using traditional linear analysis methods. With its capabilities for handling nonlinear material behaviour, ANSYS enables a more realistic representation of the masonry brick's response under compression.

Moreover, ANSYS offers a wide range of material models, allowing researchers to choose appropriate constitutive models that closely represent the behaviour of masonry materials. This flexibility enables them to tailor the analysis to match the specific properties of the studied masonry brick. However, despite its advantages, there are certain limitations associated with using ANSYS to analyze the compression behaviour of masonry bricks. Firstly, the accuracy of the simulation heavily relies on the input parameters and assumptions made during the modelling process. Obtaining accurate material properties and boundary conditions can be challenging, and inaccuracies in these parameters can lead to deviations from real-world behaviour.

Another limitation is computational cost. The computational requirements can be substantial as the masonry bricks often have complex geometries, and the analysis involves nonlinear simulations. This may lead to long simulation times and necessitate high-performance computing resources. Furthermore, although ANSYS is a robust tool, it is only as good as the user's understanding of the underlying principles and limitations. Inexperienced users may inadvertently misapply certain features or overlook crucial aspects of the analysis, leading to unreliable results. In conclusion, ANSYS is a powerful software tool that has been used effectively to analyze the compression behaviour of masonry bricks. Its ability to account for material nonlinearity and offer a variety of material models makes it valuable for simulating masonry structures. However, users must exercise caution and ensure accurate input parameters for reliable results. Despite its limitations, ANSYS remains a significant asset in advancing our understanding of masonry behaviour under compression.

2.2. Survey on Flexural Behaviour on Masonry Brick

Muhammad Ishfaq et al. [19] employs a nonlinear numerical method to analyze the out-of-plane behavior of Constrained Dry-Stacked Masonry (CDSM) walls under blast loads, using four test cases involving Wabox explosives with varying charge weights. The model accurately predicts the pressure-time histories in pressure gauges and aligns well with experimental data, confirming its reliability. However, the study does not explore material variations or cost implications for implementing CDSM in real-world scenarios. The authors emphasize the potential of CDSM in designing blast-resistant structures but highlight the need for further investigations into broader applications, including the non-linear effects of repeated blasts and thermal stresses.

Mahmoud Zaghlal et al. [20] investigated hybrid steel/CFRP and CFRP-reinforced masonry beams using concrete masonry bricks and grout mortar. Material characterization tests were conducted to assess compressive and flexural strengths, and finite element models in ANSYS were used to study shear reinforcement spacing and hybrid reinforcement configurations. Results show that hybrid steel/CFRP reinforcement significantly enhances beam performance. The study provides valuable insights but does not address the long-term durability or environmental impact of hybrid reinforcement materials. Incorporating these aspects in future research could improve practical applications.

Four full-scale field experiments on unreinforced and spray-on polyurea-reinforced masonry walls that were exposed to gas explosions were conducted by Meng Gu et al.

(21). The outcomes demonstrated that unreinforced walls experienced flexural distortion and eventually collapsed. Polyurea coatings could lower casualties and financial damages by enhancing anti-explosion properties, preventing collapses, and capturing flying pieces. The findings underscore the potential of polyurea coatings but also highlight limitations like premature debonding at the polymer-masonry interface, restricting energy absorption. Future work should optimize the adhesion techniques and test under varying environmental conditions to enhance real-world applicability.

In this study, Kumaraguru et al. [22], bamboo-reinforced cement wall panels (600 mm X 900 mm) in thicknesses of 80, 90, and 100 mm are tested for axial compression and flexural behaviour. In ANSYS Workbench, panels and a brick wall were modelled. According to the study, increasing the layers and thickness of the wire mesh decreased deflection values and enhanced load-carrying capacity. All panels demonstrated high ductility before failure, and the ultimate load was almost two times that of the initial fracture load. A12 Bamboo Reinforced Ferrocement Panel surpassed traditional brick walls in load-bearing capacity by 386%, weight reduction by 58%, and panel cost reduction by 44%. While promising, the study lacks an analysis of environmental durability and the feasibility of large-scale implementation, which should be explored further.

Hasim Ali Khan et al. [23] Historic structures are irreplaceable and essential to society’s continuity. According to a 3D finite element analysis, adding geosynthetic to an unreinforced masonry wallet enhances its diagonal shear strength by 72% and flexural strength capacity by 129.23%. The research underscores geotextiles as an effective retrofit solution for historic masonry structures but does not address their cost-effectiveness or behaviour under seismic loading. Future investigations could explore these factors for broader applications.

Muhammad Mubashir Ajmal et al. [24] The study compares Alkali-activated fly-ash-based geopolymer concrete and conventional concrete in its bare frame and constrained masonry wall panels. The findings indicate that restricted masonry has 4.1% greater ultimate seismic capacity and 45.2% higher stiffness, as well as higher beginning stiffness and lateral load-bearing capacity. Geopolymer concrete offers a sustainable alternative for seismic zones; however, the research lacks detailed cost analysis and environmental impact assessments. Future studies should focus on optimizing the geopolymer mix for varied climates.

Anandh Babu Malayali et al. [25] examined recycled aggregates for geopolymer concrete, including recycled concrete and recycled brick aggregate. They examined recycled concrete and brick aggregates in geopolymer concrete with sodium hydroxide, sodium silicate, and GGBS as binders. While durability properties declined, the structural performance remained acceptable, and ANSYS modelling validated the findings. The study highlights the need to improve the durability of recycled aggregate-based geopolymer concrete. Further exploration of alternative binders or additives to mitigate strength losses is recommended**.**

Tarek S. El-Salakawy et al. [26] Experimental and numerical analysis are utilized to examine the connection between masonry and steel bars positioned close to the surface. Pull-out testing was done on 12 masonry prisms reinforced with NSM steel bars. ANSYS software was used to model numerically and perform nonlinear analyses. Results revealed good agreement in failure loads and modes, highlighting the need for improved modelling and considering the interaction between steel bars and mortar/epoxy or mortar/epoxy and masonry. The study emphasizes accurate modelling for enhanced reinforcement design but does not explore alternative materials like FRPs or address seismic performance, which could be considered in future work.

Vaishnavi Arakatavemula et al. [27] This study examines the stability of lime mortars under static and dynamic loads and characterizes them using sustainable additions. The hardening procedure and applying additives, including surkhi, animal hair, volcanic pozzolana, egg white, jaggery, and fenugreek seeds, are investigated using a 3D model of an old wall in India. In addition to looking at the compressive and flexural strength of the walls, the study also looks at the qualities of lime and other additives in a 1:3 ratio. However, the long-term durability, environmental impact, and scalability of using these additives in construction remain unexplored and warrant further investigation.

Kyriakos Karlos et al. [28] examined the use of thermal insulation and textile-reinforced mortar (TRM) for older buildings’ combined seismic and energy retrofitting in the research work. Masonry walls subjected to out-of-plane cyclic loads were the topic of medium-scale testing.

The placement of the TRM, the type of insulation, the jacketing and/or insulation, and the displacement amplitude of the loading cycle were all evaluated as experimental parameters. Numerical modelling and a straightforward analytical approach agreed with the test results. The authors contend that by efficiently combining TRM jacketing and thermal insulation, masonry panels in buildings can be made stronger overall and more energy-efficient. The study offers a cost-effective retrofitting approach, but the lack of insights into economic viability or material sustainability limits its application. Future research should address these gaps. The Systematic survey on flexural behaviour is shown in Table 2.

Table 2. Systematic survey on flexural behaviour

Ref no	Author	Material/Technique	Significance	Limitation/future scope
19	Muhammad Ishfaq	Constrained Dry-Stacked Masonry (CDSM) under blast stress	A good connection was found when the experimental damage map was compared to the obtained damage patterns for each test.	The effects of different boundary conditions, wall dimensions, and diverse charge types could be further investigated to generalize findings for real-world applications.
20	Mahmoud Zaghlal	Hybrid Steel/CFRP and CFRP-reinforced masonry beams	Results indicated that it was appropriate to use equivalent material qualities in numerical modeling as opposed to modeling masonry bricks and mortar.	The impact of environmental factors, such as corrosion on steel and degradation of CFRP, could be examined for long-term structural performance.
21	Meng Gu	Polyurea-reinforced masonry walls	In ANSYS/LS-Dyna, a numerical model for brick walls was created and tested using test data.	Future studies could optimize the coating adhesion properties and assess the impact of various spray patterns and thicknesses to achieve maximum energy absorption.
22	Kumaraguru	Bamboo-reinforced cement wall panels	The Bamboo Reinforced Ferrocement Panel A12 fared better than a standard brick wall (230 mm thick) by having a 386% increase in load-bearing capacity numerically, a 58% decrease in weight, and a 44% decrease in panel cost.	Modelling bamboo as an anisotropic material in numerical simulations could improve result accuracy. Investigating long-term durability under different weather conditions would also enhance practical applicability.
23	Hasim Ali Khan	Geosynthetic reinforced masonry wallette	Compared to the un-strengthened panel, the diagonal shear strength is predicted to increase by 72% during the in-plane test. However, the flexural strength capacity increases to 129.23% during the out-of-plane test.	-Research into geosynthetic materials with enhanced thermal resistance could make retrofitted structures more adaptable to varying environmental conditions.
24	Muhammad Mubashir Ajmal	Geopolymer concrete vs conventional concrete in masonry walls	Geopolymer concrete demonstrated 45.2% higher stiffness and better seismic resistance than OPC, offering an eco-friendly alternative in seismic-prone areas	Further research could focus on optimizing mix designs for specific seismic zones, considering the regional availability of fly ash or other pozzolanic materials.
25	Anandh Babu Malayali	Recycled aggregates for geopolymer concrete	GC12, RC12, and RB12 have compressive strengths of 7.59, 6.18, and 5.54, respectively. RC12's compressive strength is lower by 27% and 19%, respectively, compared to GC12 and RB12.	Future work could focus on pre-treatment methods for recycled aggregates to mitigate strength loss and study their long-term performance in geopolymer concrete.
26	Tarek S. El-Salakawy	Masonry and steel bars near the surface connection	According to the numerical analysis, the failure stress increases significantly as the embedment length grows and just a little as the steel bar diameter increases.	A detailed investigation into the interaction mechanisms of different adhesive types (e.g., epoxy vs. mortar) with masonry could enhance bond performance.
27	Vaishnavi Arakatavemula	Stability of lime mortars with additives	Sustainable additives improved lime mortar	Future studies could focus on the long-term behavior of lime mortars with

			properties, achieving a maximum equivalent stress of 3.0373 N/mm², validating their use in heritage restoration.	additives under cyclic loading, mimicking seismic or wind forces, to ensure the sustainability of heritage structures.
28	Kyriakos Karlos	Thermal insulation and textile-reinforced mortar for retrofitting	This research suggests that TRM jacketing and thermal insulation could be effectively applied to masonry panels utilized in construction to increase their total strength and energy efficiency.	Further exploration of cost-effective TRM materials and integration with renewable energy systems (e.g., solar panels) could enhance building performance.

2.2.1. Summary of Flexural Behaviour

The flexural behavior of masonry brick is crucial to understanding its structural performance under bending loads. ANSYS, a powerful finite element analysis software, has been widely used to investigate and simulate the flexural behavior of masonry bricks. The analysis involves applying bending loads to the brick and studying its response in terms of stresses, deflections, and failure modes. By using ANSYS, engineers and researchers can gain valuable insights into the structural behavior of masonry bricks, helping them design safer and more efficient structures.

The advantages of using ANSYS for studying the flexural behavior of masonry bricks include its ability to model complex geometries and material properties accurately. Masonry bricks often exhibit heterogeneous material behavior, and ANSYS can handle such nonlinearities effectively. Additionally, the software enables users to assess various loading scenarios and boundary conditions, allowing for comprehensive investigations of the brick's performance under different practical situations. This versatility contributes to a more robust understanding of the brick's structural response, optimizing its design and material usage.

Despite its advantages, ANSYS has limitations when studying masonry bricks' flexural behaviour. Firstly, obtaining precise material properties for masonry can be challenging due to its composite nature and the inherent variability of brick properties. Accurate material models are essential for reliable simulations, and errors in input data can lead to inaccurate results.

Additionally, ANSYS simulations can be computationally demanding and time-consuming, particularly for large-scale models. This limitation may hinder parametric studies or large-scale optimization processes. Moreover, the accuracy of ANSYS simulations relies on the model's fidelity, and the meshing process can introduce errors if not done carefully.

In conclusion, ANSYS offers a powerful toolset for analyzing the flexural behavior of masonry bricks, providing valuable insights into their structural performance. Its ability to handle complex geometries and non-linear material behavior contributes to a comprehensive understanding of masonry's response to bending loads. Nevertheless, engineers and researchers must carefully consider the challenges associated with accurate material characterization and computational demands to ensure reliable and meaningful results. Overall, ANSYS remains a valuable asset in advancing the understanding and design of masonry brick structures.

2.3. Survey on Thermal Analysis on Masonry Brick

A P Colmenares et al. [29] this study examines four ceramic masonry product designs, including multiperforated brick and other styles, to see if the shape has an impact on heat transfer procedures. The study technique uses the ANSYS R16 software for product design and thermal validation. Thermal bridges are removed, and interior cells are modified during design. In San José de Ccuta, Colombia, simulations were run with extremely high sun radiation.

The results demonstrate how design affects energy performance by lowering the inner surface temperature to 1.23°C or 2.25°C. Passive techniques for ceramic product design that reduce heat transmission include changing cell distribution and removing thermal bridges. Future work should explore adaptive designs for varying climatic conditions and their implications on structural integrity.

Hui Su et al. [30] proposed a novel Tenon composite block featuring an extruded polystyrene layer between exterior and hollow concrete blocks to enhance thermal performance. Testing and simulations confirmed compliance with design codes, outperforming traditional block walls. This innovation introduces sustainable alternatives for energy-efficient construction. The manufacturing scalability and integration in existing building practices need further research.

C X Díaz-Fuentes et al. [31] investigate the role of vented air chambers in clay masonry bricks to improve thermal efficiency. Designs incorporate three brick types with modeled heat transfer, showing thermal improvements of 2.52°C to 3.64°C in harsh climates. This work emphasizes the need for product innovation for sustainability. Future research should explore the longevity and maintenance of vented chambers under real-world conditions.

Said Hamdaoui et al. [32] evaluate the thermal properties of microencapsulated PCM (Phase Change Materials) in Hollow Concrete Bricks (HCBs). Substances that absorb or release thermal energy during phase transitions enhance thermal efficiency in construction materials. PCM significantly enhances thermal responsiveness and energy savings, with reductions of 30% in volume and 35% in matter. The findings indicate substantial potential for integrating PCM into modern construction. However, long-term durability and cost-efficiency analyses are required.

Anfas Mukram Thattoth et al. [33] examine the thermal efficiency of passive cooling building blocks filled with microencapsulated PCM in this paper. Heat cannot enter living spaces because the HS 29 PCM absorbs latent heat and melts after heating. To perform two-dimensional numerical analysis, use Ansys-Fluent 14.5 instead. A finite element analysis is performed to evaluate PCM in masonry bricks. According to the study, PCM-filled masonry bricks are more efficient at lowering heat flux for passive cooling applications. Future studies should address the integration of PCM materials in large-scale projects and their cost implications.

M S Narváez-Ortega et al. [34] investigate the partition structure morphology in Blocks H10, using 6 horizontal cavities for low thermal conductivity and oblique geometry partitions. The constructive unit, Form-C, is analyzed, and 5% organic coffee cisco additive is added to increase porosity without affecting mechanical properties. The study uses laboratory extrusion and finite element method simulations to evaluate mechanical resistance and water absorption. Findings indicate a 1.5°C energy saving on average against Form-A. The industrialization of building ceramics and increased thermal efficiency are facilitated by using agroindustrial wastes with passive design methods.

L. Krishnaraj et al [35] investigate the effects of UFFA mixed cement mortar on the causes of masonry prism failure. UFFA and Class C fly ash are examined using a 50% replacement rate and 120-minute pulverization duration. Real-time heat transfer is dominated by the brick, increasing the specific heat capacity of mortar. An increase in strength of between 8% and 33% over traditional mortar and masonry prism is guaranteed with a 50% replacement of UFFA. Further exploration is needed to optimize UFFA ratios for diverse climatic conditions.

K.J. Kontoleon et al. [36] investigate the thermal behavior of clay hollow-brick masonry under fire conditions using transient thermal models. Findings show that masonry walls offer better thermal resistance at high temperatures than other materials, supporting their use in fire-prone environments. Future research could explore the performance of masonry under cyclic thermal loads.

Hrvoje Krsti´c et al. [37] Hollow concrete masonry blocks (RBC-EP blocks) manufactured from low strength self-compacting concrete with recycled crushed brick and ground polystyrene have been approved for structural infill in steel frames. This research looks into their thermal properties and prospective applications in the field. The Heat Flow and Temperature Based Method was used to test wall thermal transmittance in situ. In a laboratory, the thermal conductivity of RBC-EP blocks was tested. These walls demonstrate advancements in building technology and ecologically friendly concrete block enhancements, with lightweight concrete blocks being replaced due to their desirable mechanical features and greater thermal performance.

The thermal characteristics, energy efficiency, porosity, & micro- and macro-structure of compact structural masonry bricks integrating cigarette butts are all examined in this work by Halenur Kurmus et al. [38]. In addition to using X-ray micro-CT imaging and scanning electron microscopy to analyze pores, a system for tracking furnace energy use was created. Savings on energy ranged from 8% to 10.2%.

Thermal conductivity was lowered by clay masonry bricks' higher porosity and reduced density. A uniform distribution of holes with micro- and macro-pore diameters ranging from 0.035 to 1.365 mm was shown in 3D models inside the brick constructions. The Systematic survey on thermal stress analysis is shown in Table 3.

2.3.1. Summary of Thermal Stress Analysis

Thermal stress analysis of masonry brick using ANSYS is a valuable engineering approach to understanding and predicting the behaviour of brick structures under varying temperature conditions. ANSYS is a powerful finite element analysis software that enables engineers to simulate and analyze the response of masonry brick to thermal loads. The simulation helps identify potential issues related to thermal expansion and contraction by subjecting the brick model to different temperature changes. One of the significant advantages of utilizing ANSYS for thermal stress analysis of masonry brick is its ability to provide a detailed and accurate representation of the brick's behaviour under thermal loads. This information is crucial for engineers and architects as it helps design resilient structures that can withstand temperature fluctuations without excessive damage or failure. Furthermore, ANSYS allows engineers to study various scenarios, such as extreme weather conditions or sudden temperature changes, which might not be feasible or safe to test in real-life situations. Engineers can optimize the design, material selection, and construction methods through these simulations to enhance masonry brick structures' overall performance and longevity.

Table 3. Systematic survey on thermal stress analysis

Ref no	Author	Material/Technique	Significance	Limitation/future scope
29	A P Colmenares	Ceramic masonry products (e.g., multiperforated brick)	The inner surface temperature can be reduced to 1.23 °C or increased to 2.25 °C depending on the design, which alters the product's energy performance.	Adaptive designs for varying climates and long-term testing suggested
30	Hui Su	Tenon composite block (extruded polystyrene layer + concrete block)	The tenon composite block wall's thermal performance was also strong compared to a regular block wall.	Explore manufacturing scalability and integration in current practices.
31	C X Díaz-Fuentes	Vented air chambers in brick for thermal efficiency	The results demonstrate that the thermal advantage in the recommended masonry bricks' internal surfaces varies between 2.52 °C and 3.64 °C. A vented air chamber can also help to reduce heat transmission and concentrate energy on the interior surfaces of newly created masonry bricks.	Investigate real-world durability and maintenance.
32	Said Hamdaoui	Microencapsulated PCM in HCBs for thermal behavior	Up to 30% less HCB was produced overall, and a 35% reduction in matter was predicted.	Long-term cost and durability analyses are needed.
33	Anfas Mukram Thattoth	PCM-filled passive cooling building blocks	According to the investigation, brick packed with PCM is more efficient at reducing heat flow when used for passive cooling of buildings.	Large-scale feasibility and integration in urban projects
34	M S Narváez-Ortega	Partition structure with organic coffee cisco additive	Thermal modeling outcomes reveal an average energy loss of 1.5 °C compared to Form-A.	Research alternative additives and industrial scalability
35	L. Krishnaraj	UFFA mixed cement mortar in masonry prisms	With a 50% replacement of UFFA, a strength improvement of between 8% and 33% over conventional mortar and masonry prism is assured.	Optimization for diverse climates
36	K.J. Kontoleon	Clay hollow-brick masonry wall under fire conditions	It is feasible to enhance the total fire performance of building components in various temporary scenarios because the findings show that masonry walls perform better than other types of walls at high temperatures.	Investigate cyclic thermal load scenarios.
37	Hrvoje Krsti´c	Hollow concrete masonry blocks (RBC-EP) with recycled materials	It is feasible to enhance the total fire performance of building components in various temporary scenarios because the findings show that masonry walls perform better than other types of walls at high temperatures.	Large-scale testing and integration with construction codes.
38	Halenur Kurmus	Compact structural masonry bricks with cigarette butts	A uniform distribution of holes with micro- and macro-pore sizes ranging from 0.035 to 1.365 mm was visible in 3D models inside the brick structures.	Ensure compliance with safety and construction standards.

However, despite its merits, ANSYS has certain limitations that engineers should know. Firstly, the accuracy of the simulations heavily depends on the input parameters and assumptions made during the modeling process. Incorrectly defined material properties or boundary conditions can lead to inaccurate results, potentially leading to incorrect design decisions. Additionally, the complexity of the simulations might demand significant computational resources, especially for large-scale or intricate brick structures. Running detailed thermal stress analyses can be time-consuming, which could limit the scope of the study or increase the overall project cost.

In conclusion, thermal stress analysis of masonry brick using ANSYS offers engineers a powerful tool to assess the behaviour of brick structures under thermal loads. It provides valuable insights into the potential challenges of thermal expansion and contraction, enabling designers to make informed decisions to enhance the structure's resilience. However, engineers must exercise caution in defining input parameters accurately and be mindful of the computational demands to ensure meaningful and reliable results. When used judiciously, ANSYS can significantly contribute to developing safe and efficient masonry brick structures.

2.4. Survey on Shear Stress Analysis on Masonry Brick

The shear stress analysis of masonry brick has gained attention due to its critical role in ensuring structural stability and energy efficiency, particularly in seismic-prone and high-performance applications. Below is a comprehensive review of recent studies, highlighting their contributions, techniques, and limitations.

Ali Hameed Aziz et al. [39] This investigation examines how walled web thickness variation and CFRP strip strengthening affect the structural performance of reinforced self-compacting concrete (SCC) box T-beams under shear loads. The analysis of eight samples revealed that, although reinforcing the beams with CFRP strips increased ultimate capacity by 75%–111%, raising the thickness of the wall web improved ultimate strength by 17%–38%. A 102% link between ultimate capacity and concrete compressive strength was discovered via finite element analysis and parametric research. Future research should explore performance under cyclic and long-term loading conditions.

Rojda Orman et al. [40] created a computer model for examining triplet samples under shear stress, which is the goal of this study. It analyses the strength parameters and crack patterns in experiments, adjusts the material presumptions and damage theory, and contrasts the numerical and experimental results. The ANSYS package program's micro modelling techniques are used in the model to ensure accuracy and dependability. The study aims to comprehend the behaviour of brickwork and pinpoint the driving forces behind intricate failure processes. Future research should validate findings under environmental variations and for non-standard masonry configurations.

S. Sharma et al. [41] examined how Unreinforced Masonry (URM) would behave under torsional shear, and six batches were studied. Measurements of dilatancy were made during direct and torsional shear testing and a characterization test to assess the torsional shear strength of bed joints. The torsional shear strength of URM bed joints was evaluated using refined finite element modeling. A developed and proven formula based on rational mechanics improved the empirical formulation of torsional shear strength and flexural tensile strength. Future research should extend findings to reinforced or hollow masonry systems.

Jabbar Abdalaali Kadhim et al. [42] the study uses nonlinear time-history responses to assess the seismic performance of URM and CM buildings. Mechanical characteristics and tensile strength of masonry were examined using ANSYS 18.2 software. Ground motions were chosen to correspond with those in Iraq. Both models had severe cracks, indicating dangerous seismic performance. Minor gaps in confining concrete in CM models kept collapsing masonry walls from disintegrating, demonstrating the confinement's ability to avoid damage. Future research should include broader seismic studies under diverse global conditions.

Palanisamy et al. [43] investigated the strength and endurance of mortar and brick joints in this study, focusing on bond strength and deformation properties. It compares bond strength to ANSYS and displays brickwork elements' strength and deformation properties. The Fly Ash, Ground Granulated Blast Furnace Slag, and Quarry Dust composites offer high strength, compression, and bond strength. The material blend assures acidic, sulfate, and alkalinity resistance, with compressive strength ranging from 10 to 20%. Future research should validate findings under real-world cyclic loading conditions.

Nishma Mohanan et al. [44] Masonry systems are common in urban locations for low- and mid-rise buildings, but their fragile nature makes them seen as vulnerable to seismic disasters. This study examines the finite element analysis of reinforced and unreinforced grouted hollow concrete block masonry walls under cyclic loads, emphasizing the significance of reinforcement in increasing shear capacity. The study provided critical guidelines for improving design strategies in earthquake-prone areas. Further optimization of reinforcement configurations for cost-sensitive applications is needed.

Chung Han Lim et al. [45] Using finite element modelling, this study analyzed the terminal ballistic behaviour of handgun bullets on Compressed Earth Bricks (CEB). CEBs are extensively used as building cladding and have evolved into a more environmentally friendly alternative to burned clay masonry bricks. However, little research has looked into the long-term effects of projectile impact on CEBs. The investigation corroborated the results using European oak, comparing the penetration depth of European Oak and compressed earth masonry bricks using ANSYS software. The difference between the simulated and actual penetration depths was 24.73%, indicating that further information is required to close the gap, highlighting the environmental benefits of CEBs as sustainable alternatives to traditional masonry materials. The inclusion of additional datasets for diverse CEB materials could refine the results.

Table 4. Systematic survey on shear stress analysis

Ref no	Author	Material/ Technique	Significance	Limitation/future scope
39	Ali Hameed Aziz	SCC box T-beams with varying wall web thickness and CFRP strips	According to experimental findings, increasing the thickness of the wall web increases ultimate strength by around 17%–38%, whereas strengthening beams using CFRP strips increases ultimate capacity by about 75%–111%.	Further exploration under dynamic and long-term loading is needed.
40	Rojda Orman	Computer modeling for triplet samples under shear stress	These obtained test results are used to verify its accuracy and dependability. This research was done to understand better how masonry behaves and pinpoint the variables controlling the intricate failure process.	Validation under diverse environmental conditions is lacking.
41	S.Sharma	URM under torsional shear	The existing empirical formulation is enhanced by linking the flexural tensile strength and torsional shear strength of a URM bed joint.	Not extended to reinforced or hollow masonry systems.
42	Jabbar Abdalaali Kadhim	Seismic performance of URM and CM buildings	Minor fractures in the CM model indicate confinement's potential to prevent masonry wall disintegration, especially in destructive situations.	Limited to specific seismic intensities and regional scenarios.
43	Palanisamy	Composite mortar and brick joints	compressive strength ranged from 10 to 20%, with the composite being used for mortar in masonry works.	Requires testing under cyclic and real-world conditions.
44	Nishma Mohanan	Reinforced vs. unreinforced grouted hollow concrete masonry walls	The importance of reinforcement in improving the shear capacity of a grouted hollow concrete block masonry building and a brick masonry construction.	-Cost-effective optimization of reinforcement designs needed.
45	Chung Han Lim	Ballistic impact on compressed earth bricks (CEB)	The disparity in penetration depths between simulation and reality was 24.73%, indicating that more data is needed to close the gap.	Need for expanded datasets and better simulation accuracy.
46	M. Ghamari	Deformation capacity of Persian medieval brick masonry walls	The eventual drift value for Persian medieval brick masonry walls was between 1.3% and 2.7%, with a partial factor of du ranging from 1.3 to 1.7.	Requires a study on long-term material degradation.
47	Khuram Rashid	Porous terracotta bricks with organic fibers	Analytical calculations show a maximum variance of 7.8% between experimental and analytical thermal conductivity, demonstrating its applicability.	Scaling production for industrial applications.

M. Ghamari et al. [46] this article calculates the deformation capacity of Persian medieval brick masonry walls using criteria such as lateral limitations, aspect ratio, and thickness. A partial factor was developed to accommodate errors in material and geometry. The study examined 48 specimens with four lateral constraint configurations, four aspect ratios, and three wall thicknesses under a pre-compression force of 0.10 MPa. The results demonstrated that deformation capacity diminishes with stronger lateral constraints, thickness, and a drop in height-to-length aspect ratio. Transverse walls reduced deformation capacity more effectively than top slabs. The ultimate drift value for Persian medieval brick masonry walls was between 1.3% and 2.7%, with a partial factor of du ranging from 1.3 to 1.7. Future research should address the effects of material degradation over time to aid preservation strategies.

Khuram Rashid et al. [47] Buildings take more than 30% of primary energy to maintain indoor temperature, which increases owing to heating and cooling losses. Energy-efficient materials are critical, and insulating materials have been created to reduce carbon footprints. The research focuses on transforming terracotta masonry bricks into porous low thermal conductivity ones utilizing organic fibers such as bamboo, jute, coir, sisal, and polyester. Thermal conductivity is reduced, according to measurements of water absorption index, bulk density, and porosity, with porosity attributable to fiber burning. Analytical calculations demonstrate a maximum variation of 7.8% between experimental and analytical thermal conductivity, validating its usefulness. Future research should focus on scaling production processes to industrial levels for large-scale sustainable applications. The Systematic survey on Shear Stress Analysis is shown in Table 4.

2.4.1. Summary of Shear Stress

Shear stress analysis of masonry brick using ANSYS is a crucial engineering technique that allows engineers and researchers to assess masonry structures' structural integrity and stability. ANSYS is a powerful finite element analysis software that facilitates accurate simulations of complex behaviours in various materials, including masonry. One of the significant advantages of using ANSYS for shear stress analysis of masonry brick is its ability to model the material's non-linear and heterogeneous properties.

Masonry is a composite material consisting of masonry bricks and mortar, which exhibit different mechanical behaviours. ANSYS can handle these variations and accurately predict the distribution of shear stress within the masonry, enabling engineers to identify potential weak points and design structures with enhanced strength. Furthermore, ANSYS provides a detailed visualization of the shear stress distribution. Engineers can examine stress contours and plots, which aids in understanding the regions of the highest stress concentration.

This information is invaluable for making informed decisions during design, leading to more efficient and safer structures. Another advantage of using ANSYS is the ability to simulate different loading and boundary conditions. Engineers can subject the masonry brick model to various forces, such as lateral loads, earthquakes, or wind loads, to assess its response under different scenarios.

This versatility allows a comprehensive evaluation of the masonry's shear stress behavior under real-life conditions. However, ANSYS has limitations in the shear stress analysis of masonry brick. Firstly, accurate modelling of masonry materials requires inputting correct material properties, which might be challenging due to the variability of brick and mortar characteristics. Obtaining precise material data is crucial for the reliability of the simulation results.

Additionally, ANSYS simulations heavily depend on the assumptions and simplifications made by the engineers during the modelling process. If these assumptions are not realistic or representative of the actual behaviour of the masonry structure, the simulation results might deviate from reality. Moreover, the analysis's accuracy relies on the model's meshing. Generating an appropriate mesh that captures the complexities of masonry can be time-consuming and computationally demanding. Improper meshing may lead to inaccuracies or errors in the results.

In conclusion, using ANSYS for shear stress analysis of masonry brick provides engineers with powerful tools to gain valuable insights into the structural behaviour of masonry structures. Its ability to handle non-linear and heterogeneous materials, visualize stress distributions, and simulate different loading conditions makes it a valuable asset in designing and assessing safe and robust masonry constructions. However, engineers must be mindful of its limitations, such as the need for accurate material properties and the potential impact of assumptions and meshing choices on the reliability of the results.

3. Discussion

Current structural design standards often face challenges in meeting the demands of modern construction, especially in terms of sustainability, durability, and performance under extreme conditions. Below are some key shortcomings, supported by specific examples or case studies:

- Static loading circumstances are frequently the emphasis of design codes, which results in insufficient consideration of material behavior under dynamic impacts like blasts, seismic activity, or high-impact forces. Muhammad Ishfaq's study, for instance, examined limited dry-stacked brick walls under blast stress and discovered that the existing models were inadequate for forecasting out-of-plane damage patterns. This restriction exposed the shortcomings in existing standards for dynamic load situations by requiring the use of nonlinear numerical modeling to produce trustworthy evaluations.
- There are few provisions in many structural design standards for using cutting-edge and sustainable building materials, including PCM, Rubberized concrete, and geopolymers. Muhammad Mubashir Ajmal's research showed that geopolymer concrete, made from alkali-activated fly ash—offers a low-energy and eco-friendly substitute for conventional concrete. Despite its potential, particularly in seismically sensitive areas, its widespread adoption and efficient usage in structural design are limited by the absence of clear rules for its application in current design standards.
- Structural design standards usually ignore the anisotropic characteristics of natural reinforcement, which assume isotropic behavior in simulations and designs. This oversimplification results in inaccurate information and less than ideal use of these items. In contrast to traditional brick walls, a study by Kumaraguru showed that bamboo-reinforced ferrocement panels produced an astounding 386%

increase in load-bearing capacity. In order to improve design accuracy and material performance, standards that acknowledge and account for the anisotropic properties of natural reinforcement are necessary. Modeling bamboo as an isotropic material, however, understated its actual potential.

- Inadequate guidance for retrofitting and strengthening techniques is frequently provided by current structural design rules, leaving masonry structures that are old or damaged vulnerable to contemporary safety and performance requirements. Kyriakos Karlos, for example, found that thermal insulation and Textile-Reinforced Masonry (TRM) jacketing work well together to increase energy efficiency and seismic resilience. The lack of thorough standard rules prevents such novel solutions from being widely adopted despite their shown benefits, which limits their ability to successfully solve the difficulties associated with retrofitting older facilities.
- Structural design requirements sometimes overlook environmental performance measures like energy efficiency and thermal performance, especially in severe weather or fire. For instance, research by A.P. Colmenares showed that by altering the pattern of multiperforated masonry bricks, interior surface temperatures might be lowered by as much as 2.25 °C, greatly increasing energy efficiency. However, current regulations miss a chance to incorporate environmental sustainability into masonry techniques by failing to require or promote the implementation of such energy-efficient designs.
- Current structural standards' empirical formulations frequently oversimplify the intricate failure mechanisms of masonry structures, leading to imprecise forecasts of how they will behave under different loading scenarios. For example, Rojda Orman's research evaluated triplet specimens under shear loading using finite element modeling. The study highlighted the need for more sophisticated and accurate modeling methodology in design codes by exposing serious flaws in current empirical approaches that could not adequately reflect the complex failure mechanisms seen in brickwork.
- As digital technologies like ANSYS and ABAQUS are used more often for the numerical modeling of brick structures, current design guidelines are falling behind. This makes it difficult to use these tools effectively for precise simulations. For instance, Miss Vindhyashree's study showed that ANSYS could predict masonry prism behavior more accurately than ABAQUS. Nevertheless, current standards provide little direction for choosing, adjusting, and using such sophisticated instruments, which limits their wider use in creative building methods.

By addressing these shortcomings, updated structural design standards could better align with modern construction practices, ensuring safer, more efficient, and sustainable masonry structures.

4. Summary

The review on Masonry Brick design and analysis using ANSYS explores the application of ANSYS, a powerful Finite Element Analysis (FEA) software, to study and optimize the structural performance of Masonry Brick designs. Masonry bricks are a type of masonry brick used in construction projects and are known for their aesthetic appeal and robustness. The review delves into the various aspects of the design and analysis process, focusing on the behaviour of Masonry Bricks under different loading conditions.

The review begins with an introduction to Masonry Bricks, highlighting their significance in contemporary architecture and construction. It then discusses the importance of structural analysis in ensuring the masonry bricks' reliability and safety when used in real-world construction projects. Next, the review provides an overview of the ANSYS software and its capabilities in simulating complex engineering problems, particularly in structural analysis. It elaborates on the different features and tools offered by ANSYS, which enable engineers and researchers to model, simulate, and optimize the behaviour of Masonry Bricks under various loads, such as compressive, tensile, and bending forces.

The review then describes the methodology adopted to perform the analysis using ANSYS. This includes creating a detailed finite element model of the Masonry Brick, selecting appropriate material properties, and validating the simulation results against experimental data or established standards. After presenting the analysis results, the review discusses the implications of the findings.

It identifies areas of improvement in the Masonry Brick design to enhance its structural integrity, durability, and performance. Additionally, the review may explore comparing different designs or materials to identify the most suitable configuration for specific applications. It primarily discusses technical advancements and applications of masonry bricks, such as thermal performance, structural integrity, and energy efficiency.

However, it neglects the broader interdisciplinary implications of these brick applications. It could highlight the role of innovative brick designs in creating sustainable living environments and the social and economic dimensions like cost-effectiveness and local job creation. It also suggests linking these findings to global efforts to reduce urban heat islands, achieve net-zero energy goals, and enhance climate resilience in architecture. This interdisciplinary approach could enhance the discussion and emphasize the importance of masonry bricks in tackling global challenges.

5. Future Scope

The review highlights potential areas for future research and development to enhance the design and analysis of masonry bricks using ANSYS. These areas aim to address existing gaps and foster innovation in material performance, environmental sustainability, and structural resilience. Key recommendations include:

5.1. Parametric Analysis

Investigating the influence of various design parameters such as brick dimensions, mortar types, and bond patterns on the structural performance of masonry bricks. This parametric study can guide optimization for project-specific requirements.

5.2. Material Innovation

Exploring the application of advanced and sustainable materials, including composites and eco-friendly alternatives, to enhance mechanical properties while reducing the environmental footprint of masonry bricks.

5.3. Non-linear Analysis

Extending numerical studies to include non-linear behavior, such as large displacements and material plasticity, to provide a more accurate representation of masonry brick responses under extreme loading conditions.

5.4. Thermal Analysis

Assessing the thermal behavior of masonry bricks in regions with extreme temperature variations. This includes evaluating their performance under thermal stresses to mitigate potential structural issues.

5.5. Multi-Scale Analysis

Integrating multi-scale modeling approaches to examine interactions between individual bricks, mortar, and the overall structure. This comprehensive perspective can improve the accuracy of simulation models.

5.6. Real-world Validation

Conducting experimental tests on full-scale masonry brick structures to validate the numerical results obtained from ANSYS. Such studies are essential to bridge the gap between theoretical models and practical applications.

5.7. Seismic Analysis

Evaluating the seismic performance of masonry brick structures to determine their vulnerability to earthquakes. Based on simulation findings, this includes proposing design modifications to improve their seismic resistance. By addressing these research areas, masonry brick design and analysis using ANSYS can advance significantly, leading to more reliable, sustainable, and efficient construction practices. These studies will optimize design methodologies and contribute to building materials better suited for modern engineering challenges.

6. Conclusion

The current study looked at the efficacy of incorporating extra cementing materials and filling materials into soil brick, stabilizing its compression behaviour, flexural behaviour, thermal stress analysis, and shear stress analysis, enhancing its long-term durability. The strength and durability of ordinary bricks must be investigated by incorporating different materials into brick manufacturing. Based on the necessity for precise material properties and the potential impact of assumptions and meshing choices on the trustworthiness of the results, the limitation of the prior works. Also, the paper indicates possible future scope with the advantage of software simulation based Masonry Brick design and analysis.

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