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Advancing Sustainable Construction: A Review on Natural Fibre Reinforced Stabilized Rammed Earth with Experimental and Fuzzy Logic Approaches

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ABSTRACT

This review explores the mechanical behaviour and sustainability potential of natural fibre reinforced stabilized rammed earth (SRE) through a comprehensive synthesis of experimental and computational research. The focal study by Baibordy et al. (2025) examines the use of cement and lime as stabilizers, reinforced with wheat straw, and integrates fuzzy logic modelling to predict mechanical performance. The paper evaluates fifteen different mix designs and analyses properties such as compressive strength, tensile strength, ultrasonic pulse velocity, and microstructural features via SEM. The experimental results show that while cement and lime significantly enhance strength and stiffness, the inclusion of straw generally reduces compressive strength but benefits tensile behaviour and ductility. A fuzzy logic-based AI model is developed to address prediction challenges under uncertainty, demonstrating superior performance across multiple defuzzification methods. The findings are contextualized with existing literature, and key gaps and future directions are identified in the pursuit of standardization, optimization, and sustainable construction practices using earthen materials.

Key words:- Stabilized rammed earth, natural fibre reinforcement, fuzzy logic modelling, sustainable construction, mechanical properties.

Introduction

The Need for Sustainable Construction Solutions

The construction sector is a major contributor to global greenhouse gas emissions, responsible for nearly 40% of total CO2 outputs. With rapid urbanization and increasing demands for infrastructure, the sector faces mounting pressure to transition toward environmentally sustainable alternatives. Sustainable construction materials, such as those sourced from local resources or recycled inputs, present an opportunity to reduce carbon footprints while meeting functional and structural demands. Integrating sustainability in construction not only addresses environmental concerns but also promotes economic efficiency, energy conservation, and long-term resilience. Rammed earth construction exemplifies this shift, leveraging natural materials and minimal processing energy to construct buildings with low embodied energy and enhanced environmental compatibility. As awareness of climate change deepens, the call for sustainable alternatives becomes more urgent, underscoring the importance of materials like stabilized rammed earth that embody both tradition and innovation.

Rammed Earth: A Traditional Material Reimagined

Rammed earth has been used for millennia in diverse climates and cultures, known for its thermal mass, breathability, and aesthetic appeal. This technique involves compacting moistened subsoil into formwork to create walls, often without the use of cement or bricks. In its traditional form, rammed earth offers ecological harmony but lacks the consistency and performance demanded by modern engineering standards. However, recent advancements in material science, including the incorporation of stabilizers and fibres, have redefined its potential. Rammed earth is now being revisited as a high-performance, low-impact building solution that aligns with contemporary sustainability goals. Modern iterations improve strength, durability, and insulation while preserving the natural aesthetics and tactile qualities of earthen walls. The result is a material that is not only environmentally friendly but also architecturally expressive and increasingly standardized for structural applications.

Limitations of Traditional Rammed Earth and Pathways to Improvement

Despite its numerous ecological and thermal benefits, traditional unsterilized rammed earth (URE) often exhibits insufficient mechanical strength, especially under tensile and compressive loads. This restricts its use in load-bearing structures and high-rise construction. Furthermore, URE is vulnerable to water damage and erosion, making it less viable in regions with high rainfall or seismic activity. To overcome these challenges, researchers have explored various modification strategies, such as incorporating cement or lime as chemical stabilizers and adding natural fibres for improved tensile resistance and crack control. These enhancements aim to retain the environmental advantages of rammed earth while extending its structural capabilities. In particular, combining minimal stabilizer use with biodegradable reinforcements aligns with green building practices and circular economy principles. These innovations pave the way for wider acceptance and code-compliant implementation of rammed earth in contemporary construction.

AI and Fuzzy Logic in Material Design

Artificial intelligence, particularly fuzzy logic, offers a powerful toolset for managing uncertainties and variabilities in construction materials. Unlike traditional models that require large, clean datasets, fuzzy logic systems excel in scenarios where data may be imprecise, incomplete, or non-linear—common challenges in natural material construction. Fuzzy logic mimics human reasoning by translating linguistic terms like "high strength" or "low stiffness" into computational rules. This approach is particularly useful in earthen construction, where variability in soil type, compaction method, and environmental conditions can drastically affect performance. In the context of stabilized rammed earth, fuzzy logic allows engineers to predict mechanical outcomes based on mix proportions and specimen characteristics, facilitating smarter, more adaptable material formulations. As the industry moves toward digital construction and smart material systems, AI tools like fuzzy logic will be instrumental in achieving optimal performance with fewer experimental trials.

Objectives and Scope of the Review

The goal of this review is to synthesize the experimental and computational findings of Baibordy et al. (2025) within the broader framework of sustainable and intelligent material design. It evaluates the mechanical behaviour of stabilized rammed earth mixtures reinforced with wheat straw, emphasizing how cement and lime contribute to strength and how straw improves ductility. Furthermore, it explores how fuzzy logic can model these mechanical properties accurately, even in the presence of material uncertainties. The review not only presents the methodologies and results but also contextualizes them within existing literature, identifying where this study confirms, challenges, or extends previous findings. Through this analysis, the paper highlights areas for further research, proposes practical applications for fuzzy logic modelling, and advocates for the integration of sustainable materials in mainstream construction practices.

Materials and Methods Overview

Soil Selection and Classification

The selection of soil plays a foundational role in determining the structural performance and workability of stabilized rammed earth (SRE). In the referenced study, the researchers employed an engineered blend of 80% coarse sand and 20% fine clay to achieve a well-graded, low-plasticity soil classified as SW (well-graded sand) with clay inclusions. This specific composition ensures optimal compaction and moisture retention, which are essential for the durability and mechanical stability of rammed earth walls. The soil's plasticity index and particle size distribution were tested using standard geotechnical methods, confirming its suitability for earth construction. The intentional mixture of coarse and fine particles supports a dense packing structure, reducing voids and improving the strength of the final composite material. Proper classification and selection of the soil also allow the prediction and control of shrinkage and cracking behaviour, which is critical when combined with stabilizers or fibres. In this context, the chosen soil provides a reliable base for experimental evaluation and ensures the reproducibility of results across different stabilization and reinforcement configurations.

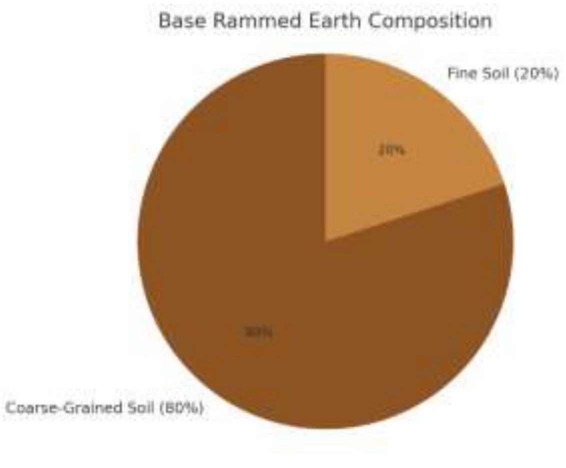

Fig. 1. Proportion of coarse and fine soil in the base rammed earth mix (80% coarse-grained, 20% fine soil).

Stabilizers: Cement and Lime

Stabilization of earthen materials using cement and lime has become a widely adopted technique to enhance compressive strength, water resistance, and durability. Cement functions as a hydraulic binder that reacts with water to form calcium silicate hydrate (C-S-H), a crystalline compound responsible for increased strength and rigidity. Lime, on the other hand, initiates pozzolanic reactions with clay particles, producing cementitious compounds over a longer curing period. In Baibordy et al.'s study, ordinary Portland cement (OPC) and hydrated lime were added in 4% and 8% dosages to assess their influence on the mechanical behaviour of rammed earth. While both stabilizers improved compressive strength, cement demonstrated a more pronounced effect, making it suitable for applications requiring early strength development. Lime, being less carbon-intensive and more compatible with traditional construction philosophies, provided moderate gains but promoted improved workability and environmental compatibility. The dual inclusion of stabilizers allowed researchers to compare performance trade-offs and develop mix designs that are both structurally viable and environmentally responsible.

Natural Fibre Reinforcement with Wheat Straw

The incorporation of natural fibres into earthen materials is gaining popularity as a strategy for enhancing tensile strength and ductility while promoting sustainability. In this study, wheat straw was chosen as a reinforcement material due to its local availability, mechanical properties, and ecological benefits. The fibres were processed and tested for tensile strength before inclusion in the mix at proportions of 0.5% and 1.0% by soil weight. Straw fibres work primarily through a bridging mechanism, holding together soil particles and delaying crack propagation under load. This action improves the post-peak behaviour and energy absorption capacity of the material, making it more resilient under dynamic or tensile forces. While the presence of straw slightly reduces compressive strength by introducing voids and disrupting compaction, the tensile benefits outweigh these drawbacks in applications where flexibility and toughness are prioritized. The use of agricultural by-products like straw also supports circular economy initiatives by reducing agricultural waste and minimizing reliance on synthetic reinforcements.

Experimental Matrix and Specimen Preparation

To comprehensively assess the effects of stabilizers and fibres, Baibordy et al. designed an experimental matrix comprising 15 distinct mix formulations. These included unstabilized rammed earth (URE), cement-stabilized (CSRE), lime-stabilized (LSRE), and combinations of straw-reinforced variants. Each mixture was proportioned by weight and carefully homogenized before compaction. Cylindrical specimens were prepared using Proctor compaction energy standards to replicate field conditions and ensure consistent density. Samples were then cured under controlled temperature and humidity conditions for 28 days to allow proper hydration and pozzolanic reactions. The systematic design of the experimental matrix facilitated comparison across different combinations of additives and helped isolate the effects of individual components. This robust methodological framework enabled the generation of reliable data sets, forming the basis for both experimental analysis and computational modelling using fuzzy logic. Such controlled experimentation is essential in developing practical construction guidelines for SRE applications.

TABLE 1: EXPERIMENTAL MATRIX AND SPECIMEN PREPARATION

Mix ID	Cement (%)	Lime (%)	Straw (%)	MDD (kg/m³)	OMC (%)	Citation
S	0	0	0.0	2035	10.20	Baibordy et al. (2025)
C4	4	0	0.0	2015	11.40	Baibordy et al. (2025)
C8	8	0	0.0	2005	11.50	Baibordy et al. (2025)
L4	0	4	0.0	1950	13.00	Baibordy et al. (2025)
L8	0	8	0.0	1830	14.50	Baibordy et al. (2025)
C4F1	4	0	1.0	1990	12.55	Baibordy et al. (2025)
L8F0.5	0	8	0.5	1873	15.00	Baibordy et al. (2025)

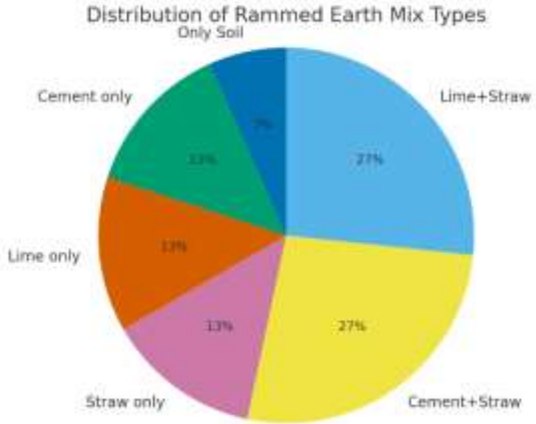

Fig. 3. Distribution of the 15 experimental rammed earth mix designs by additive type.

Mechanical Testing Techniques

Mechanical properties of the SRE specimens were evaluated using a suite of standardized tests to measure compressive strength, tensile strength, and ultrasonic pulse velocity (UPV). The unconfined compressive strength (UCS) test quantified the load-bearing capacity of each mix, revealing the structural viability of different stabilization techniques. The indirect tensile strength (TS) test, often conducted via the Brazilian splitting method, assessed the material's ability to resist tensile failure, which is crucial for preventing cracking and spalling. Ultrasonic pulse velocity testing served as a non-destructive method to evaluate internal homogeneity, detect voids, and infer elastic modulus. These tests provided complementary insights into both the macro and micro-mechanical behaviour of the specimens. Each result was cross-validated using replicate samples to ensure statistical reliability and to understand the influence of variables like compaction, curing, and material proportions. This rigorous testing regime not only validated the experimental formulations but also supplied the foundational data required to develop accurate fuzzy logic prediction models.

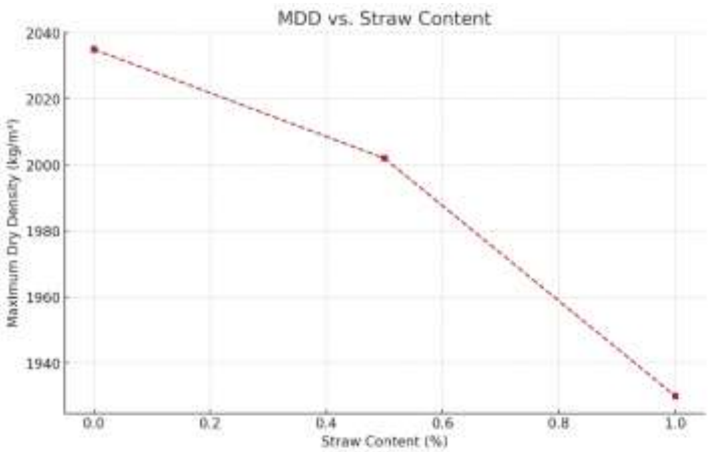

Fig. 4. Maximum dry density (MDD) decreases as straw content increases, due to the introduction of voids and lighter organic material.

Experimental Results and Discussion

Effects of Stabilization on Compressive Strength

The unconfined compressive strength (UCS) of stabilized rammed earth (RE) specimens demonstrated considerable improvements with the addition of stabilizers. Cement stabilization at 4% and 8% significantly increased UCS by 365% and 640%, respectively, compared to unstabilized RE (URE). Lime stabilization, though effective, showed lower improvements—109% and 237% at 4% and 8% dosages, respectively. The more significant strength gains with cement were attributed to the formation of stronger hydration products, such as calcium silicate hydrate (C-S-H). Cement stabilization also improved the elastic modulus, indicating greater stiffness in the material. The UCS results confirm the efficacy of chemical stabilization in enhancing the compressive strength of RE, making it more suitable for structural applications.

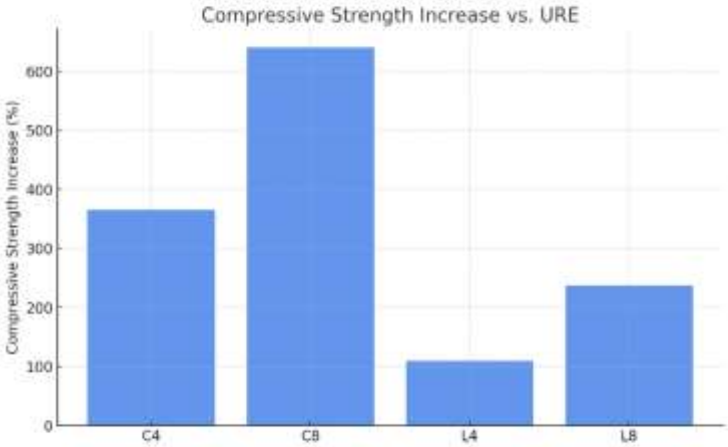

Fig. 5. Percentage increase in compressive strength with cement and lime stabilization compared to unstabilized rammed earth.

Influence of Straw Fibres on Strength and Ductility

The addition of natural fibres, particularly wheat straw, into the rammed earth mixture demonstrated a unique impact on both compressive strength and ductility. While the presence of straw fibres slightly reduced compressive strength, it notably enhanced the tensile strength and ductility of the material. Specifically, straw-reinforced unstabilized RE (SURE) showed up to 35% improvement in tensile strength. The fibres functioned through a bridging mechanism, connecting soil particles and enhancing crack resistance. Moreover, the strain capacity of fibre-reinforced samples was improved, allowing the material to exhibit more controlled deformation before failure. These results highlight the dual role of straw: while it may compromise compressive strength, it significantly enhances the toughness and flexibility of RE, making it suitable for dynamic and seismic applications.

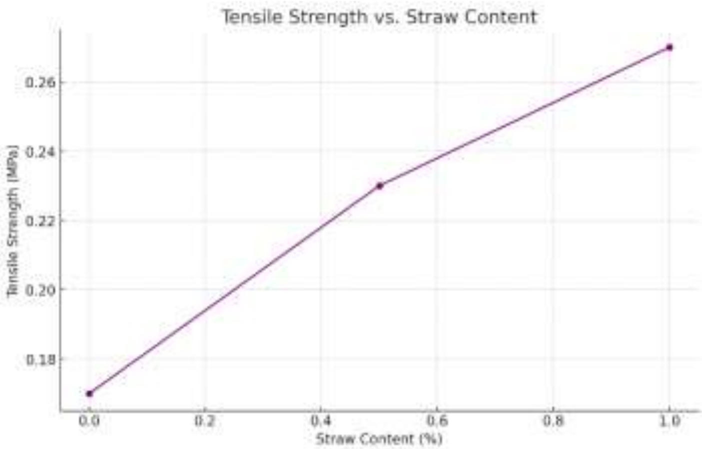

Fig. 6. Tensile strength increases with higher straw content, indicating improved ductility and crack resistance in unstabilized rammed earth.

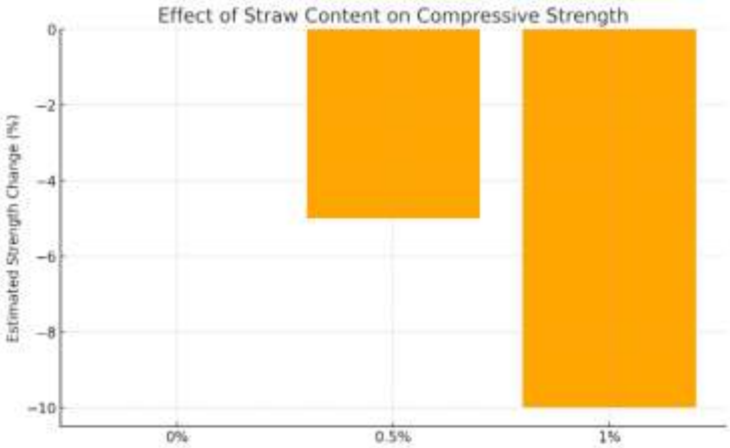

Fig. 7. Estimated decrease in compressive strength with increasing straw content.

Elastic Modulus and Stress–Strain Behaviour

The analysis of the elastic modulus (E) reveals the impact of stabilizers and fibre inclusion on the stiffness of rammed earth (RE) mixtures. Cement stabilization (4% and 8%) led to a significant improvement, increasing the elastic modulus by up to 345%. Lime stabilization, on the other hand, showed a more modest increase of 11% at 8% lime content. These changes in stiffness highlight cement's ability to strengthen the overall matrix, enhancing the load-bearing capacity of RE, making it more suitable for structural applications. Additionally, stress-strain curves demonstrated that stabilized RE specimens exhibited linear elastic behaviour up to 70-75% of the maximum stress, followed by plastic deformation, reflecting the typical response of cement-stabilized materials under compression. The strain at failure (εu) and strain at maximum compressive stress (εc) further confirmed the improved ductility and energy absorption capacity of the stabilized specimens, with cement-stabilized mixes showing the highest strain improvement indices.

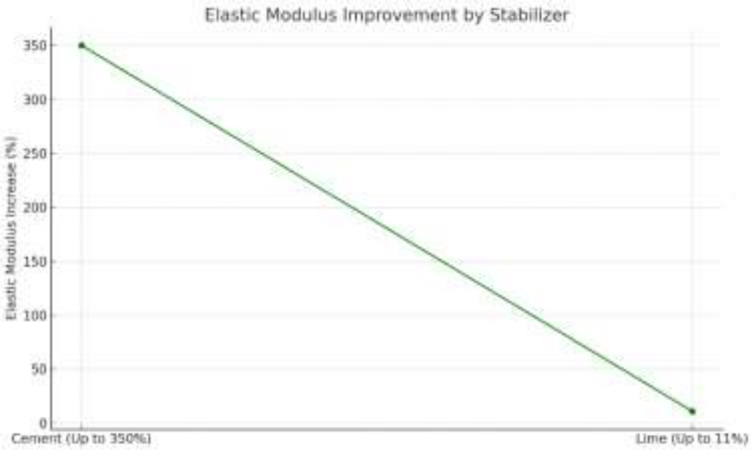

Fig. 8. Improvement in elastic modulus due to stabilizers (cement and lime).

Non-Destructive Testing and Microstructural Validation

Ultrasonic Pulse Velocity (UPV) tests were used to evaluate the internal homogeneity and quality of the rammed earth specimens. These non-destructive tests indicated that cement and lime stabilization improved the internal consistency of the mixtures, with higher UPV values correlating with increased strength and stiffness. Scanning Electron Microscopy (SEM) analyses further corroborated these findings, revealing the formation of denser microstructures in cement-stabilized samples due to the presence of calcium silicate hydrate (C-S-H) compounds. Lime-stabilized specimens displayed characteristic pozzolanic products, though these were less dense than the hydration products from cement. The SEM results also showed that the fibre-reinforced samples exhibited more heterogeneous microstructures, with voids and organic fibres visible in the matrix, which influenced their mechanical performance. This combination of non-destructive and microstructural testing provides critical insights into the material properties of stabilized and fibre-reinforced rammed earth.

Summary of Hybrid Stabilization Performance

The hybrid approach of combining cement, lime, and straw reinforcement proved to be effective in improving the mechanical properties of rammed earth. While cement-stabilized mixtures exhibited the highest increases in compressive strength and elastic modulus, lime provided a more environmentally friendly option with moderate improvements. The addition of straw fibres enhanced the tensile strength and ductility of the mixtures, particularly in unstabilized and lightly stabilized samples. This dual improvement—enhanced compressive strength through stabilization and improved tensile strength through fibre reinforcement—suggests that rammed earth can be adapted for more structural applications while maintaining its ecological and costeffective advantages. The synergy between chemical stabilization and natural fibre reinforcement holds promising potential for advancing sustainable construction with rammed earth.

Fuzzy Logic Modelling in SRE

Rationale for Using Fuzzy Logic

Fuzzy logic provides a powerful tool for addressing the inherent uncertainties in predicting the mechanical properties of natural fibre-reinforced stabilized rammed earth (SRE). Unlike traditional models, fuzzy logic handles imprecision and vagueness effectively, making it ideal for the construction sector, where material variability and environmental factors often lead to unpredictable outcomes. By mimicking human reasoning and incorporating expert knowledge, fuzzy systems can offer more reliable predictions despite limited data. This capability is particularly crucial when dealing with complex, multi-variable systems like SRE, where factors such as soil composition, stabilizer percentage, and fibre content influence material behavior.

System Design and Rule-Based Reasoning

The fuzzy logic model used in Baibordy et al.’s study was based on the Mamdani inference system, which is well-suited for handling linguistic variables and qualitative relationships. The system’s design involved defining membership functions for each input parameter—such as cement, lime, and fibre content—and specifying a set of fuzzy rules that describe how these inputs influence the output mechanical properties. By applying the "if-then" logic, the fuzzy system can compute intermediate results for each input and combine them to predict compressive strength or tensile strength. This rule-based approach allows the model to adapt to different mix designs and account for various uncertainties in the data.

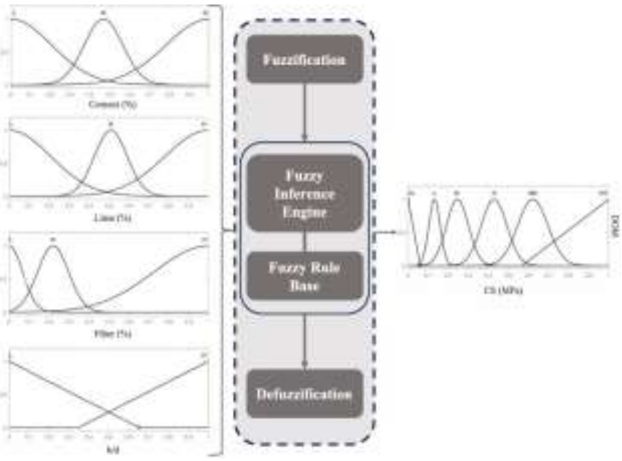

Fig. 9. Schematic of the fuzzy logic model applied to stabilized rammed earth (SRE). Input variables (cement, lime, fibre content, and aspect ratio) are fuzzified and processed through a rule-based inference engine. The defuzzified output predicts compressive strength (CS) in MPa. Adapted from Baibordy et al. (2025).

Model Validation and Performance Metrics

To assess the accuracy and effectiveness of the fuzzy logic model, Baibordy et al. used performance metrics such as the mean absolute error (MAE), root mean square error (RMSE), and correlation coefficient (R). These metrics help quantify the model's predictive reliability. In the study, the centroid defuzzification method was shown to yield the best prediction accuracy. The fuzzy logic model demonstrated strong correlation with experimental data, offering a robust method for estimating the mechanical properties of SRE. Its ability to handle uncertainty and provide reasonable predictions even with sparse data makes it a valuable tool for future research and practical applications in sustainable construction.

Practical Implications and Broader Applications

The application of fuzzy logic in predicting the properties of SRE extends beyond just compressive and tensile strengths. Its adaptability allows it to model other important aspects such as moisture retention, thermal conductivity, and long-term durability under varying environmental conditions. Moreover, the fuzzy logic model can be integrated into real-world construction practices by offering a user-friendly decision support system for engineers and architects. By providing quick, reliable predictions for material behavior, the model could streamline the design process, reduce experimental costs, and facilitate the widespread adoption of sustainable materials like SRE in both urban and rural settings.

Comparative Analysis with Literature

Benchmarking Cement and Lime Stabilization

Baibordy et al.'s study corroborates and extends findings from previous research on cement and lime stabilization of rammed earth (RE). Cement-stabilized rammed earth (CSRE) outperformed lime-stabilized rammed earth (LSRE) in terms of compressive strength, a result consistent with studies by

Reddy et al. (2017) and others. However, lime stabilization is still a viable option for sustainability due to its lower carbon footprint. Comparing the findings across various studies provides insights into the optimal stabilizer content for RE, offering a balance between mechanical performance and environmental impact.

The Role of Natural Fibres in Enhancing Tensile Strength

Natural fibre reinforcement, particularly with wheat straw, has been widely acknowledged for improving the tensile strength and ductility of RE. Straw’s inclusion in unstabilized and stabilized RE mixtures enhances the material's post-peak behavior, delaying crack propagation. Studies by Liu et al. (2022) and Sabbà et al. (2021) have similarly noted the contribution of fibres in increasing tensile strength, with Baibordy et al.'s work reinforcing the advantages of straw over other fibres. The tensile improvements are critical for dynamic load resistance and earthquake resilience in RE structures.

Innovation in Predictive Modelling with Fuzzy Logic

The application of fuzzy logic in predicting the mechanical properties of RE represents an innovation in construction material modelling. Unlike traditional methods, fuzzy logic can accommodate uncertainty and variability inherent in natural materials and construction processes. Baibordy et al.'s fuzzy logic model successfully predicted compressive and tensile strength based on limited experimental data. This contrasts with machine learning approaches, which require larger datasets. The model’s accuracy in predicting RE’s performance underscores the potential for fuzzy systems in optimizing material design with minimal testing, offering a new approach for the construction industry.

Research Gaps and Confirmations

While Baibordy et al.'s study significantly contributes to the understanding of RE's mechanical properties, gaps remain, particularly regarding long-term durability and the effects of climatic conditions on stabilized and fibre-reinforced RE. Literature confirms the effectiveness of cement and lime stabilizers, but further research is needed to standardize the best mix designs for various climates and applications. Moreover, exploring the combination of different fibres and stabilizers under diverse environmental conditions would help optimize the performance of RE materials in practical construction settings.

Sustainability Assessment

Embodied Energy and Carbon Implications

The environmental impact of cement and lime stabilization is a critical factor in assessing the sustainability of RE. While cement enhances mechanical strength, it also contributes significantly to carbon emissions. Lime, a more sustainable stabilizer, results in lower carbon emissions but provides less strength compared to cement. Baibordy et al.’s study emphasizes the balance between strength and environmental impact, suggesting that lime stabilization, though less effective than cement, offers a greener alternative. Incorporating natural fibres like straw, which are carbon-neutral, further improves the ecological profile of RE.

The Ecological Value of Straw Fibre Reinforcement

Wheat straw, an agricultural by-product, provides multiple ecological benefits when used in RE. By reinforcing RE, straw not only enhances mechanical properties but also contributes to a circular economy by reusing agricultural waste. The environmental advantages of using straw include reduced waste in landfills and a lower demand for synthetic reinforcement materials. This natural fibre is biodegradable and locally available, making it an ideal choice for sustainable construction. Baibordy et al.’s study highlights straw’s role in reducing the carbon footprint of RE materials, offering an eco-friendly alternative to conventional building methods.

Resource Efficiency and Passive Performance Benefits

Stabilized rammed earth, particularly when using local soil and agricultural waste, is highly resource-efficient. The use of local materials reduces transportation emissions and material waste, while minimizing the need for imported or processed construction products. Furthermore, RE offers passive performance benefits such as thermal mass and moisture buffering, contributing to energy-efficient buildings. Baibordy et al. underscore these benefits, suggesting that RE can significantly reduce operational energy use, especially when stabilized and reinforced with fibres like straw. These properties make RE a promising material for sustainable, energy-efficient construction.

Alignment with Circular Economy and SDG Goals

Baibordy et al.'s work aligns closely with the United Nations’ Sustainable Development Goals (SDGs), particularly those related to affordable housing, sustainable cities, and responsible consumption. By utilizing local soils, lime, and agricultural waste such as straw, RE contributes to a circular economy that minimizes waste and environmental impact. Additionally, the low embodied energy of RE materials supports the goal of reducing carbon emissions in the construction sector. The study’s findings support the broader adoption of RE as a sustainable solution in achieving SDG targets, particularly in regions facing resource scarcity and rapid urbanization.

Future Directions

Advanced Optimization and AI Integration

As the construction industry continues to seek sustainable solutions, advanced optimization techniques such as multi-objective genetic algorithms and neural networks can be integrated into the design of stabilized and fibre-reinforced rammed earth. These AI techniques could help optimize the mix design by balancing strength, ductility, and sustainability, providing a more efficient path for large-scale applications. Baibordy et al.'s fuzzy logic model is a step in this direction, but the inclusion of machine learning and AI-based optimization can further enhance material performance prediction and customization, making RE a more viable material for global construction.

Expanding Binder and Fibre Options

While cement and lime have been the primary stabilizers in rammed earth research, exploring alternative binders such as geopolymers or bio-based stabilizers can further reduce the environmental footprint. Similarly, investigating a wider range of natural fibres, such as hemp or coconut coir, may improve mechanical properties and diversify the application of RE. Future studies should focus on combining these novel stabilizers and fibres to develop customized materials that maximize both sustainability and performance, expanding the potential of RE in modern construction practices.

Digital Fabrication and Prefabrication Potential

The integration of digital fabrication techniques, such as 3D printing and robotic compaction, could revolutionize the construction of rammed earth structures. These technologies would enable precise control over the mixing and compaction processes, reducing material waste and labour costs. Additionally, prefabricated RE components could be mass-produced, increasing efficiency and reducing construction time. Baibordy et al.'s work provides a foundation for the future of RE in modern construction, where automation and digital tools could streamline the material's production and implementation, making it a more accessible and scalable option for sustainable building projects.

Durability, Standards, and Field Implementation

While laboratory results for stabilized and fibre-reinforced rammed earth are promising, further research is needed to evaluate the long-term durability of RE in real-world conditions. This includes studying the effects of weathering, freeze-thaw cycles, and seismic activity on the material. Additionally, there is a need for standardized testing methods and performance-based codes for RE construction. Future research should focus on field trials and pilot projects to gather real-world data and develop regulatory frameworks that will allow for the broader adoption of RE in construction, particularly in regions with harsh climates or seismic risks.

Capacity Building and Knowledge Transfer

The widespread adoption of stabilized and fibre-reinforced rammed earth will require significant capacity building at the community and professional levels. Education and training programs for engineers, architects, and construction workers are essential to ensuring that RE construction methods are properly understood and implemented. Knowledge transfer programs can help local communities and builders gain the necessary skills to effectively use RE in construction, empowering them to adopt sustainable building practices. Collaboration between academic institutions, industry, and governments will be key to promoting the benefits of RE and ensuring its scalability.

Conclusion

Key Insights from Experimental and Computational Analysis

Baibordy et al.'s research highlights the potential of stabilized and fibre-reinforced rammed earth as a sustainable construction material. The study demonstrates that both cement and lime stabilization significantly enhance the mechanical properties of RE, particularly compressive strength and stiffness. The addition of natural fibres like straw improves tensile strength and ductility, making RE more resilient to dynamic loads. Furthermore, the integration of fuzzy logic modelling provides a novel approach to predicting the material's performance, reducing the need for extensive experimental testing.

Strategic Value of SRE in Sustainable Construction

Rammed earth, particularly in its stabilized and fibre-reinforced forms, offers a sustainable alternative to conventional construction materials. By using local soils and agricultural by-products, such as straw, RE minimizes environmental impact while providing strong, durable building materials. The low embodied energy of RE, combined with its thermal mass and moisture buffering properties, makes it a highly energy-efficient building solution. The study underscores the strategic value of RE in achieving global sustainability goals, particularly in addressing affordable housing and reducing carbon emissions in the construction sector.

Path Forward for Research and Practice

The future of stabilized and fibre-reinforced rammed earth lies in continued innovation and collaboration. Future research should focus on optimizing mix designs using advanced computational tools, improving the durability of RE in diverse climates, and developing regulatory frameworks to support its use. Pilot projects and real-world applications will be crucial in demonstrating the viability of RE in modern construction. By combining traditional materials with cutting-edge technologies, stabilized rammed earth can become a key player in sustainable construction practices worldwide.

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