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Development of a Seismic-Resilient Adobe Housing Framework

Zara Asghar[1], Khizra Kulsoom[2], Sidra Asghar[3]
Department of Civil Engineering, University of Engineering and Technology, Peshawar, Pakistan

Abstract: ***Traditional adobe buildings are highly vulnerable to earthquakes due to weak masonry, inadequate structural connections, and poor construction practices. This study aims to develop a seismic-resilient adobe housing framework and practical improvements to conventional construction techniques. The proposed study focuses on developing a mud-brick infill system reinforced with wooden mesh for earthquake forces and environmental condition. The improved masonry system will incorporate locally available wooden mesh and enhanced structural detailing to strengthen walls and improve structural integrity. The proposed framework emphasizes reinforcement continuity, effective wall connections, and crack control to support better lateral load transfer. The developed approach provides greater resistance to earthquake-induced forces while maintaining the affordability, simplicity, and environmental benefits of traditional adobe construction. The study contributes to the development of practical and sustainable earthquake-resilient housing solutions suitable for local construction.***
Keywords: adobe construction, seismic resilience, mud-brick masonry, wooden mesh reinforcement, earthen housing, earthquake-resistant construction

I. INTRODUCTION

Adobe construction is one of the oldest building techniques and remains widely practiced in rural communities across Asia, Africa, and Latin America. Sun-dried mud bricks are produced using locally available soil and water, making them an affordable and environmentally sustainable alternative to conventional construction materials. Their low production energy, thermal properties, and simple construction requirements make adobe particularly suitable for low-cost housing [1]. Unlike conventional construction materials, adobe bricks can be manufactured with minimal equipment and locally available labour, reducing dependence on industrial materials and transportation. These advantages make earthen construction an important option for sustainable housing, particularly in developing countries such as Pakistan. The use of locally available reinforcement materials has also attracted research interest as a means of improving traditional earthen construction while preserving its economic and environmental benefits [2], [3].

Despite these advantages, conventional adobe buildings are vulnerable to earthquakes due to weak masonry, inadequate structural connections, and poor construction practices. The low tensile and shear strength of mud bricks limits their resistance to lateral loading, particularly when walls are constructed without proper reinforcement. Earthquake damage assessments have identified several common failure mechanisms, including diagonal cracking, separation at wall intersections, and out-of-plane wall collapse [4]. Experimental investigations have further demonstrated the limitations of unreinforced adobe masonry under repeated lateral loading [5]. Inadequate connections between walls and roofing elements can also affect overall structural integrity and contribute to progressive damage [6]. These problems are particularly important in rural housing, where traditional construction practices often lack adequate engineering supervision and quality control.

Various strengthening techniques have been investigated to address these limitations. Timber reinforcement, external meshes, natural fibers, and improved wall connections have shown potential for improving the structural behavior of earthen masonry. Experimental investigations on modified adobe walls incorporating wooden structural elements have demonstrated improvements in wall performance and damage control [7]. Other strengthening approaches have also been explored for existing adobe buildings, although their practical application depends on material compatibility, construction requirements, and cost [8]. Research on natural-fiber-reinforced rammed earth has similarly highlighted the potential of locally available materials for improving earthen construction [9], [10]. These findings suggest that relatively simple reinforcement arrangements can contribute to better masonry performance without completely replacing traditional materials and construction methods.

Although previous studies provide useful experimental evidence, developing practical housing solutions requires an integrated approach that considers masonry reinforcement, structural connections, material availability, and ease of construction. Many strengthening techniques focus on individual masonry components, while their implementation within a complete housing system requires further consideration.

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In particular, the continuity of reinforcement, connections between adjoining structural elements, and compatibility with conventional mud-brick construction are important considerations. Therefore, there is a need to develop an affordable and practical adobe housing framework that combines suitable reinforcement techniques with improved construction detailing and can be adopted under local conditions.

This study aims to develop a seismic-resilient adobe housing framework incorporating an improved mud-brick infill system with locally available wooden mesh reinforcement and enhanced structural detailing. The proposed framework is developed through an assessment of conventional adobe construction practices, comparative evaluation of published experimental findings, and consideration of relevant construction standards. The study focuses on improving wall integrity, reinforcement continuity, and structural connections through practical modifications to traditional construction techniques. The proposed approach seeks to provide a foundation for safer and more sustainable adobe housing while maintaining the affordability, simplicity, and environmental benefits of conventional earthen construction.

II. METHOD AND MATERIALS

A. Research Approach

This study adopts an experimental and engineering-based approach to develop a seismic-resilient adobe housing framework using locally available materials and improved construction practices. The methodology involves assessing conventional adobe construction, identifying structural weaknesses, developing an improved mud-brick masonry system, and evaluating its performance through preliminary laboratory investigations and published experimental findings. Relevant construction standards are also considered to support the development of a practical and sustainable housing framework.

B. Assessment of Conventional Adobe Construction

The study begins with an assessment of traditional adobe construction practices and their structural limitations. Common weaknesses include low masonry strength, inadequate wall connections, poor construction quality, and susceptibility to cracking under lateral loading. Typical earthquake-related damage mechanisms are reviewed to identify the main areas requiring improvement. Particular attention is given to wall stability, structural continuity, and connections between building components.

C. Development of the Improved Adobe Masonry System

An improved adobe masonry system is proposed using conventional mud bricks, locally available reinforcement materials, and enhanced structural detailing. The system incorporates wooden mesh reinforcement to improve wall integrity and provide additional resistance to cracking and lateral deformation.

The development process considers material compatibility, reinforcement arrangement, wall connections, and ease of construction. The proposed approach aims to improve the overall behavior of adobe masonry while maintaining the simplicity, affordability, and environmental advantages of traditional construction.

D. Assessment of Environmental Suitability

The environmental suitability of the proposed system is assessed by considering locally available materials, moisture exposure, and construction durability. Particular attention is given to protecting earthen masonry and reinforcement against deterioration caused by environmental conditions. Suitable material selection, protective finishes, and construction detailing are considered to improve the practical application and long-term performance of the system.

E. Comparative and Code-Based Evaluation

Published experimental studies on conventional and improved earthen masonry are reviewed to assess the effectiveness of different strengthening techniques [2], [3], [7], [9], [10]. The comparison considers reported improvements in masonry strength, lateral resistance, cracking behavior, and structural integrity.

Relevant national and international construction standards are also examined to evaluate material requirements, wall configuration, reinforcement, and structural connections. The findings are used to refine the proposed adobe housing framework and establish practical recommendations for improved construction under local conditions.

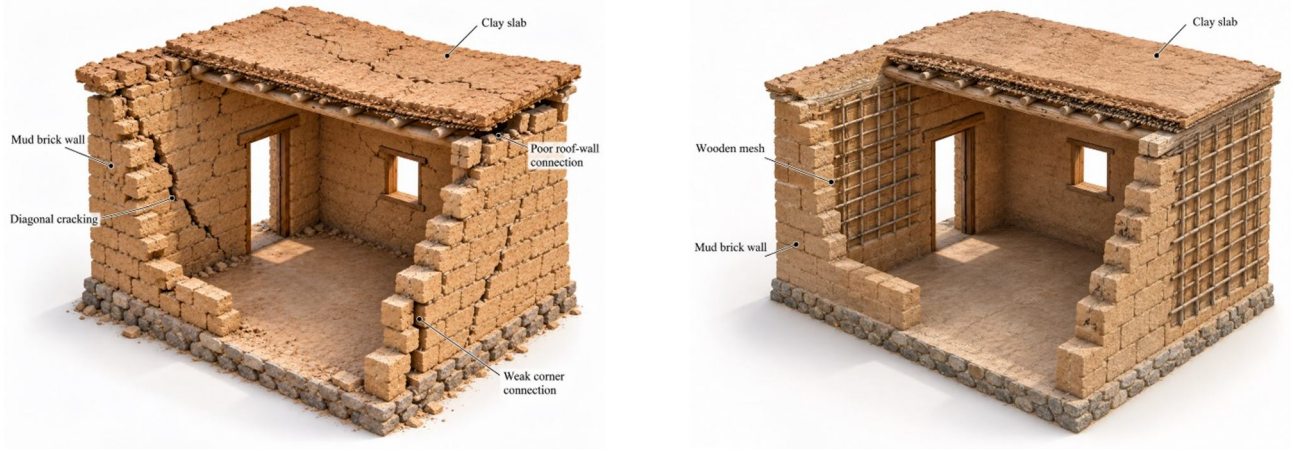
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III. RESULTS AND DISCUSSION

A. Development of the Proposed Adobe Housing Framework

The proposed adobe housing framework focuses on improving the structural integrity and lateral load resistance of traditional mud-brick masonry through locally available reinforcement materials and enhanced construction detailing. The system is intended to address common weaknesses of conventional adobe construction, including low tensile and shear resistance, cracking, and inadequate connections between structural components, as illustrated in Fig. 1(a).

The framework combines improvements in masonry reinforcement, wall continuity, and structural connections to develop a more integrated earthquake-resistant construction approach, as shown in Fig. 1. Particular consideration is given to affordability, material availability, and compatibility with local construction practices.



(a) (b)

Fig. 1 Three-dimensional models of adobe housing framework: (a) conventional unreinforced adobe building; (b) improved adobe building incorporating wooden mesh reinforcement

B. Comparison of Experimental Results

The potential effectiveness of the proposed approach was evaluated through a comparative assessment of published experimental studies on reinforced adobe masonry.

Aizaz et al. [2] investigated mud-brick masonry strengthened with bamboo-strip mesh and dried jute-thread reinforcement. The experimental results demonstrated improvements in the mechanical performance of reinforced specimens compared with conventional unreinforced masonry. Bamboo-strip reinforcement increased compressive strength by 30%, shear strength by 96%, and energy absorption by 195%. Similarly, dried jute-thread reinforcement improved these properties by 40%, 102%, and 314%, respectively.

TABLE I

COMPARISON OF CONVENTIONAL AND REINFORCED MUD-BRICK MASONRY BASED ON PUBLISHED EXPERIMENTAL FINDINGS [2]

Performance parameter	Bamboo reinforcement	Jute reinforcement
Compressive strength improvement	+30%	+40%
Modulus of elasticity improvement	+19%	+69%
Shear strength improvement	+96%	+102%
Modulus of rigidity improvement	+82%	+110%
Energy absorption improvement	+195%	+314%

These findings indicate that locally available reinforcement materials can considerably improve the mechanical properties of adobe masonry. Wang et al. [7] further investigated modified adobe masonry walls incorporating timber columns and reinforcement ties under quasi-static cyclic loading. For comparable specimens with steel-wire-mesh ties, the maximum lateral load increased from 33.59 kN for the unmodified mud-wall configuration to 41.69 kN for the modified mud-wall configuration, representing an improvement of approximately 24.1%.

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These experimental observations provide supporting evidence for developing an improved adobe masonry system. However, the reported improvements are specific to the materials, reinforcement configurations, and loading conditions investigated in the respective studies.

C. Assessment with Reference to Construction Standards

The proposed framework was also examined against established provisions for earthen construction.

The Building Code of Pakistan 2021 includes provisions for adobe masonry under Section 2109, while international references, including ASTM E2392/E2392M-24, NZS 4297:2024, and Peru's E.080 standard, provide additional guidance for earthen building systems.

TABLE II

CODE-BASED ASSESSMENT OF THE PROPOSED ADOBE HOUSING FRAMEWORK [11]–[15]

Design consideration	Relevant reference	Application to proposed framework
Adobe masonry design	Building Code of Pakistan 2021	Review applicability and design limitations
Earthen wall construction	ASTM E2392/E2392M-24	Material and structural design considerations
Structural design	NZS 4297:2024	Engineering assessment of earth walls
Material quality	NZS 4298:2024	Material production and construction quality
Seismic reinforcement	Peru E.080 (2017)	Reinforcement and structural continuity principles

The assessment emphasizes that improvements in wall strength must be accompanied by adequate connections, suitable building geometry, and continuous load-transfer mechanisms. Accordingly, the proposed framework considers both the strengthening of individual masonry walls and their integration into a structurally connected housing system.

These standards provide useful design references; however, compliance of the proposed system requires project-specific verification.

D. Discussion of the Proposed System

The reviewed experimental findings demonstrate the potential of locally available reinforcement materials to improve the structural behavior of conventional adobe masonry. Improvements in shear strength, deformation resistance, and crack control are particularly relevant to the development of earthquake-resilient housing.

The proposed system builds on these findings by integrating improved mud-brick masonry with practical reinforcement arrangements and structural detailing. Unlike conventional adobe construction, which often relies on unreinforced masonry walls, the proposed framework aims to provide better structural continuity and resistance to earthquake-induced lateral forces.

The comparison also highlights the importance of considering overall building behaviour rather than improving masonry strength alone. The effectiveness of the developed framework will ultimately depend on the performance of wall connections, reinforcement anchorage, and the interaction between the masonry and supporting structural components.

Although the literature provides a strong technical basis for the proposed development, further laboratory evaluation is required to quantify the actual improvement achieved by the new system.

E. Practical Implications

The proposed framework provides an initial basis for developing safer and more sustainable adobe housing in earthquake-prone regions. Its emphasis on locally available materials and improved construction practices may support adoption in rural communities where conventional engineered construction solutions are less accessible.

IV. CONCLUSIONS

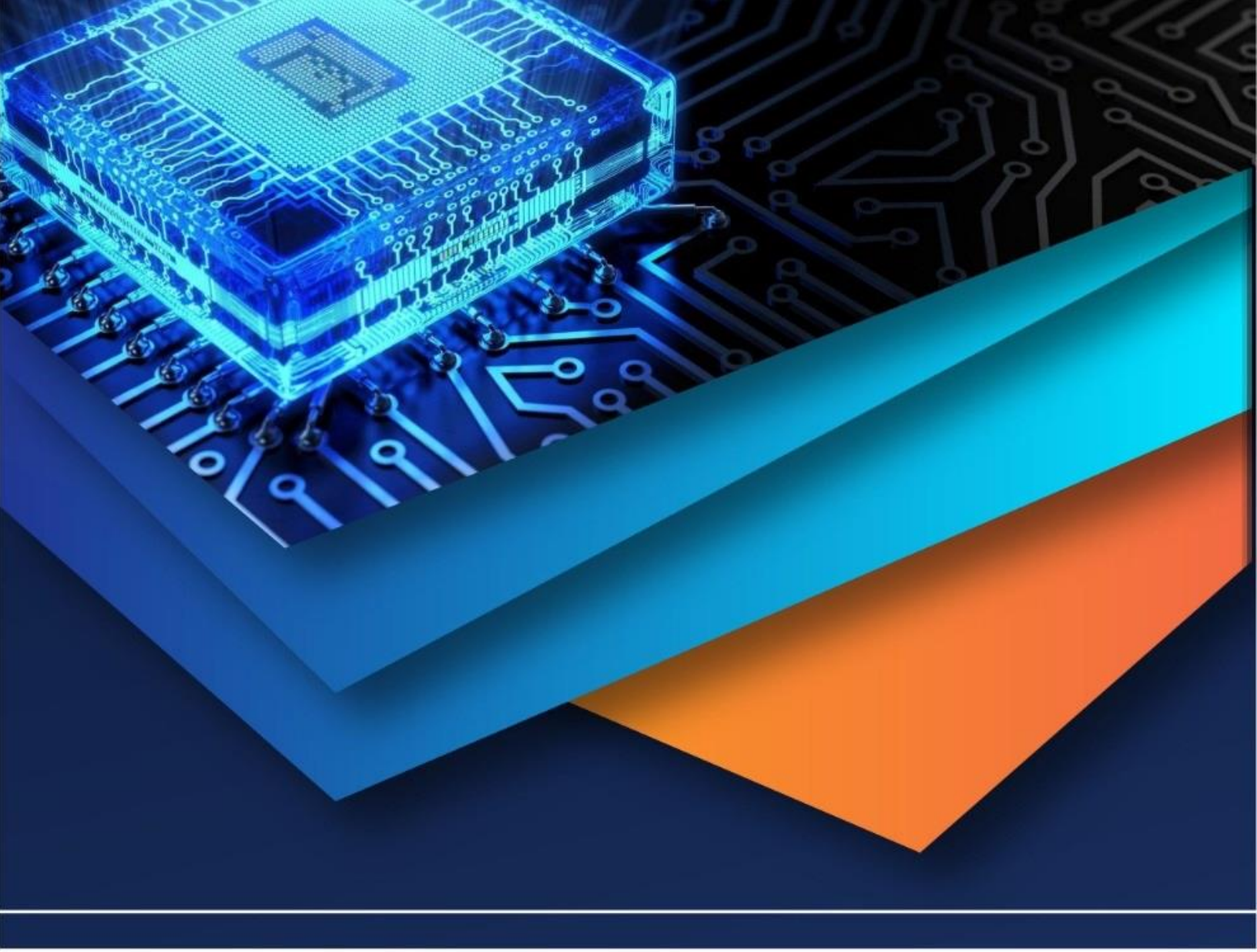
This study presents a seismic-resilient adobe housing framework incorporating improved mud-brick masonry, locally available wooden mesh reinforcement, and enhanced structural detailing. The proposed system aims to improve wall integrity, crack control, and resistance to lateral loading through effective reinforcement arrangements and structural connections.

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The integration of wooden mesh with conventional adobe masonry offers a practical approach to improving structural stability while maintaining the affordability, simplicity, and environmental benefits of traditional construction. The developed framework provides a basis for sustainable and earthquake-resilient housing suitable for local construction practices. Further experimental investigations are recommended to evaluate the structural performance and long-term durability of the proposed system under earthquake loading and environmental conditions.

REFERENCES

[1] W. Jinwuth, B. Samali, K. Heathcote, and C. Wang, "A study into the earthquake resistance of circular adobe buildings using static tilt tests," in Proc. Australian Earthquake Engineering Society Conf., Perth, Australia, 2010.
[2] M. Aizaz, K. Shahzada, A. Gul, and M. Saqib, "Experimental study on the in-plane behavior of mud brick walls strengthened with bamboo strip mesh and dried jute thread," Structures, vol. 68, Art. no. 107238, 2024, doi: 10.1016/j.istruc.2024.107238.
[3] M. S. Islam and K. Iwashita, "Fiber reinforced composite soil as an earthquake resistant building material," in Proc. 6th Int. Earth Building Conf. (Earth USA 2011), USA, 2011.
[4] E. Işık, "Structural failures of adobe buildings during the February 2023 Kahramanmaraş (Türkiye) earthquakes," Appl. Sci., vol. 13, no. 15, Art. no. 8937, 2023, doi: 10.3390/app13158937.
[5] F. Wu, H.-T. Wang, G. Li, J.-Q. Jia, and H.-N. Li, "Seismic performance of traditional adobe masonry walls subjected to in-plane cyclic loading," Mater. Struct., vol. 50, Art. no. 69, 2017, doi: 10.1617/s11527-016-0927-0.
[6] E. L. Tolles, E. E. Kimbro, F. A. Webster, and W. S. Ginell, Seismic Stabilization of Historic Adobe Structures: Final Report of the Getty Seismic Adobe Project. Los Angeles, CA, USA: Getty Conservation Institute, 2000.
[7] H. Wang, K. Yuan, S. Zhang, and J. Guo, "Experimental study on the seismic behavior of a modified adobe-brick-masonry composite wall with a wooden-construction center column," Sustainability, vol. 15, no. 10, Art. no. 8360, 2023, doi: 10.3390/su15108360.
[8] T. L. G. Michiels, "Seismic retrofitting techniques for historic adobe buildings," Int. J. Archit. Heritage, vol. 9, no. 8, pp. 1059–1068, 2015, doi: 10.1080/15583058.2014.924604.
[9] B. Sen and R. Saha, "Experimental and numerical investigation of mechanical strength characteristics of natural fiber retrofitted rammed earth walls," Geotext. Geomembr., vol. 50, no. 5, pp. 970–993, 2022, doi: 10.1016/j.geotexmem.2022.06.004.
[10] B. Sen and R. Saha, "Structural stability evaluation of natural fiber retrofitted low-cost rammed earthen houses under seismic loading," Struct. Eng. Int., vol. 35, no. 2, pp. 286–305, 2025, doi: 10.1080/10168664.2024.2338221.
[11] Pakistan Engineering Council, Building Code of Pakistan 2021, Ch. 21, Sec. 2109, "Empirical Design of Adobe Masonry," Pakistan, 2021.
[12] Standard Guide for Design of Earthen Wall Building Systems, ASTM E2392/E2392M-24, ASTM International, West Conshohocken, PA, USA, 2024, doi: 10.1520/E2392_E2392M-24.
[13] Engineering Design of Earth Buildings, NZS 4297:2024, Standards New Zealand, Wellington, New Zealand, 2024.
[14] Materials and Construction for Earth Buildings, NZS 4298:2024, Standards New Zealand, Wellington, New Zealand, 2024.
[15] Ministerio de Vivienda, Construcción y Saneamiento, *Norma Técnica E.080: Diseño y Construcción con Tierra Reforzada*, Reglamento Nacional de Edificaciones, Peru, 2017.



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