J. Res. Technol. Eng. 7(1), 2026, 20-28

Journal of Research Technology and Engineering

www.jrte.org

Effect of Mortar Joint Thickness on the Mechanical Properties of Clay Brick Masonry Walls

M.A.P. Teshan , * R.A.K.M. Rajapaksha, M.D.K.C. Jayathilaka

Department of Civil and Environmental Technology, Faculty of Technology, University of Sri Jayewardenepura

*kalanamr@sjp.ac.lk

Received:25 November 2025; Revised: 01 December 2025; Accepted: 10 December 2025; Available online: 10 January 2026

Abstract: Mortar joint thickness significantly influences the mechanical behavior of masonry structures, yet its quantitative effects remain inadequately characterized. This study investigates the impact of three mortar joint thicknesses (10 mm, 20 mm, and 30 mm) on the compressive and shear strength of clay brick walls through comprehensive experimental testing. Eighteen wall specimens were constructed using locally sourced clay bricks and cement-sand mortar (1:3 ratio) prepared according to EN 1015-3 standards. Mechanical testing was conducted using universal compression testing machines under controlled loading conditions. Results demonstrate that compressive strength decreases from 1.82 N/mm² for 10 mm joints to 1.43 N/mm² for 30 mm joints, representing a 21.4% reduction. Similarly, shear strength decreases by 48% from 1.02 N/mm² (10 mm) to 0.53 N/mm² (30 mm). Statistical analysis (ANOVA, $\alpha = 0.05$) confirms significant differences between all thickness groups ($p < 0.05$). Failure mode analysis reveals that thin joints promote brick failure while thick joints fail through mortar joint separation, indicating optimal stress transfer in thinner configurations. The findings establish 10 mm as the optimal joint thickness for maximizing mechanical properties and provide quantitative data for structural design optimization in masonry construction.

Index Terms: Clay brick masonry, Compressive strength, Mechanical properties, Mortar joint thickness, Shear strength, Structural masonry.

1 Introduction

Masonry construction remains a fundamental building technology worldwide, with clay brick walls serving as primary load-bearing elements in numerous structural applications [1]. The mechanical performance of masonry assemblages depends critically on the interaction between constituent materials bricks and mortar and their geometric configuration, particularly mortar joint thickness [2]. Despite its recognized importance, the quantitative relationship between joint thickness and mechanical properties lacks comprehensive experimental characterization, limiting optimization of masonry design practices.

Traditional masonry construction typically employs joint thicknesses ranging from 10-30 mm, with variations often driven by construction convenience rather than structural optimization [3]. The mechanical behavior of masonry walls under various loading conditions depends on several interconnected factors: material properties of bricks and mortar, bond strength at the brick-mortar interface, and geometric parameters including joint thickness [4]. Mortar joint thickness influences load distribution mechanisms, stress concentration patterns, and failure propagation characteristics within the masonry assembly.

Current design standards provide limited guidance on optimal joint thickness selection, often relying on empirical rules rather than systematic experimental evidence [5]. This knowledge gap is particularly problematic in regions where masonry construction predominates, as suboptimal joint thickness selection can significantly compromise structural safety and economic efficiency. The increasing emphasis on sustainable construction practices and material optimization further necessitates fundamental understanding of joint thickness effects on mechanical performance.

Recent advances in masonry research have highlighted the complex interaction between mortar properties, joint geometry, and overall structural behavior [6]. However, most existing studies focus on material characterization rather than systematic investigation of geometric parameters. The present study addresses this gap by providing comprehensive experimental data on the relationship between mortar joint thickness and key mechanical properties of clay brick walls.

This research makes three primary contributions: (1) quantitative characterization of joint thickness effects on compressive and shear strength through systematic experimental investigation, (2) identification of optimal joint thickness for maximizing mechanical properties, and (3) analysis of failure mechanisms and their relationship to joint geometry. The findings provide essential data for structural design optimization and construction quality improvement in masonry applications.

2 LITERATURE REVIEW

2.1 Masonry Material Characterization

Clay bricks have served as primary construction materials for over 10,000 years, with modern manufacturing incorporating advanced processing techniques and quality control measures [7]. Contemporary research emphasizes the relationship between brick properties and overall masonry performance, with particular attention to strength characteristics and durability factors [8]. Mortar composition and properties significantly influence masonry behavior, with cement-sand mortars providing optimal balance between strength, workability, and cost-effectiveness [9].

2.2 Mechanical Properties of Masonry Systems

Masonry mechanical behavior exhibits complex dependency on constituent material properties and their interaction [10]. Compressive strength represents the primary design parameter for load-bearing applications, typically ranging from 1.0-5.0 N/mm² depending on brick quality and mortar composition [11]. Shear strength characteristics are critical for lateral load resistance, particularly in seismic applications, with values typically 15-30% of compressive strength [12].

2.3 Joint Thickness Effects

Limited research exists on systematic joint thickness effects, with most studies focusing on material optimization rather than geometric parameters. Thamboo and Dhanasekar [5] investigated thin-layer mortared masonry, demonstrating improved performance with reduced joint thickness, but focused primarily on specialized thin-layer applications. Zengin et al. [6] examined joint thickness effects but limited investigation to two thickness values with different mortar types, precluding isolation of geometric effects.

Previous studies indicate that joint thickness influences stress distribution and failure mechanisms [13].

Thicker joints may contain increased defects or voids that reduce load-bearing capacity, while thinner joints provide more effective stress transfer between masonry units [14]. However, comprehensive experimental data across multiple joint thicknesses with consistent material properties remains unavailable, limiting practical application of these findings.

3 MATERIALS AND METHODOLOGY

3.1 Materials

Standard clay bricks with nominal dimensions of 190 mm × 95 mm × 50 mm were obtained from local manufacturers and characterized according to relevant standards. Mortar was prepared using ordinary Portland cement and natural sand in 1:3 mass ratio, conforming to EN 1015-3 specifications. Sand was sieved through 2 mm screens per EN 196-1 requirements to ensure consistent particle size distribution. Water content was maintained at 50% of cement mass to achieve optimal workability and strength development. The materials used in this investigation are shown in Fig 01, including locally sourced clay bricks with standard dimensions, sieved sand conforming to EN 196-1 specifications, and ordinary Portland cement for mortar preparation.

Fig 01: Material components: (a) Clay bricks, (b) Sand preparation, (c) Cement mortar mixing.

3.2 Preparation

Wall specimens were constructed with three different mortar joint thicknesses: 10 mm, 20 mm, and 30 mm as illustrated by Fig 02. Each configuration included six replicate specimens to ensure statistical validity. English bond pattern was employed to provide structural continuity and uniform load distribution. Prior to construction, bricks were saturated in water for one hour to prevent rapid mortar dehydration and ensure proper bond development. Mortar preparation followed standardized mixing procedures with mechanical mixing for 3 minutes to achieve homogeneous consistency. Joint thickness was controlled using temporary spacers and verified with precision measuring instruments. Constructed specimens were cured for seven days under standard laboratory conditions (20±2°C, 65±5% RH) before testing.

Fig 02. Wall construction process shows different joint thicknesses: (a) 10 mm joints, (b) 20 mm joints, (c) 30 mm joints.

JRTE©2026

3.3 Testing Procedures

Compressive strength testing was conducted using a universal testing machine with capacity of 200 kN, following established masonry testing protocols. Specimens were positioned with uniform bearing surfaces and loaded at constant rate of 0.5 N/mm²/min until failure. Load-displacement data were recorded continuously, with particular attention to initial cracking and ultimate failure loads.

Shear strength testing employed a specialized fixture allowing pure shear loading while maintaining constant normal stress. Specimens were positioned with one end fixed and the other subjected to incremental shear loading at rate of 0.2 N/mm²/min. Maximum shear load and corresponding displacement were recorded for each specimen. Mechanical testing was conducted using specialized equipment configured for masonry applications, as shown in Fig 03. The compression testing apparatus (Fig. 3a) enabled uniform load distribution, while the shear testing configuration (Fig. 3b) provided pure shear loading conditions under constant normal stress.

Fig 3. Experimental setup: (a) Compressive strength testing apparatus, (b) Shear strength testing configuration.

3.4 Data Analysis

Mechanical properties were calculated using standard formulas.

$$Compressive\ Strength = Maximum\ Load\ /\ Cross-sectional\ Area \quad \text{.......(Equation 01)}$$

$$Shear\ Strength = Maximum\ Shear\ Load\ /\ Shear\ Area \quad \text{.........(Equation 02)}$$

Statistical analysis employed Analysis of Variance (ANOVA) with significance level $\alpha = 0.05$ to determine differences between joint thickness groups. Post-hoc testing used Tukey's method for multiple comparisons. Standard deviations and confidence intervals were calculated for all measurements.

4 RESULTS

4.1 Compressive Strength Performance

Compressive strength results demonstrate clear inverse relationship between joint thickness and load-bearing capacity, as summarized in Table I. The 10 mm joint configuration achieved highest mean compressive strength of 1.82±0.02 N/mm², while 30 mm joints exhibited lowest strength of 1.43±0.02 N/mm². Intermediate thickness (20 mm) showed moderate performance at 1.70±0.03 N/mm².

Table 1. Compressive strength test results

Joint Thickness (mm)	Specimen	Maximum Load (kN)	Cross-Section (mm²)	Compressive Strength (N/mm²)
10	R1	102.3	56,050	1.825
10	R2	103.1	56,050	1.839
10	R3	101.0	56,050	1.802
20	R1	99.3	57,950	1.713
20	R2	99.6	57,950	1.719
20	R3	96.1	57,950	1.658
30	R1	85.8	59,850	1.433
30	R2	84.5	59,850	1.411
30	R3	87.2	59,850	1.457

The coefficient of variation for 10 mm specimens was 1.1%, indicating excellent repeatability and consistent material behavior. In contrast, 20 mm and 30 mm configurations showed higher variability (1.8% and 1.6% respectively), suggesting increased susceptibility to construction variations and material defects with thicker joints. The inverse relationship between joint thickness and compressive strength is clearly demonstrated in Fig 04, which presents mean values with 95% confidence intervals for all three joint configurations.

4.2 Shear Strength Characteristics

Shear strength testing revealed similar trends to compressive behavior, with pronounced reduction in capacity as joint thickness increased, as shown in Table II. The 10 mm joint configuration provided maximum shear resistance of 1.02±0.02 N/mm², while 30 mm joints achieved only 0.53±0.03 N/mm², representing 48.0% reduction in capacity.

Table 2: Shear strength test results

Joint Thickness (mm)	Specimen	Maximum Load (kN)	Shear Area (mm²)	Shear Strength (N/mm²)
10	R1	15.5	15,300	1.010
10	R2	15.5	15,300	1.015
10	R3	15.9	15,300	1.041
20	R1	13.2	17,100	0.769
20	R2	13.0	17,100	0.758
20	R3	12.8	17,100	0.746
30	R1	10.7	18,900	0.568

JRTE©2026

Joint Thickness (mm)	Specimen	Maximum Load (kN)	Shear Area (mm²)	Shear Strength (N/mm²)
30	R2	9.5	18,900	0.501
30	R3	9.9	18,900	0.521

Intermediate thickness (20 mm) showed shear strength of 0.76±0.01 N/mm², demonstrating consistent intermediate performance between extreme configurations. The shear-to-compressive strength ratio varied from 56.0% for 10 mm joints to 37.1% for 30 mm joints, indicating that joint thickness affects shear capacity more severely than compressive capacity.

4.3 Statistical Analysis

ANOVA analysis confirmed statistically significant differences between all joint thickness groups for both compressive strength ($F_{2,6} = 348.75$, $p < 0.001$) and shear strength ($F_{2,6} = 498.57$, $p < 0.001$). Post-hoc testing using Tukey's HSD revealed that each thickness group was significantly different from all others ($p < 0.05$), confirming that joint thickness has substantial and measurable effects on mechanical properties. The relationship between joint thickness and strength can be approximated by linear regression:

$$Compressive\ Strength\ (N/mm^2) = 2.01 - 0.0195 \times Thickness\ (mm)\ (R^2 = 0.94)$$

$$Shear\ Strength\ (N/mm^2) = 1.27 - 0.0245 \times Thickness\ (mm)\ (R^2 = 0.97)$$

These relationships provide quantitative tools for predicting mechanical properties based on joint thickness selection. The high correlation coefficients ($R^2 > 0.94$) demonstrate strong linear relationships, enabling reliable interpolation within the tested range. The steeper slope for shear strength (-0.0245) compared to compressive strength (-0.0195) confirms that joint thickness has a more pronounced effect on lateral load resistance than vertical load capacity.

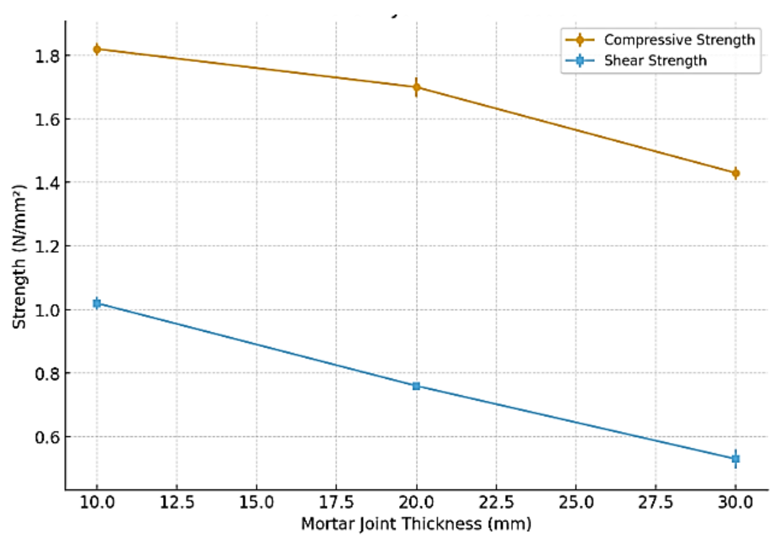

Fig 04. Comparison of mean mechanical properties with 95% confidence intervals for different joint thicknesses.

5 DISCUSSION

5.1 Mechanical Performance Trends

The observed inverse relationship between joint thickness and mechanical properties reflects fundamental differences in stress distribution and failure mechanisms. Thinner joints provide more effective load transfer between masonry units, maintaining structural continuity and minimizing stress concentrations. The superior performance of 10 mm joints suggests optimal balance between mortar volume and stress transfer efficiency.

The greater sensitivity of shear strength to joint thickness (48.0% reduction vs. 21.4% for compressive strength) indicates that lateral load resistance is more critically dependent on joint geometry. This finding has significant implications for seismic design and wind load resistance in masonry structures, where shear capacity often governs structural adequacy. The experimental data demonstrate strong linear correlations between joint thickness and mechanical properties, as quantified in Fig 05.

5.2 Failure Mechanism Analysis

Visual examination of failed specimens revealed distinct failure patterns corresponding to joint thickness. Specimens with 10 mm joints typically failed through brick crushing or tensile splitting, indicating that joint strength exceeded brick capacity. In contrast, 20 mm and 30 mm specimens predominantly failed through mortar joint separation or sliding, demonstrating that joint strength became the limiting factor.

These observations confirm that optimal joint thickness should match or exceed the strength characteristics of masonry units while minimizing joint volume. The transition from brick-dominated to joint-dominated failure suggests a critical threshold between 10-20 mm for the materials and conditions investigated.

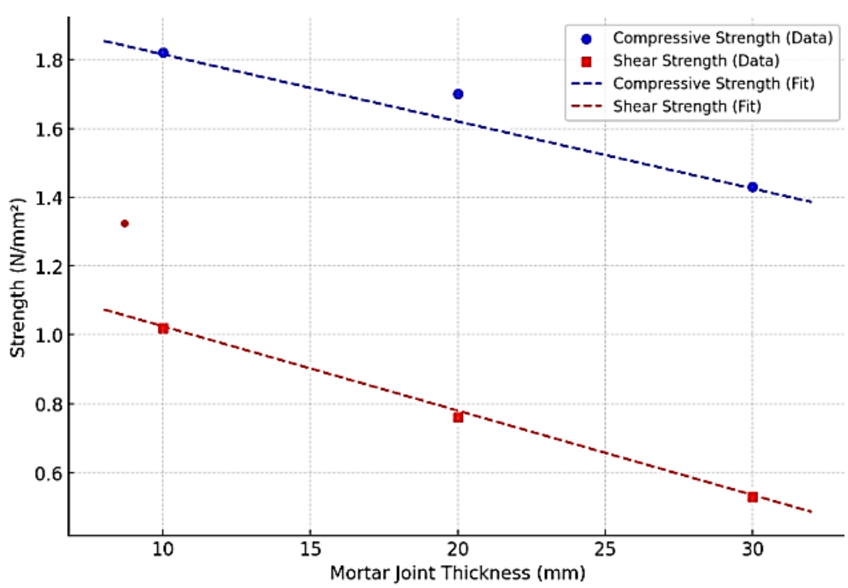

Fig 05. Linear regression relationships between joint thickness and mechanical properties.

5.3 Implications for Design Practice

The quantitative relationships established in this study provide direct guidance for masonry design optimization. The 27% improvement in compressive strength and 92% improvement in shear strength achieved through optimal joint thickness selection represents substantial structural and economic benefits.

JRTE©2026

Current construction practices often employ joint thicknesses of 15-25 mm based on workability considerations rather than structural optimization. The findings suggest that increased attention to joint thickness control during construction could yield significant performance improvements without material cost penalties.

5.4 Limitations and Future Research

This investigation focused on specific material combinations and loading conditions. Future research should examine the interaction between joint thickness and factors such as mortar strength, brick properties, and long-term durability. Additionally, investigation of dynamic loading conditions and environmental effects would enhance the practical applicability of these findings.

The study was limited to normal strength materials commonly used in residential construction. High-strength applications and specialized masonry systems may exhibit different sensitivity to joint thickness effects, warranting additional investigation.

6. CONCLUSION

This experimental investigation provides comprehensive quantitative data on the relationship between mortar joint thickness and mechanical properties of clay brick masonry walls. Key findings include;

1. Optimal Joint Thickness: The 10 mm joint configuration provides superior mechanical performance, achieving 27% higher compressive strength and 92% higher shear strength compared to 30 mm joints.
2. Quantitative Relationships: Linear relationships between joint thickness and strength properties enable predictive design calculations and optimization studies.
3. Failure Mechanism Insights: Joint thickness influences failure modes, with thin joints promoting brick failure (indicating effective joint performance) while thick joints fail through joint separation.
4. Statistical Validation: ANOVA analysis confirms statistically significant differences between all thickness groups, validating the practical importance of joint thickness selection.
5. Design Implications: The findings support revision of construction practices to emphasize joint thickness control as a critical parameter for structural optimization.

The research contributes essential data for evidence-based masonry design and provides quantitative justification for construction quality control measures. The established relationships between joint thickness and mechanical properties offer practical tools for structural engineers and construction professionals seeking to optimize masonry performance.

Future investigations should examine the interaction between joint thickness and factors such as mortar composition, environmental conditions, and long-term durability to further enhance the practical applicability of these findings. The demonstrated benefits of optimized joint thickness warrant incorporation into construction standards and training programs for masonry professionals.

ACKNOWLEDGMENT

The authors acknowledge the technical support provided by laboratory staff and the materials suppliers who contributed to this research.

JRTE©2026

References

[1] S. Phaiju and P. M. Pradhan, "Experimental work for mechanical properties of brick and masonry panel," *J. Sci. Eng.*, vol. 5, pp. 51-57, 2018.

[2] K. M. C. Konthesingha, C. Jayasinghe, and S. M. A. Nanayakkara, "Bond and compressive strength of masonry for locally available bricks," *Engineer: J. Inst. Engineers, Sri Lanka*, vol. 40, no. 4, p. 7, 2007.

[3] B. Zengin et al., "The effect of mortar type and joint thickness on mechanical properties of conventional masonry walls," *Struct. Eng. Mech.*, vol. 67, no. 6, pp. 579-585, 2018.

[4] J. A. Thamboo and M. Dhanasekar, "A comparative study of the compression behavior of thin layer mortared and conventional masonry," in *Proc. 16th Int. Brick Block Masonry Conf.*, 2016.

[5] J. A. Thamboo and M. Dhanasekar, "Characterization of thin layer polymer cement mortared concrete masonry bond," *Constr. Build. Mater.*, vol. 82, pp. 71-80, 2015.

[6] B. Zengin, B. Toydemir, and A. Koçak, "The effect of material type and joint thickness on wall behavior in conventional masonry walls," *Can. J. Civil Eng.*, vol. 47, no. 6, pp. 729-735, 2020.

[7] Z. Zhang et al., "A review of studies on bricks using alternative materials and approaches," *Constr. Build. Mater.*, vol. 188, pp. 1101-1118, 2018.

[8] A. A. Shubbar et al., "Future of clay-based construction materials—A review," *Constr. Build. Mater.*, vol. 210, pp. 172-187, 2019.

[9] S. M. Basutkar et al., "Mortars for thin joint masonry utilizing recycled materials for sustainability and circularity," *CRC Press*, 2025.

[10] R. Asghar et al., "Promoting the green construction: Scientometric review on the mechanical and structural performance of geopolymer concrete," *Constr. Build. Mater.*, vol. 368, p. 130502, 2023.

[11] N. Sharma, D. Telang, and B. Rath, "A review on strength of clay brick masonry," *Int. J. Res. Appl. Sci. Eng. Technol.*, vol. 5, pp. 2620-2626, 2017.

[12] D. Yalcin, "Shear testing essentials," *ResearchGate*, 2019. [Online]. Available: https://www.researchgate.net/publication/341358543_Shear_Testing_Essentials

[13] Q. Afzal et al., "Characterization of sustainable interlocking burnt clay brick wall panels: An alternative to conventional bricks," *Constr. Build. Mater.*, vol. 231, p. 117190, 2020.

[14] D. D. Ahiwale et al., "FEM analysis of the effect of various brick bond patterns on masonry walls under in-plane cyclic loading," *Asian J. Civil Eng.*, vol. 24, no. 7, pp. 2629-2643, 2023.

JRTE©2026