Journal of Engineering Research and Application
https://dx.doi.org./10.55953/JERA.2025.02
Volume 4, July 2025
pp 15- 17

Exprimental study on concrete brick masonry

Ajay Pratap[1]
[1] Research Scholar, Dr. B. R. Ambedkar Natioanl Institute of Technology, Jalandhar
e-mail: ajayp839gmail.com

***Abstract*— This study presents the nonlinear stress-strain behavior and failure mechanisms of concrete brick masonry and its components, under compression and shear forces. Experimental investigations were conducted to derive simple relationships for estimating the modulus of elasticity of concrete brick masonry prisms based on their compressive strength. Shear strength and shear modulus of the masonry were determined by testing masonry wallets of scaled sizes. A parametric analysis was performed to assess the influence of the compressive strength of brick masonry prisms on the shear strength of masonry wallets.**

***Keywords*— Concrete brick, mortar, Masonry prism, Compression test, Tension test**

I. Introduction

Masonry walls are commonly used in construction for load bearing, cladding, and partitioning due to the availability of materials and ease of construction. Their strength and stiffness vary based on regional material differences, with bricks in northern India having a compressive strength of about 18 MPa, while those in southern India range from 3.2 to 11 MPa. Besides strength, brick stiffness significantly affects structural performance, especially during seismic events. Over the past three decades, extensive research has focused on understanding the nonlinear behavior of clay brick masonry **(Sarangapani et al. 2005; Kaushik et al. 2007).**

With the rise of industrial by-products, sustainable alternatives like concrete bricks are gaining popularity. These bricks, made from concrete, offer an eco-friendly solution by reducing greenhouse gas emissions associated with traditional brick firing. Although various studies have explored their manufacturing process and physical properties, their nonlinear stress-strain characteristics require further investigation**; (Singhal and Rai 2014)**.

Seismic forces subject masonry walls to flexural and shear failures. While research has been conducted on the shear strength of burnt clay brick masonry and reinforcement methods, concrete bricks brick masonry's behavior under diagonal compression needs experimental analysis.

This study investigates the nonlinear stress-strain behavior of concrete bricks masonry prisms under compression and evaluates the shear performance of masonry wallets under diagonal loading. Locally available sun-dried concrete bricks were used, with a 1:4 aggregate-to-binder ratio. The bricks were manufactured using a pan mixer and molded in an automatic machine before being sun-dried for 1–2 days and water-cured for 15–21 days to improve strength and durability.

II. Experimental Program and Test Setup

This study investigates the properties of Concrete brick masonry, including water absorption, initial rate of absorption, split tensile strength, and nonlinear compressive stress-strain behavior. Stress-strain characteristics of three grades of 50-mm mortar cubes and stack-bonded masonry prisms were evaluated under monotonic compressive loading. Masonry wallets were tested under diagonal compression to assess shear behavior.

Concrete bricks (230 × 110 × 75 mm) and masonry prisms (420 mm height) with 10–12 mm mortar joints were tested using a 2000 kN HEICO Compression testing machine (CTM). The modulus of elasticity was calculated using the secant slope method, considering strain between 5% and 33% of maximum compressive strength. Deformations were measured with the installation of dial gauge reading. Stress-strain curves were derived using the double averaging method, excluding outliers for accuracy.

III. Result and Discussion

A. Study on concrete brick units

This study evaluates the properties of concrete brick units, including water absorption (WA), initial rate of absorption (IRA), compressive strength, and split tensile strength. The standard size of the brick units was 230 × 110 × 75 mm. WA was measured as per **IS 3495 (BIS 1992b)**, while the IRA was tested by immersing bricks in a 3-mm-deep water bath for 1 minute, following **ASTM C67-13** guidelines. WA results ranged from 17.5% to 19%, averaging 18.3%, which complies with the 20% maximum limit set by **IS 12894 (BIS 2002)**.

Compressive strength was determined by testing three brick specimens under direct compression, in line with **ASTM C67-13** and **IS 3495 (BIS 1992a)**. The brick units were placed with their frog-filled face toward the loading surface between soft plywood sheets and subjected to uniaxial monotonic loading. Compressive strength values ranged between 10.5 MPa and 12.5 MPa, with an average of 11.5 MPa. Vertical splitting cracks initiated at the brick edges and extended to the center before failure.

For split tensile strength, tests were conducted as per **ASTM C1006-07** by applying compressive line loads using bearing rods. The average split tensile strength of the brick units was approximately 0.5 MPa, representing about 9% of

www.jera.co.in
ISSN2583-3987

the average compressive strength, with a coefficient of variation of 0.18.

Fig. 1.1 Compressive and tensile test of concrete brick unit.

B. *Compression Test*

Compressive strength of masonry was determined by applying a uniaxial load in the direction perpendicular to the bed joints of the stack bonded prism. Five full size bricks of size 230x110x75 mm were constructed in stack bond in accordance with **IS 1902** and tested under uniaxial compression test. The bricks were bonded with the help of 1:3 grade mortar and considered for both tensile and compressive tests specimens, see **Figs. 1.2**. The thickness of each joint is kept 12 mm, see **Fig. 1.2**. The compression test on masonry has been performed in HEICO Compression testing machine of 2000 kN capacity. Three samples of concrete masonry prism have been taken. The compressive stress-strain curve were obtained from all three experimental tests. See **Fig 1.3.** Compressive strength values ranged between 4.3 MPa and 6.9 MPa, with an average of 5.7 MPa.The density and Young's modulus of the concrete prism assemblage wass measured through simple tests whereas the poission's ratio of the concrete prism was assumed as 0.18 see Table 1.

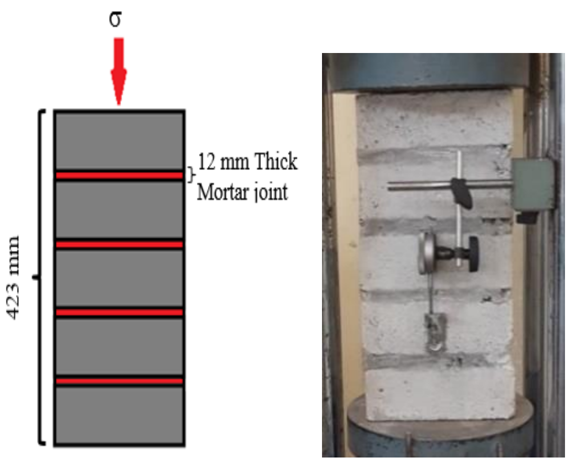

Fig 1.2. Stack bonded prism of schematic and testing arrangement.

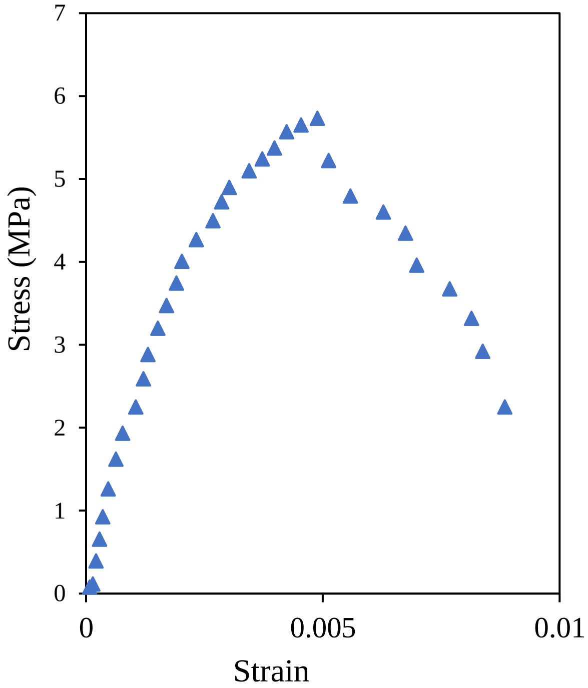

Fig. 1.3. Stress strain curve for concrete brick masonry against Compression.

Table 1. Elastic property of concrete brick assemblage

Density	Young's modulus	Poisson's ratio
2200 kg/m3	2562 N/mm2	0.18

C. *Digonal Tension Test*

The size of the specimen was reduced to $^{1}/_{3rd}$ of the standard size (1.2mx1.2m) due to unavailability of equipment for testing and the specimen were constructed in the Concrete Structures Laboratory, Deaprtment of Civil Engineering, see **Fig. 1.4 (a), (b).** In accordance with **ASTM E519**, tension test assemblages with 4 units high and $1\frac{1}{2}$ long were prepared with running bond and tested diagonally. Further the values were normalized as specified in **Basha & Kaushik (2015); Singhal and Rai (2015)** such that it can be utilized for the modelling of concrete walls. Various interpretations (ASTM 2010) are available in the literature to evaluate the masonry shear strength from diagonal compression tests. The standard interpretation of the test assumes that the state of stress at the center of the panel is of pure shear and that the shear stress is equal to themaximum principal tensile strength under diagonal compression. Following the standard interpretation, **ASTM (2010)** proposed. Eqs. (1) and (2) to determine the shear strength (V) and shear strain(γ), respectively, for masonry wallettes.

$V=0.707P/A_n$ Equation 1

$\gamma = (\Delta V+\Delta H)/g$ Equation 2

where A_n is the net area calculated as the average of the width and height of the specimen times its thickness and ΔV, ΔH are displacement of digonal assemblages along horizontal and vertical direction, g is the length of masonry wallets measured digonally.

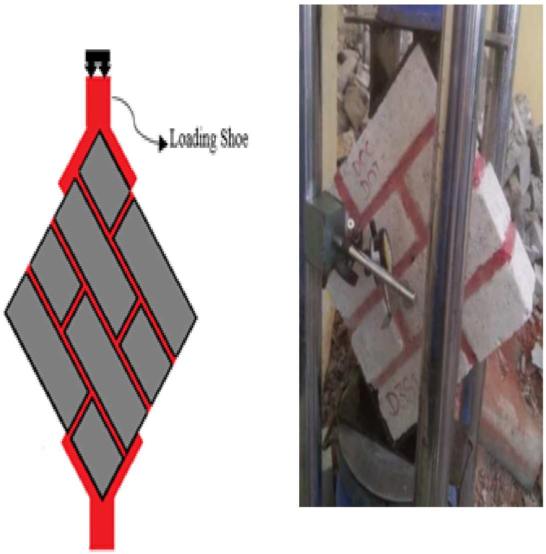

Fig 1.4. Diagonal test assemblage of (a) schematic and (b) testing arrangement.

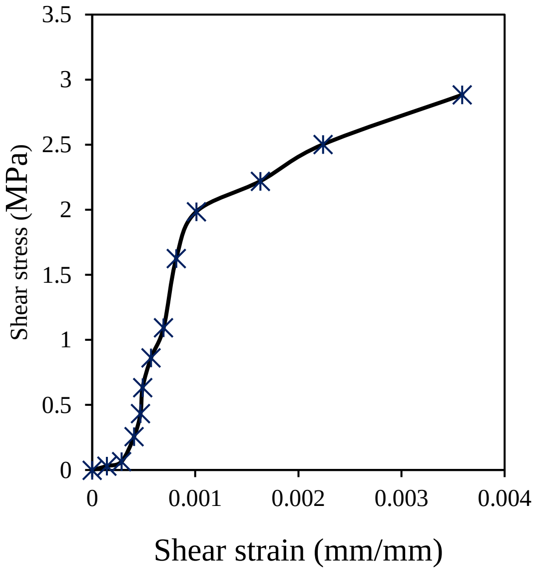

Fig. 3.7. Stress strain curve for concrete brick masonry against (a) Compression (b) Tension tests.

IV. CONSLUSION

Around 30 specimens, including concrete bricks, mortar cubes, masonry prisms, and masonry wallettes, were tested under monotonic and diagonal compressive loads using a CTM to analyze the nonlinear behavior of masonry built with mortar in comparison to bricks. The average water absorption (WA) of brick units was 18.3%, higher than that of traditional burnt clay bricks, while the initial rate of absorption (IRA) averaged 5.1 kg/m²/min, exceeding the specified limits for burnt clay bricks. Failure modes in masonry prisms indicated that a strong bond could be achieved with the use of higher-grade mortar. The average shear modulus of specimens was roughly 0.27 times the elastic modulus of the corresponding masonry prisms. A strong correlation was observed between masonry shear strength and the compressive strength of both bricks and masonry prisms. The findings highlight the need for careful design and construction when using softer and weaker bricks compared to mortar, as their behavior significantly differs from conventional masonry made with stronger and stiffer bricks.

REFERENCES

[1] Kaushik, H. B., Rai, D. C., and Jain, S. K. (2007). "Stress-strain characteristics of clay brick masonry under uniaxial compression." J. Mater. Civ. Eng., 10.1061/(ASCE)0899-1561(2007)19:9(728), 728–739..

[2] Sarangapani, G., Venkatarama Reddy, B. V., and Jagadish, K. S. (2005). "Brick-mortar bond and masonry compressive strength." J. Mater. Civ. Eng., 10.1061/(ASCE)0899-1561(2005)17:2(229), 229–237.

[3] Singhal, V., and Rai, D. C. (2014). "Suitability of half scale burnt clay bricks for shake table tests on masonry walls." J. Mater. Civ. Eng., 10.1061/(ASCE)MT.1943-5533.0000861, 644–657.

[4] Bureau of Indian Standards (BIS). (1992a). "Indian standard methods of test of burn clay building bricks—Part 1: Determination of compressive strength." IS 3495, Third Revision, New Delhi, India.

[5] Bureau of Indian Standards (BIS). (1992b). "Indian standard methods of test of burn clay building bricks—Part 2: Determination of water absorption." IS 3495, Third Revision, New Delhi, India.

[6] Bureau of Indian Standards (BIS). (2002). "Indian standard pulverized fuel ash-lime bricks—Specification." IS 12894, First Revision, New Delhi, India..

[7] ASTM. (2013b). "Standard test methods for sampling and testing brick and structural clay tile." C67-13, West Conshohocken, PA.

[8] ASTM. (2007). "Standard test method for splitting tensile strength of masonry units." C1006-07, West Conshohocken, PA.

[9] IS : 1920 – 1987, Indian standard code of practice-specification for hemp lines, Bureau of Indian Standards, New Delhi, India.

[10] ASTM E519(2015), American Society for Testing and Materials, Standard Test Method for Diagonal Tension (Shear) in Masonry Assemblages, ASTM International, USA.

[11] Basha ,S.H., Kaushik, H.B.: Evaluation of nonlinear material properties of fly ash brick masonry under compression and shear. Journal of Materials in Civil Engineering 27(8), (2015). doi:10.1061/(asce)mt.1943-5533.0001188.

[12] Singhal,V., Rai,D.C.: Suitability of Half-Scale Burnt Clay Bricks for Shake Table Tests on Masonry Walls. Journal of Materials in Civil Engineering 26(4), 548-560(2015).