REVISTAMATÉRIA V.28 N.01
ISSN 1517-7076 articles e20220260, 2023

Influence of strength behavior in brick masonry prism and wallette under compression

Soundar Rajan M[1], Jegatheeswaran D[2]

[1]Sengunthar Engineering College, Civil Engineering, Namakkal, Tamilnadu 637205, India.
[2]Sona College of Technology, Civil Engineering, Salem, Tamilnadu 636005, India.
e-mail: soundarrajan06@gmail.com, profdjpillai@gmail.com

ABSTRACT

For decades, prisms and wallette have been used to explore masonry's strength and deformation capabilities under uniaxial compression; moreover, the link between these two main test methods needs to be better established. Using standard masonry design expressions and data, the prism or wallette test can determine compression qualities. The researchers compared the standards and came to judgments on their conservatism or lack thereof, independent of how the rules for those design standards were formed. As a result, an attempt was made to link the behaviour of the enormous masonry prism to the wallette pressure behaviour. Prisms and wallette were made and tested by three different types of units and three mortar compositions. According to test results, the compressive strength of prism tests is consistently higher than that of identical wallette samples. It has remained demonstrated that a linear relationship concerning the compressive strengths of prisms and wallette is tolerable. To test data from the prisms and wallette, a simplified analytical model for the deformation properties of masonry is given.

Keywords: Strength under Compression; Initial Rate of Absorption; Peak Strain; Ductility.

1. INTRODUCTION

Masonry has traditionally been a frequent and profitable potential of cladding and load-bearing structures. Today, it constitutes a vast share of global constructions regularly of ancient and cultural significance. Masonry is a heterogeneous cloth with a complex, nonlinear, anisotropic behavior which can be attributed to the unique fabric elements and the great interfaces. For centuries, masonry used to be specific with lime mortars. However, as most limes construct energy slowly via carbonation, they have been superseded; first by using hydraulic limes and then via Portland cement which rapidly develops strength on hydration. However, over two decades, there has been a renewed focus on using hydrated and hydraulic lime mortars for repairs and new buildings. The experience of masonry energy and deformation traits is vital as these decide overall masonry performance over time and allowable stress and stiffness in diagram codes for new buildings [1].

The final years witnessed considerable advances in masonry mechanics, each with recognition of experimental trying out and numerical modelling. Despite this, the composite behavior of whole concrete block masonry nevertheless represents a genuine challenge. Hollow concrete blocks are constructions constituted by thin walls that interact between themselves and usually feature one-of-a-kind geometries. Besides the difficulties in symbolizing the mechanical property of mortar internal the composite, the mechanical strength of the concrete from the blocks are commonly no longer known because the checks are carried out on entire blocks [2]. The strength of masonry under compression is a fundamental property in the design of masonry structures. Although test specimens of wall panels for determining the compressive strength of masonry as per AS3700 of stack bonded prisms tests. The compression behaviour of masonry prisms depends on the thickness of mortar joints, the stiffness of masonry units and mortar, and the units' shape [3].

Bond properties are essential for masonry walls' integrity, serviceability, and flexural and shear response. Various investigations address improving the bond between the masonry assemblies and the mortar layers. The method of bond improvement commences as quickly as the clean mortar is utilized on the masonry units. The absorption of mortar fluids precedes the cement compounds' subsequent placement into the masonry unit and the consequential transport of mortar fines in the joint to the mortar unit interface [4]. The laboratory-constructed prisms were tested, and predictive expressions touching masonry compressive

Corresponding Author: Soundar Rajan M Received on 12/10/2022 Accepted on 07/12/2022

DOI: https://doi.org/10.1590/1517-7076-RMAT-2022-0260

strength to the constituent ingredient compressive strengths and the masonry modulus of elasticity were developed based on the experimental results. Masonry compression stress-strain numerical fashions have been additionally developed to predict masonry stress-strain behaviour [5, 6].

In-plane shear strength of unreinforced masonry partitions relies upon in most cases, shear/tensile bond strength, issue ratio and pre-compression levels; compressive strength of masonry solely influences when the last failure is dominated. Failure of traditional unreinforced masonry shear partitions is characterized by brittle tensile/shear cracking via the susceptible bond between the unit and mortar [7]. The important mechanical properties of masonry partitions are the compression, tensile, flexural and shear strengths. Of these properties, the most essential is the compression strength because, in general, masonry partitions are submitted to greater excessive vertical load than horizontal load produced through wind or seismic activity. Concrete hollow block masonry buildings are currently being used conspicuously in many parts of the world. There is an urgent need to conquer experimental and numerical information of special bonding preparations [8].

As mentioned, figuring out the last strength has been a primary study of masonry studies. Some of the troubles that also want explanation consist of the implicit assumption that masonry failure takes place on the last strength and that there may be no enormous distinction between masonry built with a susceptible and a sturdy mortar. The observation herein indicates that the failure mechanism of whole concrete block masonry is a chain of consecutive outcomes and is no longer an unmarried last event. The observation indicates that masonry failure relies upon the relative strength of the mortar and block. This expertise might also assist engineers in deciding a preferred overall performance degree for their masonry shape in place of, without a doubt the last strength and very last mode of failure [9, 10]. Irrespective of the share of reinforcement, no proof of yielding of the steel bar steel bar with confining detail may be determined in the literature; this suggests that the confining factors used to date showcase very restricted cracking till the fall apart of the masonry, even though the masonry energy is superior through the confining factors. Since there's clean proof within the literature that the steel bar with confining factors no longer take part significantly in this research and most uncomplicated and not using a shear tie has been used [11, 12].

Containment of cement-based materials is typically done using ribbons, spirals, or circular hoops. Such a configuration is usually very long in cross-section in one dimension and challenging to achieve with relatively thin masonry walls in the other dimension. For masonry, one approach to inclusion is to use thin galvanized steel sheets placed at the mortar joints during construction. Boundary plates serve the same purpose as the lateral rebar of standard concrete components. As the compressive strain of the masonry increases, the masonry grows, and the tensile strain of the panel upturns. Next, the masonry is in a 3-axis compressed state, improving the strength and elasticity of the masonry [13, 14]. Given the importance of seismic action and the potential seismic susceptibility of masonry structures, an essential part of these efforts will be devoted to numerical simulations of masonry rupture under tensile and shear forces [15, 16]. Due to changes in regulations and use, masonry buildings often require structural reassessment and possibly retrofit measures. In this context, the compressive response of masonry plays a decisive role in evaluating the strength of masonry buildings concerning both the effects of vertical loads caused by vertical and horizontal actions. The response properties of masonry to compression include determining parameters such as the compressive strength, modulus of elasticity, and general curve of compressive deformation under static and cyclic loading of the composite material [17, 18].

2. EXPERIMENTAL PROGRAM

2.1. Materials

A set of three different types of units and three types of mortar compositions were used to construct the specimens. These masonry units have been deliberately chosen to cover a range of geometric dimensions and strengths. This work used three types of mortar compositions to construct the samples in combination with five different types of units as per codes [19–22]. The cement-sand ratios of M1:3, M1:4 and M1:5 was used for the mortar mix as per IS 269. The properties of six samples with different cement mortar compositions are shown in Table 1. The Geometric property values of the units are shown in Table 2. Clay bricks are entitled in the subsequent descriptions C.B. charted by their sequential figure. Six samples were cast, tested and analyzed to determine the properties.

2.2. Testing methodology

The Bureau of Indian Standards codes [23] commends the examination of masonry prisms of least 40 cm in height with height-to-thickness proportion in the middle of 2 to 5 for defining the strength of the masonry under compression behaviour. The British standard [24] commends the analysis of masonry panels of range between

Table 1: Properties of cement mortar compositions as per IS 269.

DESCRIPTION	M1:3	M1:5
Density (kg/m^3)	1900	1800
Water absorption (%)	8.6	8.5
Compressive strength (MPa)	6.5	4.2
Flexural strength (MPa)	1.15	1.02
Elastic modulus (MPa)	4500	3500

Table 2: Properties of masonry unit assembly as per IS 1905.

DESCRIPTION	CB1	CB2	CB3
Density (kg/m^3)	1900	2010	1700
Compressive strength (MPa)	5.3	15.8	3.8
Modulus of rupture (MPa)	1.83	3.66	1.26
Water absorption (%)	10.6	4.5	12.9

Table 3: Details of casted specimens.

DESCRIPTION	DIMENSIONS (l × t × h) mm	h/t RATIO
	Prism	
CB 1	225 × 150 × 490	3.27
CB 2	210 × 100 × 410	4.10
CB 3	200 × 90 × 440	4.89
	Wallette	
CB 1	460 × 150 × 490	3.27
CB 2	430 × 100 × 410	4.10
CB 3	410 × 90 × 440	4.89

1.2 to 1.8 m in length and range between 2.4 to 2.7 m in height, which wants an extravagant test setup. Hence, masonry Wallets of size are part of the masonry prisms and masonry wall panels that have been tried out in this examination. The intention of taking such mortar compositions is to analyze the consequence of maximum strength-stiff mortar and minimum strength-soft mortar on the strength of masonry under compression behaviour. The wallets would characterize the behaviour of walls superior to prisms due to the occurrence of joints [25]. In this study, 30 prism and 20 wallette samples were designed and tested for the three different dimensions and with three cement mortar combinations to evaluate the strength and strain behavior of the masonry under compression. The complete test matrix and sample dimensions are given in Table 3.

The dimensions and the number of courses between the combinations varied since their units' dimensions differed. However, the relationship between the height and thickness of the prisms and the corresponding wallettes remained the same for each combination. The prisms were built and tested in accordance with ASTM C1314-16 and illustrate similar prism test methods for evaluating the compressive strength of masonry. The sample specimens were evaluated under the steady state in a Universal Testing Machine of 600kN capacity. A thin 3 mm plywood sheet was positioned on top and bottom of the sample specimen overloaded in the middle of 25 mm thick steel plates. The sample Wallets were evaluated by insertion them in a self-pulling loading frame and loaded using hydraulic jacks with capabilities of 500kN and 1000kN. The schematic diagram of the test setup for Prism/Wallets is shown in the Figures 1 and 2. Displacement transducers were attached to the samples to record the vertical deformation of the prisms and wallets under compression.

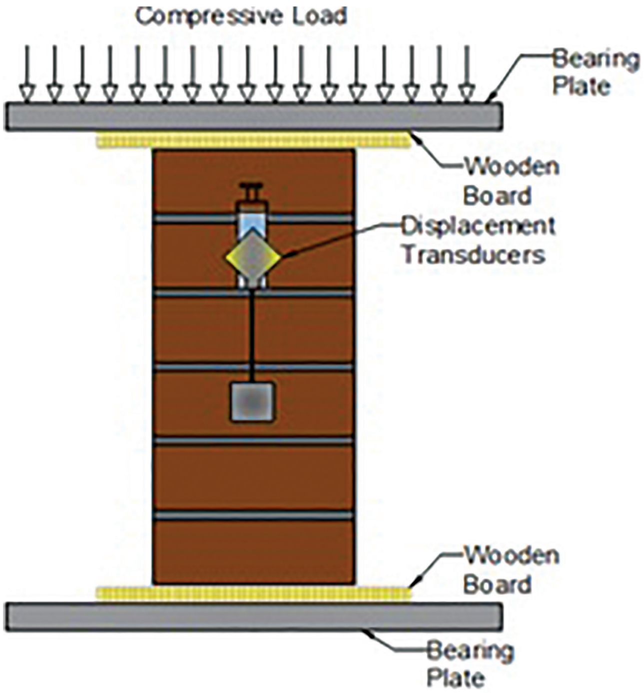

Figure 1: Test setup for masonry prism.

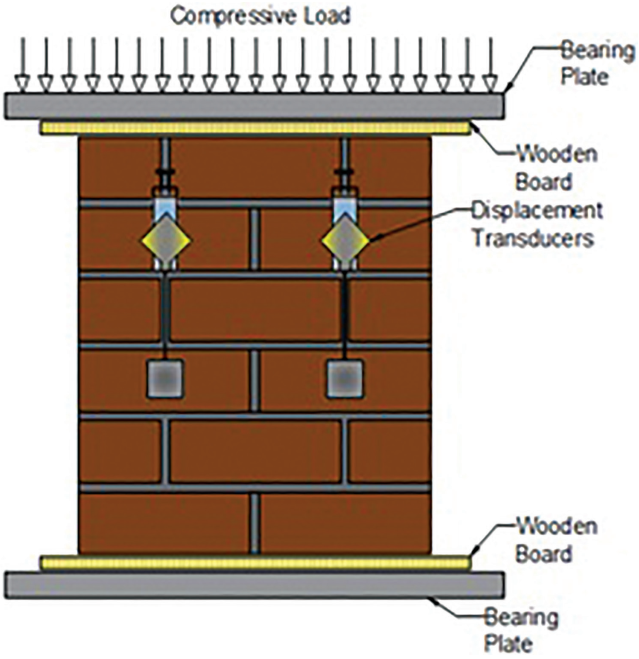

Figure 2: Test setup for masonry wallette.

The measurement of the mean deformation was carried out to eliminate possible eccentricities in the direction of the height and thickness of the samples. Loads and displacements were measured and recorded with a synchronized data acquisition system. The deformation measurements were carried out in the three test pieces [26].

3. RESULT AND DISCUSSIONS

3.1. Compressive strength

The strength of the prisms and Wallets in compression was determined under a uniaxial pressure load arrangement. The average compressive strengths of the tested prisms and wallets are given in Table 4 and graphical representation format as shown in Figures 3 and 4. Uniform strength has dominated the compressive strength of wall prisms and wallets. However, a slight increase in the compressive strength of the masonry prisms and wallets while changing the strength of the mortar was caused. Therefore, the results authenticate that the compressive strength of mortar has a negligible influence on the compressive strength of masonry, which is consistent with the results of preceding studies [27]. In some cases, high-strength bonding can cause block failure. The thin mortar layer and high adhesion contributed to increasing the compressive strength of the bricks due to the low lateral expansion of the mortar layer [28].

In the combinations tested, it can be seen that the compressive strength of the prism is higher than that of the wallette. Prism-to-wallette compressive strength ratios range from 1.05 to 1.26, depending on the ratio of filler to mortar. Although the lowest and highest ratios were recorded for the CB1 (M1:3) and CB3 (M1:3) mortar combinations, the reason for the discrepancy in strength values of the prism and wallette cannot be explained

Table 4: Compressive strength of specimens.

DESCRIPTION	CATEGORY	MEAN COMPRESSIVE STRENGTH	
		M1:3	M1:5
CB 1	Prism	2.35	2.18
	Wallette	1.75	1.59
CB 2	Prism	7.47	6.92
	Wallette	6.65	6.25
CB 3	Prism	1.58	1.31
	Wallette	1.32	1.18

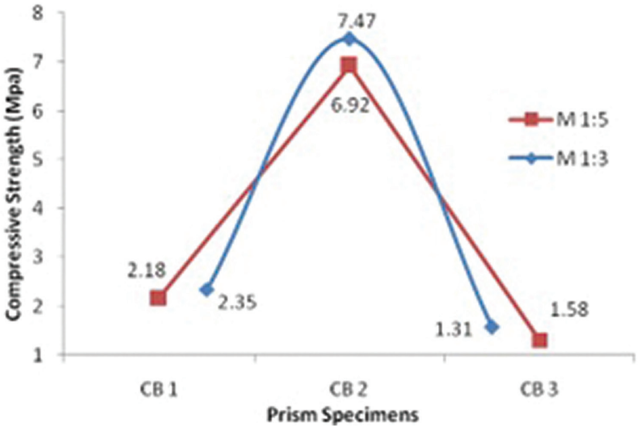

Figure 3: Compressive strength of masonry prism.

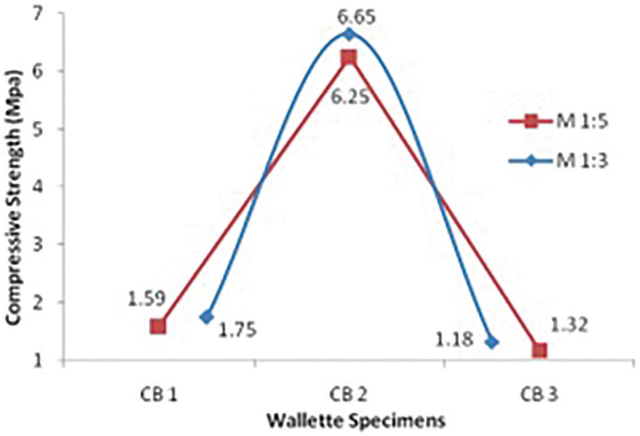

Figure 4: Compressive strength of masonry wallette.

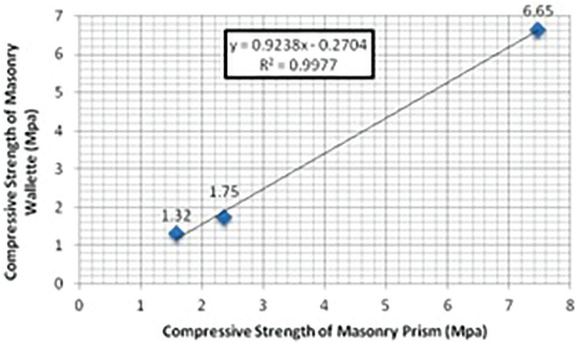

Figure 5: Correlation between compressive strength of masonry prism and wallettes (M1:3).

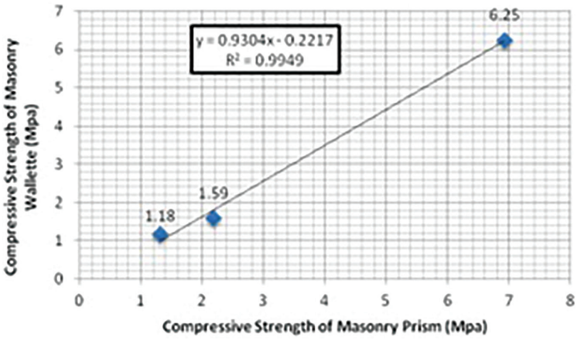

Figure 6: Correlation between compressive strength of masonry prism and wallettes (M1:5).

as there may be inherent differences. However, evaluation of the compressive strength of masonry has been reported in many studies in the past and has behaviored limited research on prism and wallette testing methods. The specimens exhibited a quasi-linear behaviour for a low load level and reduced their stiffness when they exceeded approximately 50% of the maximum load [29]. The equation arrived from the correlation between the compressive strength of Masonry prisms and wallettes Mortar Mix. The correlation between compressive strength of masonry prism and wallette graphical figure is shown in Figures 5 and 6.

$$\text{For Mix M1:3 } Y = 0.9238x - 0.2704$$

$$R^2 = 0.9947$$

$$\text{For Mix M1:5 } Y = 0.9304x - 0.2217$$

$$R^2 = 0.9949$$

3.2. Stress strain curve

The axial stress values were calculated by dividing the recorded axial displacements by the gauge length (usually more than one-third of the sample height). The matching stress values from the load measurement were fitted to record the deformation of the stress curves of the sample. Under uniaxial compression, both masonry prisms and Wallets displayed quasi-brittle behaviour.

All samples had a nearly linear stress-strain response until they reached 25 to 50 per cent of their breaking strength, then a nonlinear pattern until the break was detected and it was shown in the Figures 7–9. The emergence of vertical fissures in the specimens was primarily responsible for their nonlinear behaviour. As a result, the elasticity modulus of the bricks CB1, CB2, and CB3 is 750 MPa, 5300 MPa, and 1500 MPa, respectively. As a result, the brick's strength and deformation qualities have significantly impacted the masonry's overall stress-strain behaviour. The stress-strain curves of the samples were impacted by the type of mortar used, particularly beyond the linear elastic portions of the curves. The M1:5 mortar ratio has a lesser compressibility than other mortar ratios. Furthermore, there was no apparent separation between the samples in the lower half of the stress-strain curves. In most cases, the testing was stopped because the samples were significantly damaged, posing a risk to the apparatus.

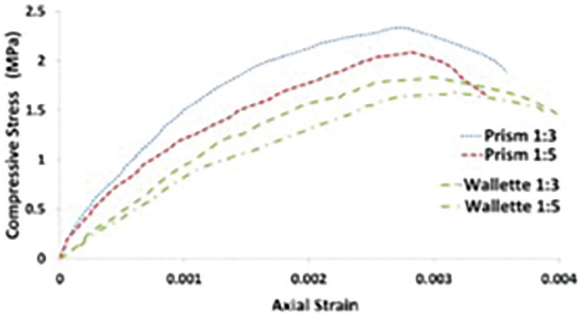

Figure 7: Stress – strain curve for CB1 type prism and wallette.

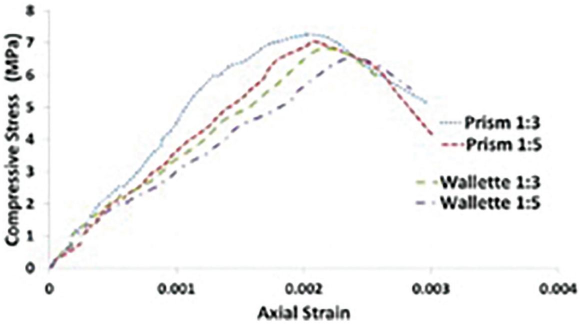

Figure 8: Stress – strain curve for CB2 type prism and wallette.

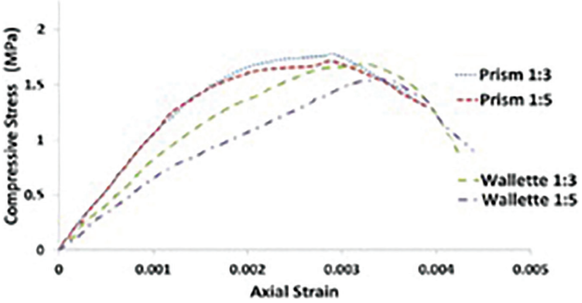

Figure 9: Stress – strain curve for CB3 type prism and wallette.

As a result, the stress-strain curves' whole downward regions need to be adequately recorded. The compressibility of the Wallets is higher than that of the matching prisms, as observed. Where the prisms are solely in a stacked bond, including bed joints and pre-mortar in Wallets, has enhanced axial deformability. At one-third of the maximum stress of the samples, the modulus of elasticity of the prisms and wallets was calculated and tabulated in Table 5. The corresponding strain measured at one-third of maximum tension is called elastic elongation. The maximum strain of the investigated samples was calculated based on their maximum stress. Simultaneously, the relatively elastic and peak strain shown in Tables 6 and 7 are observed and listed. The strain at break was calculated based on 80% of the post-peak stress. The stress-strain curve, modelled as an elastic-perfect-plastic curve, was used to determine the elasticity of the prisms and wallet [30, 31]. The intersection point of the bilinear approximation corresponds to the yield strain. The mortar proportion may not affect the elasticity modulus of the brickwork and its characteristics. This is especially true for the low-strength brick-and-mortar combinations studied in this study.

Because ductility is defined as the link between strain at break and elastic limit, there was no systematic difference in ductility tested between prisms and Wallets; the ductility values listed in Table 8 support this conclusion. Consequently, averaging the ten possibilities yielded a value of 1.7 for the elasticity of the brickwork evaluated under pressure in this investigation. It should be noted, however, that every other standard data, with the exception, is based on prism testing. As a result of the findings of this study, the relationships between the modulus of elasticity and the compressive strength of prisms and Wallets have been established and are depicted

Table 5: Elastic modulus of tested specimens.

DESCRIPTION	CATEGORY	ELASTIC MODULUS (MPA)	
		M1:3	M1:5
CB 1	Prism	1880	1567
	Wallette	996	839
CB 2	Prism	4989	4912
	Wallette	3962	3705
CB 3	Prism	1035	933
	Wallette	696	506

Table 6: Elastic strain of tested specimens.

DESCRIPTION	CATEGORY	ELASTIC STRAIN	
		M1:3	M1:5
CB 1	Prism	0.00039	0.00043
	Wallette	0.00058	0.00065
CB 2	Prism	0.00041	0.00043
	Wallette	0.00049	0.00054
CB 3	Prism	0.00045	0.00051
	Wallette	0.00063	0.00087

Table 7: Peak strain of tested specimens.

DESCRIPTION	CATEGORY	PEAK STRAIN	
		M1:3	M1:5
CB 1	Prism	0.0028	0.0028
	Wallette	0.0030	0.0031
CB 2	Prism	0.0020	0.0021
	Wallette	0.0023	0.0025
CB 3	Prism	0.0030	0.0032
	Wallette	0.0033	0.0035

Table 8: Ductility of tested specimens.

DESCRIPTION	CATEGORY	DUCTILITY		AVERAGE DUCTILITY
		M1:3	M1:5	
CB 1	Prism	1.8	1.5	1.65
	Wallette	1.7	1.8	1.75
CB 2	Prism	1.6	1.4	1.50
	Wallette	1.3	1.2	1.25
CB 3	Prism	1.9	2.1	2.00
	Wallette	2.0	1.5	1.75

and expressed in pictorial representation in Figures 10–13. For the prism and wallette combinations, excellent correlations were found. The elastic modulus of the prism is almost 34% larger than that of the comparable wallettes elastic modulus.

Furthermore, the strain peak is one of the primary characteristics that determine the stress-strain curve of brickwork under pressure (p). The maximum elongation varies between 0.002 and 0.0032 for prisms and

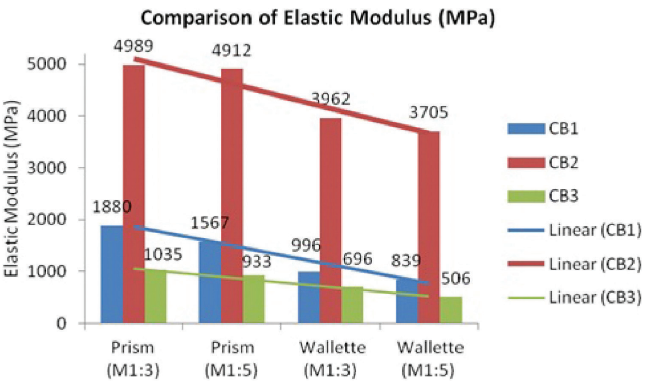

Figure 10: Comparison of elastic modulus of masonry prisms and wallette.

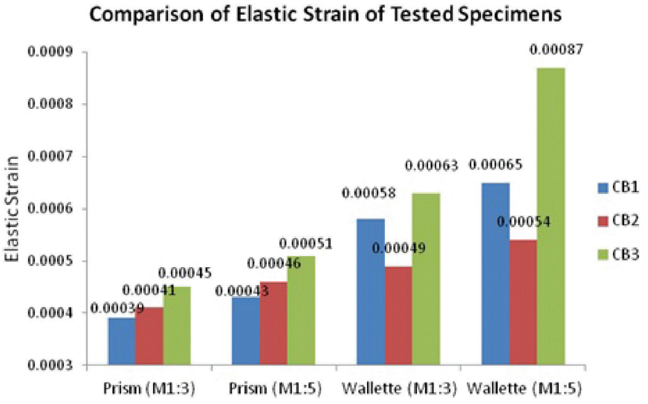

Figure 11: Comparison of elastic strain of masonry prisms and wallette.

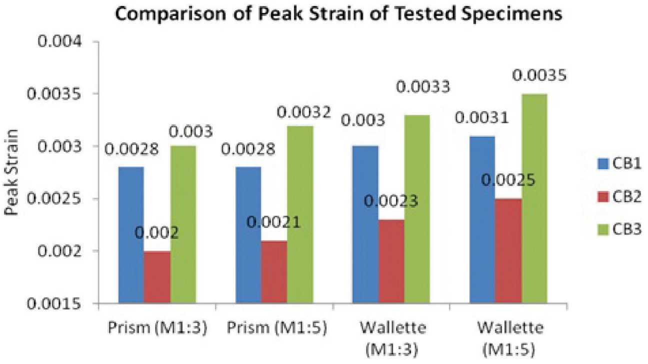

Figure 12: Comparison of peak strain of masonry prisms and wallette.

0.0023-0.0035 for wallets. As a result, various scholars have proposed formulas for calculating maximal deformations based on masonry strength, mortar strength, and modulus of elasticity [31–33].

3.3. Failure mechanisms in masonry

Failure theories established on elastic analysis have been developed for brick masonry on strain compatibility at brick–mortar interface. The theories do not interpret for nonlinear behaviour of cement mortar [26, 27]. According to these theories, the state of stress established in brick-and-mortar masonry constituents is influenced by their relative elastic properties. In Indian conditions, the bricks are moderately easier than the mortar in brick masonry. Suppose the brick–mortar interface bond remains unbroken up to the miscarriage of masonry. In that

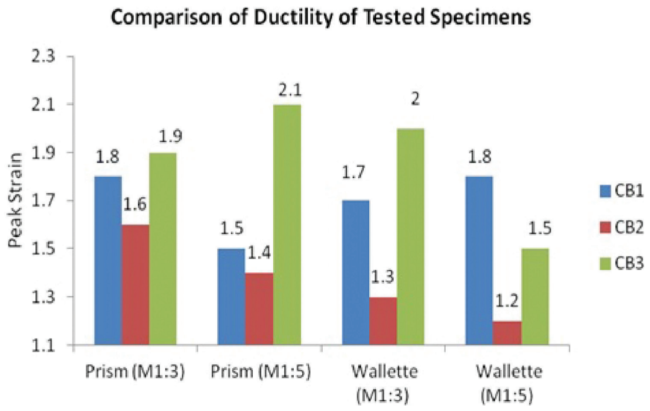

Figure 13: Comparison of ductility of masonry prisms and wallette.

case, the bricks will be beneath triaxial compression, and the mortar will be beneath uniaxial compression and bilateral tension. In such a condition, the miscarriage of masonry is started by the tensile excruciating of the mortar in the joint if the brick–mortar bond is unbroken. The mortar miscarriage will then extend to the brick, causing masonry.

The regular letdown of solid masonry under pressure is well understood from previous studies. The incompatible elastic properties of the element and the mortar cause cracks in the masonry or mortar elements parallel to the direction of loading under pressure. All prisms and Wallets failed with vertical cracks parallel to the load direction on the front and side surfaces of the specimens. Most of the time, the cracks in the mortar interfaces started around 70–85% of the final failure of the samples. For the safety of the instrumentation, the test was cancelled after the maximum load was reduced by almost 20–50% due to the samples showing severe cracks. The axial stress values were calculated by dividing the recorded axial displacements by the gauge length. The matching stress values from the load measurement were fitted to record the stress curves deformation of the sample. Under uniaxial compression, both masonry prisms and Wallets displayed quasi-brittle behaviour.

4. CONCLUSIONS

The experimental examination of masonry prisms and Wallets under uniaxial compression is presented in this article. To evaluate the strength and strain behavior, 30 prisms and 24 Wallets with three different units and three types of mortar were tested. The experimental data acquired in this inquiry can be used to derive the following findings.

- According to the empirical connection determined using linear regression analysis, the prism's compressive strength is roughly 25% more than the wallette strength. Taking the property factor into consideration, the compressive strength of the wallette may be safely estimated to be 0.67 times that of the prism why Masonry standards overstate masonry's compressive strength, mainly when low-strength units (less than 5 MPa) are applied.
- Prisms and Wallets' modulus of elasticity may be predicted using relationships based on their compressive strength. Other formulas are proposed to predict the maximum elongation of the prism and the bag under compression based on the piece and mortar's compressive strengths.
- A simple stress-strain analytical model for the ascending section of the brick prism and Wallets under pressure is provided, with a second-order polynomial function for the ascending part and a linear model for the descending part. The suggested model requires the unit and mortar compressive strengths to create the stress-strain curves.
- Using the wallette strength to prism connection presented in this publication, you may convert prism strength to wallette strength and apply design standards to incorporate it into genuine load-bearing wall construction. Solid blocks and bricks are the only materials that can be converted, while hollow block masonry supported by a shell was not considered.

BIBLIOGRAPHY

[1] COSTIGAN, S., PAVÍA, S., KINNANE, O., "An experimental evaluation of prediction models for the mechanical behaviour of unreinforced, lime-mortar masonry under compression", *Journal of Building Engineering*, v. 4, pp. 283–294, 2015. doi: http://dx.doi.org/10.1016/j.jobe.2015.10.001.

[2] BARBOSA, C.S., LOURENCO, P.B., HANAI, J.B., "On the compressive strength prediction for concrete masonry prisms", *Materials and Structures*, v. 43, n. 3, pp. 331–344, 2010. doi: http://dx.doi.org/10.1617/s11527-009-9492-0.

[3] THAMBOO, J.A., DHANASEKAR, M., YAN, C., "Effects of joint thickness, adhesion and web shells to the face shell bedded concrete masonry loaded in compression", *Australian Journal of Structural Engineering*, v. 14, n. 3, pp. 291–302, 2013. doi: http://dx.doi.org/10.7158/S12-035.2013.14.3.

[4] THAMBOO, J.A., DHANASEKAR, M., "Characterisation of thin layer polymer cement mortared concrete masonry bond", *Construction & Building Materials*, v. 82, pp. 71–80, 2015. doi: http://dx.doi.org/10.1016/j.conbuildmat.2014.12.098.

[5] LUMANTARNA, R., BIGGS, D.T., INGHAM, J.M., "Uniaxial compressive strength and stiffness of field extracted and laboratory constructed masonry prisms", *Journal of Materials in Civil Engineering*, v. 26, n. 4, pp. 567–575, 2014. doi: http://dx.doi.org/10.1061/(ASCE)MT.1943-5533.0000731.

[6] FORTES, E., PARSEKIAN, G., FONSECA, F., "Relationship between the compressive strength of concrete masonry and the compressive strength of concrete masonry units", *Journal of Materials in Civil Engineering*, v. 27, n. 9, pp. 04014238, 2015. doi: http://dx.doi.org/10.1061/(ASCE)MT.1943-5533.0001204.

[7] DHANASEKAR, M., THAMBOO, J.A., NAZIR, S., "On the in-plane shear response of the high bond strength concrete masonry walls", *Materials and Structures*, v. 50, n. 5, pp. 214, 2017. doi: http://dx.doi.org/10.1617/s11527-017-1078-7.

[8] MOHAMAD, G., LOURENCO, P.B., ROMAN, H.R., "Study of the compressive strength of concrete block prisms: stack and running bond", *Revista IBRACON de Estruturas e Materiais*, v. 4, n. 3, pp. 347–358, 2011. doi: http://dx.doi.org/10.1590/S1983-41952011000300002.

[9] MOHAMAD, G., FONSECA, F.S., VERMELTFOORT, A.T., *et al.*, "Strength, behaviour, and failure mode of hollow concrete masonry constructed with mortars of different strengths", *Construction & Building Materials*, v. 134, pp. 489–496, 2017. doi: http://dx.doi.org/10.1016/j.conbuildmat.2016.12.112.

[10] GIARETTON, M., DIZHUR, D., PORTO, F., *et al.*, "Constituent material properties of New Zealand unreinforced stone masonry buildings", *Journal of Building Engineering*, v. 4, pp. 75–85, 2015. doi: http://dx.doi.org/10.1016/j.jobe.2015.08.005.

[11] JANARAJ, T., DHANASEKAR, M., "Effectiveness of two forms of grouted reinforced confinement methods to hollow concrete masonry panels", *Journal of Materials in Civil Engineering*, v. 27, n. 12, pp. 04015038, 2015. doi: http://dx.doi.org/10.1061/(ASCE)MT.1943-5533.0001295.

[12] DHANASEKAR, M., SHRIVE, N.G., "Strength and deformation of confined and unconfined grouted concrete masonry", *Acids Structural Journal.*, v. 99, n. 6, pp. 819–826, 2002.

[13] EWING, B.D., KOWALSKY, M.J., "Compressive behaviour of unconfined and confined clay brick masonry", *Journal of Structural Engineering*, v. 130, n. 4, pp. 650–661, 2004. doi: http://dx.doi.org/10.1061/(ASCE)0733-9445(2004)130:4(650).

[14] ZAHRA, T., DHANASEKAR, M., "A generalised damage model for masonry under compression", *International Journal of Damage Mechanics*, v. 25, n. 5, pp. 629–660, 2016. doi: http://dx.doi.org/10.1177/1056789516656745.

[15] DROUGKAS, A., ROCA, P., MOLINS, C., "Numerical prediction of the behaviour, strength and elasticity of masonry in compression", *Engineering Structures*, v. 90, pp. 15–28, 2015. doi: http://dx.doi.org/10.1016/j.engstruct.2015.02.011.

[16] THAMBOO, J.A., DHANASEKAR, M., "Nonlinear finite element modelling of high bond thin-layer mortared concrete masonry", *International Journal of Masonry Research and Innovation*, v. 1, n. 1, pp. 5–26, 2016. doi: http://dx.doi.org/10.1504/IJMRI.2016.074727.

[17] SEGURA, J., PELA, L., ROCA, P., "Monotonic and cyclic testing of clay brick and lime mortar masonry in compression", *Construction & Building Materials*, v. 193, pp. 453–466, 2018. doi: http://dx.doi.org/10.1016/j.conbuildmat.2018.10.198.

[18] RAVULA, M.B., SUBRAMANIAM, K.V.L., "Experimental investigation of compressive failure in masonry birck assemblages made with soft brick", *Materials and Structures*, v. 50, n. 1, pp. 19, 2017. doi: http://dx.doi.org/10.1617/s11527-016-0926-1.

[19] AMERICAN SOCIETY FOR TESTING AND MATERIALS, *ASTM C90-16a Standard Specification for Load bearing Concrete Masonry Units*, West Conshohocken, ASTM International, 2016.

[20] AMERICAN SOCIETY FOR TESTING AND MATERIALS, *ASTM C1314-16, Standard Test Method for Compressive Strength of Masonry Prisms*, West Conshohocken, ASTM International, 2016.

[21] AMERICAN SOCIETY FOR TESTING AND MATERIALS, *ASTM C67-17, Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile*, West Conshohocken, ASTM International, 2017.

[22] AMERICAN SOCIETY FOR TESTING AND MATERIALS, *ASTM C1403-15, Standard Test Method for Rate of Water Absorption of Masonry Mortars*, West Conshohocken, ASTM International, 2015.

[23] BUREAU OF INDIAN STANDARDS, *IS: 1905-1987 Code of Practice for Structural Use of Unreinforced Masonry*, New Delhi.

[24] BRITISH STANDARDS INSTITUTION, *BS 5628- 1978, Code of Practice for Structural Use of Masonry*, London.

[25] GUMASTE, K.S., NANJUNDA RAO, K.S., VENKATARAMA REDDY, B.V., *et al.*, "Strength and elasticity of brick masonry prisms and Wallettes under compression", *Materials and Structures*, v. 29, n. 2, pp. 241–253, 2007. doi: http://dx.doi.org/10.1617/s11527-006-9141-9.

[26] HILSDORF, H.K., "An investigation into the failure mechanisms of brick masonry loaded in axial compression", In: Johnson, F.B. (ed), Designing, Engineering and Constructing with Masonry Products, Houston, Tex., Gulf Pub. Company, pp. 34–41, 1969.

[27] FRANCIS, A.J., HORMAN, A.J., "The effect of joint thickness and other factors on the compressive strength of brickwork. In: West, H.W.H., Speed, K.H. (eds), Proceedings of the 2nd International Brick Masonry Conference, Stoke-on-Trent, British Ceramic Research Association, pp. 31-37, 1971.

[28] BINDA, L., FONTANA, A., FRIGERIO, G., "Mechanical behaviour of brick masonries derived from unit and mortar characteristics", In: Proceedings of the 8th International Brick and Block Masonry Conference, pp. 205–216, Dublin, 1988.

[29] CAVALERI, L., FAILLA, A., LA MENDOLA, L., *et al.*, "Experimental and analytical response of masonry elements under eccentric vertical loads", *Engineering Structures*, v. 27, n. 8, pp. 1175–1184, 2005. doi: http://dx.doi.org/10.1016/j.engstruct.2005.02.012.

[30] MUGURUMA, H., NISHIYAMA, M., WATANABE, F., *et al.*, "Ductile behaviour of highstrength concrete columns confined by high strength transverse reinforcement", *Proceedings of the ACI International Conference*, v. 2, n. 3, pp. 877– 891, 1991.

[31] KAUSHIK, H.B., RAI, D.C., JAIN, S.K., "Stress-strain characteristics of clay brick masonry under uniaxial compression", *Journal of Materials in Civil Engineering*, v. 19, n. 9, pp. 728–739, 2007. doi: http://dx.doi.org/10.1061/(ASCE)0899-1561(2007)19:9(728).

[32] ZHOU, Q., WANG, F., ZHU, F., *et al.*, "Stress-strain model for hollow concrete block masonry under uniaxial compression", *Materials and Structures*, v. 50, n. 2, pp. 106, 2017. doi: http://dx.doi.org/10.1617/s11527-016-0975-5.

[33] JEGATHEESWARAN, D., SOUNDAR RAJAN, M., "Comparative studies of compressive strength on different brick masonry prisms", In: Proceedings of International Conference on Innovative Technologies for Clean and Sustainable Development, Cham, Springer, 2022. doi: http://dx.doi.org/10.1007/978-3-030-93936-6_56.