International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-9 Issue-2, July 2020

Effect of Embedding Reinforcement on Brick Works Built by Three Different Types Bricks and Two Different Mortar Ratios

Suyamburaja Arulselvan, G..Puvaneswari

Abstract: Experimental investigations have been conducted on brick prism specimens to study its performance with the presence of reinforcement. Brick prisms were constructed using red bricks, fly ash bricks and concrete bricks with and without embedding steel reinforcement. Cement mortar with 1:5 and 1: 6 mixes have been used to build prisms. Concrete bricks of same sizes were casted in the lab and used after proper curing. Brick prisms were subjected to compressive force by Universal Testing Machine. Compressive strength of different types of brick prisms were compared and plotted. Compressive strengths were improved by embedding steel reinforcement in the brick works. Reinforced Concrete brick prisms contributed higher strength. Reinforced fly ash brick prism contributed higher compressive strength than the red brick. By embedding reinforcements in the brick works, load carrying capacity and stability of brick works have been improved. Due to ductile properties of steel reinforcement, steel embedding brick works led to ductile and reduce brittle cracks. Overall performance of brick works improved by embedding steel reinforcement

Keywords : Red bricks, fly ash bricks, concrete bricks, normal brick prisms, reinforced brick prisms, compressive strength.

I. INTRODUCTION

In this research, red bricks, fly ash bricks and concrete bricks were taken to experimental study. Cement mortar with mixes 1:5 and 1:6 have been used to make prisms. Two types of prisms viz. normal brick prisms, reinforced brick prisms were constructed. Reinforcements can be used to improve ductile behavior of the brickwork. This will give beneficial to the occupants of the buildings. Strength of individual red brick, fly ash brick and solid brick were found 4.35 N/mm^2, 9.75 N/mm^2 and 8.50 N/mm^2. This research was mainly focused on compressive strength of three types of different bricks and two mixes. Amin Al-Fakih, et. al., (2018) [1] have been studied the behavior of the mortorless dry bed Joint and its behavior, Anna Brignola, et. al., (2008) [2] have identified the shear parameters of masonry panels through the in-situ diagonal compression test research, Antonio Borri, et.al., (2011) [3], have been studied the shear behavior of unreinforced and reinforced masonry panels subjected when it was subjected to in situ diagonal compression, Antonio Borri, et. al., (2016) [4] carried out shear tests on masonry panels made of solid bricks retrofitted with a new technique based on the use of glass fiber-reinforced polymers (GFRP) grids inserted into a thermal insulating jacketing. Ayed HB, et.al. (2016) [5] have been conducted the research to study the mechanical behavior of interlocked blocks, Başak ZENGİN1, et.al. (2017) [6], carried out the research to study the effect of the bricks used in masonry walls on characteristic properties, Dawei Huang, et. al., (2020) [7] have been conducted the bond strength tests under pure shear and tension between masonry and sprayed mortar, Gumaste, K.S., et. al., (2007) [8] have been studied the properties of brick masonry using table moulded bricks and wire-cut bricks of India with various types of mortars. They have been evaluated the strength and elastic modulus of brick masonry under compression for strong-brick soft-mortar and soft-brick strong-mortar combinations. Jasiński R, et. al., (2016) [9], conducted the study of autoclaved aerated concrete masonry walls with horizontal reinforcement under compression and shear, Jose M. Adam, et. al., (2010) [10], discussed the outcomes of nonlinear finite element modelling of the tests looking for a deeper insight into the micromechanics of brickwork collapse. Kaushik, H., et. al. (2007) [11], have been studied the uniaxial monotonic compressive stress-strain behavior and other characteristics of unreinforced masonry and its constituents by several laboratory tests. Kunasegaram Sajanthan, et.al., (2019) [12], conducted the experiments to the prediction of compressive strength of stabilized earth block masonry, Marco Corradi, et,al., (2008) [13], have been studied the experimental evaluation of shear and also compared compression strength of masonry wall before and after reinforcement by deep re-pointing technique, McNary, W., et. al. (1985) [14], have been investigated the strength and deformation of clay-unit masonry under uniaxial concentric compressive force. Nassif Nazeer, et, al., (2018) [15], have been conducted the research to study behaviour and strength assessment of masonry prisms, Piyawat Foytong, et,al., (2016) [16], carried out the research to study the effect of brick types on compressive strength of masonry prisms, Radosław Jasiński (2019) [17], conducted the research on the influence of bed joint reinforcement on strength and deformability of masonry shear walls, Sarangapani, G., et. al., (2005) [18], have been investigated the bond strength on masonry compressive strength through an experimental program using local bricks and mortars, S Valerio Alecci, et, al., (2013) [19], carried out the work to study shear strength of brick masonry walls assembled with different types of mortar, Valluzzi M.R., et, al., (2002) [20] have been conducted the experiment to study behavior of masonry panels strengthened by FRP laminates.

Revised Manuscript Received on June 22, 2020.

***** Correspondence Author

Dr. Suyamburaja Arulselvan, M.E., Ph.D., Associate Professor, Department of Civil Engineering, Coimbatore Institute of Technology, Coimbatore, Tamilnadu, India. E-mail: arulselvan@cit.edu.in

Dr. G.Puvaneswari, M.E., Ph.D, Assitant Professor (SG), Department of ECE, Coimbatore Institute of Technology, Coimbatore, Tamilnadu, India. E-mail: puvaneswari@cit.edu.in

1.1 Objective

The objective of this research is to study the compressive strength of brick prisms with three different types of bricks. The experiments involved to quantify the strength of brick prisms with two different mixes. Also experiments were conducted to study the strength differences of brick prisms using steel reinforcement embedded in the middle of the prisms.

II. MATERIALS

Materials used in this research were ordinary Portland cement confirmed 53 grade as per IS: 4031-1988. Natural river sand confirming to IS-383 zone II was used as fine aggregate. Locally available potable water confirming to IS 456 was used. Normal red bricks, Fly ash bricks, solid bricks were used to built the brick specimens (Fig.1).

III. PREPARATION AND CASTING OF BRICK PRISMS

In this study, cement mortars 1:5 and 1:6 mixes with mortar thickness 12 mm were used. Steel reinforcements with 10 mm diameter HYSD bars used after two layers of bricks.. Construction of brick prisms, placement of steel reinforcements, making cavities and filling with sand and curing of specimens are shown in Fig. 2 to Fig. 3.

IV. TEST SET UP AND TESTING OF THE SPECIMENS:

The specimens were tested in the structural engineering laboratory to study compressive strength of brick specimens. Normal brick specimens, specimens with reinforcement were tested separately. Two square steel plates used in the top and bottom of specimens to even distribution of loads. The test setup and testing of specimens are shown in Fig. 4

V. BEHAVIOUR OF MASONRY BRICK PRISMS

5.1 Compressive Strength:

5.1.1 Red brick specimens

Laboratory Tests were carried out to determine the compressive strength of normal, reinforced,. Brittle cracks were predicted during testing of normal prism. This was occurred by the brittle behavior of red bricks and cement mortar. Brittle fractures were found less in reinforced brick prism. This was obtained by embedding steel reinforcement in the middle of brick prism. Steel reinforcements contributed ductile behaviors to the prism. Load carrying capacity was found higher in the reinforced prim than the normal brick prism. Specimens with 1:5 mix contributed higher strength than the 1:6 mix. Higher bonding strength of 1:5 mix led to higher strength. The values of compressive strengths are shown in Table 1 to 4 and the behaviors are shown in Fig. 5 to 12.

5.1.2 Fly ash brick specimens

Investigations have been carried out to determine the compressive strength of normal, reinforced, Bond strengths were found higher in fly ash brick prisms. This bond strength was led higher tensile strength in these brick prisms. The higher bonding capacity with cement mortar was led to higher compressive strength in fly ash brick specimens. In the three types of specimens, fly ash brick prism with embedded steel reinforcement contributed higher compressive strength.

5.1.3 Concrete Brick Specimens

Investigations also have been carried out to determine the compressive strength of normal, reinforced, cavity concrete brick prism specimens. The bond strength was also higher in concrete brick with cement mortar. The bond strength and in addition to frictional resistance, the concrete brick prisms contributed higher strength in compression..

5.1. 4 Behavior of three types of normal brick specimens with 1:5 mix

Compressive strength behavior of three types brick specimens were compared. The inherent behavior of concrete bricks, the concrete brick prisms were contributed higher strength than the other two types of brick specimens. The fly ash brick specimens contributed strength next to concrete specimens. Fly ash specimen contributed 90.07 percent higher than the red brick specimen. The variation of strength between red brick specimens and fly ash brick specimen was different from variation in strength between fly ash specimen and concrete brick specimen. Relationship of three types of normal brick specimens of 1:5 mix is

$$y = -0.473x^2 + 3.688x - 1.136 \text{ with } R^2 = 1, \quad (1)$$

Relationship of three types of reinforced brick specimens of 1:5 mix is

$$y = -0.472x^2 + 4.063x - 0.944 \text{ with } R^2 = 1 \quad (2)$$

Relationship of three types of cavity brick specimens of 1:5 mix is

$$y = -0.062x^2 + 1.656x + 0.038 \text{ with } R^2 = 1 \quad (3)$$

5.1.5 Behavior of three types of normal brick specimens with 1.6 mix

Compressive strength behavior was studied using 1:6 mix. Reinforced concrete brick prism obtained maximum strength than the other prism specimens. Fly ash obtained compressive strength higher than red brick prism and lower than the concrete prism. In the reinforced brick specimens, concrete brick prism contributed 123.12 percent higher compressive strength than red brick and 44.95 percent higher than fly ash prism. Fly ash specimen obtained 53.49 percent higher than red brick prism. Relationship of three types of normal brick specimens of 1:6 mix is

$$y = -0.189x^2 + 1.514x + 0.376 \text{ with } R^2 = 1 \quad (4)$$

Relationship of three types of reinforced brick specimens of 1:6 mix is

$$y = 0.188x^2 + 0.758x + 1.51 \text{ with } R^2 = 1 \quad (5)$$

Relationship of three types of cavity brick specimens of 1:6 mix is

$$y = -0.285x^2 + 1.997x - 0.406 \text{ with } R^2 = 1 \quad (6)$$

VI. FIGURES AND TABLES

6.1 list pf figures:

Fig.1 Types of bricks

Fig.2:Casting of normal brick prism

Fig.3: Casting of reinforced brick prism

Fig. 4 Testing of brick prism

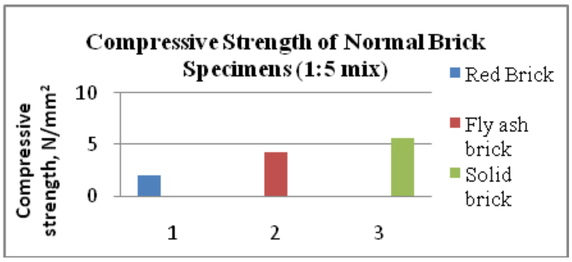

Fig. 5: Compressive strength of 1:5 normal brick specimen

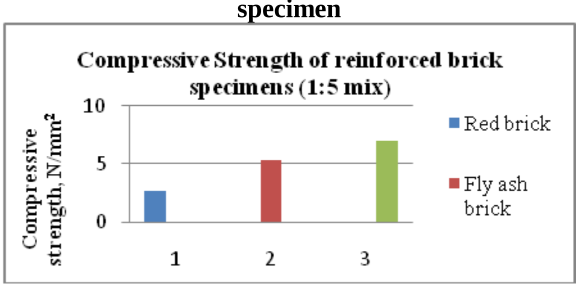

Fig. 6: Compressive strength of 1:5 reinforced brick specimen

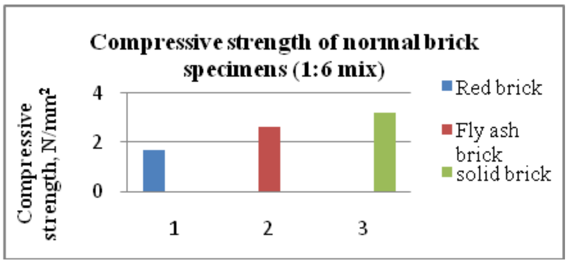

Fig. 7: Compressive strength of normal brick specimen with 1: 6 mix

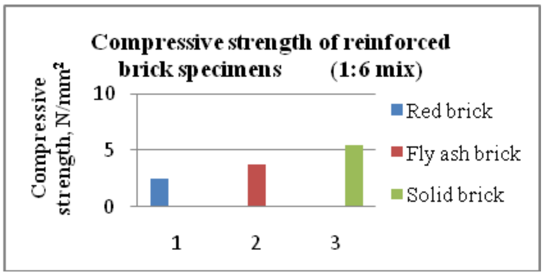

Fig. 8: Compressive strength of reinforced brick specimen with 1: 6 mix

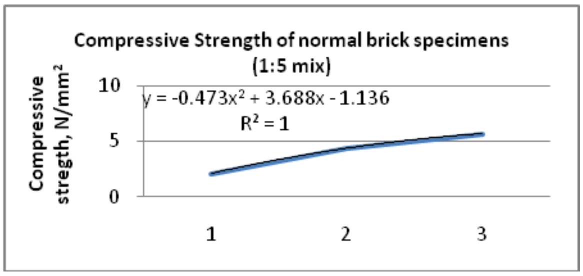

Fig. 9: Relationship of three types normal brick specimens of 1:5 mix

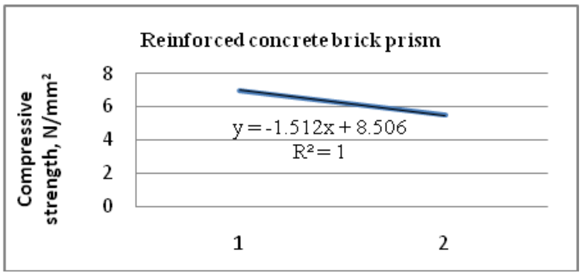

Fig. 10: Relationship between compressive strength of reinforced concrete brick prism and mixes

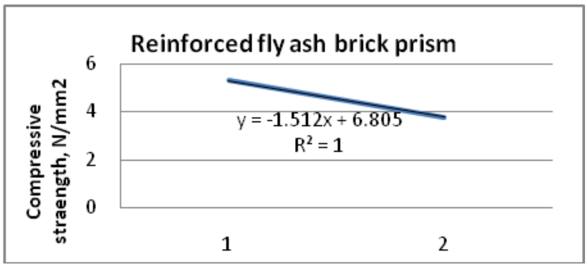

Fig. 11 Relationship between compressive strength of reinforced fly ash brick prism and mixes

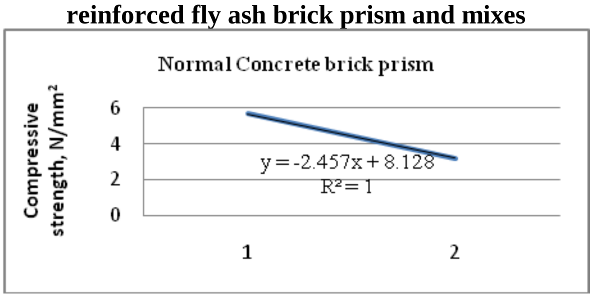

Fig. 12 Relationship between compressive strength of normal concrete brick prism and mixes

6.2 LIST OF TABLES:

Table1: Compressive strength of 1: 5 mix normal red brick specimen

Red Brick Specimens (1:5 mix)	Compressive Strength, N/mm^2
Normal	2.03
Reinforced	2.45

Table: 2 Compressive strength of 1:6 fly ash normal brick specimen

Fly ash Specimens (1:6)	Compressive Strength, N/mm^2
Normal	3.403
Reinforced	3.781

Table: 3 Compressive strength of 1:5 concrete normal brick specimen

Concrete Brick Specimens (1:5)	**Compressive Strength, N/mm^2**
Normal	5.671
Reinforced	6.994

Table: 4 Compressive strength of normal brick specimen with 1:5 mix

Normal Brick Specimens (1:5 mix)	**Compressive Strength, N/mm^2**
Red Brick	2.079
Fly ash Brick	4.348
Concrete Brick	5.671

VII. CONCLUSION

Brick wall is one of an important component in residential buildings. Brick walls are used as load bearing wall, partition wall as well as infill in the RCC frames. Load bearing wall is used for support vertical load and shear force along with RCC frames. Both vertical load carrying capacity and lateral load resisting capacity of brick wall are improved by introducing steel reinforcement in the brick wall. This concept was taken in this research to study the behavior of brick prisms by embedding steel reinforcement in the specimens.

Reinforced brick prisms contributed higher compressive strength in all types of brick specimens. Steel reinforcements provided tension resistance capacity and acted as crack arresters. This was led to delayed crack propagation in the brick specimen. Reinforcement layers provided additional ductility and stiffness to the prisms. Inherent behavior of concrete led to higher strength in compression. Concrete bricks made good bonding with cement mortar mixes. With additional ductility and stiffness from steel reinforcement layers, concrete brick specimens contributed higher strength.

The role of cement mortar ratio was also significant in compressive strength of prisms. The cement mortar with 1:5 mix made higher bonding with bricks, led to higher strength. Due to higher bonding and presence of steel reinforcements, specimens with 1:5 mix led to more strength than the other mix. Because of higher bonding capacity and frictional resistance capacity, concrete brick prisms led to more strength than fly ash and red brick prisms. Due to high bonding capacity of fly ash bricks, fly ash brick prisms led to higher compressive strength than the red brick prisms. Concrete brick prisms contributed better results than fly ash specimens and fly ash specimens contributed higher results than the red brick prisms in all the stages. The overall behavior of brick prisms were improved by embedding steel reinforcement in the specimens.

REFERENCES

1. Amin Al-Fakih, Bashar S M , Md Shahir L., "Behavior of the Dry Bed Joint in the Mortarless Interlocking Masonry System: an Overview. Civil Eng Res J. 2018; 4(3): 555639.. DOI: 10.19080/ CERJ. 2018.04.555639
2. Anna Brignola, Sara Frumento, Sergio Lagomarsino, Stefano Podestà, "Identification of Shear Parameters of Masonry Panels Through the In-Situ Diagonal Compression Test", International Journal of Architectural Heritage 3(1):52-73, 2008, DOI.10.1080/ 15583050802138634
3. 3. Antonio Borri, Giulio Castori, Marco Corradi, Emanuela Speranzini, "Shear behavior of unreinforced and reinforced masonry panels subjected to in situ diagonal compression tests", Construction and Building Materials 25 (12):4403-4414, 2011, DOI: 10.1016/ j.conbuildmat. 2011.01.009
4. Antonio Borri, Marco Corradi, Romina Sisti, Cinzia Buratti, Elisa Belloni, Elisa Moretti, "Masonry wall panels retrofitted with thermal-insulating GFRP-reinforced jacketing", Materials and Structures, October 2016, Volume 49, Issue 10, pp 3957–3968, DOI: 10.1617/s11527-015-0766-4
5. Ayed HB, Limam O, Aidi M, Jelidi A (2016) Experimental and numerical study of Interlocking Stabilized Earth Blocks mechanical behavior. J Build Eng 7: 207-216.
6. Başak ZENGİN1 , Ali KOÇAK, "The Effect of the Bricks used in Masonry Aalls on Characteristic Properties", Sigma J Eng & Nat Sci 35 (4), 2017, 667-677,
7. Dawei Huang, Oriol Pons and Albert Albareda, "Bond Strength Tests under Pure Shear and Tension between Masonry and Sprayed Mortar", Materials, 13, 2183, 2020, 1-19
8. Gumaste, K.S., Nanjunda Rao, K.S., Venkatarama Reddy, B.V, Jagadish, K.S, " Strength and elasticity of brick masonry prisms and wallettes under compression", Materials and Structures, March 2007, Volume 40, Issue 2, pp 241–253, DOI: 10.1617/ s11527-006-9141-9
9. Jasiński R., Drobiec Ł. Study of Autoclaved Aerated Concrete Masonry Walls with Horizontal Reinforcement under Compression and Shear. Procedia Eng. 2016; 161:918–924. doi: 10.1016/ j.proeng. 2016.08.758.
10. Jose M. Adam , Antonio Brencich, Tim G. Hughes, Tony Jefferson, " Micromodelling of eccentricallyloaded brickwork: Study of masonry wallettes", Engineering Structures, Volume 3, Issue 5, May 2010, Pages 1244–1251, doi:10.1016/j.engstruct.2009.12.050
11. Kaushik, H., Rai, D., and Jain, S. (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.
12. Kunasegaram Sajanthan, Balasingam Balagasan, and Navaratnarajah Sathiparan, "Prediction of Compressive Strength of Stabilized Earth Block Masonry", Advances in Civil Engineering Volume 2019, Article ID 2072430, 13 pages , doi.org/ 10.1155/ 2019/2072430
13. Marco Corradi, Cristina Tedeschi, Luigia Ada Binda, Antonio Borri, "Experimental evaluation of shear and compression strength of masonry wall before and after reinforcement: Deep repointing", Construction and Building Materials 22(4):463-472, 2008, DOI: 10.1016/j.conbuildmat.2006.11.021

14. McNary, W. and Abrams, D. (1985). "Mechanics of Masonry in Compression." *J. Struct. Eng.*, 10.1061/ (ASCE) 0733-9445 (1985) 111:4 (857), 857-870.
15. Nassif Nazeer Thaickavil Job Thomas, "Behaviour and strength assessment of masonry prisms", Case Studies in Construction Materials, Volume 8, 2018, Pages 23-38, doi.org/ 10.1016/ j.cscm.2017.12.007
16. Piyawat Foytong, Maetee Boonpichetvong, Natthapong Areemit, Jaruek Teerawong, "Effect of Brick Types on Compressive Strength of Masonry Prisms", International Journal of Technology 7(7):1171, 2016, DOI. 10.14716/ijtech.v7i7.4640
17. Radosław Jasiński, "Research on the Influence of Bed Joint Reinforcement on Strength and Deformability of Masonry Shear Walls", Materials, 12(16): 2543, 2019, doi: 10.3390/ ma12162543
18. Sarangapani, G., Venkatarama Reddy, B., and Jagadish, K. (2005). "Brick-Mortar Bond and Masonry Compressive Strength." *J. Mater. Civ. Eng.*, 10.1061/(ASCE)0899-1561(2005)17:2(229), 229-237.
19. S Valerio Alecci, Mario Fagone, Tommaso Rotunno, Mario De Stefano, "Shear strength of brick masonry walls assembled with different types of mortar", Construction and Building Materials , 40:1038-1045, March 2013, DOI: 10.1016/j.conbuildmat.2012.11.107
20. Valluzzi M.R., Tinazzi D., Modena C. "Shear behavior of masonry panels strengthened by FRP laminates", Constr. Build. Master. 2002; 16:409–416. doi: 10.1016/S0950-0618 (02)00043-0

AUTHORS PROFILE

Dr. Suyamburaja Arulselvan, M.E., Ph.D., is now working as an Associate Professor in the Department of Civil Engineering, Coimbatore Institute of Technology, Coimbatore, Tamilnadu, India, The author published forty six papers in International and National journals and International and National Conferences, His area of research is in civil, structural, earthquake, engineering survey and construction management, He is a member of The Institution of Engineers (India), Fellow of Institution of Valuers, Member of Institution of Structural Engineers, Member of Institution of Geotechnical Society. He is a life member of ISTE chapter. He has received honorary doctorate degree of D.Litt. and also he has received seven awards in state levels.

Dr.G.Puvaneswari, M.E., Ph.D., is now working as an Assistant Professor (Senior Grade) in the Department of Electronic and Communication Engineering,, Coimbatore Institute of Technology, Coimbatore, Tamil Nadu, India. Her research interest includes data analysis, analog circuits and bio-medical engineering. She published twenty papers in International and National journals and International and National conferences. She is a life member ISSE,