Flexural Strength of Fly ash Brick Masonry Wall with four different bond

Shenbagavalli S*, Ramesh Babu Chokkalingam

*Associate Professor, Department of Civil Engineering, Kalasalingam Academy of Research and Education, Krishnankoil, India
*Corresponding author E-mail: c.rameshbabu@klu.ac.in

Abstract. The strength of the masonry mainly depends on type of bond, types of bricks, compressive strength of the bricks and mortar used. The types of bonds play a major role in the properties of brick masonry wall. The most common types of bond used in practice are English bond, Flemish bond, Stretcher bond and Header bond. A lot of study has been performed on the load-carrying capacity of masonry walls. In this paper, effort has been taken to study the influence of different bonds on the flexural strength of the flyash brick masonry wall. For this wall of size 1m x 0.76m x 0.22m has been casted, cured for 28 days and tested in a loading frame. From the results, it was found the English bond gave higher flexural strength compared to other bonds such as Flemish, Stretcher and Header bond. The flexural strength of English bond was around 45 to 50% higher than the other bonds. The crack pattern at failure was also noted for all the masonry walls.

1. Introduction

The strength of the masonry mainly depends on type of bond, type of bricks used, compressive strength of the bricks and mortar used. Based on bonding style of bricks, they were classified into different types of bonds in brick masonry wall construction. The most common types of bonds used in brick masonry are English Bond, Flemish Bond, Stretcher Bond and Header Bond. SyyedAdnan et al (2019) [1] studied five different bonds with four different cement-sand mortar ratios. English bond was found to have maximum compressive strength and flexural strength by using mortar ratio of 1:3. Khaleel et al. (2020) [2] studied the strengthening of brick masonry wall against failure by earthquake using textile reinforce mortar (TRM) and fiber reinforced polymer matrix (FRP). They found that the flexural strength was higher in case of FRP than TRM. Andreas etal. (2015) [3] experimentally found that the flexural strength of reinforced wall was high when compared to unreinforced walls. Steel reinforcement increases the flexural strength values and also leads to brittle failure. Susanta et al (2020) [4] suggested a method for improving the flexural behavior of masonry walls with wire mesh. They found that diagonally strengthened brick masonry prism was found to have higher shear strength than unreinforced brick masonry. Freeda Christy et al., (2012) [5] experimentally investigated the bond strength of brick masonry. In this paper, they experimentally investigated the burnt clay and fly ash brick masonry samples for both unreinforced and reinforced with woven wire mesh. From the results, they found that the bond strength of flyash brick masonry was higher than that of clay burnt brick masonry. Also reinforced brick masonry(both clay and flyash bricks) has higher bond strength than the unreinforced masonry.
Sathiparani et al. (2013) [6] investigated the flexural strength of masonry wall retrofitted using polypropylene mesh. They found that burnt clay bricks strength was higher than that of unburnt clay bricks. Grimm and Tucker (1985) [7] found that the flexural strength depends on the workmanship, method of loading and number of joints in the masonry wall. Jayasinghe C (2007) [8] experimentally investigated and compared the test results of burnt-clay bricks and compressed earth blocks. The walls were constructed by using different types of bonds such as English bond, Stretcher bond and rat-trap bond. They found that compressed stabilized bricks with English bond exhibited higher strengths than the other ones. Gourav and Venkatrama Reddy(2014) [9] investigated the properties of fly ash brick masonry. They studied the properties such as compressive strength, flexural strength and the stress-strain characteristics of fly ash brick masonry. They found that the flexural strength of fly ash brick masonry wall using cement-lime mortar was higher than clay bricks built using the same mortar.

2. Experimental Programme

2.1 Materials Used

2.1.1. Flyash Bricks. The Masonry walls were built using Fly ash bricks with four different types of bonds such as English, Flemish, Stretcher and Header bond. The properties of the flyash bricks was tested as per IS 3495-1992 [10] and was tabulated in Table 1 and 2 respectively. The average strength of the flyash brick was found to be 8.5 N/mm². Based on the strength, the flyash bricks falls under Class 7.5 as per IS 1077-1992[11]. The average water absorption of the flyash bricks tested was 12.73%. As per the bricks classification based on compressive strength C7.5, the water absorption should be less than 20%. The flyash bricks used conforms to the specification provided as per Indian standard IS 1077-1992.

| Size of the Brick | Load (kN) | Compressive Strength (N/mm²) | Average Compressive Strength (N/mm²) |
|------------------|-----------|-------------------------------|-------------------------------------|
| 230x110x75       | 203.3     | 7.99                          | 8.5                                 |
| 230x110x75       | 233.3     | 9.22                          |                                     |
| 230x110x75       | 210       | 8.30                          |                                     |

| Size of the Brick | Water Absorption (%) | Average(%) |
|------------------|----------------------|------------|
| 230x110x75       | 12.77                |            |
| 230x110x75       | 12.68                | 12.73      |
| 230x110x75       | 12.73                |            |

2.2. Masonry Wall Construction

The walls were constructed with four different types of bonds such as English Bond, Flemish Bond, Stretcher Bond and Header Bond. The size of the wall was 1m x 0.76m x 0.22m. Bricks were bonded together by using cement mortar of thickness 10mm. The cement mortar used for the construction of flyash brick masonry wall was 1:3. The walls were cured for 28 days by covering with wet burlap and spraying water whenever it is dry. Fig.1 to 4 shows the brick masonry wall with different bonds.
Figure 1. English Bond Wall

Figure 2. Flemish Bond Wall

Figure 3. Stretcher Bond Wall
2.3. Flexural Strength of Masonry Wall

Flexural strength of the masonry walls with four different bonds English bond, Flemish bond, Stretcher bond and Header bonds were determined by testing the walls under single point loading in loading frame using hydraulic jack. The experimental setup was shown in Fig. 5 to 8. Walls were tested after 28 days of casting and failure load was noted and the crack pattern was also observed. The flexural strength of brick masonry was determined using the formula

\[ \text{Flexural Strength} = \frac{PL}{bd^2} \]

Where P is the failure load in N
L is the length in mm
b is the width of the wall in mm
d is the depth of the wall in mm
3. Results and Discussion

The flexural strength of the flyash masonry walls for the four bonds was tabulated in Table 3. From the table, it was found that English bond was found to have higher flexural strength than other bonds. The flexural strength of Flemish bond was found to have 54% of the flexural strength of the English bond. The flexural strength of the stretcher bond was found to have 60% of the flexural strength of the English bond, whereas in case of header bond it is the lowest and it was around 50% of the flexural strength of the English bond. This result was found to have similar pattern obtained by Syyed Adnan et al.(2019) in the investigation of flexural strength of brick masonry wall with English bond, Flemish bond and Header bond. They have used clay bricks whereas; in our
investigation flyash brick was used to build the wall. Similar results were also obtained by Jeyasinghe (2007) for English bond, where he used compressed stabilized earth bricks. The crack pattern at failure for English bond masonry wall was shown in Fig. 9. The crack for all the walls was found to initiate at the bottom centre and propagate inwards towards the top and then the specimen reached the ultimate load and failed.

Table 3. Flexural Strength of Flyash Brick Masonry Wall

| Bond Type       | Load (kN) | Flexural Strength (N/mm²) |
|-----------------|-----------|---------------------------|
| English Bond    | 437.42    | 3.4                       |
| Flemish Bond    | 231.17    | 1.82                      |
| Stretcher Bond  | 259.06    | 2.03                      |
| Header Bond     | 217.22    | 1.7                       |

Figure 9. English bond after crack

4. Conclusion

From the experimental results, the following conclusion can be drawn

- The strength of the flyash bricks was higher than the burnt clay bricks
- The walls built using flyash bricks was found to have better properties
- The flexural strength of the flyash brick masonry wall revealed that the flexural strength was higher when compared to the clay brick masonry wall
- English bond was found to have higher flexural strength compared to the other bonds Flemish bonds, Stretcher bond and Header bond

References

[1] R.S. Syyed Adnan, A. Hunain, F. Muhammad, S.R. Syed, M.K. Mudasser, I. Sunera, S. Gullnaz, A. Q. Muhammad, and W. Muhammad, Sustainable Brick Masonry Bond Design and Analysis: An Application of a Decision-Making Technique, *Applied Sciences*, 2019, pp. 1-19

[2] S. Khaleel, K. Madhavi, S.M. Basutkar, Mechanical characteristics of brick masonry using natural fiber composites, *Materials Today: Proceedings*, October, 2020, pp 1-8.

[3] T. Andreas, S.B.N. Arif, D.F. D.F. Athanasius, O. Faris, Flexural strength and ductility of concrete brick masonry wall strengthened using steel reinforcement, *Procedia Engineering*, 2015, 940-947

[4] B. Susanta, N. Sanket, and D. Sreekanta, Shear and flexural behaviour of unreinforced masonry wallets with steel wire mesh, *Journal of Building Engineering*, 30, 2020, pp. 1 – 23

[5] C. Freeda Christy, R. MercyShanthi, and D. Tensing, Bond strength of the brick masonry, *International Journal of Civil Engineering and Technology*, 2012, pp 380-286
[6] N. Sathiparani and K Meguro, Shear and flexural bending strength of masonry wall retrofitted using PP-band Mesh, Construct II, 2013, pp 1-12

[7] C.T. Grimm and R. L. Tucker, Flexural strength of masonry prisms versus wall panels, Journal of Structural Engineering, 1985, 2021-2032

[8] C. Jayasinghe, Comparative Performance of Burnt Clay Bricks and Compressed Stabilized Earth Bricks and Blocks, Engineer, 2, 2007, pp 33-40

[9] K. Gourav and B. V. Venkatarama Reddy, Characteristics of compacted fly ash bricks and fly ash brick masonry, Journal of Structural Engineering Vol. 41, No. 2, June - July 2014 pp. 144-157

[10] IS 3495 : 1992 Part 1 to 4, Method of Test of Burnt Building Clay Bricks

[11] IS 1077 : 1992 Common Burnt Clay Bricks – Specification, Fifth Revision