STRENGTH CHARACTERISTICS OF LOW COST FLY ASH BRICK MASONRY

I.K. Khan

Department of Civil Engineering, Aligarh Muslim University, Aligarh 202 002 (U.P.), India,
E-mail: ikk01in@yahoo.co.in

Abstract: Fly ash brick (FAB) is a building material, specifically masonry units, containing class C fly ash and water, compressed at 28 *MPa* and cured for 24 *hrs* in a 66 *°C* steam bath, then toughened with an air entrainment agent, the bricks last for more than 100 freeze-thaw cycles. Owing to the high concentration of calcium oxide in class C fly ash, the brick is described as "self-cementing". The manufacturing method saves energy, reduces mercury pollution, and costs 20% less than traditional clay brick manufacturing. In the present study three types of FAB masonry referred as Type A (conventional masonry in English bond), Type B (odd course of bricks on edge and even course on bed) and Type C (all bricks on edge in Flemish bond) had been considered. Since Type B and C masonry consist of inside cavity that resulted in the saving of number of bricks by 25%. The reduction in the manufacturing cost of fly ash bricks and saving in the number of bricks resulted in the considerable reduction in the overall cost of masonry structure.
Keywords: Fly ash, Masonry, Brick, English bond, Flemish bond, Compressive strength, Shear strength and cavity wall.

1.   Introduction

The advantages of such types of low cost FAB masonry (Type B and C) options over the conventional solid FAB masonry (Type A) are:

i)   Use of 228 *mm* cavity wall (Type B and C) results in the saving of bricks by 25%.

ii)   Reduction in the number of bricks used will result in the reduction of dead load of the superstructure, thereby reducing the cost of foundation.

iii) Use of 228 *mm* cavity wall also reduces the quantity of cement mortar to be used for the construction of such walls.

iv)   Opening inside the cavity walls act, as an insulator and is also helpful in electrification.

Types of FAB masonry

For the purpose of identification, the prisms were classified into three groups. Each group consists of twelve samples, out of which, six samples each were tested for compressive and shear strength. Two low cost options viz., (i) Type B: odd course of bricks on edge and even course on bed (ii) Type C: all bricks on edge in Flemish bond were studied; and besides these

two low cost FAB masonry types, conventional FAB masonry i.e. Type A masonry in English bond was also taken for the study.

The schematic diagram of different types of masonry prisms are shown in Figure 1.
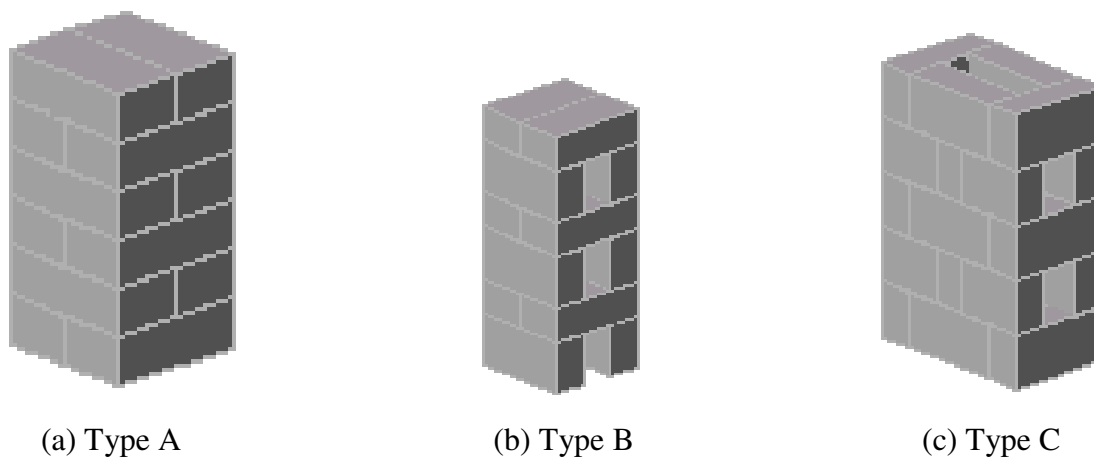

(a) Type A   (b) Type B   (c) Type C

Figure 1: Different types of FAB masonry prisms

In the present research mechanical properties like compressive strength and shear strength of different types of low cost FAB masonry have been studied. Most of the research work carried out in this area is for the prediction of strength of conventional clay brick masonry. There is very little literature available regarding the strength prediction and performance study of low cost brick masonry. However, the available published literature in the field of conventional clay brick masonry will also be useful in understanding the behaviour of low cost FAB masonry.

As revealed by various investigators, strength of clay brick masonry, σ_{bm}, depends upon many factors: (i) strength of brick, σ_b; (ii) strength of mortar, σ_m; (iii) strength of bond; and (iv) method of bonding of bricks etc. Different formulae for predicting the strength of clay brick masonry proposed by different investigators are summarized in Table 1.

Table 1: Models for compressive strength of clay brick masonry

Reference	Model for compressive strength	Values of parameters
Deodhar (1995)	$\sigma_{bm} = \sigma_b - 0.5r'$	r' = sum of ratio of mortar mix
Dayaratnam (1981)	$\sigma_{bm} = K\sqrt{\sigma_b \sigma_m}$	K= 0.275 and 0.303 for loading perpendicular and parallel to joint respectively
Gross (1969)	$\sigma_{bm} = K_1(2.76 + K_2\sigma_b)$	K_1 = 0.67 without inspection and 1.00 with inspection K_2 = 0.20 for N-type mortar, 0.25 for S-type mortar and 0.30 for M-type mortar
Lenczner (1972)	$\sigma_{bm} = K\left(\sigma_b\right)^{\alpha}\left(\sigma_m\right)^{\beta}$	α = 0.50, β = 0.25, K depends on fitting
Pande (2001)	$\sigma_{bm} = K\left(\sigma_b\delta_{mf}\delta_s\right)^{\alpha}\left(\sigma_m\right)^{\beta}$	α = 0.75, β = 0.25, K = 0.40, δ_{mf} = moisture factor to account for the moisture content of clay brick masonry, δ_s = shape factor to account for the shape and size of brick

2. Experimental Investigations

Testing of Materials

Properties of constituent materials like brick, cement, sand and mortar etc. were tested in accordance to Bureau of Indian Standards (B.I.S.) specifications and test results so obtained were found to be within the prescribed limits.

Preparation of prisms

The test prisms were made in 1:6 cement-sand mortars with water cement ratio as 0.80. Thickness of mortar was kept uniform at $D/6$, where D is the thickness of brick.

Testing of prisms in compression and shear

Prisms in the compression were tested under compression testing machine and in shear; prisms were tested with help of Universal testing machine as shown in Fig. 2. Dial and Demac gauges were used to record compressive strain in prisms.
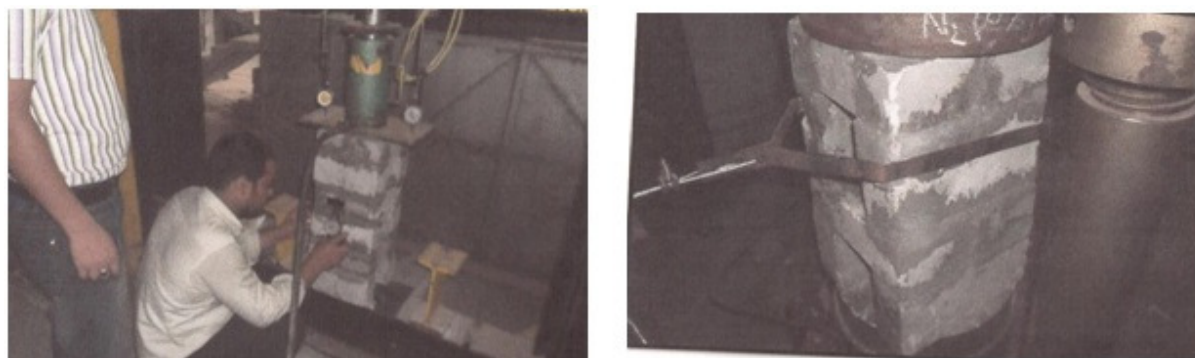
(a)   Testing of prism in compression   (b) Testing of prism in shear

Fig. 2: Testing of prisms in compression and shear

3.   Mechanical Properties

Compressive strength and crushing strain

The ultimate load, compressive strength and crushing strain for different types of FAB masonry are given in Table 2.

Table 2: Compressive strength, maximum vertical axial load per unit length and crushing strain

Masonry type	Compressive strength (*MPa*)	Maximum vertical axial load per unit length (*kN/m*)	Crushing strain
A	1.22	279.30	1.32%
B	0.84	167.5	0.53%
C	1.41	247.19	0.78%

Shear strength

The shear strength of different types FAB masonry found from experiment conducted on masonry prisms are given in Table 3.

Table 3: Shear strength of different types FAB masonry prisms

S. No.	Masonry type	Shear strength, (*MPa*)	Percentage decrease as compared to masonry Type A
1	A	0.46	00.00
2	B	0.21	54.35
3	C	0.35	23.91

Conclusions

Based on the experimental and analytical studies of conventional and low cost and conventional FAB masonry, following conclusions have been drawn:

i) All the FAB masonry prisms, tested in compression failed due to cracks developed along the vertical mortar joints.

ii) All the FAB masonry prisms tested in shear failed by sliding along the horizontal mortar bed which is the weakest plane in shear.

iii) Compressive strength of low cost FAB masonry Type C is higher than Type B , which is 15.57% higher than conventional FAB masonry Type A.

iv) Crushing strain of low cost FAB masonry Type C is also higher than Type B , which is 40.91% less than conventional FAB masonry Type A.

v) Shear strength of low cost FAB masonry Type C is higher than Type B , which is 23.91% less than conventional FAB masonry Type A.

References

[1] Deodhar, S.V. and Patel, A.N. (1995). Strength relationship between brick and brick masonry. Institution of Engineer's India. Vol. 76(1): pp. 158-159.

[2] Dayaratnam, P., Ranganathan, R., Mukhopadhyay, S. and Dasgupta, N. (1981). Experimental investigation on behaviour of brick and reinforced brickwork. Report No. DST/427/3, I.I.T. Kanpur, India.

[3] Gross, G.J., Dikhars, R.D. and Corogan, J.C. (1969). Recommended practice for engineered brick masonry. Structural Clay Product Institute, U.K.

[4] Lenczner, D. (1972). Elements of load bearing brickwork. International Series of Monograms in Civil Engineering, Vol. 5, Pergamon Press, New York.

[5] Pande, G.N., Kralj, B. and Middleton. J. (2001). Analysis of compressive strength of masonry given by the equation $\sigma_{bm} = K\left(\sigma_b \delta_{mf} \delta_s\right)^{\alpha} \left(\sigma_m\right)^{\beta}$". Structural Engineering. Vol. 130(3): pp. 386-395.