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Behaviour Of Reinforced Column Made Of Hollow Brick Subjected To Eccentric Compressive Load

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Abstract:

Inherent advantages of brick masonry have made it popular in construction industries. Relatively low tensile strength of brick work has restricted its use to compression members only, this limitation can be eliminated by incorporating reinforcement in hollow brick masonry. Present investigation includes construction and testing of reinforced hollow brick column subjected to eccentric loading, results shows good correlation with the column design by limit state design method, also it is observed that the effect of reinforcement is significant. The composite action of bricks, grout and reinforcement controls the rate of crack development and prevent sudden and total collapse, the reinforcement reserve strength beyond first cracking.

Keywords: *masonry construction, hollow brick, masonry column, brick masonry.*

1.Introduction

Shelter is one of the three basic requirements of human being. Initially ancient man started living in caves excavated below ground level on near the hill ends .thereafter, they started constructing walls from mud, and in due course of time, the developed the techniques of burnt clay brick masonry to form the structural part of the shelter. Bricks and Bricks masonry have been used in building activities for centuries and they continues to dominates among commonly used building materials.

Building construction is a multi disciplined technology. It involves an exchange of thoughts, experience and ideas among those engaged in the various disciplined of the construction activity in order to achieve overall economy and proper serviceability of the construction project at hand. It should also make use of innovative methods in the field of material technology by the use of improved materials resulting in the production of economical, aesthetically acceptable and durable structure.

The resistance to any change comes not only from the artisans and makers but even from engineers, contractors, owners and public in general.It is a human attitude of unwillingness to come out of a well established route.

Load bearing wall is one of the oldest structural systems. Man has laid one stone upon another and built walls to support roof or floor. This system was then replaced by frame structures for economy, as the load bearing walls being thick; require a large quantity of materials.

2.Experimental Program

The basic object of present study is to know the load carrying capacity of reinforced hollow brick columns under combined bending and axial stress.

Before starting actual construction of test specimens, it was necessary to know the characteristic compressive. Strength fck of brick masonry assemblage, Therefore, characteristic compressive strength of masonry assemblage was determined through prism test.

Next the question arised about the application of an eccentric load to the masonry columns. The problem was overcome by providing reinforced concrete projection at top and bottom of columns. The R.C. projections were designed to safely transfer the moment to column.

The experimental program including testing of twelve reinforced hollow brick columns. All columns were 1.80 m high 230 mm x 230 mm cross-section. Out of these twelve columns, two columns were subjected to axial load while others were subjected to eccentric load. The eccentricity of vertical load was kept as 50 mm, 100 mm, 20 mm, 300 mm and 400 mm for sets of columns. Each set of columns includes six columns.

Before construction of test columns various tests were conducted on brick, cement and cement mortar to check their adequacy. Prism test was also carried out to know the characteristic compressive strength of brick masonry. The characteristic compressive strength of brick masonry was used to calculate, theoretically, load carrying capacity of columns and accordingly R.C. projections were designed as cantilever beams, subjected to point loads.

3.Materials And Specimens

Brief discussion of various materials used in the experimental work is as follows.

3.1.Bricks

The specially prepared hollow Bricks were used for the construction of reinforced brick column specimens. Hollow bricks were manufactured from fired clay. Size of each unit was 23 cm x 11 cm x 7.6 cm and each unit was having two cells of plan dimension 6 cm x 8 cm. The crushing strength and water absorption tests were conducted according to IS : 3495 - 1976.

To determine crushing strength, six bricks were selected at random and then tested under compression Testing machine according to procedure laid in is:3495 (part-I). The Test results are as follows.

Sr no	Net area ($mm^{2)}$	Crushing load (t)	Crushing load (n)	Crushing strength (N/mm2)
1	15700	20.5	205000	13.2
2	15700	16.0	160000	10.2
3	15700	15.0	150000	09.6
4	15700	21.0	210000	13.4
5	15700	15.5	155000	09.9
6	15700	18.5	185000	11.8

Table 1: Crushing Strength Of Bricks

Average crushing strength of hollow brick unit = 11.3 n/ mm^2

The water absorption test for brick was carried out as specified in is: 3495 (part-II). Six oven dry brick units were weighed separately (w1) and then immersed in cold water for 24 hours. After 24 hours these units were taken out of the water and allowed to drain for one minute by placing them on a wire mesh and then weighed immediately (w2). The percentage water absorption determined as

$$\%\ \text{of water absorption} = \frac{W2 - W1}{W1} X100$$

Sr.no	Dry weight w1 grm	24 hrs. wt weight w2 grm	% water absorption
1	2025	2365	16.79
2	2020	2345	16.09
3	2040	2385	16.91
4	1990	2310	16.08
5	2010	2340	16.42
6	2025	2360	16.54

Table 2: Water Absorption Test Results

Average percentage water absorption by hollow bricks = 16.47%

3.2.Mortars

Ordinary Portland cement conforming to IS: 269-1976, Sand used for preparation of mortar was river sand, medium to coarse in nature. Water used for preparation of mortar was drinking water.

3.3.Compressive Strength Of Mortar

Cement mortar used for brickwork was in the proportion of 1:3. The compressive strength of mortar was determined as specified in IS: 2250-1981. Five cubes of 50 cm3 area were casted of cement mortar at different stages of construction after 28 days of curing, cubes were tested on compression testing Machine. Test results are represented in Table-3.0

Sr.no	Area cm^2	Load kg	Compressive strength (kg/cm2)	Av. Strength kg/cm2	Is:2250-1981 specified Stret
1	50	8000	160	160.25	75 and above
2	50	7650	153		
3	50	7900	158		
4	50	8500	170		

Table 3: Compressive Strength Of Mortar

Thus the mortar mix used for the construction of columns was conforming to the IS code.

3.4.Grout

The ingredients of grout i.e. cement, fine aggregates and coarse aggregates used were conforming to IS codes depending upon the dimension, and the coarse grout was used. According to UBC standards, the mix proportion for coarse grout is 1:3:2 by volume. For reinforced hollow concrete blocks, IS: 2572 specifies that a coarse grout in a proportion of 1:2:3 by volume was used. The w/c ratio was kept as 0.65 to achieve required workability.

3.5.Compressive Srength Of Grout

As there is no IS specification for grout testing, test samples were obtained according to UBC standards. Test samples were having h/d ratio of 2.0 the cross-sectional dimension of test samples was 7.6 cm X7.6 cm. The test results are given in Table-4.0

The average compressive strength of grout is 11.02 N/mm^2 which is slightly less than the crushing strength of bricks. Thus grout was adequate because grout should not have strength more than crushing strength of brick.

Sr.no	Area cm^2	Load kg	Compressive strength (kg/cm2)	Av. Compressive Strength kg/cm2
1	57.76	6500	112.54	110.2
2	57.76	6250	108.21	
3	57.76	6700	116.20	
4	57.76	6000	103.90	

Table 4:Compressive Strength Of Grout

Average compressive strength of grout = 11.02 N/mm2

3.6 Characteristic Compressive Strength Of Masonary

The compressive strength of masonry assemblage was determined by prism test. Three prisms of 23 cm X 23 cm x 46 cm sizes in 1:3 cement mortars were casted. Grouting was done using the same grout mix as used for columns. Test prisms before and after testing are shown in plates attached. The results of test are given in table-5.0

Sr no	Prism size cm x cm x cm	Area (cm2)	Load (kg)	Compressive strength 9kg/cm2)
1	23 x23 x 46	529	37500	70.89
2	23 x23 x 46	529	36000	68.05
3	23 x 23 x 46	529	40500	76.56

Table 5:Compressive Strength Of Masonry

Average compressive strength strength = 71.8 kg/cm2 Thus characterstic compressive strength of masonry assemblage, fk = 0.73 X 7.18 = 5.25 N/mm2

4.Description Of Test Columns

All the test columns were having a cross-section of 230 mm X 230 mm and height of 10.80m.the details of reinforcement and the joint mortar used in various columns was as given in table-6

Sr.no	Size of columns	Main reinforcement	Transverse reinforcement	Mortar mix	No. of columns
1	230 mm x 230mm	4-#10	#6 @ 160 c/c	1;3	6
2	230 mm x 230mm	4-#12	#6 @ 160 c/c	1:3	6

Table 6: Test Columns Details

4.1.Construction Of Test Columns

From construction point of view, test columns can be divided in two groups. First group includes those four columns which were subjected to loads at eccentricity less than or equal to 50 mm. second group includes those eight columns which were subjected to vertical loads at eccentricity more than 50 mm. Construction of first group of columns was started on a polythene sheet, speeded on the floor. Cement mortar in proportion of 1:3 was used. After laying just two courses reinforcing bars were kept in place, because lateral ties were to be placed after every two courses. Thereafter bricks and ties could be placed only after threading them through the longitudinal reinforcing bars. Grouting was done after every two courses with 1: 2:3 concrete. Columns were casted in three days with a lift of 0.6m each day. Construction of second group of columns was carried out in three stages. In the first stage a R.C. projection of required size was casted using M20 concrete. A wooden formwork was used for casting. Second stage includes actual casting of 1.8 m high columns. Construction procedure is same as specified for first group of columns. In third stage, reinforcing bars bent according to design and vertical stirrups were tied at suitable spacing. After doing shuttering, centering and leveling, concreting and leveling, concreting was done using M20 concrete mix. Curing of R.C. projection was done for 28 days using gunny bags. Curing period for brick columns was kept 14 days. The reinforcement provided for columns, was extended in to top and bottom projections, to avoid any joint failure between brick columns and R.C. projection.

4.2.Testing Of Columns

Testing of columns was carried out on compression Testing Machine. For both axially and eccentrically loaded columns, the experimental set up is as shown in plates.

Testing of columns was carried out by successively increasing eccentricity of loading from 0 to 400 mm. For the application of eccentric load, top spherical seating was replaced by a roller, provided at top and bottom.The test columns were adjusted and leveled properly on compression Testing machine. Then the load at requisite eccentricity was applied on R.C. projections, through rollers, was transferred to the brick columns as a moment and axial load P. Load was increased gradually till initial cracks appeared first. The loading was continued further, gradually, till ultimate failure occurred.

5.Results And Discussions

The reinforced hollow brick columns were tested after 28 days of curing. The test results are represented in tabular form in TABLE-5.7 and table 5.8

Sr.no	Eccentricity(mm) A	Ultimate load (t) B	Applied moment in N-m=Axbx10
1	0	22.5	0
2	50	14.9	7450
3	100	10.2	10200
4	200	5.95	11900
5	300	4.25	12750
6	400	3.5	14000

Table 7:Hollow Brick Column Reinforced With 4-10 # Hysd Bars

Sr.no	Eccentricity(mm) A	Ultimate load (t) B	Applied moment in N-m=Axbx10
1	0	33.0	0
2	50	19.75	9875
3	100	13.1	13100
4	200	7.25	14500
5	300	5.1	15300
6	400	4.1	16000

Table 8:Hollow Bricks Columns Reinforced With 4-12 # Bars

6.Conclusion

The characteristic compressive strength of brick masonry assemblage must be obtained through actual field tests – instead of directly taking from codes.

Effect of reinforcement is significant. Plain brick masonry is very weak in tension, especially when it is under eccentric load, but due to presence of reinforcement in columns the moment carrying capacity will be increased.

The load carrying increases significantly with increase in percentage reinforcement.

Load factor obtained from working stress method varies from 2.0 to 3.0 for axially loaded columns and from 4.5 to 6.75 for eccentrically loaded columns. These high values of load factor are reasonable because of large factor of safety in formula.

Load factor obtained from limit state method varies from 1.0 to 1.5 for axially loaded columns. While for eccentrically loaded columns it varies from 1.9 to 2.3 in all cases except one. The load factor for columns subjected to vertical load at eccentricity of 50 mm is less than one. This may be because of poor workmanship especially for grouting of hollow cells of columns.

The initial cracks become visible at loads ranging from 70 to 80 % of respective ultimate failure loads in all cases i.e. there is a significant reserve of strength beyond initial cracking.

Failure of reinforced hollow brick column under axial compressive load is due to breakdown of bond between grout and brick shells, leading to the formation of vertical cracks in columns.

The column subjected to smaller eccentric loading fails essentially due to crushing of brickwork of more compressed face.

The columns subjected to vertical loads at larger eccentricity fails due to excessive bending.

The grout (1:2:3) provides bond for reinforcement, thus composite behavior of materials was present. This composite action controls the rate of crack development and prevents sudden add total collapse.

The moment carrying capacity of reinforced column using hollow bricks must be more than that of solid brick column. This is because of longer level arm available in hollow brick column for the same column cross-section.

In axially loaded columns, failure has taken place at top. While in eccentrically loaded failure occurs within middle third of the column height.

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