VALIDATION OF RAT-TRAP BOND FOR COST EFFECTIVE HOUSING

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ABSTRACT

In India most of the houses constructed in villages and towns are either one storey or two storey high. The spans of rooms are 2.5 or 3m.Under these circumstances, the stress in the brickwork is nominal. However most of the structures use solid 230mm brickwork using English Bond. In recent times HUDCO, a techno financing organization sponsored a project for considering the use of Rat trap Bond wall, which has a cavity in the wall. This type of construction is very advantageous in a tropical humid climate. This paper deals with a series of tests on full-scale wall specimens made with 23 cm solid wall as well as 23 cm Rat-trap hollow wall specimens. The specimens were loaded and tested to destruction. A computer analysis was also made to simulate the behaviour of the wall. The material presented shows that the Rat-Trap bond wall can be successfully adopted for normal buildings and will result in 25% saving in bricks and more than 30% saving in mortar. The dead load on the foundation would also be reduced by at least 20%.In addition this type of wall does not need thick plastering as both front and rear face of the wall are fair faces. Examples of Structures built with this type of bond are illustrated. The wall also lends itself to be reinforced when structures are built in earthquack or cyclone prone areas.

Key words: Brick work – Bonds - Fullscale Test – Economy – Reinforcement

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INTRODUCTION

In India, most of the houses constructed in villages and towns are either one storey or two storey high. The span of rooms are 2.5 m to 3.5 m. Under these circumstances the stresses in brick work are nominal. However most of the structures use solid brick work using English Bond. The main reason for adopting this type of walling system is the availability of bricks in all parts of India. Though English bond has been used extensively, only recently alternative more efficient systems have been tried.

RAT-TRAP BOND BRICK MASONRY

Brick placed on edge in 1:6 cement mortar as indicated in Fig. 1 is a typical rat-trap bond. If the bricks available, are having a compressive strength of more than 4 N/mm^2, then Rat-trap Bond Masonry can be adopted.

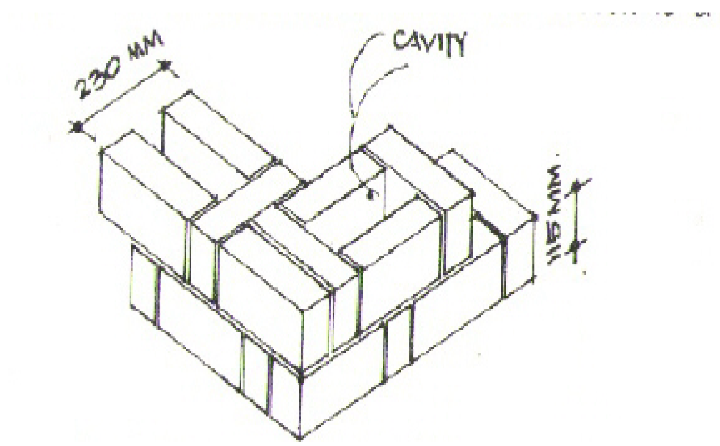


Figure 1. Typical Arrangement of bricks in a Rat-Trap Bond wall corner

METHOD OF CONSTRUCTION

The method of construction is illustrated is Fig. 2 and in Table 1. The materials and labour required for this type of construction is given is Table 2.

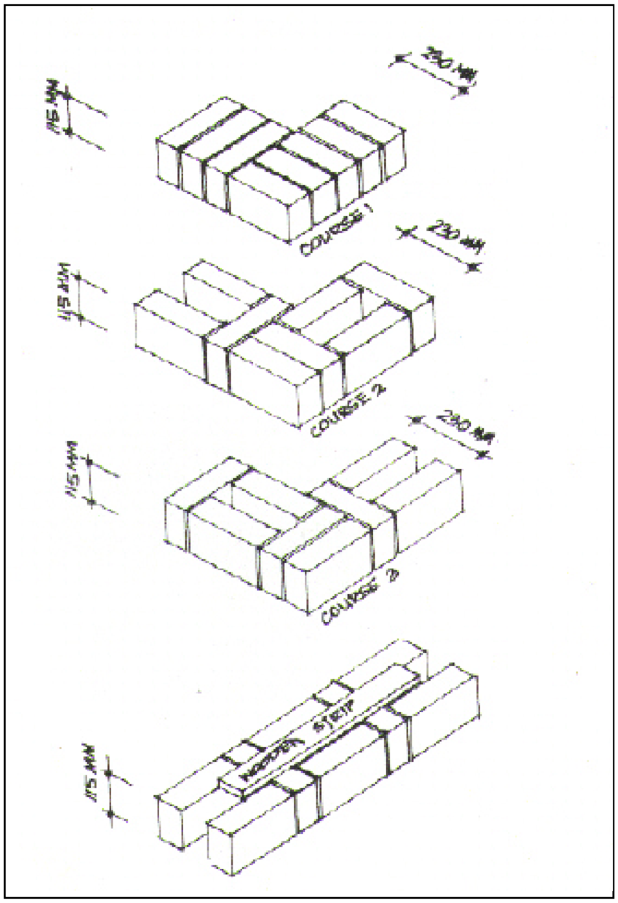


Figure 2. Steps adopted for Construction

Table 1. Method of Construction

STEPS	METHOD
1.	Lay the first course with brick on edge in 1:6 cement mortar.
2.	Lay the second course as shown in the sketch and repeat the same in the course number 4,6,8,10 etc.
3.	Lay the third course as shown in the sketch and repeat the same in the course number 5,7,9,11.
4.	As the mortar is laid on each course, a wooden strip may be used to prevent mortar from falling into the cavities.

Table 2. Data for 1 cubic meter of Rat-Trap Bond Brick Masonry

	MATERIAL		LABOUR	
S.No	Material	Quantity	Labour	Mandays
1.	Bricks	400 No.	Skilled	1.56
2.	Cement	36.0 Kg	Unskilled	3.95
3.	Sand	0.15 m^3	Curing labour	0.496
4.	Scaffolding	2.00m^3		

ADVANTAGES OF RAT-TRAP BOND WALLS

The following are the main advantages

1. Consumption of bricks is 25% less
2. Consumption of mortar is 30% less
3. Stability of wall is not affected
4. Dead load is less and hence saving in foundation cost by 20%
5. Since the wall is adjusted to have fair face, plastering can either be avoided or if plastered thickness can be reduced.
6. Labour intensive and hence can generate work in a country like India.

EXPERIMENTAL PROGRAMME

To study the behaviour and to find the allowable compressive stress of the Rat-Trap Bond wall, eight specimens of size 920x920x230 mm were constructed. Six specimens were constructed with conventional bricks, one using conventional bricks for stretchers and flyash-lime-gypsum (FAL-G) brick as headers and another with conventional bricks as stretchers and with wire tied conventional bricks as headers. To compare the behaviour with the English bond wall, three specimens of the same size with conventional bricks in English bond wall were constructed. The experimental setup for the specimens are shown in the Fig. 3.

The lateral deflection undergone by the wall were measured at 11 points. The position of the deflectometers are shown in the Fig. 3.

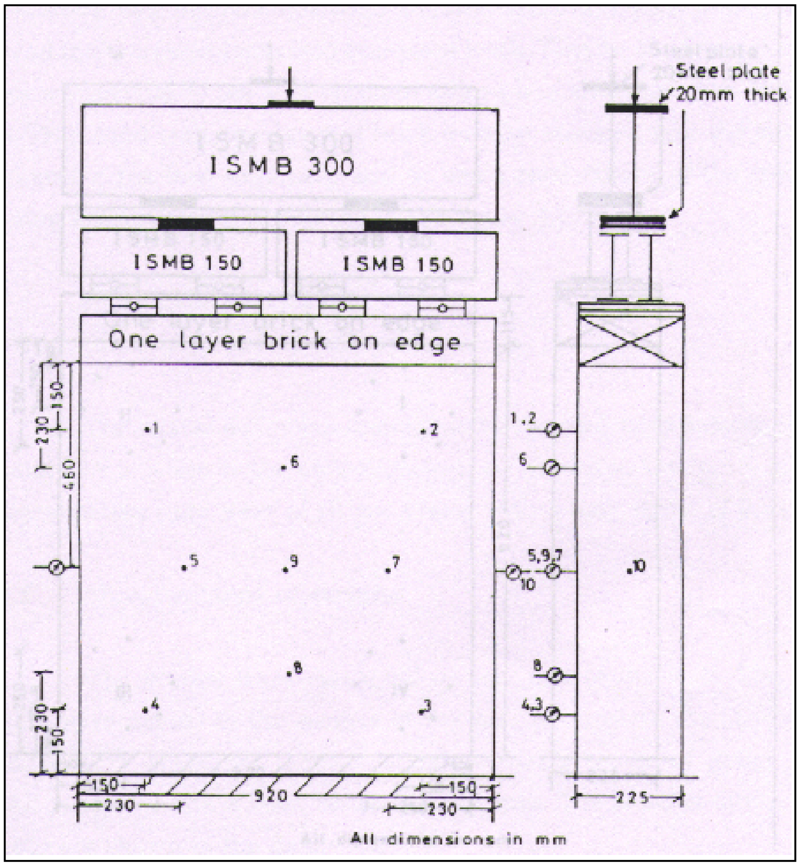


Figure 3. Schematic diagram of the loading arrangements and position of the dial gauges in a wall panel

The strains were measured on one face of the wall. The demec points were pasted to the surface of the wall to measure the strains. The strains were measured using a standard strain gauge of gauge length 203.2 mm (8"), with a least count of 0.02 mm.

PARTICULARS OF RAT -TRAP BOND WALL

Eight specimens were constructed in Rat-Trap bond wall. Three specimens (1 to 3) were constructed with conventional bricks having a compressive strength of 5.69 N/mm^2 when kept flat and 3.71 N/mm^2 when kept on-edge. The cement mortar 1:3 having a compressive strength of 17.02 N/mm^2 was used for construction. Another three specimens (4 to 6) were constructed with conventional bricks having a compressive strength of 4.02 N/mm^2 when kept flat and 3.12 N/mm^2 when kept on–edge in cement mortar 1:3 having a compressive strength of 12.7 N/mm^2.

The specimen 7 was constructed with conventional bricks having a compressive strength of 4.02 N/mm^2 when kept flat and 3.12 N/mm^2 when kept on-edge as stretchers and Flyash-lime-gypsum (FAL-G) bricks having a compressive strength of 8.62 N/mm^2 when kept flat and 9.07 N/mm^2 when kept on-edge was used as headers.

The specimen 8 was constructed with conventional bricks having a compressive strength of 4.02 N/mm^2 when kept flat and 3.12 N/mm^2 when kept on-edge a stretchers. The same bricks tied with binding wire was used as headers.

PARTICULARS OF THE ENGLISH BOND WALL

Three specimens were constructed in English bond wall with conventional bricks having a compressive strength of 5.69 N/mm^2 in cement mortar 1:3 having a compressive strength of 17.02 N/mm^2.

TEST RESULTS AND DISCUSSIONS

The stress-strain curve for typical specimens are given in Fig.4. and Fig 5. From the stress-strain curve, it is observed that the behaviour of both English and Rat-Trap Bond wall (Specimen 1 to 5) is almost linear upto the range of 40 to 60% of the ultimate load. After that the behaviour is nonlinear. The lateral deflection of the wall over the height of the specimen are given in Fig. 6 to Fig 7. The out of plane deflection of both English and Rat-Trap Bond wall is insignificant.

From the experiments, it was observed that the weaker zone in the Rat-Trap Bond wall is the header bricks. Hence, to improve the load carrying capacity of the wall, bricks having relatively higher strength than the bricks used for stretchers can be used for headers. To observe this, one specimen was constructed with conventional bricks as stretchers and FAL-G bricks as headers. Another one with conventional bricks as stretchers and with wire tied conventional bricks as headers.

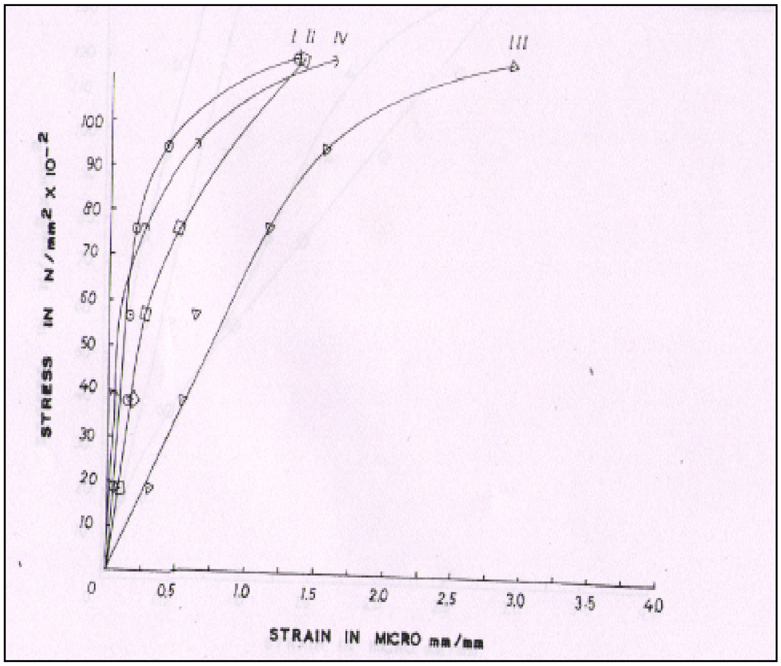


Figure 4. Typical stress strain curves for a Rat-Trap Bond wall.

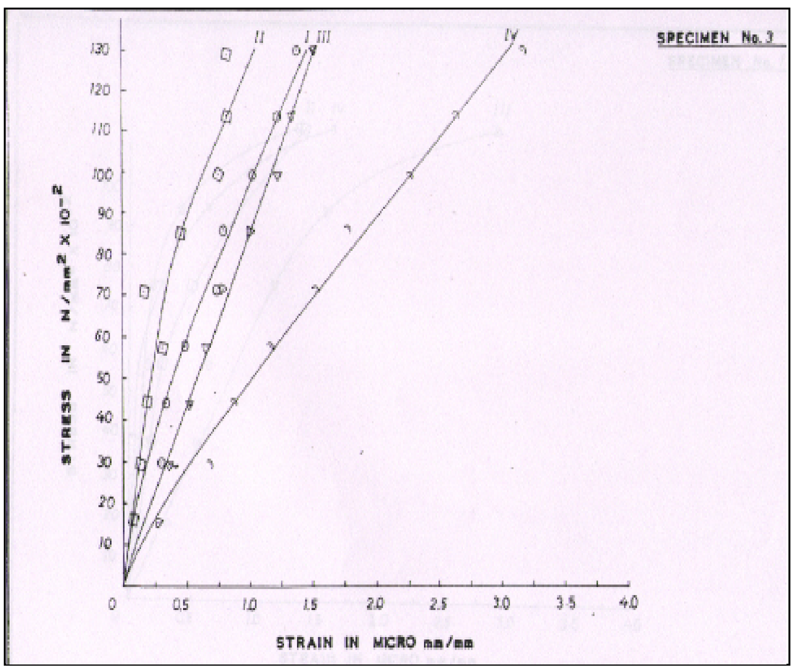
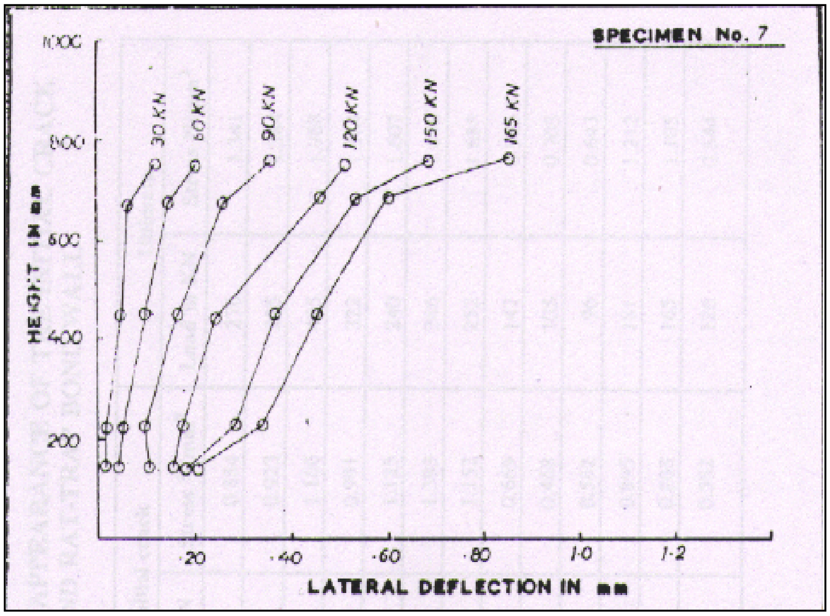
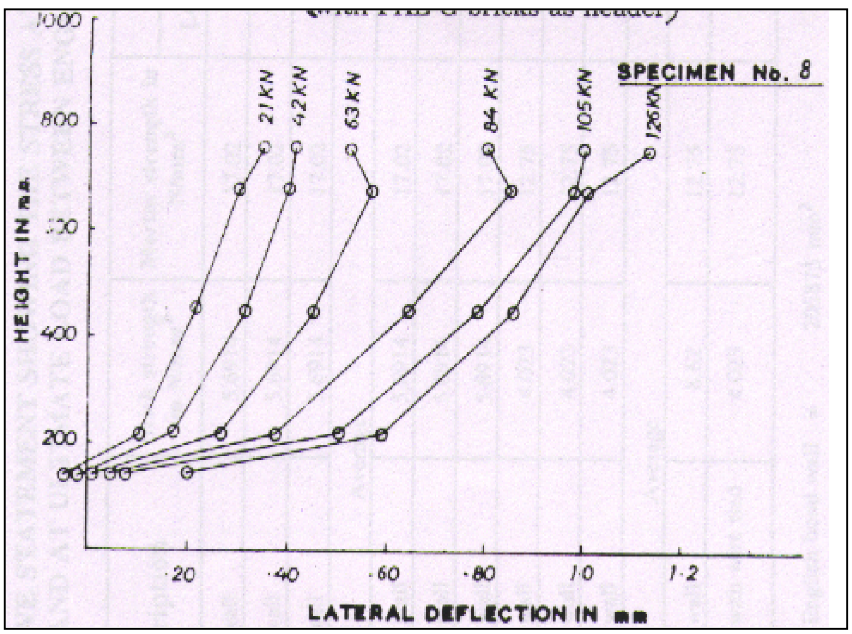


Figure 5. Typical stress strain curve for English Bond wall

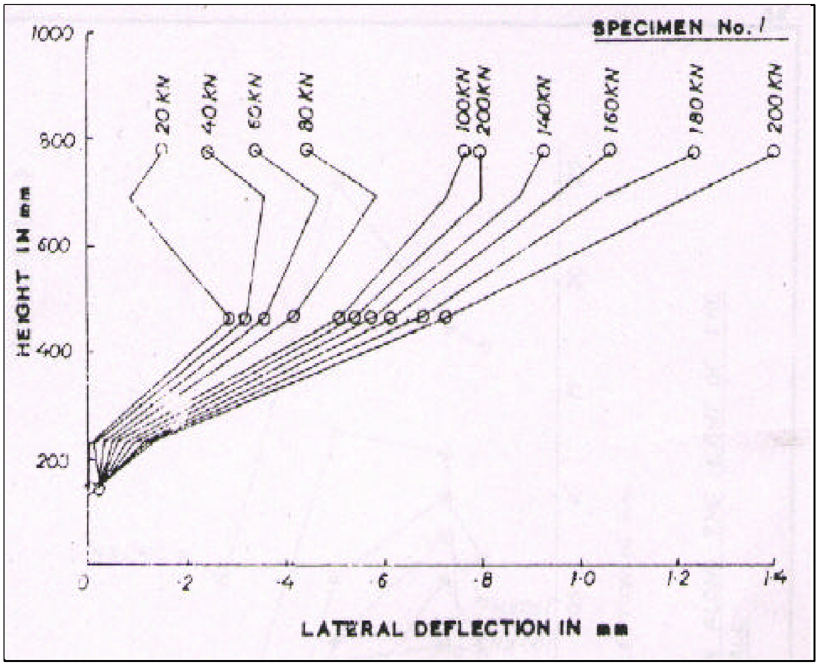


(a.)with FAL – G bricks as header

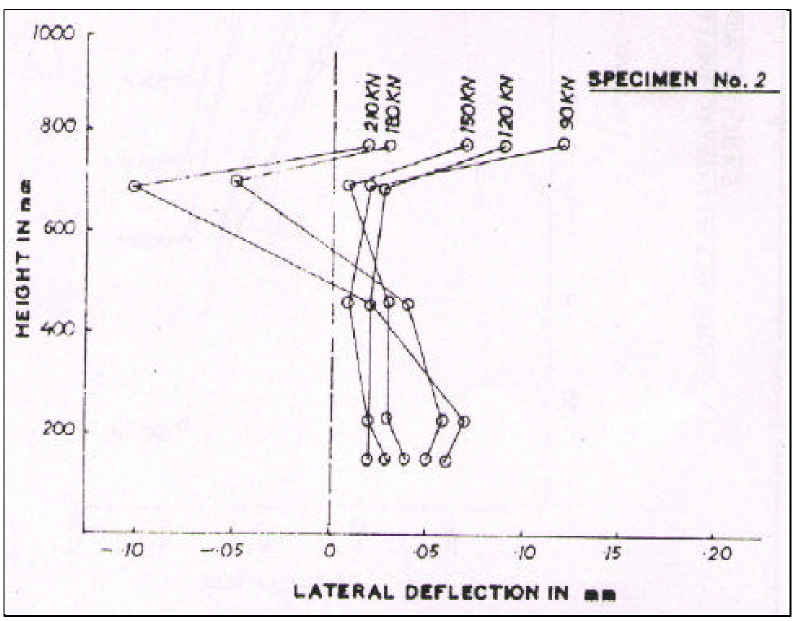


(b)with wire tied bricks as header

Figure. 6. Typical lateral load – deflection for Rat-Trap Bond wall



(a) Specimen 1



(b) Specimen 2

Figure 7. Typical lateral load – deflection for English Bond wall

COMPARISON OF BEHAVIOURS OF TWO TYPES OF BOND

A comparative statement showing the stress at the appearance of the first crack and at ultimate load between English and Rat-Trap bond wall is given in Table 3. From the Table 3, it is seen that the load carrying capacity of the Rat-Trap bond wall (Specimen 4 to 6) is only about 50% of that specimens 1, 2 & 3. This may be due to the possible low compressive strength of bricks and mortar used for the construction. The load carrying capacity of the FAL-G brick is about 40% higher than that constructed with conventional bricks (Specimen 4, 5 & 6). The load carrying capacity of the specimen constructed with wire tied bricks as headers was same as that of the specimen constructed with conventional bricks. This was due to the local failure of the bricks in the brick on-edge layer.

Fig. 8 shows how rat-trap bond wall can be reinforced horizontally and vertically for providing necessary seismic resistance.

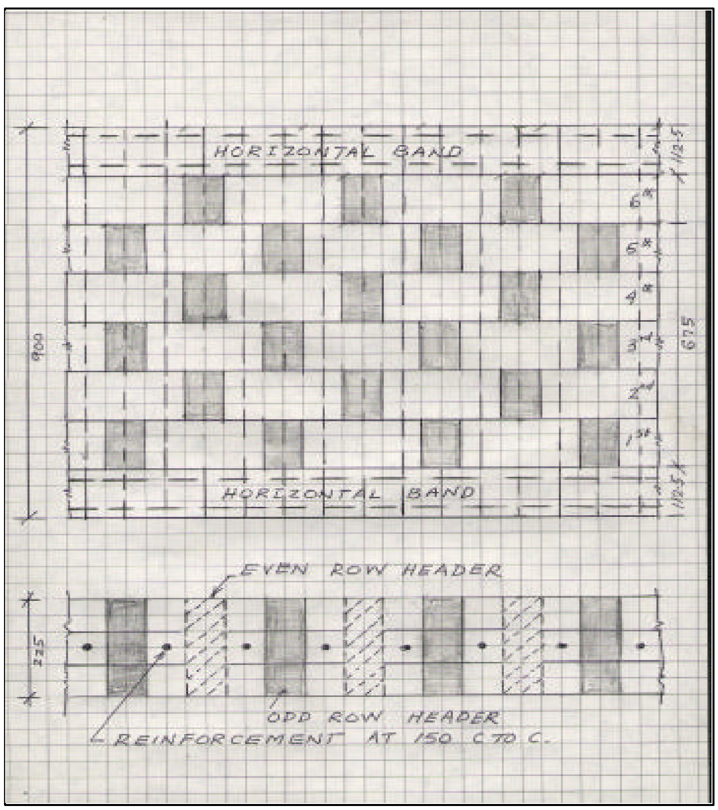


Figure 8 Vertical and Horizontal reinforcement bands for seismic resistance

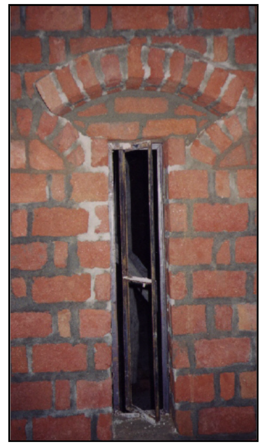
Table 3. Comparative Statement Showing The Stress At The Appearance Of The Initial Crack And At Ultimate Load Between English And Rat-Trap Bond Wall

Sp. No.	Description	Brick strength in N/mm^2	Mortar strength in N/mm^2	Initial crack		Ultimate	
				Load in KN	Stress N/mm^2	Load in KN	Stress N/mm^2
1	English bond wall	5.6914	17.02	182	0.884	276	1.341
2	English bond wall	5.6914	17.02	190	0.923	285	1.384
3	English bond wall	5.6914	17.02	240	1.166	405	1.968
	Average			204	0.991	322	1.564
1	Rat-Trap bond wall	5.6914	17.02	168	1.125	240	1.607
2	Rat-Trap bond wall	5.6914	17.02	208	1.393	246	1.648
3	Rat-Trap bond wall	5.6914	17.02	172	1.152	252	1.688
4	Rat-Trap bond wall	4.023	12.75	100	0.669	147	0.985
5	Rat-Trap bond wall	4.023	12.75	70.0	0.468	105	0.703
6	Rat-Trap bond wall	4.023	12.75	84.0	0.562	96	0.643
	Average			133.67	0.895	181	1.212
7	Rat-Trap bond wall	8.62	12.75	120	0.803	165	1.105
8	Rat-Trap bond with wire tied header bricks	4.023	12.75	84	0.562	126	0.844

Cross-sectional area of English bond wall = 205875 mm^2

Effective are of Rat-Trap bond wall = 149256 mm^2

(A) Traditional Colony



(B) Close Up View

(C) Office Buildings

Figure 9. Typical Rat-Trap bond wall building constructed in India

CONCLUSIONS

1. The average ultimate stress for the English bond wall is 1.564 N/mm^2 and for Rat-Trap bond wall is 1.212 N/mm^2. The allowable compressive stress using a factor of safety of 1.50 works out to 1.042 N/mm^2 and 0.808 N/mm^2 respectively.
2. The failure of the Rat-Trap bond wall is due separation of the two leaves of the wall caused by splitting of the header bricks, which fails primarily in shear.
3. The computer analysis made and the test results indicate that for normal buildings rate trap bond wall can be used with advantage provided wall span in less than 3.5 m.

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