Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 5, Issue 8; October-December, 2018, pp. 579-582

http://www.krishisanskriti.org/Publication.html

An Experimental Investigation of the Behaviour of Modified Rat-Trap Bond Concrete Brick Masonry Wall Panel under Uniaxial Compressive Cyclic Loading

Sunil Prasad Shrivastava[1], Binod Kumar Singh[2] and Munish Kumar Bhardwaj[3]

[1]*Assistant Professor in Civil Engg., Deptt. of Architecture, SPA, New Delhi, India*
[2]*Professor of Civil Engg. ABES Engg. College, Ghaziabad (Uttar Pradesh), NCR, India*
[3]*Associate Professor, IGNOU, New Delhi, India*

Abstract—*In the present study an attempt has been made to improve the efficiency and performance of conventional brick masonry by developing a modified rat-trap bond masonry system. The system was developed considering advantage of air gap between perpends for thermal comfort. Flemish bond was modified as rat-trap bond.*

In order to increase the economic viability and sustainability of the product, simple equipment and process has been adopted that use locally available men and materials (cement, fly ash, fine aggregate and water in proportions of 1:1:4:0.60) for the manufacture of its units. The fly ash cement bricks used in the construction help to reduce the pollution level by consuming fly-ash, a by-product of thermal power plants which are responsible for air pollution.

Experimental investigations has been conducted to study the structural behavior of modified rat-trap bond masonry system under uniaxial cyclic compressive loading in the direction perpendicular to bed joint Two types of tests have been conducted under uniaxial cyclic compressive loading (i) Monotonic test (ii) Common point test For each type of test three specimen of size 545mm × 495mm ×95mm were constructed. A mutually perpendicular biaxial types (+) strain gauge (gauge length 60mm, gauge resistance 120 ohm and gauge factor 2.13) were used to record the deformation with load in real time through data acquisition system which was further connected with P.C. to display the data on monitor.

Overall the study reveals that the development of modified rat-trap bond masonry system is a significant improvement over the conventional brick masonry system and has potential for use as a high performance and high strength masonry.

1. INTRODUCTION

The Rat-Trap bond is developed by the Architect Laurie Baker with HABITAT Research center in India. This technology has been used in India for over 37 years and has been successfully adopted in Sri Lanka by practical action in partnership with Rural Center for Development. The Rat-Trap bond is laid by placing the brick on their sides having an internal cavity with alternate course of stretcher and headers. Hence the name Rat -Trap was given. The air medium that is created by bond inside capable of acting as an insulator reducing the indoor temperature unlike other bond patterns. Thus it helps in maintaining a good thermal comfort inside the building. The interior remains cooler in summer and warmer in winter.

As the construction is appearing pleasant to the eye both internally and externally plastering is not necessary.

The present work is an attempt to address the drawbacks of Rat-Trap bond masonry by developing Modified Rat-Trap bond masonry. Flemish bond was modified as rat-trap bond by providing small gap between the bricks laid in stretcher position considering the advantage of thermal comfort of Rat-Trap bond with improved compressive strength.

2. EXPERIMENTAL PROGRAM

Selection of material

The fly ash cement bricks used in the construction help to reduce the pollution level by consuming fly-ash, a by-product of thermal power plants which are responsible for air pollution. The use of fly ash bricks also reduce the consumption of virgin material like soil, mud which are used at large scale in manufacturing clay bricks. This fulfils the requirement of green building. The gap between perpends allow reinforced and pre stressed construction.

Cement

The cement used was 43grade Ordinary Portland Cement.

Fly ash

The fly ash used in the production of fly ash bricks was chimney fly ash procured from Thermal Power Plant, Badarpur, Haryana, India.

Aggregate

The fine aggregate used in the production of fly ash bricks as well as in mortar was locally available sand which confirms to grading Zone II of IS: 383-1970

Water

The quality of water used in the production of fly ash bricks, in mortar as well as for curing of bricks and walls was Portable water available in the laboratory conforming IS:456-2000.

Mix Proportion

Fly ash bricks:

Cement: Fly ash: Sand: Water = 1: 1: 4: 0.60

for mortar, the mix proportion decided was

Cement; Sand=1:5

Test Specimens

Experimental investigations were carried out on unreinforced Rat-Trap bonded masonry panel constructed with fly ash concrete bricks. Test specimens were made by placing masonry units leaving an internal cavity of 5mm.

Cement fly ash bricks of half scale modular brick size (95 mm x 45mm x 45mm) were used for the purpose.

The test specimen for wallet prepared for testing walls under cyclic loading were of dimension (495mm x 545mm x 95mm) with a gap of 5mm between the two bricks laid in stretcher position.

Three cubes of 70.70 mm size (control specimen) were also made for each specimen.

All the specimens as well as control specimens were cured for 28days by covering the same with wet jute sacks.

Fig. 1: Steel mould for casting fly-ash concrete bricks

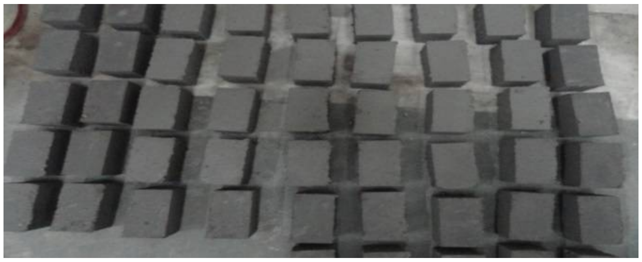

Fig.2: Production of fly-ash concrete bricks

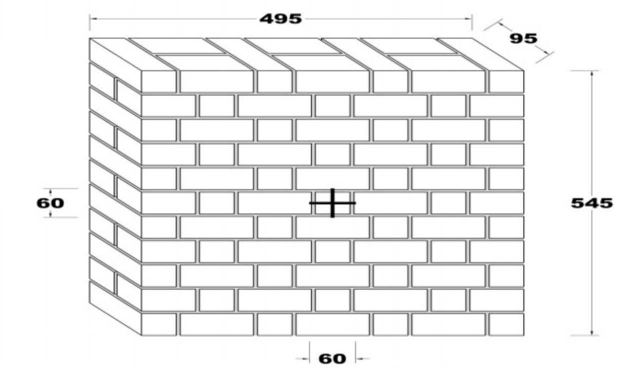

Fig. 3: Wallet to be tested under cyclic loading

Fig. 4: Loading arrangement for testing under cyclic compressive loading

3. INSTRUMENTATION

The instrumentation for the test specimens were done for the measurement of axial and lateral displacement with the fix gauge lengths. A mutually perpendicular biaxial types (+) strain gauge (gauge length 60mm, gauge resistance 120 ohm and gauge factor 2.13) were glued in position using araldite, an epoxy resin on both the faces of brick panel. The strain connected in parallel to data acquisition system which was further connected with P.C. This was used to display, monitor and record the deformation with load in real time.

4. TEST PROCEDURE

Two types of test were conducted on modified rat-trap bonded brick masonry panels. Ten specimens were tested for each type of loading.

Type I test (Monotonic loading test):

In this type of test, the load was applied uniaxial and increased steadily to failure. The rate of loading applied was such that the failure of the specimen was reached in about 3 to 5 minutes.

Type II test (Common point test):

In the cyclic loading, the specimens were loaded up to peak stress-strain curve as obtained from monotonic load test and then unloading started. In this way, the peak stress-strain in each cycle of loading followed almost the same curve as obtained from envelope curve from monotonic test. The envelope curve is the locus of limiting values of stress-strain within which all stress-strain curves lies irrespective of the loading pattern. The loading was done at a stress rate of approximately 3 N/mm^2 per minute and unloading was done at the rate of 6 N/mm^2 per minute by hydraulic pressure unit. The rate of increment of strain from $0.4x10^{-3}$to $0.5x10^{-3}$in each cycle was found appropriate for loading curve to reach the envelop curve. The unloading was done in the descending zone when the loading curve tended to descend. The point of intersection of reloading curve with unloading curve of previous cycle is called common point and the locus of points where reloading curve crosses the unloading curve of previous cycle on stress-strain curve is called common point curve.

Fig. 5: Failure mode of modified rat-trap bond masonry under cyclic loading

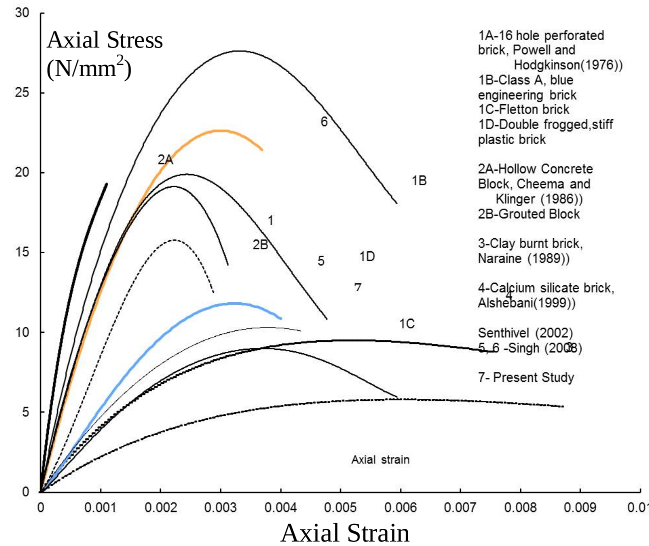

Fig. 6: Comparison of stress-strain curves for brickwork in axial compression

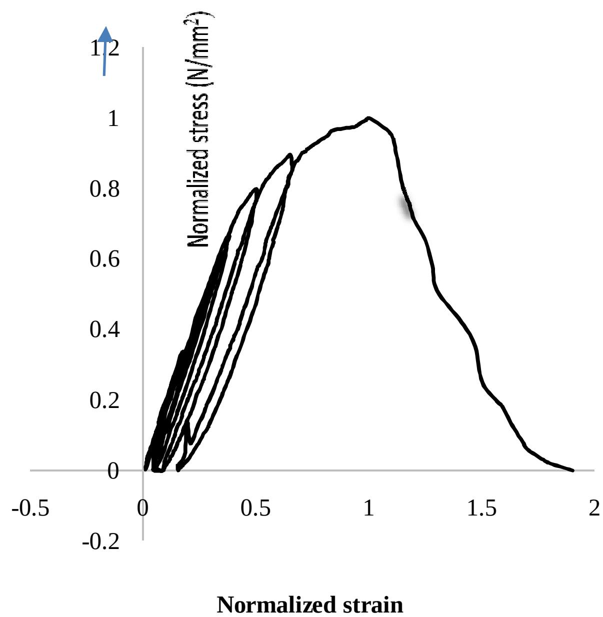

Fig. 7: Normalized Stress-Strain curve for cyclic loading

The failure of modified rat-trap bond was observed in form of cracks which developed initially at head joint followed by a vertical cracks and crushing of the bricks. The mechanism of failure was somewhat similar to the conventional masonry in which a combination of vertical brick failure and joint failure occurs by formation of tensile cracks parallel to axis of loading except in this case where crushing of the bricks took place.

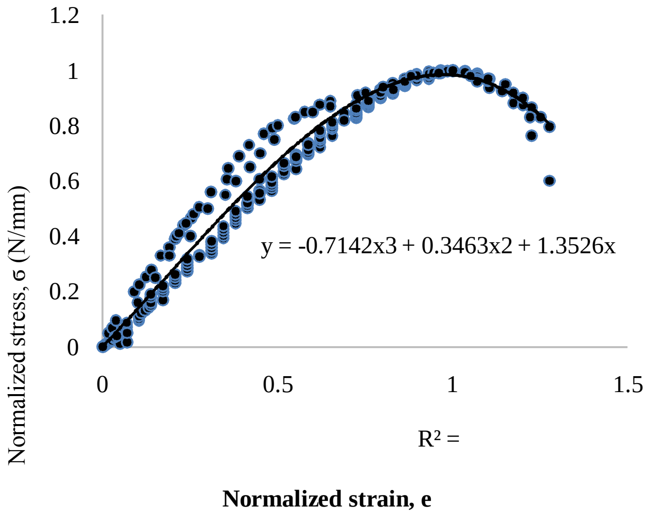

Fig. 8: Stress-Strain Envelope curve for cyclic loading

A view of the failure pattern in some of the specimen have been shown in fig.6.The mean ultimate strength for modified rat-trap bond was found to be 10.52 N/mm^2 The ratio of mean ultimate strength for the specimen to the mean crushing strength of the brick was 0.65.

5. CONCLUSIONS

As compared to the conventional masonry the developed modified rat-trap bond masonry with cement fly ash bricks has better constructability due to its faster rate of construction as non-filling of the air gaps created between the perpends for thermal insulation saves the time of construction. Due to better appearance from both the faces it also doesn't require external or internal plastering. The cement-fly ash bricks are also capable of beings demolded easily and a number of bricks can be produced in one go. The bricks may be produced at site with the use of locally available materials/industrial waste and allows saving expenses of transportation and fossil fuel consumption. A uniform and faster rate of construction may be ensured even by semi- skilled labor.

Failure of conventional masonry being heterogeneous composite takes place by the development of tension crack parallel to the axis of loading resulting from the tensile stresses at right angle to the primary compression. Also the conventional masonry has different load carrying capacity for different direction of loading i.e. parallel to bed joint and perpendicular to bed joint. The masonry efficiency factor for conventional masonry has been reported by different researchers ranging from 0.3 to 0.4. However, the behavior of modified rat-trap bond masonry under uniaxial cyclic loading was different from conventional masonry in the following terms:

- Failure under uniaxial cyclic compressive loading occurred by crushing.
- The masonry efficiency of modified rat-trap bond masonry ranged from 0.63 to 0.70 as against 0.30 to 0.40 for the conventional masonry.
- The difference between common point and stability point curve was small as compared to that reported for conventional masonry by Naraine (1989), Alshebani (1999) and Senthivel (2003)
- The tangent and secant modulus of elasticity at forty percent of ultimate load are nearly equal, therefore it exhibits linear behavior under forty percent of ultimate load. The modulus of elasticity increases with the increase in strength of masonry.
- Compressive strength of Flemish bond masonry and modified rat-trap masonry is almost similar which infers that filling of perpends doesn't affect the compressive strength of masonry.
- In general, homogeneous brittle material exhibits failure by crushing under compression test. Therefore, the failure of modified rat-trap bond in crushing tends to behave like a homogeneous brittle material under compression.

Due to the characteristics of having high efficiency factor and to behave like a homogeneous brittle material under compression, the modified rat-trap bond masonry has potential for use as high performance and high strength masonry.

Overall the study indicates that the developed modified rat trap bond masonry system is a significant improvement over the conventional masonry system and has potential for use as high performance and high strength masonry.

REFERENCES

[1] Alshebani, M.M. and Sinha S.N. (1999), "Stress-Strain characteristics of Brick Masonry under Cyclic Loading. *"Journal of Structural Engineering, ASCE*, Vol.125, No.6, 600-604.

[2] Naraine, K. (1989). "Behavior of brick masonry under cyclic compression loading." *Ph.D.Thesis*, Indian Institute of Technology, Delhi, India

[3] Powell B. and Hodgkinson H.R. (1976), "The Determination of Stress-Strain Relationship of Brickwork." *Proc. 4th International Brick Masonry Conference, Brugge, 2.A.5.1-2.A.5.6*

[4] Senthivel, R. and Sinha S.N. (2003), "Energy Dissipation Response of Brick Masonry under Cyclic Compressive Loading." Structural Engineering. And Mechanics, Vol.16, No.4

[5] Singh B.K. and Sinha S.N. (2004), "Deformation Characteristics of Interlocking Grouted Mud Block Masonry." *7th Australian Masonry Conference, New Castle, New South Wells, Australia, pp. 437-44*