Original Research Paper Engineering

Study the Behaviour of RC Frame with Brick Masonry Infill for Lateral Load

N.Jayaramappa Associate Professor, UVCE, Bangalore University, Bangalore-560056

ABSTRACT

This paper presents an experimental investigation on the behaviour of a 2D single bay two storey reinforced concrete (RC) frame with brick infill. RC frame with brick infill is casted in the laboratory to a scale down of 1:3.25; the dimension of frame is 2.3 m height and 1m width. The cross section of beam and column are 100mm x 70 mm and 70 mm thick brick infill. The proposed model is subjected to lateral load at each storey level and their performance was assessed based on load carrying capacity and deflection. The present study includes the entire range of loading from the initial elastic stage until the ultimate failure stage. Analytical study was also conducted for the similar frame; analytical results were obtained using finite element analysis software Etabs -13. Analytical results were compared with experimental results , results are tabulated and conclusions are drawn .

KEYWORDS 2D RC frame with brick infill, pushover analysis, lateral loading frame, behaviour of bare frame. Plastic hinges

1. INTRODUCTION

Reinforced concrete (RC) frames consist of horizontal elements (beams) and vertical elements (columns) connected by rigid joints with brick infill. These structures are cast monolithically that is, beams and columns are cast in a single operation in order to act in unison. Frames participate in resisting the lateral loads resulting from earthquakes or wind or storms, and the portion of the forces resisted by each one depends on its rigidity, modulus of elasticity and its ductility, and the possibility to develop plastic hinges in its parts. The moment-resisting frame must be capable of resisting at least 25 percent of the base shear, and the system must be designed to resist the total lateral load in proportion to their relative rigidity. It describes the characteristic of the frame, and the results.

2. FRAMES TESTED

The lateral loading frame is used to test RC frame brick infill .The Frame is tested to its ultimate failure load. In the frame a lot of cracks were observed at the junction of the columns and beams of masonry.

Table 1: Parameters of RC frame with brick infill .

Parameter		Frame
Type of frame		2D
Number of bays		1
Number of story		2
Bay length [m]		1
Storey height		1
Structural material		Reinforced concrete
Concrete	Compressive strength [MPa]	26.6 N/mm^2
Reinforcement.	Modulus of elasticity [MPa]	25787.59 N/mm^2
	Yield strength f_y [MPa]	415
Column.	Section length [mm]	100
	Section width [mm]	70
	Reinforcement	4 Ø 8
	Percentage of steel	2.87
Beam.	Section height [mm]	100
	Section width [mm]	70
	Reinforcement Percentage of steel	4 Ø 8 2.87
Brick	Density	19.2 kN/m^3
	Mass	19.57 kN/m^3
	Water absorption	8.6%
	Poisson Ratio	0.15
	Modulus of elasticity [MPa]	2750.0 N/mm^2

3. SPECIMEN PREPARATIONS AND TEST SETUP (METHODOLOGY)

RC bare frame is casted in the laboratory to a scale down model of 1:3.25; the dimension of frame is 2.3 m height and 1m width. The cross section of beam and column are 100mm x 70 mm. The concrete mix is designed as per IS: 269-1976 for a characteristic strength of 20N/mm^2. After 24 hours of concrete, the frame is covered with wet gunny bags and watering is done continuously for 28 days. The frame is lifted and transported in to the loading frame with the help of the overhead crane available in the laboratory. Frame is filled with a table moulded bricks using cement mortar 1:3.

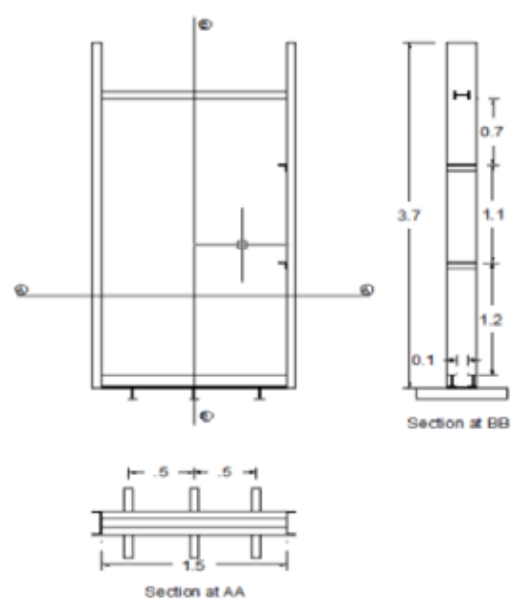


Figure 1. Schematic diagram showing Loading Frame

The test setup is schematically shown in Fig. 3. As the lateral force is applied to the frame it is subjected to the tension on the face of loading. Hence, that column is fixed by using a suitable MS plate clamping system. For fixing the testing frame to base plate of loading frame, Nitobond solution was applied in between the column base and the base plate of testing frame. Towards compression side of the frame MS blocks were placed to resist the lateral moment in the frame

to provide realistic behaviour of the frame. Frame is checked for plumb line on all four faces to ensure the verticality of the frame before testing. Frame is tested for horizontality by placing the spirit level at all the horizontal members of the frame.

Two load points are located at first and second storey levels. The load points roughly simulate the equivalent static seismic load in the frame. The static lateral incremental loads are applied at the jack locations of the frame by hydraulic jacks of 500kN capacity with least measurable value of 2.5kN. The jacks are placed horizontal in line with centre of beams; its horizontality is confirmed using spirit level. The jacks are fixed to the loading frame. Load is transferred to the specimen by the jacks in the form of uniformly distributed load pattern; the jacks are controlled by an individual console. For the application of load, hand operated oil pumps are used.

LVDTs (Linear Variable Displacement Transducer) of least count 0.01mm was used to measure displacement at each storey level. LVDTs are placed in between loading frame and test specimen .LVDTs was firmly fixed to the loading frame and precautions are taken not to disturb the LVDT instrument during testing.

The deflections at all storey levels are measured using LVDT at each increment of loading. The load increments are continued till the final crack occurred in all the joints. Table 2 shows the load and displacement values observed during the experimentation.

4. EXPERIMENTAL INVESTIGATION

The lateral load is applied at the 1st and 2nd storey level using hydraulic jacks. The load increment for each interval is 2.5kN. The first crack is observed at the total load (P_1+P_2) of 15kN for a deflection of 21.82mm. Gradually load is increased for further intervals to develop cracks at all the joints. At the load of 30.0kN cracks were observed at all joints in the frame for a deflection of 42.62mm. The application of load was stopped at 33.75kN for deflection of 53.72mm, as the cracks widened and further no new cracks were developed. The analytically obtained ultimate base shear was 33.75kN at 54.85mm deflection using Etabs 2013(pushover method). It is found that the observed analytical ultimate load by Etabs is 1.58% more than that obtained from experimental study. The variation of maximum top storey deflection with respect to base shear is presented in Fig. 8. At the ultimate load, the top storey deflection is found to be 54.37mm (experimental value) whereas it is obtained as 54.85mm from Etabs on pushover analysis.

Figure 3. Schematic diagram showing 2D RC frame with brick infill

a) First crack appear in mortar

b) Final crack appear in mortar back side view

c) First crack appear in mortar back side view

d) Final crack appear in mortar front view

Figure 4.Observing the cracks developed during test

ANALYTICAL INVESTIGATIONS

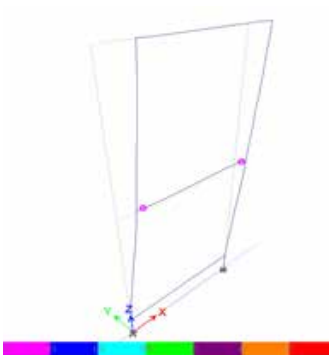
Modelling of 2D RC Bare frame was done using Etabs 2013, grid is taken of 2 lines in X axis and 1 line in Y axis. 3 stories in Z axis. Material is defined as M20 grade concrete and Fe415 steel according to Indian standard code. Frame sections such as beam and column are of 100mmX70mm dimensions, provided with 4no's of 8 mm dia bars in column section and 4 no's of 8mm . Base of the structure is fixed.

Load patterns such as dead weight of structure was consid-

ered and Earth quake load is considered in X direction, with zone II, soil type medium, importance factor of 5. The load case is defined for push over analysis using displacement control method. Restricting displacement to 55.72 mm as observed during experimental investigation, taking acceleration in X direction for a scale of -1. The observed results are discussed below.

Frame model in Etabs

3D RENDER VIEW OF FRAME



Deflection due to pushover

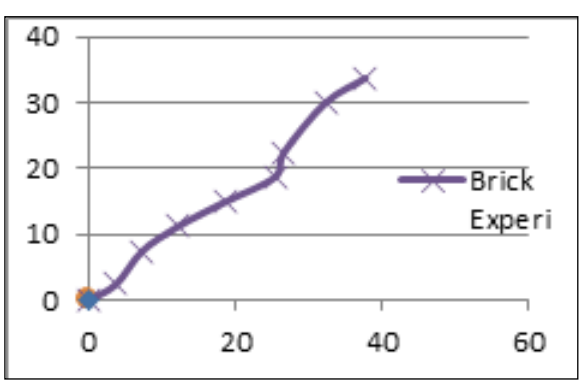
Figure 5. Analytical modelling of frame

Results

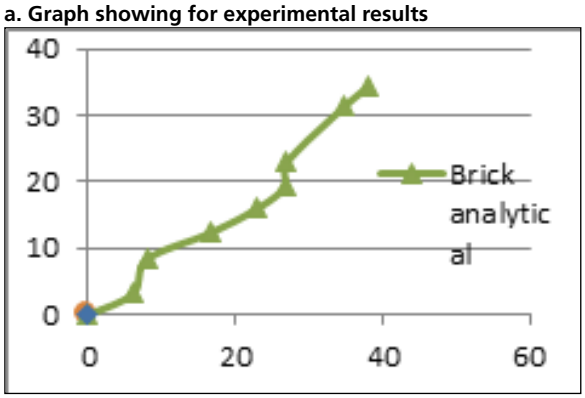
2D RC bare frame with brick infill was tested in the laboratory, the lateral load is applied at the 1st and 2nd storey level using hydraulic jacks, and displacements were measured using LVDT. The load increment for each interval is 2.5kN. The first crack in mortar joint was observed at the total load (P_1+P_2) of 15.0 kN for a deflection of 21.82mm, details are shown in table (2). Gradually load is increased for same intervals. At the load of 22.5kN cracks have been developed at joints in the frame for a deflection of 37.82 mm. The application of load is stopped at 33.75kN for deflection of 55.72mm, as the cracks widened and no further new cracks have developed. Width of cracks are measured, all the cracks are of 3 to 3.5 mm wide at the starting points and reduces towards end. Figures (4a to 4d) show the cracks at joints and figure (6.d) shows the pushover curve.

Table 2: Table for experimental and analytical results

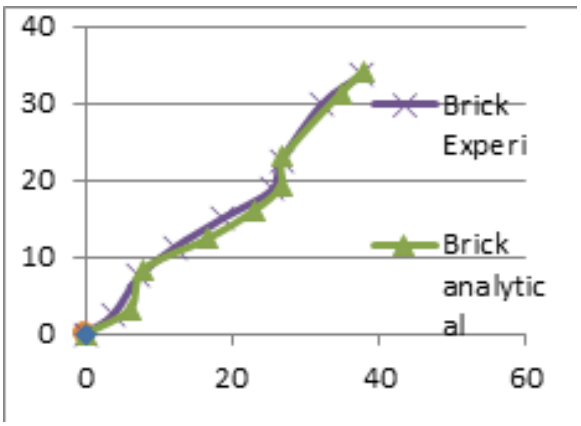
Sl No	Experimental					Analytical		Remarks
	Load			Displacement		Load	Displacement	
	P 1 Top	P2 (kN) Bottom	Total (kN)	D1 (mm) Bottom	D2 (mm) Top	(kN)	(mm)	
1	2.50	0	2.50	2.112	3.80	2.50	3.02	
2	5.00	2.50	7.50	5.74	18.720	7.50	17.81	
3	7.50	3.75	11.25	8.19	19.03	11.25	18.53	
4	10.00	5.00	15.00	12.13	21.82	15.00	20.98	First Crack in mortar
5	12.5	6.25	18.75	18.23	32.62	18.75	31.94	
6	15.00	7.50	22.50	21.2	37.82	22.50	36.98	Cracks at joints 5
7	20.00	10.00	30.00	23.41	42.62	30.00	41.86	Cracks at all joints
8	22.50	11.25	33.75	28.86	55.72	33.75	54.85	Cracks are wider, no additional cracks



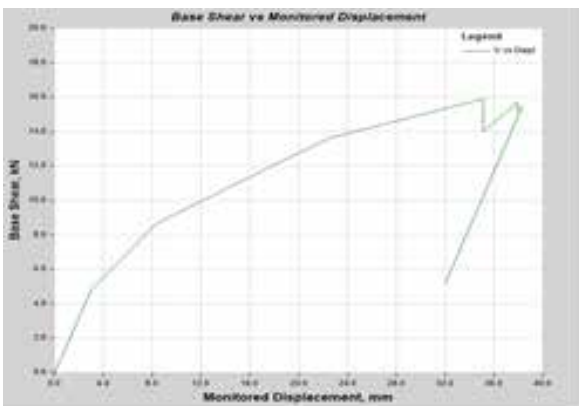
a. Graph showing for experimental results



b. Graph plotted for Analytical results



c. experimental and analytical results



d. pushover curve

Figure 6., Graph plotted for comparison of experimental and analytical results

CONCLUSIONS

In the present study RC bare frame was subjected to lateral loads and the obtained results were compared with analytical results obtained by ETABS software on similar model. The obtained values of base shear and deflections by experimental and analytical results compare favourably well and further the experimentally obtained values are found to be within permissible limit.

References

1. Mr. V. P. Jamnekar1, Dr. P. V. Durge2, "SEISMIC EVALUATION OF BRICK
2. MASONRY INFILL", International Journal of Emerging Trends in Engineering & Technology (IJETET) Vol. 02, No. 01, 2013.
3. L. Landi, P.P. Diotallevi & A. Tardini (2012),"Calibration of an Equivalent Strut Model for the Nonlinear Seismic Analysis of Infilled RC Frames", Department of Civil, Environmental and Materials Engineering - DICAM, University of Bologna, Bologna, Italy .
4. Sachin R Patel , Sumant B patel (May 2011) " "Effect of Brick Infill Panel in Design of High Rise Building ",National Conference on Recent Trends in Engineering & Technology, B.V.M. Engineering College, V.V.Nagar,Gujarat,India.
5. K. Chethan, R. Ramesh Babu, Katta Venkataramana and Akanshu Sharma, (Jun 2010), " Influence of masonry infill on fundamental frequency of 2D RC frames", Journal of Structural Engineering, vol 37,no2 June-July 1010.
6. Ebrahim Khalizadh Vahidi, Maryam Mokhtari Malekabadi, (2009), " Conceptual Investigation of Short- Columns and Masonry Infill Frames Effect in the Earthquake" , World Academy of Science, Engineering and Technology 59.
7. Robin Davis, Devdas Menon and Meher Prsad, (2009), " Earthquake-resistant
8. design of open ground story RC framed buildings", Journal of Structural Engineering, vol 37,no2.