Behaviour of Two Storey RC Frame Subjected to Lateral Load

R. Anu, S. Thirugnanasambandam

Abstract*—Reinforced concrete (RC) bare frames are being used to resist lateral loads.These frames behaviour is depending on stiffness of frames and materials used.A two storey RC bare frame with single bay is tested for lateral loading at beam column joint in each storey.The dimension of the specimen such as beam, column and exterior, interior and top corner beam – column joints were designed as per IS: 13920-1993 recommendations. The test specimen was reduced to 1/4th scale to suit the loading arrangement and test facilities. Prototype specimen had beam dimensions of 230 mm x 350 mm including the slab thickness and column dimension of 300 mm x 300 mm. The dimensions of beam and column were made as 170 mm x 120 mm and 200 mm x 120 mm respectively. The length of the beam for the test specimen was 1200mm. The height of the column for test specimen was 1000mm.RC frame was cast, as bare frame. The RC frame was subjected to lateral load and the behaviour of frames was studied till failure.Important parameters such as capacity of frame, energy absorption and ductility were determined.

Index Terms*— Behaviour of frames, Lateral load, Prototype, RC frame.

I. INTRODUCTION

Reinforced concrete framed structures are the most common type of structures used in the modern construction field [1].RC frame consists of beams and columns.The flat plane supported on beams is called slabs.In RC frames, columns are rigidly connected with beams.The size of columns and beams are selected to suit the actual design requirements of gravity loads.The column should be strong enough than beam to ensure the safety and stability of the framed structures [2].The framed structures are classified into rigid and flexible frame structures based on fixed conditions.Generally the rigid frame structure are supported by fixed supports and the flexible framed structures are supported by pinned supports.The RC framed structures are more beneficial than the load bearing structures in many ways such as economical, ease in construction, more floor area, more lateral resistant, easy for alternation work.The load bearing structures will have higher damage to lateral loads such as wind loads, earthquake loads, blast loads compared to RC framed structures.The main aim of this study is to outcome the behaviour of RC walls against lateral loadings.Generally the lateral loads will have serious effects on structures than the gravity loadings such as dead load and vertical imposed loadings.

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R. Anu,Research Scholar, Department of Civil and Structural Engineering, Annamalai University, Annamalainagar-608002.(anuravichandran17@gmail.com)

S. Thirugnanasambandam,Associate Professor, Department of Civil and Structural Engineering, Annamalai University, Annamalainagar-608002 (agstsai@gmail.com)

II. PREPARATION OF MODEL FRAME STRUCTURE

Materials used for casting model frame

Materials were chosen based on the IS stipulations.53 grade Ordinary Portland Cement (OPC) was used as binding materials with a specific gravity of 3.15.The specific gravity of fine aggregate and coarse aggregate are 2.68 and 2.7 respectively.A super plasticizer is used to enhance the workability of concrete.The mix proportion was designed for M30 grade with a mix ratio of 1: 2.12: 3.37 [3].The w/c ratio is taken as 0.47%.The dimensions of the beams and columns are 170 x 120 mm and 200 x 120 mm respectively.The height of the frame model is 2.84 m and the width of the frame is 1.2 m.The frame was cast in the laboratory and it was under water curing for 28 days continuously.After completion of curing period the frame was tested under lateral loading conditions.Fig. 1 shows the casting and curing of reinforced concrete frame model.

Fig.1Casting and curing of RC frame model

Loading setup for frame model

The prototype of the RC frame is reduced to 1/4th scale. The test setup for bare frame is shown in Fig. 2.It consists of loading arrangement and instrumentation for measuring deflection.Load points were located at top-storey levels in line with the beams [4].The frame which is used for the loading arrangements was fixedrigidly to the test floor.Loading jacks of 25 Ton capacity were placed at the each storey levels.Lateral load was applied through hydraulic jacks and the corresponding lateral displacement was measured by Linear Variable Differential Transducers (LVDT).The least count of these LVDT's is 0.01mm.

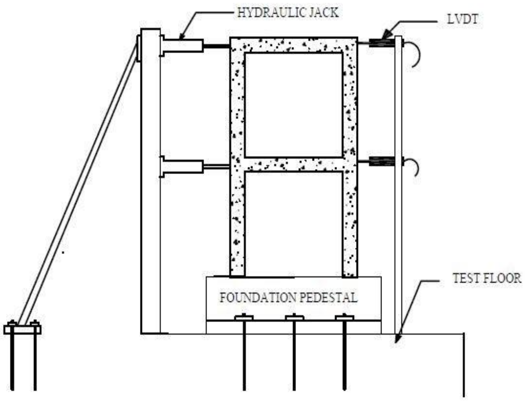

Fig.2 Test Setup of RC Frame Model

Proper care was taken to avoid displacements due to rotation of frame from pedestal and the foundation block used to arrest the rotation of the frame with respect to test floor the testing of RC frame as shown in Fig.3.

Fig.3Testing of RC Frame Model

The loading sequence of the frame was 0, 15, 30, 45 kNupto 82.52 kN and 0, 12, 24, 36 kNupto 66 kN.At the end of each increment of load, the deflection values were noted.The Linear Variable Differential Transducers were connected at the opposite end of the frame loading point to measure the displacement.LVDT were used at the beam column joint in line with the beam member.Two LVDT were used to measure the lateral deflection at bottom and top storey for push and pull type lateral loading conditions.The Fig.4 shows the RC frame model after testing under lateral loading conditions.The crack patterns are shown in Fig.5-6

Fig.4Testing of RC Frame Model

Fig.5Crack pattern at beam column joint at the opposite to loading end

Fig.6Crack pattern at beam column joint at loading end

III. EXPERIMENTAL INVESTIGATIONS

The displacements measured at each lateral load level for push and pull conditions are given in Table 1.The load versus corresponding displacement curve was plotted as shown in Fig.7 - 10. These values are used to draw the load – displacement at each storey level of RC frame.The crack at yield point load was found to be 15 kN and the corresponding deflection is 8 mm for pushing load at bottom storey.The crack at the yield point load was found to be 12 kN and the corresponding deflection was 9 mm at bottom storey.The crack at ultimate was found to be 82.50 kN and the corresponding deflection is 49 mm for pushing load at bottom storey.The crack at the ultimate load was found to be 66 kN and the corresponding deflection was 62.30 mm for pulling load at bottom storey.The crack at yield point load was found to be 15 kN and the corresponding deflection is 11 mm for pushing load at top storey.The crack at the yield point load was found to be 12 kN and the corresponding deflection was 12 mm for pulling at top storey.The crack at ultimate was found to be 82.50 kN and the corresponding deflection is 68.30 mm for pushing load at top storey.The crack at the ultimate load was found to be 66 kN and the corresponding deflection was 69.35 mm for pulling load at top storey.

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Table 1 Load – Displacement behaviour of RC frame model

Sl. NO	Load (kN)		Deflection (mm)			
			Bottom Storey		Top storey	
	Push	Pull	Push	Pull	Push	Pull
1	0	0	0	0	0	0
2	15	12	8.00	9.00	11.00	12.00
3	30	24	16.00	20.00	26.40	28.30
4	45	36	27.00	33.30	39.40	41.60
5	60	48	36.00	44.60	51.30	53.60
6	75	60	44.90	56.30	62.30	64.30
7	82.5	66	49.0	62.30	68.30	69.35

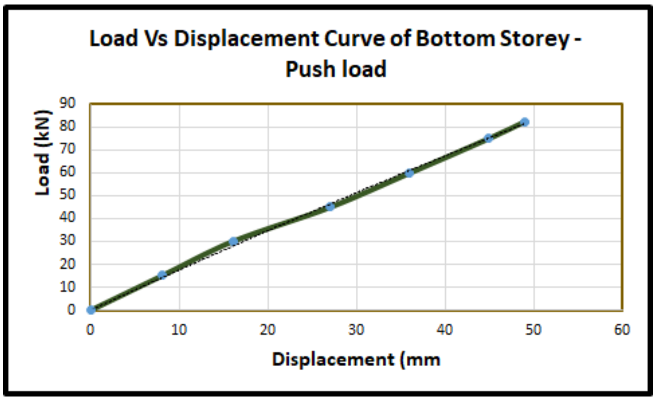

Fig.7Load Vs Displacement curve for RC frame for bottom storey – Push type loading

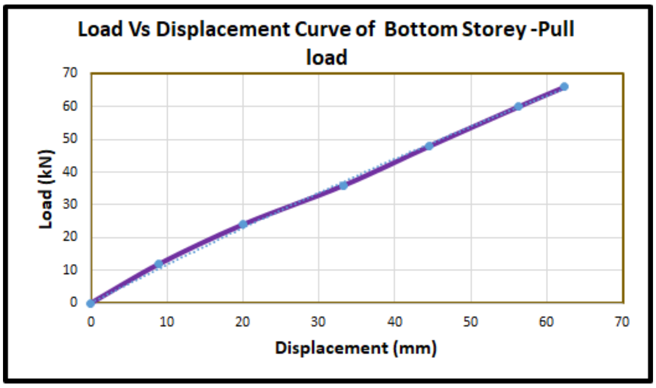

Fig.8Load Vs Displacement curve for RC frame for bottom storey – Pull type loading

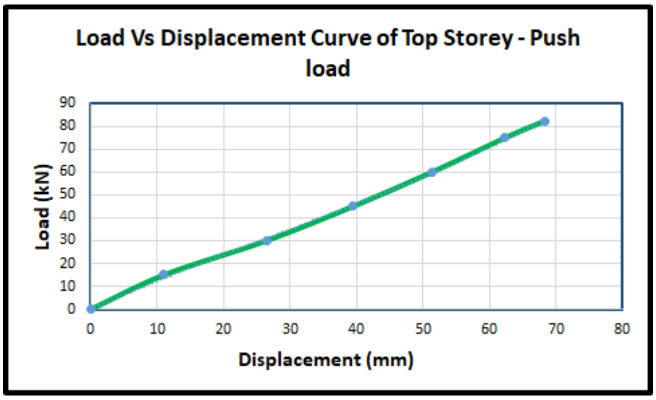

Fig.9Load Vs Displacement curve for RC frame for Top storey – Push type loading

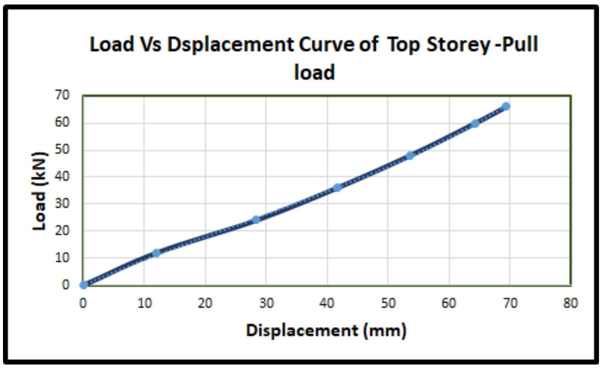

Fig.10Load Vs Displacement curve for RC frame for Top storey – Pull type loading

IV. RESULTS AND DISCUSSIONS

The behaviour of RC frame model under lateral loading conditions are obtained from the experimental investigations and the results are presented.The stiffness characteristics of RC bare frame at each storey level is calculated and compared in Fig.11.The slope of initial tangent (dy/dx) is calculated as stiffness of frame.The ductility characteristics of RC bare frame at each storey level is calculated and compared in Fig. 12.The ductility factor is the ratio between displacement at ultimate load and displacement at yield load.The energy absorption capacity characteristics is founded at each storey and compared in Fig. 13.The area under load – displacement curve is calculated as energy absorption capacity of RC bare frame [5].The stiffness and ductility characteristics of the top storey is higher than the bottom storey.The energy absorption capacity of the bottom storey is higher than the top storey.

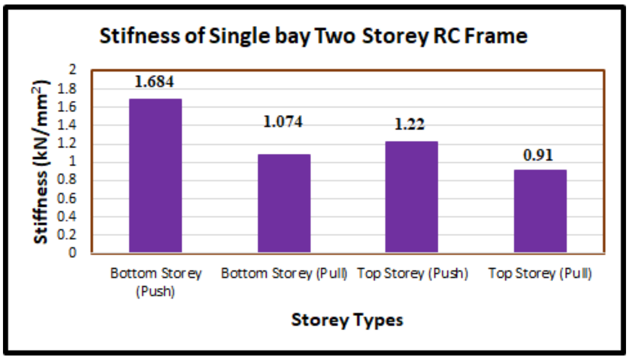

Fig.11 Stiffness characteristics of RC frame model

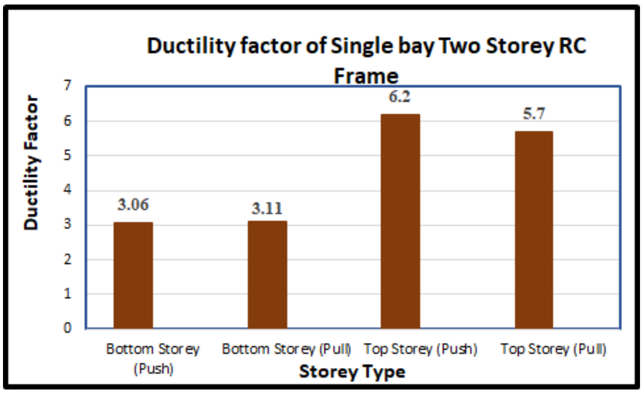

Fig.12 Ductility characteristics of RC frame model

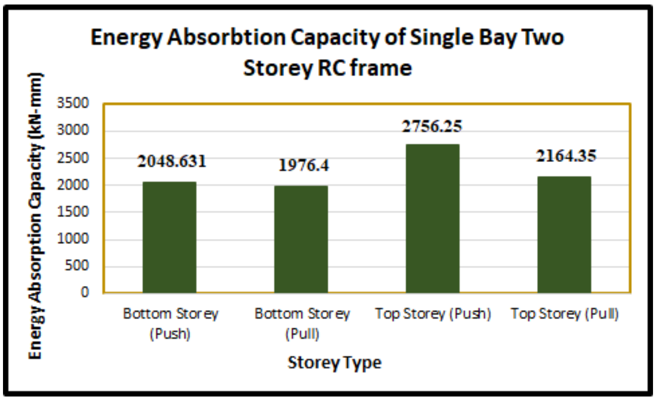

Fig.13 Energy absorption capacity of RC frame model

V. CONCLUSIONS

The following conclusions are made from this thesis work.

1. The suitable materials for conducting experiment are found and collected from the locally available market.Preliminary tests are conducted for cement, fine and coarse aggregate.The specific gravity of cement, sand and coarse aggregate are found as 3.15, 2.68, and 2.7 respectively.From the sieve analysis of fine aggregate, zone and fineness modulus are obtained as II and 2.89 respectively.Fine modulus of coarse aggregate is found as 6.73.
2. M30 grade mix is selected for casting RC frame and mix proportion obtained using IS 10262 – 2009.The mix proportion is 1: 2.12: 3.37 with w/c ratio of 0.47. To get workable concrete, super plasticizer of dosage 0.4 % is added to concrete.It is found that, the slump of the concrete is 55 mm.Compressive strength 150 mm cubes is obtained as 31.67, 36.26 and 38.60 N/mm^2 at 7, 14 and 28 days respectively.
3. The RC bare frame ultimate lateral load capacity at each storey level is found as 82.50kN for push loading.The maximum displacement corresponding to this ultimate load is 49.00 mm and 68.30 mm at bottom and top storeylevel respectively.
4. The RC bare frame ultimate lateral load capacity at each storey level is found as 66 kN for pull loading.The maximum displacement corresponding to this ultimate load is 62.30 mm and 69.35 mm at bottom and top storey level respectively.
5. The stiffness of the bottom storey and thetop storey level of RC bare frame for push type loading is 1.68kN/mm and 1.22 kN/mm respectively.
6. The stiffness bottom storey and top storey level of RC bare frame for pull type loading is 1.07kN/mm and 0.91 kN/mm respectively.
7. The ductility factor at the bottom storey and the top storey level of RC bare frame under push type loading are 3.06 and 6.20 respectively.
8. The ductility factor at thebottom storey and the top storey level of RC bare frame under pull type loading are 3.11 and 5.70 respectively.
9. The energy absorption capacity of the bottom storey and the top storeylevel for push type loadings are 2048.63 kN-mm and 2756.25kN-mm respectively.
10. The energy absorption and the bottom storey and the top storeylevel for pull typeloadings are 1976.40 kN-mm and 2164.35kN-mm respectively.

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BIOGRAPHY

R. Anu,is doing her Ph.D., Department of Civiland Structural Engineering, Annamalai University.She had completed her Master Degree in Annamalai University.She had published 02 research papers and attended some National & International Conference.

Dr. S. Thirugnanasambandam is presently working as Associate Professor in Annamalai University.He had completed his Master Degree and Doctoral Degree in Annamalai University.He is working in the Department of Civil and Structural Engineering since 1999. Four of his scholars awarded Ph.D., degree and presently guiding seven Ph.D., Scholars.He had published 74 research papers and attended many National and International Conference.His areas of interest are damage assessment and repair of structures.Also, he is familiar in development of Geopolymer concrete products.