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Seismic Behaviour of RCC Framed Structure with Different Bracing System

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ABSTRACT

Structures in high seismic risk areas may be susceptible to severe damage in a major earthquake. For the variety of structures and possible deficiencies that arise, several retrofitting techniques can be considered. Bracing system is one of the retrofitting techniques and it provides an excellent approach for strengthening and stiffening existing building for lateral forces. Also, another potential advantage of this system is the comparatively small increase in mass associated with the retrofitting scheme since this is a great problem for several retrofitting techniques. The seismic performance of reinforced concrete (RC) building using steel bracings is investigated. A thirteen storey (G+12) building is analyzed for seismic zone III as per IS 1893 (Part1): 2002. Static behavior of the RC building without bracings and with different types of bracings is investigated. The effectiveness of various types of steel bracings in rehabilitating the thirteen storey building is studied. Displacement was found less for all braced frames. From the study it was concluded that the steel X bracings is more effective to resist lateral loads compared to forward and backward for steel bracings.

Keywords : Retrofitting, ETABS 2015, Displacement, Bracings.

I. INTRODUCTION

Earthquake is a manifestation of rapid release of stress waves during a brittle rupture of rock. Earthquake causes ground to vibrate and structures supported on ground in turn are subjected to this motion. The various factors contributing to the structural damage during earthquake are vertical irregularities, irregularity in strength and stiffness, mass irregularity, torsional irregularity etc.

Earthquake ground motions are the most dangerous natural hazards where both economic and life losses occurs. Most of the losses are due to building collapses or damages. Earthquake can cause damage not only on account of vibrations which results from them but also due to other chain effects like landslides, floods, fires etc. Therefore, it is very important to design the structures to resist, moderate to severe earthquake ground motions depending on this site location and importance of the structure.

Structures in high seismic risk areas may be susceptible to severe damage in a major earthquake. For the variety of structures and possible deficiencies that arise, several retrofitting techniques can be considered. Bracing system is one of the retrofitting techniques and it provides an excellent approach for strengthening and stiffening existing building for lateral forces. Also, another potential advantage of this system is the comparatively small increase in mass associated with the retrofitting scheme since this is a great problem for several retrofitting techniques. Our ability to build seismically safe structures with adequate seismic resistance has increased significantly in the past few decades. Many reinforced concrete frame structures built in seismically active areas are expected to perform inadequately in a seismic event.

Braced frames are known to be efficient structural systems for buildings under high lateral loads such as seismic or wind loadings. The fact that the lateral resistance of frame can be significantly improved by the addition of a bracing system has led to the idea of retrofitting seismically inadequate reinforced concrete frames with steel bracing system. Bracing systems have both practical and economical advantages. The potential advantage of bracing system is the comparatively small increase in mass associated with the retrofitting scheme since this is a great problem for several retrofitting techniques.

1.1 Description of the building

In this study, A G+12 storey reinforced building have been considered for investigating the effect of X, V, and Inverted V bracings and their arrangements in various position in the building.

1. Reinforced concrete multi storey building without bracing system.
2. Reinforced concrete multi storey building with X, V and Inverted V type bracing system.

Other building details are given below:

Type of the structure RCC (ordinary moment resisting frames)

All RC exterior column size = 300mmX600mm.
All RC interior column size = 300mmX500mm.
All RC beam sizes = 300mmX400mm.
Slab thickness =150mm.
Bracing details = ISMB 500.
Grade of concrete for beams and slabs = M20.
Grade of concrete for column = M25.
Grade of steel = Fe415.

II. STRUCTURAL MODELING AND ANALYSIS

A G+12 storey reinforced concrete building with X, V and inverted V bracing provided on various positions in the building are analyzed for earth quake loading. The method of seismic analysis used in the present study is seismic coefficient method which is a linear static approach. Building is designed according to IS:456-2008 and earth quake loading is applied as per the recommendation of IS:1893-2002. Building is assumed to be located in seismic zone 3 of India and rest on medium soil condition. Following seismic parameters considered for the present study.
Zone factor for seismic zone 3 = 0.16.
For important building importance factor = 1.0.
Response reduction factor = 5.0.
Damping = 5%.
Soil site factor for medium soil condition = 2.0.

The structures are demonstrated by utilizing computer programming ETABS 2015. The floor finish is taken as 1 kN/m^2. The live load is taken as 2 kN/m^2.

Total 10 models are analyzed in this study.
One bare frame model.
Three models of X bracing.
Three models of V bracing.
Three models of inverted V bracing.
Figures given below shows the various arrangements of X type, V type and inverted V type bracing in the building frame.

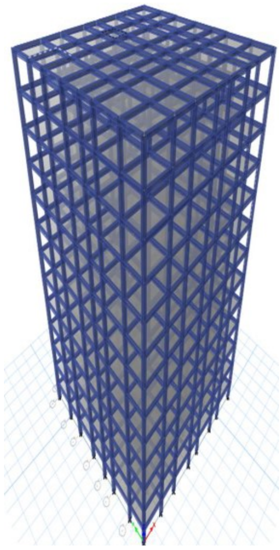

Figure 1. Bare frame

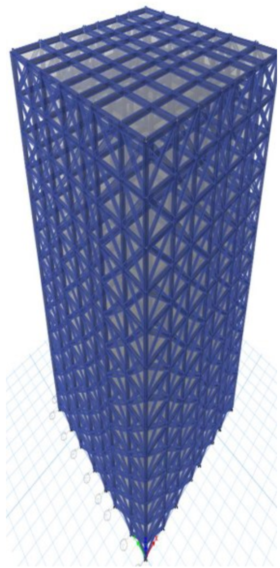

Figure 2. X bracing with exterior periphery

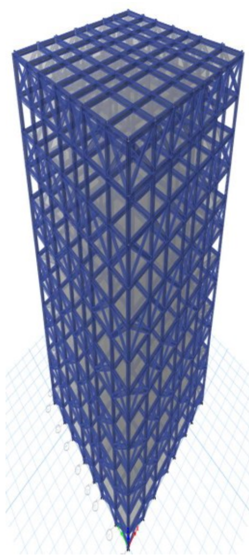

Figure 1. X bracing with Vertical alternative

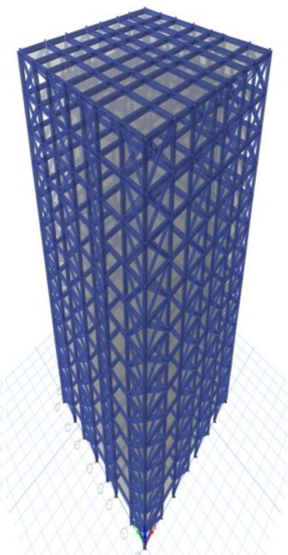

Figure 4. X bracing with horizontal alternative

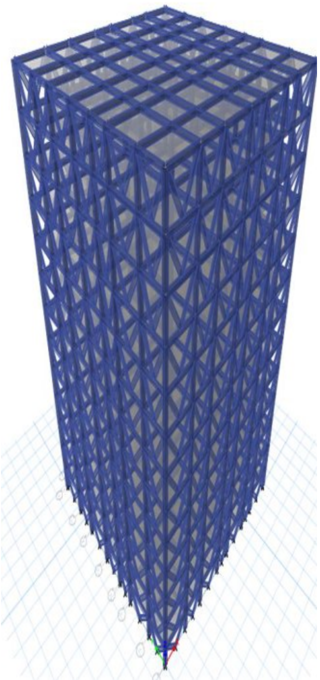

Figure 5. V bracing with Exterior periphery

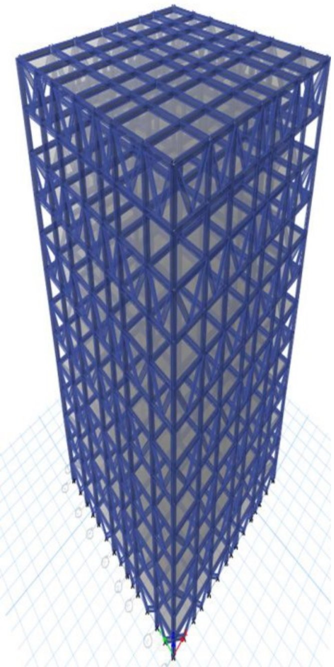

Figure 6. V bracing with vertical alternatives

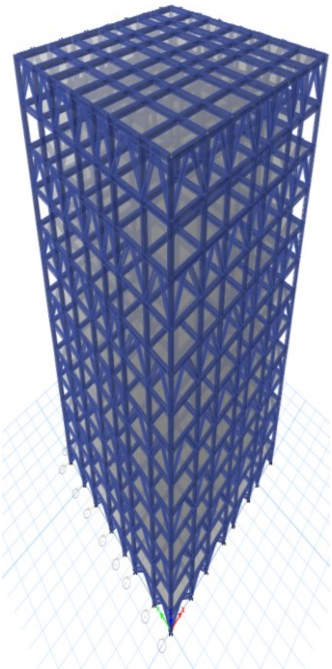

Figure 9. inverted V bracing bracing With vertical alternatives alternatives

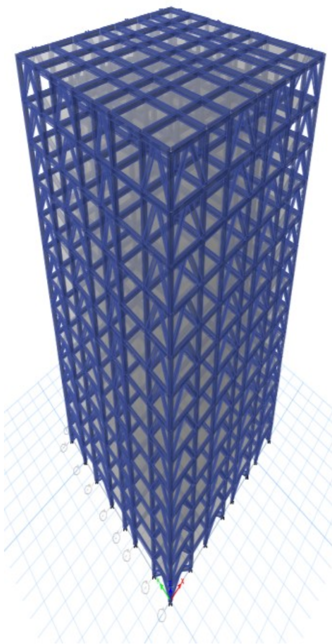

Figure 10. inverted V with horizontal

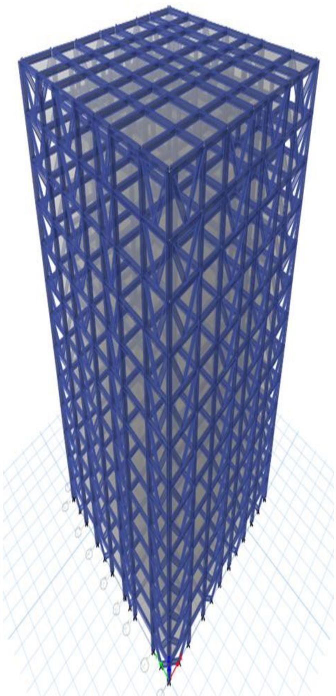

Figure 7. V bracing with horizontal alternatives periphery

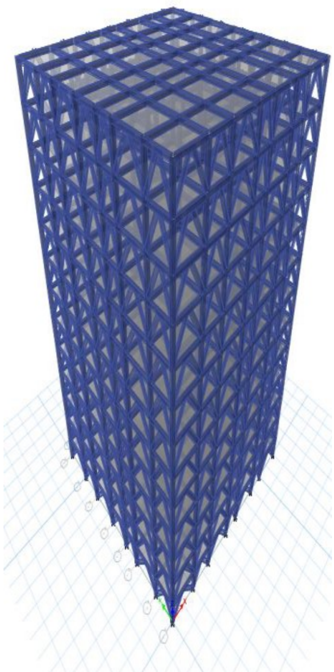

Figure 8. inverted V bracing with exterior

III. RESULTS

Results of analysis are present in the form of graphs and their discussion.

3.1 X bracings

Table 1 : Variation of displacement (mm) for models 1, 2a, 2b and 2c along X-X direction

DISPLACEMENT (mm) XX DIRECTION				
storeys	Model 1	Model 2a	Model 2b	Model 2c
Base	0.00	0.00	0.00	0.00
Storey1	4.48	0.63	0.38	0.12
Storey2	17.18	1.63	6.90	2.30
Storey3	32.37	2.74	7.56	4.70
Storey4	48.17	3.93	13.84	7.73
Storey5	63.93	5.18	14.56	11.24
Storey6	79.31	6.46	20.62	15.11
Storey7	94.03	7.74	21.34	19.23
Storey8	107.80	9.01	26.76	23.51
Storey9	120.30	10.23	27.46	27.85
Storey10	131.19	11.37	31.82	32.18

Storey11	140.11	12.42	32.37	36.44
Storey12	146.46	13.34	35.04	40.60
Storey13	151.11	14.10	35.40	44.58

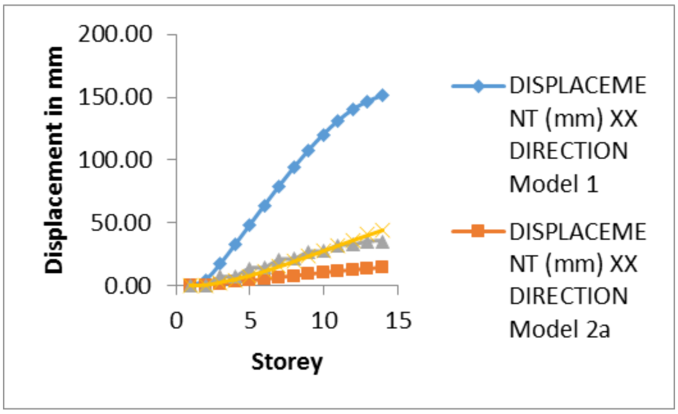

Figure 11. Variation of displacement (mm) for models 1, 2a, 2b and 2c along X-X direction

From Table 1 it was observed that, the displacement is less in model 2a, model 2b and model 2c compared to bare frame (i.e. 90% less for model 2a, 77% less for model 2b and 70% less for model 2c) both in Equivalent Static Force method and Response Spectrum method in X-X direction. The displacement value goes on decreases from top storey to bottom storey in all models. This shows stiffness participates less in top storey compared to bottom storey in all models. The variation is given in Figure 11.

Table 2: Variation of displacement (mm) for models 1, 2a, 2b and 2c along Y-Y direction

DISPLACEMENT (mm) YY DIRECTION				
Storeys	Model 1	Model 2a	Model 2b	Model 2c
Base	0.00	0.00	0.00	0.00
Storey1	6.47	0.64	0.04	0.67
Storey2	22.82	1.64	9.57	2.52
Storey3	40.69	2.74	9.98	5.24
Storey4	58.65	3.93	19.07	8.68
Storey5	76.32	5.17	19.51	12.68
Storey6	93.48	6.44	28.21	17.09
Storey7	109.87	7.72	28.66	21.81
Storey8	125.17	8.98	36.44	26.70
Storey9	139.04	10.19	36.85	31.67
Storey10	151.09	11.33	43.02	36.63
Storey11	160.88	12.37	43.36	41.52
Storey12	167.95	13.29	47.01	46.30
Storey13	172.02	14.05	47.25	50.92

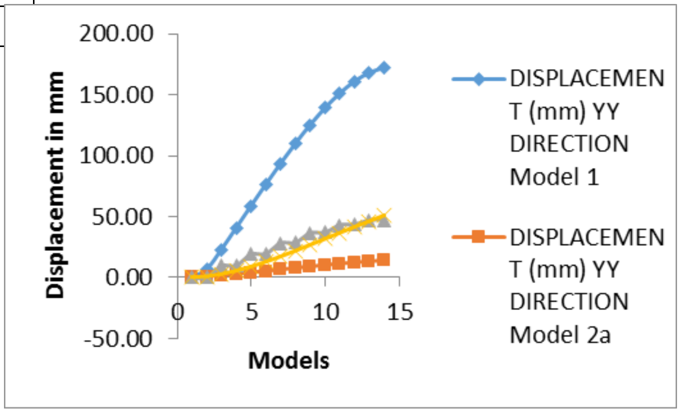

Figure 12. Variation of displacement (mm) for models 1, 2a, 2b and 2c along Y-Y direction

From Table 2 it was observed that, the displacement is less in model 2a, model 2b and model 2c compared to bare frame (i.e. 79.1% less for model 2a, 72% less for model 2b and 70% less for model 2c) both in Equivalent Static Force method and Response Spectrum method in Y-Y direction. The displacement value goes on decreases from top storey to bottom storey in all models. This shows stiffness participates less in top storey compared to bottom storey in all models. The variation is given in Figure 12.

3.2 V bracings

Table 3: Variation of displacement (mm) for models 1, 3a, 3b and 3c along Y-Y direction

DISPLACEMENT (mm) XX DIRECTION				
storeys	Model 1	Model 3a	Model 3b	Model 3c
Base	0.00	0.00	0.00	0.00
Storey1	4.48	0.70	0.50	0.89
Storey2	17.18	2.04	6.93	3.02
Storey3	32.37	3.48	7.94	5.82
Storey4	48.17	5.00	14.21	9.15
Storey5	63.93	6.57	15.28	12.89
Storey6	79.31	8.16	21.32	16.95
Storey7	94.03	9.74	22.37	21.20
Storey8	107.80	11.29	27.81	25.57
Storey9	120.30	12.76	28.76	29.97
Storey10	131.19	14.13	33.12	34.32
Storey11	140.11	15.35	33.88	38.58
Storey12	146.46	16.41	36.55	42.70
Storey13	151.11	17.26	37.02	46.62

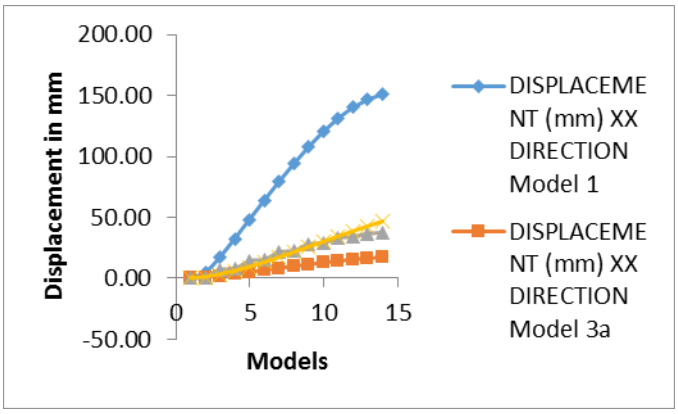

Figure 13. Variation of displacement (mm) for models 1, 3a, 3b and 3c along X-X direction

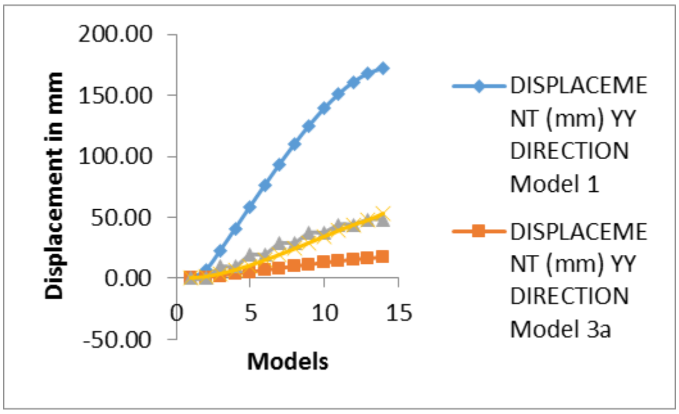

Figure 14. Variation of displacement (mm) for models 1, 3a, 3b and 3c along Y-Y direction

From Table 3 it was observed that, the displacement is less in model 3a, model 3band model 3c compared to bare frame (i.e. 88% less for model 3a,75% model 3b and 70% less for model 3c) both in Equivalent Static Force method and Response Spectrum method in X-X direction. The displacement value goes on decreases from top storey to bottom storey in all models. This shows stiffness participates less in top storey compared to bottom storey in all models. The variation is given in Figure 13

Table 4: Variation of displacement (mm) for models 1, 3a, 3b and 3c along Y-Y direction.

DISPLACEMENT (mm) YY DIRECTION				
storeys	Model 1	Model 3a	Model 3b	Model 3c
Base	0.00	0.00	0.00	0.00
Storey1	6.47	0.72	0.33	1.03
Storey2	22.82	2.05	9.55	3.45
Storey3	40.69	3.49	10.20	6.63
Storey4	58.65	5.00	19.22	10.43
Storey5	76.32	6.57	19.90	14.71
Storey6	93.48	8.15	28.53	19.34
Storey7	109.87	9.73	29.20	24.21
Storey8	125.17	11.27	36.93	29.21
Storey9	139.04	12.73	37.54	34.24
Storey10	151.09	14.10	43.66	39.23
Storey11	160.88	15.32	44.15	44.12
Storey12	167.95	16.37	47.79	48.05
Storey13	172.02	17.22	48.09	53.37

From Table 4 it was observed that, the displacement is less in model 3a, model 3b and model 3c compared to bare frame (i.e. 90% less for model 3a, 72% less for model 3b and 69% less for model 3c) both in Equivalent Static Force method and Response Spectrum method in Y-Y direction. The displacement value goes on decreases from top storey to bottom storey in all models. This shows stiffness participates less in top storey compared to bottom storey in all models. The variation is shown in Figure 14.

3.3 Inverted V bracings

Table 5: Variation of displacement (mm) for models 1, 4a, 4b and 4c along X-X direction.

DISPLACEMENT (mm) XX DIRECTION				
storeys	Model 1	Model 4a	Model 4b	Model 4c
Base	0.00	0.00	0.00	0.00
Storey1	4.48	0.65	0.47	0.44
Storey2	17.18	1.91	6.89	1.92
Storey3	32.37	3.30	7.86	4.22
Storey4	48.17	4.78	14.13	7.18
Storey5	63.93	6.31	15.17	10.65
Storey6	79.31	7.88	21.12	14.51
Storey7	94.03	9.44	22.24	18.61
Storey8	107.80	10.95	27.69	22.87
Storey9	120.30	12.40	28.61	27.17
Storey10	131.19	13.74	32.97	31.43
Storey11	140.11	14.93	33.71	35.58
Storey12	146.46	15.95	36.37	39.57
Storey13	151.11	16.75	38.70	43.32

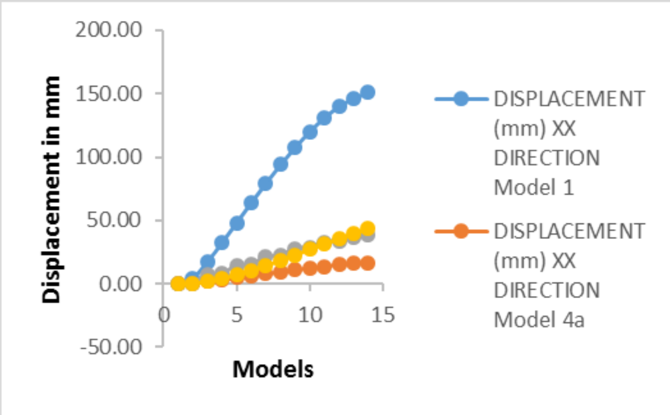

Figure 15. Variation of displacement (mm) for models 1, 4a, 4b and 4c along X-X direction.

From Table 5 it was observed that, the displacement is less in model 4a, model 4b and model 4c compared to bare frame (i.e. 88% less for model 4a, 90% less for model 4b and 71% less for model 4c) both in Equivalent Static Force method and Response Spectrum method in X-X direction. The displacement value goes on decreases from top storey to bottom storey in all models. This shows stiffness participates less in top storey compared to bottom storey in all models. The variation is shown in Figure 15.

IV. CONCLUSIONS

In this dissertation work, an analytical investigation has been carried out to study the behavior of RC and steel braced RC frames. Multi-storied buildings have been analyzed with and without bracings. The following conclusion can be drawn based on the results of the analysis carried out.

1. The displacement of the building decreases depending upon the different bracing system employed and the bracing sizes.

2. Comparing to bare frame all braced models have less displacement. The building frames with X bracing system in X-X direction (steel bracing) have less/minimum displacement in comparison with other bracing system in same direction that is about 90% of the displacement is reduced. This may be due to increased flexibility of steel compared to concrete.

From this it can be concluded that the steel X bracings is more effective to resist lateral loads (i.e. Earthquake static and dynamic load) compared to v bracing placed in different location.

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