Optimisation of RC Bracing Configuration on Seismic Evaluation of RC Framed Buildings

Jumi K M[1], Dr. Sreemahadevan Pillai.[2]

Abstract—A structure situated in high seismic area will have to withstand lateral load along with the gravity load. This may result in the development of high stress which leads to the severe damage of the structure. Shear wall, bracings are the most common type of lateral load resisting systems. The types of bracing, location of bracing have significant effects to the lateral capacity of the structure. This paper present an elastic seismic response of reinforced concrete frames with reinforced concrete braces in X braced pattern which are analyzed numerically for eleven storey building with 5-bay structures. The responses of braced frames of different patterns (bay, level and combinations thereof) have been compared with unbraced i.e. bare frame. Results such as time period, top storey displacement and inter storey drift have been compared.

Index Terms— RCBracing, Etabs 9.7.2, Linear Static Analysis, Response Spectrum Analysis.

1 Introduction

The primary purpose of all kinds of structural system in a building is to transfer the gravity load effectively and thus ensure safety of the structure. Apart from these vertical loads, structure is also subjected to lateral loads which can develop high stress resulting in the sway of the structure. So the structure should be such that it has sufficient strength and stiffness against these loads. Bracings, shear walls are the common lateral load resisting systems.

Reinforced concrete structures which are tall located in earthquake prone areas cannot withstand large displacements on its own. The drifts and large displacements in buildings which may cause damage to buildings and death to humans, can be resisted to a large extend by using bracing systems. The main objective of the present work is to find a suitable bracing configuration that will effectively reduce the response of the structure to external excitation (seismic excitation).

The main objectives of this study is to evaluate the seismic behavior of RC building retrofitted with RC X bracing by performing response history analysis. A comparative study of seismic performance is done for concentrically placed lateral load resisting systems at different locations like bay wise, level wise and their combinations. Storey displacement and storey drift are the parameters considered for the comparison.

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2 Theoretical Background

A Braced Frame is a structural system which is designed primarily to resist wind and earthquake forces. Bracings resist the lateral load by bracing action of inclined members. They stimulate forces in the associated beams and columns such that the whole work like a truss subjected to axial stress. This axial stress reduces the moment which in turn results in the reduced sections of the columns.

The bracing members are arranged in many forms, which carry solely tension, or alternatively tension and compression. The bracing is made up of crossed diagonals, when it is designed to resist only tension. Based on the direction of wind, one diagonal takes all the tension while the other diagonal is assumed to remain inactive. One of the most common arrangements is the cross bracing. Bracings hold the structure stable by transferring the loads sideways (not gravity, but wind or earthquake loads) down to the ground and are used to resist lateral loads, thereby preventing sway of the structure.

3 Modelling And Analysis

Structural modelling is a tool to establish a mathematical models consisting of three basic components: structural members or components, joints (nodes, connecting edges or surfaces), and boundary conditions (supports and foundations).

Structural analysis is a process to analyze a structural system to predict its responses and behaviors. The main objective of structural analysis is to determine internal forces, stresses and deformations of structures under various load effects.

3.2 Analysis Software

ETABS is a Powerful and Integrated Structural Analysis and Design Software. ETABS is comprehensive software were we could carry out Finite Element Modelling, Static, Dynamic and Non-Linear Analysis and Design of Structures. The geometry can be idealized by considering the structure to be made up of linear elements and plane two-dimensional elements. The program ETABS is employed herein to perform the response spectrum analysis.

3.3 Building Configuration and Details

An eleven storey building with a storey height of 3.5m in each floor is considered. The building has five bays in X direction and five bays in Y direction with the plan dimension 25 m × 20 m. The building is considered to be located in seismic zone V as per IS: 1893-2002. Structural details of the building such as grade of concrete, grade of steel, beam sizes, column sizes, size of bracings and all the other parameters are assumed as per Table I.

The building is kept symmetric in both mutually perpendicular directions in plan to avoid torsional effects. The orientation and size of column is kept same throughout the height of the structure. The columns are oriented in such a way that the depth is along the longest span.

Table I

Building Details

No	Building Details	
1	Grade of concrete	M 25
2	Grade of steel	Fe 415
3	Floor to floor height	3.50 m
5	Slab thickness	120 mm
6	Bracings	200 X 200
8	Column	450 X 900
9	Beam	350 X 500
10	Live load	3.5 kN/m²
11	Floor finish	1.5 kN/m²

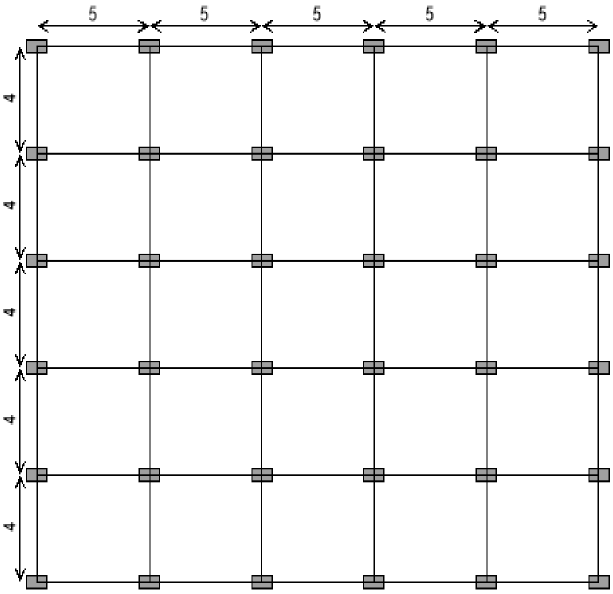

Fig. 1: Building Plan

4 Results And Discussions

4.1 Bare Frame

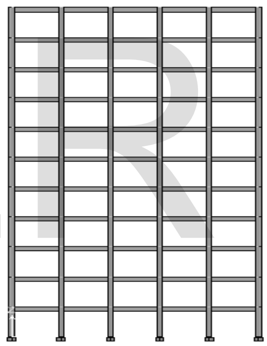

Fig. 2: Bare frame

4.2 Optimum Levelwise Location

To study the behavior of level wise bracing pattern 5 bay 12 storey structures are modelled and analyzed. A typical bracing pattern of this type is shown in Fig.3.

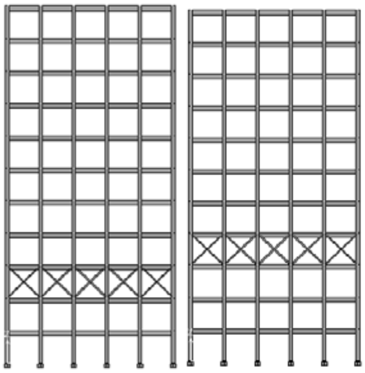

Fig. 3: Level braced models

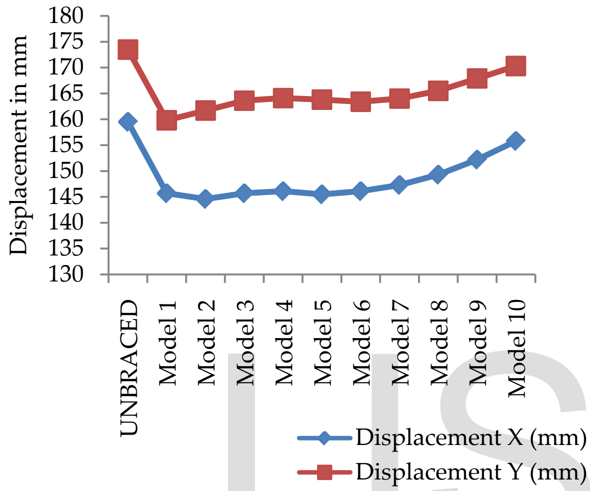

Fig. 4: Variation of displacement

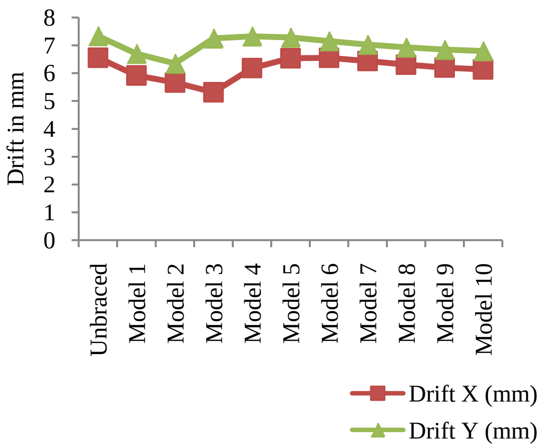

Fig. 5: Variation of drift

When the position of the bracings changed from level 1 to level 10, the time period of the structure initially decreased and then found to increase. But minimum time period was observed when the bracings are provided at the second level along the transverse direction. The drift was also seemed to be minimum at that level. The displacement and drift reduced considerably after providing bracings level wise. Drift was found to be minimum when bracings are provided in the second level along the transverse direction and third level along the longitudinal direction i.e. at the level where the drift was maximum when the structure was unbraced.

4.3 Optimum Baywise Location

To study the behavior of baywise bracing pattern, 5 bay 12 storey structures are modeled and analyzed numerically. A typical bracing pattern of this type is shown in Fig. 6

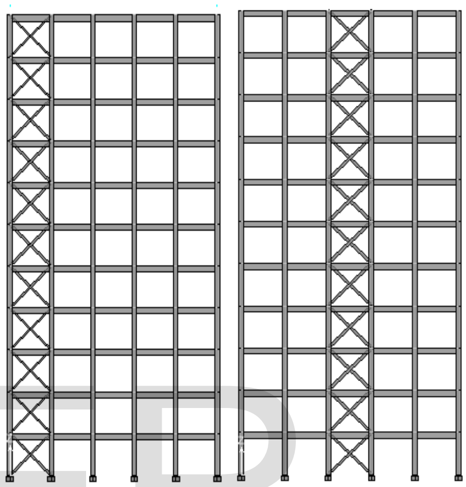

Fig. 6: Bay braced models

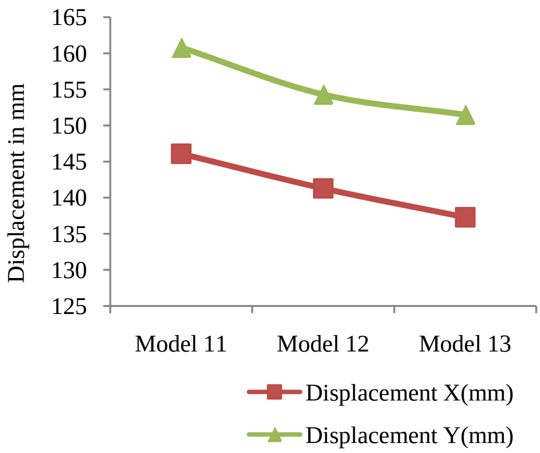

Fig. 7: Variation of displacement

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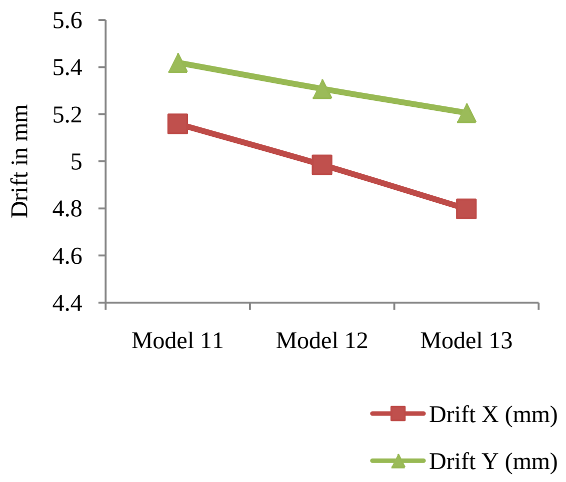


Fig. 8: Variation of drift

When the position of the bracing is changed from first bay to the third bay, the time period of the structure tend to decrease. The bracings provided in the third bay was found to be effective in controlling the roof displacement and the maximum inter storey drift.

4.4 Outrigger i.e. Partially Braced Frames

The logic of placing the braces bay wise and level wise share the algorithm which allows for combining them evolving a "braced frame with outrigger" i.e. a partially braced frame which results in the new combination of above two scenarios. To study the behavior of such outrigger frames, 5 bay 12 storey structures are modeled and analyzed. A typical frame of this type is shown in Fig. 5.

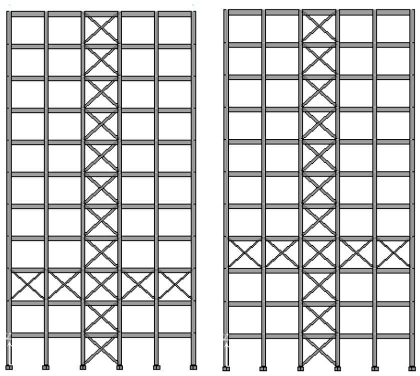


Fig. 9: Level and bay braced models

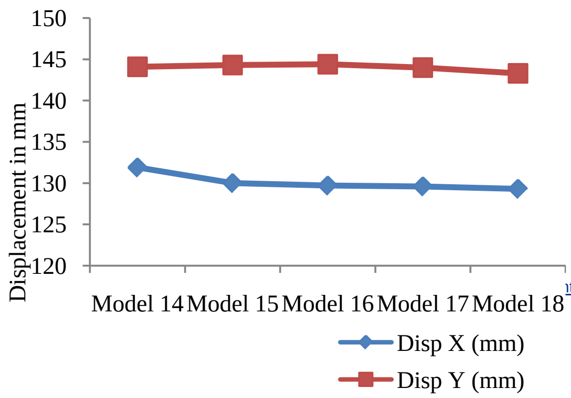
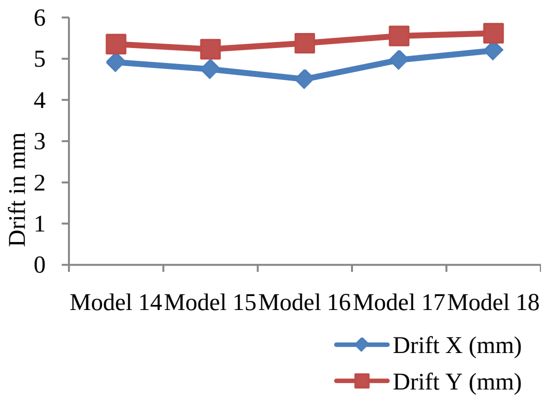


Fig. 10: Variation of displacement

Fig. 10: Variation of displacement



Brac... bay... char... decı... riod was obtained when second level was braced along with the third bay. The drift was also found to be minimum when bracings are provided in the second level and third level in the transverse and longitudinal direction respectively. The reduction in displacement was around 20%.

4.5 Level Combinations

Models with 2 levels braced are modeled and analyzed to study the seismic effect.

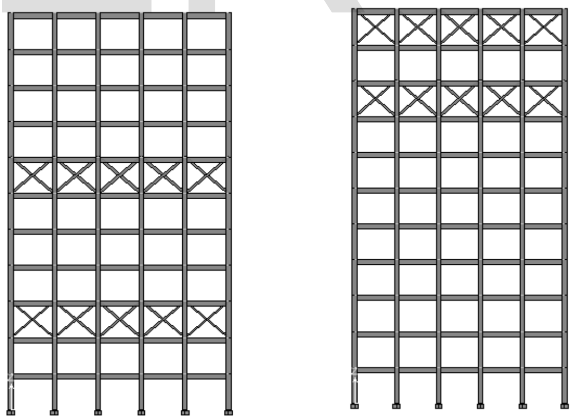


Fig. 11: Level combinations

By providing bracing in two levels time period found to be less than when single level is braced. But when higher levels are braced there is no decrease in the time period. The time period was found to be minimum when the levels 1 and 3 are braced. The displacement was also the least for the same model. The graph showed a trend that the alternate levels when braced exhibit less time pe-

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riod than when adjacent levels braced.

The displacement and inter storey drift for the level combinations are shown in figures 13 and 14 respectively.

Fig. 11: Variation of drift

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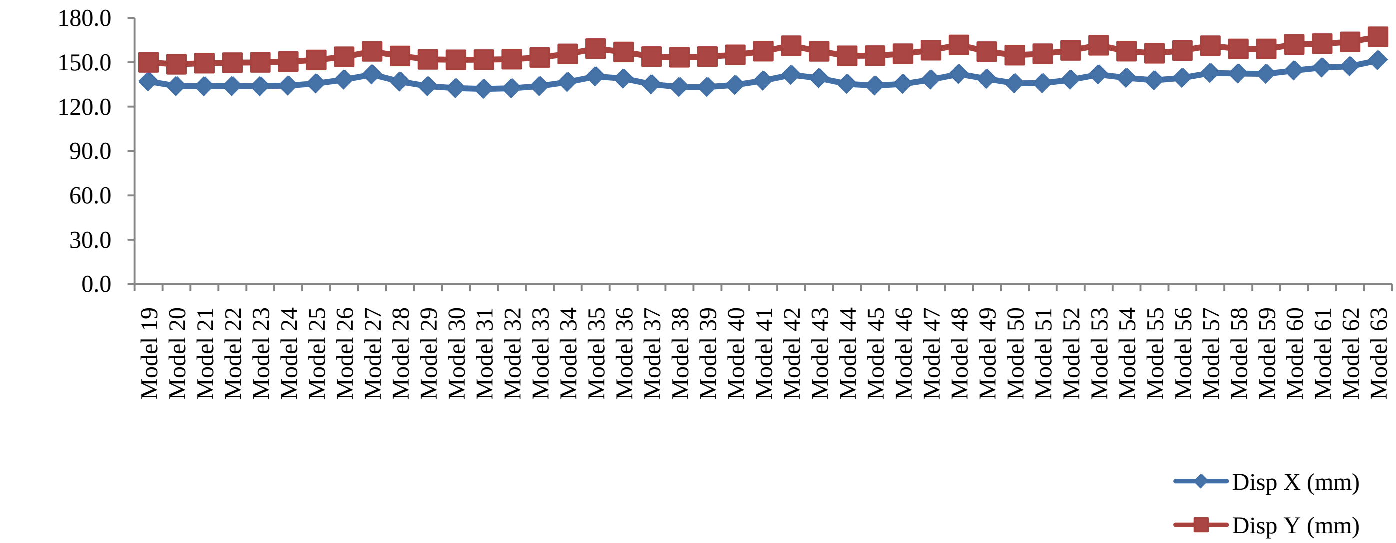

Fig. 12: Variation of displacement

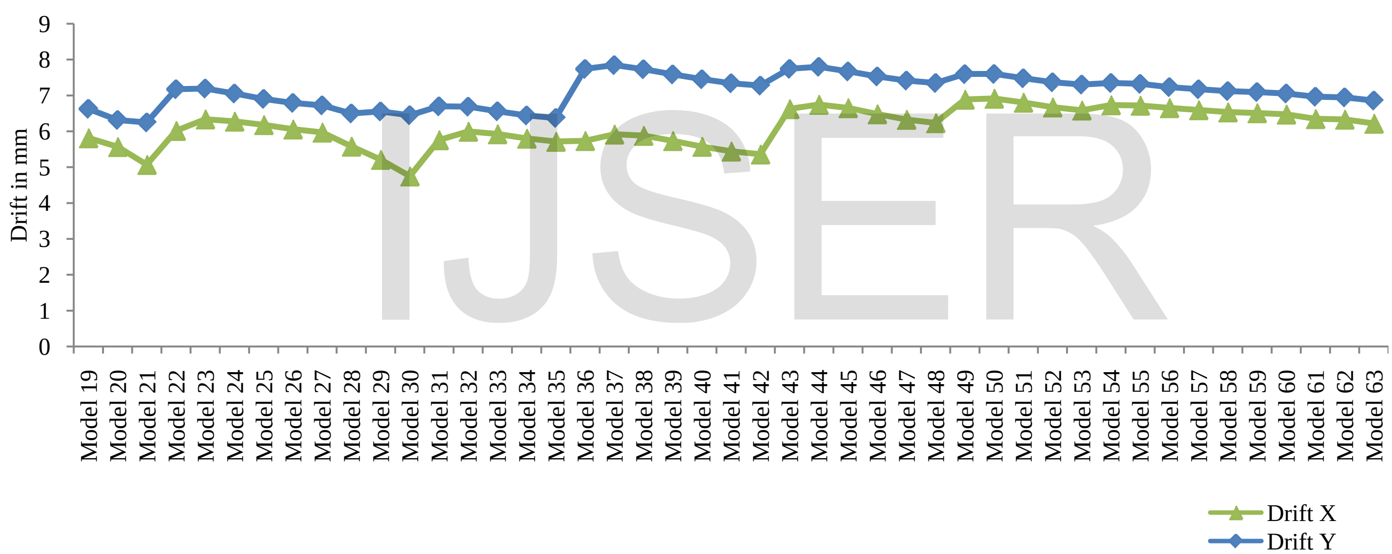

Fig. 13: Variation of drift

CONCLUSIONS

A significant amount of increase in the lateral stiffness has been observed in all models of braced frame compared to bare frame.

Time period was found to be decreasing when bracings are provided in the lower levels.

Usage of bracings increase the base shear on the buildings

It was found that more effective configuration is obtained when bracings are placed in that level which is subjected to high lateral drift when unbraced.

Bracings seemed to be not much effective when placed at higher levels.

Maximum reduction in displacement and drift was observed when third bay and second level in case of transverse direction and third bay and third level in case of longitudinal direction is braced. i.e. drift reduced by about 31.3%.

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