

Seismic Study of Multistorey RC Building With Different Bracings

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ABSTRACT: Previous earthquakes show that not only non-engineered structures, but also engineered structures need to be designed in such a way that they perform better under seismic loading. Structures situated in high seismic risk areas may be susceptible to severe damage in a major earthquake. Shear wall and steel bracings are the most popular system to resist lateral load due to earthquake. Bracing system is one of the retrofitting techniques and it provides strength and stiffness to existing building against lateral forces. Bracing can be applied as eccentric bracing or concentric bracing. There are different possibilities to arrange steel bracings such as Diagonal, X, V, Inverted V. Bracing increase lateral stiffness and they increase the natural frequency and usually decrease the lateral drift. This study concentrates on seismic studies of reinforced concrete building with different bracing system. From the study it was found that X bracing is more effective bracing system compared to other bracings. Further study is carried out with X bracing with different aspect ratio by changing the height of the building. Different heights selected for the study are 6m, 9m, 12m. ETABS 2016 software is used for the study. Response spectrum analysis is carried out. The results such as storey drift and displacements are compared.

KEYWORDS: Bracings, Response spectrum, shear wall

I. INTRODUCTION

An earthquake is a natural phenomenon and it is generated in the earth's crust. Duration of earthquake is normally short. Structures situated in seismic risk areas may be subjected to severe damage in a major earthquake. During earthquake motions, deformations take place across the elements of the load-bearing system. Due to these deformations internal forces develop across the elements of the load-bearing system and cause displacement of the building. Displacement demand varies depending on the stiffness and mass of the building. Buildings with higher stiffness and lower mass have less horizontal displacements demands. The primary objective of all kinds of structural systems used in the building is to transfer gravity loads effectively. Dead load, live load and snow loads are the common loads produced by the effect of gravity. Besides the vertical loads, buildings subjected to horizontal loads caused by wind, blasting or earthquake. Lateral loads can develop high stresses cause vibration. Therefore, it is very important for the structure to have sufficient strength and stiffness to resist lateral loads. Bracing System is one of the retrofitting techniques and it increase strength and stiffness of existing building against lateral force. Bracing is an effective strategy to enhance the global stiffness and strength of steel frames. It can increase the energy absorption of structures or decrease the demand like displacement, drift imposed by earthquake loads.

The bracing system has more plastic deformation before collapse and can absorb more energy during the earthquake. Members in the braced frame made of structural steel and strong in both tension and compression. The beams and columns of the structure to carry vertical loads and bracing carry lateral load. Braces will be subjected to both tension and compression, because lateral loading on a building is reversible, so they are usually designed for the more stringent case of compression. For this reason, bracing systems with shorter braces like K bracing suitable for full diagonal types. Double diagonal are designed to carry in tension.

A.R. Khaloo and M. Mahdi Mohseni[4] conducted study on nonlinear response of reinforced concrete frames which contain reinforced concrete braces as the major structural elements against earthquake loads. Two different braced frames with K and X braces are analyzed for four, eight and twelve story buildings. According to the study it is

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concluded that besides effective lateral stiffness rising in reinforced concrete braced frames, there is a considerable amount of energy dissipation during earthquake loading. Padmakar Maddala [6] conducted study on the seismic performance of a typical six story building with different types of bracing like Diagonal, V and K. The software used for the analysis is SAP2000. They concluded that shear capacity of the structure can be increased by addition of steel bracing in the structural system and bracing can be effectively used as retrofit. Khan and Khan [2] They conducted study on a 15 story steel frame building with different types of bracing system like V, X, Diagonal and Exterior X. ISMB, ISMC and ISA sections are used to compare for same type of bracing. An ISMB section gives more stiffness and better performance compared to other section for similar type of brace. Gunderao V Nandi & G S Hiremath [7] They conducted study on seismic performance of non- ductile reinforced concrete (RC) buildings with eccentric steel bracing of inverted V type. The behaviour of eccentric braced frame (EBF) is compared with conventional RC frame. EBF reduces all the seismic hazards efficiently hence EBFs are well suitable for seismic regions till 15 storey.

The main objectives of this paper are to study the seismic response of RC building with different type of bracings such as X, Inclined, V and Inverted V by performing response spectrum analysis. Compare various parameters like storey drift, storey displacement, base shear time period for different models considered. Identify suitable bracing system for resisting seismic load effectively. To study effect of aspect ratio by performing response spectrum analysis on most effective bracing system

II. GEOMETRY AND MATERIAL PROPERTY

In order to perform seismic analysis of building with bracing a base model selected from the Journal: Seismic evaluation of RC building by using steel bracing with and without shear panel (Aparna s patil and G.R Patil). Base model is modified to structure consist of 6 bays in x direction and 5 bays in y direction. This study concentrates on seismic study of reinforced concrete building with different system and find out the most effective bracing system. For the study different bracings like X brace, diagonal brace, Inverted V brace are selected. Further study is carried out with effective bracing with different aspect ratio by changing the height of the building. Different heights selected for the study are 6m, 9m, 12m. Then study carried out with irregularity of the building. ETABS 2016 software is used for the study. Response spectrum analysis is carried out. The results such as storey drift, base shear and displacements are compared. Analysis is done using response spectrum analysis. Table 1 shows the material and geometric property of model.

Table 1 Material property of model

Grade of concrete	M20
Grade of steel	Fe415
Floor to floor height	3m
Slab thickness	125mm
Wall	230mm
Column	230× 600mm
Beam	230× 300mm
Live load on all floors & roof	3kN/m ²
Floor finish	1kN/m ²

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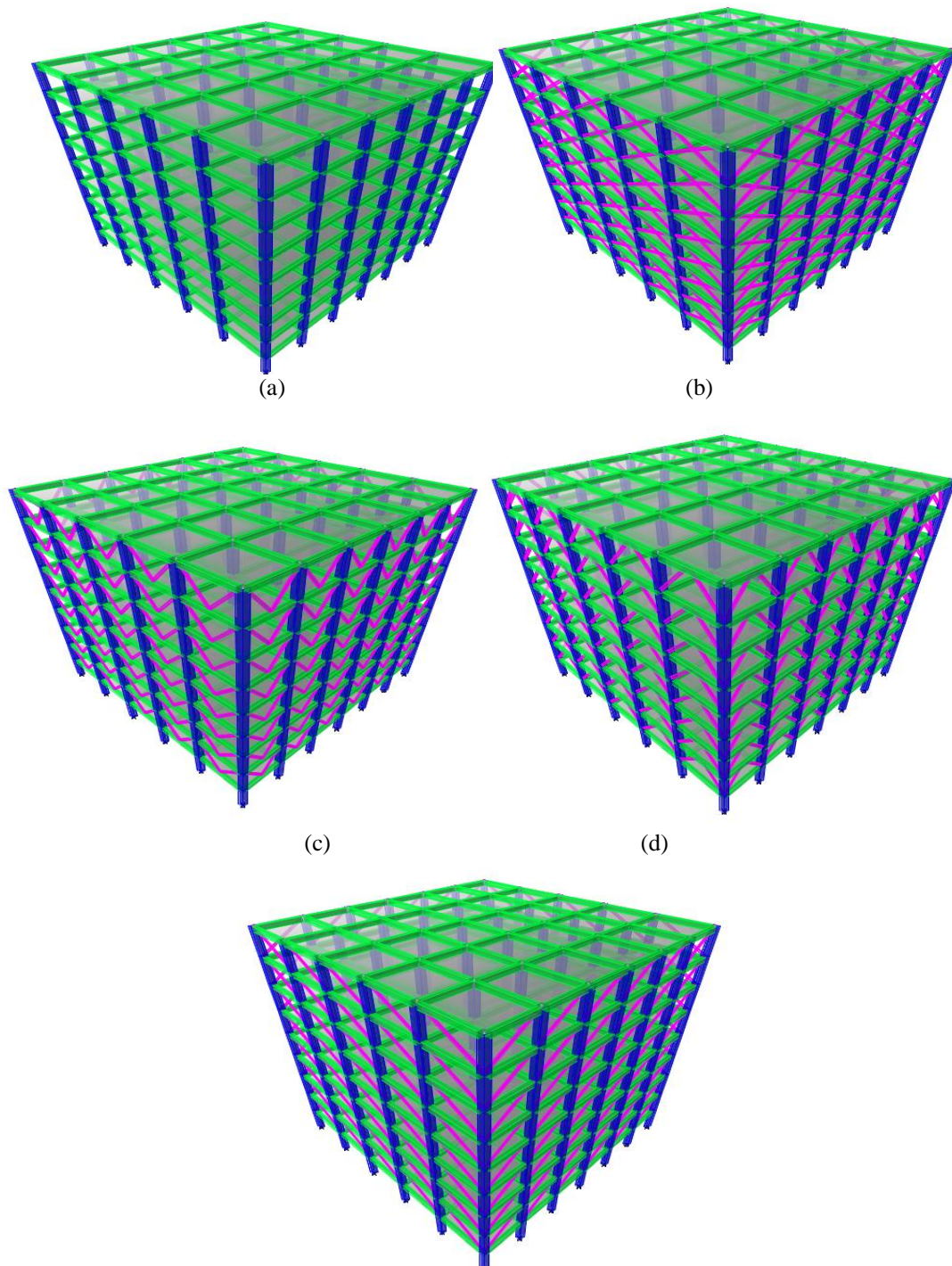


Fig 1 3D model of building (a)Without bracing (b)With X bracing (c) With V brace(d)With inverted V brace
(e) With inclined brace

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Fig 1 shows the 3D of model with different bracings. 5 models prepared for the study. building without bracing, with x bracing, with V bracing, with inverted v bracing, inclined bracing.

III. SEISMIC ANALYSIS

3-1 Comparison of seismic performance of different bracings

A 9 storey building is selected for the study. 5 models prepared for the study. The prepared model is analysed using response spectrum analysis. Fundamental time period, story displacement, story drift are determined using Etabs 2016 software.

In order to perform the seismic analysis and design of a structure the actual time history record is required. But it is not possible to have such records at each and every location and the seismic analysis of structures cannot be carried out simply based on the peak value of the ground acceleration. To overcome the above disadvantages earthquake response spectrum is used for seismic analysis of structures. Response spectrum analysis is a linear-dynamic analysis method which determines the contribution from each natural mode of vibration. Structures of small period experience large acceleration, whereas those of longer period experience greater displacement. Response of a SDOF system is determined by time domain or frequency domain analysis. For a given time period of system, maximum response is picked. This process is continued for all range of available time periods of SDOF system. Final plot with time period on x-axis and response quantity on y-axis is the required response spectra. Repeat the Same process is with different damping ratios to obtain overall response spectra.

3-2 Seismic study based on different aspect ratio

Seismic study is carried out for different aspect ratio. Aspect ratio changed by changing height of the building. Aspect ratios selected for the study are 0.7, 0.8, 0.9. Study is carried out for both braced frame building and bare frame building. Both braced frame and bare frame building were analysed using response spectrum analysis. Then the responses like story displacement, story drift were compared.

IV. RESULTS FROM SEISMIC ANALYSIS

Time period means response of the building during earthquake. Time period more means it shows more response during earthquake. Time period low means it shows less response during earthquake.

Table 2 Time period of different bracing

Bracing Type	Maximum Time period(s)
without	2.02
X brace	.912
Inclined brace	1.073
V brace	.956
Inverted v brace	.949

Table 2 shows the time period of building with different bracings. Fundamental time period of building without bracing 2.02 seconds which is more compared with bracings. In braced building X bracing shows low time period which is .912 seconds and inclined bracing shows high time period which is 1.073 seconds. Time period less means it produce less response during earthquake so X bracing is more effective. Inclined bracing produce more response during earthquake. By using X bracing time period reduced 54%.

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Table 3 Displacement of different bracing

Bracing types	Maximum Displacement (mm)
Without	47.895
X brace	21.719
Inclined brace	25.699
V brace	22.74
Inverted v brace	22.53

Storey displacement means displacement of the building relative to ground. Table 3 shows displacement of building with different bracings. Displacement of building without bracing 47.895 mm which is more compared with bracings. In braced building X bracing shows low displacement which is 21.719mm and inclined bracing shows high time period which is 25.699mm. displacement less means it produce less response during earthquake so X bracing is more effective. Inclined bracing produce more response during earth quake. By using X bracing displacement reduced 54%.

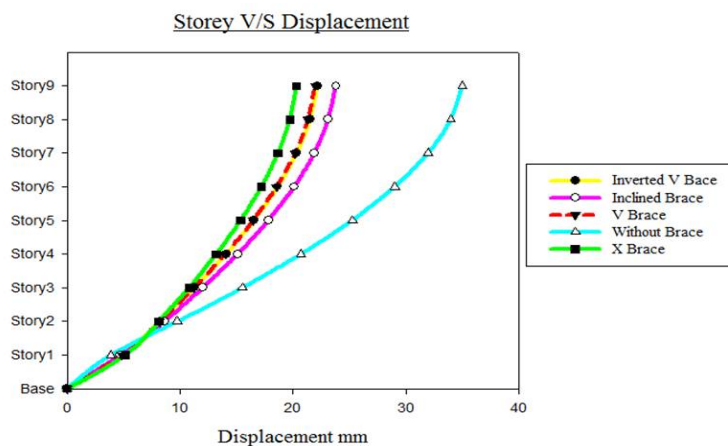


Fig 2 displacement graph of different bracings

Fig 2 shows the storey vs. displacement graph. From the fig it is clear that displacement is more for building without bracing. By applying bracing displacement reduced. Maximum displacement occur in top storey.

Table 4 Drift of different bracing

Bracing types	Maximum Drift
Without	.0017
Xbrace	.000147
Inclined brace	.00135
V brace	.00139
Inverted v brace	.0014

Drift means relative displacement between two stories. Table 4 shows maximum drift of the building with different bracing. Drift of building without bracing is .0017 which is more compared with bracings. In braced building X bracing shows low displacement which is .000147 and inclined bracing shows high time period which is .00135.drift

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less means it produce less response during earthquake so X bracing is more effective. Inclined bracing produce more response during earth quake. By using X bracing drift reduced 90%.

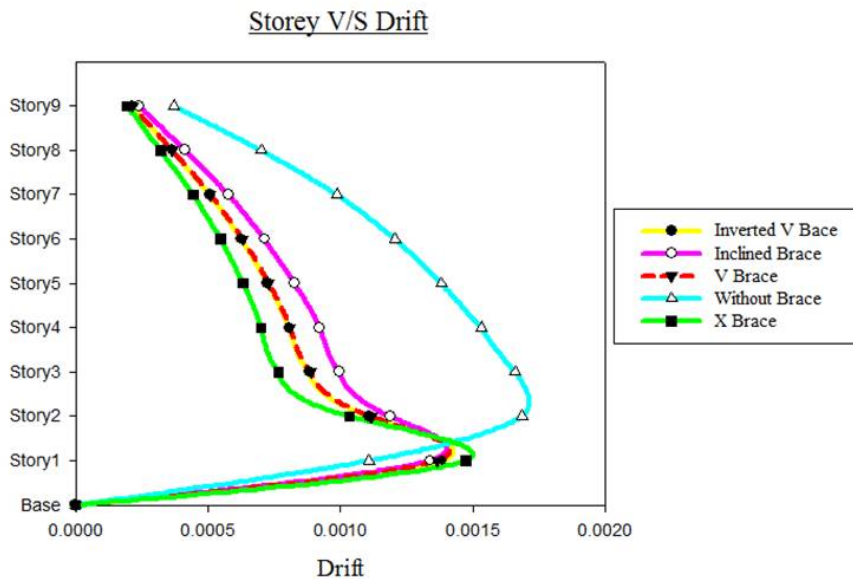


Fig 3 drift graph of different bracings

Fig 3 shows the storey vs. drift graph. From the fig it is clear that drift is more for building without bracing. By applying bracing drift reduced. Maximum drift occur in bottom story.

Table 5 Displacement with different aspect ratio

Aspect ratio	Maximum Displacement (mm) Without brace	Maximum displacement (mm) With X brace
0.7	22.84	14.80
0.8	37.24	27.71
0.9	47.89	29.20

Table 5 shows the maximum displacement of building with bracing and without bracing for different aspect ratio. Aspect ratio selected for the study is 0.7,0.8,0.9. Maximum displacement obtained in aspect ratio 0.9 which is 47.89mm before the application of bracing and 29.20mm after the application of bracing. Minimum displacement obtained in aspect ratio 0.7 which is 22.84 mm and 14.80mm. maximum displacement reduced to 25%,35%,39% respectively for aspect ratio 0.7,0.8,0.9 after the application of bracing. AS the aspect ratio increases reduction of displacement increases after the application of bracing.

Table 6 Drift of building with different aspect ratio

Aspect ratio	Maximum drift without brace	Maximum drift with x bracing
0.7	.00169	.00145
0.8	.00172	.00147
0.9	.00175	.00148

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Table 6 shows the maximum drift of the building with bracing and without bracing for different aspect ratio. The maximum value of drift shows in aspect ratio 0.9 which is .00175 before application of bracing and 0.00148 after application of bracing. The minimum value of drift in aspect ratio 0.7 which is .00169 before application of bracing and .00145 after application of bracing. The value of drift not show much variation with increase in aspect ratio. Drift reduced approximately 15% in 3 aspect ratio by the application of bracing.

V. CONCLUSIONS

- ❖ Study shows by the addition of bracing story response like displacement, drift, time period can be reduced.
- ❖ X bracing is more effective than other bracing because it shows less seismic response than other bracing. Because it consist of two elements so it take both compression and tension
- ❖ By the addition of x bracing 45% reduction in displacement, time period.
- ❖ Inclined bracing shows less performance compared with other bracings. Because it consist of one member which take either compression or tension.
- ❖ Base shear is increase after the application of brace but after the application of brace building become more stiff to absorb more base shear.
- ❖ After the application of bracing, reduction of displacement increases with increase in aspect ratio.
- ❖ . The value of drift not shows much variation with increase in aspect ratio.

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