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Study on Dynamic Analysis of Steel Structure with Different Types of Bracings

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ABSTRACT

The structure in high seismic areas may be susceptible to the severe damage. Now a days steel bracings in steel structure are most popular system to resist lateral load due to earthquake. Braced frame resist seismic excitation with comparatively less deformations than gravity load resisting system as they form a stiff system. Steel bracing is economical, easy to erect, occupies less space and has flexibility for meeting the required strength and stiffness. In the present work it is exposed, effect of seismic loading in 15 storey regular bare building using ETABS software. This buildings adapted different types of bracings such as diagonal, braced diagonal, X, K, K with bracing, chevron, braced chevron, V, eccentric diagonal and Knee bracings. The seismic response are evaluated by using equivalent static analysis, response spectrum analysis and linear time history analysis for bhuj earthquake data on Zone- V. Finally analysis results are carried out such as maximum storey displacement, inter storey drift, storey shear and natural time period. Based on the results regular braced buildings are compared and studied best braced structure to resist lateral loads. In three methods of analysis results in regular braced models, X bracings and chevron bracings system showed better resistance to seismic forces than the other specified bracing systems. The bracings provide adequate stiffness and continuous load path.

Keywords: Regular Building, Different Types Of Bracings, Displacements, Inter Storey Drift, Storey Shear and Natural Time Period

I. INTRODUCTION

Earthquake occurs in quick movements within the Earth's crust it cause stresses to build up at points of weakness and rocks to deform. These stresses exceeds the rock strength which will develop fracture along the fault line at the weak zone of rock. In the earth crust, stresses stored in rock suddenly releases in the form of seismic waves causes huge vibrations in the earth. In most buildings are designed with lateral-force-resisting systems (or seismic systems) to resist the effects of earthquake forces and this makes building stiffer against horizontal forces, thus minimize the amount of relative lateral movement and consequently the damage. In now a days steel bracings are using in a structures to resist the seismic excitation, it has less deformations than gravity load resisting system as they form a stiff system. Extensive research are still conducted on braced frames with the main goal of improving the bracing system and performance of beam-column and brace connection. Structural steel materials are usually used for construction of buildings because it gives more strength, speed erection, prefabrication, demount ability, uniformity, light weight, good at ductility and providing an energy dissipation capability.

1.1 Braced Frame

A structural system of braced frame is peripherally to resist the earthquake lateral forces. Braced member are work under both tension and compression, it is similar to a truss. These braced frames are generally composed of steel members and it will very common form of construction for economic to construct and simple to analysis. Use of steel structures proves to be less expensive usually in pinned connections between beams and columns. Bracing which provides stability and resists lateral loads may be from diagonal steel members. In braced construction, beams and columns are designed under vertical load only and assuming that the bracing system carries all lateral loads.

1.2 Types of Bracings

Types of bracings are concentric and eccentric bracings. In concentric bracings lateral stiffness and natural frequency increases and decrease in the storey drift of the frame. However if stiffness of structure increases which will resist more earthquake inertia forces of the structure. Further it reduces column bending moment and shear force also increases axial compressive forces. The bracing are used in work is diagonal bracing, braced single brace, x bracings, k-type bracings and k with bracing.

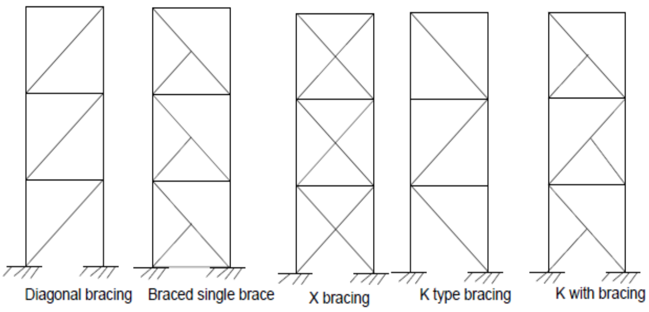


Figure 1. Concentric bracings

In eccentric bracings reduce lateral stiffness and increase energy dissipation capacity of the buildings. The lateral stiffness of the building depends on the beams and columns flexural stiffness property. The bracings are used in the work is chevron bracing, braced chevron brace, eccentrical diagonal bracing, v-type bracing and knee bracing.

1.3 Objective

1. The initial step of the present work is to choose a plan.
2. To study the 3D modeling of steel bare frame and vertically geometric irregularity steel bare frame by using ETABS software for the height of 52.5m.
3. To study the behavior of buildings by adopting different types of Diagonal braced, single braced, X, K type, K with bracing, chevron, braced chevron, eccentrically diagonal, V-type and Knee bracings.
4. To study the bracing member in the buildings to check the critical axial load for selection of size.
5. To study the seismic response of regular and irregular braced buildings by using equivalent static analysis, response spectrum analysis and time history analysis for bhuj earthquake data on Zone – V.
6. To study the different models results such as storey displacement, inter storey drift, storey shear and natural time period.
7. To study the best bracing system to resist lateral load in a buildings.

II. METHODS AND MATERIAL

2. Methodology of the Study

In a building resting on the ground if starts vibrating is due to effect of inertia forces in the earthquake. These forces are very dangerous to the structure, so that need to evaluate the forces and seismic behaviour to resist the structures. In several researchers are worked out by different methods to find the forces in all over the world. In this work three methods are used to the find the forces such as equivalent static, response spectrum and time history methods of analysis by using ETABS software based on IS 1893(part-1) - 2002.

3. Modelling and Analysis

The investigation modeling are done by ETABS software, it is fully integrated and its work based on finite element method. Considered regular steel structures here base width is 40m X 40m and height is 52.5 m. Then these structures adopted diagonal, braced single brace, X, K type, K with bracing, chevron, braced chevron, eccentrically diagonal, V-type and Knee bracings and these bracings are same section size. In each bracing are separately introduced in each model.

3.1 Building Details

The industrial steel buildings are considered for investigation of 15 stories and each storey height are 3.5m. In regular building considered same parameters details are

Table 1. Building details

PARAMETERS	DESCRIPTION
Structure type	SMRF
Height of the building	52.5 m
Each storey height	3.5 m
Zone	V
Soil condition	MEDIUM
Response reduction factor	5
Seismic zone factor	0.36
Importance factor	1
Thickness of slab	75 mm
Column section	ISMB 500
Beam section	ISMB 450
Bracings (double angle)	ISA 150X150X12
Live load for typical floor	4 kN/m^2
Live load on roof	2 kN/m^2
Grade of steel	Fe 250
Density of steel	77 kN/m^3
Poisons ratio	0.3
Modulus of elasticity	210000 Mpa

3.2 Models Description

Buildings are modeled by ETABS software. Beams and columns are modeled as a two noded beam elements of six degree of freedom system. In bracing member are modeled as a beam elements and slabs are assigned by shell. These elements are assigned by regular buildings base dimensions is 40m x 40m. The following models are considered.

Table 2. Models description

MODELS NAME	MODELS DETAIL
M 1	Regular steel building without bracing
M 2	Regular steel building with diagonal steel bracing
M 3	Regular steel building with braced single steel brace
M 4	Regular steel building with X steel bracing
M 5	Regular steel building with K type steel bracing
M 6	Regular steel building with K with steel bracing
M 7	Regular steel building with chevron steel bracing
M 8	Regular steel building with braced chevron steel brace
M 9	Regular steel building with eccentric diagonal steel bracing
M 10	Regular steel building with diagonal V-type steel bracing
M 11	Regular steel building with Knee type steel bracing

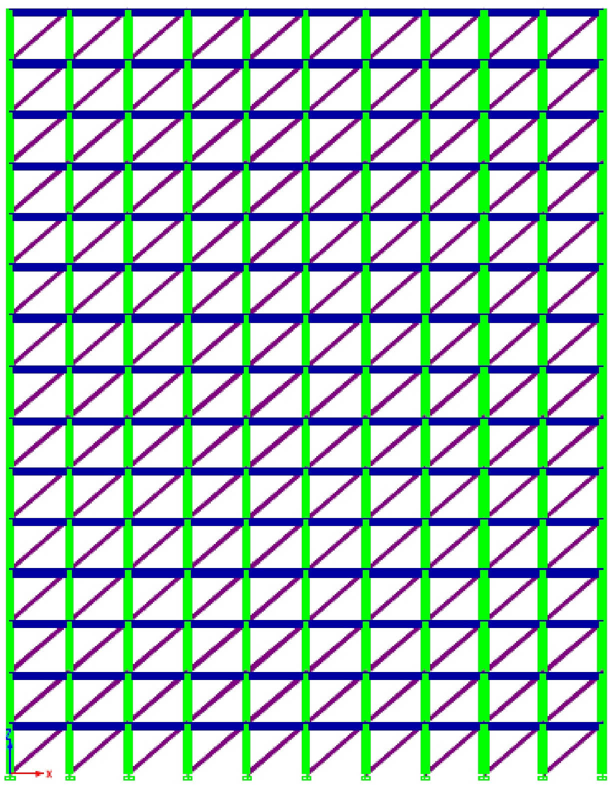
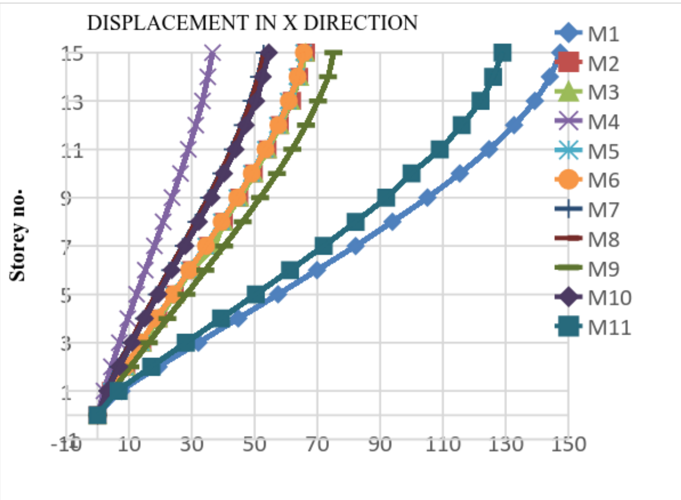


Figure 2. Elevation of M2

In the figure 2 shows the diagonal bracings provided in the building and similarly all types bracings are provided in the building. The equivalent static, response spectrum and time history analysis is to be conducted in all models.

III. RESULT AND DISCUSSION

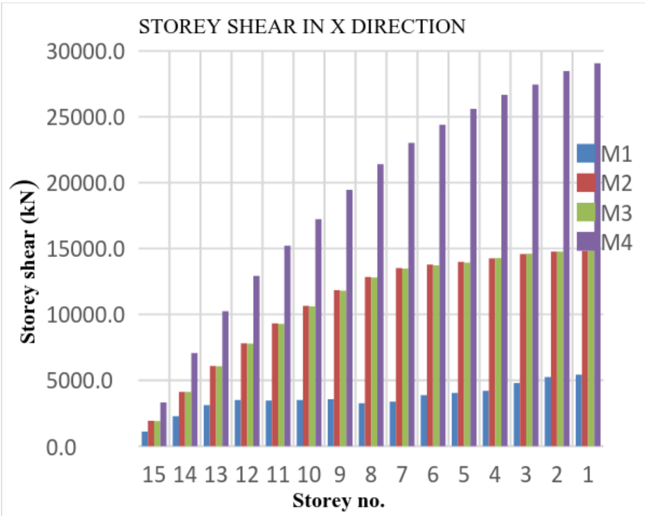
After that the analysis results are carried out such as maximum displacement, inter storey drift, storey shear and time period collected in excel sheets. Those results are tabulated in tables and graph formats, based on this results pursuing the discussions like comparing the results of bare frame to braced frame and finding the effectiveness of braced frames on lateral loads. In the paper showed maximum results in three methods of analysis.



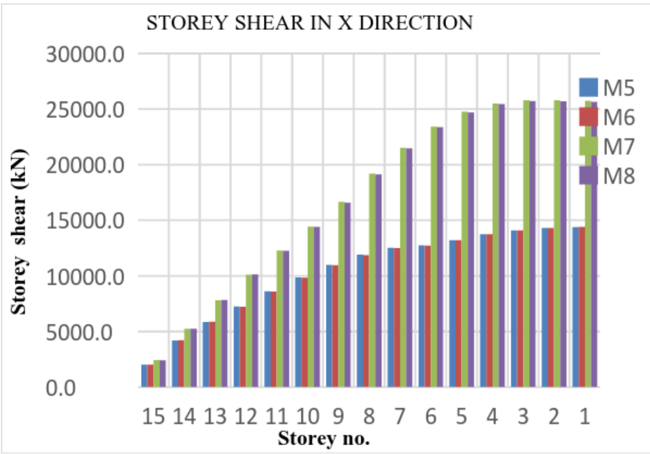
Graph 1: Equivalent static analysis displacement for X direction

From the graph 1 it is observed that X direction displacement maximum in M1 and minimum in M4 at top floor level. The displacement in models M7, M8, M10, M5, M6, M3, M2, M9 and M11 are reduced 66.11%, 63.97%, 63.02%, 55.49%, 55.0%, 54.95%, 49% and 12.48% respectively at top storey level has compared with the model M1. The minimum displacement and maximum reduction indicates the stiffer against the lateral loads.

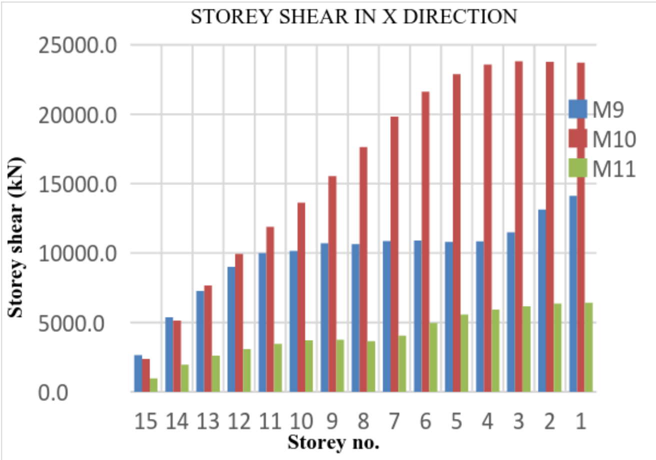
The results in the graph 2 it is observed that x direction inter storey drift maximum in M1 at third floor level and minimum in M4 at fifth floor level. The inter storey drift in models M7, M8 and M10 are decreased 69.34%, 69.22% and 68.59% respectively at fourth floor has compared with the model M1 at third storey. Where has M2, M3, M5, M6 and M9 are reduced 59.56%, 59.47%, 58.55%, 58.46% and 53.26% respectively at second floor level compared to the model M1 at third storey. All so M11 storey drift at third floor level are reduced 13.63% compared to M1 at third storey



Graph: 2 Time history analysis storey shear in X direction

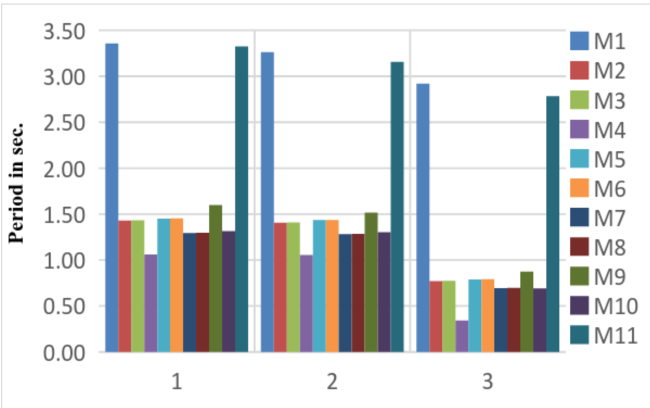


Graph: 3 Time history analysis storey shear in X direction



Graph: 4 Time history analysis storey shear in X direction

From the graph 2, 3 and 4 it is observed that x direction storey shear maximum in M4 and minimum in M1 at first floor. The storey shear in models M7, M8, M10, M2, M3, M6, M5, M9 and M11 are increased 78.93%, 78.85%, 77.14%, 63.45%, 63.48%, 62.33%, 62.31%, 61.58% and 15.59% respectively at first floor compared to M1 at first storey.



Graph: 5 Natural time period for regular buildings

From the graph 5 it is observed that time period maximum in M1 and minimum in M4. The time period in models M7, M8, M10, M2, M3, M5, M6, M9 and M11 are reduced 61.60%, 61.30%, 60.71%, 57.44%, 57.38%, 56.84%, 56.54%, 52.38% and 1.19% respectively compared with the M1.

IV. CONCLUSION

1) The displacement and inter storey drift are within limits as per the codal requirements and are reduced in different braced frame models compared with the bare frame models, due to additional stiffness of bracings.
2) The displacement and inter storey drift are less in X and chevron braced regular models compared to other braced models.
3) The storey shear are increased in braced models compared with the bare frame models due to additional mass and stiffness of bracing elements.
4) The displacements and inter storey drifts in regular models are decreased when we provide bracing systems. This indicates that bracings are significantly reduce the amount of forces by increasing the stiffness and ductility of the structure against seismic forces and also increases strength against the seismic forces.
5) In equivalent static analysis method for regular models, the maximum lateral displacements are reduced after the use of X bracings of about 75.16% and chevron bracings of about 66.11% as compared with the bare frame model
6) In response spectrum analysis for regular braced models, the maximum inter storey drift reduced to about 79.01% in X bracings at storey 5 and 69.35% in chevron bracings at storey 3 compared with the bare frame model because of in this method overall response of building decreases and stiffness increases.
7) It is seen that the different types of regular braced models significantly experienced more storey shear than the bare frame model. This is due to effect of bracing elements mass and stiffness.
8) The regular braced models storey shear maximum in time history analysis as compared with the equivalent static and response spectrum analysis. In X and V braced regular models were showed maximum storey shear.
9) The time periods are decreased in braced models compared to bare frame models. The reduction in time period in braced models is due to effect of shear rigidity of the bracings.
10) Based on the analysis results in regular and irregular braced models, X bracings and chevron bracings system showed better resistance to seismic forces than the other specified bracing systems.

V. Future Scope

1) The analysis can be carried out for vertical irregularity by adopting soil structure interaction.
2) The pushover analysis in vertical irregularity structures by use of different types of isolators.

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