Lateral Systems in Tall Buildings for Medium Soil Type and Different Seismic Zones

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***Abstract*— In this work, it is proposed to carry out an analytical study, on multistory building of 35 stories, was carried out accounting for different seismic zones and medium soil type. The suitability and efficiency of different lateral bracing systems that are commonly used and also that of concrete infills were investigated. The different bracing systems viz., X-brace, V-brace, inverted V or chevron brace and infills are introduced in these analytical models. These building models are analyzed, using SAP 2000 software, to the action of lateral forces employing linear static and linear dynamic approaches as per IS 1893 (Part I): 2002.**

***Keywords*— Bracing systems, linear static and dynamic analysis, different seismic zones and soil type and RC frame.**

1. INTRODUCTION

From the ancient pyramids to today's modern skyscraper, a civilization's power and wealth has been repeatedly expressed through spectacular and monumental structures the design of skyscrapers is usually governed by the lateral loads imposed on the structure. As buildings have taller and narrower, the structural engineer has been increasingly challenged to meet the imposed drift requirements while minimizing the architectural impact of the structure.

A. Engineering seismology:

Seismology is the study of the generation, propagation and recording of elastic waves in the earth and the sources that produce them. An earthquake is a sudden tremor or movement of the earth's crust, which originates shock waves caused by nuclear tests, man-made explosions etc. About 90% of all earthquakes results from tectonic events, primarily movements on the faults. The remaining is related to volcanism, collapse of subterranean cavities or man-made effects.

The epicenters of earthquakes are not randomly distributed over the earth's surface. The epicenters of 99% earthquakes are distributed along narrow zones of interpolate seismic activity.

B. Seismic zones of India {as per is 1893 (part i): 2002}:

The goal of seismic zoning is to delineate of similar probable intensity of ground motion in a country, for providing a guideline for provision of an adequate earthquake resistance in constructed facilities, as a step to disaster mitigation. Earthquake causes two types of losses known as primary loss and secondary loss. A primary loss is irrecoverable loss, which results in the loss of human life in earthquake. All the other losses incurred due to earthquake that can be recoupled are termed as secondary losses. Thus minimum standard in a code to withstand earthquake is prescribed such that complete collapse of structure is prevented which ensures that no human life is lost. This requires a forecast of the strongest intensity of likely ground motion at a particular site during the service life of structure. Seismic zoning map of a country segregates country in various areas of similar probable maximum intensity of ground motion.

C. Effect of soils:

The seismic motion that reaches a structure on the surface of the earth is influenced by the local soil conditions. The subsurface soil layers underlying the building foundation may amplify the response of the building to earthquake motions originating in the bedrock. Greater structural distress is likely to occur when the period of the underlying soil is close to the fundamental period of the structure. Tall buildings tend to experience greater structural damage when they are located on soils having a long period of motion because of the resonance effect that develops between the structure and the underlying soils. If a building resonates in response to ground motion, its acceleration is amplified.

As per IS 1893 (Part I) – 2002, soils classification can be taken as Type – I, Rock or Hard soil: Well graded gravel and sand mixtures with or without clay binder and clayey sands poorly graded or sand clay mixtures, whose N (standard penetration value) should be above 30. Type – II, Medium soils: All soils with N between 10 and 30, and poorly- graded sands or gravelly sands with little or no fines. Type – III, Soft Soils: All soils other than whose N is less than 10.

2. SEISMIC ANALYSIS

Earthquake and its occurrence and measurements, its vibration effect and structural response have been continuously studied for many years in earthquake history and thoroughly documented in literature. Since then the structural engineers have tried hard to examine the procedure, with an aim to counter the complex dynamic effect of seismically induced forces in structures, for designing of earthquake resistant structures in a refined and easy manner.

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Main features of seismic method of analysis (Riddell and Llera, 1996) based on Indian Standard 1893 (Part I): 2002 are described as follows.

Equivalent lateral force:

Seismic analyses of most of the structures are still carried out on the basis of lateral (horizontal force assumed to be equivalent to the actual (dynamic) loading. The base shear which is the total horizontal force on the structure is calculated on the basis of structure mass and fundamental period of vibration and corresponding mode shape. The base shear is distributed along the height of structures in terms of lateral forces according to code formula. This method is usually conservative for low to medium height buildings with a regular conformation.

Response Spectrum Analysis:

This method is applicable for those structures where modes other than the fundamental one significantly the response of the structure. In this method the response of Multi-Degree-of –Freedom (MDOF) system is expressed as the superposition of modal response, each modal response being determined from the spectral analysis of single-degree-of-freedom (SDOF) system, which is then combined to compute the total response. Modal analysis leads to the response history of the structure to a specified ground motion; however, the method is usually used in conjunction with a response spectrum.

Elastic Time History Analysis:

A linear time history analysis overcomes all the disadvantages of modal response spectrum analysis, provided non-linear behaviour is not involved. This method requires greater computational efforts for calculating the response quantities are preserved in the response histories. This is important when interaction effects are considered in design among stress resultants.

3. MODELING

In this study a 35 storey building having same plan in different type of zones (as per IS 1893 (Part I): 2002) and different type of soils is taken. The tall building with different types of braces introduce in the central location in two bays is consider to study the effect of lateral deflection, base shear, bending moment, shear force and axial force caused due to lateral load .i.e. due to quake load (both static and dynamic).

The building is 40m x 40m in plan with columns spaced at 5m from center to center. A floor to floor height of 3.0m is assumed. The location of the building is assumed to be at different zones and different types of soils. An elevation and plan view of a typical structure is shown in fig. (a) and (b).

Material and geometrical properties:

Following material properties are considered for the modeling of the proposed structure frame:-

Table 3.1: Details of material and geometrical properties

S.No	Description	Parameter
1	Depth of foundation	3.0 m
2	Floor to Floor height	3.0 m
3	Grade of concrete	M-40
4	Type of steel	Fe-415
5	Column size (Bottom 6 storeys)	1.4 m x1.4 m
6	Column size (From 7 to 12 storeys)	1.2 m x1.2 m
7	Column size (From 13 to 18 storeys)	1.0 m x1.0 m
8	Column size (From 19 to 24 storeys)	0.8 m x0.8 m
9	Column size (From 25 to 30 storeys)	0.6 m x0.6 m
10	Column size (Top 5 storeys)	0.4 m x0.4 m
11	Beam size	0.55 m x 0.6m
12	Unit wt. of masonry wall	20 kN/m^3
13	Slab thickness	150 mm
14	Shear wall thickness	120 mm

Loading conditions:

Following loadings are adopted for analysis:-

A) Dead Loads:

Top floor:

a. External wall load =2.76 kN/m^2
b. Floor Finish load = 1 kN/m^2
c. Water proofing =1 kN/m^2

Remaining floors:

a. External wall load =11.04 kN/m^2
b. Floor Finish load = 1 kN/m^2
c. Internal Wall Loads =5.52 kN/m^2

B) Live Loads:

Live Load on typical floors = 4 kN/m^2

C) Earth Quake Loads:

The earth quake loads are derived for following seismic parameters as per IS: 1893(2002)

a. Earth Quake Zone-II, III, IV, V
b. Response Reduction Factor: 5
c. Soil Type: Medium

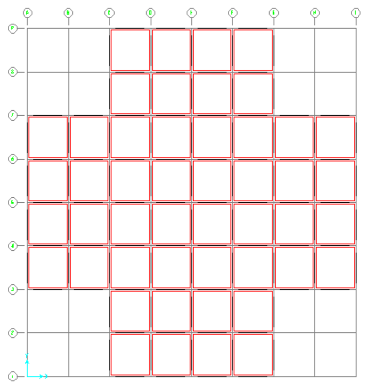

Fig 3.1: Building plan dimension (Common to all floors, all models; units 'm').

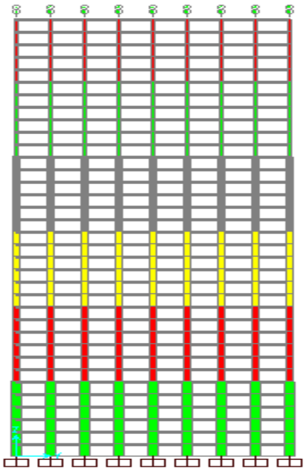

Fig 3.2: Storey Height (Common to all models; units 'm').

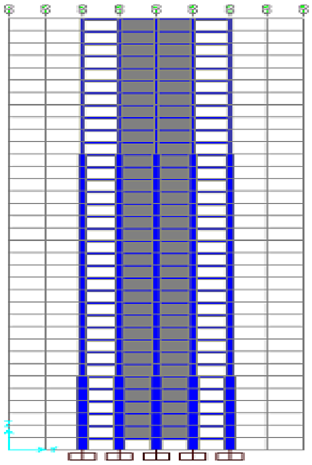

Fig 3.3: Elevation of 35 storey model showing infill (Shear wall) in two central bays at outer periphery.

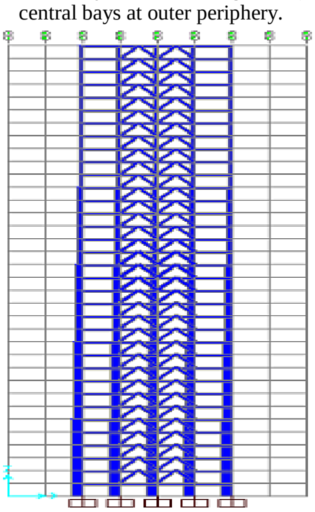

Fig 3.4: Elevation of 35 storey model showing Chevron (inverted brace) in two central bays at outer periphery.

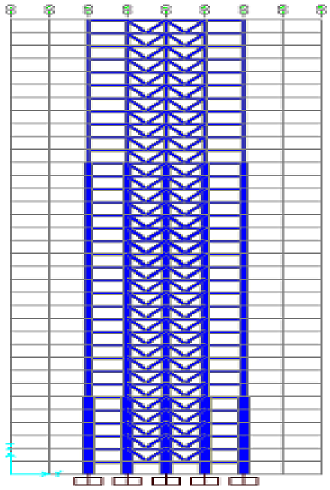

Fig 3.5: Elevation of 35 storey model showing V-braces in two central bays at outer periphery.

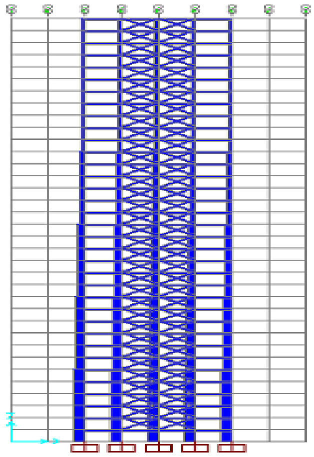

Fig 3.6: Elevation of 35 storey model showing X-brace in two central bays at outer periphery.

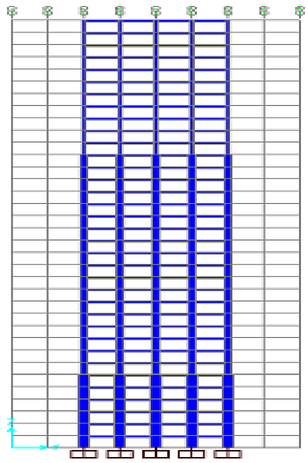

Fig 3.7: Elevation of 35 storey model showing no braces.

4. RESULTS AND DISCUSSION

Table 4.1: Showing Lateral displacements with respect to all Zone factors for Soil Type-II in Ux Direction loading Static.

ZONE FACTORS	LATERAL DISPLACEMENTS				
	WITHOUT BRACE	WITH X - BRACE	WITH V- BRACE	WITH INV.V- BRACE	WITH SHEAR WALL
Z2	94.8	83	83.4	84.4	77.8
Z3	125.4	110.6	111.1	112.1	104.6
Z4	166	147.4	148.1	149	140.4
Z5	268.8	202.5	203.6	204.3	194
NOTE: ALL UNITS ARE IN 'MM'.					

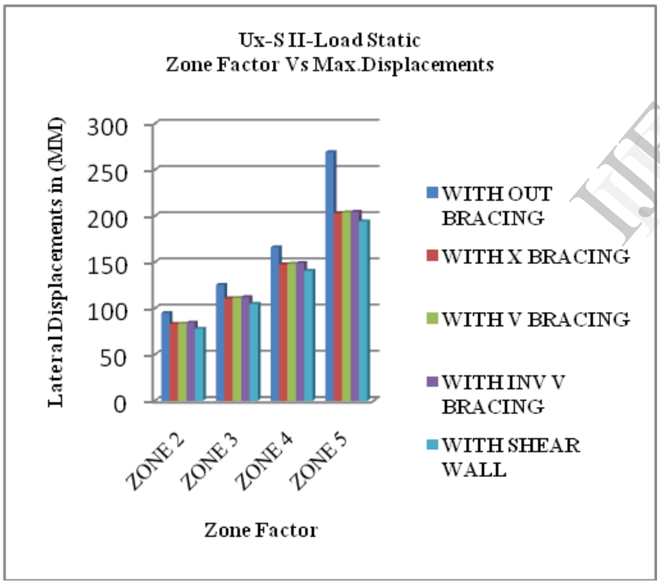

Fig 4.1: Zone Factors Vs Max. Displacement of different systems for Soil Type II, Static load.

Table 4.2: Showing Lateral displacements with respect to all Zone factors for Soil Type-II in Ux Direction loading Dynamic (Response Spectrum Analysis)

ZONE FACTORS	LATERAL DISPLACEMENTS				
	WITHOUT BRACE	WITH X - BRACE	WITH V- BRACE	WITH INV.V- BRACE	WITH SHEAR WALL
Z2	73	63.8	64	65.1	58.8
Z3	90.5	79.9	80.1	81.2	74.2
Z4	113.7	101.1	101.6	102.7	94.8
Z5	167.6	133.1	133.7	134.9	125.6
NOTE: ALL UNITS ARE IN 'MM'.					

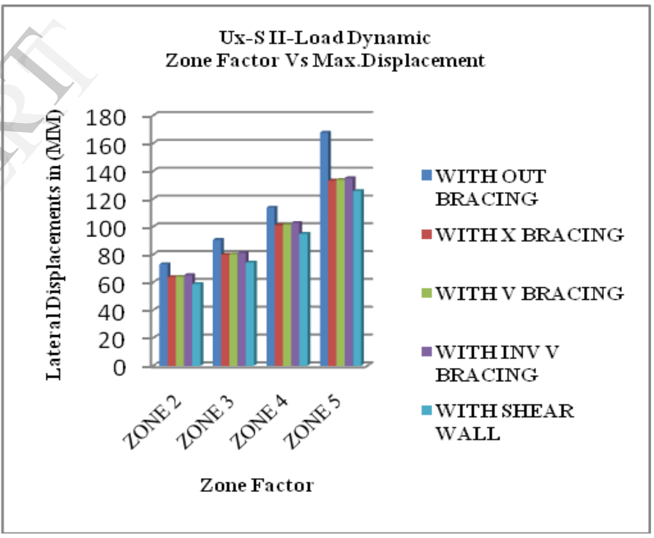

Fig 4.2: Zone Factors Vs Max Displacement of different systems for Soil Type II, Dynamic load

Table 4.3: Showing Base Shears with respect to all Zone factors for Soil Type-II loading Static

ZONE FACTORS	BASE SHEAR				
	WITHOUT BRACE	WITH X - BRACE	WITH V- BRACE	WITH INV.V- BRACE	WITH SHEAR WALL
Z2	4611.8	5151	5109.9	5027.7	5470
Z3	7378.9	8241.7	8175.9	8044.3	8752.1
Z4	11068.3	12362.5	12263.9	12066.4	13128.2
Z5	17237.5	18543.8	18395.9	18099.7	19692.3
NOTE: ALL UNITS ARE IN 'KN'.					

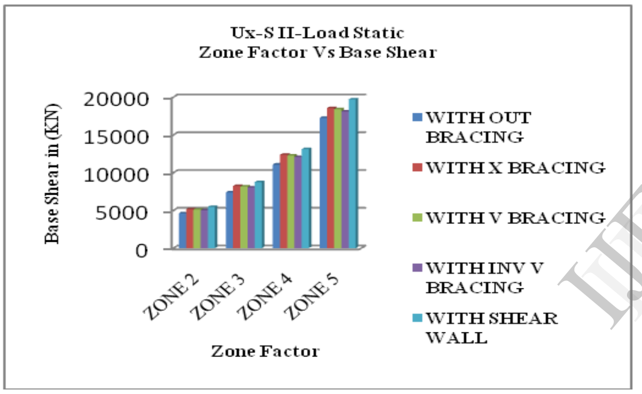

Fig 4.3: Zone Factors Vs Base Shear of different systems Soil Type II, Static load

Table 4.4: Showing Base Shears with respect to all Zone factors for Soil Type-II loading Dynamic (Response Spectrum Analysis)

ZONE FACTORS	BASE SHEAR				
	WITHOUT BRACE	WITH X - BRACE	WITH V- BRACE	WITH INV.V- BRACE	WITH SHEAR WALL
Z2	3844.4	4502.6	4447.1	4293.1	4957.6
Z3	6151.2	7204.2	7115.4	6868.9	7932.2
Z4	9226.7	10806.3	10673.2	10303.4	11898.4
Z5	11596.3	16209.4	16009.7	15455.2	17847.5
NOTE: ALL UNITS ARE IN 'KN'.					

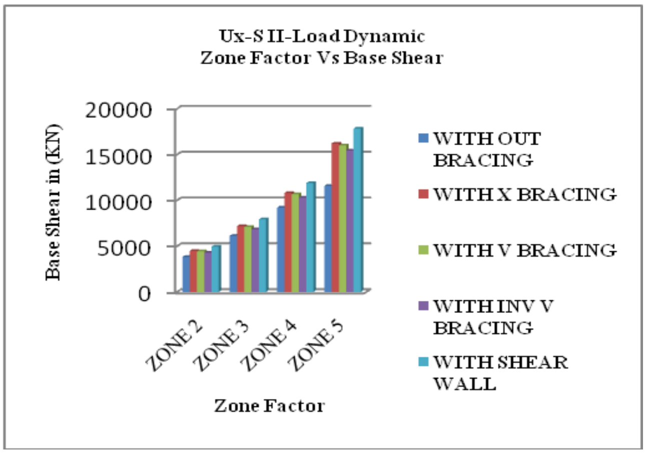

Fig 4.4: Zone Factors Vs Base Shear of different systems Soil Type II, Dynamic load

Table 4.5: Showing Total Weight and Seismic Weight of the building for Different types of systems.

TYPES OF BRACINGS	TOTAL WEIGHT OF THE BUILDING(DL+LL)	TOTAL SEISMIC WEIGHT OF THE BUILDING(DL+0.5LL)
WITH OUT BRACING	866221.2	783421.2
WITH X-BRACING	873516.9	790716.9
WITH V-BRACING	871107.3	788307.3
WITH INV.V-BRACING	871107.3	788307.3
WITH SHEAR WALL	878461.2	795661.2
NOTE: ALL UNITS ARE IN 'KN'.		

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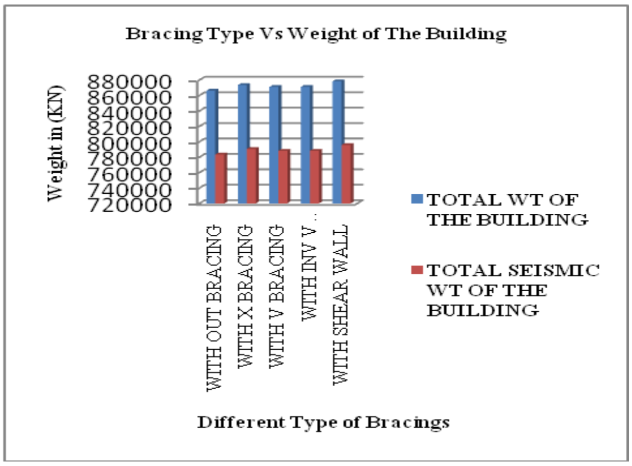

Fig 4.5: Different Type of Bracing Vs Weight for different systems.

Table 4.6: Showing Stiffness of the Structure for Different type of systems.

TYPES OF BRACINGS	STIFFNESS OF A STRUCTURE
WITH OUT BRACING	83333.3
WITH X-BRACING	100000
WITH V-BRACING	100000
WITH INV.V-BRACING	100000
WITH SHEAR WALL	111111.1
NOTE: ALL UNITS ARE IN 'KN / M'.	

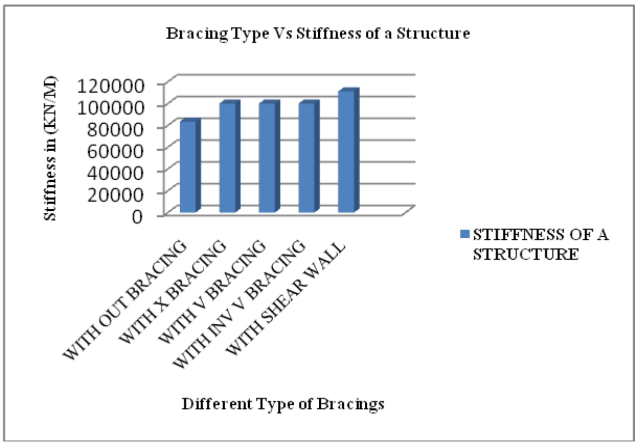

Fig 4.6: Different Type of Bracing Vs Stiffness for different Systems.

Table 4.7: Showing Displacements in Ux-direction of different type of systems

DIFFERENT MODELS	DIFFERENT GROUND MOTIONS			
	BHUJ	CHAMBA	CHAMOLI	UTTARAK ASI
WITH OUT BRACING:	1113	19.9	208.5	153.1
WITH SHEAR WALL:	971.5	26.3	133	148.8
WITH X BRACING:	1057	24.7	135.8	151.9
WITH V BRACING:	1071	24.3	141.3	155.2
WITH INV V BRACING:	1078	23.2	147.3	152.8
NOTE: ALL UNITS ARE IN 'MM'.				

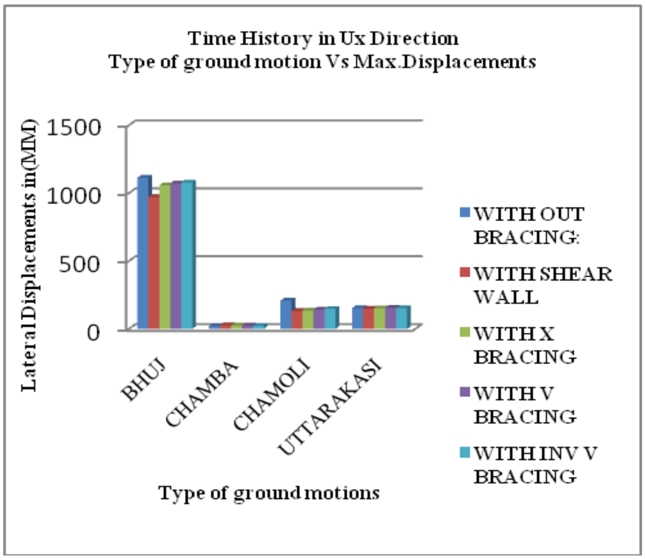

Fig 4.7: Type of ground motion Vs Lateral displacements for different systems

5. DISCUSSION OF RESULTS

Case 1:

Displacement variation for different types of bracing in all zones and soil types:

It was observed that the roof displacement for 35 storeys building the displacement increases with the increase in the zone factor. Both for static and dynamic loads for 35-storey model the variation of displacement is about 28.5% for zone Z2 to Z3 and about 28.5% from Z3 to Z4 and about 34.7% from Z4 to Z5 in Ux direction for static and for dynamic the variation of displacement is about 22.3% for zone Z2 to Z3 and about 23.5% from Z3 to Z4 and about 29.5% from Z4 to Z5.It means that the displacements in the zone factor are increases at linearly. This is true for dynamic loading case also. The higher the zone the more is the lateral displacements.

Case 2:

Base shear of Different type of system when compared to zone factors:

In this case the effect of base shear is study with reference to zone factors. The zone factors are taken on x-axis and the base shears taken is on y-axis, the graphs are plotted. For different types of loading conditions (Static and dynamic).

The observations made through this case study is, the base shear value increase with the increase of zone factors. The percentage of increase from Z2 to Z5 in Ux direction.

Case 3:

Stiffness of the Structure of different type of systems:

In this case the Stiffness of the Structure is studied .The different type of systems is taken on x-axis and the stiffness taken is on y-axis, the graphs are plotted. For different types of loading conditions (Static and dynamic).

The observations made through this case study is, the stiffness is of infill model is comparatively larger than the x-brace, v-brace, inv-v- brace and without brace.

Case 4:

Linear Modal Time History Analysis is done for different brace structures:

In this study we have done linear time history analysis, the displacement are drawn with respect to time.

We have found the max displacement among all the ground motions is BHUJ in Ux direction.

6. CONCLUSIONS

Based on the study of analysis of results the following conclusions are drawn:

1. The structural performance among three bracing systems (X-brace, V-brace, Inverted V-brace), one infill (introduce at the place of braces), the variation of displacement is smaller in infill system.
2. with the provision of bracings, infills the stiffness of the structure is increasing and there by the base shear is decreasing with the increase in height of the structure.
3. Structural capacity is greatly influence by the concrete infills.
4. Time history analysis is performed among the X-Brace, Infills and Without Brace structures and found that the infill system is have lesser displacements with respect to time

7. REFERENCES

(1). Zhixin Wang, Haitao Fan and Haungjuan Zhao (2012) *"Analysis of the seismic performance of RC frame structures with different types of bracings"* Applied Mechanics and Material Vols. 166-169 , May 2012 pp 2209-2215.

(2). Huanjun Jiang, Bo Fu and Laoer Liu (2012) "*Seismic Perfromance Evaluation of a Steel-Concrete Hybrid Frame-tube High-rise Building Structure*" Applied Mechanics and Materials Vol. 137, Oct 2011, pp 149-153.

(3). Behruz Bagheri Azar, Mohammad Reza Bagerzadeh Karimi (2012) "*Study the Effect of using Different Kind of Bracing System in Tall Steel Structure*" American Journal of Scientific Research, ISSN 1450-223X Issue 53, 2012, pp 24-34.

(4). Shi Qun Guo (2011) "*Analysis on Seismic Behavior of Irregular High-rise RC structure Using Eccentrically Braces*" Advance Materials Research Vols. 243-249, May 2011, pp 4001-4004.

(5). Paul W. Richards, P.E., M.ASCE (2009) "*Seismic Column Demands in Ductile Braced Frames*" Journal of Structural Engineering, Vol. 135, No.1, January 2009, ISSN 0733-9445/2009/1-33-41.

(6). Mir M. Ali and Kyoung Sun Moon (2007) "*Structural Developments in Tall Buildings; Current Trends and Future Prospects"* Architectural Science Review, Vol. 50.3, 13 June 2007, pp 205-223.

(7). Jinkoo Kim, Hyunhoon Choi (2004) "*Response modification factors of Chevron-braced frames*" Engineering Structures, Vol-27, 16 October 2004, pp 285-300.