

Seismic Performance of High Rise Building with Bracing System

Mohammad Abdul Rehman¹, Subodhkumar V Dhoke², Wakas Kabir Rahman³,
Anup K Chitkeshwar⁴, Nikhil A. Gadge⁵

Assistant Professor, Department of Civil Engineering, PRPCEM, Amravati, Maharashtra, India¹

Assistant Professor, Department of Civil Engineering, PRPCEM, Amravati, Maharashtra, India²

Assistant Professor, Department of Civil Engineering, PRMCEAM, Amravati, Maharashtra, India³

Assistant Professor, Department of Civil Engineering, PRPCEM, Amravati, Maharashtra, India⁴

Assistant Professor, Department of Civil Engineering, PRPIER, Amravati, Maharashtra, India⁵

ABSTRACT: Buildings located in seismic zones with no ductile detailing represents considerable hazard during earthquake. As a result, they suffer severe damage and are responsible for most of the loss of life even for small magnitude of earthquake. In recent years, a significant amount of research has been devoted to the study of various strengthening techniques i.e. to increase the lateral stiffness and resistance to enhance the seismic performance of reinforced concrete multistoried buildings. In the present research study, an attempt has been made to increase the stiffness of the high rise building by using different types of bracing. As a result of this, lateral maximum deflection can be controlled. An analytical study has been carried out by studying G+10 storey reinforced concrete building by using STAAD.proV8i. To find the effect of bracing four models incorporating various types of bracings have been developed. Response Spectrum Method of seismic analysis has been adopted with view to understand the accurate dynamic parameters. The study reveals that, storey drift, as well as element displacements is reduced considerably and are well within permissible limits.

KEYWORDS: Bracing, Response spectrum method, base shear, storey drift, displacement.

I. INTRODUCTION

Due to increased seismicity of various parts of the country, earthquake has become the important force which must be considered while designing. Many existing reinforced concrete frame buildings located in seismic zones are deficient to withstand moderate to severe earthquakes. Insufficient lateral resistance along with poor detailing of reinforcement is the main reasons for inadequate seismic performance of these structures. In recent years, a significant amount of research has been devoted to the study of various strengthening techniques to enhance the seismic performance of reinforced concrete frame members and structures. While many of these techniques can effectively improve the lateral stiffness and resistance of the existing structures, adequate seismic behavior will be obtained only if the retrofitting structure can satisfy the strength and ductility demands imposed by the earthquake. In this regard bracing systems proves to be one of the most promising techniques to achieve this objective.

Braces are one of the most efficient lateral force resisting elements in high rise building. It is increasingly used by designers in new structure as well as rehabilitation of existing ones. Pure frame for high-rise buildings have almost disappeared, since they are technically less efficient and not economically viable. Braces are incorporated in conjunction with reinforced concrete moment resisting frame to resist the major portion of lateral load induced by an earthquake. In tall structure, the vertical load, i.e. dead and live load do not pose many problems in the analysis or design, as they are mostly deterministic. But the lateral loads due to wind or earthquake, are a matter of concern. These require special consideration in the design of tall buildings. These lateral forces can produce critical stresses in the structure, induce undesirable vibrations or cause excessive lateral sway of the structure. Advancements in the design of high rise building frame have emphasized the importance of limiting the side sway under the action of lateral loads. Braced frame building has less lateral sway when compared to buildings with traditional rigid frames. The presence of bracings in the frame alters the overall behavior especially when the structure is subjected to lateral loads

II. LITERATURE REVIEW

Mayuri D. Bhagwat et.al [1]. Studied dynamic analysis of G+12 multistoried practiced RCC building considering for Koyna and Bhuj earthquake is carried out by time history analysis and response spectrum analysis and seismic responses of such building are comparatively studied and modeled with the help of ETABS software. Two time histories (i.e. Koyna and Bhuj) they have been used to develop different acceptable criteria (base shear, storey displacement, storey drifts). Himanshu Bansal et. al [2] Studied the storey shear force was found to be maximum for the first storey and it decreased to a minimum in the top storey in all cases. He was found that mass irregular building frames experience larger base shear than similar regular building frames. The stiffness irregular building experienced lesser base shear and has larger inter storey drifts. A. B. M. Saiful Islam et. Al [3] Showed that isolation system considerably reduce earthquake induced load on building. Furthermore, method of analysis has been found to have considerable effect on the response of low to medium rise buildings. Time history analysis shows significant less base shear than that from response spectrum analysis. Also, less isolator displacement is obtained from time history analysis than that from response spectrum analysis. Mohd. Abdul Rehman [4] develop an effective and economical seismic resistance system so that the buildings can withstand to moderate or severe earthquake. In the present research study, an attempt has been made to increase the stiffness of the multi-storied or tall buildings by using bracing system. As a result of this, lateral maximum deflection can be controlled. To achieve these objectives, an analytical study has been carried out by studying G+10 storey reinforced concrete building by using versatile and practical analytical tool such as STAAD.pro 2007.

III. METHODOLOGY

Basic terminology

Damping:

The effect of internal friction, imperfect elasticity of material, slipping, sliding, etc in reducing the amplitude of vibration and is expressed as a percentage of critical damping.

Ductility:

Ductility of a structure, or its members, is the capacity to undergo large inelastic deformations without significant loss of strength or stiffness.

Importance Factor (I):

It is a factor used to obtain the design seismic force depending on the functional use of the structure, characterized by hazardous consequences of its failure, its post- earthquake functional need, historic value, or economic importance.

Natural Period (T):

Natural period of a structure is its time period of undamped free vibration.

Response Reduction Factor (R):

It is the factor by which the actual base shear force, that would be generated if the structure were to remain elastic during its response to the Design Basis Earthquake (DBE) shaking, shall be reduced to obtain the design lateral force.

Response Spectrum:

The representation of the maximum response of idealized single degree freedom systems having certain period and damping, during earthquake ground motion. The maximum response is plotted against the undammed natural period for various damping values, and can be expressed in terms of maximum absolute acceleration, maximum relative velocity, or maximum relative displacement.

Seismic Mass:

It is the seismic weight divided by acceleration due to gravity.

Seismic Weight (W):

It is the total dead load plus appropriate amounts of specified imposed load.

Structural Response Factors (S_r/g):

It is a factor denoting the acceleration response spectrum of the structure subjected to earthquake ground vibrations, and depends on natural period of vibration and damping of the structure.

Zone Factor (Z):

It is a factor to obtain the design spectrum depending on the perceived maximum seismic risk characterized by Maximum Considered Earthquake (MCE) in the zone in which the structure is located. The basic zone factors included in this standard are reasonable estimate of effective peak ground acceleration.

Horizontal Bracing System:

It is a horizontal truss system that serves the same function as a diaphragm lateral displacement of building resulting from seismic forces.



Storey Drift: It is the displacement of one level relative to the other level above or below.

Table 1 Zone Factor, Z (Clause 6.4.2)

Seismic Zone	II	III	IV	V
Seismic Intensity	Low	Moderate	Severe	Very severe
Z	0.10	0.16	0.24	0.36

Importance Factor Z and Response Reduction Factor R The minimum value of important factor, 1, for different building systems shall be as given in Table 6. The response reduction factor, R, for different building systems shall be as given table.

Table 2 Multiplying Factors for Obtaining Values for Other Damping (Clause 6.4.2)

Damping percent	0	2	5	7	10	15	20	25	30
Factors	3.20	1.40	1.00	0.90	0.80	0.70	0.60	0.55	0.50

Analytical data for all models:

The data used for the analytical study comprising all the models is given in Table.

Table 3 Analysis data

Title	Value
Number of storey	G+10
Type of building used	Commercial
Storey Height	3.20 m
Grade of concrete	M30
Grade of steel	Fe 500
Density of RCC	25 kN/m ²
Thickness of slab	0.150 m
Beam size	0.30m X 0.45 m
Column size	0.90m X 0.30 m
Bracing size	0.23m X 0.23 m
Seismic zone (Z)	IV
Importance factor (I)	1.5
Response reduction factor	5
Soil type	Medium soil

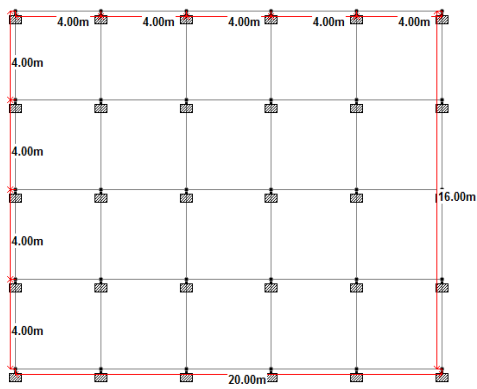


Fig (a) Plan of Building

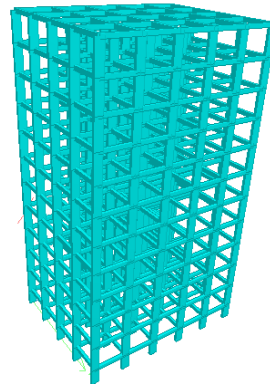


Fig (b) 3D view

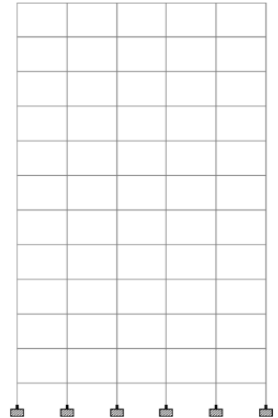


Fig (c) M-1 Without Bracing

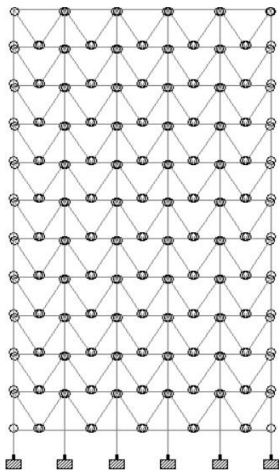


Fig (d) M-2 V Bracing

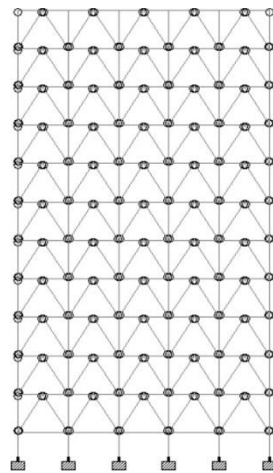


Fig (e) M-3 Inverted V Bracing

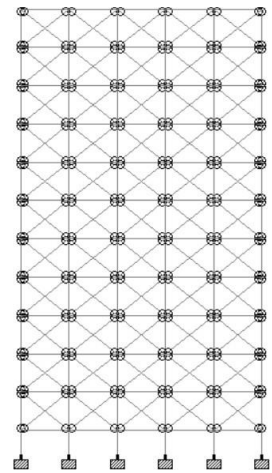
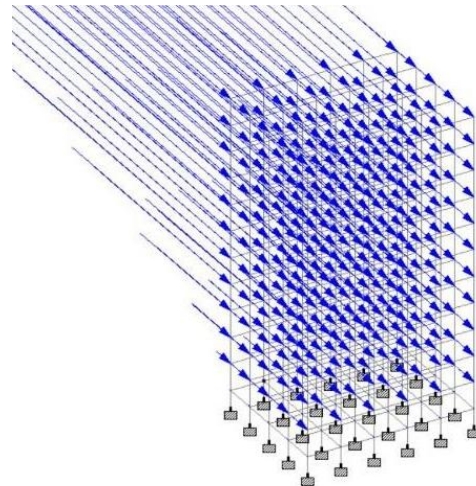
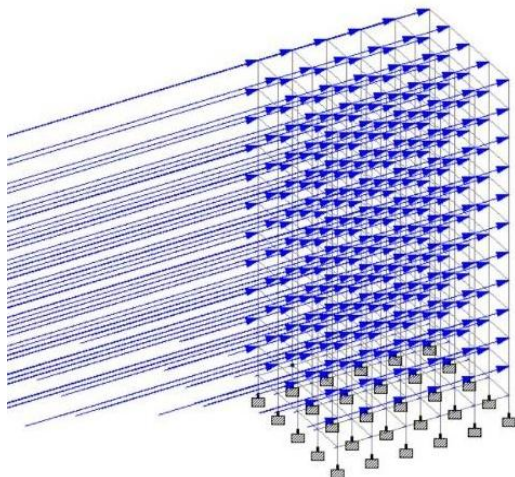


Fig (f) M-4 X Bracing

Seismic forces acting on building along X and Z directions.





IV. EXPERIMENTAL RESULTS

Storey Shears:

The distribution of base shears along the height of the building in case of equivalent static method and Response Spectrum method for different models are given in the Tables. In the Response Spectrum method the design base shear (V_B) is shown in table given below.

Table 4 Comparison of Base Shear

Model	Base Shear In- X	Base Shear In-Z
Without Bracings	3824.78	3572.31
V-Bracings	3255.24	2973.32
Inverted V- Bracings	3199.16	3128.55
X-Bracings	3039.73	2959.47

Table 5 Displacement in X & ZDirection

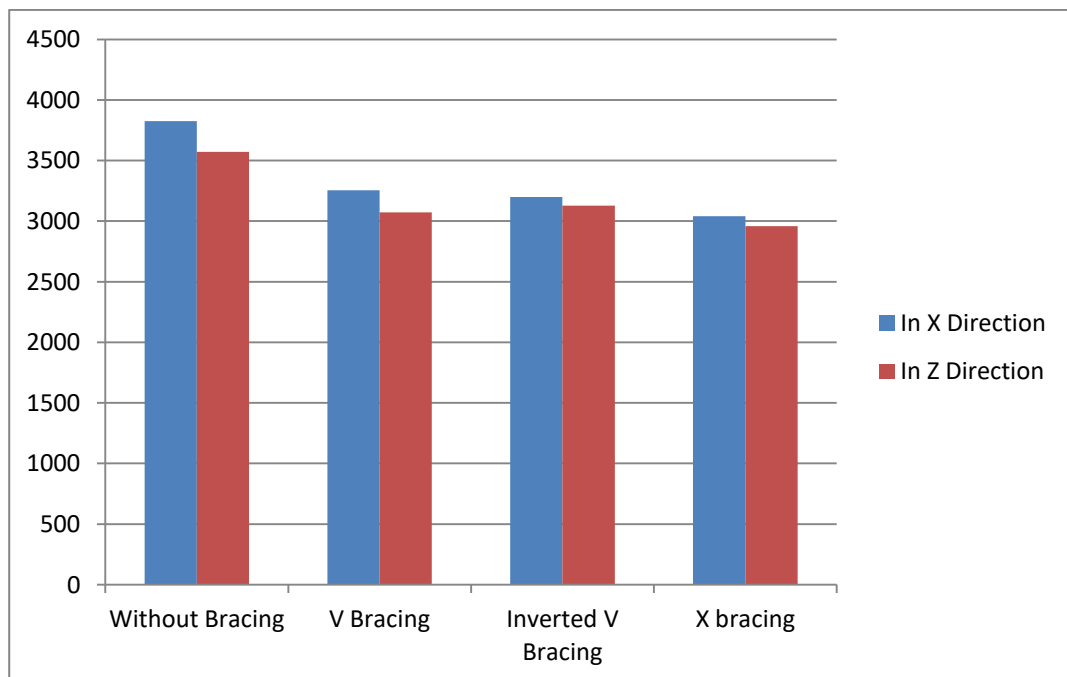
Story	Without Bracings		V-Bracings		Inverted V-Bracings		X-Bracings	
	X-Dir	Z-Dir	X-Dir	Z-Dir	X-Dir	Z-Dir	X-Dir	Z-Dir
12	131.38	207.92	56.08	80.09	57.00	80.83	47.67	69.22
11	121.42	202.40	52.72	76.00	53.96	77.54	44.92	66.15
10	119.46	192.52	48.59	70.72	50.06	72.28	41.47	61.44
9	110.20	178.62	43.68	63.39	45.23	65.57	37.26	55.52
8	98.91	161.53	38.24	55.85	39.73	57.97	32.54	48.89
7	85.99	141.96	32.48	47.96	33.81	49.89	27.52	41.92
6	71.87	120.56	26.57	39.98	27.70	41.62	22.41	34.86
5	56.94	97.91	20.67	32.02	21.56	33.36	17.34	27.87
4	41.66	74.48	14.89	24.16	15.53	25.18	12.43	21.00
3	26.61	50.69	9.38	16.39	9.79	17.10	7.79	14.24
2	12.80	27.02	5.19	12.03	5.25	12.34	4.51	11.23
1	2.45	5.53	2.10	8.35	2.17	8.75	2.08	8.57



Table 6 Drift in X & Z Direction

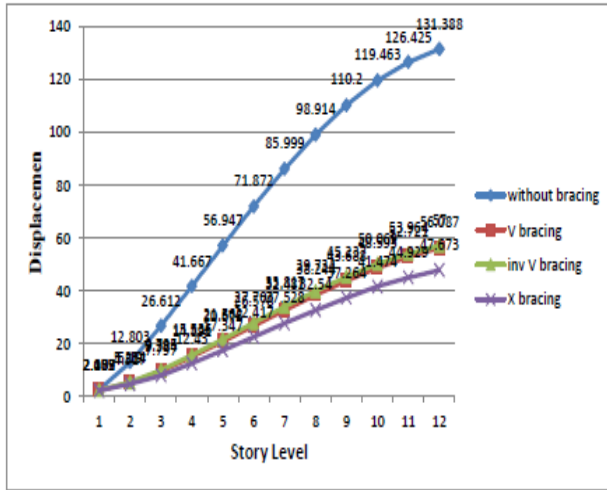
Story	Without Bracings		V-Bracings		Inverted V-Bracings		X-Bracings	
	X-Dir	Z-Dir	X-Dir	Z-Dir	X-Dir	Z-Dir	X-Dir	Z-Dir
11	19.34	21.48	3.08	3.67	3.08	3.58	2.43	2.72
10	17.80	23.67	4.19	4.32	4.54	4.75	3.28	3.00
9	15.99	23.79	5.50	7.77	5.74	8.08	4.63	6.76
8	15.28	23.42	5.78	7.86	6.06	8.17	4.91	6.87
7	14.92	22.65	5.98	7.95	6.14	8.26	5.07	6.99
6	14.12	21.39	5.90	7.98	6.11	8.26	5.11	7.05
5	12.91	19.57	5.76	7.88	5.91	8.07	5.01	6.96
4	11.28	17.08	5.44	7.54	5.50	7.60	4.72	6.63
3	9.26	13.90	4.90	7.32	4.83	6.70	4.21	5.91
2	6.96	9.88	4.12	5.28	3.89	5.25	3.45	4.71
1	4.96	5.51	3.36	4.08	3.03	3.28	2.74	3.06

Graph 1 Base shear for different models in X & Z direction.

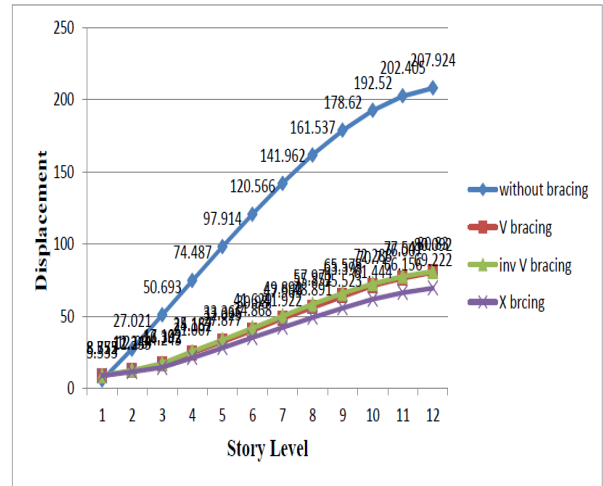




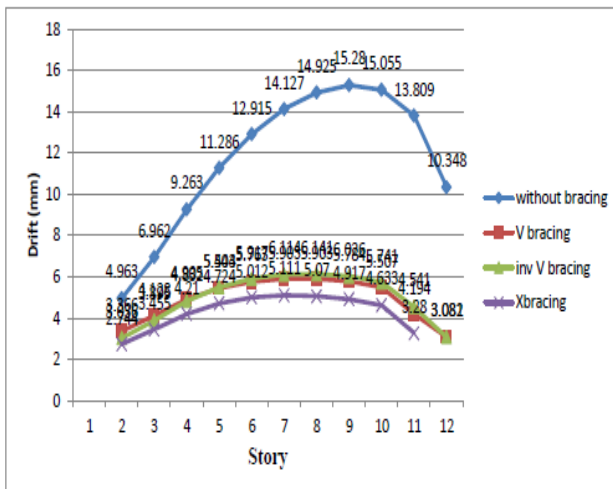
Graph 2 Displacements in X direction



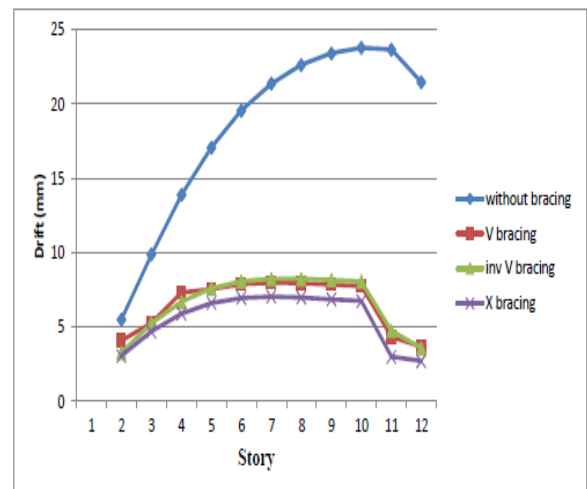
Graph 3 Displacements in Z direction



Graph 4 Drift X direction



Graph 5 Drift in Z direction



V. CONCLUSION

The performance of G+10 storey reinforced concrete building with bracing system have been investigated analytically for six types of bracing systems models to increase lateral stiffness and resistance. Based on the results of analysis conclusions are , A significant amount of decrease in the storey displacement & drift has been observed in model 2, model 3, model 4 in comparison to model 1.This implies that the stiffness of bracings increases the lateral stiffness of the buildings. The bare frame idealization leads to severe overestimation of the lateral displacements compared to the braced frame. Due to significant amount of increase in the lateral stiffness of building by using bracing, the bracing system takes near about all the lateral forces acting on building.

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