THOMSON REUTERS ENDNOTE
[Jain* *et al.*, 5(12): December, 2016]
IC™ Value: 3.00
ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

COMPARATIVE STUDY AND SEISMIC ANALYSIS OF A MULTISTOREY STEEL BUILDING

Shubham Kumar Jain [*], Dr. S.S. Bhadoria , Dr. Suresh Singh Kushwah
[*] Department of Civil Engineering UIT(RGPV), Bhopal(MP)

DOI: 10.5281/zenodo.221019

ABSTRACT
Steel Building in the world in the last decades, the steel structure for the building industry has played an important role in the most useful content. Providing the strength, stability and flexibility are the key purposes of seismic design. It is to design a structure under seismic load is required to perform. Structural bracing element in the system plays an important role in structural behavior during earthquakes. Bracing pattern of massive steel framed building can modify the behavior of the global seismic. In this research time history analysis is carried out for 7 storey and 12 storey steel frame building with different pattern of bracing system. Three types of sections i.e. ISMB, ISWB and ISB sections are used to compare for same patterns of beam, column and bracings. A software package SAP2000 is used for the analysis of steel buildings and different parameters are compared. The property of the section is used as per IS 800:2007 which incorporates Limit State Design philosophy. In this 7 storey and 12 storey steel frame building is analyzed for various types of concentric bracings like inverted V, X and without bracing and Performance of each frame is carried out and studied the comparatively through time history analysis.

KEYWORDS: Braced Frame ,Inter-story drift,X-braced,inverted V-braced,time-history function ,drift, displacement etc..

INTRODUCTION

1.1 General

The earthquake is a natural phenomenon, which is generated in the earth's crust. Earthquake period is generally rather low, more than a few seconds to a minute or permanent. But different parts of the world, thousands of people lose their lives in the earthquake. Building collapse or damage caused by the earthquake ground motion are a big loss. In an earthquake, the building based high frequency movements inertial forces on the building and its components is the result of experience. The building is created by the force of the tendency to remain at rest, and is in its original position, even if it is rising from the ground below. Assessment of seismic vulnerability of structures and seismic action levels beyond traditional linear behavior of the need for an accurate prediction of the seismic responses of non-deterministic characteristics is a very complex issue. The main factor influencing the choice of stable performance is bracing systems. Before destruction one more plastic deformation bracing system that can absorb more energy during the earthquake. Seismic analysis and structural analysis is a subset of the earthquake response of the structure of a building is calculated. The structural design, structural engineering or earthquake assessment and retrofit areas where earthquakes are prevalent in the part of the process. Providing strength, stability and flexibility are the key purposes of seismic design

Bracing System: A Braced Frame is a structural system which is designed primarily to resist wind and earthquake forces. Members in a braced frame are designed to work in tension and compression, similar to a truss. Braced frames are almost always composed of steel members. The commonly used lateral force resisting systems, moment resisting and concentrically braced frames, generally provide economic solutions to one or the other of the two requirements but not both; vis., moment resisting frames are ductile but often too flexible to economically meet drift control requirements, whereas concentrically braced frames are stiff but possess limited energy dissipation capability. Recently, eccentrically braced frames have been advanced as an economic solution to the seismic design problem. An eccentrically braced frame is a generalized framing system in which the axial forces induced in the braces are transferred either to a column or another brace through shear and bending in a segment of the beam. This critical beam segment is called an "active link" or simply "link" and will be designated herein by its length e. These links act to dissipate the large amounts of input energy of a severe seismic event via material yielding.

Bracing configuration: The selection of a bracing configuration is dependent on many factors. These include the height to width proportions of the bay and the size and location of required open areas in the framing elevation. These constraints may supersede structural optimization as design criteria. The introduction of the parameter, e/L, leads to a generalization of the concept of framing system. It has been shown that high elastic frame stiffness can be achieved by reducing the eccentricity, e. The reduction of e, however, is limited by the ductility that an active link can supply.

Bracing systems are generally three types:

1. Moment resisting frames (MRFs)
2. Concentric braced system (CBFs)
3. Eccentric braced frame (EBFs)

a) Moment Resisting Frames (MRFs): Moment-resisting frames are rectilinear assemblages of beams and columns, with the beams rigidly connected to the columns. Resistance to lateral forces is provided primarily by rigid frame action-that is, by the development of bending moment and shear force in the frame members and joints. By virtue of the rigid beam-column connections, a moment frame cannot displace laterally without bending the beams or columns depending on the geometry of the connection. The bending rigidity and strength of the frame members is therefore the primary source of lateral stiffness and strength for the entire frame.

b) Concentric Braced System: Steel concentrically braced frames (CBFs) are considered effective and economic lateral load resisting systems to withstand earthquake loading in seismic regions around the world. A steel brace as part of a CBF typically buckles globally under compression and yields under tension axial loads. Because of the complex asymmetric inelastic behavior of the steel braces and the wide range of steel brace configurations, it is nearly impossible to design the steel braces to achieve a uniform demand-to-capacity ratio along the height of CBFs and ultimately avoid local story mechanisms that are associated with concentration of plastic deformations. These mechanisms induce structural collapse of CBFs under extreme earthquakes.

c) Eccentric Braced Frame : Eccentrically braced frames(EBFs)are a lateral load resisting system for steel buildings that can be considered a hybrid between conventional moment resisting frame (MRFs) and concentrically braced frame (CBFs) EBFs are in effect an attempt to combine the individual advantages of MRFs and CBFs , while minimizing their respective disadvantages. The eccentrically braced steel frame provides an efficient structural system for resisting lateral loads caused by wind or seismic activity, this versatile system can reduce overall material requirements and result in a frame which is still under moderate loads yet ductile at extreme overloads, an essential feature in seismic design.

In eccentrically braced frames, the vertical force components in the diagonal braces are transferred to columns or other braces through shear and bending in the beams. In a sense, this makes eccentrically braced frames a compromise between a truss and a moment resisting frame. The truss-like characteristics endow the frame with high stiffness while the moment resisting frame-like characteristics provide the frame with large ductility capability. For these reasons eccentrically braced frames can be used to advantage in earthquake-resistant construction. A typical EBF consists of a beam, one or two braces, and columns. Its configuration is similar to traditional braced frames with the exception that at least one end of each brace must be eccentrically connected to the frame. The eccentric connection introduces bending and shears forces in the beam adjacent to the brace.

Advantages of bracing system:

There are lots of advantages of the bracing systems so that they are widely used. These are:

1. Braced frames are applicable to all kind of structures like bridges, aircrafts, cranes, Buildings and electrical transmission towers.
2. Braced frames are easy to fabricate and construct. No lots of knowledge or skills are needed.
3. If the bolted connections are used, there is no deformation problem at the connections.

Technical Terminology:

Capacity: The overall capacity of a structure depends on the strength and deformation capacities of the individual components of the structure. In order to determine capacities beyond the elastic limits, some form of nonlinear analysis, such as the pushover, incremental dynamic analysis procedure is required.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

Demand (Displacement): Ground motions during an earthquake produce complex horizontal displacement patterns in structures that may vary with time. Tracking this motion at every time-step to determine structural design requirements is -judged impractical. Traditional linear analysis methods use lateral forces to represent a design condition. For nonlinear methods it is easier and more direct to use a set of lateral displacements or inter story drift ratio as a design condition. For a given structure and ground motion, the displacement demand is an estimate of the maximum expected response of the building during the ground motion.

Performance: Once a capacity curve and demand displacement is defined, a performance check can be done. A performance check verifies that structural and nonstructural components are not damaged beyond the acceptable limits of the performance objective for the forces and displacements implied by the displacement demand. The next three subsections provide step by step procedures for determining capacity, demand and performance using the capacity spectrum method and the displacement coefficient method.

Inter-story drift: Inter-story drift is one of the particularly useful engineering response quantity and indicator of structural performance, especially for high-rise buildings. The inter-story drifts of building structures as relative translational displacement between two consecutive floors. It consists of the following three parts.
(1) Inter-story shear drift induced by vertical members;
(2) Inter-story flexural drift induced by vertical members in calculated story
(3) Inter-story flexural drift induced by vertical members in inferior story
.

1.2 Objective of study
The objective of the study comprises of the following:
1. Comparative study of the behavior of different type of steel bracing structures such as without braced, inverted V-braced and X-braced.
2. To perform the static linear and static nonlinear analysis on steel structures.
3. To calculate the material consumption in the same configuration of the different bracing steel structures such as without bracing, inverted V-bracing and X bracing.

1.3 Software Used
SAP2000 is used for design of the steel building for seismic force. It is used to perform linear and nonlinear static analysis of structure. The structural analysis program SAP2000 is a software package from Computers and Structures, which is based on the finite element method for modeling and analysis. Also it has the capability of designing and optimizing building structures. Apart from that Windows software is also used.

MATERIALS AND METHODS
The seismic performance i.e. analysis of steel structures is attempted in the current project. For this, the proposed methodology is as follows:
1. An extensive survey of the literature on the response of steel structures to seismic loading is performed.
2. Different type of steel structure are taken and analyzed by static linear and static nonlinear analysis.
3. Different type of bracing system of steel structures are taken and analyzed by different ground motion with the help of time history analysis.
4. Calculate the total steel consumption in three different types of steel structure i.e. without bracing, inverted V-bracing and X-bracing.
5. Plot different curves from static linear and static nonlinear analysis for three different types of steel structure i.e. without bracing, inverted V-bracing and X-bracing.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

GEOMETRY AND MODELLING

Grade of concrete is considered M25
Grade of steel is considered Fe-410

Problem Description:

Table 1: Structural modeling specification of 7 Storey Buildings

Type of Structure	Without bracing	Inverted V-bracing	X-bracing
Bay Width in longitudinal direction	30m	30m	30m
Bay Width in Transverse direction	30m	30m	30m
Total Height	21m	21m	21m
Live Load	3.50 KN/m2	3.50 KN/m2	3.50 KN/m2
Floor Finishing	0.50KN/m²	0.50KN/m²	0.50KN/m²
Wall Load	12KN/m	12KN/m	12KN/m
Grade of concrete	M-25	M-25	M-25
Type of steel	Fe-410	Fe-410	Fe-410
Each column height	3 m	3m	3m
Support condition	Fixed	Fixed	Fixed

Frame Geometry: Model 1 is symmetric plan. Model 2 is asymmetric plan and hence a single plane frame is considered to be representative of building in one direction for modal 1 and in two directions for modal 2.

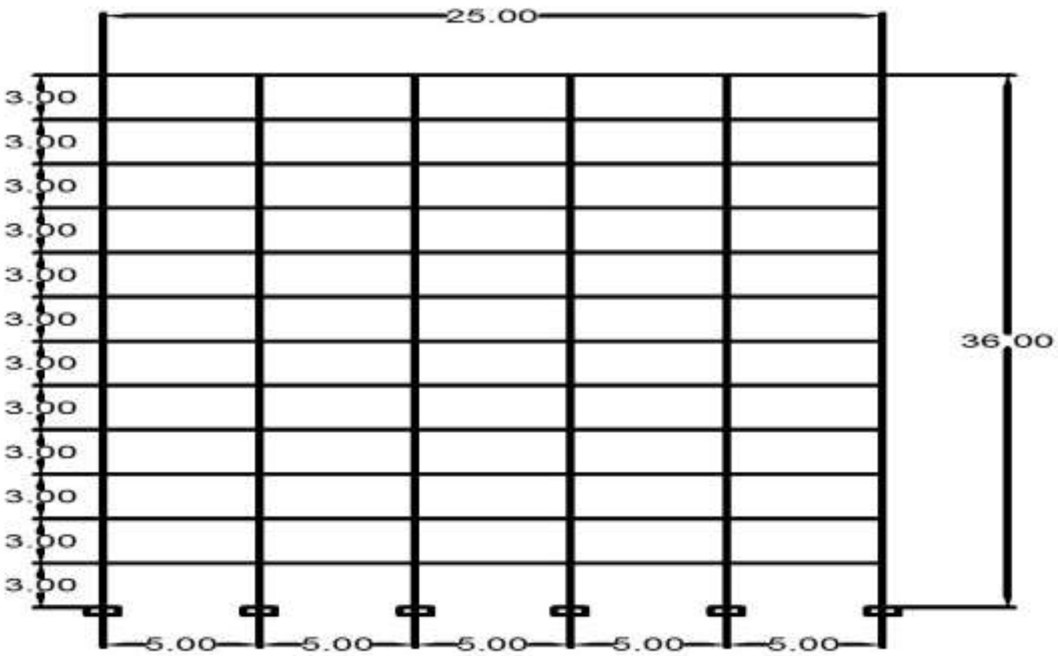


Figure 1: Elevation of 12 storey building without bracing in longitudinal direction

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

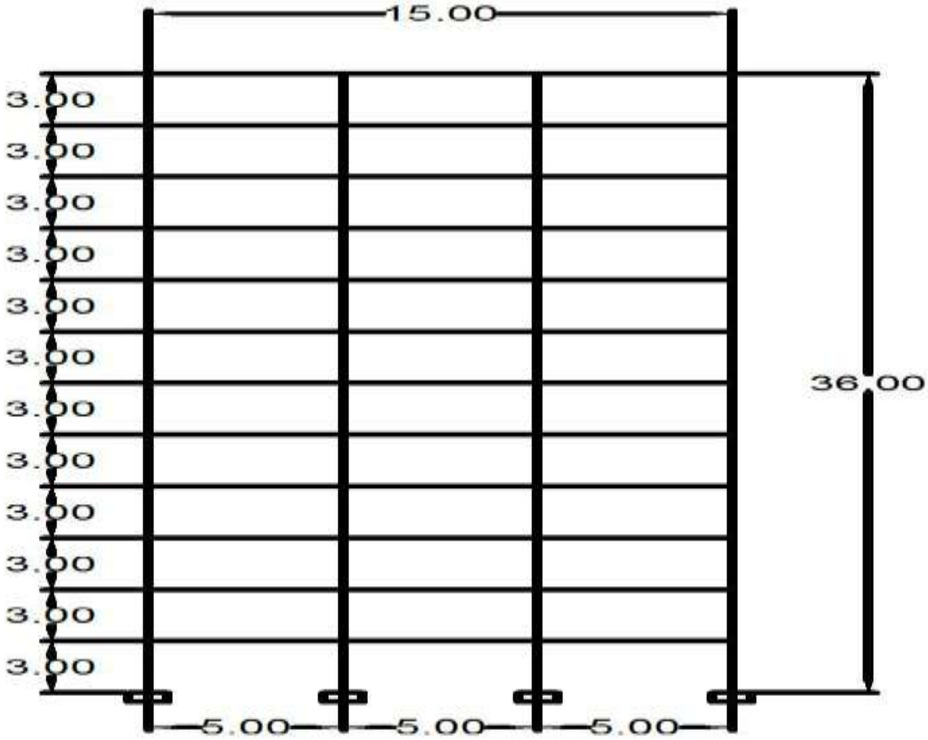


Figure 2: Elevation of 12 storey building without bracing in transverse direction

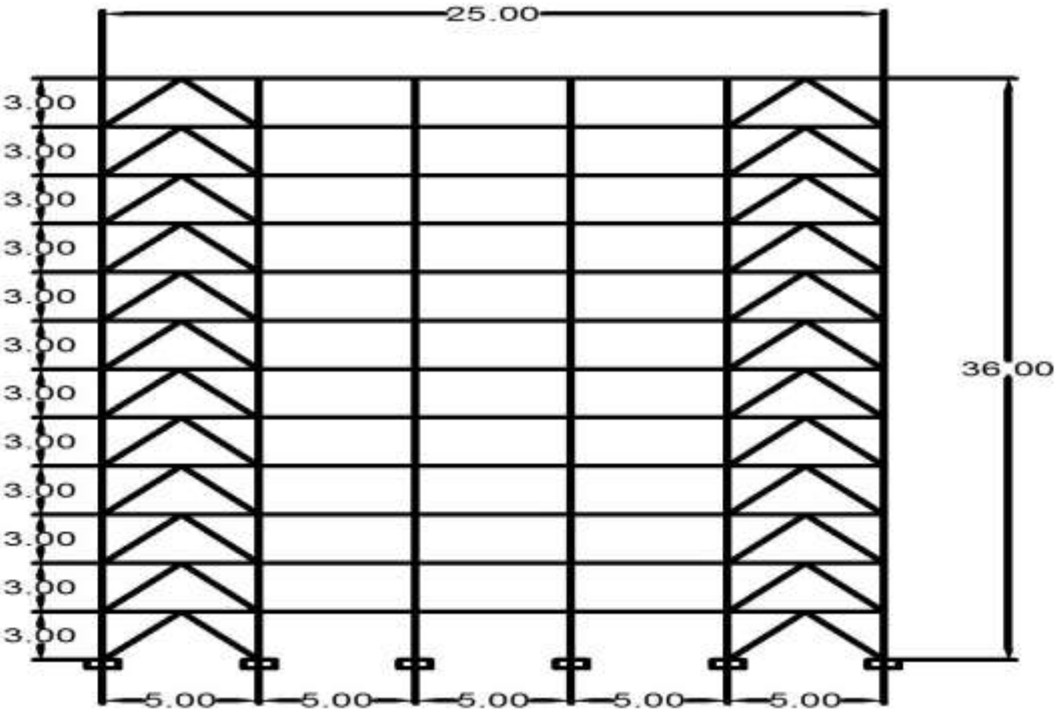


Figure 3: Elevation of 12 storey building with inverted V-bracing in longitudinal direction

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

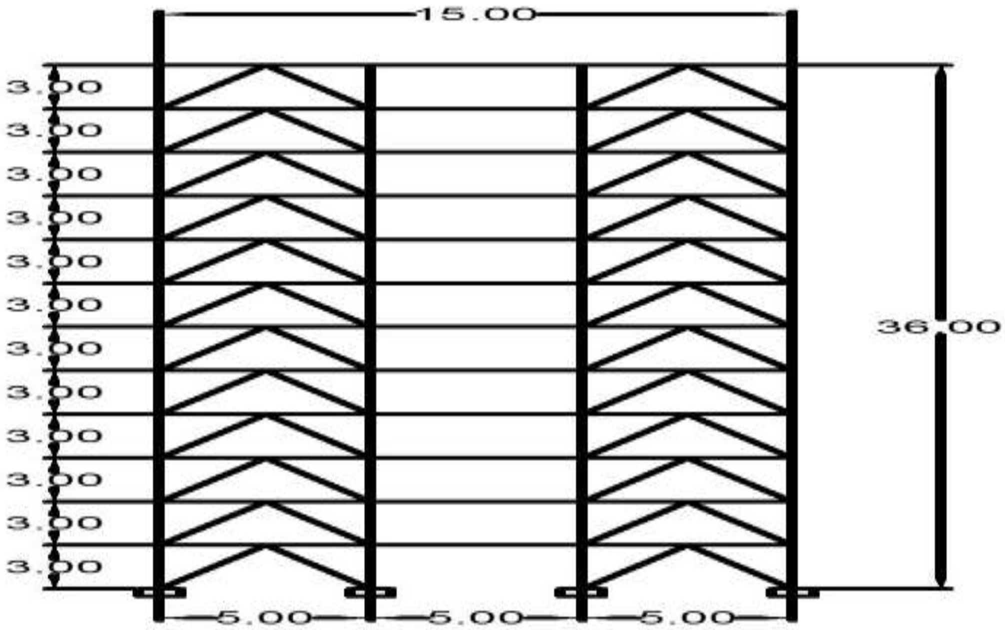


Figure 4: Elevation of 12 storey building with inverted V-bracing in transverse direction

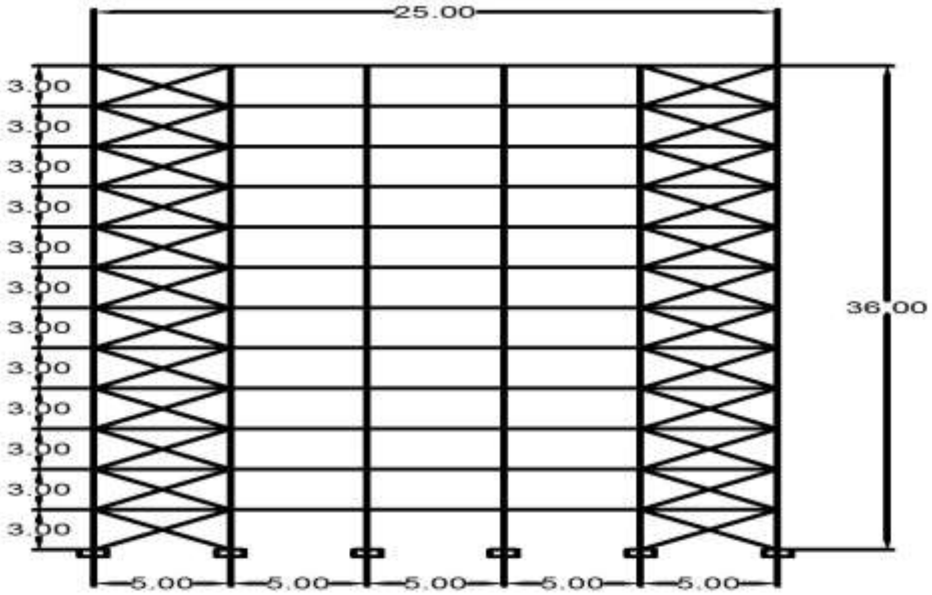


Figure 5: Elevation of 12 storey building with X-bracing in longitudinal direction

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

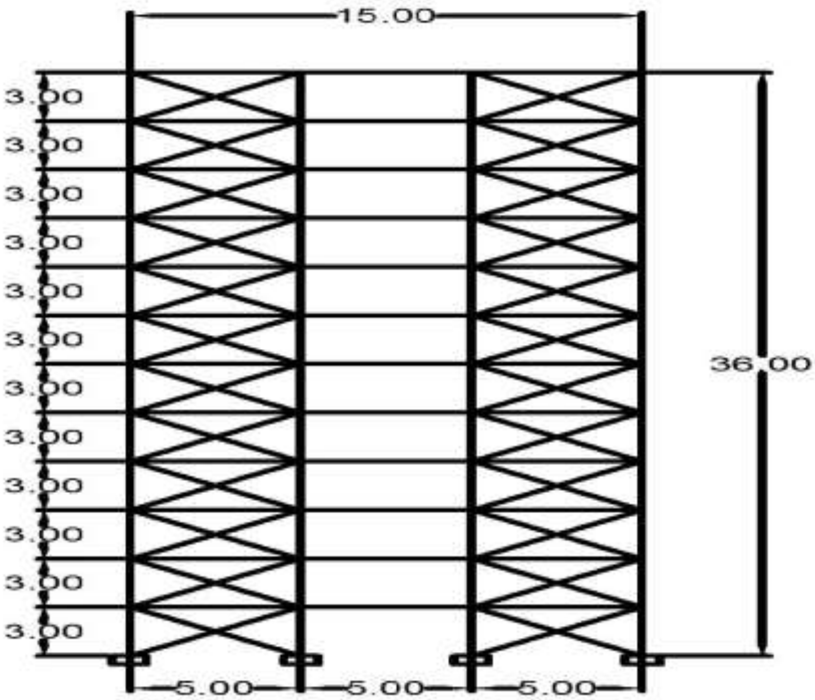


Figure 6: Elevation of 12 storey building with X-bracing in transverse direction

Time History Function Details

No.	nomenclature	Name & Detail	Filter point		NPTS	DT (Second)	Max .Acc.	Min. Acc.
			HP	LP				
1	P1	LOMA PRIETA 10/18/89 00:05	0.20	30	8000	0.005	0.1591	-0.14874
2	P2	IMPERIAL VALLEY 10/15/79 2316	0.10	40	3749	0.005	0.05677	-0.05212
3	P4	IMPERIAL VALLEY 10/15/79 2316	0.20	41	7921	0.005	0.24385	-0.22748
4	P5	LOMA PRIETA 10/18/89 00:05	0.10	29	7990	0.005	0.17911	-0.15293
5	P6	IMPERIAL VALLEY 10/15/79	0.05	UN	8000	0.005	0.28566	-0.30855
6	P7	LOMA PRIETA 10/18/89 00:05	0.10	40	7850	0.005	0.169	-0.207
7	P8	IMPERIAL VALLEY 10/15/79	0.20	40	7901	0.005	0.11696	-0.10901

RESULTS AND DISCUSSION

General

After performing time history analysis on the 6 different models with the set of 7 different time histories obtained different curve. These curves are used to analysis and further for displacement and drift estimation.

The results obtained from time history analysis are given in various Figures and tables as follows:

Table 1: Joint Displacement of 12 Storey Building due to P1 TH in X-direction

storey	Without Bracing	Inverted V-bracing	X-bracing	% difference in Inverted V-bracing	% difference in X-bracing
12th	187.68	100.18	35.98	46.62	80.83
11th	189.42	93.34	35.38	47.97	81.39
10th	165.85	84.78	30.71	48.88	81.48
9th	151.73	76.28	27.82	49.73	81.67
8th	136.50	67.84	24.66	50.30	81.93
7th	120.02	59.08	21.33	50.83	82.22
6th	102.03	49.97	17.81	51.02	82.54
5th	83.165	41.65	14.20	49.91	82.92
4th	63.91	32.83	10.66	48.32	83.21
3rd	43.92	23.54	7.57	46.40	82.76
2nd	24.77	14.07	4.48	43.19	81.91
1st	8.38	5.29	1.72	36.84	79.50

Table 2: Joint Displacement of 12 Storey Building due to P1 TH in Y-direction

storey	Without Bracing	Inverted V-bracing	X-bracing	% difference in Inverted V-bracing	% difference in X-bracing
12th	301.31	168.83	65.09	43.97	78.40
11th	281.59	155.96	60.42	44.62	78.54
10th	251.20	141.28	54.48	43.76	78.31
9th	220.33	125.12	47.76	43.21	78.32
8th	191.31	107.68	41.35	43.72	78.38
7th	165.74	90.47	35.23	45.42	78.74
6th	137.86	74.54	28.96	45.93	78.99
5th	112.73	60.81	22.76	46.06	79.84
4th	86.99	47.38	16.72	45.52	80.78
3rd	63.50	34.33	11.25	45.94	82.28
2nd	40.07	21.70	6.74	45.84	83.19
1st	17.85	10.06	2.9	43.66	83.24

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

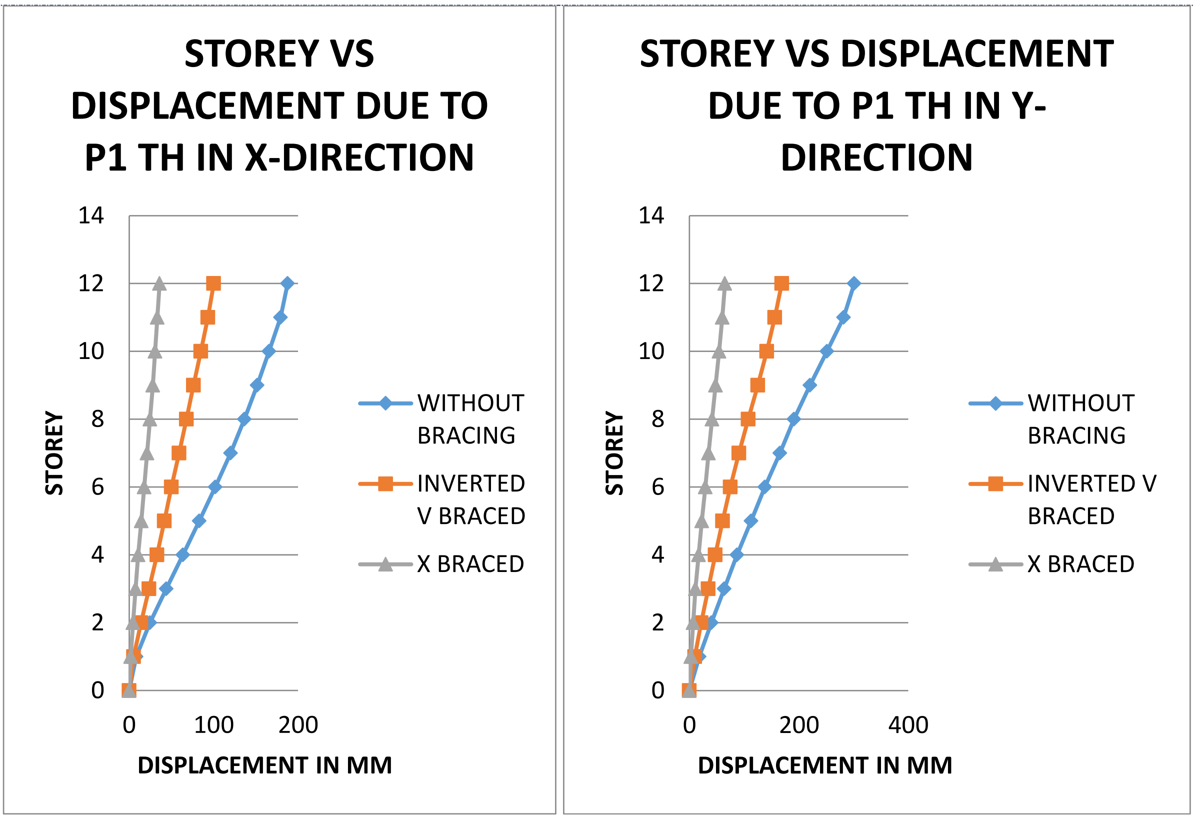


Figure 7: Storey vs. Displacement curves of 12 storey building due to P1 TH

Discussion

- Lateral displacement is continuously increased from 1st to top storey in X and Y direction.
- The displacement increased as increment of the storey height in both X and Y direction.
- The displacement is largest in without braced building then decreases in inverted V-braced and X-braced building in both X and Y- direction.
- The maximum percentage difference in lateral displacement of the inverted-V bracing and X-bracing are 51.02, 83.21 & 46.06, 83.24 as compared to without bracing in X & Y-direction respectively.

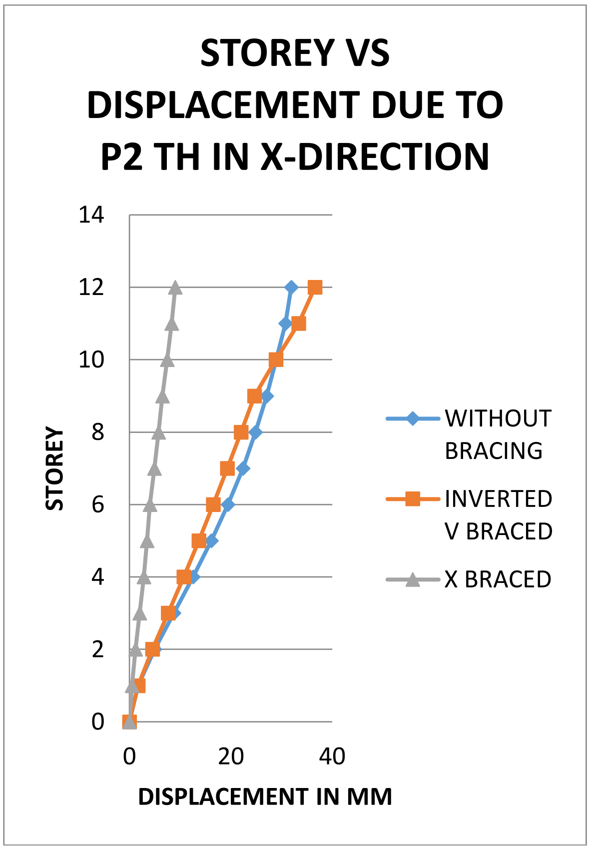
Table 3: Joint Displacement of 12 Storey Building due to P2 TH in X-direction

storey	Without Bracing	Inverted V-bracing	X-bracing	% difference in Inverted V-bracing	% difference in X-bracing
12th	31.91	36.59	9.04	-14.68	71.68
11th	30.76	33.34	8.34	-8.39	72.91
10th	28.96	28.92	7.42	0.14	74.37
9th	27.04	24.67	6.52	8.79	75.88
8th	24.87	21.99	5.71	11.58	77.02
7th	22.36	19.30	4.90	13.69	78.10
6th	19.43	16.53	4.06	14.95	79.08
5th	16.15	13.68	3.49	15.27	78.40
4th	12.53	10.71	2.81	14.53	77.60
3rd	8.76	7.64	2.04	12.83	76.74
2nd	4.98	4.54	1.22	8.80	75.44
1st	1.69	1.70	0.47	-0.36	72.05

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

Table 4: Joint Displacement of 12 Storey Building due to P2 TH in Y-direction

storey	Without Bracing	Inverted V-bracing	X-bracing	% difference in Inverted V-bracing	% difference in X-bracing
12th	68.13	36.57	24.15	46.32	64.56
11th	63.01	33.93	22.34	46.15	64.54
10th	54.43	31.01	19.98	43.03	63.29
9th	44.71	27.88	17.31	37.65	61.28
8th	36.99	24.53	15.03	33.70	59.38
7th	31.65	21.13	12.97	33.26	59.02
6th	25.94	17.71	11.04	31.73	57.44
5th	20.44	14.34	9.05	29.84	55.74
4th	15.79	10.99	6.96	30.37	55.92
3rd	12.62	7.81	4.89	38.13	61.26
2nd	8.66	4.82	2.96	44.31	65.83
1st	4.04	2.18	1.30	46.03	67.73



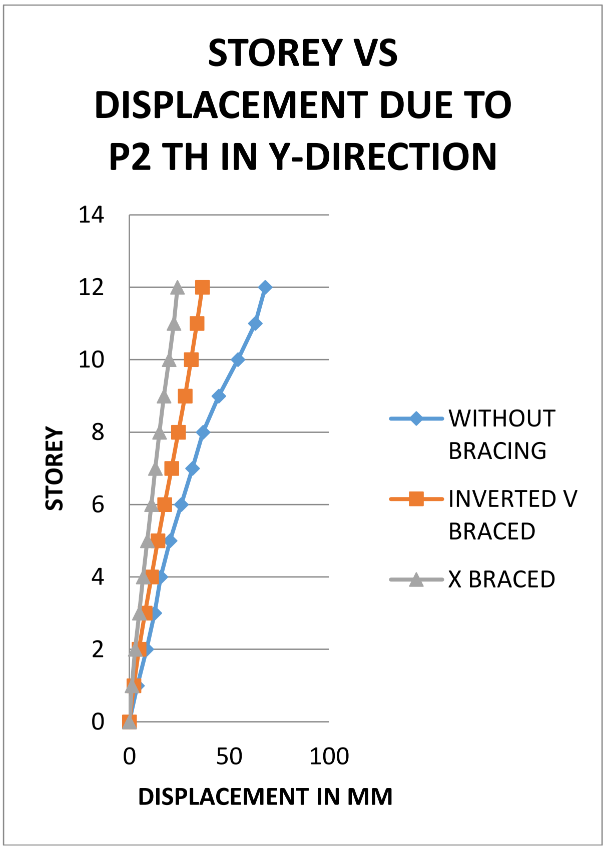


Figure 8: Storey vs. Displacement curves of 12 storey building due to P2 TH

Discussion

- Lateral displacement is continuously increased from 1st to top storey in X and Y direction.
- The displacement is largest in without braced building then decreases in inverted V-braced and X-braced building in both X and Y- direction but in inverted V braced building the displacement is large from 10th to 12th compared to without braced building in X-direction.
- The maximum percentage difference in lateral displacement of the inverted-V bracing and X-bracing are 15.27, 79.08 & 46.32, 67.73 as compared to without bracing in X & Y-direction respectively.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

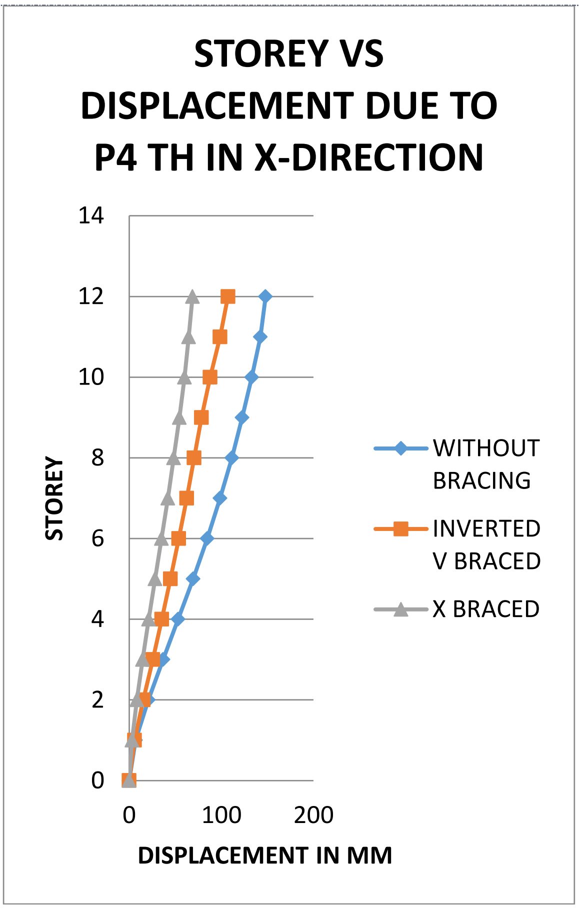
Table 5: Joint Displacement of 12 Storey Building due to P4 TH in X-direction

storey	Without Bracing	Inverted V-bracing	X-bracing	% difference in Inverted V-bracing	% difference in X-bracing
12th	148.10	107.20	68.70	27.62	53.61
11th	142.38	98.77	64.70	30.63	54.56
10th	132.89	87.86	59.94	33.88	54.90
9th	122.71	78.46	54.43	36.06	55.64
8th	111.38	70.50	48.41	36.70	56.54
7th	98.78	62.33	41.97	36.90	57.51
6th	84.62	53.77	35.11	36.46	58.51
5th	69.40	44.91	28.06	35.38	59.57
4th	53.22	35.48	21.05	33.34	60.46
3rd	36.88	25.53	14.41	30.78	60.93
2nd	20.80	15.28	8.24	26.51	60.40
1st	7.03	5.74	3.06	18.27	56.50

Table 6: Joint Displacement of 12 Storey Building due to P4 TH in Y-direction

storey	Without Bracing	Inverted V-bracing	X-bracing	% difference in Inverted V-bracing	% difference in X-bracing
12th	144.35	170.48	88.00	-18.10	39.04
11th	127.29	159.04	81.70	-24.95	35.81
10th	106.22	146.43	74.03	-37.86	30.31
9th	96.04	132.54	65.58	-38.00	31.72
8th	92.85	117.04	57.03	-26.05	38.58
7th	84.01	101.3	49.05	-20.27	41.61
6th	68.64	85.33	41.07	-24.32	40.16
5th	53.93	70.27	32.90	-30.30	39.00
4th	45.13	55.37	24.67	-22.68	45.33
3rd	36.15	40.69	16.94	-12.57	53.14
2nd	26.22	26.05	10.05	0.67	61.66
1st	12.58	12.14	4.37	3.54	65.31

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7



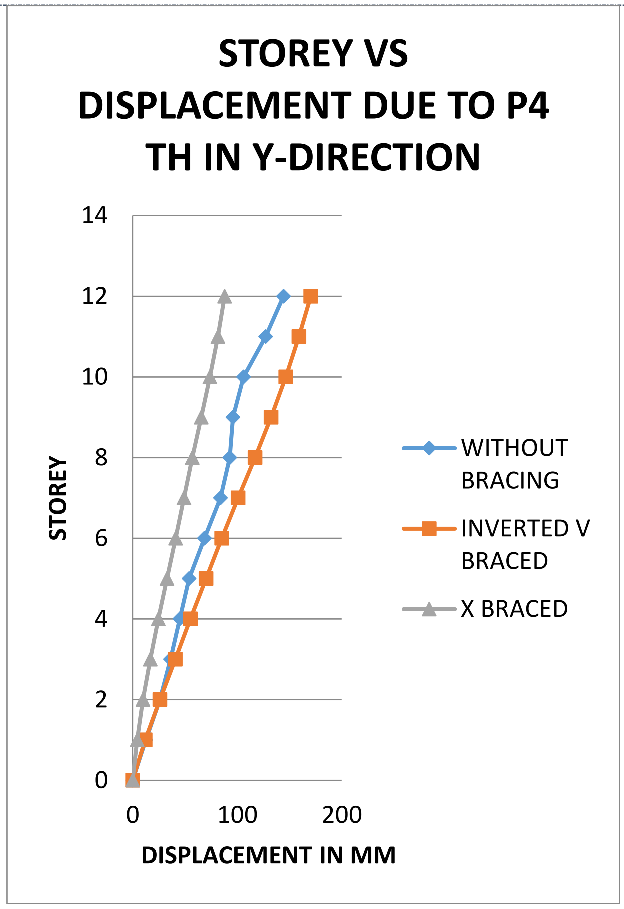


Figure 9: Storey vs. Displacement curves of 12 storey building due to P4 TH

Discussion:

- Lateral displacement is continuously increased from 1st to top storey in X and Y direction.
- The displacement is largest in without braced building then decreases in inverted V-braced and X-braced building in X direction. But displacement is largest in inverted V-braced building then decreases in without braced and X-braced building in Y- direction.
- The maximum percentage difference in lateral displacement of the inverted-V bracing and X-bracing are 36.90, 60.93 & 3.54, 65.31 as compared to without bracing in X & Y-direction respectively.

Table 7: Joint Displacement of 12 Storey Building due to P5 TH in X-direction

storey	Without Bracing	Inverted V-bracing	X-bracing	% difference in Inverted V-bracing	% difference in X-bracing
12th	159.88	152.46	45.08	4.64	71.81
11th	150.92	140.25	42.20	7.07	72.04
10th	136.78	123.69	38.55	9.57	71.82
9th	123.09	108.42	34.24	11.92	72.18
8th	109.29	95.89	29.64	12.35	72.88
7th	95.29	82.72	25.03	13.19	73.73
6th	80.76	69.40	20.42	14.06	74.71
5th	65.98	56.30	15.98	14.68	75.89
4th	50.67	43.22	11.79	14.69	76.73
3rd	35.23	23.34	7.98	13.86	77.33
2nd	19.93	17.81	4.54	10.66	77.23

1st	6.76	6.60	1.68	2.35	75.11

Table 8: Joint Displacement of 12 Storey Building due to P5 TH in Y-direction

storey	Without Bracing	Inverted V-bracing	X-bracing	% difference in Inverted V-bracing	% difference in X-bracing
12th	140.64	164.96	70.84	-17.30	49.63
11th	135.97	151.68	66.09	-11.55	51.39
10th	117.85	138.59	60.25	-17.60	48.87
9th	93.72	123.92	53.63	-32.23	42.78
8th	84.62	107.45	46.49	-2.98	45.06
7th	85.59	90.58	39.37	-5.84	54.00
6th	82.36	73.71	32.26	10.50	61.84
5th	75.90	57.25	25.21	24.56	66.78
4th	64.73	42.47	18.46	34.39	71.48
3rd	52.78	30.70	12.37	41.83	76.56
2nd	35.86	19.56	7.15	45.45	80.07
1st	16.65	9.09	3.02	45.38	81.89

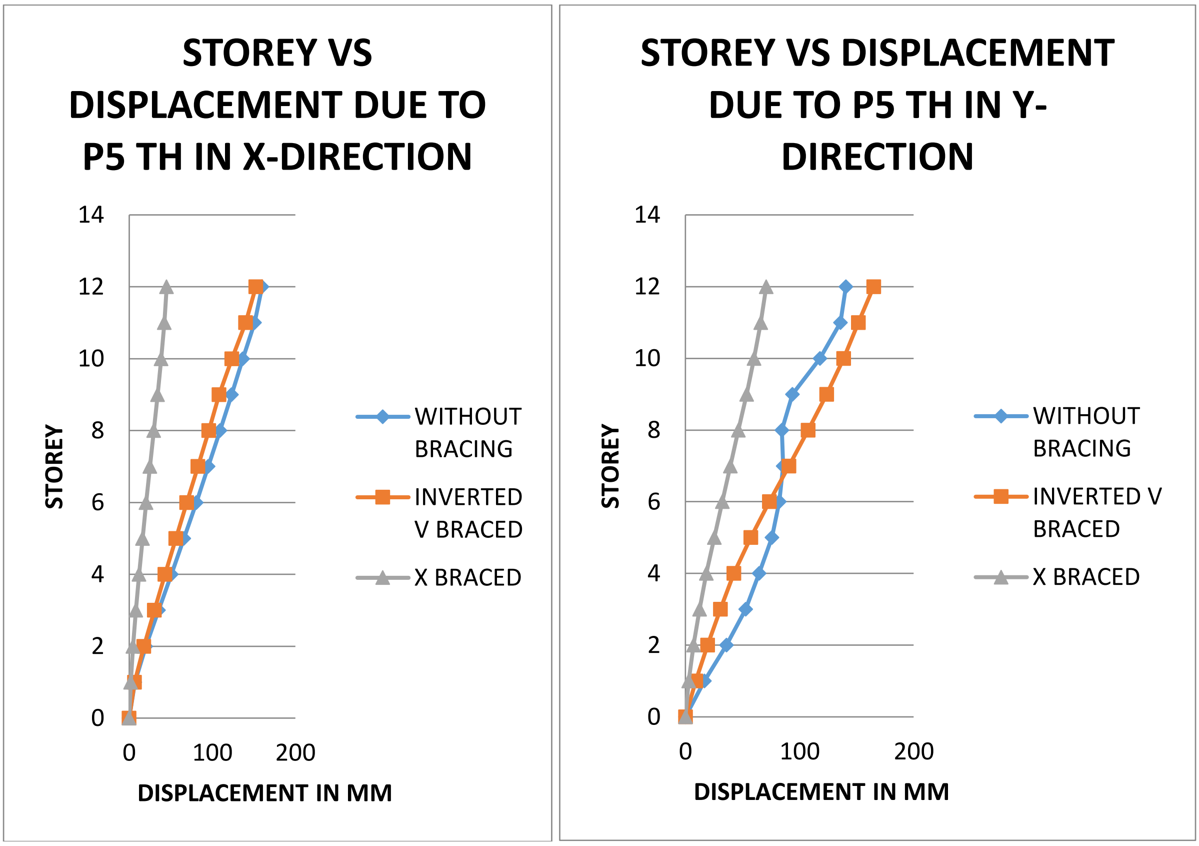


Figure 10: Storey vs. Displacement curves of 12 storey building due to P5 TH

Discussion:

- Lateral displacement is continuously increased from 1st to top storey in X and Y direction.
- The displacement is largest in without braced building then decreases in inverted V-braced and X-braced building in X direction. But displacement is largest in without braced up to 7th floor then decreased up to top floor as compared to inverted V-braced building in Y- direction.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

- The maximum percentage difference in lateral displacement of the inverted-V bracing and X-bracing are 14.69, 75.11 & 45.45, 81.89 as compared to without bracing in X & Y-direction respectively.

Table 9: Joint Displacement of 12 Storey Building due to P6 TH in X-direction

storey	Without Bracing	Inverted V-bracing	X-bracing	% difference in Inverted V-bracing	% difference in X-bracing
12th	199.24	175.08	101.29	12.13	49.16
11th	190.65	165.33	94.99	13.28	50.17
10th	177.90	152.89	87.09	14.06	51.05
9th	165.60	138.90	77.68	16.12	53.09
8th	152.27	124.03	67.53	18.55	55.65
7th	137.15	107.39	57.20	21.70	58.30
6th	119.49	89.83	46.74	24.82	60.88
5th	101.57	72.90	36.57	28.22	64.00
4th	81.92	56.81	26.92	30.65	67.14
3rd	58.99	40.74	18.13	30.94	69.26
2nd	34.20	24.41	10.23	28.65	70.09
1st	11.77	9.18	3.76	22.00	68.06

Table 10: Joint Displacement of 12 Storey Building due to P6 TH in Y-direction

storey	Without Bracing	Inverted V-bracing	X-bracing	% difference in Inverted V-bracing	% difference in X-bracing
12th	286.37	204.86	111.02	28.46	61.23
11th	276.40	191.56	103.20	30.70	62.66
10th	265.40	176.63	93.47	35.45	64.78
9th	245.76	160.34	82.68	34.76	66.36
8th	219.47	143.12	71.89	34.89	67.29
7th	194.10	126.05	61.70	35.06	68.21
6th	166.93	108.77	51.65	34.84	69.06
5th	142.53	94.89	41.49	33.42	70.89
4th	115.33	79.05	31.35	31.45	72.82
3rd	86.79	60.38	21.73	30.43	74.96
2nd	55.48	39.72	13.01	28.40	76.54
1st	24.84	18.89	5.79	23.97	77.11

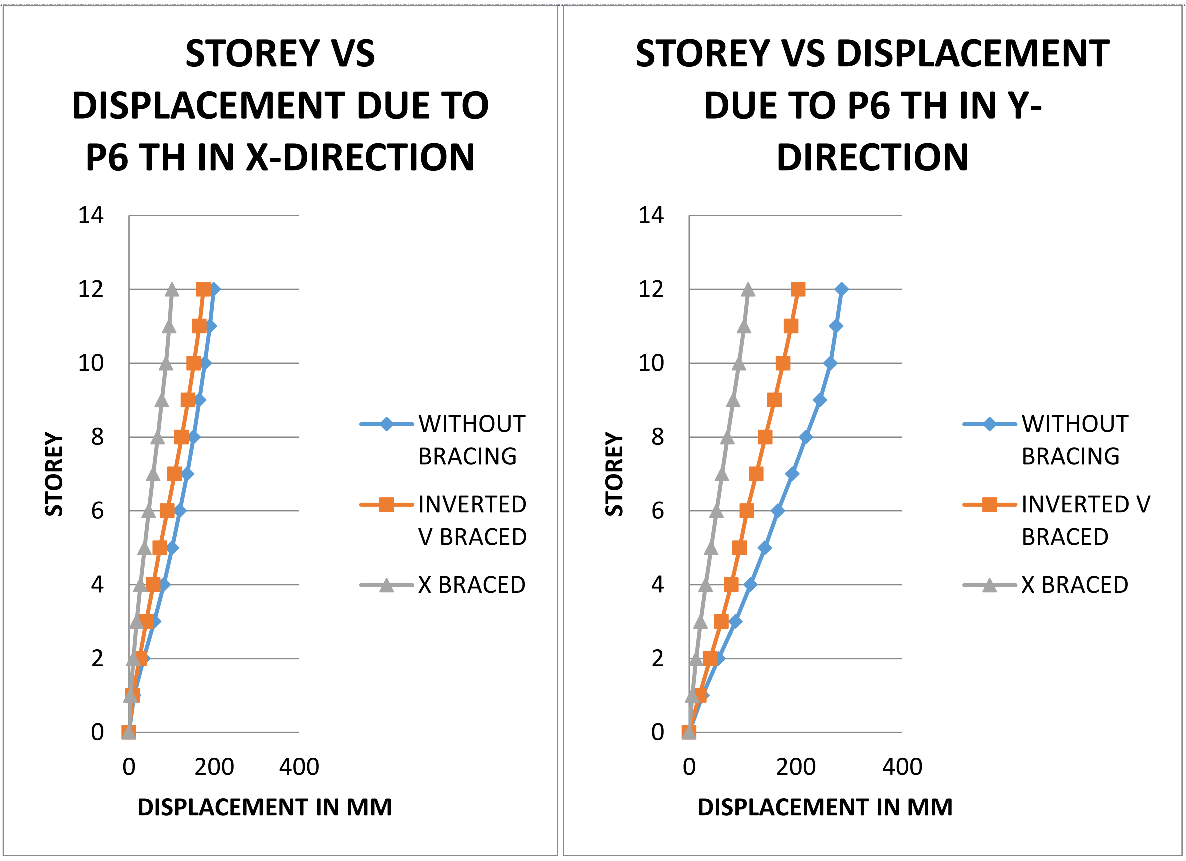


Figure 11: Storey vs. Displacement curves of 12 storey building due to P6 TH

Discussion:

- Lateral displacement is continuously increased from 1st to top storey in X and Y direction.
- The displacement increased as increment of the storey height in both X and Y direction.
- The displacement is largest in without braced building then decreases in inverted V-braced and X-braced building in both X and Y- direction.
- The maximum percentage difference in lateral displacement of the inverted-V bracing and X-bracing are 30.94, 70.09 & 34.89, 77.11 as compared to without bracing in X & Y-direction respectively.

Table 11: Joint Displacement of 12 Storey Building due to P7 TH in X-direction

storey	Without Bracing	Inverted V-bracing	X-bracing	% difference in Inverted V-bracing	% difference in X-bracing
12th	182.08	148.81	46.00	18.27	74.73
11th	174.45	137.78	43.13	21.02	75.28
10th	161.87	123.66	39.59	23.60	75.54
9th	148.61	108.55	35.63	26.96	76.03
8th	134.12	94.11	31.67	29.83	76.39
7th	118.27	84.20	27.75	28.81	76.53
6th	100.75	72.61	23.65	27.93	76.53
5th	82.81	60.06	19.30	26.95	76.52
4th	62.77	46.72	14.81	25.57	76.41
3rd	43.33	33.04	10.35	23.75	76.12
2nd	24.37	19.50	6.03	20.01	75.57
1st	8.22	7.26	2.27	11.66	72.34

Table 12: Joint Displacement of 12 Storey Building due to P7 TH in Y-direction

storey	Without Bracing	Inverted V-bracing	X-bracing	% difference in Inverted V-bracing	% difference in X-bracing
12th	668.44	196.62	72.73	70.58	89.12
11th	623.18	182.69	68.04	70.69	89.08
10th	567.42	167.15	32.45	70.54	88.99
9th	505.48	150.27	56.05	70.27	88.91
8th	439.28	131.94	49.00	69.97	88.85
7th	378.72	113.26	41.83	70.09	88.96
6th	312.24	94.71	34.60	69.67	88.92
5th	252.94	76.67	27.75.	69.69	89.03
4th	193.16	58.94	20.88	69.49	89.19
3rd	142.35	42.03	14.40	70.48	89.88
2nd	91.10	26.04	8.57	71.41	90.60
1st	40.88	11.80	3.72	71.14	90.91

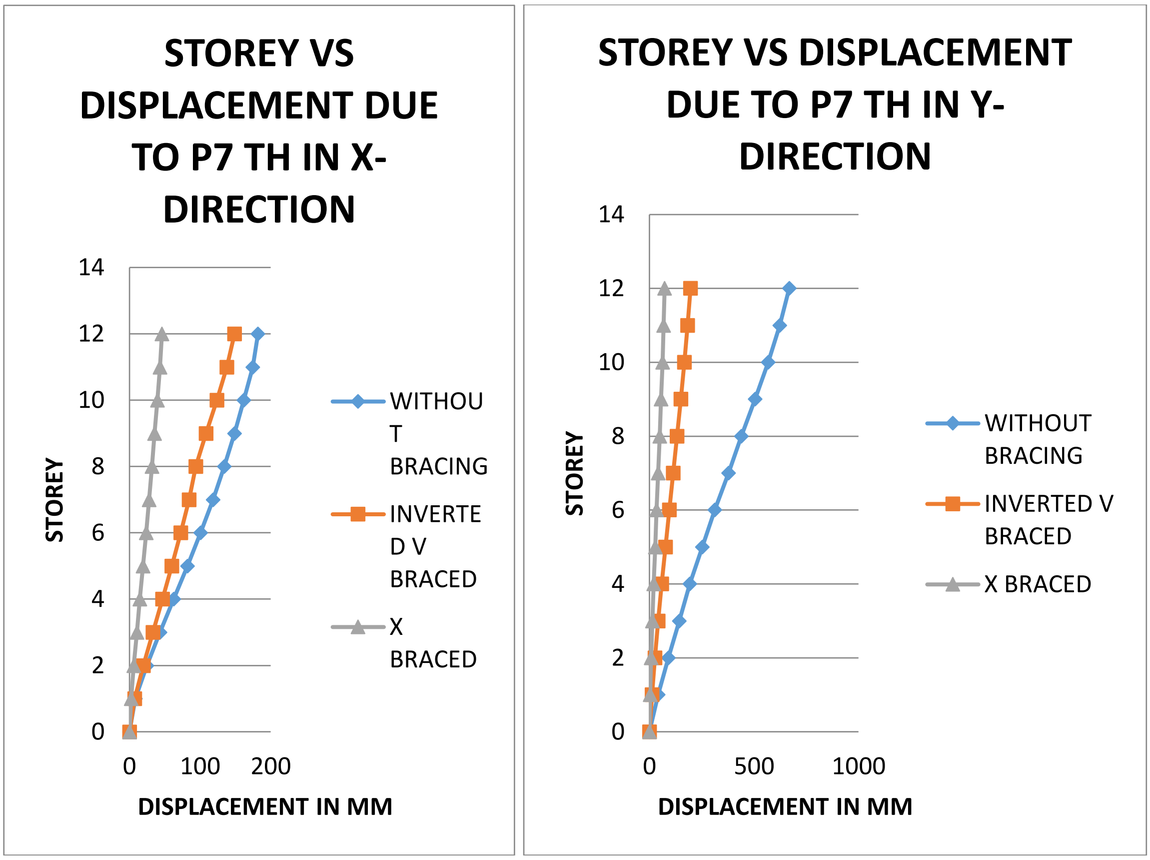


Figure 12: Storey vs. Displacement curves of 12 storey building due to P7 TH

Discussion:

- Lateral displacement is continuously increased from 1st to top storey in X and Y direction.
- The displacement increased as increment of the storey height in both X and Y direction.
- The displacement is largest in without braced building then decreases in inverted V-braced and X-braced building in both X and Y- direction.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

- The maximum percentage difference in lateral displacement of the inverted-V bracing and X-bracing are 29.83, 76.53 & 71.41, 90.91 as compared to without bracing in X & Y-direction respectively.

Table 13: Joint Displacement of 12 Storey Building due to P8 TH in X-direction

storey	Without Bracing	Inverted V-bracing	X-bracing	% difference in Inverted V-bracing	% difference in X-bracing
12th	110.45	70.45	19.99	36.22	81.90
11th	104.10	65.74	18.57	38.04	82.50
10th	98.90	59.43	17.15	39.91	82.66
9th	91.22	52.83	15.87	42.09	82.61
8th	82.72	46.55	14.37	43.72	82.63
7th	73.29	40.77	12.70	44.37	82.67
6th	62.73	35.03	10.82	44.16	82.75
5th	51.41	28.80	8.81	43.98	82.87
4th	39.40	22.23	6.72	43.59	82.95
3rd	27.29	15.58	4.67	42.91	82.88
2nd	15.38	9.30	2.71	39.53	82.41
1st	5.20	3.51	1.02	32.48	80.47

Table 14: Joint Displacement of 12 Storey Building due to P8 TH in Y-direction

Storey	Without Bracing	Inverted V-bracing	X-bracing	% difference in Inverted V-bracing	% difference in X-bracing
12th	169.88	116.62	40.29	31.35	76.29
11th	168.53	107.13	37.64	36.43	77.67
10th	161.36	96.96	34.40	39.91	78.68
9th	147.80	86.36	30.70	41.57	79.23
8th	130.45	75.01	26.69	42.50	79.54
7th	113.34	64.48	22.76	43.11	79.92
6th	64.05	54.13	18.84	42.44	79.97
5th	76.72	43.73	14.97	43.00	80.49
4th	59.30	33.27	11.26	43.89	81.00
3rd	43.20	23.81	7.83	44.89	81.88
2nd	27.05	15.12	4.71	44.11	82.59
1st	11.99	7.01	2.06	41.56	82.80

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

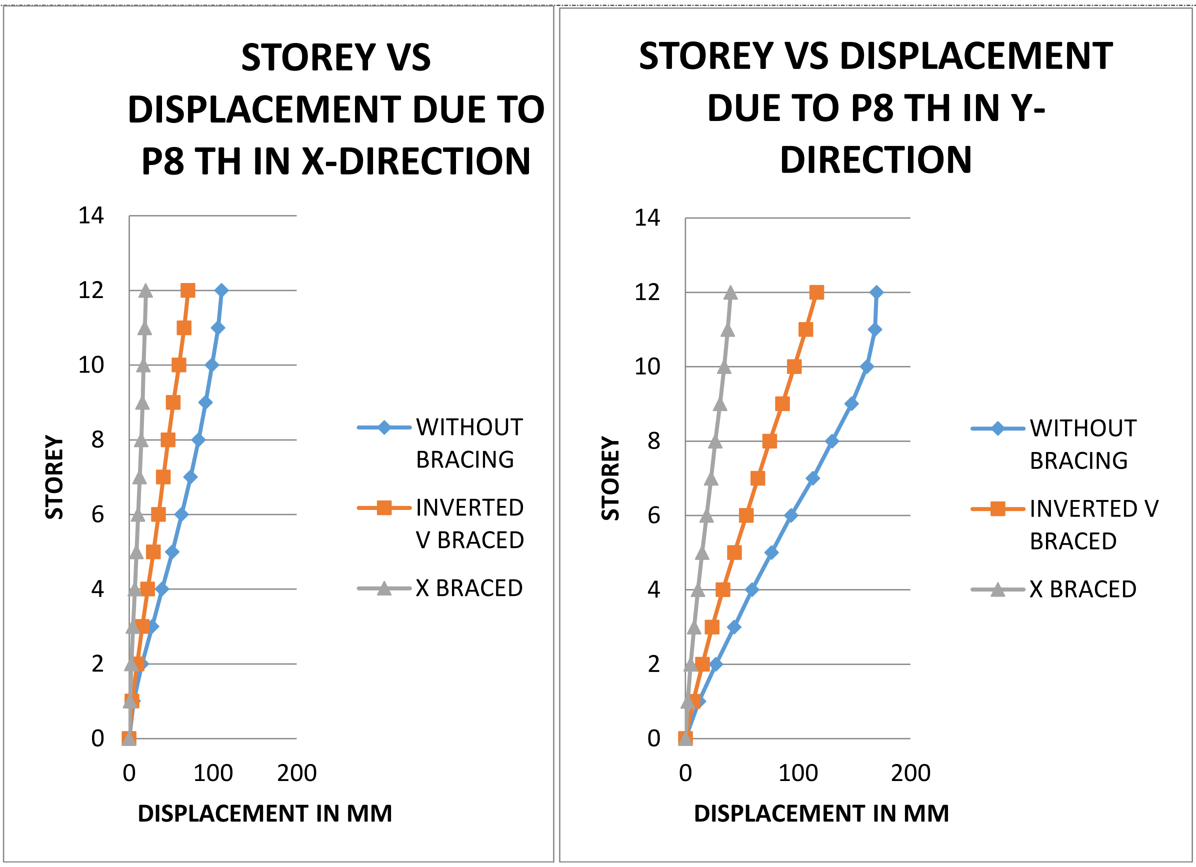


Figure 13: Storey vs. Displacement curves of 12 storey building due to P8 TH

Discussion:

- Lateral displacement is continuously increased from 1st to top storey in X and Y direction.
- The displacement increased as increment of the storey height in both X and Y direction.
- The displacement is largest in without braced building then decreases in inverted V-braced and X-braced building in both X and Y- direction.
- The maximum percentage difference in lateral displacement of the inverted-V bracing and X-bracing are 44.37, 82.95 & 44.89, 82.80 as compared to without bracing in X & Y-direction respectively.

CONCLUSION

There are the conclusions after the analysis of the structures:

- As per displacement criteria bracing system are good to reduce the displacement.
- The reaction and weight of structure are more in different type of bracing system as compared to unbraced structure with same configuration.
- The storey drift of the braced structures either increases or decreases as compared to the without braced building with the same configuration for the different bracing system.
- In 12 storeys building base shear is largest of without bracing as compared to inverted V-bracing and X-bracing in both longitudinal and transverse direction.
- In 12 storeys building displacement is smallest of X-bracing as compared to without bracing and inverted V-bracing in both longitudinal and transverse direction with same configuration.
- Steel consumption in inverted V-braced and X-braced 12 storey building is 11.79% and 13.23% respectively more than compared to without braced building.

REFERENCES

1. Kamath K. & Rao S.S (2015) "Comparative Study on Concentric Steel Braced Frame Structure due to Effect of Aspect Ratio using Pushover Analysis " International Journal of Scientific Research Engineering & Technology (IJSRET), ISSN 2278 – 0882 Volume 4
2. Tremblay R. (2015) "Seismic Response and Design of Steel Building Structures with X-braced Frames of the Conventional Construction Category " 6th International Conference on Advances in Experimental Structural Engineering
3. Khan M.I.& Khan K.N.(2014) "SEISMIC ANALYSIS OF STEEL FRAME WITH BRACINGS USING PUSHOVER ANALYSIS " International Journal of Advanced Technology in Engineering and Science Volume No.02, Issue No. 07
4. Kumawat M.S. ,Kalurkar L.G. (2014) "STATIC &DYNAMIC ANALYSIS OF MULTISTORY BUILDING USING COMPOSITE STRUCTURE" International Journal of Research in Engineering and Technology(IJRET),EISSN: 2319-1163 | PISSN: 2321-7308
5. Omar M.(2014) " Seismic Response of Braced Steel Frames with Shape Memory Alloy and Mega Bracing Systems " World Academy of Science, Engineering and Technology International Journal of Civil, Structural, Construction and Architectural Engineering Vol:8, No:2
6. Jagadish, Tejas D. Doshi(2013) " A Study On Bracing Systems On High Rise Steel Structures " International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue IJERT ISSN: 2278-0181
7. Zhou J. , Bu G.B. & Li K.N. (2012)" Calculation Methods for Inter-Story Drifts of Building Structures "15 WCEE
8. Sangle K.K, Bajoria K.M. & Mhalungkar V. (2012) "SEISMIC ANALYSIS OF HIGH RISE STEEL FRAME WITH OR WITHOUT BRACING " 15 WCEE
9. Tremblay R, Archambault M. H. & Filiatrault A. (2003) "seismic response of concentrically braced steel frame made with rectangular bracing members " JOURNAL OF STRUCTURAL ENGINEERING © ASCE