Analysis of Braced Frame Multistoreyed Structure with Different Angles As Per Indian Standards by using E-Tabs

Maruthi T
Department of Civil Engineering
Jain Institute of Technology, Davangere
Karnataka, India

Ravigouda Patil
Dept. of Civil Engineering
Jain Institute of Technology,
Davangere

Surekha G Patil
Dept. of Civil Engineering
Jain Institute of Technology,
Davangere

Sujatha Lingadahalli
Dept. of Civil Engineering
Jain Institute of Technology,
Davangere

Vinay Kumar S
Dept. of Civil Engineering
Jain Institute of Technology,
Davangere

***Abstract*— The main purpose of this extended three-Dimensional Analysis of Building systems software is to design multi-story building in a systematic process. It caters for multi- storey-building analysis and building design part. It was analyzed with the lateral loading impact earthquake. This project is designed as per Indian Codes IS 1893-Part-2: 2002, IS 456: 2000, IS 875 Part-2, IS 800:2007. In this project from the overall results, we can conclude that the seismic analysis of multistory buildings with considering different bracing such as Inverted V and X bracing analyzed by using ESM. By comparing Inverted V bracing and X bracing to the conventional building it shows that the Lateral displacement, Storey drift and Base shear are minimum in case of X bracing. Hence multistory building with X bracing is safe.**

Keyword—Equivalent staticmethod, ETABS softwar tool, Multi storied residential building, Seismic analysis, Seismic loads

1. INTRODUCTION

Extended three-dimensional analysis in building system (E-Tabs) is a sophisticated yet easy to use, special purpose analysis and design program developed specifically for building system making it the tool choice for the structural engineers in building industry by computers and structures Inc.

E-Tabs features intuitive and powerful, all interface couple with unlimited modelling, analytical and design procedures, all integrated using a common database.

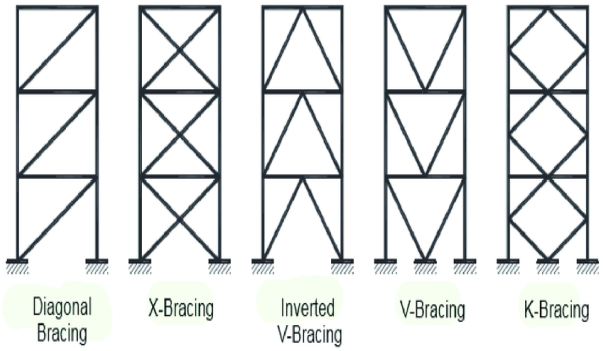


Fig 01:- Types of steel bracing systems

1.1 LOADS TO BE CONSIDERED

1.1.1 Dead load

A dead load is nothing but the self-weight of its structural element. It is mainly considered for its density of materials.

1.1.2 Live load

Live loads are imposed loads that are temporary and of a short duration, are movingloads.

1.1.3 Wind load

The effect of wind load is not considered as the structure satisfies the following requirements as per the national building code of1970.

a. The building or a part of a building of which “h” does not exceed twice theeffective width.

b. A wing of such a building, if it does not project more than twice its own width.

1.1.4 Seismic load

Seismic load is the basic concept of earthquake engineering, which means the application of an earthquake’s generated agitation to a shape.

2. OBJECTIVES OF STUDY

The main objectives of this study aresummarized in few points as follows:

- Modelling the multi storeyed building using E-Tabs software.
- Applying gravity loads combinations as per Indian codal provision
- Analysing of braced frame multi storeyed with
- different angles as per Indian standards for worst case of load combination. -
- To verify maximum lateral displacement, story drift and base shear by using E tabs with IS codal provision.
- Comparison of maximum lateral displacement, storey drift and base shear for gravity loads and seismic loads.

3.MODELING AND ANALYSIS

ETABS is used as the analysis software. ETABS is expanded as extended three dimensional analysis of building systems. All thenecessary tools, like create, modify, analyse and optimize etc., which are required for structural engineers are provided by this software.

3.1 MATERIAL DESCRIPTIONS (STRCTURAL DETAILS)

1. The floor to floor height = 3.5m.
2. The live load = 3 KN/m^2 for all floors.
3. Floor finish load is 1 KN/m^2.
4. Thickness of slab = 0.2 m.
5. Number of floors = 10
6. Column to column distance = 5m.
7. The area of all the buildings = 400 m^2
8. The unit weight of concrete = 25kN/m^3.
9. The compressive strength of concrete = 25 N/mm^2.
10. Characteristic compressive strength of steel = 500 N/mm^2.
11. The modulus of elasticity of concrete 27386.13 MPa.
12. The modulus of elasticity of steel = 2×10^5N/mm^2.
13. The steel bracing used is Composite circular bracing with 100mm diameter.
14. Located in seismic region II sub-soil type 2g(medium).
15. Importance factor = 1

3.2 DIFFERENT TYPES OF MODELS CONSIDERD FOR ANALYSIS

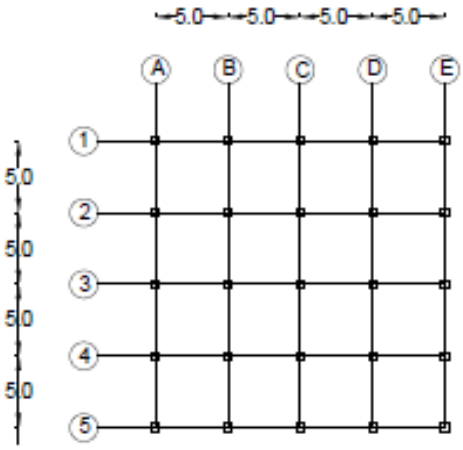
Model 1. Building without bracings.

Model 2. Building with Inverted V- Bracing at various heights.

Model 3. Building with X- Bracing at various heights.

Table 1:- Seismic Loading Zone as per IS-1893

DETAIL	VALUE
R	3
I	1
Z	11
Sa/g	0.88



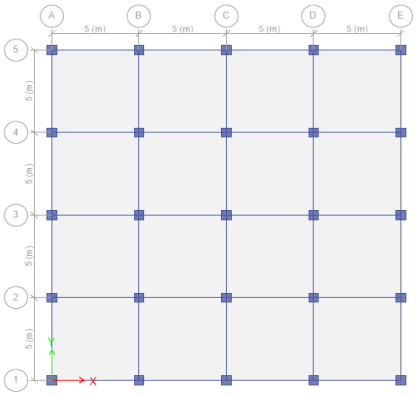


Figure 2 : *Plan* of Structural building

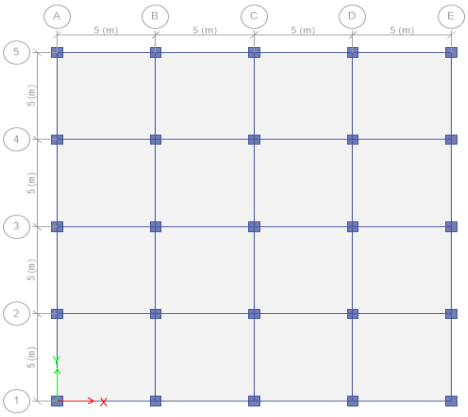


Figure 3 : Center Line Daigram with Load Combinations

3.3 PROCEDURE FOR USING E-TABS

Step 1: Model Initialization
Step 2: Custom grid settings
Step 3: Defining the materials
Step 4: Defining frame properties
Step 5: Defining slab properties
Step 6: Draw beams and column
Step 7: Defining load patterns
Step 8: Assigning shell loads
Step 9: Assigning frame loads
Step 10: Analyse/Check model

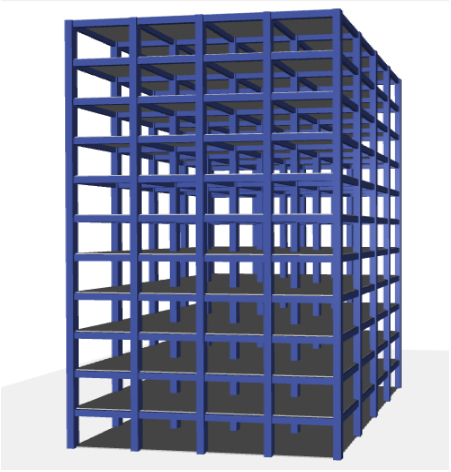


Figure 4: Rendered view of the building.

4. RESULTS AND DISCUSSIONS

4.1.1 LATERAL DISPLACEMENT

The results obtained for the lateral displacement along X and Y directions for the different load combinations with Conventional, Inverted V and X Bracings are expressed in the below table.

Table 2: Lateral displacement in mm of 10 storied building for load combination 1.2 (DL+LL+WX)along X direction.

STOREY	CONVENTIONAL	INVERTED V BRACINGS	X BRACINGS
	X-Dir (mm)	X-Dir (mm)	X-Dir (mm)
10	3.4	3.2	3.2
9	3.3	3.2	3.1
8	3.1	3.1	3
7	2.9	2.8	2.7
6	2.7	2.5	2.5
5	2.3	2.4	2.3
4	2	2	1.9
3	1.5	1.4	1.3
2	1.1	0.8	0.7
1	0.6	0.2	0.1
0	0	0	0

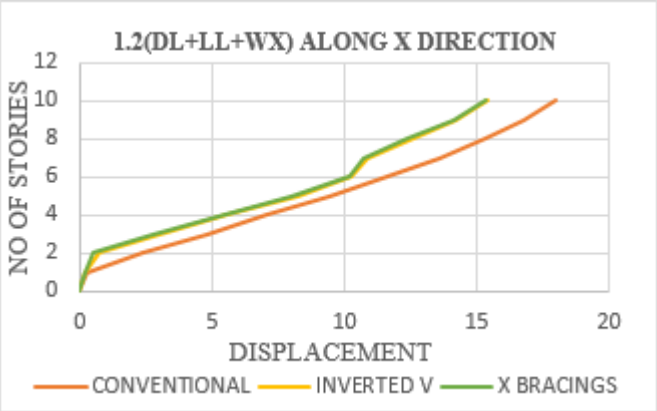


Figure 5: Lateral displacement in mm of 10 storied building for load combination 1.2(DL+LL+WX) along X direction.

Table 2 shows the results of lateral displacement along the X direction for the load combination 1.2 (DL+LL+WX). Fig. 5 shows the lateral displacement along the X-direction with Different bracings such as Conventional, Inverted V and X bracings, In this case, the X-Bracing lateral displacement decreases gradually 58% when compared conventional Bracing & The Inverted V and X bracings from the 10^{th} storey to the ground.

Table 3: Lateral displacement in mm of 10 storied building for load combination 1.2(DL+LL+WY)along Y direction

STOREY	CONVENTIONAL	INVERTED V BRACINGS	X BRACINGS
	Y-Dir (mm)	Y-Dir (mm)	Y-Dir (mm)
10	4.6	2.3	2.1
9	4.5	2.3	2.1
8	4.3	2.1	2.0
7	4.1	2.0	1.8
6	3.7	1.8	1.6
5	3.3	1.7	1.5
4	2.7	1.4	1.3
3	2.1	1.0	0.9
2	1.5	0.6	0.5
1	0.8	0.2	0.1
0	0	0	0

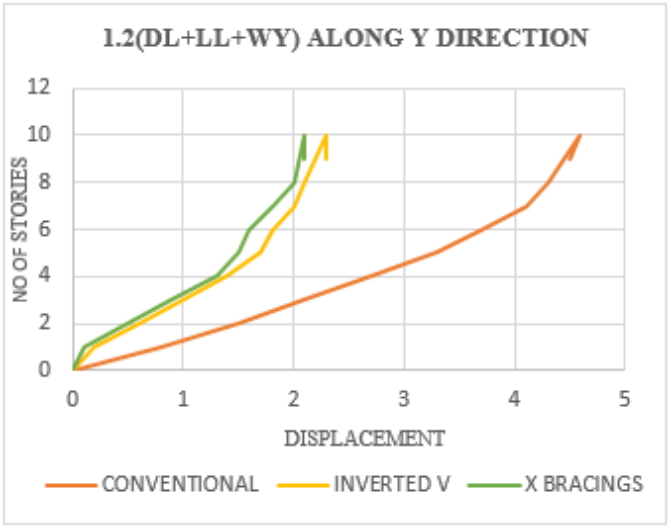


Figure 6: Lateral displacement in mm of 10 storied building for load combination 1.2 (DL+LL+WY) along Y direction.

Table 3 shows the results of lateral displacement along the Y direction for the load combination 1.2 (DL+LL+WY). Fig. 6 shows the lateral displacement along the Y-axis with Different bracings such as Conventional, Inverted V and X bracings, In this case, the displacement decreases gradually 53% and 58% when compared conventional with Inveryed V and X bracings from the 10^{th} storey to the ground.

Table 4: Lateral displacement in mm of 10 storied building for load combination 1.5(DL+WX)along X direction

STOREY	CONVENTIONAL	INVERTED V BRACINGS	X BRACINGS
	X-Dir (mm)	X-Dir (mm)	X-Dir (mm)
10	4.1	4.0	3.9
9	3.9	3.8	3.7
8	3.7	3.5	3.4
7	3.3	3.1	3.1
6	2.9	3	2.9
5	2.5	2.5	2.4
4	1.9	1.8	1.7
3	1.3	1.0	0.9
2	0.7	0.2	0.2
1	0.1	0.1	0.1
0	0	0	0

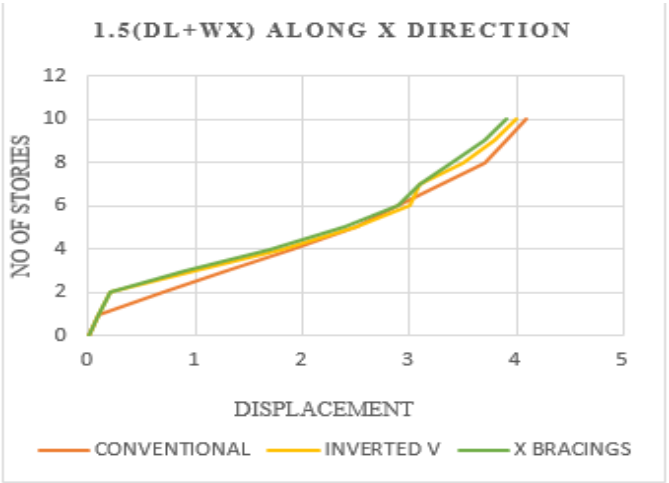


Figure 7: Lateral displacement in mm of 10 storied building for load combination 1.5 (DL+ WX)along X direction.

Table 4 shows the results of lateral displacement along the X direction for the load combination 1.5 (DL+LL+WX). Fig. 5 shows the lateral displacement along the X-axis with different bracings such as conventional, Inverted V and X bracings, In this case, the displacement decreases gradually 58% when compared conventional with Inverted V and X bracings from the 10th storey to the ground.

Table 5: Lateral displacement in mm of 10 storied building for load combination 1.5 (DL+WY) along Y direction.

STOREY	CONVENTIONAL	INVERTED V BRACINGS	X BRACINGS
	Y-Dir (mm)	Y-Dir (mm)	Y-Dir (mm)
10	5.7	4.2	3.9
9	5.4	4.0	3.7
8	5.1	3.6	3.4
7	4.6	3.2	3.1
6	4.1	3.1	3.0
5	3.4	2.5	2.5
4	2.7	1.8	1.7
3	1.8	1.0	0.9
2	0.9	0.2	0.2
1	0.1	0.1	0.1
0	0	0	0

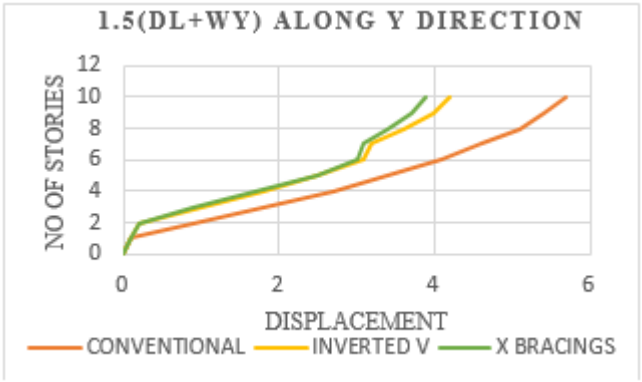


Figure 8: Lateral displacement in mm of 10 storied building for load combination 1.5 (DL+ WY)along Y direction.

Table 6 shows the results of lateral displacement along the X direction for the load combination 1.5 (DL+EQY). Fig. 8 shows the lateral displacement along the X-axis with different bracings such as conventional, Inverted V and X bracings, In this case, the displacement decreases 26.31% and 28.31% gradually when compared conventional with Inverted V and X bracings from the 10th srorey to the ground

5.1.2 STOREY DRIFT

The storey drift obtained from theanalysis of the 9-storey interlaced building is systematized in the below table. These values are represented with the help of a gap along with the X and Y directions separately.

Table 6: Storey drift of 10 storied building for load combination 1.2 (DL+LL+EQX) along Xdirection.

STOREY	CONVENTIONAL	INVERTED V	X BRACINGS
	X-Dir (mm)	X-Dir (mm)	X-Dir (mm)
10	0.000321	0.000343	0.000349
9	0.000431	0.000476	0.000485
8	0.000513	0.000484	0.00048
7	0.000576	0.000177	0.000178
6	0.000623	0.000611	0.00061
5	0.000657	0.000734	0.000747
4	0.000678	0.000755	0.000768
3	0.000683	0.00066	0.000662
2	0.000609	0.000143	0.000098
1	0.00019	0.000125	0.000119
0	0	0	0

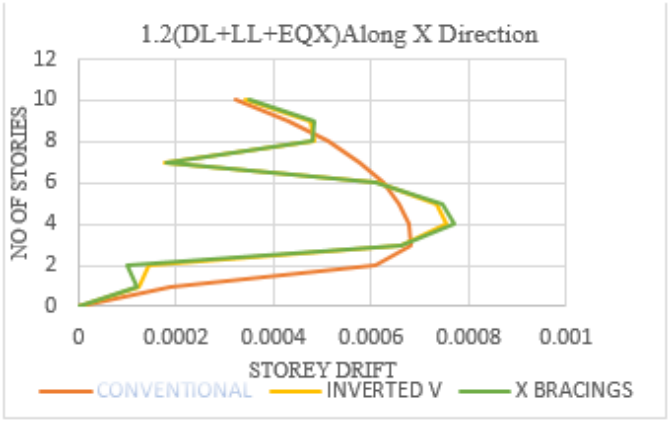


Figure 9: Storey drift of 10 storied building for load combination 1.2 (DL+LL+EQX) along X direction.

Table 6 shows the results of storey drift along the X direction for the load combination 1.2 (DL+LL+EQX). Fig. 9 shows the lateral displacement along the X-axis with different bracings such as conventional, Inverted V and X bracings, In this Storey drift is maximum the 6th storey 4th storey drift is minimum at that floor.

Table 7: Storey drift of 10 storied building for load combination 1.2 (DL+LL+EQY) along Ydirection.

STOREY	CONVENTIONAL	INVERTED V BRACINGS	X BRACINGS
	Y-Dir (mm)	Y-Dir (mm)	Y-Dir (mm)
10	0.000323	0.000338	0.000343
9	0.000425	0.00047	0.000478
8	0.000507	0.000479	0.000483
7	0.00057	0.000175	0.000228
6	0.000618	0.000606	0.00061
5	0.000651	0.000728	0.000778
4	0.000672	0.00075	0.00076
3	0.000678	0.000655	0.000655
2	0.000605	0.000142	0.000095
1	0.000189	0.000123	0.000117
0	0	0	0

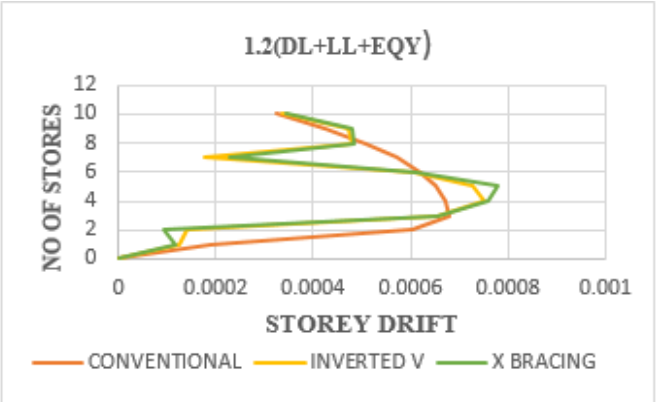


Figure 10: Storey drift of 10 storied building for load combination 1.2 (DL+LL+EQY) along Y direction.

Table 6 shows the results of storey drift along the X direction for the load combination 1.2 (DL+LL+EQY). Fig. 9 shows the lateral displacement along the X-axis with different bracings such as conventional, Inverted V and X bracings, In this Storey drift is maximum the 5th storey In 9th storey drift is minimum at that floor.

Table 8: Storey drift of 10 storied building for load combination 1.5 (DL+EQX) along X direction.

STOTREY	CONVENTIONAL	INVERTED V BRACINGS	X BRACINGS
	Y-Dir (mm)	Y-Dir (mm)	Y-Dir (mm)
10	0.000404	0.000423	0.000428
9	0.000531	0.000588	0.000598
8	0.000633	0.000598	0.000603
7	0.000713	0.000290	0.000278
6	0.000772	0.000757	0.000762
5	0.000814	0.000911	0.000923
4	0.00084	0.000938	0.00095
3	0.000848	0.000819	0.000818
2	0.000756	0.000177	0.000118
1	0.000236	0.000154	0.000146
0	0	0	0

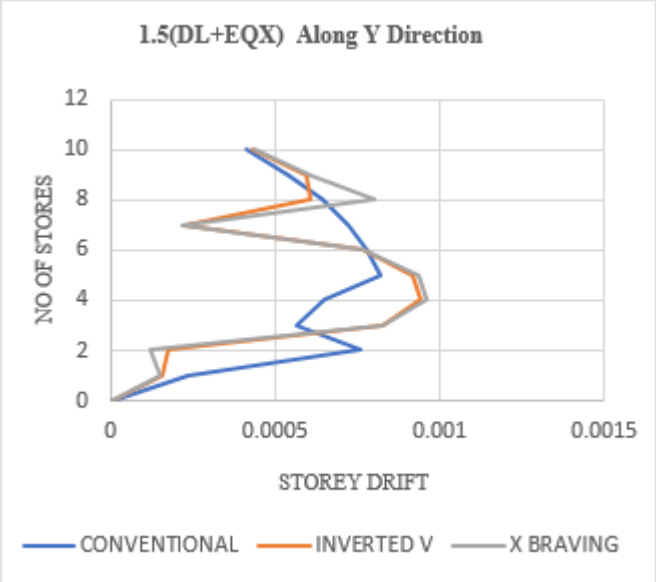


Figure 11: Storey drift of 10 storied building for load combination 1.5 (DL+EQX) along Xdirection.

Table 7 shows the results of storey drift along the X direction for the load combination 1.2 (DL+EQX). Fig. 9 shows the lateral displacement along the X-axis with different bracings such as conventional, Inverted V and X bracings, In this Storey drift is maximumat the 4th storey In 9th storey drift is minimum at that floor.

Table 9: Storey drift of 10 storied building for load combination 1.5 (DL+EQY) along Y direction.

STOTREY	CONVENTIONAL	INVERTED V BRACINGS	X BRACINGS
	Y-Dir (mm)	Y-Dir (mm)	Y-Dir (mm)
10	0.000404	0.000423	0.000428
9	0.000531	0.000588	0.000598
8	0.000633	0.000598	0.000603
7	0.000713	0.000290	0.000278
6	0.000772	0.000757	0.000762
5	0.000814	0.000911	0.000923
4	0.00084	0.000938	0.00095
3	0.000848	0.000819	0.000818
2	0.000756	0.000177	0.000118
1	0.000236	0.000154	0.000146
0	0	0	0

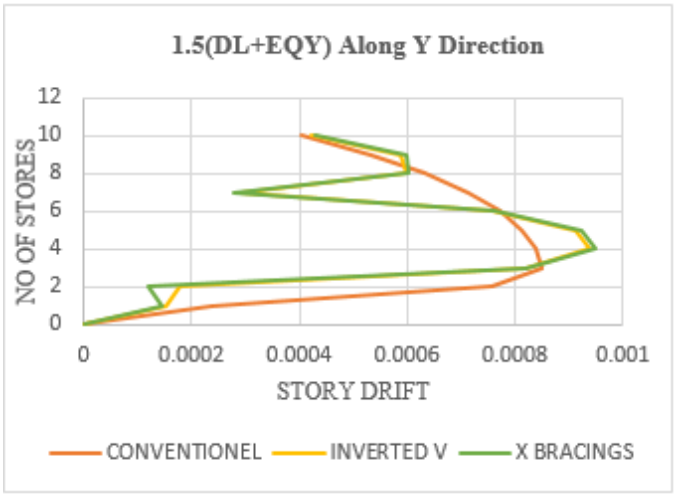


Figure 12: Storey drift of 10 storied building for load combination 1.5 (DL+EQY) along Y direction.

Table 8 shows the results of storey drift along the X direction for the load combination 1.2 (DL+EQX). Fig. 9 shows the lateral displacement along the X-axis with different bracings such as conventional, Inverted V and X bracings, In this Storey drift is maximumum the 4th storey In 9th storey drift is minimum at that floor.

I. BASE SHEAR

The base shear is obtained from theequivalent static method below. The following tables show the base shear for the load combinations 1.2 (DL + LL + EQX), 1.2 (DL + LL+ EQX) and 1.5 (DL + EQX), 1.5 (DL + EQY).

Table 10: Base shear for load combination 1.2 (DL+LL+EQX) and 1.2 (DL+LL+EQY) for Conventional, Inverted V and X Bracing

MODELS	FZ (kN)	MX (kN-m)	MY (kN-m)
CONVENTIONAL	48811.59	386123.5	-229597
	48811.59	392017	-224784
INVERTED V	41946.82	332438.9	-197318
	41946.82	337153.7	-193467
X BRACINGS	41946.82	332438.9	-202708
	41946.82	343754.4	-193467

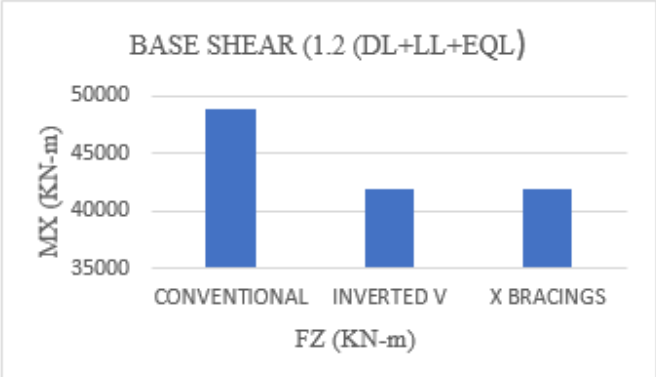


Figure 13: Base shear of 10 storied building for load combination 1.5 (DL+LL+EQL)

Table 11: Base shear for load combination 1.5 (DL+EQX) and 1.5 (DL+EQY) for Conventional, Inverted V and X Bracing

MODELS	FZ (kN)	MX (kN-m)	MY (kN-m)
CONVENTIONAL	48811.59	386123.5	-229597
	48811.59	392017	-224784
INVERTED V	41946.82	332438.9	-197318
	41946.82	337153.7	-193467
X BRACINGS	41946.82	332438.9	-202708
	41946.82	343754.4	-193467

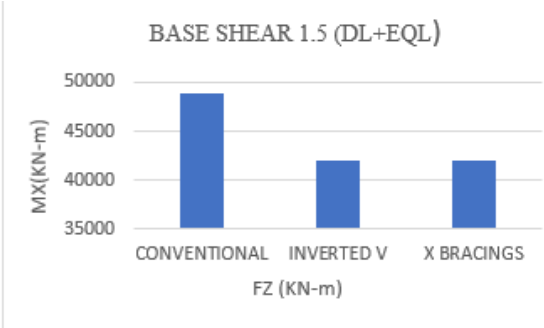


Figure 14: Base shear of 10 storied building for load combination 1.5 (DL+EQL)

CONCLUSION

From this study learnt about the analysis by Equivalent Static Method (ESM) the variation of lateral displacement, storey drift, and base shear in different bracings such as Conventional, Inverted V and X Bracings along X and Y directions. This present study is concluded with the following conclusions.

- In ESM for the load combinations 1.2 (DL+LL+WL) and 1.5 (DL+LL+WL) and the variation of lateral displacement is compared with inverted V Bracing & X Bracing along both Xand Y directions in which X Bracing shows less displacement then that of both conventional and inverted V Bracings.
- In ESM for the load combinations 1.2 (DL+LL+EQL) and 1.5 (DL+EQL) and the variation of lateral displacement is compared with inverted V Bracing & X Bracing along both X and Y directions in which X Bracing shows less displacement then that of both conventional and inverted V Bracings.
- In ESM for the load combination of 1.2 (DL+LL+WL) and 1.5 (DL+LL+WL) the variation of story drift compared with both inverted V bracing and X bracing along X and Y direction. The storey drift is maximum in 3rd ,5th & 9th stories compared to the other storeys.
- In ESM for the load combination of 1.2 (DL+LL+EQL) and 1.5 (DL+EQL) the variation of storey drift compared with both inverted V bracing and X bracing along X and Y direction. The storey drift is maximum in 3rd ,5th & 9th stories compared to the other stores.
- In ESM for the load combination of 1.2 (DL+LL+WL) and 1.5 (DL+LL+WL). the variation of base shear as compared with both inverted V bracing and X bracing both X&Y direction the base shear is more in case of X bracing.
- In ESM for the load combination of 1.2 (DL+LL+EQL) and 1.5 (DL+EQL). the variation of base shear as compared with both inverted V bracing and X bracing both X&Y direction the base shear is more in case of X bracing.
- In ESM for both the load combinations of 1.5 (DL+EQL) and 1.5 (DL+LL+WL). In which the base reaction is maximum at column number B6, because it carries maximum surrounding slab area around the column. There for B6 column is considered for the design of the footings.
- From the overall results, conclude that the seismic analysis of multistory buildings with considering different bracing such as Inverted V and X bracing using ESM. By comparing Inverted V bracing and X bracing to the conventional building it shows the lateral displacement storey drift and base shear are minimum in case of X bracing hence multistory building with X bracing is safe.

REFERENCES

[1] Bhavik R Suthar, Dr. Indrajit N. Patel "Study of G + 20 Storey RC Framed Structure with Structural Steel Braces (02 JULY 2021)"
[2] Manoj Kumar M, Victor Samson Raj A "Inelastic Behaviour of Braced Steel Framed Structure by Pushover Analysis" (01 MAY 2020)
[3] S.M. Razak, T.C. Kong "A Review of Influence of Various Types of Structural Bracing to the Structural Performance of Buildings" (JAN 26 2019)
[4] Harshith M K 1, Vasudev M V "Analysis of RC Framed Structure with Structural steel Braces Using E-tabs" (JAN - 2018)
[5] Safvana P and Anila S "Seismic Analysis of Braced Steel and Composite Structures Using E-Tabs
[6] Maruthi T, Pruthviraj S R, Raghavendra S, Ravi Kumar C M (2020). Usage of Poly- Propylene Fiber to enhance the Compressive Strength of Conventional and Partially Replaced Fly Ash Concrete, *Journal of Construction and Building Materials Engineering*, 6(3), Available at: http://matjournals.in/index.ticle/view/5908.
[7] Pruthvi Raj SR, Raghavendra S, Maruthi T (2019). Performance Tests on Waste CrumbRubber and Bitumen Used in Bitumen Mix for the Application of Flexible Pavement, *International Research Journal of Engineering and Technology*, 6(12),Available
[8] Pruthvi Raj SR, Raghavendra S, Maruthi T (2020). Stability Analysis of Rubber Bituminous Mix, *Journal of Recent Activities in Infrastructure Science*, 5(1), Available at: https://zenodo.org/record/3630201#.YmfibtpBzIU
[9] Maruthi T, Pruthviraj S R, Raghavendra S, Ravi Kumar C M (2020). Usage of Poly- Propylene Fiber to enhance the Compressive Strength of Conventional and Partially Replaced Fly Ash Concrete, *Journal of Construction and Building Materials Engineering*, 6(3), Available at: http://matjournals.in/index.php/JOCBME/article/view/5908
[10] Ravi Kumar C M, Pruthvi Raj S R and Maruthi T (2020). Case Study on Preparation and Constructional Procedure of Reinforced Earthen Wall, *Journal of Environmental Engineering and Studies*, 5(2), Available at: http://matjournals.in/index.php/JoEES/article/view/5694
[11] Yagnodbhavi H. M, Pruthvi Raj SR andMaruthi T (2020). Mix Design of M-30 Grade Concrete for Rural Roads as per IRC44-2017, Journal of Recent Activities
[12] Bhavik R Suthar, Dr. Indrajit N. Patel "Study of G + 20 Storey RC Framed Structure with Structural Steel Braces (02 JULY 2021)"
[13] Manoj Kumar M, Victor Samson Raj A "Inelastic Behaviour of Braced Steel Framed Structure by Pushover Analysis" (01 MAY 2020)
[14] S.M. Razak, T.C. Kong "A Review of Influence of Various Types of Structural Bracing to the Structural Performance of Buildings" (JAN 26 2019)
[15] Harshith M K 1, Vasudev M V "Analysis of RC Framed Structure with Structural steel Braces Using E-tabs" (JAN - 2018).