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A Stability Check of Outrigger Structural System with Different Aspect Ratio in Seismic Zone III

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ABSTRACT

In recent time Reinforced concrete framed structures have gained lots of attention especially in urban areas of metropolitan. Lots of research work is going on in the analysis and safe design of RCC Multi-storey frames. In the view of enhancement of stability of a structure the introduction of outriggers & belt truss system has been done in the buildings. Response of high-rise buildings are quite different then multi-storied buildings because high rise building suffers lots of lateral drift or lateral displacement and their lateral stability is a great concern in seismic and wind design keeping in view the lateral stability of high-rise building. In this Study total Six models of RC structural frames with different configuration in STAAD.PRO have been made, such that Case1 having G+9 RCC frame with V-Belt truss at 4 & 8 Storey, Case 2 having G+9 RCC frame with X-belt truss at 4 & 8 Storey, Case 3 having G+14RCC frame with V-belt truss at 4,8 & 12 Storey, Case 4 having G+14 RCC frame having X-belt truss at 4,8 & 12 Storey, Case 5 having G+19 RCC frame having V-belt truss at 4,8,12 & 16 Storey &Case 6 having G+19 RCC frame having X-belt truss at 4,8,12 & 16 Storey.

Keywords: R.C structural frames, Base Shear, lateral displacement, Shear force, Belt trusses.

INTRODUCTION

We are living in that world where the voracity for taller structure will be increasing day by day. Although the requirement of high-rise building is in demand but the structural safety is always a matter of concern because we would not take risk with human life. As the structural safety is primary concern but the frugality of project is also important so we must have to maintain the poise in economy of project along with structural safety. So for making our structure safer, various structural arrangement have been developed with the increasing demand and necessity some of them are shear wall, bracing etc. One of these safety arrangements is made possible by shear wall belt system sometimes also known as Belt Supported System is a part of Outrigger System of stability.

Outrigger Belt System: -

Generally, when we talk about as Outrigger Wall Supported System it simply means an additional framework provided in the multistory building to resist lateral loading. Structurally the Outrigger Wall Supported System is provided in such a way so that the horizontal loading is resisted by lateral members connected between inner structural core and the peripheral columns. Providing structural safety through these connections lateral stiffness of the system will be increased by increasing the moment arm of the inner core structure. As per analysis done by a researcher, the Outrigger system is found significant for tall skyscrapers or multistory building equal to or more than 60 stories.

METHODOLOGY

The modeling part consist of modeling of RCC framed building on Staad.pro software. The total six models are analyzed on the staad.pro. The model 1 having G+9 storey building with V- Shaped concrete truss belt system at 4th &8th storey and from model 2 to 6 are modeled with Truss belt system having different shapes at different storey levels with variation in aspect ratios of the building respectively. The model description is tabulated on table no. 1 are as follows:

Table 1: Model Description

S. No.	Models	Descriptions
1.	**Model 1**	Building with V-shaped concrete truss belts system at 4th & 8th storey.
2.	**Model 2**	Building with X-shaped concrete truss belts system at 4th & 8th storey.
3.	**Model 3**	Building with V-shaped concrete truss belts system at 4th, 8th & 12th storey.
4.	**Model 4**	Building with X-shaped concrete truss belts system at 4th, 8th & 12th storey.
5.	**Model 5**	Building with V-shaped concrete truss belts system at 4th, 8th, 12th & 16th storey.
6	**Model 6**	Building with X-shaped concrete truss belts system at 4th, 8th, 12th & 16th storey.

MODELING AND ANALYSIS

RCC framed building with different truss system is taken into account for the analysis. Six various types of building models with bay width of 5m in X-direction, 5m in Z-direction and storey height of 3.5 m were taken into consideration for this analysis. The structure was modeled using STAAD.PRO V8i computer software. All the selected models were designed with M-30 grade of concrete being used and Fe-500 grade of reinforcing steel as per IS code of practice. The concrete truss belt to be taken as V-shaped & X-shaped with different groups 2, 3 & 4 in a different building respectively. The truss belt being provided at 4, 8, 12 & 16 storey in the building. These Six model are modeled in Staad.pro software by taking truss belt system at different location in X & Z direction respectively. The plan, elevation & 3DView are as follows from Fig1toFig 8.

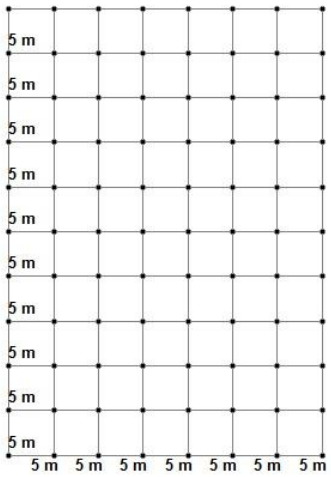


Fig. 1: Grid Plan View

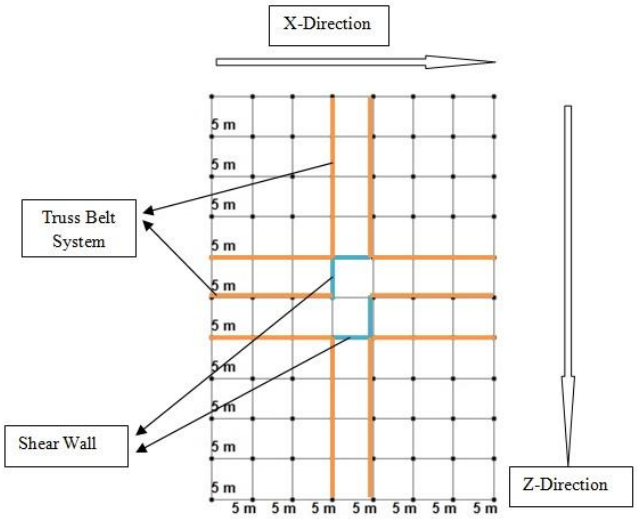
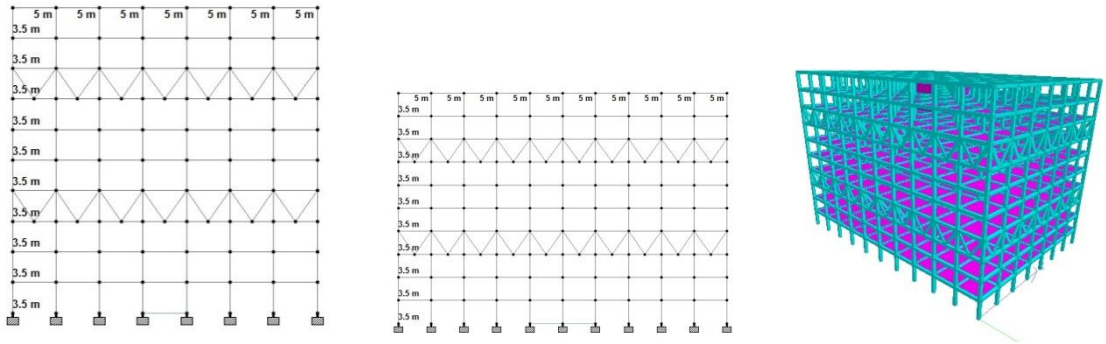


Fig. 2: Plan view with position of concrete truss belt and shear wall

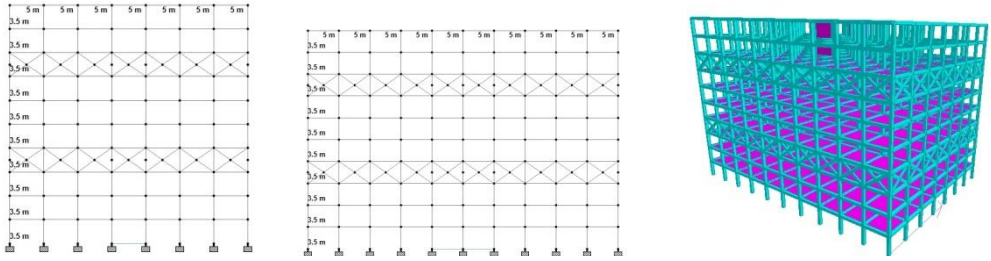
Model 1: G+9 storey building with V- Shaped concrete truss belt system at 4th &8th storey.



a) Elevation @ X direction **b) Elevation @ Z direction** **c) 3D view**

Fig. 3: Model 1- G+14 Storey Building with Square geometrical plan

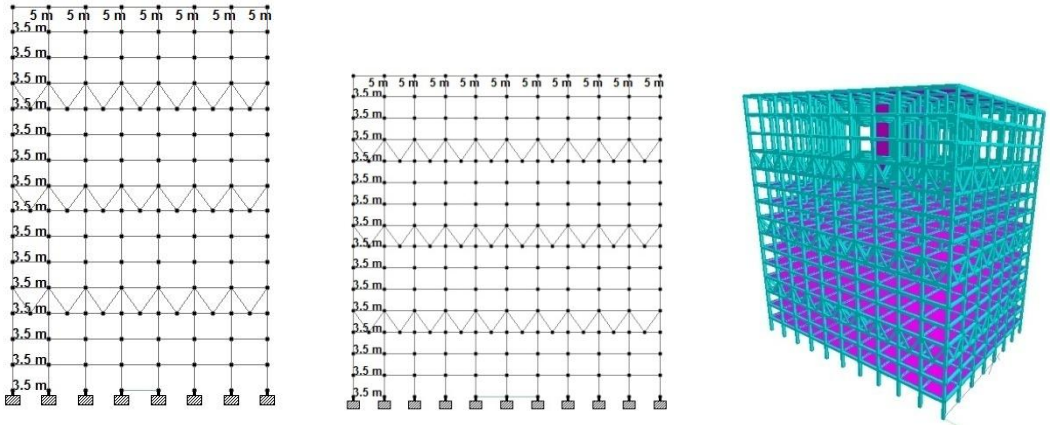
Model 2: G+9 storey building with X- Shaped concrete truss belt system at 4th & 8th storey.



a) Elevation@ X direction **b) Elevation@ Z direction** **c) 3D view**

Fig.4: Model 2- G+9 storey building with X- Shaped concrete truss belt system at 4th & 8th storey.

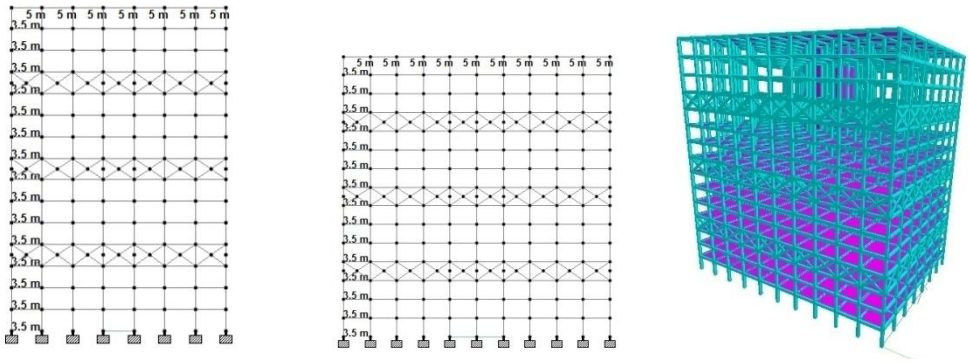
Model 3: G+14 storey building with V- Shaped concrete truss belt system at 4th, 8th& 12th storey.



a) Elevation@ X direction **b) Elevation@ Z direction** **c) 3D view**

Fig. 5: Model3: G+14 storey building with V- Shaped concrete truss belt system at 4th, 8th& 12th storey.

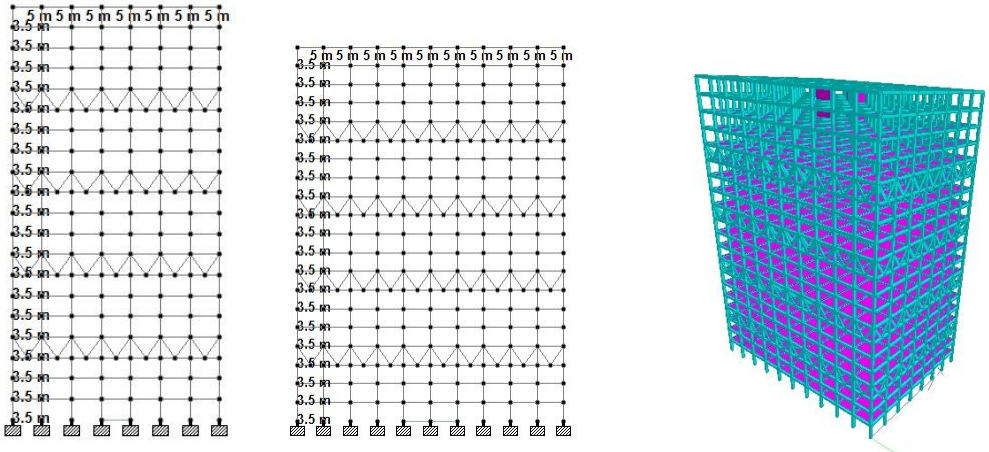
Model 4:G+14 storey building with X-Shaped concrete truss belt system at 4th, 8th& 12th storey.



Elevation @ X direction **b) Elevation@ Z direction** **c) 3D view**

Fig. 6: Model4- G+14 storey building with X-Shaped concrete truss belt system at 4th, 8th& 12th storey.

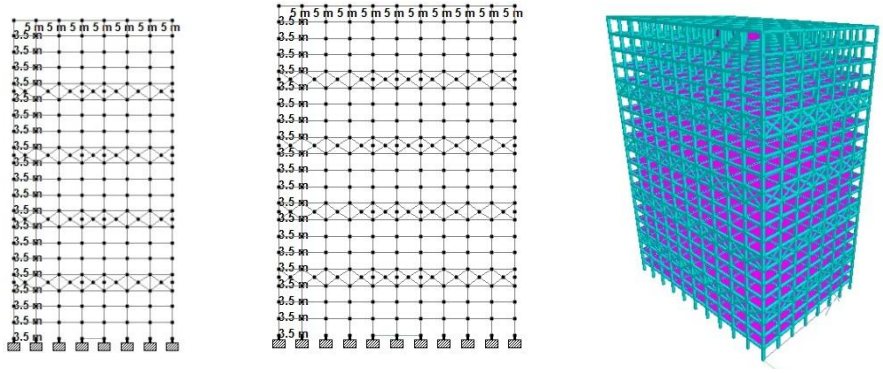
Model 5: G+19 storey building with V-Shaped concrete truss belt system at 4th, 8th,12th & 16th storey.



a) Elevation @ X direction **b) Elevation @ Z direction** **c) 3D view**

Fig. 7: Model 5- G+19 storey building with V-Shaped concrete truss belt system at 4th, 8th,12th & 16th storey.

Model 6: G+19 storey building with X-Shaped concrete truss belt system at 4th, 8th,12th & 16th storey.



a) Elevation @ X direction b) Elevation @ Z direction **c) 3D view**

Fig. 8: Model 6- G+19 storey building with X-Shaped concrete truss belt system at 4th, 8th,12th & 16th storey.

Material & Geometrical properties

Table 2:Material properties of elements of Structural

Descriptions of Elements used	**Material Grade**
Column	M-30
Beam	M-30
Equivalent shear wall	M-30
Slab Thickness	M-30
Reinforcement	HYSD-500

Table 3 Structural elements Details of Building.

Particulars	Details
Plinth Area (m^2)	1750 m^2
No. of bay in X- direction	7 no. @ 5m c/c
No. of bay in Z- direction	10 no. @ 5m c/c
Storey height	3.5 m each
Beam Size n X direction	500 mm x 450 mm
Beam Size n Z direction	450 mm x 500 mm
Column Size	450 mm x 500 mm
Slab Thickness	180 mm
shear wall Thickness	180 mm
Concrete truss belt bracing size	230 mm x 450 mm

Earthquake Data

Table 4:Earthquake Data

Earthquake Zone	III
Importance Factor	1
Types of Soil	Medium Soil
Response Reduction Factor	4
Time period both X & Z Direction	1.53533
Damping	0.05
Method of Analysis	Response Spectrum Analysis

CONCLUSION

The results are evaluated based on modeling and analysis of the RCC Building frames having Six different models. The model 1 to model 6 is based on different concrete truss belt system located at different storey in RCC building.

Maximum Storey Displacement: - The maximum displacement value will be taken for all 6 models which is obtained on the top storey of each model. Table 5tabulated the results of maximum storey displacements. The fig. 9 shows the bar chart representation of maximum displacement of all models.

Table 5 Maximum Storey Displacement Results

Maximum Storey Displacement (mm)			
S.No.	**Models**	**X - Direction**	**Z -Direction**
1	**Model 1**	32.635	32.104
2	**Model 2**	31.715	30.106
3	**Model 3**	62.414	60.858
4	**Model 4**	58.366	57.563
5	**Model 5**	101.515	96.114
6	**Model 6**	95.256	91.123

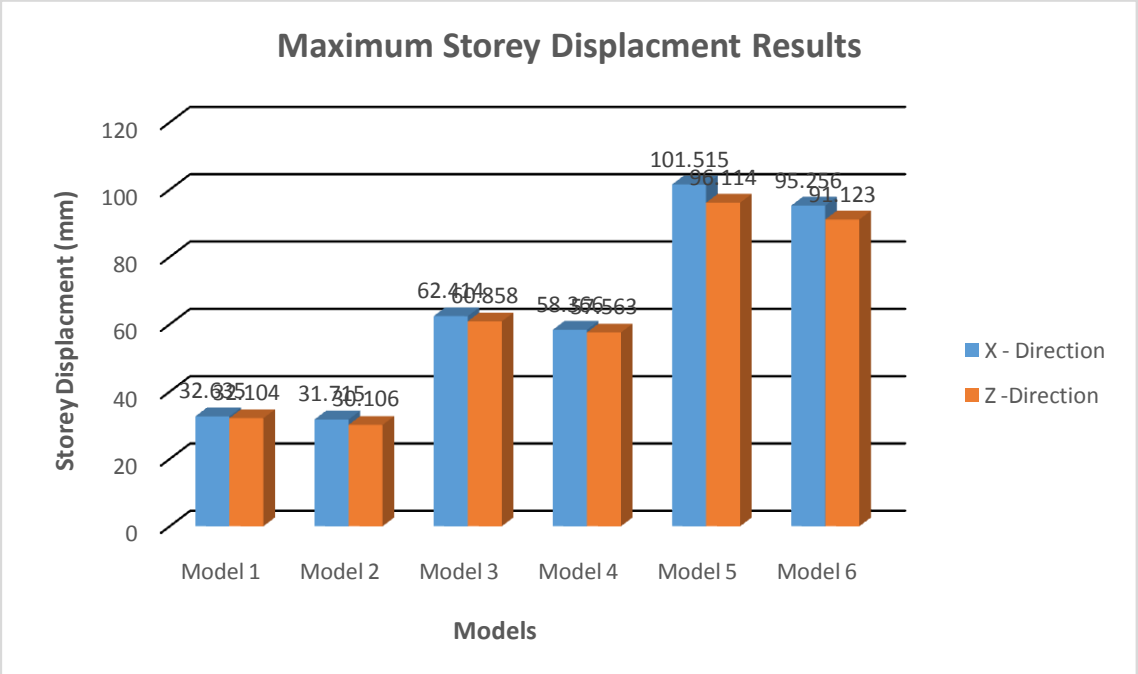


Fig. 9: Bar chart Representations of Max. Storey Displacement Results

Maximum Shear Force in Building: The Maximum Shear Force in Building value will be taken for all 6 models, one by one for each model. Table 6 tabulated the results of Maximum Shear Force in Building. The fig. 10 shows the bar chart representation of Maximum Shear Force in Building of all models.

Table 6 Maximum Shear Force in Building

Maximum Shear Force in Building (KN)			
S. No.	**Model Description**	**X-Direction**	**Z-Direction**
1	**Model 1**	267.581	113.646
2	**Model 2**	169.355	104.242
3	**Model 3**	370.234	160.144
4	**Model 4**	195.16	147.49
5	**Model 5**	471.956	197.204
6	**Model 6**	219.334	179.931

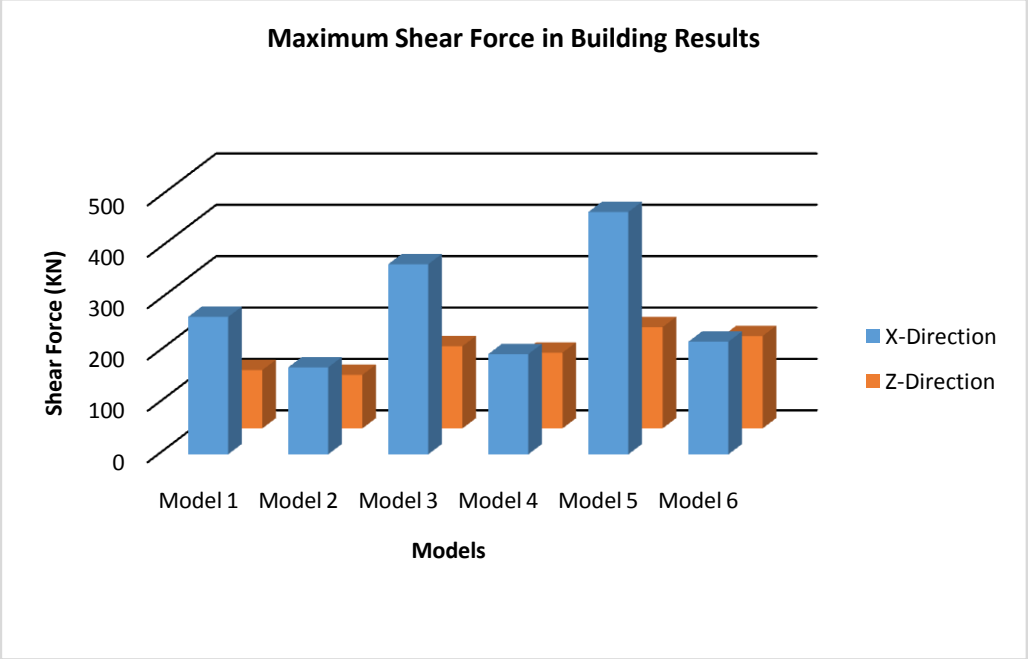


Fig. 10: Bar chart Representation of Maximum Shear Force in Building

Maximum Bending Moment in Building: The Maximum Bending Moment in Building value will be taken for all 6 models, one by one for each model. Table 7 tabulated the results of Maximum Bending Moment in Building. The fig. 11 shows the bar chart representation of Maximum Bending Moment in Building of all models.

Table 7: Maximum Bending Moment in Building

Maximum Bending Moment in Building(KN)			
S.No.	**Model Description**	**X-Direction**	**Z-Direction**
1	**Model 1**	200.67	362.469
2	**Model 2**	195.143	269.613
3	**Model 3**	285.329	510.459
4	**Model 4**	264.696	340.714
5	**Model 5**	359.616	646.594
6	**Model 6**	321.496	406.723

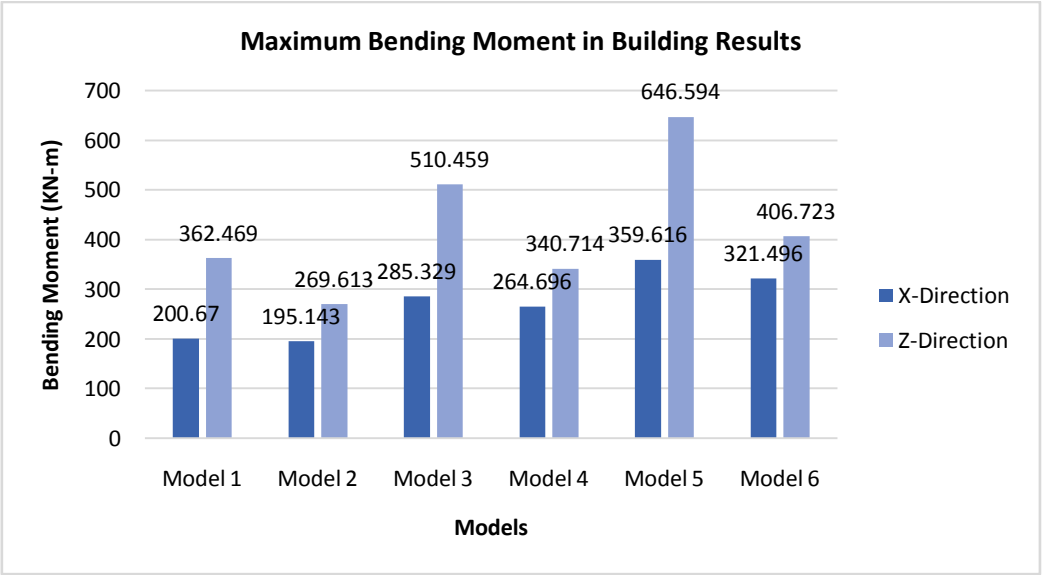


Fig. 11: Bar chart Representations of Maximum Bending Moment in Building

Column Axial Force Results

Table 8:Column Axial Force Results

Column Axial Force (KN)		
S. No.	**Model Description**	**Axial Force(KN)**
1	**Model 1**	7311.887
2	**Model 2**	7254.966
3	**Model 3**	10452.669
4	**Model 4**	10339.074
5	**Model 5**	13361.163
6	**Model 6**	13196.383

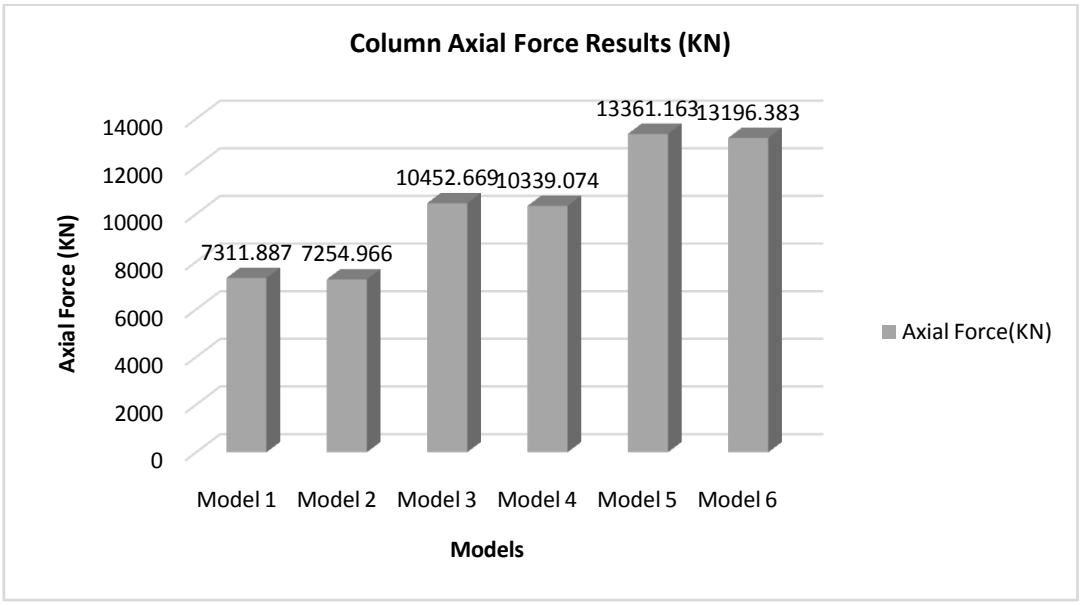


Fig. 12 Bar chart Representations of Column Axial Force

Base Shear Result

Table 9:Base Shear Results

Base Shear Result (KN)			
S.No.	**Model Description**	**X-Direction**	**Z-Direction**
1	**Model 1**	14246.69	12125.68
2	**Model 2**	14295.87	12369.97
3	**Model 3**	14009.19	12129.91
4	**Model 4**	14233.58	12454.06
5	**Model 5**	13425.8	11663.16
6	**Model 6**	13681.83	11993.91

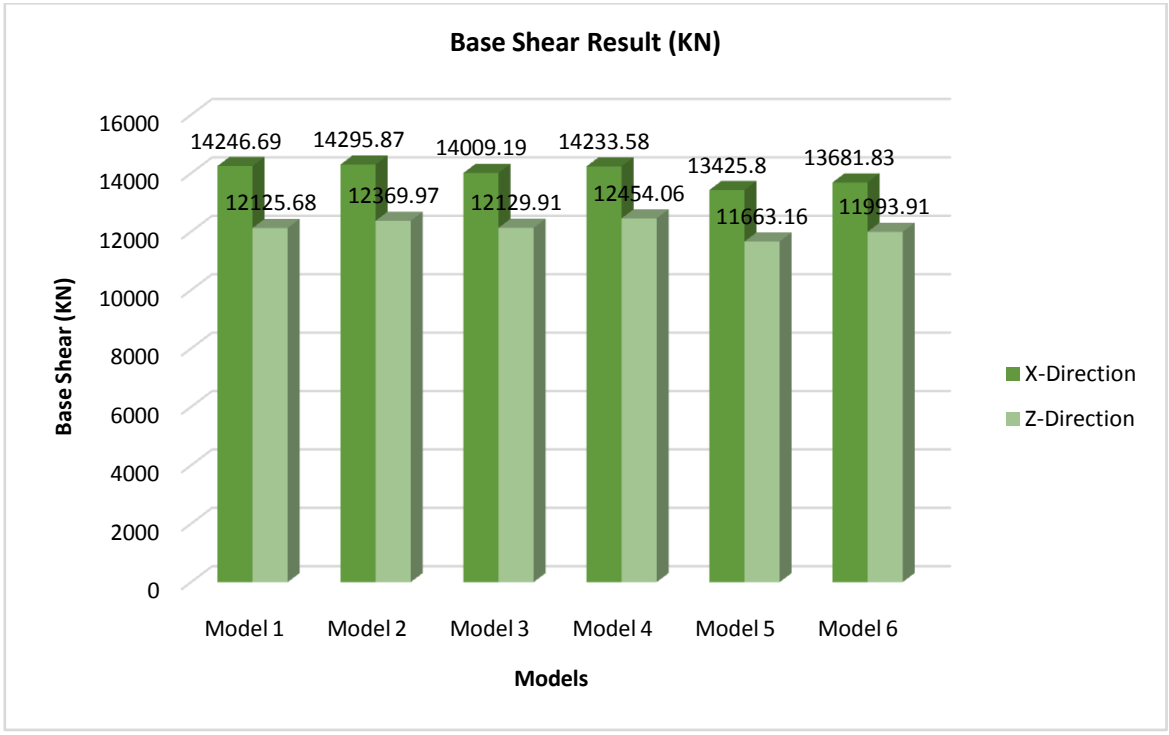


Fig. 13 Bar chart Representations of Base Shear Results

Maximum Beam Torsion

Table 10: Maximum Beam Torsion Results

Maximum Beam Torsion (KN)		
S. No.	**Model Description**	**Torsion (KN)**
1	**Model 1**	9.759
2	**Model 2**	10.154
3	**Model 3**	14.096
4	**Model 4**	12.771
5	**Model 5**	20.064
6	**Model 6**	13.91

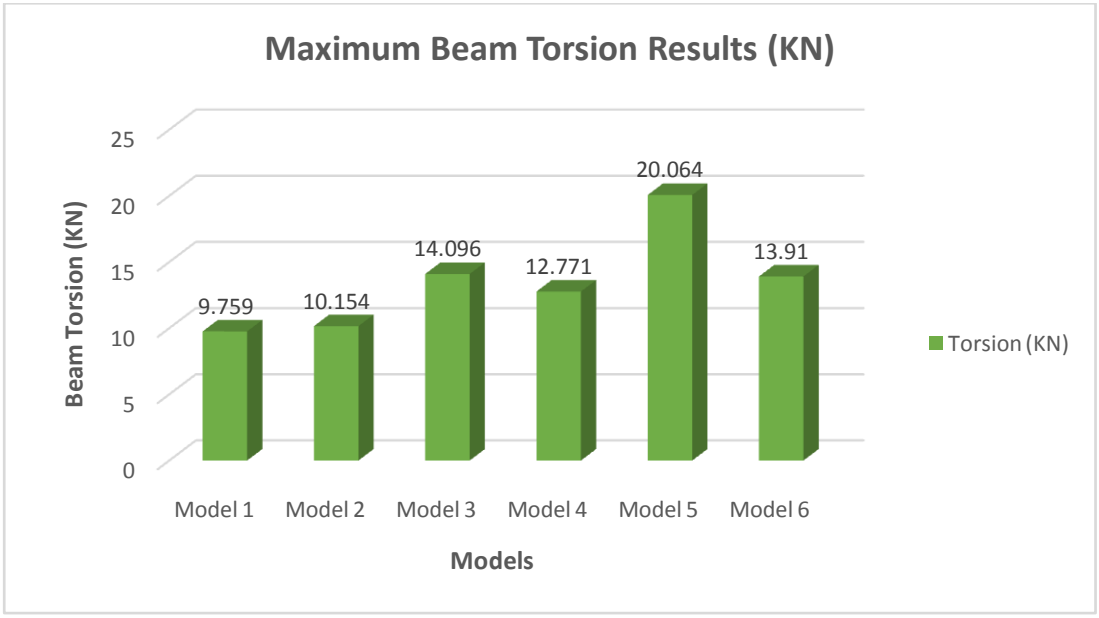


Fig. 14:Bar chart Representations of Maximum Beam Torsion

Maximum Stresses developed

Three types of stresses are be considered in this project. The stresses are VON MIS TOP, TRESCA TOP and Max. TOP, the obtained results are tabulated by table 11 and bar chart plot are shown on fig. 15.

Table 11 Maximum Stresses developed Results

Maximum Stresses developed (N/mm2)				
S. No.	**Models**	**VON MIS TOP (N/mm2)**	**TRESCA TOP (N/mm2)**	**Max. Absolute (N/mm2)**
1	**Model 1**	18.1935	19.3389	6.95771
2	**Model 2**	18.2378	19.3665	7.0756
3	**Model 3**	27.6828	30.0404	6.97411
4	**Model 4**	28.0393	30.2969	7.126
5	**Model 5**	37.8438	41.3578	6.70164
6	**Model 6**	38.3965	41.7717	6.86038

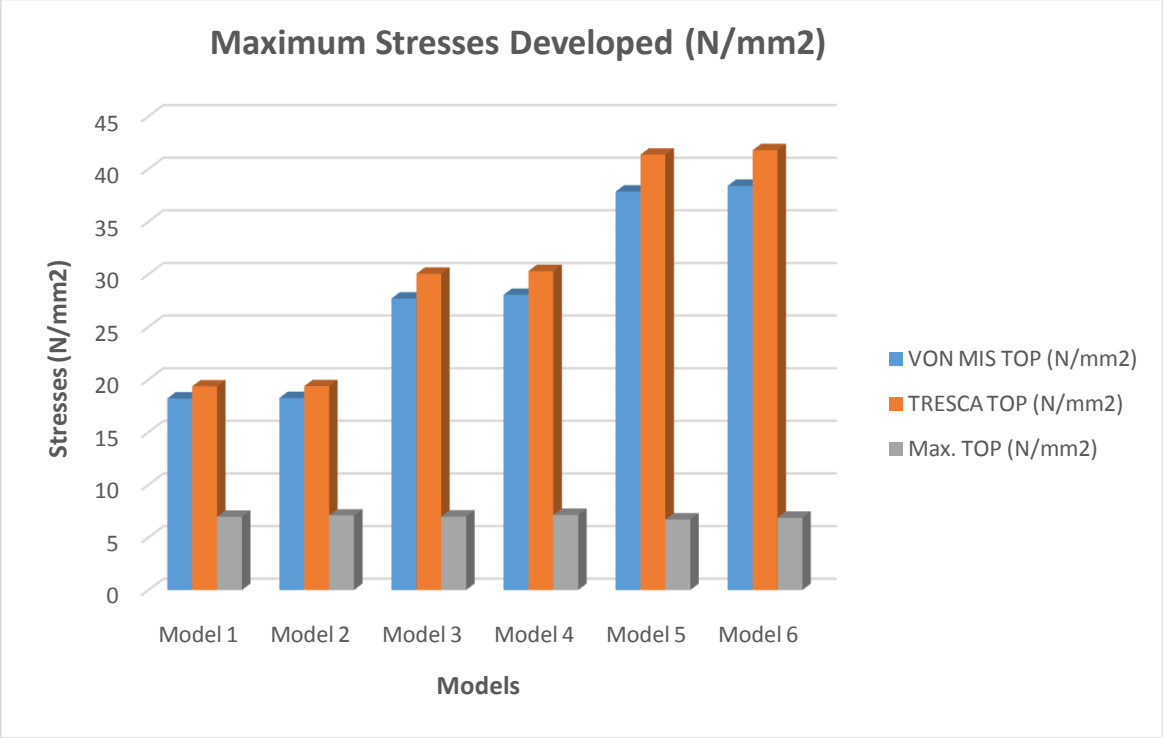


Fig. 15:Bar chart Representations of Maximum Stresses developed

CONCLUSIONS

The following conclusions are drawn from the research which is given below:

- The Storey displacement will be increased when Height of the building will be increased also when concrete truss Belt shape is changed from X- belt to V-belt System. The maximum storey displacement occurs in G+19 Storey building with V-shaped Truss Belt System and minimum storey displacement occur in G+9 Storey building with X-shaped Truss Belt System in X-direction. Similarly, the maximum storey displacement occurs in G+19 Storey building with V-shaped Truss Belt System and minimum storey displacement occur in G+9 Storey building with X-shaped Truss Belt System in Z-direction.
- The Shear force shows increment when Height of the building will be increased. The maximum shear force occurs in G+19 Storey building with V-shaped Truss Belt System and minimum shear force occur in G+9 Storey building with X-shaped Truss Belt System in X-direction. Similarly, in Z-direction the maximum shear force occurs in G+19 Storey building with V-shaped Truss Belt System and minimum shear force occur in G+9 Storey building with X-shaped Truss Belt System.
- The bending moment shows increment when Height of the building will be increased. The maximum bending moment occurs in G+19

Storey building with V-shaped Truss Belt System and minimum bending moment occur in G+9 Storey building with X-shaped Truss Belt System in X-direction. Similarly, in Z-direction the maximum bending moment occurs in G+19 Storey building with V-shaped Truss Belt System and minimum bending moment occur in G+9 Storey building with X-shaped Truss Belt System.

- The column axial forces value shows decrement when building with V-belt truss system is changed to X-belt truss system.
- The Base Shear will be decreased when Height of the building will be increased also when concrete truss Belt shape is changed from X-belt to V-belt System. The maximum Base Shear occurs in G+9 Storey building with X-shaped Truss Belt System and minimum Base Shear occur in G+19 Storey building with V-shaped Truss Belt System in X-direction. Similarly, in Z-direction the maximum Base Shear occurs in G+9 Storey building with X-shaped Truss Belt System and minimum Base Shear occur in G+19 Storey building with V-shaped Truss Belt System.
- There is increment in stresses being observed when height of the building is increased in Buildings with Truss belt System.

As overall it concluded that by taking different aspect ratios in the building with Concrete truss belt system lateral resistance is decreased. Out of the following six models the model 2 with G+9 Storey Building having X- Shaped concrete truss belt system at 4th & 8th storey shows the best results among safety than all other models. Also Considering the shapes of the concrete truss belt system the X- shaped belt truss system is more effective than V- shaped belt truss in resisting lateral forces.

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