Outrigger Connection of Multistoried Building at Plinth level to Increase Lateral Load Handling Capacity under Seismic Loading

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Abstract— The requirements of high-rise buildings are increasing regularly in all over the world. The high-rise building expansion has outspread promptly nearly the earth because now, individuals attempt to live in high-rise buildings. A building is supposed to acceptable if the design measures in it resist with the seismic forces. The shear wall was implemented to oppose tangential loads. To complete these characteristics the wall Outrigger system should be used in the building. In this project a G+16 Storey building is examined using seven diverse cases called as C1 to C7. 1 to 7 indicates wall outrigger system at various locations at plinth level in equal direction. In this investigation a high-rise structure building consists of G+ 16 storied structure in seismic Zone III. The plinth area is in use as 900 m2. The 5 bay & 6 bay with grid spacing is taken as 5 m & 6 m in x and y direction respectively. The purpose of the study is Outrigger Connection of Multistoried Building at Plinth level to Increase Lateral Load Handling Capacity under Seismic Loading.

Keywords- **Outrigger, Multi-storey, Plinth Level, Seismic effects.**

I. INTRODUCTION

With the increasing demand for high-quality buildings that encourage construction, as well as customization in the area, the various themes and daily expansions at high altitudes present the novel challenges and the need for new security systems. In order to survive earthquakes and strong winds due to structural improvements, such as unstable building developments and high altitudes, we need to break down some defenses. A small example are spacers, shortcuts, escape systems, and more. Outrigger & Wall Belts building has been around ever since the competition continues nationwide.

The underlying reason under this is that when a load is taken from a building, with a straight and vertical support system, there are a number of similar loads made of the structure, and this load must be supported by the building itself. As seismic activity causes vibrations from the ground, it is connected to the structure, and the most effective way to use this resistance is to use this joint system to use stabilizing materials, system support belts, and stability and support system belt. Outriggers are objects that contain poles or contact plates from the center to the outside of both sides, preventing the formation and operation of connecting links.

The base is made in the form of an available beam, which held tightly to the entire structure to withstand the loads and transport the same loads to the foundations. This type of construction provides high durability of the standard frame. The outrigger combines two elements to attach a strong body to withstand the force of an emergency. If an external reinforcement is inclined to deviate from wind loads or earthquakes, the outrigger connects a large wall to and from the top; the side load block replaces the complete layout of the structure. The best method used in multi-storey buildings is body support, be it a basic belt or a rafter strap system.

These are real estate agents and communicators. They are called belt support systems because the belt usually consists of roads or bolts that connect a building line. The load is removed from each object, still distributed evenly throughout the body. External straps and straps are used to absorb wave energy and maintain structural stability. The rules are that external renovations are focused on a barcode with gaps and gaps in one or more items. Spear straps are attached to the outer column of the house, and the outside is attached to the front or center wall. The reason is that this method is associated with a decrease in the amount that occurs in the sound structure compared to the traditional method.

II. OBJECTIVES OF THE PROJECT

This investigation is grounded on the Effectiveness Location of Outrigger Connection of Multistoried Building at Plinth level to Increase Lateral Load Handling Capacity Under Seismic Loading. Under the analysis it is appears that the used of these types of idea in the building growing lateral load management capacity. The subsequent objectives are taken for this project are as follows: -

1) To Study about Outrigger Wall Connection.
2) To prepared a G+16 storey multistory Building in CSI- ETABS design software.
3) To conclude various outcomes limitations such as Maximum displacement, Base shear, axial force, bending moment, Torsional moment & Stresses in required X Y and Z.
4) To compare the various models which is prepare in ETABS C1 (regular model) with C2 to C7 model (Wall Outrigger modeled structure).
5) To observe the ideal Location of Location of Outrigger Connection of Multistoried Building at Plinth level to Increase Lateral Load Handling Capacity Under Seismic Loading System.

III. MODELING AND ANALYSIS

The assorted cases of wall Outrigger system are modeled by using fem-based CSI- ETABS software. The Notations of cases are as follows:

1) Results for Regular Building with no outriggers support Case C1
2) Results for Regular Building 1st wall Outrigger connection at AB – 34 Case C2
3) Results for Regular Building 2nd wall Outrigger connection at BC – 34 Case C3
4) Results for Regular Building 3rd wall Outrigger connection at CD – 34 Case C4
5) Results for Regular Building 4th wall Outrigger connection at DE – 34 Case C5
6) Results for Regular Building 5th wall Outrigger connection at EF – 34 Case C6
7) Results for Regular Building 6th wall Outrigger connection at FG – 34 Case C7

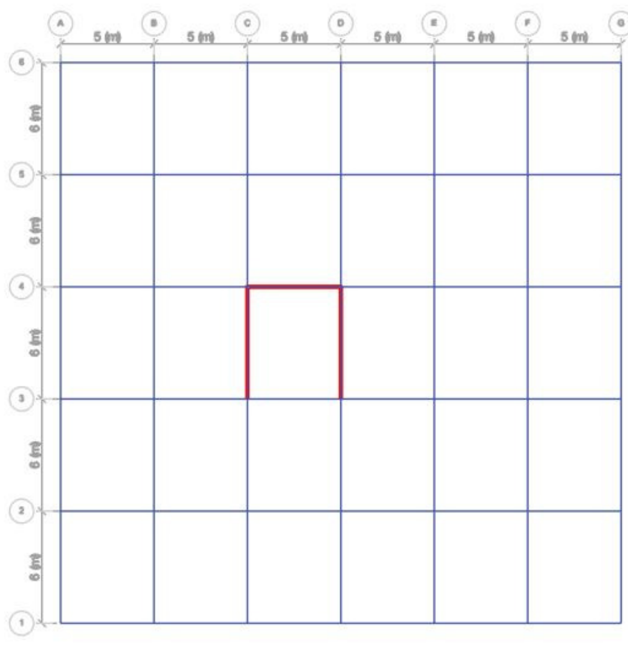

Figure 1: Plan of the Structure

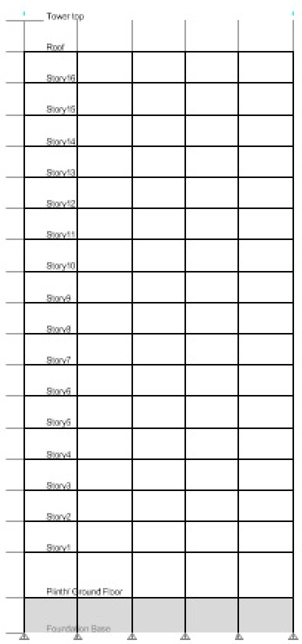

Figure 2: Front View of the Structure

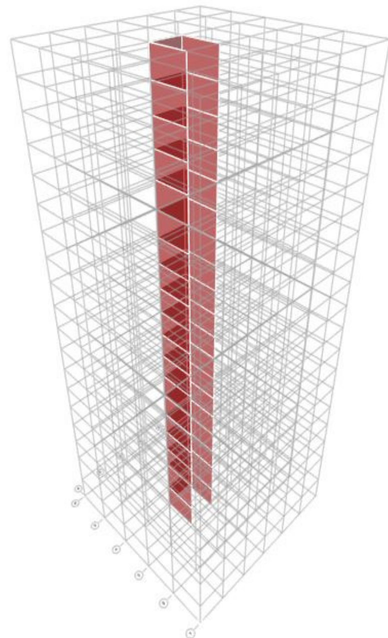

Figure 3: Case C1: Inside Stability view of the Structure

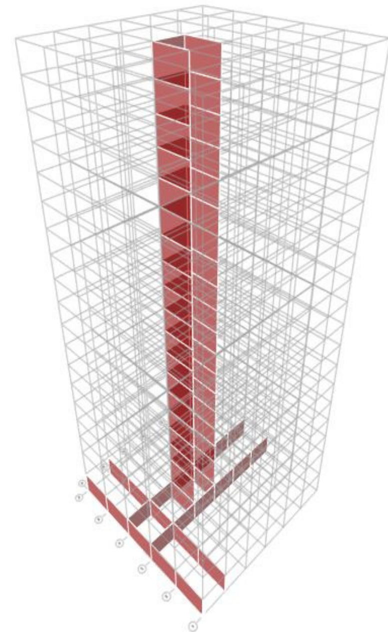

Figure 4: Case C2: Inside Stability view of the Structure

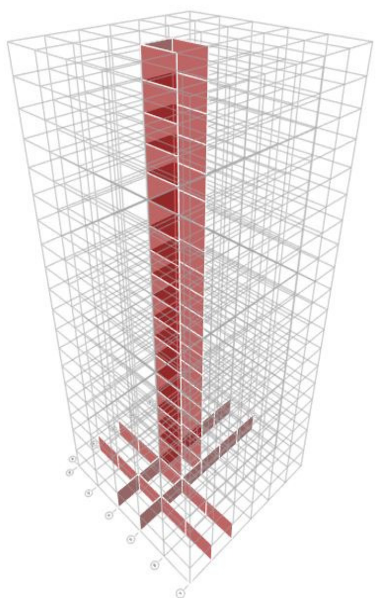

Figure 5: Case C3: Inside Stability view of the Structure

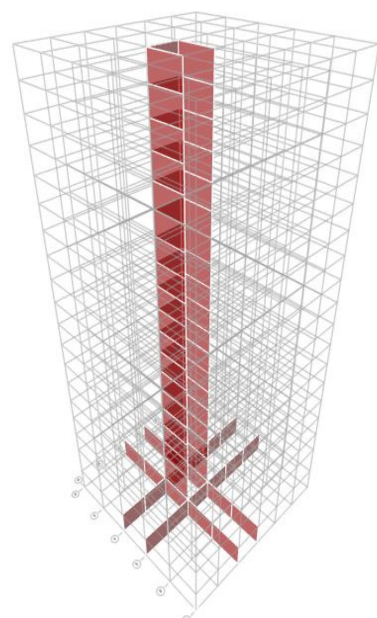

Figure 6: Case C4: Inside Stability view of the Structure

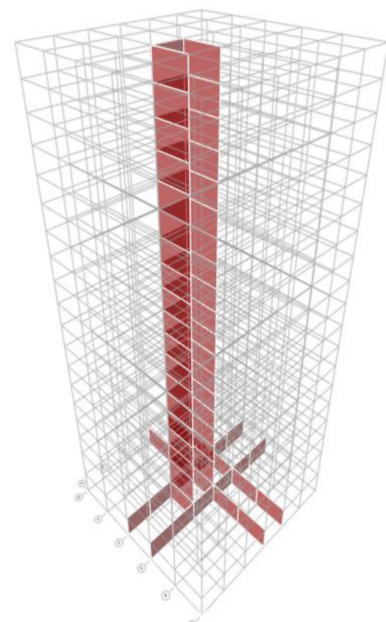

Figure 7: Case C5: Inside Stability view of the Structure

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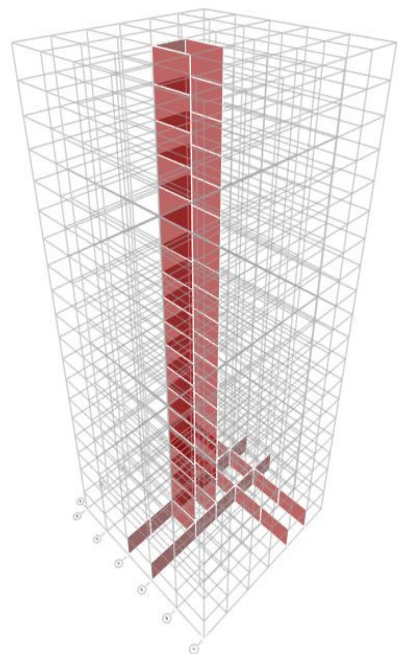

Figure 8: Case C6: Inside Stability view of the Structure

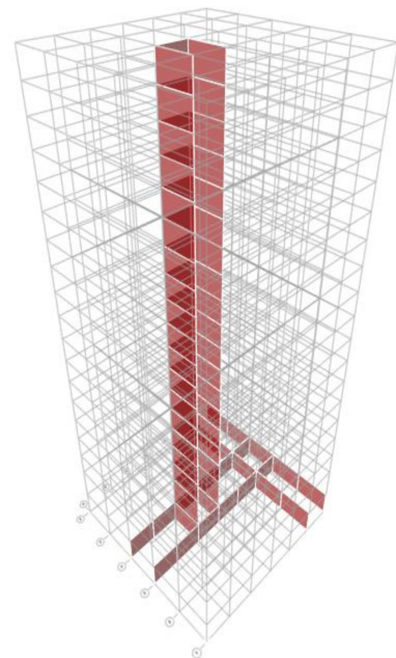

Figure 9: Case C7: Inside Stability view of the Structure

Structural Parameters used in this work:

Table 1 & Table 2 shows the basic parameters used in the analysis of building.

Table 1. Structural Parameters

S. No.	Element Name	Description
1	Building Types	Semi-Commercial
2	No. of Storey	G+16
3	Plinth Area	900 m^2
4	Floor Height	5m GF & 3.5m each floor
5	Dimensions of Beam	0.50 m. x0.40 m.
6	Dimensions of Column	0.60 m. x 0.55 m.
7	Slab Thickness	0.160 m.
8	Shear wall	0.140 m.
10	Grade of Concrete	M25
11	Steel Used	Fe 500
12	Staircase Wait slab	1.555 m.
13	Grid Spacing in X- Direction	5 m.
14	Grid Spacing in Y- Direction	6 m.
15	Time Period	1.1256 Second
16	Analysis Software used	CSI-Etabs

Earthquake Parameters used in G+5 Storey:

Table 2. Earthquake Parameters

S. No.	Parameters	Description
1	Earthquake Code	IS 1893(Part 1):2016
2	Earthquake Zone	III
3	Response Factor(RF)	4

4	Importance Factor(IF)	1.2
5	Soil Types	Medium
6	Damping	0.05
7	Structural Type	RCC Framed Building
8	Earthquake method	Response Spectrum Method

IV. RESULTS AND DISCUSSION

The Following results are to be obtained from the modeling and analysis of Multi storey building of G+16 Storey building in Csi-Etabs software. The results are as follows:

Maximum Displacement:

Table 3. Maximum Displacement in X and Z direction for all Outrigger Wall Cases

Wall Belt Stability Case	**Maximum Displacement (mm)**	
	For X Direction	**For Z Direction**
Case C1	269.319	250.292
Case C2	242.943	231.807
Case C3	240.953	225.502
Case C4	240.438	225.15
Case C5	240.292	225.173
Case C6	240.683	225.192
Case C7	241.038	228.64

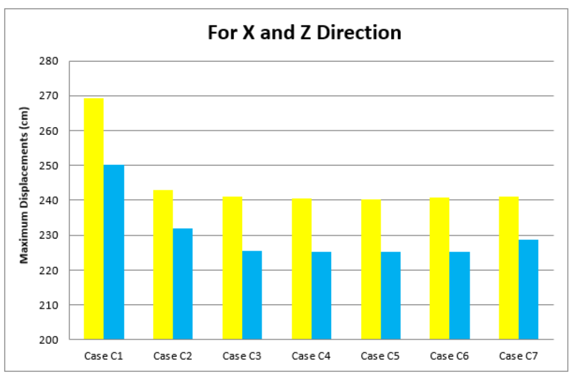

Figure 10: Graphical Representation of Maximum Displacement in X and Z direction for all Outrigger Wall Cases at Plinth Level

Table 4. Base Shear in X and Z direction for all Outrigger Wall Cases

Wall Belt Stability Case	**Base Shear (KN)**	
	X direction	**Z direction**
Case C1	5241.8226	5241.8226
Case C2	5278.2774	5278.2774
Case C3	5276.3754	5276.3754
Case C4	5274.4735	5274.4735
Case C5	5276.3754	5276.3754
Case C6	5278.2774	5278.2774
Case C7	5278.9819	5278.9819

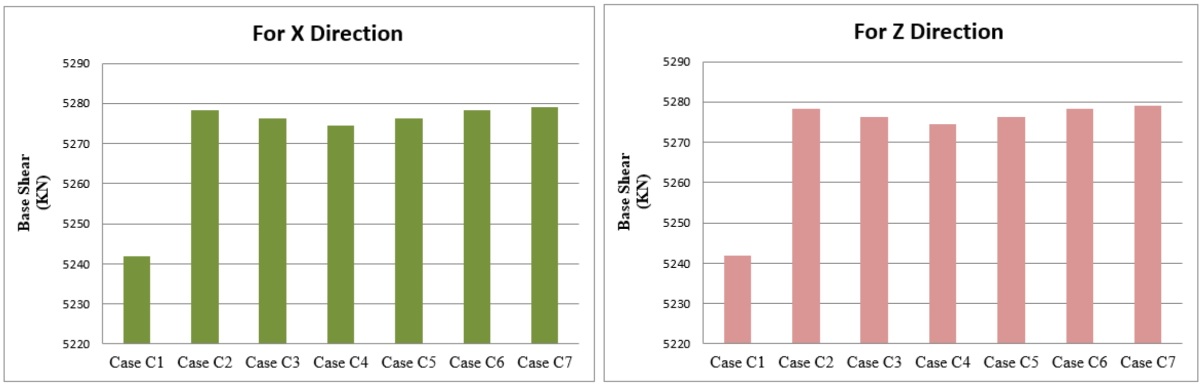

Figure 11: Base Shear in X and Z direction for all Outrigger Wall Cases

Maximum Axial Forces:

Table 5. Maximum Axial Forces in Column for all Outrigger Wall Cases

Wall Belt Stability Case	Column Axial Force (KN)
Case C1	8250.8124
Case C2	7158.0418
Case C3	7063.9491
Case C4	7273.6257
Case C5	7353.4797
Case C6	7146.2662
Case C7	7130.4856

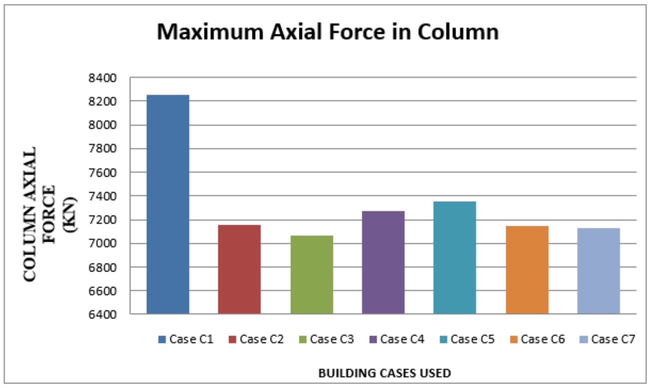

Figure 12: Maximum Axial Forces in Column for all Outrigger Wall Cases

Maximum Shear Force in Column:

Table 6. Maximum Shear Force in Column for all Outrigger Wall Cases

Wall Belt Stability Case	Column Shear Force (KN)	
	Shear along Y	**Shear along Z**
Case C1	121.0122	119.7215
Case C2	118.0562	118.3998
Case C3	118.2468	116.7324
Case C4	118.2859	116.3564
Case C5	118.5906	117.707
Case C6	118.5096	118.3887
Case C7	117.8194	118.4245

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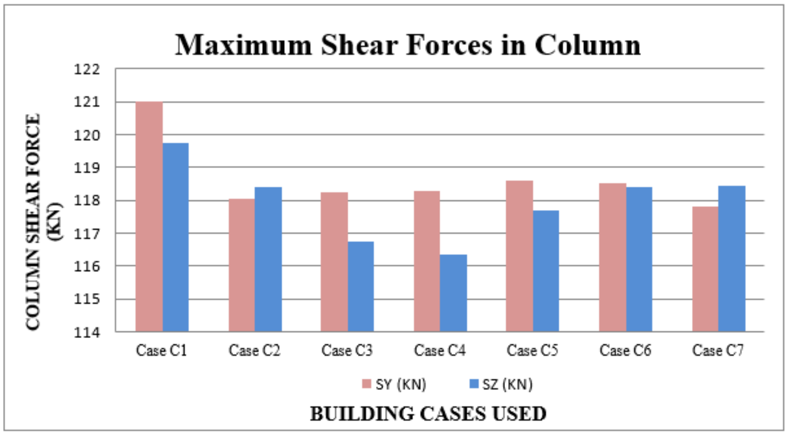


Figure 13: Maximum Shear Force in Column for all Outrigger Wall Cases

Maximum Bending Moment in Column:

Table 7. Maximum Bending moment in Column for all Outrigger Wall Cases

Wall Belt Stability Case	**Column Bending Moment (KNm)**	
	Moment along Y	**Moment along Z**
Case C1	188.1929	198.2612
Case C2	186.0936	253.6941
Case C3	183.507	253.8893
Case C4	182.905	244.5835
Case C5	184.9991	247.1935
Case C6	186.0784	253.5785
Case C7	197.4707	250.4739

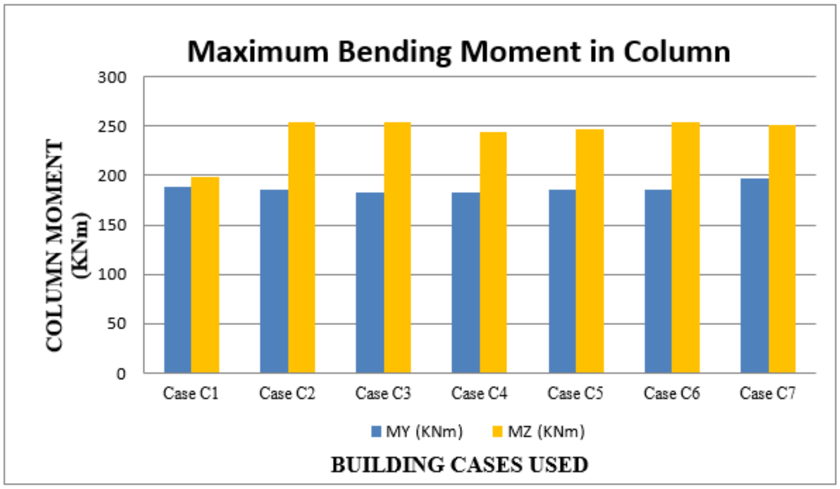


Figure 14: Maximum Bending Moment in Column for all Outrigger Wall Cases

Maximum Shear Force in Beam:

Table 8. Maximum Shear Force in beam for all Outrigger Wall Cases

Wall Belt Stability Case	Beam Shear Force (KN)	
	Shear along Y	Shear along Z
Case C1	141.4607	0
Case C2	137.8148	0
Case C3	137.4281	0
Case C4	138.2235	0
Case C5	138.4087	0
Case C6	138.3767	0
Case C7	137.9696	0

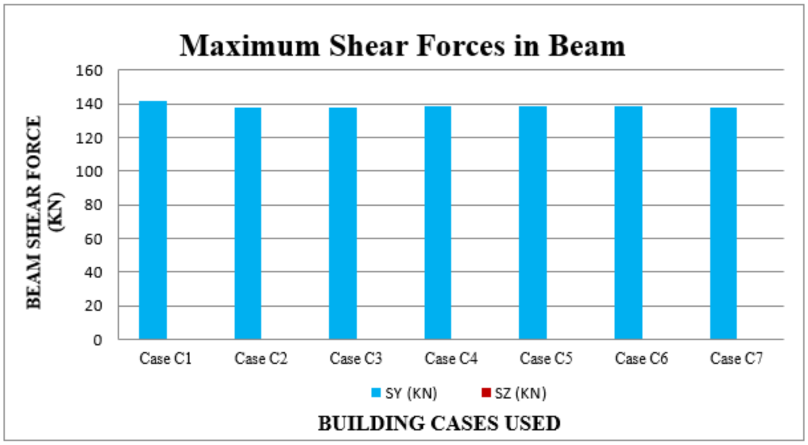


Figure 15: Maximum Shear Force in beam for all Outrigger Wall Cases

Maximum Bending Moment in Beam:

Table 9. Maximum Bending Moment in Beam for all Outrigger Wall Cases

Wall Belt Stability Case	Column Bending Moment (KNm)	
	Moment along Y	Moment along Z
Case C1	0	244.2174
Case C2	0	241.0994
Case C3	0	237.0811
Case C4	0	236.9587
Case C5	0	238.9302
Case C6	0	240.4891
Case C7	0	241.51

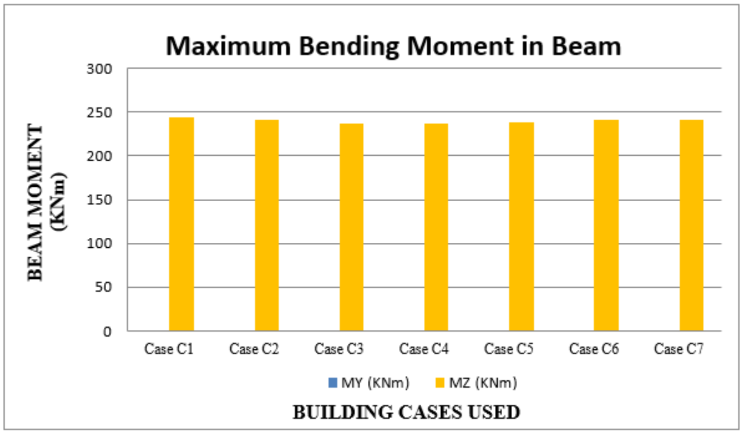


Figure 16: Maximum Bending Moment in Beam for all Outrigger Wall Cases

Maximum Torsional Moments in Beam and column:

Table 10. Maximum Torsional Moments in Beam and column for all Outrigger Wall Cases

Wall Belt Stability Case	Beam Torsional Moments (KNm)	Column Torsional Moments (KNm)
Case C1	9.5622	21.1282
Case C2	9.8877	16.1118
Case C3	9.5541	16.1549
Case C4	9.5701	16.1189
Case C5	9.4862	16.072
Case C6	11.4105	16.0085
Case C7	9.5509	15.9231

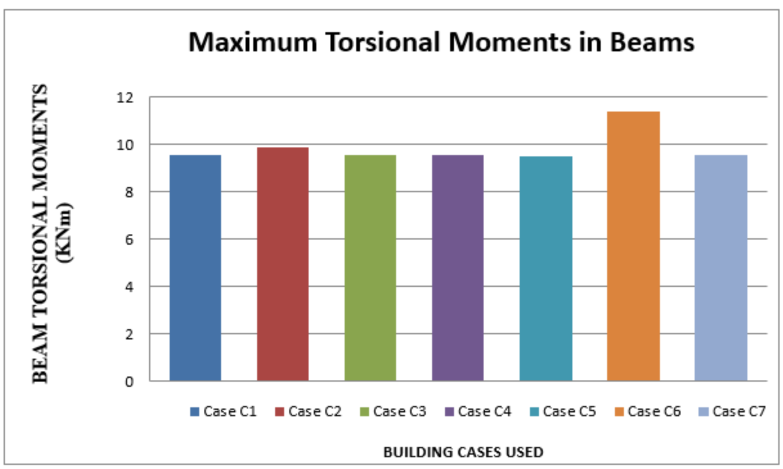


Figure 17: Maximum Torsional Moments in beam for all Outrigger Wall Cases

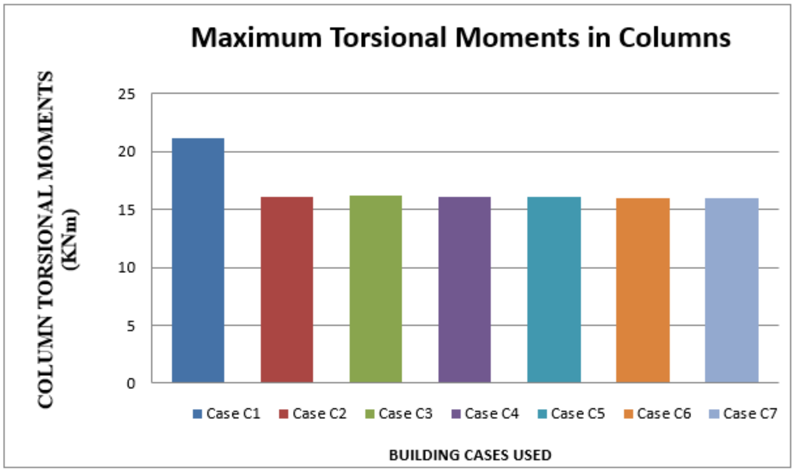
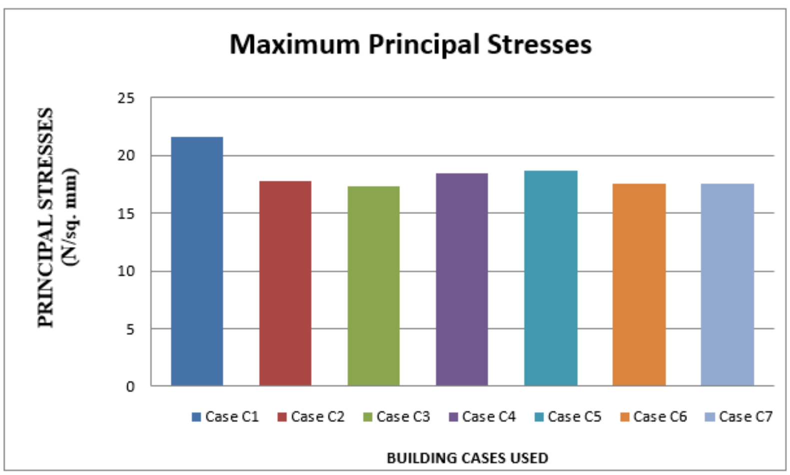


Figure 18: Maximum Torsional Moments in Columns for all Outrigger Wall Cases

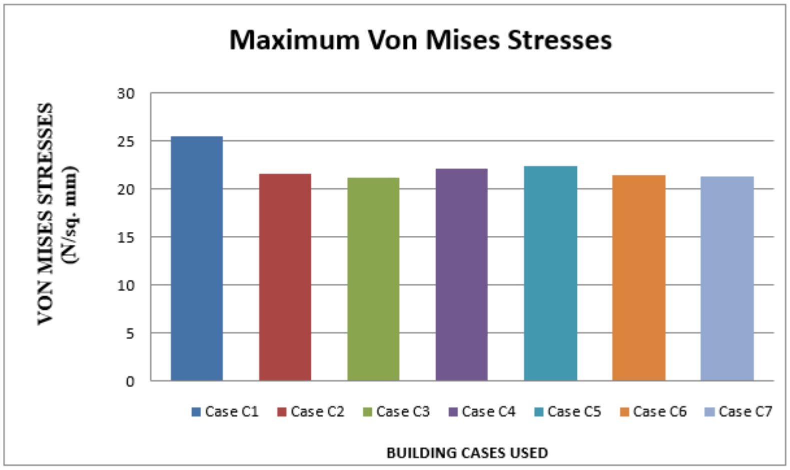
Maximum Stresses developed:

Table 11. Maximum Principal Stresses for all Outrigger Wall Cases

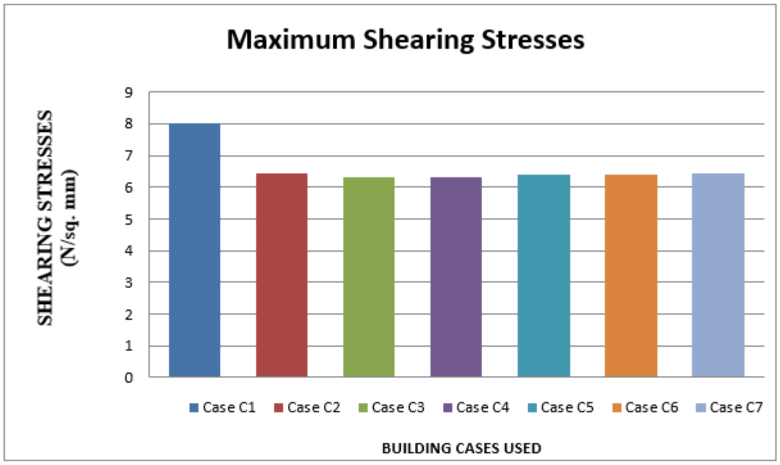
Maximum Stresses developed (N/sq. mm)			
Wall Belt Stability Case	**Maximum Principal Stresses (N/sq. mm)**	**Maximum Von Mises Stresses (N/sq. mm)**	**Maximum Shearing Stresses (N/sq. mm)**
Case C1	21.61	25.5	8.03
Case C2	17.71	21.61	6.44
Case C3	17.35	21.16	6.33
Case C4	18.38	22.14	6.32
Case C5	18.66	22.43	6.39
Case C6	17.59	21.4	6.41
Case C7	17.53	21.32	6.42



(a)



(b)



(c)

Figure 19: Bar chart of Max.Stresses developed-
Principal Stresses (a), Von Mises Stresses (b) & Shearing Stresses (c)

V. CONCLUSIONS

The conclusion can be pointed out are as follows:-

1. Maximum displacement in X direction other than building with no outriggers seems less in Case C4 i.e. Building with Wall Outrigger at Location 3 and Case C5 i.e. Building with Wall Outrigger at Location 4.
2. For Z direction, the trend follows same as that seen in X direction. This is because the dimension of the building is same from X and Z direction. Here, again Case C4 and C5 seem to be efficient with a minimum value of 225.15 mm and 225.173 mm respectively.
3. As it had previously proved that the Base shear values increases with increase in additional member in a structure. As for the horizontal plane, for both the transitional axis, the value of Base shear first increases, then it decreases gradually up to Case C4 with a minimum value of 5274.4735 KN.
4. For, the Maximum Axial Forces in Column, the value drastically decreases to Case C3 and then it increases to Case C5.The increasing and decreasing trend keep on continuing. With a minimum value of 7063.9491 KN observed at Case C3, proved to an efficient case.

5. Column Shear force decreases as the outrigger at plinth level is applied. The trend observed as it moves down when it is near the Shear Core i.e. lift area. For both Shear forces along Y and along Z, Case C4 obtained as an effective Case for stability.
6. The moment in column observed less when no outrigger is applied. But after application and comparing all the outrigger cases, Cases C4 obtained as best case among all the outrigger cases with a minimum value of 182.905 KNm for My and 244.5835 KNm for Mz respectively.
7. With the minimum value of 137.4281 KNm, the shear force generated in beam observed less in Case C3. The same case obtained less in computation of moment in beams on comparing all he outrigger cases. Case C3 proved best among all.
8. For Torsional Moments generated in beams, the lesser value Case C5 i.e. Building with Wall Outrigger at Location 4 observed as an effective case for less torsion generation.
9. Torsion values observed in column members are nearly same when comparing all the outrigger cases provided at plinth level.
10. The Case C3 proved to be lesser in parametric value for Maximum Principal Stresses with a least value of 17.35 N/sq. mm after the application of outrigger wall at plinth level.
11. Again for Von Mises Stress, Case C3 after the application of outrigger wall at plinth level proved to be efficient with a minimal value.
12. Maximum Shearing Stresses seems less in Case C3 and Case C4 with the application of outrigger wall connection at plinth level.

Observing all the parametric values in all aspects, Case C4 observed and proved as efficient case. The outrigger parallel to X direction and parallel to Z direction shows the stability feature proved at plinth level. This case should be recommended when this type of stability feature in building will be provided.

REFERENCES

1. Patel N. & Jamle S. (Aug.-2019) “Use of Shear Wall Belt at Optimum Height to Increase Lateral Load Handling Capacity in Multi-story Building: A Review” International Journal of Advanced Engineering Research and Science (IJAERS), Vol-6, Issue-4,Apr-2019,ISSN:2349-6495(P),2456-1908(O),pp310-314. https://dx.doi.org/10.22161/ijaers.6.4.36,
2. Soni P., Tamrakar P.L. & et. al. (Feb.-2016) “Structural Analysis of Multi-story Building of Different shear Walls Location and Heights” International Journal of Engineering Trends and Technology (IJETT) ,Volume 32, Number 1- ISSN: 2231-5381, pp 50-57.
3. Dangi A. & Jamle S. (Sept.- 2018) “Determination of Seismic parameters of R.C.C. Building Using Shear Core Outrigger, Wall Belt and Truss Belt Systems” International Journal of Advanced Engineering Research and Science (IJAERS),Vol-5, Issue-9, Sept- 2018,ISSN:2349-6495(P),2456-1908(O),PP-305-309. https://dx.doi.org/10.22161/ijaers.5.9.36
4. Nadh V.S., Sumanth B.H. (Feb.- 2020) Ideal Location Of Outrigger System And Its Efficiency For Unsymmetrical Tall Buildings Under Lateral Loadings, International Journal Of Scientific & Technology Research volume 9, ISSUE 02, ISSN 2277-8616, Pp 2917-2920.
5. Salman K. , Kim D. & et. al. (2020)Optimal control on structural response using outrigger braced frame system under lateral loads , Journal of Structural Integrity and Maintenance ISSN: 2470-5314 (Print) 2470-5322 (Online) vol. 5, no. 1, Pp 40–50 https://doi.org/10.1080/24705314.2019.1701799
6. Tavakoli R. , Kamgar R. (Feb.-2019) “Seismic performance of outrigger–belt truss system considering soil–structure interaction” International Journal of Advanced Structural Engineering, pp 45-54, https://doi.org/10.1007/s40091-019-0215-7
7. Urjal Das , Ankit Pal , Arvind Vishwakarma. (2020) Location of Efficient Single Outrigger Wall Connection and Wall Belt Supported System over Horizontal Plane Journal of Xi'an University of Architecture &

Technology, Volume XII, Issue VIII, 2020 https://doi.org/10.37896/JXAT12.08/2728 ISSN No. : 1006-7930 pp 1326-1337

8. Joshi A. , Pal A. , Vishwakarma A. (2020) Determination of Performance Point of Stability Improvement of the Multistoried Building using Different Grade of Concrete in Beams at Different Levels over Soft Soil: A Review International Journal of Advanced Engineering Research and Science Vol-7, Issue-8, DOI: https://dx.doi.org/10.22161/ijaers.78.25, ISSN: 2349-6495(P) 2456-1908(O) pp 241-246
9. Apurva Joshi, Ankit Pal . (2020) Determination of Performance point of stability improvement of the multistoried building using different grade of concrete in beams at different levels over soft soil Journal of Xi'an University of Architecture & Technology, Volume XII, Issue IX, 2020 https https://doi.org/10.37896/JXAT12.09/2858 ISSN No. : 1006-7930 pp 92-103
10. Shubham Patel, Ankit Pal (2020) A Review Study- Base Shear Reduction by Using Optimum Size of Beam in Top Floors in Multistoried Building at Different Levels International Journal of Advanced Engineering Research and Science Vol-7, Issue-10, DOI: https://dx.doi.org/10.22161/ijaers.710.22 , ISSN: 2349-6495(P) 2456-1908(O) pp 213-218
11. Shubham Patel, Ankit Pal (2020) Determination of Base Shear Reduction by Using Optimum Size of Beam in Top Floors in Multistoried Building at Different Levels Journal of Xi'an University of Architecture & Technology, Volume XII, Issue XI, 2020 https://doi.org/10.37896/JXAT12.11/29718ISSN No. : 1006-7930 pp 169-179
12. Ashish Sadh, Ankit Pal. "A Literature Study of Wind Analysis on High Rise Building", International Journal of Advanced Engineering Research and Science (ISSN : 2349-6495(P) | 2456-1908(O)),vol.5,no. 11, pp.263-265,2018.
13. Ashish Sadh, Sagar Jamle and Ankit Pal Response of Multistory Irregular L Shape Building under Basic Wind Speed of 39 m/s International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161
14. Tak, N., Pal, A. and Choudhary, M. (2020). A Review on Analysis of Tower on Building with Sloping Ground. International Journal of Advanced Engineering Research and Science, 7(2), pp.84-87.
15. Tak, N., Pal, A. and Choudhary, M. (2020). Analysis of Building with Tower on Sloping Ground International Journal of Current Engineering and Technology, DOI: https://doi.org/10.14741/ijcet/v.10.2.10 E-ISSN 2277-4106, P-ISSN 2347-5161 pp 247-254
16. Kumawat, M., Pal, A. and Choudhary, M. (2020). Determination of efficient Shape of twin tower subjected to Seismic Loading. International Journal of Advanced Engineering Research and Science, 7(2), pp.95-99.
17. Kumawat, M., Pal, A. and Choudhary, M. (2020). A Review Study-Use of Different Shapes of Twin Towers High Rise building under Seismic Loading International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161 pp 37-39
18. Urjal Das , Ankit Pal , Arvind Vishwakarma. (2020) Location of Efficient Single Outrigger Wall Connection and Wall Belt Supported System over Horizontal Plane Journal of Xi'an University of Architecture & Technology, Volume XII, Issue VIII, 2020 https://doi.org/10.37896/JXAT12.08/2728 ISSN No. : 1006-7930 pp 1326-1337.