Location of Efficient Single Outrigger Wall Connection and Wall Belt Supported System over Horizontal Plane

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Abstract

The demands of multi story building with architectural impact are increases day by say in all over the world. The multistory building improvement has spread rapidly around the world because now, people try to live in multi-storey structures. A Structure is said to acceptable if it satisfy the design criteria in it to resist the lateral foresees. Loads mainly from severe earthquakes. The shear wall was implemented to resist lateral loads. To fulfill these aspects the Outrigger & wall belt system should be used in the structure. In this project a G+20 Storey structure is analyzed using six different cases named as HP1 (Horizontal plan1) to HP6 (horizontal plan 6). 1 to 6 indicates ground level to 20 storeys. In this study a multi storey building consist of structure made up of G+ 20 storey's building in Zone III. The plinth area is taken as 900 m^2. The 5 bay & 6 bay with grid spacing is taken 5 m. & 6 m in x and y direction respectively. For determination of Performance of structure under efficient location of single outrigger wall connection and wall belt supported system over horizontal plane in CSI-ETABS different levels of building is major objective of project. The project concluded that Optimum height for placing shear wall belt to increase lateral load handling capacity from above objective parameters will be at 11.50 m i.e. structure with shear strip at 3rd floor. Two more location also predominate in it ie 3^{rd} & 6^{th} floor. Analytically If N no. of storey is taken than optimum location lies under ((N/2)-1) to ((N/2) +1), most preferably at (N/2) Storey.

Keywords – *HP (Horizontal Plan), outrigger, wall belt, CSI-ETABS, Multi-storey.*

Introduction

With the growing demand for high-quality and architecturally impressive structures, as well as custom-made roundabouts, the different themes and the daily increase in heights bring new challenges and the need for new security systems. In order to withstand earthquakes and strong winds due to building growth, such as increased building instability and high heights, we need to break some protective measures. Small examples are spacers, cross-wall, outrigger systems, and more. Outrigger Structure Outrigger & Wall Belts Ever since the competition continues in the country. The reason taken under this is that when a load is taken on a structure, with a system of vertical and horizontal supports, there is a huge amount of combined loads that are generated by the structure, and this load must be supported by the structure itself. Since an earthquake causes vibrations from the ground, they are related to the structure, and the most effective way to use this to resist the structure is by using this combined system to use stabilizers, belts supported by the system, and stabilization and system supporting belt. Outriggers are elements that consist of beams or contact plates from the center to the outside of the uprights on both sides, which block the structure and operation of the connecting links. The core was made in the form of a removable beam, which firmly held the entire structure in order to withstand loads and move the same loads from the supports. This type of construction provides greater rigidity than a conventional frame. The outrigger combines two elements to add a robust body to resist emergency power. If a building reinforced with outriggers is subject to deflection from wind or seismic loads, the outrigger connects the main wall to and from the uprights; the side load block replaces the complete structural system. The best technique used in multi-storey buildings is body support, be it a core strap or a rafter strap system. These are representatives of structural nodes and communication through them. They are called belt support systems because a belt usually consists of trusses or bolts that connect a line of a structure. The load is discharged from each element, distributed equally across the body. External straps and straps are used to

accommodate the force of the wave and to maintain the stability of the structure. The rules are for the outer uprights to be centered on the crossbar with spacers and straps in one or more positions. The truss straps are attached to the outer column of the house, and from the outside they are attached to the main or center vertical wall. The reason is that this approach is associated with a decrease in the value that occurs in the noise structure compared to the traditional method.

Objectives of the project:

This research is based on the Location of Efficient Single Outrigger Wall Connection and Wall Belt Supported System over Horizontal Plane. Under the study it is seems that the used of these type of concept in the structure increasing lateral load handling capacity. The following objectives are taken for this project areas follows:-

- To Study about Outrigger Wall Connection and Wall Belt Supported System.
- To Modeled a G+20 storey multistory Building in CSI- ETABS.
- To find different results parameters such as Maximum displacement, Base shear, axial force, bending moment & Stresses in required X Y and Z.
- To compare the HP1 (regular model) with HP2 to HP6 model (Outrigger and wall belt models).
- To find the optimum Location of Efficient Single Outrigger Wall Connection and Wall Belt Supported System under above objectives.

Modeling and Analysis:

The Different case of horizontal plan with Outrigger and wall belt supported system are modeled by using fem based CSI- ETABS software. The notations of cases are as follows:

Case HP1 : Regular structure with no outriggers support
Case HP2 : Outrigger and wall belt system at B1
Case HP3 : Outrigger and wall belt system at C1
Case HP4 : Outrigger and wall belt system at D1
Case HP5 ; Outrigger and wall belt system at E1
Case HP6 : Outrigger and wall belt system at F1

Abbravation used:
HP x : Horizontal Plane on x –storey,
B1,C1,D1,E1,F1 : denotes the Outrigger and wall belt provide at 1,2,3,4,5 storey respectivily.

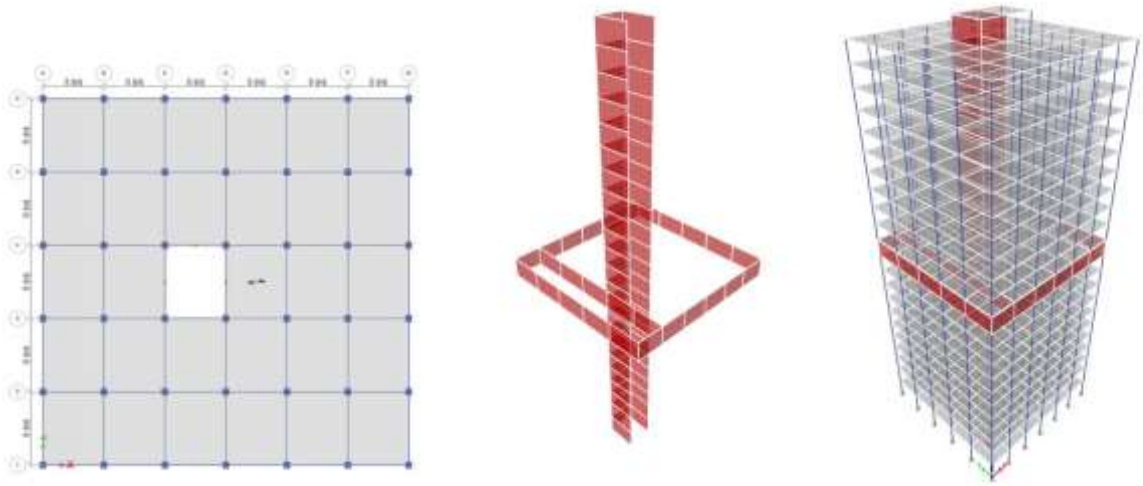


Figure 1: G+20 Storey with Plan, Cut Out View and 3D view

Structural Parameters used in G+ 20 storey:

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	Residential
2	No. of Storey	G+20
3	Plinth Area	900 m^2
4	Floor Height	4.5 GF & 3.5 each floor
5	Dimensions of Beam	0.55 m. x0.45 m.
6	Dimensions of Column	0.60 m. x 0.55 m.
7	Slab Thickness	0.150 m.
8	Shear wall	0.155 m.
10	Grade of Concrete	M25 & M30
11	Steel Used	Fe 500
12	Outrigger and wall belt supported at	1,2,3,4,5 Storey
13	Grid Spacing in X- Direction	5 m.
14	Grid Spacing in Y- Direction	6 m.
15	Time Period	1.3474 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

Result & Discussions

The Following results are to be obtained from the modeling and analysis of Multi storey building of G+20 Storey building using software approach. The results are as follows:

Maximum Displacement: It is defined as the maximum displacement or distance moved by a point on a vibrating body or wave measured from its equilibrium position. Table 3 Shows that max. value of displacement in G+20 Storey Building for different cases from HP1 to HP6.

Table 3: Maximum Displacement Results

Cases	Maximum Displacement (mm)	
	For X Direction	For Z Direction
Case HP1	284.688	269.734
Case HP2	246.908	211.959
Case HP3	246.221	195.675
Case HP4	247.135	190.66
Case HP5	246.61	207.583
Case HP6	246.286	212.696

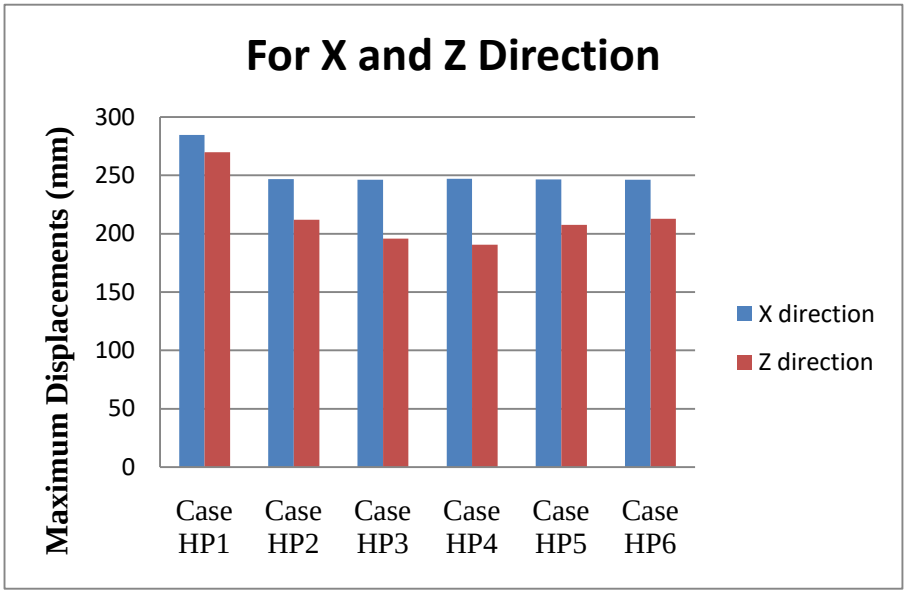


Figure 2: Bar chart of Max. Displacement under HP1 to HP6

As per the tabulated results and bar char representation the maximum value of storey displacement. On comparing The maximum value is obtained in the case of HP1 is 284.688 mm & 269.734 mm for both X & Y direction respectively & minimum value of displacement is 246.221 mm &190.66 mm in the case of HP3 & HP4 for X & Y direction respectively. This show that the outrigger and wall belt system are efficient t in middle of the floor and do not needed for base side of the storey.

Baser Shear*:* Base shear is an estimate of the maximum expected lateral force on the base of the structure due to seismic activity. Table 4 Shows that max. Value of Base shear in G+20 Storey Building for different cases from HP1 to HP6 in X& Z direction.

Table 4: Base Shear Results

Cases	Base Shear (KN)	
	X direction	**Z direction**
Case HP1	5321.9388	5321.9352
Case HP2	5389.3595	5389.356
Case HP3	5384.4732	5384.4728
Case HP4	5384.4729	5384.4747
Case HP5	5387.1615	5387.1619
Case HP6	5387.1612	5387.1582

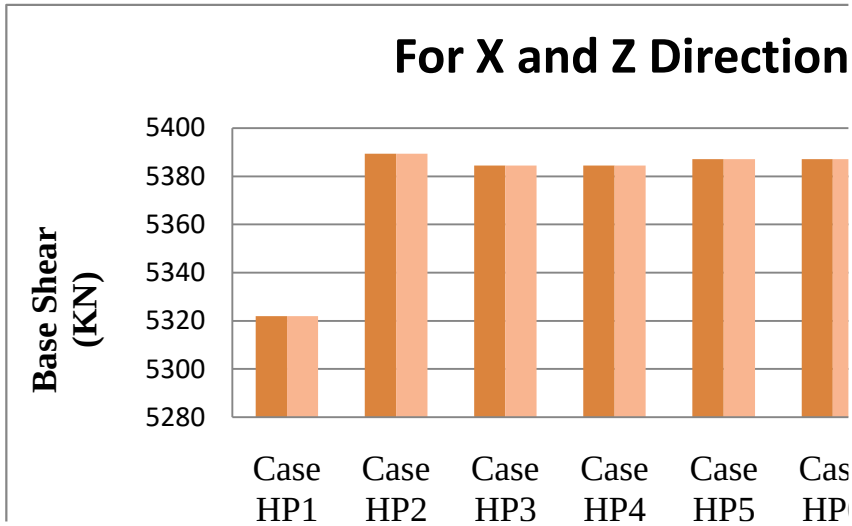


Figure 3: Bar chart of Max. Base Shear under HP1 to HP6

As per the tabulated (Table 4) results and bar char (figure 3) represented the maximum value of base shear for different cases. On comparing the maximum value is obtained in the case of HP2 is 5389.35 KN for both X & Y direction respectively & minimum value of base shear is 5321.93 KN in the case of HP1 both X & Y direction respectively. There is also showed that form HP2 to HP6 the nearest value is obtained except HP1.
This show that the outrigger and wall belt system is efficient t in HP2 TO HP6.

Maximum Axial Forces: If the load on a column is applied through the center of gravity of its cross section, it is called an axial load. Axial force is the compression or tension force acting in a member. Table 5 Shows that max. value of Axial forces in G+20 Storey Building for different cases from HP1 to HP6.

Table 5: Maximum Axial Forces Results

Cases	Column Axial Force (KN)
Case HP1	7913.5328
Case HP2	7188.1145
Case HP3	7122.2883
Case HP4	7077.9609
Case HP5	7158.6939
Case HP6	7220.0373

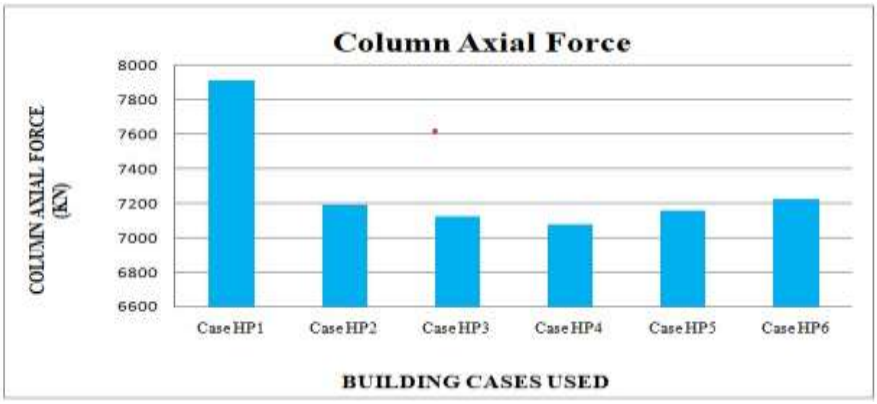


Figure 4: Bar chart of Max. Axial Forces under HP1 to HP6

As per the tabulated (Table 5) results and bar char (figure 4) represented the maximum value of axial forces for different cases of HP1 to HP6. On comparing the maximum value is obtained in the case of HP21 is 7913.5328 KN & minimum value of axial forces is 7077.9609 KN in the case of HP4. There is also showed that form HP4 is much efficient and also HP3, HP5 also resisting through.

Maximum Shear Force in Column*:* Shearing forces are unaligned forces pushing one part of a body in one specific direction, and another part of the body in the opposite direction. When the forces are aligned into each other, they are called compression forces. Table 6 Shows that max. value of shear Forces Results in G+20 Storey Building for different cases from HP1 to HP6.

Table 6: Maximum shear Forces in column Results

Cases	Column Shear Force (KN)	
	Shear along Y	Shear along Z
Case HP1	137.4636	136.0902
Case HP2	180.9536	196.1098
Case HP3	183.4581	188.5578
Case HP4	181.9816	189.0116
Case HP5	181.3896	176.9272
Case HP6	180.4866	193.1373

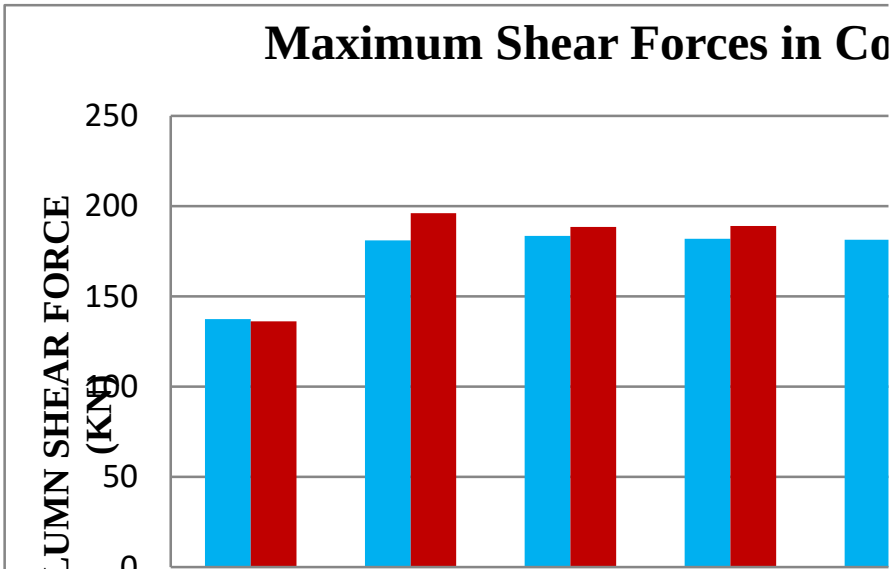


Figure 5: Bar chart of Max. shear Forces under HP1 to HP6

As per the tabulated (Table 6) results and bar char (figure 5) the maximum value of shear forces. On comparing The maximum value is obtained in the case of HP3 is 183.4581 KN & 196.109 KN for X & Z direction respectively & minimum value of Shear force is 137.4636 KN & 136.0902 KN in the case of HP1 for both X & Y direction respectively.

Maximum Bending Moment in Column: A bending moment is the reaction induced in a structural element when an external force or moment is applied to the element causing the element to bend. The most common or simplest structural element subjected to bending moments is the beam. Table 7 Shows that max. value of bending moment Results in G+20 Storey Building for different cases from HP1 to HP6

Table 7: Maximum Bending Moment Results

Cases	Column Bending Moment (KN.m)	
	Moment along Y	Moment along Z
Case HP1	208.4792	239.2556
Case HP2	462.0692	404.54
Case HP3	434.764	411.8289
Case HP4	436.8066	409.866
Case HP5	411.9202	408.6063
Case HP6	447.5797	403.877

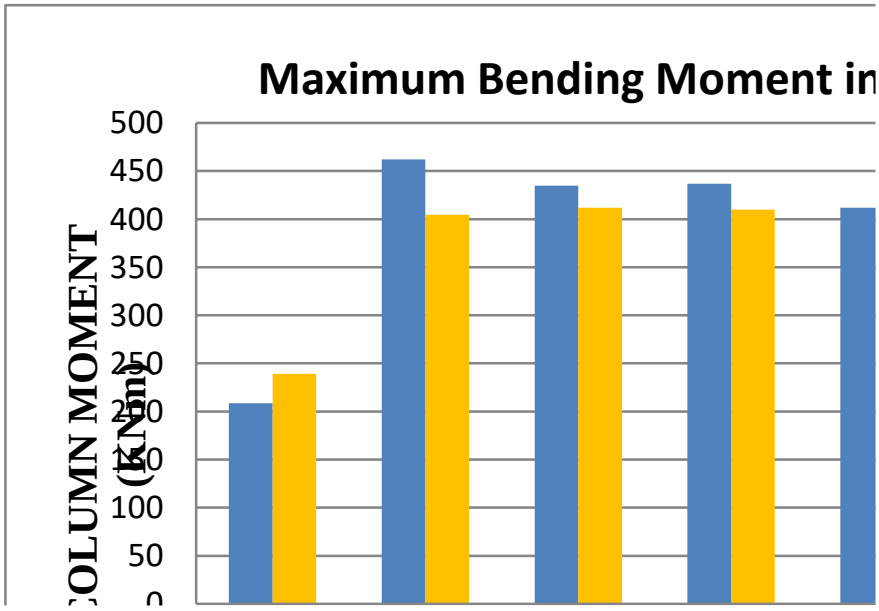


Figure 6: Bar chart of Max. Bending Moment in column under HP1 to HP6

As per the tabulated (Table 7) results and bar char (figure 6) the maximum value of bending moment. On comparing the maximum value is obtained in the case of HP2 is 462.0692 KN.m & 411.8289 KN.m for Y & Z direction respectively & minimum value of Shear force is 208.4792 KN.m & 239.2556 KN.m in the case of HP1 for both X & Y direction respectively. Base side exhibits lesser moments.

Maximum Shear Force in Beam*:* Table 8 Shows that max. value of bending moment Results in G+20 Storey Building for different cases from HP1 to HP6.

Table 8: Maximum Shear Force in Beam

Cases	Beam Shear Force (KN)	
	Shear along Y	Shear along Z
Case HP1	169.8228	1.7354
Case HP2	153.5409	2.1935
Case HP3	141.8859	1.8916
Case HP4	150.6706	1.8552
Case HP5	152.5359	2.248
Case HP6	152.7412	1.7263

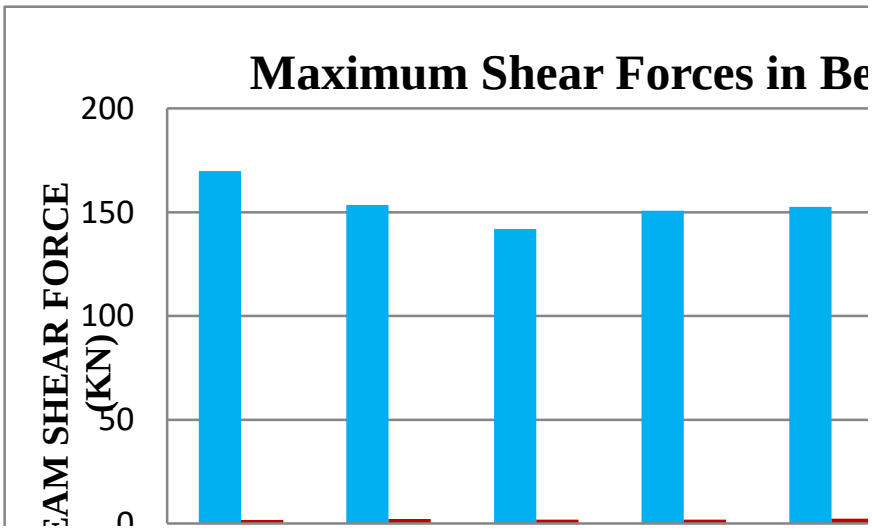


Figure 7: Bar chart of Max. shear force in beam under HP1 to HP6

Maximum Bending Moment in Beam:

Table 9: Maximum Bending Moment in beam

Cases	Beam Bending Moment (KNm)	
	Moment along Y	**Moment along Z**
Case HP1	3.8294	312.7863
Case HP2	5.0307	275.1726
Case HP3	4.6556	250.9902
Case HP4	4.5916	268.8208
Case HP5	5.2171	273.0119
Case HP6	3.8102	273.4766

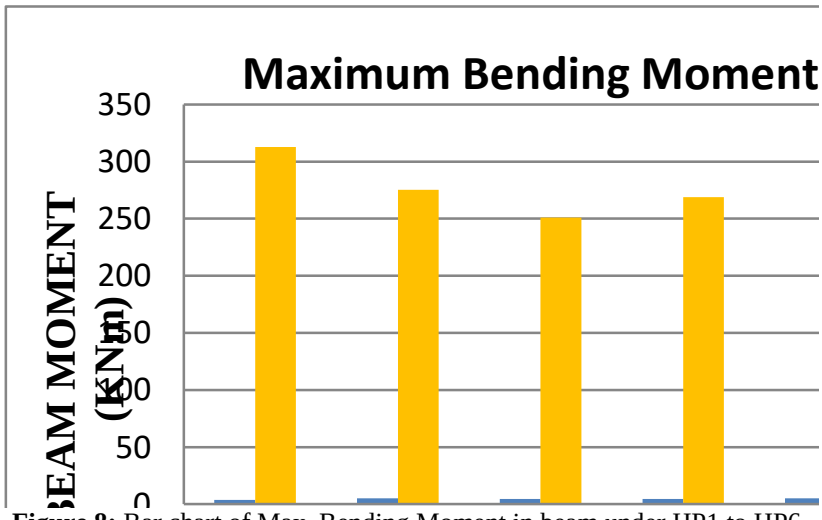
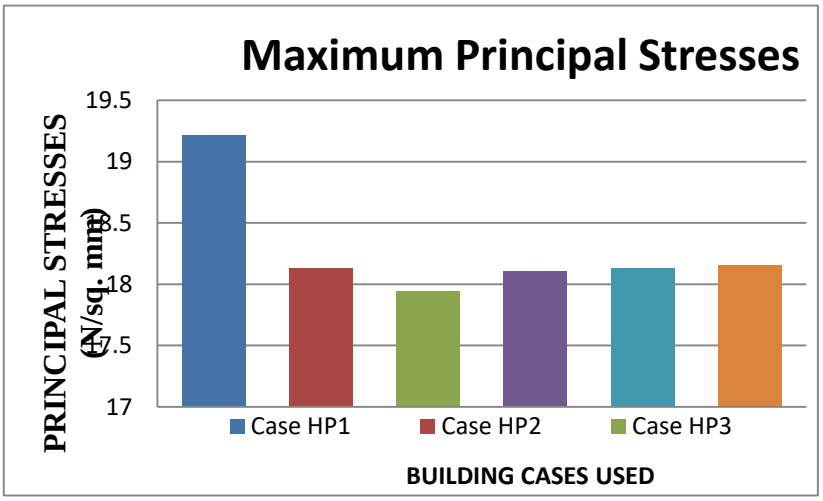


Figure 8: Bar chart of Max. Bending Moment in beam under HP1 to HP6

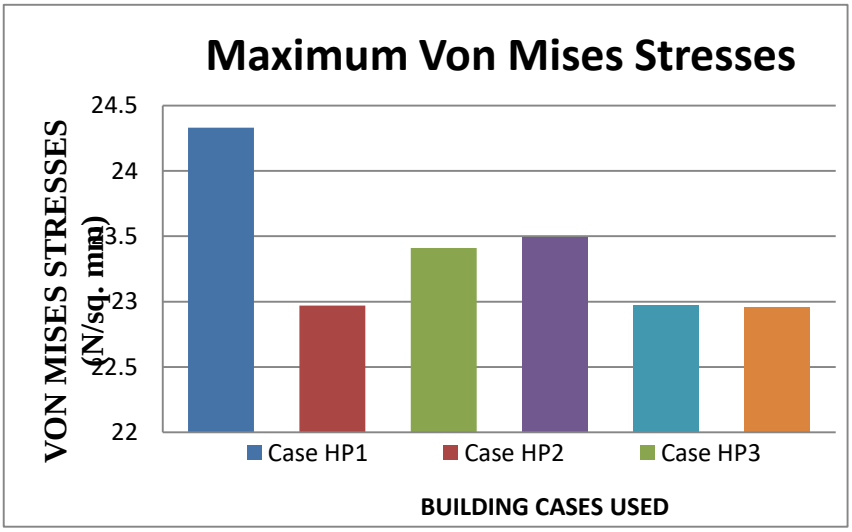
Maximum Stresses developed: Stress is a physical quantity that expresses the internal forces that neighboring particles of a continuous material exert on each other. In this project three types stresses are to be analyzed i.e principal stresses, Von Mises Stresses,Shearing Stresses with their maximum magnitude

Table 10: Maximum Stresses developed

Maximum Stresses developed (N/sq. mm)			
Beam Stability Case	**Maximum Principal Stresses (N/sq. mm)**	**Maximum Von Mises Stresses (N/sq. mm)**	**Maximum Shearing Stresses (N/sq. mm)**
Case HP1	19.21	24.33	7.13
Case HP2	18.13	22.97	7.17
Case HP3	17.94	23.41	11.52
Case HP4	18.11	23.49	11.49
Case HP5	18.13	22.97	7.29
Case HP6	18.15	22.96	7.16



(a)



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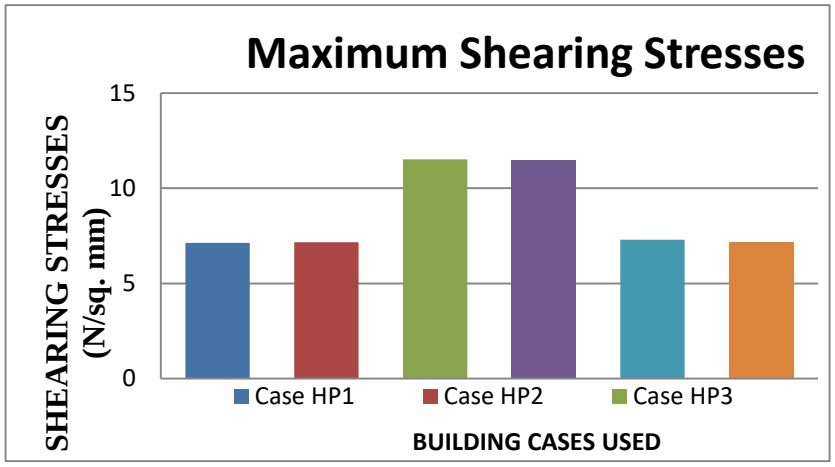

(c)

Figure 9: Bar chart of Max. Stresses developed- Principal Stresses (a) Von Mises Stresses (b) & Shearing Stresses (c) under HP1 to HP6

Conclusions

The following conclusions are obtained based the different results obtained of model HP1 to model HP6.
The Response spectrum approach is adopted in this. The entire conclusion are valid only and only for this project. The conclusions are as follows:

1. The decrement is observed in different parameters & resisting capacity is increases when the outrigger and wall belt is provided.
2. The decrement in the maximum displacement value is 13.27%, 13.51%, 13.19%, 13.38%, 13.49% & 32.31 % in HP2 to HP6 with respect to HP1(regular structure) is observed in X-direction. Similarly 21.41%, 27.45%, 29.31%, 23.04%, 21.14% decrement is observed in HP2 to HP6 with respect to HP1(regular structure) is observed in Z-direction.
3. There is an average value obtained of base shear i.e. 5375.76 KN. The little bit variation is lies in between 1 to 1.3% in base shear value in both X & Z direction. Least value in HP1 & maximum value is in HP2, Other are obtained similar value in it.
4. The outrigger and wall belt system obtained the lesser value of column axial forces. There is decrement of 9.16%, 9.99%, 9.99%, 10.55%, 9.53%, 8.76% is observed in HP2 to HP6 respectively with reference to HP1 model.
5. The increment in the column shear force value is 31.63%, 33.45%, 32.38%, 31.955, 31.29% in HP2 to HP6 respectively with reference to HP1 model in Y direction. Similarly 44.10% , 38.55%, 38.88%, 30.00%, 41.91% increment obtained in HP2 to HP6 respectively with reference to HP1 model in Z direction.
6. The value of column bending moment is increases 2.21, 2.08, 2.09, 1.97, 2.14 times in HP2 to HP6 respectively with reference to HP1 model in Y direction. 1.69, 1.72, 1.71, 1.70, 1.68 times increment is observed in Z direction.
7. There is decrement of 9.58%,16.45%, 11.27%,10.17%,10.05% observed in shear force value in beam in HP2 to HP6 respectively with reference to HP1 model in Y direction. In Z direction the value decreases 26.39%, 9.00%, 6.90%, 29.53% in HP2 to HP5 respectively with reference to HP1 model and slight increment of 0.52% in HP6.
8. There is increment in bending moment value in beam is observed which is 31.37, 21.57, 19.90, 36.23, 0.50% with respect to HP1 in HP2 to HP6 respectively. The decrement is observed Z direction which is 12.02%, 19.75%, 14.05%, 12.71%, 12.56% in HP2 to HP6 respectively with reference to HP1 case.
9. Maximum magnitude of stresses is observed in the Von Mises Stresse, than principal stresses, Shearing Stresses under the respective order of decrement. Slight variation is observed in different model in particular stresses only shear stresses varation is seen mor due to outrigger and wall belt system.

10. All three types stresses i.e principal stresses, Von Mises Stresses,Shearing Stresses with their maximum magnitude are lies under permissible limit as per IS 456-2000 codal provision.
11. Optimum height for placing shear wall belt to increase lateral load handling capacity from above objective parameters will be at 11.50 m i.e. structure with shear strip at 3rd floor. Two more location also predominate in it ie 2^{nd} & 4^{th} floor.
12. The Concept also observed that If N no. of storey is taken Than optimum location is lies under((N/2)-1) to ((N/2)+1), most preferably at (N/2) Storey.

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