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EFFECT OF OUTRIGGER STRUCTURAL SYSTEM IN HIGH RISE BUILDING SUBJECTED TO LATERAL LOADS

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Abstract: Accumulation of growing population especially in developing countries has resulted in an increased height of buildings, this need creating impact on structural development of tall building. And hence tall building construction has been rapidly increasing worldwide. Lateral forces are the most important factors to be considered when it comes to controlling lateral deflection of the building. And for that several lateral load resisting systems have been implemented in the field since years. Outrigger-belt truss system has been found to be one of the most effective system and hence are used worldwide. In the present study a 40 storey multistoried R.C.C building model is modelled using Etabs 2018 software. Response spectrum analysis is made by considering building situated in zone III.Building models are analyzed by Etabs 2018 software to study the effect of storey shear, base shear, base moments, maximum displacement, time period and maximum storey drifts etc

Keywords: Outrigger-belt truss system, tall building, Response spectrum analysis, Etabs software.

I. INTRODUCTION

A. Outrigger systems

Outriggers are deep and stiff beam/truss which connect the central core to the exterior most columns in a frame. This reduces the deflection of the building by keeping all the columns in their position and making the building act as a single unit. This reduces the horizontal movement of core and makes the structure stiffer.

Fig. 1 Outrigger systems

The performance of the outrigger system is affected by the outrigger locations along the height of the building, the number of level of outriggers provided, their plan locations, presence of the belt trusses, outrigger truss depth and primary structural materials used in our study, braced core frame i.e. reinforced concrete shear wall core acting in conjunction with the concrete. belt truss and outrigger struts are provided which resist the earthquake loads by stiffening the whole structure.

B. Objectives of the Present Study

1.To study the behavior of lateral forces on high rise buildings with varying geometry in high seismic zones.

2.To apply outrigger systems on the structures and find out the optimum performance of this systems with suitable geometry in the respective seismic zone.

3.To compare the structures based on stiffness parameters, relative displacement, ductility and resistance compared with each other.

4.To propose a suitable, economic and optimum position of outrigger system suitable according to the respective lateral load.

5.To study the response of buildings in terms of storey shear, storey drift, storey displacement, time period, Base shear, Base moments, storey displacement, etc.

II. MATERIALS AND METHODS

A. Preliminary data required for Rectangular Geometry Analysis

Two models are prepared in this study for the analysis and study. The constant parameters in all the two models are as below:

Model No 1: Rectangular geometry without outrigger belt truss system for zone III

Model No 2: Rectangular geometry with outrigger belt truss system for zone III

Table 1 Parameters to be consider for rectangular geometry analysis

Sr. No.	Parameter	Values
1.	Number of storey	G+40
2.	Floor height	3.2m
3.	Infill wall	150 mm thick
4.	Materials	Concrete 50 and Reinforcement Fe 500
5.	Frame size	18m X 24m building size
6.	Grid spacing	4.5m grids in X-direction and 6m grids in Y-direction.
7.	Size of column	1000 mm x 1000 mm
8.	Size of beam	300mm x 600 mm
9.	Outrigger truss beam	500mm x 550 mm
10.	Belt truss beam	500mm x 550 mm
11.	Cross Bracing	300mmx300mm
12.	Depth of slab	225 mm
13.	Plan area	432 m^2
14.	Shear wall	300mm

B. Load details

Table 2. Load details

a.	Dead load	In ETABS the software itself calculates the dead loads by applying a self-weight multiplier factor of one which is taken by the structure and the rest load cases are kept zero. Its defined in the load cases section.
b.	Live load on roof and floors	2 kN/m^2 (roof) and 4 kN/m^2 (Floors) as per IS:875 (part -2)
c.	Floor finish on roof and floors	1.5 kN/m^2 as per IS:875 (part -2)
d.	Wall load on all levels	8.1 kN/m

C. Seismic data required for analysis

Table 3 Seismic data required for analysis

Sr. No.	Parameter	Values as per IS 1893:2016 (Part1)	Reference
1.	Type of structure	Special RC moment resisting frame	Table 9, Clause 7.2.6
2.	Seismic zone	III	Table 3, Clause 6.4.2
3.	Location	Pune	Annex E
4.	Zone factor (Z)	0.16	Table 2, Clause 6.4.2
5.	Type of soil	Rock or Hard Soil	Clause 6.4.2.1
6.	Damping	5 %	Clause 7.2.4
7.	Response spectra	As per IS 1893 (part 1):2016	Figure 2, Clause 6.4.6
8.	Load combinations	1) 1.5(DL + IL) 2) 1.2(DL+IL+ EL) 3) 1.5(DL + EL) 4) 0.9DL + 1.5 EL	Clause 6.3.1
9.	Response reduction factor (R)	5	Table 9, Clause 7.2.6
10.	Importance factor (I)	1.5 (Hospital, Schools, Hotel Buildings)	Table 8, Clause 7.2.3

D. Wind data required for analysis

Table 4 Wind data required for analysis

Sr. No.	Parameter	Values as per IS 875-2015 (Part3)	Reference
1.	Basic wind speed (Vb)	Pune=39m/sec,	Annex A
2.	Risk coefficient k1	1	Table 1, Clause 6.3.1
3.	Terrain category	3	Table 2, Clause 6.3.2.2
3.	Topography Factor k3	1	Table 3, Clause 6.4.2
3.	Importance Factor k4	1	Clause 6.3.4
5.	Windward coefficient cp	0.8	Clause 7.3.3
6.	Leeward coefficient cp	0.5	Clause 7.3.3

Model No 1: Plan of rectangular geometry without outrigger belt truss system for zone III

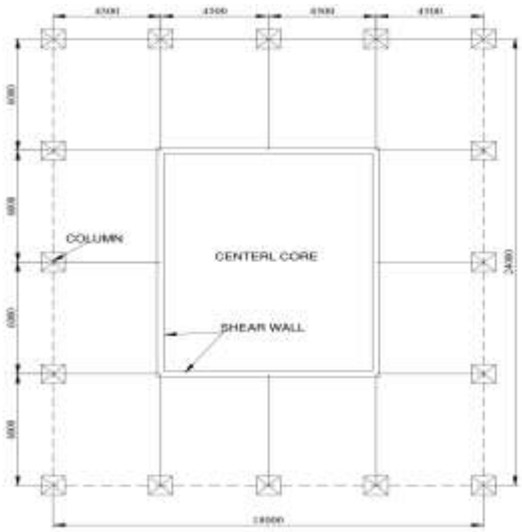


Fig. 2 Plan of rectangular geometry without outrigger belt truss system for zone III

Model No 1: Elevation of rectangular geometry without outrigger belt truss system for zone III

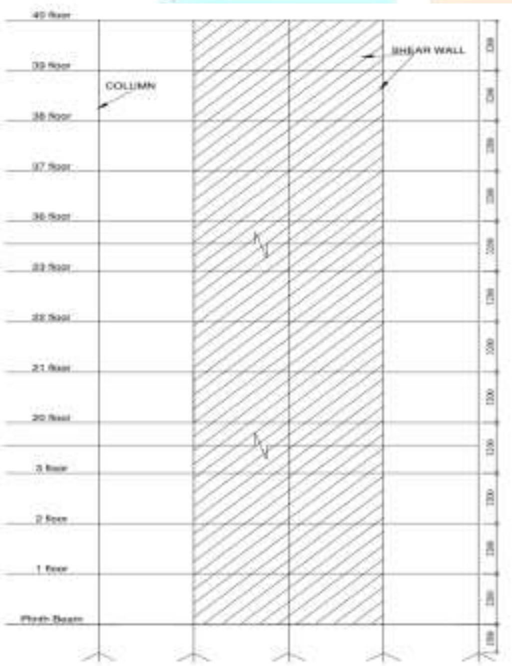


Fig. 3 Elevation of rectangular geometry without outrigger belt truss system for zone III

G. Model No 2: Plan of rectangular geometry with outrigger belt truss system for zone III

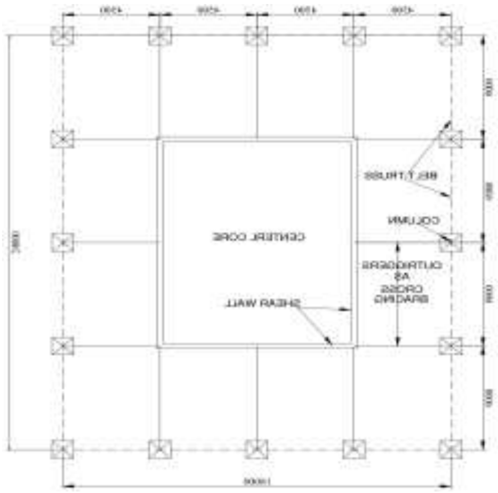


Fig. 4 Plan of rectangular geometry with outrigger belt truss system for zone III

H. Model No 2: Elevation of rectangular geometry with outrigger belt truss system for zone III

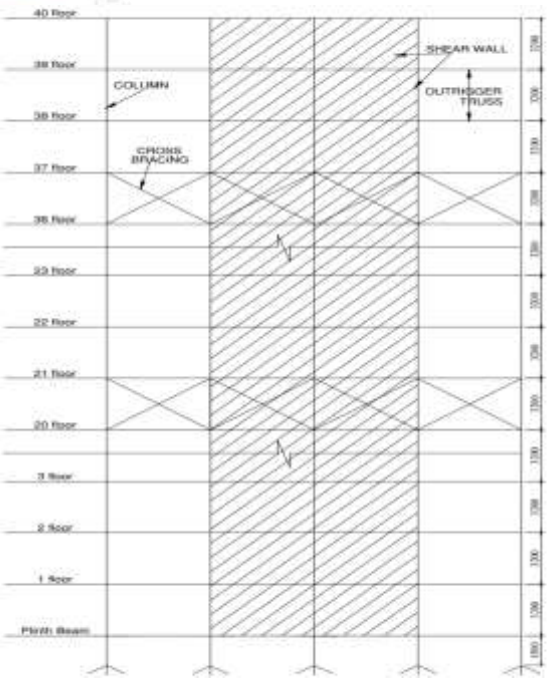
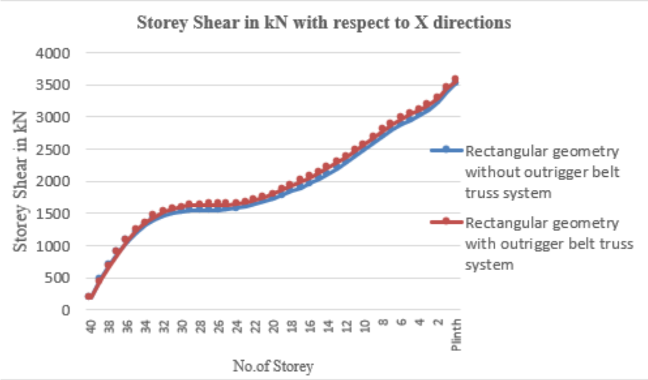


Fig. 5 Elevation of rectangular geometry with outrigger belt truss system for zone III

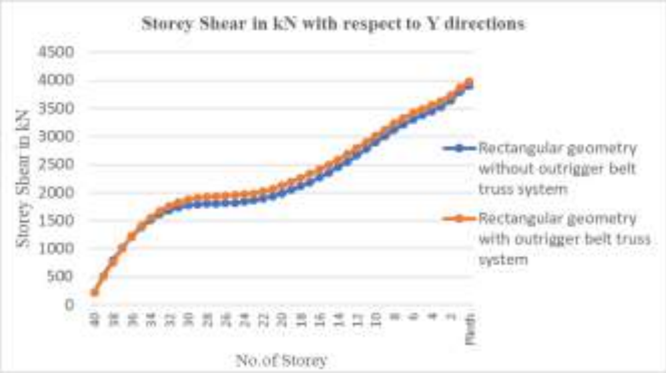
III. RESULTS AND DISCUSSION

3.1 Storey Shear (in KN)

Storey shear values for rectangular geometry with and without outrigger belt truss system for zone III models are obtained using Response spectrum analysis from the Etabs software



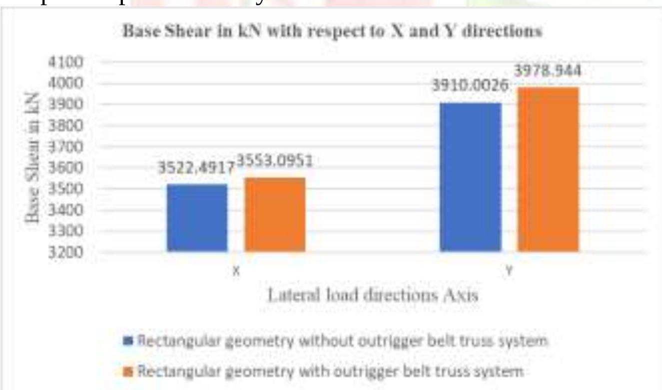
Graph 1 Storey Shear in kN with respect to X



Graph 2 Storey Shear in kN with respect to Y

3.2 Base Shear (in KN)

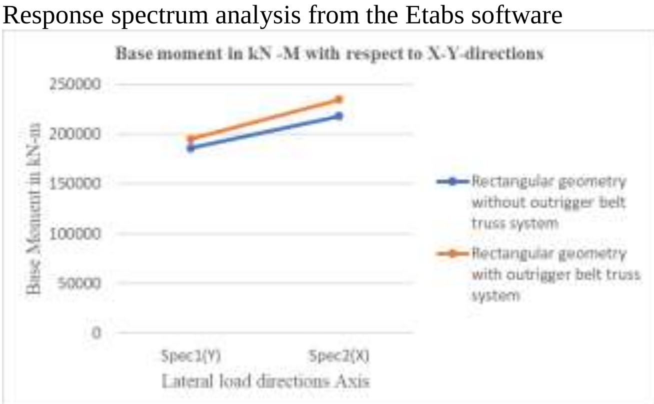
Base shear values for rectangular geometry with and without outrigger belt truss system for zone III models are obtained using Response spectrum analysis from the Etabs software



Graph 3 Base Shear in kN with respect to X and Y-direction

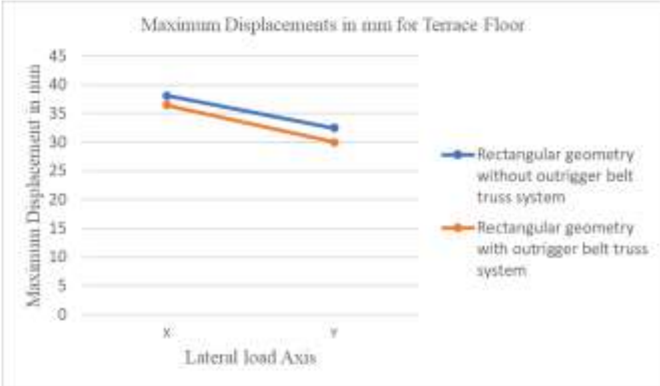
3.3 Base Moment (in KN-m)

Base moment values for rectangular geometry with and without outrigger belt truss system for zone III models are obtained using Response spectrum analysis from the Etabs software



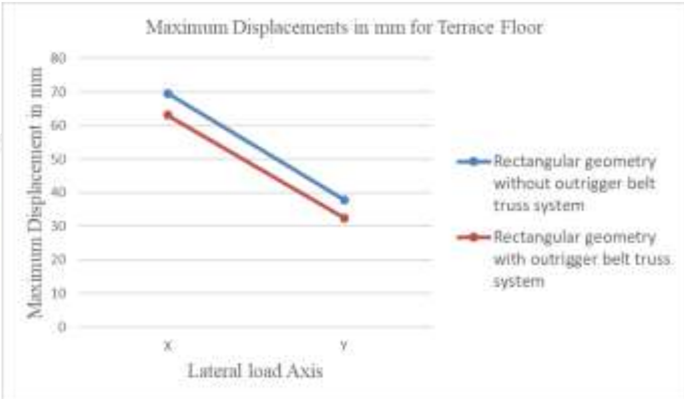
Graph 4 Base Moment in kN-m with respect to X and Y-directions

3.4 Maximum Displacements for Earthquake Load Case



Graph 5 Maximum Displacements for rectangular geometry with and without outrigger belt truss system for Earthquake Load Case

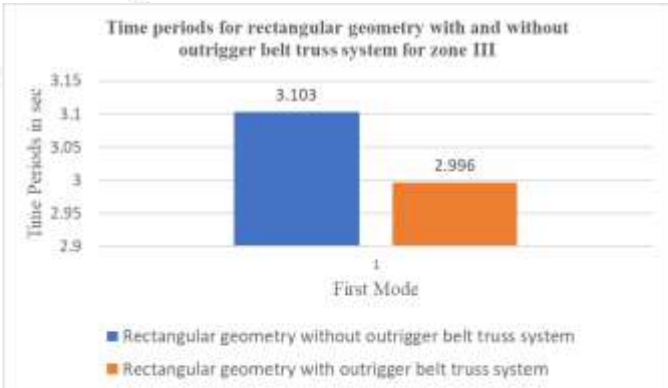
3.5 Maximum displacement for Wind Load Case



Graph 6 Maximum Displacements for rectangular geometry with and without outrigger belt truss system for Wind Load Case.

3.6 Time period:

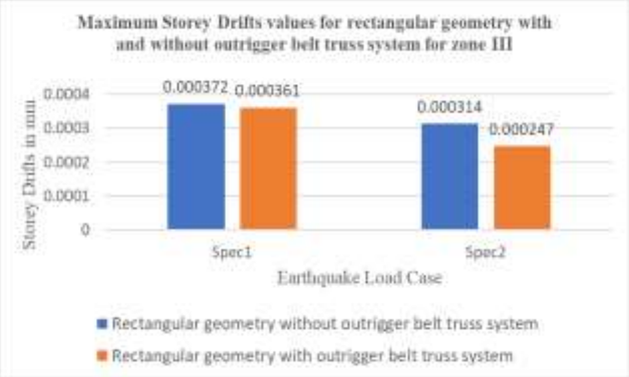
Time Period values for rectangular geometry with and without outrigger belt truss system for zone III models are obtained using Response spectrum analysis from the ETABS software



Graph 7 Time Period values for rectangular geometry with and without outrigger belt truss system for zone III

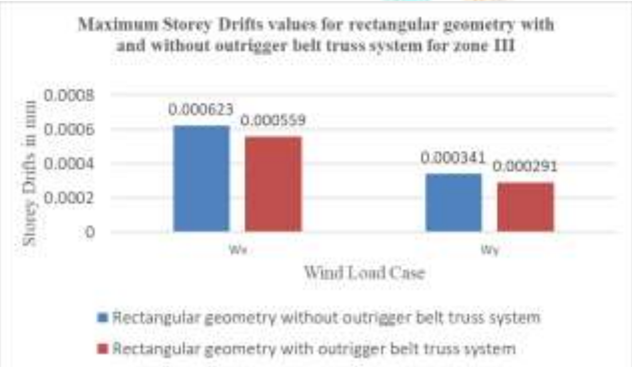
3.7 Maximum Storey Drifts for Earthquake Load Case

Maximum Storey Drifts values for rectangular geometry with and without outrigger belt truss system for zone III



Graph 8 Maximum Storey Drifts values for rectangular geometry with and without outrigger belt truss system for Earthquake Load Case

3.8 Maximum Storey Drifts for Wind Load Case



Graph 9 Maximum Storey Drifts values for rectangular geometry with and without outrigger belt truss system for Wind Load Case

IV. CONCLUSIONS

The performance and implementation of proposed outrigger structural system are very much dependent on the number of factors such as its position, construction cost, construction time, bracing type and material etc. The behavior of a structure against lateral loads is highly dependent on the location of outrigger beam. The optimum location of outrigger beam, in general, can be said to be at mid-height of the building for single outrigger.

1. As per IS 1893-2016 (part 1) a structure with core structural walls, perimeter columns, outriggers and belt truss system structural system has enhanced lateral stiffness, where in core structural walls and perimeter columns are mobilized to act with each other through the outriggers, and the perimeter columns themselves through the belt truss. The global lateral stiffness is sensitive to flexural stiffness of the outrigger elements, the axial stiffness of the outrigged columns and the flexural stiffness of the outrigger elements connecting the core structural walls to the perimeter columns.
2. When the system is provided with two outriggers, out of which one is fixed at 0.9H from bottom of the building, the optimum location of the second outrigger is at 0.5H from bottom of the building.
3. The use of outrigger structural method will increase the total stiffness of the structure via connecting the building core to the remote column and makes the whole device to behave as a one unit in resisting the total lateral load.
4. Outrigger structural system provides stiffness to the structure hence making it one of the most effective systems against seismic as well as wind forces.
5. Earthquake load cases: The X-Axis of Maximum displacements for rectangular geometry without outrigger belt truss system for zone III is 4.25 % more than rectangular geometry with outrigger belt truss system for zone III
6. Earthquake load cases: The Y Axis of Maximum displacements for rectangular geometry without outrigger belt truss system for zone III is 7.56 % more than rectangular geometry with outrigger belt truss system for zone III.
7. Wind load cases: The X-Axis of Maximum displacements for rectangular geometry without outrigger belt truss system for zone III is 9.23 % more than rectangular geometry with outrigger belt truss system for zone III
8. Wind load cases: The Y-Axis of Maximum displacements for rectangular geometry without outrigger belt truss system for zone III is 13.99 % more than rectangular geometry with outrigger belt truss system for zone III
9. Earthquake load cases: The X-Axis of Maximum Storey Drifts for rectangular geometry without outrigger belt truss system for zone III is 2.96 % more than rectangular geometry with outrigger belt truss system for zone III
10. Earthquake load cases: The Y-Axis of Maximum Storey Drifts for rectangular geometry without outrigger belt truss system for zone III is 21.33 % more than rectangular geometry with outrigger belt truss system for zone III.
11. Wind load cases: The X-Axis of Maximum Storey Drifts for rectangular geometry without outrigger belt truss system for zone III is 10.27 % more than rectangular geometry with outrigger belt truss system for zone III
12. Wind load cases: The Y-Axis of Maximum Storey Drifts for rectangular geometry without outrigger belt truss system for zone III is 14.66 % more than rectangular geometry with outrigger belt truss system for zone III

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