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Analysis of Multistoried Buildings to Study the Influence of Depth of Belt Truss System

Shahana E[1], Arathi S[2]

[1]PG Student, Sree Buddha College of Engineering, Elavumthitta, Pathanamthitta, Kerala

[2]Assistant Professor, Sree Buddha College of Engineering, Elavumthitta, Pathanamthitta, Kerala

Abstract: ***As height of building increases its displacement, storey drift and storey shear of the building increases abruptly. So, in order to restrain those parameters in the building especially under lateral loading, suitable methods are to be taken. In present tall buildings, those forces are often resisted by a system of Belt Truss. Belt truss is defined as the truss provided to the peripheral column of the structure around the core at particular height of the building, in order to provide sufficient firmness and strength against lateral loads. The paper aims to study the influence of depth of belt truss system in multistoried buildings. And also studied the effectiveness of belt truss system in irregular buildings. Response Spectrum Method is used for the dynamic analysis in the software ETABS 9.6. The parameters considered in the study are storey displacement, drift and base shear of the buildings. Results show that belt truss reduces storey displacement and drift and increases base shear of buildings. There is no much effect for increasing the depth of belt truss than single storey height.***

Keywords: belt truss system, irregular building, depth, response spectrum analysis

1. Introduction

Contemporary tall buildings developed in 1880's were mostly used for commercial and residential building purposes. Due to quick augmentation of population and pressure on the limited space available tends to increase tall buildings. Tall buildings are constructed based on the purpose they are used, whether it may be for commercial or residential purposes. Loads acting on a building will be of vertical, horizontal or torsion type of load which has different effects on building. The primary function of the structural elements is to resist the gravity loading from the weight of the building and its contents. Secondary function of the vertical structural elements is to resist the wind and earthquakes whose magnitude will be varied from the epicenter to epicentral distance, which is obtained from IS 1893-2002. As height of structure increases, its displacement, storey drift, storey shear of the building decreases abruptly. So, in order to restrain those parameter in the building especially under seismic and wind load suitable method should be taken to reduce those effects in the building.

This thesis focuses on the effectiveness of belt truss system on irregular buildings and influence of depth of belt truss systems. Belt trusses are provided at the top and mid-height of the buildings.

2. Objectives

- To investigate the effectiveness of belt truss system in various irregular plan shape.
- To investigate the influence of depth of belt truss systems in multistoried buildings.

3. Methodology

Response spectrum analysis is adopted for the analysis.

4. Modeling and Analysis

4.1 Geometric Modeling of Buildings

A G+30 storied Square, Cross, T, L and Step shaped buildings are modeled using ETABS 9.6 software for this study. Buildings are considered in zone III and soil type II. Here, buildings having belt truss system with different depth combinations are studied. They are:

1) Building without belt truss system (T0M0)
2) Single storey depth at top and mid height of the building (T1M1)
3) Single storey depth at top and double storey depth at mid height of the building (T1M2)
4) Double storey depth at top and single storey depth at mid height of the building (T2M1)
5) Double storey depth at top and mid height of the building (T2M2)

Table 1: Dimensional Details Of Building

Property	*Value*
Floor height	3m
Beam Size	450×450mm
Column Size	700×1000mm
Slab Thickness	125mm
Shear Wall Thickness	300mm
Wall Thickness	230mm

Table 2: Plan Dimensions

Shape	*Plan dimension*	*No of bays*	
		X	*Y*
Square	33.54 x 33.54 m	7	7
Cross	35 x 35 m	7	7
T shape	45 x 50 m	9	10
Step shape	40 x 40 m	8	8
L shape	50 x40 m	10	8

Table 3: Material Properties

Property	*Value*
Concrete Grade	M30
Modulus of Elasticity	22360N/mm^2
Compressive Strength	30N/mm^2
Steel	Fe500
Strength of Steel	500N/mm^2

Table 4: Properties Of Belt Truss

Property	*Details*
Material	Fe 415
Section Shape	Steel Pipe
Outside Diameter	300 mm
Inside Diameter	149 mm
Shape Considered	Belt X

Fig. 1 shows the position of belt truss system in a G + 30 building.

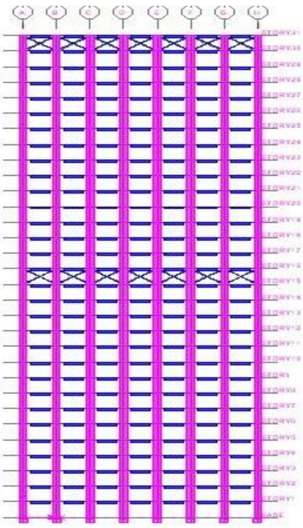

Figure 1: Position of Belt Truss System (T1M1)

Table 5: Loading Details

Type of Load	*Value*
Wall load	11.73 kN/m
Parapet load	6.9 kN/m
Live load	3 kN/m^2
Roof Load	1.5 kN/m^2
Floor Finish	1 kN/m^2

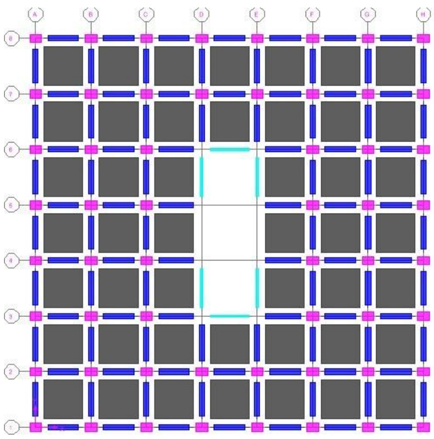

Figure 2: Plan of regular Square Building

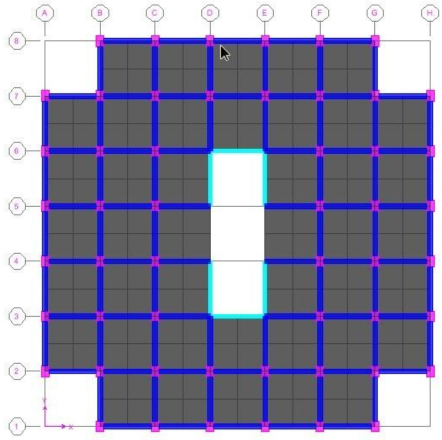

Figure 3: Plan of Cross Shaped Building

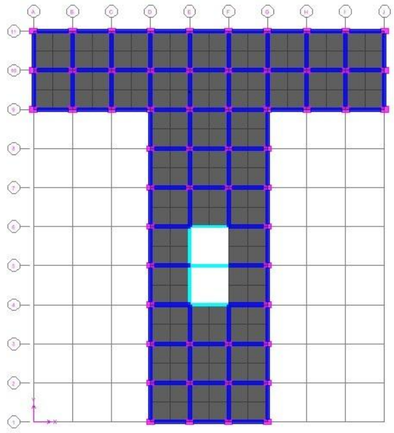

Figure 4: Plan of T Shaped Building

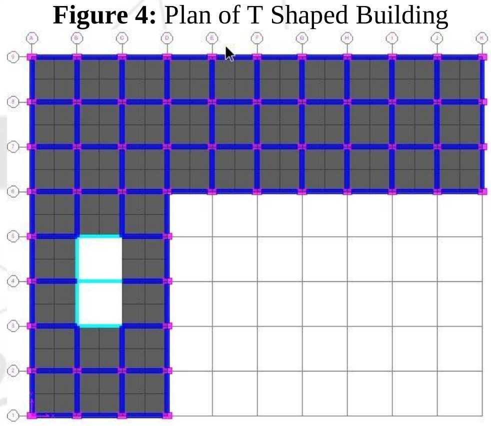

Figure 5: Plan of L Shaped Building

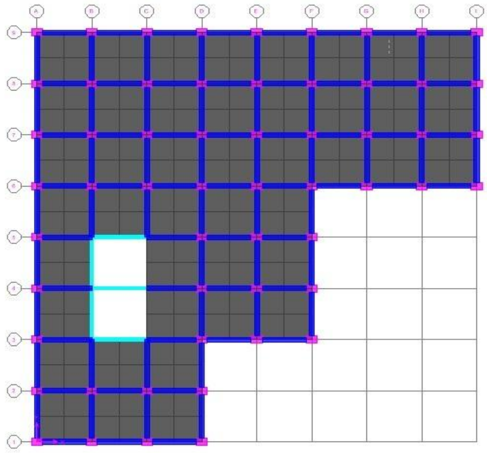

Figure 6: Plan of Step Shaped Building

4.2 Analysis

Response spectrum analysis is carried out in G+30 square, cross, T , L and step shaped buildings with and without belt truss systems. Maximum storey displacement, drift and base shear along X and Y directions are obtained from the analysis and percentage variations are calculated.

Percentage variation of displacement, drift and base shear are given table 6 to table 10 for different plan shaped buildings. The results obtained during the analysis of buildings are tabulated.

Table 6: Analysis Results of Square Shaped Buildings

Parameter	*Storey Displt. (mm)*		*Drift × 10^{-4}*		*Base Shear (kN)*	
Direction	*X*	*Y*	*X*	*Y*	*X*	*Y*
T0M0	25.93	28.5	1.890	2.039	2783.19	2524.0
T1M1	24.38	26.4	1.366	1.570	2906.79	2631.7
T1M2	23.6	25.6	1.410	1.546	2988.19	2726.9
T2M1	23.96	26.1	1.033	1.160	2926.12	2648.5
T2M2	23.32	25.3	1.068	1.919	3008.76	2745.6

It is observed from the Table 6, displacement has almost same value for TIM2, T2M1 and T2M2. Drift has minimum value for T2M1. Base shear has minimum value for T1M1 but, T1M1 and T2M1 has only slight variation. There is no much more difference in the values of displacement, drift and base shear for all these combinations.

Table 7: Analysis Results of Cross Shaped Buildings

Parameter	*Storey Displt. (mm)*		*Drift × 10^{-4}*		*Base Shear (kN)*	
Direction	*X*	*Y*	*X*	*Y*	*X*	*Y*
T0M0	22.69	24.03	1.920	1.886	2120.16	1968.7
T1M1	21	21.7	1.168	1.106	2239.69	2104.63
T1M2	19.95	21.07	1.166	1.1	2306.26	2190.76
T2M1	20.64	21.35	0.793	0.784	2255.99	2126.18
T2M2	19.95	20.72	0.797	0.766	2323.32	2201.76

It is observed from the Table 7, displacement in x direction has minimum value for TIM2 and T2M2. Displacement in y direction has minimum value for T1M2. All combinations have only slight variation in the value of displacement. Drift has minimum value for T2M1 and T2M2. Base shear has minimum value for T1M1 but, T1M1 and T2M1 has only slight variation. There is no much more difference in the values of displacement, drift and base shear for all these combinations.

Table 8: Analysis Results of T Shaped Buildings

Parameter	*Storey Displt. (mm)*		*Drift × 10^{-4}*		*Base Shear (kN)*	
Direction	*X*	*Y*	*X*	*Y*	*X*	*Y*
T0M0	59.51	42.63	4.672	3.364	2139.4	2877.2
T1M1	51.14	36.96	2.157	1.314	2132.7	3039.1
T1M2	49.32	35.12	2.082	1.268	2235.8	3156.8
T2M1	49.86	35.88	1.612	0.953	2197.6	3082.7
T2M2	47.97	34.24	1.569	0.986	2242.3	3193.2

It is observed from the Table 8, displacement has minimum value for T2M2. Drift in x direction has minimum value for T2M2 and in y direction for T2M1. Base shear has minimum value for T1M1 but, T1M1 and T2M1 has only slight variation. For T1M2 and T2M2, base shear has almost same value.

Table 9: Analysis Results of L Shaped Buildings

Parameter	Storey Displt. (mm)		Drift × 10^{-4}		Base Shear (kN)	
Direction	X	Y	X	Y	X	Y
T0M0	21.84	27.51	1.633	1.279	9701.72	8189.5
T1M1	19.95	26.26	1.308	0.949	10259.5	8344.1
T1M2	19.84	26.02	1.307	0.950	10386.9	8488.4
T2M1	19.95	26.10	1.143	0.879	10315.1	8374.9
T2M2	19.62	25.77	1.167	0.868	10420	8518.8

It is observed from the Table 9, displacement has almost same value for all combinations. Drift has also only slight variations. Base shear has minimum value for T1M1 but, T1M1 and T2M1 has only slight variation. There is no much more difference in the values of displacement, drift and base shear for all these combinations. There is no much effect in increasing depth of belt truss system for L shaped building. Table 10 gives the analysis results of step shaped buildings.

Table 10: Analysis Results of Step Shaped Buildings

Parameter	*Storey Displt. (mm)*		*Drift × 10^{-4}*		*Base Shear (kN)*	
Direction	*X*	*Y*	*X*	*Y*	*X*	*Y*
T0M0	44.63	47.02	3.005	2.629	2294.4	2207.02
T1M1	38.16	41.26	1.323	1.295	2442.0	2266.74
T1M2	36.31	39.13	6.462	7.629	2503.4	2216.08
T2M1	37.29	40.51	0.885	0.859	2435.2	2257.35
T2M2	35.22	38.59	0.862	0.811	2522.5	2246.52

It is observed from the Table 10, displacement has minimum value for T2M2 and then T1M2. Drift has minimum value for T2M1 and T2M2. Base shear in x direction has minimum value for T1M1 but, T1M1 and T2M1 has only slight variation. Base shear in y direction has minimum value for T1M2 and all combinations have only slight variations in value.

5. Results and Discussion

T and step shaped buildings shows better percentage reduction for displacement and drift by providing belt truss system in the building. Therefore, Belt truss system is found to be more effective in case of T and Step shaped buildings. The value of displacement and drift is reduced little more for T and step shaped buildings when compared with other shaped buildings, by introducing double storey depth for belt truss systems. But it can be negligible while considering the economic factors. Thus providing belt truss system in single storey depth at top and mid height of the building is suitable for better performance. There is no effect on decreasing the displacement and drift of the multistoried buildings by increasing the depth of belt truss system.

6. Conclusions

The study is carried out to find out the effectiveness of belt truss system in various irregular shaped buildings and to find out the influence of depth of belt truss systems in multistoried buildings. From the above study, following conclusions were drawn.

- The usage of belt truss system in a building increases the efficiency when compared to the building without belt truss under the action of seismic loads.
- Buildings without belt truss system shows higher storey displacement and drift with lower base shear than the building with belt truss system.
- As compared to regular square building, belt truss system is more effective in irregular shaped buildings.
- Belt truss system is found to be more effective in case of T and Step shaped buildings
- Providing belt truss system in single storey depth at top and mid height of the building is suitable for better performance.
- There is no effect on decreasing the displacement and drift of the multistoried buildings by increasing the depth of belt truss system.

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Author Profile

Shahana E, P.G student in Computer Aided Structural Engineering, Department of Civil Engineering, Sree Buddha College of Engineering, APJ Abdul Kalam Technological University, Kerala. Obtained Btech from Musaliar College of Engineering and Technology, Pathanamthitta under Mahathma Gandhi University, Kottayam in the year 2015.

Arathi S, Assistant Professor, Department of Civil Engineering, Sree Budha College of Engineering, Pathanamthitta, APJ Abdul Kalam Technological University, Kerala. Obtained Bachelor's degree in Civil Engineering from Sree Buddha college of Engineering, Pattoor in the year 2012. Masters degree in Structural Engineering from NSS College of Engineering, Palakkad in the year 2015.