# RCC Framed Building with Using Belt Truss

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*Abstract:* There may be a high demand for highrise buildings in modern society and therefore the proceeded demand for development and highrise buildings has established the requirement for more extraordinary and efficient construction systems. One such system is that the Outrigger system. These lateral loads are wind and seismic loads. To forestall this lateral load on high-rise buildings and appropriate working construction system must be identified. For lateral resistance of high buildings there are many construction working systems. In tall buildings the stiffness and the drift of the building is even more important and useful. The aim of the paper is to detailed and conceptualizing the varied configurations of belt truss structures system and to integrate current tall structures into longer by use of belt truss system. Additionally many issues associated with outriggers and belt truss systems are also discussed in the paper in detailed. A close scrutiny of literature accessible within the field of Outrigger system is applied and therefore the summary and gaps encountered and discussed within the study are listed during this paper. This paper introduces a substitute concept of virtual Outrigger system. In which using the belt truss structural within the RCC construction building so as to extend the performance of the building under the dynamic loads is researched. The assorted benefits of using virtual Outrigger over traditional ones are emphasized. Knowledge of Basements as a Virtual outrigger is further reviewed inside the paper.

**Index Terms - Belt Truss, Outrigger, High Rise Building, Lateral Load Resisting System (LLRS).**

## I. INTRODUCTION

The development in high rise buildings has progressed rapidly in recent last few years. Now a day's population from rural areas is migrating in large numbers to metro cities. Because of this, metro cities have gotten densely populated day by day. As population is getting denser the provision of land is diminishing and price is additionally increasing. Hence to beat these problems multi-story buildings is most prominent and efficient solution. There's no formal definition for Tall Buildings, building having height quite 35 meters is taken into account as tall building. It doesn't necessarily depends on height but also the locality within which the building is to be constructed, as an example - A 12 storied building might not be considered a tall building during a High-rise city like metropolis or Singapore but might be considered a tall building in less developed cities. Development in tall buildings involves various compound aspects as an example, Shortage of land in urban areas, Increasing demand for business and residential space, Technological Advancements, Innovations in structural systems, economic process , Concept of city skyline, Cultural signification and prestige, Human aspiration to create higher In developing country like India and increased number of population, tall buildings may well be effectively wont to meet the strain of the technologically advancing society of our generation and solve the matter of limited availability of land for construction and is most.

### 2.1 Structural Systems

There are two categories of reinforced cement concrete framed structural system, Interior structures and Exterior structures. When the foremost a part of the lateral load resisting system is found within the inside part of the building it's called as interior structure and if the foremost part of the lateral load-resisting system is found at the perimeter of the building, this method is categorized as an exterior structure.

***Interior Structure***

- Rigid Frames System
- Shear Wall System/ Hinged Shear Wall (Or Shear Truss) System
- Outrigger And Belt Truss StructureSystem

***Exterior Structure***

- TubeSystem
- Space Truss Structural System
- Super Frames System

Each complex variety of this structural category, tall buildings are designed with different form of structural systems, like braced tube, diagrid and outrigger systems. Recently in commercial and residential construction industry, the belt truss and outrigger system is widely accustomed reduce lateral drift. The location of outrigger trusses in building increases the effective depth of the structure and significantly improves the lateral stiffness of the structure under lateral load.

### 2.2 Outrigger and Belt Truss as Structural System

The Outrigger and Belt truss system is usually used as one of the structural system to effectively control the excessive drift because of lateral load, so that, during small or medium lateral load because of wind or earthquake load, the danger of structural and non-structural damage will be decreased. From many years' structure are built using belt truss and outrigger system for lateral load transfer. This technique is extremely effective when employed in tall buildings. The belt truss tied the peripheral column of building however the outriggers engross them with main or central shear wall. The outrigger concept is in widespread use today within the design of tall buildings. During this concept, "outrigger" trusses (or, occasionally, girders) extend from a lateral load-resisting core to columns at the outside of the building. The core may encompass either shear walls or braced frames. The core is also centrally situated with outriggers extending on either side or in some cases it's going to be situated on one side of the building with outriggers extending to the building columns on the opposite side.

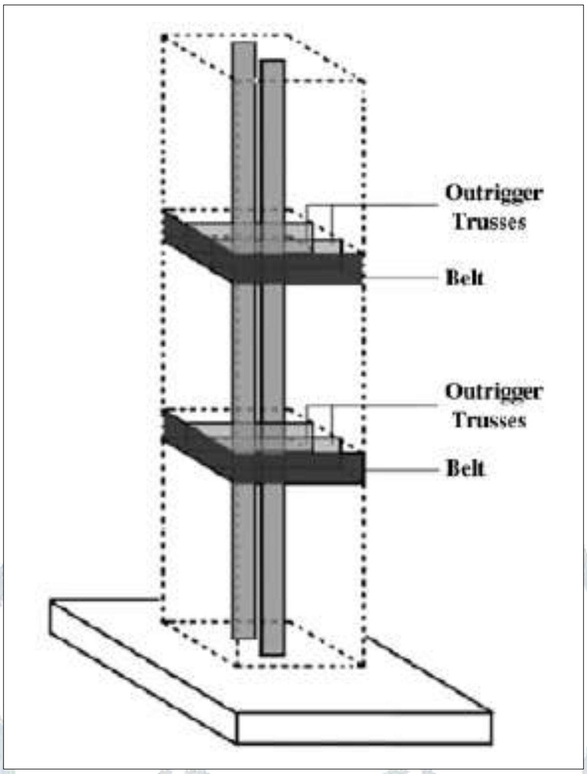


*Figure 1 Multi-Level Belt Truss and Outrigger*

The outriggers and belt truss are generally within the kind of trusses in steel member structures, or walls in concrete structural system, that effectively act in structure as stiff headers inducing a tension-compression couple in the structure or member within the outer columns. The outrigger systems could also be formed in any combination of steel, concrete and composite construction. Belt trusses are often provided to distribute these tensile and compressive forces to an outsized number of exterior frame columns. The belt trusses in the structure also help in minimizing differential elongation and shortening of columns of the structure. Outriggers can even be supported on mega-columns within the perimeter of the building. Although this structure in the building is primarily an indoor system for the structure, the belt trusses or mega-columns offer a wider perimeter in the construction, thus resisting the lateral push i.e lateral load of the building's

**2.3Advantages of Outrigger Structural System**

1. All external columns (not just specific outrigger columns) play a task in resisting overturning moment.
2. Core overturning moments of the structure will be reduced through the reverse moment applied to the core wall at each outrigger connection of the structure.
3. Exterior frame of RCC structure can incorporates simple beam and column framed without the requirement for rigid-frame-type connection, thus reducing the general cost of the structure.
4. Reduction or elimination of uplift pressure within the structure and net tension forces within the structure without the column and foundation system.
5. There aren't any trusses within the space between the within core and out of doors of the building.

## 3. METHODOLOGY:

1. In this project an RC multi-storeyed building is used with shear walls and belt truss at different locations."
2. In this study following methodology was adopted, in order to attain the described objectives:
3. The use of belt truss in structural system as a virtual outrigger truss placed at different location of the building, by using shear wall to control the deflection of multistoried building against lateral loads acting by seismic load.
4. For earthquake loading calculation, IS 1893(PART–I):2002is used.
5. For the design of shear wall and other components IS 456-2000 and IS 13920 is used.
6. Modelling& Analysis: G+24 multi-storey building modelled with and without belt truss, using ETABS software and on further carrying out response spectrum analysis in EQ zone IV, performance comparison was done for both the structure.
7. Analysis of same prototype with and without bracings.
8. Analyzing the model with static as well as with dynamic loading and comparing the results is done.
9. Simplification of result and elaborative conclusion will be done.

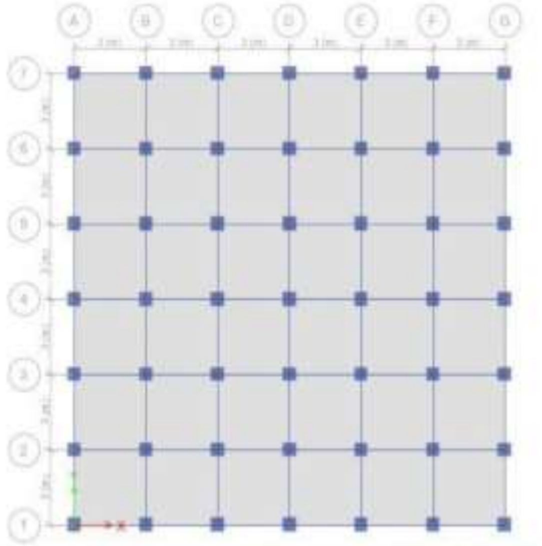


*Fig1 Plan Layout*

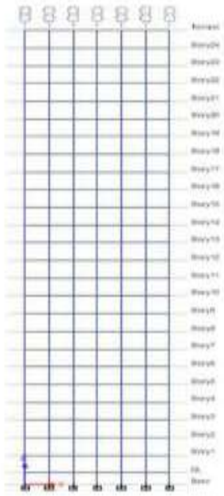

*Fig 2 Plan Layout*

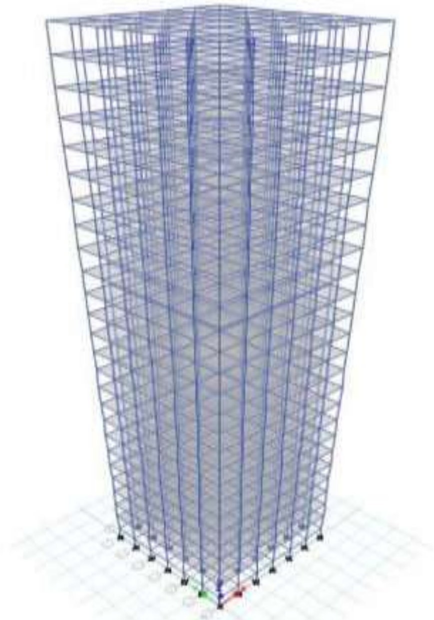

*Fig 3 Sectional Elevation Of Building Model 1(Without Outrigger)*

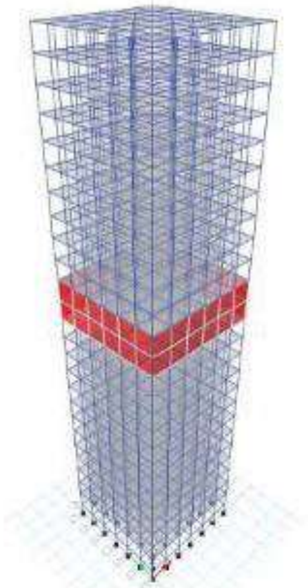

*Fig 4 Perspective View Of A Storey At Outrigger Location Madel 2 (With X Outriggers)*

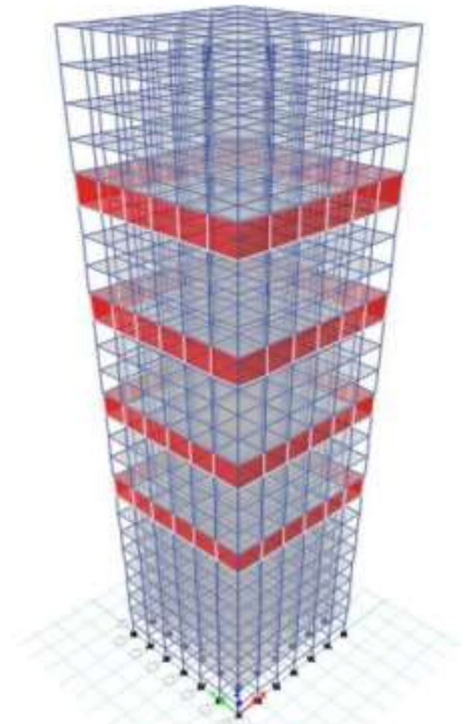

*Fig 5 Perspective View Of A Storey At Outrigger Location Madel 2 (With X Outriggers)*

## 4. RESULTS AND DISCUSSIONS

### 4.1 Overview

This chapter presents the analysis result of G+24 storied RC building. Analysis has been performed using ETABS software. The models are analyzed by equivalent static analysis for seismic in accordance with IS 1893-2002 and dynamic analysis method that is only response spectrum method for zone IV. The results achieved from calculative are compared, discussed as follows.

### 4.2 Building without and with Belt Truss

#### 4.2.1 Modal Time Period

**Table 4.2.1 Modal Time Period for Building without & with Belt Truss**

| Mode | Building without Belt Truss | Belt Truss at 13 & 14 Storey | Belt Truss at 8 & 16 Storey | Belt Truss at 8, 12, 16 & 20 Storey |
|---|---|---|---|---|
| 1 | 2.74 | 2.432 | 2.37 | 2.285 |
| 2 | 2.74 | 2.432 | 2.37 | 2.285 |
| 3 | 2.401 | 2.067 | 1.99 | 1.897 |
| 4 | 0.884 | 0.767 | 0.767 | 0.714 |
| 5 | 0.884 | 0.767 | 0.767 | 0.714 |
| 6 | 0.794 | 0.653 | 0.661 | 0.577 |
| 7 | 0.495 | 0.44 | 0.426 | 0.37 |
| 8 | 0.495 | 0.44 | 0.426 | 0.37 |
| 9 | 0.468 | 0.42 | 0.399 | 0.338 |
| 10 | 0.345 | 0.28 | 0.289 | 0.27 |
| 11 | 0.345 | 0.28 | 0.289 | 0.27 |
| 12 | 0.329 | 0.265 | 0.274 | 0.253 |

#### 4.2.2 Storey Displacement

**Table 4.2.2 Storey Displacement for Building without & with Belt T**

| Storey | Building without Belt Truss | Belt Truss at 13 & 14 Storey | Belt Truss at 8 & 16 Storey | Belt Truss at 8, 12, 16 & 20 Storey |
|---|---|---|---|---|
| GL | 0 | 0 | 0 | 0 |
| Story1 | 2.7 | 2.4 | 2.5 | 2.6 |
| Story2 | 5.2 | 4.6 | 4.7 | 4.9 |
| Story3 | 7.8 | 6.9 | 7 | 7.3 |
| Story4 | 10.4 | 9.1 | 9.3 | 9.7 |
| Story5 | 12.9 | 11.3 | 11.6 | 12.1 |
| Story6 | 15.4 | 13.5 | 13.8 | 14.4 |
| Story7 | 17.9 | 15.7 | 15.9 | 16.7 |
| Story8 | 20.2 | 17.8 | 17.5 | 18.3 |
| Story9 | 22.6 | 19.9 | 18 | 18.9 |
| Story10 | 24.8 | 22 | 19.5 | 20.4 |
| Story11 | 27.1 | 24 | 21.4 | 22.3 |
| Story12 | 29.2 | 25.9 | 23.3 | 23.9 |
| Story13 | 31.3 | 27.4 | 25.2 | 24.5 |
| Story14 | 33.3 | 28 | 27.1 | 26 |
| Story15 | 35.3 | 28.6 | 28.8 | 27.7 |
| Story16 | 37.2 | 29.9 | 30.2 | 29.1 |
| Story17 | 39 | 31.4 | 30.8 | 29.8 |
| Story18 | 40.7 | 32.9 | 32.1 | 31 |

| | | | | |
|---|---|---|---|---|
| Story19 | 42.3 | 34.4 | 33.5 | 32.4 |
| Story20 | 43.8 | 35.7 | 34.8 | 33.6 |
| Story21 | 45.1 | 37 | 36.1 | 34.3 |
| Story22 | 46.4 | 38.2 | 37.3 | 35.3 |

| | | | | |
|---|---|---|---|---|
| Story23 | 47.5 | 39.2 | 38.4 | 36.3 |
| Story24 | 48.4 | 40.1 | 39.3 | 37.3 |
| Terrace | 49.2 | 40.9 | 40.1 | 38.1 |

### 4.2.3 Storey Drift

**Table 4.2.3 Storey Drift for Building without & with Belt Truss**

| Storey | Building without Belt Truss | Belt Truss at 13 & 14 Storey | Belt Truss at 8 & 16 Storey | Belt Truss at 8, 12, 16 & 20 Storey |
|---|---|---|---|---|
| GL | 0.000299 | 0.000273 | 0.000279 | 0.000291 |
| 1 | 0.000708 | 0.000631 | 0.000646 | 0.000673 |
| 2 | 0.000838 | 0.000732 | 0.000748 | 0.00078 |
| 3 | 0.000864 | 0.000751 | 0.000767 | 0.000802 |
| 4 | 0.000863 | 0.000753 | 0.000769 | 0.000804 |
| 5 | 0.000856 | 0.000751 | 0.000766 | 0.000802 |
| 6 | 0.000848 | 0.000748 | 0.000757 | 0.000792 |
| 7 | 0.00084 | 0.000745 | 0.000722 | 0.000757 |
| 8 | 0.000833 | 0.000741 | 0.000552 | 0.00058 |
| 9 | 0.000824 | 0.000737 | 0.000195 | 0.000206 |
| 10 | 0.000815 | 0.00073 | 0.000533 | 0.000557 |
| 11 | 0.000803 | 0.000717 | 0.000684 | 0.000689 |
| 12 | 0.000791 | 0.000682 | 0.000705 | 0.000562 |
| 13 | 0.000778 | 0.000541 | 0.000702 | 0.000236 |
| 14 | 0.000762 | 0.000226 | 0.000689 | 0.000538 |
| 15 | 0.000745 | 0.000226 | 0.000653 | 0.000647 |
| 16 | 0.000724 | 0.000495 | 0.000516 | 0.000531 |
| 17 | 0.0007 | 0.000596 | 0.000242 | 0.000249 |
| 18 | 0.000673 | 0.000596 | 0.000468 | 0.000484 |
| 19 | 0.000641 | 0.000574 | 0.000555 | 0.000558 |
| 20 | 0.000603 | 0.000542 | 0.000542 | 0.000458 |
| 21 | 0.000557 | 0.000503 | 0.000506 | 0.000248 |
| 22 | 0.000501 | 0.000456 | 0.000458 | 0.000372 |
| 23 | 0.000434 | 0.000399 | 0.000402 | 0.000394 |
| 24 | 0.00036 | 0.000338 | 0.00034 | 0.000345 |
| Terrace | 0.000293 | 0.00028 | 0.000283 | 0.000288 |

### 4.3 Graphical Representation of Results

**Response Spectra Analysis**

Response spectrum analysis generally carried out from understanding the behavior structure at the time of earthquake occurring conditions in this analysis compare graphs is discussed.

**4.3.1 Model time period**

Basically model time period is based on mass of storey and stiffness of structure. If the stiffness of structure increases then model time period is decreases the comparative graphs of modern time period of Building without & with Belt Truss are given below.

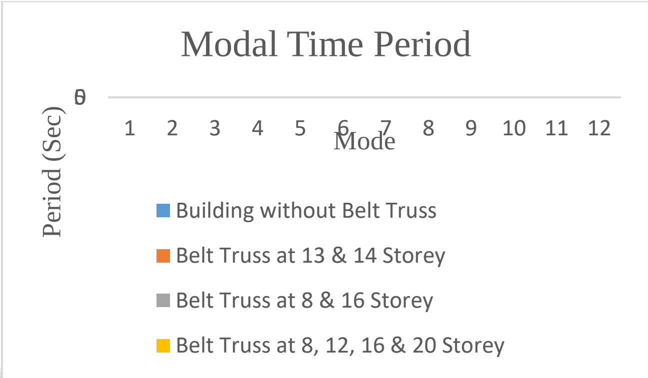


Figure 4.3.1.1 Modal Time Period of Building without & with Belt Truss

If the stiffness of structure increases then the model time period is decreases. Model time period of Building without & with Belt Truss is showing in figure 4.3.1.1 In above figure in above figure color column represents the time period of Building without belts truss, Belts truss at 13 & 14 Storey, Belts truss at 8 & 16 Storey, Belts truss at 8, 12, 16 & 20 Storey

**Table 4.3.1.1 First Modal Time Period for Building without & with Belt Truss**

| Mode | Building without Belt Truss | Belt Truss at 13 & 14 Storey | Belt Truss at 8 & 16 Storey | Belt Truss at 8, 12, 16 & 20 Storey |
|---|---|---|---|---|
| 1 | 2.74 | 2.432 | 2.37 | 2.285 |

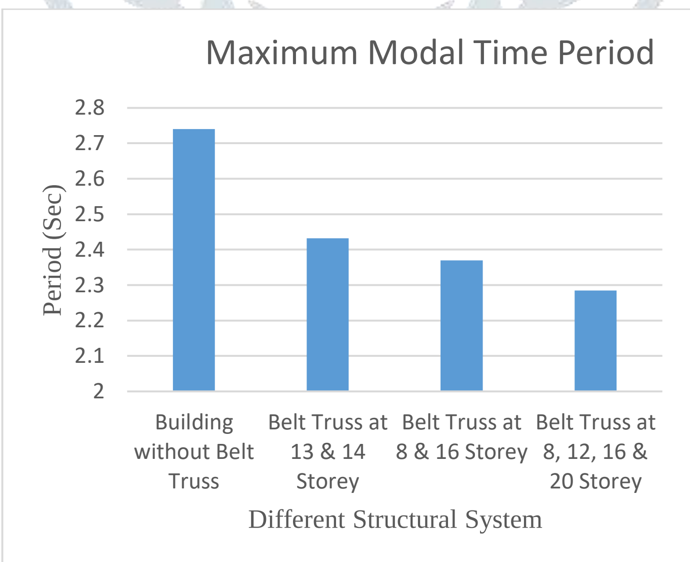


Figure 4.2.1.6 First Modal Time Period

The time period for of Building without belts truss, Belts truss at 13 & 14 Storey, Belts truss at 8 & 16 Storey, Belts truss at 8, 12, 16 & 20 Storey. It can be seen that for Building without belts truss system the time period is more when compared to other with belt truss system.

The maximum reduction in time period of building with Belt Truss at 13 & 14 Storey is 11.24 % less compared to Building without belts truss system, the maximum reduction in time period of building with Belt Truss at 8 & 16 storey is 13.5 % less compared to Building without belts truss, the maximum reduction in time period of building with Belt Truss at 8, 12, 16 & 20 Storey is 16.60 % less compared to Building without belts truss system which will directly affect the displacement of structure

As the Belts truss in the structure increases the Modal time period gives better performance for Building with belt truss system than building without belt truss system.

**4.3.2 Storey Displacement**

Displacement of all system is shown in figure. The minimum storey displacement of the building with Belt Truss at 8, 12, 16 & 20 Storey system. This result shows that the stiffness of building with Belt Truss at 8, 12, 16 & 20 Storey system and storey displacement more with increasing the height of structure.

**Table 4.3.2.1 Maximum Storey displacement for Building without & with Belt Truss**

| Storey | Building without Belt Truss | Belt Truss at 13 & 14 Storey | Belt Truss at 8 & 16 Storey | Belt Truss at 8, 12, 16 & 20 Storey |
|---|---|---|---|---|
| Terrace | 49.2 | 40.9 | 40.1 | 38.1 |

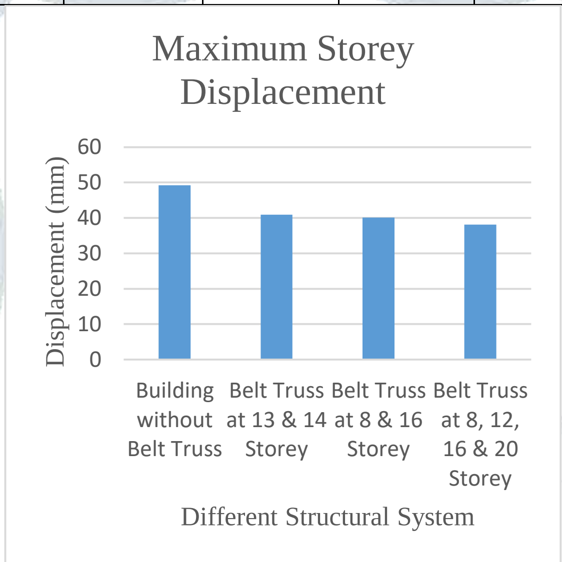


Figure 4.2.2.3: Maximum Storey displacement of Building without & with Belt Truss

The comparative maximum displacement for Building without & with Belt Truss structure is shown in Fig. It is observed that displacement for Building without belts truss system due earthquake is higher compared to Building with belt truss.

The maximum storey displacement of building with Belt Truss at 13 & 14 Storey is 16.86 % less compared to Building without belts truss system, the maximum storey displacement of building with Belt Truss at 8 & 16 storey is 18.5 % less compared to Building without belts truss, the maximum storey displacement of building with Belt Truss at 8, 12, 16 & 20 Storey is 22.56 % less compared to Building without belts truss system

It is found that displacement of building with Belt Truss at 8, 12, 16 & 20 Storey is less than relatively in system. Also the performance of building with Belt Truss at 8, 12, 16 & 20 Storey is better than remaining system. And as we increase belts truss the storey displacement gives better performance.

**4.3.3 Storey Drift**

Storey Drift of all system is shown in figure. The minimum storey drift is in the building with Belt Truss at 8, 12, 16 & 20 Storey system then other system. This result shows that the storey displacment of structures decreases and storey drift also reduce.

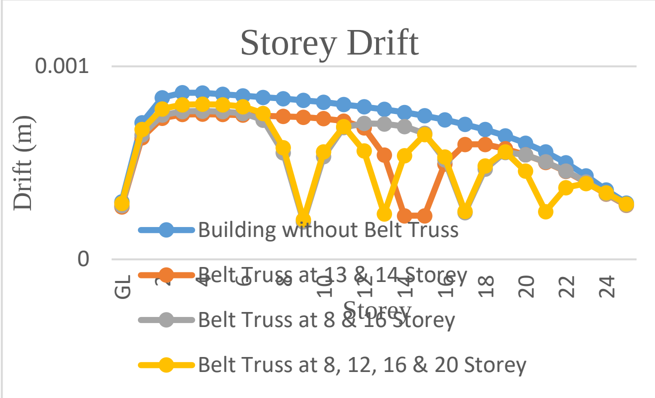


Figure 4.3.3.1: Storey Drift of Building without & with Belt Truss

**Table 4.3.3.1 Maximum Storey Drift for Building without & with Belt Truss**

| Structural system | Building without Belt Truss | Belt Truss at 13 & 14 Storey | Belt Truss at 8 & 16 Storey | Belt Truss at 8, 12, 16 & 20 Storey |
|---|---|---|---|---|
| Maximum Drift | 0.000864 | 0.000753 | 0.000769 | 0.000804 |

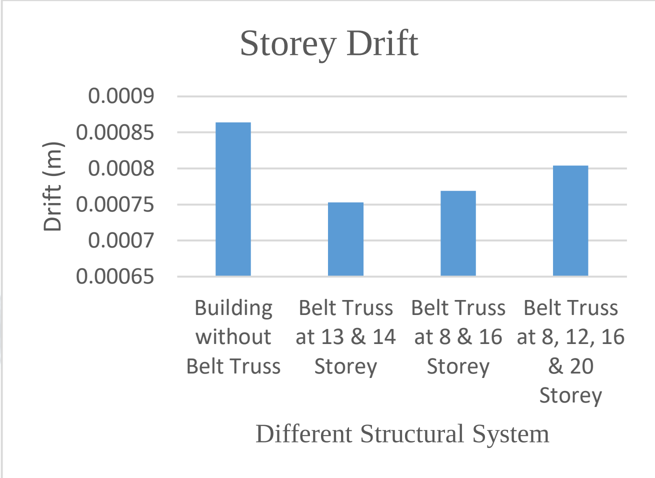


Figure 4.3.3.2: Maximum Storey Drift of Building without & with Belt Truss

It is found that storey drift for building with belt truss structure system is less than relatively in building without belt truss system. Also the performance of building with belt truss system is better than building without belt truss system.

The maximum storey drift of building with Belt Truss at 13 & 14 Storey is 12.84 % less compared to Building without belts truss system, the maximum storey displacement of building with Belt Truss at 8 & 16 storey is 11 % less compared to Building without belts truss, the maximum storey displacement of building with Belt Truss at 8, 12, 16 & 20 Storey is 7 % less compared to Building without belts truss system

**4.3.4 Storey Stiffness**

The distribution of storey Stiffness along the height for Building without & with Belt Truss structure is due earthquake is shown in Fig. The stability of Rcc-structure is increase with increase in stiffness of column

**Table 4.3.4.1 Maximum Storey Drift for Building without & with Belt Truss**

| Structural system | Building without Belt Truss | Belt Truss at 13 & 14 Storey | Belt Truss at 8 & 16 Storey | Belt Truss at 8, 12, 16 & 20 Storey |
|---|---|---|---|---|
| Maximum Storey Stiffness | 3634365.201 | 4250761.723 | 4254793.009 | 4251837.764 |

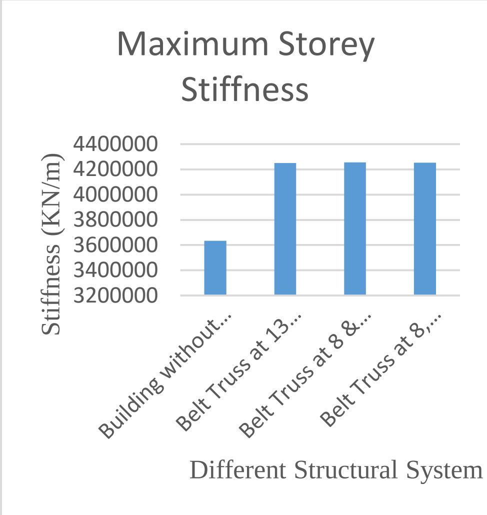


Figure 4.3.4.2: Maximum Storey Stiffness of Building without & with Belt Truss

It is found that storey stiffness for building with belt truss structure system is more than relatively in building without belt truss system. Also the performance of building with belt truss system is better than building without belt truss system.
The maximum storey stiffness of building with Belt Truss at 13 & 14 Storey is 14.5 % more compared to Building without belts truss system, the maximum storey displacement of building with Belt Truss at 8 & 16 storey is 14.58 % more compared to Building without belts truss, the maximum storey displacement of building with Belt Truss at 8, 12, 16 & 20 Storey is 14.22 % more compared to Building without belts truss system

## 5. CONCLUSION

1. Researchers have utilized various techniques and methods for locating uses of belt truss in tall structure.
2. A belt truss with a separate hard floor diaphragm can reduce deflection by conventional triggering, but triggering with a belt truss will escape maximum deflection than an individual belt truss or outrigger.
3. Differing kinds of research were conducted as per the assorted accessible standards. Common parameters designed by different researchers in the paper above are different levels of belt truss, lateral slip, center moment and column reaction.Various researches focused on obtaining the optimum position of belt truss for satisfying deflection criteria and also the optimum position of belt truss for satisfying deflection additionally as moment criteria.
4. For belt truss system X-type belt truss is most fitted for many of the structures.
5. Belt truss system is effective for all variety of composite, steel and concrete structures.
6. Belt truss is cost effective structural system which is one among the foremost developing structural systems in new construction.

## 6. ACKNOWLEDGEMENT

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