JSRT JOURNAL
PAGES: 63-80
9/18/24
JOURNAL OF SCIENTIFIC RESEARCH AND TECHNOLOGY VOLUME-2 ISSUE-9 SEPTEMBER

Analysis Of Multistoried RCC Building With Optimization Of Shear Wall And Belt Truss System Under Different Seismic Zones Using Software Techniques

Mohammad Sameed Ahmed[1], Prof Sujeet Patil[2],

[1]*Student, Department of Civil Engineering, Poojya Doddappa Appa College of Engineering Kalaburagi India. sameed.yg@gmail.com*

[2]*Assistant Professor, Department of Civil Engineering, Poojya Doddappa Appa College of Engineering Kalaburagi India. sujeet2801@gmail.com*

ABSTRACT

In multi-story buildings, shear walls are among the most suitable and significant structural elements. Consequently, research on the structural reaction and related systems in multi-story buildings would be highly intriguing. Shear walls increase the structure's strength and stiffness during earthquakes, something that is sometimes overlooked in the building and design process. This investigation has demonstrated that shear walls significantly affect a structure's susceptibility. To test this, a G+20 storey structure in addition to and instead of shear walls was analysed, accounting for a variety of factors such as base shear, story drift ratio, lateral displacement, bending moment, and shear force. Two models were used to investigate the significance of the shear wall; the first model was shear-free.

As of right now, the corresponding design codes provide the basic design techniques at higher altitudes. Therefore, this study's objective is to use ETABS software to extensively assess high-rise buildings under various design load combinations and using alternative codal provisions. First, the building must be built to its natural state in order to resist forces and avert collapsing beneath its own weight. Secondly, the construction must be inexpensive.

In contrast to other high-rise buildings in the same area, the primary benefit of shear walls is their merging in the wall, which helps to lower the cost of conventional wall designing. Additionally, using a shear wall will automatically lower the installation and maintenance costs in the future.

Keywords: Equivalent Static Analysis, Response Spectrum, Shear Wall, Belt Truss System, High Rise Buildings, ETABS.

I.INTRODUCTION

1.1 GENERAL:

The assembly of bridges, buildings, industries, and other infrastructure has increased significantly in the majority of emerging nations in the twenty-first century, particularly India. Infrastructure development is being done owing to the expanding population and to meet their expectations. There is little land because it is scarce in metropolitan areas. Tall, thin, multi-story buildings are often built as a solution to this issue. These kinds of structures are probably subjected to significant lateral loads on a regular basis. When the wind pushes against the building or when inertia forces from ground vibrations or excitement cause the structure to go through lateral loads, it can shear and bend.

The infill wall panels in framed buildings provide lateral resistance, while the frames alone resist vertical stresses. The frame action produced by the interplay of slabs and columns is insufficient to provide the necessary lateral rigidity for framed buildings taller than ten stories, making framed structures an unworkable solution for towering structures. Using a shear wall system is one of the finest ways to guarantee the lateral stability of tall buildings, which resists the lateral stresses caused by wind and earthquakes. Most residential and commercial buildings in use today have shear walls up to thirty floors, after which tubular structures are advised.

Shear walls may be incorporated into the construction in one or both of its planes. Occlusions in shear walls can sometimes be added to enhance both the building's design requirements and functionality. The apertures are not being examined in this study; the shear wall's placement is the main subject.

II. LITERATURE REVIEW

2.1 Introduction:

A synopsis of many studies on the design and analysis of shear walls is provided in this chapter. It incorporates recently finished experimental and computational investigations that are accessible in the published literature, as well as protocols and recommendations regarding the shear design walls by various authors.

2.2 Previous Research:

2.2.1 ABDUL KARIM MULLA AND SHRINIVAS B.N (2015)

"A STUDY ON OUTRIGGER SYSTEM IN A TALL R.C STRUCTURE WITH STEEL BRACING"

They conducted research on both vertically irregular and regular structures to introduce an outrigger structural system with steel bracing to boost axial stiffness with outside columns and withstand the overturning moment. Under the effect of an earthquake, researchers evaluated in three dimensions, with and without an outrigger beam, twenty-story symmetrical layouts with regular and vertically uneven morphologies. The "ETABS" software was used to model the structure. In accordance with Indian standard coding practice, the structure was analysed using the response spectrum approach and the corresponding static method. To determine the structure's efficiency, the authors have considered current displacement, drift, base shear, and fundamental natural period. In keeping with this, authors have also looked at how the structure responds to different seismic zones when concrete and steel outriggers are used. Additionally, they have concentrated on figuring out where the outrigger beam should be placed in order to reduce lateral displacement.

According to this study, the installation time of outriggers for both regular and irregular building structures can be greatly reduced, and the overall rigidity of the framework can be increased. Additionally, it was found that in contrast to steel

outriggers, the displacement of an irregular building utilising concrete outriggers can be resisted by up to 18%. The use of outriggers reduces inter story drift. Based on this investigation, it was determined that concrete outriggers reduce lateral story displacement more effectively than steel outriggers with X bracing type.

Conclusions: -

- The use of an outrigger system in a building increases its efficiency against lateral stresses as compared to a building without them.
- Distinct buildings exhibit distinct behaviours when subjected to earthquake loads.
- When comparing the outrigger given at the middle floors to the uppermost floor of the house, there is a smaller displacement decrease.
- In both standard and atypical construction structures, The total rigidity of the framework is gradually decreased by including outriggers.
- The towering structure system's implementation of outriggers will minimise inter-story drift.

2.2.2 KIRAN KAMATH. (2012)

"A STUDY ON STATIC AND DYNAMIC BEHAVIOR OF OUTRIGGER STRUCTURAL SYSTEM FOR TALL BUILDINGS"

In the present work, ETABS software was used to analyse the actions of numerous alternative 3D models for RC structures having walls in the centre core and outriggers, additionally without outriggers. Furthermore, the outrigger has been repositioned between 0.4 and 0.975 in height. Among the characteristics considered in this work are variations when deflecting laterally and inter-storey drifts for static and dynamic analysis of a three-dimensional model.

The complete investigation demonstrates that midway up the structure is made of the ideal site for an outrigger for both categories of analysis when accounting for the requirement for a reduction in top displacement.

Additionally, they have demonstrated that, in addition to being effective at controlling top displacements, the outrigger structural structure greatly reduces inter-story drifts. The fundamental forces of a structure are significantly reduced when an outrigger system is included, especially the bending moment.

Conclusions: -

- Although the outrigger atop of the structure is lower functional, it may be more aesthetically pleasing to place it there in many situations. Although it is not as effective as when it is at mid-height, the benefits are still very impressive, as they can minimise drift by as much as fifty percent.
- When peak acceleration is the design criterion, the optimal place is at the top, where it can be lowered by up to 30%.
- The force within the core BM is considerably decreased upon the implementation of a pivot mechanism.

2.2.3 P.M.B. RAJKIRAN NANDURI AND ETAL (2013)

“OPTIMUM POSITION OF OUTRIGGER SYSTEM FOR HIGH RISE REINFORCED CONCRETE BUILDINGS UNDER WIND AND EARTHQUAKE LOADINGS”

The purpose of this paper's analysis is to assess the effects of outrigger provision and determine the best place for outriggers together with belt trusses. Thirty-nine-story three-dimensional models of the conventional and virtual outtrigger systems were evaluated, compared, and exposed to wind and seismic load in order to estimate the decrease of drift and lateral displacement. The software application ETABS was chosen to carry out the analysis. At the peak of the structure, drift was the paramount fundamental parameter tracked during the entire analytical process. To ascertain various characteristics, wind analysis and comparable static analysis were carried out.

The ensuing deductions are drawn from the present study

- Installing outriggers on the uppermost floor has been shown to minimise drift by 4.8%.
- Comparing a constructing with merely a core wall to one having an outrigger system with a belt truss at the top, about 5.3% of the drift is controlled.
- The drop in height with and without a belt truss is 18.55% and 23.06%, respectively, when using a second outrigger at middle height with a cap truss.
- The halfway the building's altitude is the best location for the second outrigger, according to drift control requirements.

2.2.4 PO SENG KIRAN AND FRITS TORANG SIAHAAN (2001)

“THE USE OF OUTRIGGER AND BELT TRUSS SYSTEM FOR HIGH-RISE CONCRETE BUILDINGS”

By adding outriggers and a belt truss system to connect the core to the outer column, they have improved on the concept to make the structure more rigid and capable of withstanding seismic and wind loads. The authors of this study have looked at how belt trusses and diagonal outriggers are used in different setups. By adding outrigger and virtual systems with eight various configurations and altering the outrigger placements, they conducted a study on a 40-story building that was susceptible to wind load. Likewise, five distinct configurations of the outrigger and belt truss systems including variable locations, numbers, and heights of diagonal outrigger beams and belt trusses were applied to sixty-story models subjected to an earthquake's force. Software from ETABS was utilised for this.

The results of the current investigation have indicated the following conclusions.

- High-rise buildings that use belt truss and outrigger systems are more rigid and possess a more effective structural form under lateral load.
- In a 2D model, the maximum less displacement occurs by 56% when a single outrigger is placed in the middle of the structure height; in contrast, a first outrigger positioned at the summit and a second outrigger positioned at the centre of the structure height reduce displacement by 65%.
- Whenever the outrigger brace is positioned optimally at the top and 33rd level, a about 18% reduction in lateral displacement can be accomplished for the 3D model subjected to the earthquake load.

2.2.5 PRAJYOT A. KAKDE, RAVINDRA DESAI (2017)

"A COMPARATIVE INVESTIGATION OF OUTRIGGER AND BELT TRUSS STRUCTURAL SYSTEM FOR STEEL AND CONCRETE MATERIAL"

Two were employed in the current study with different materials to try to figure out how an outrigger system would respond to a 70-story building. The outrigger is made of steel and concrete, and its dimensions are 30 by 30 meters, with a height of 3 meters for each story. The modelling was done using Etabs software, and wind analysis was done to look into variables like maximum storey displacement, inter-story drift, and building comparisons with the use of outriggers made of steel and concrete at different heights. The used outrigger positions are 0.25H, 0.5H, and 0.75H.

Following conclusions were drawn

- By reducing displacement, Observations indicate that making advantage of an outrigger system in conjunction with a belt truss successfully regulates lateral loads.
- In comparison to the concrete outrigger model, the bottom shear of the steel outrigger model was lower.
- The displacement at the first story without an outrigger was discovered to be 323.31mm. When steel and concrete outriggers were employed in in tandem with belt trusses, the displacement decreased to 227.23mm and 239.25mm respectively.
- The displacement was reduced to a maximum of 29.71%.

III. OBJECTIVES

- ✓ Analysis of a 20-story structure in relation to two distinct seismic zones, namely zone II and V.
- ✓ The aim is to examine how a 20-story structure responds to seismic stresses, including base shear, storey drift, storey displacement with two separate sites shears walls and belt truss systems.
- ✓ This plan's primary objective is to analyse and contrast several shear wall models utilising ETABS currently instructions to ascertain the best location for shear walls inside structures.
- ✓ The design uses the Limit State Plan as the design approach for the study, in line with the Indian Standard Code of Practice, and incorporates load calculations and analysis through modelling software Etabs.

IV. METHODOLOGY

This study's objective is to examine how the multistorey G+20 reinforced cement concrete building model is affected by earthquakes. With ETABS 2017, a 20-story R.C.C. framed building's modelling is produced. After the models are made, the best place for the shear wall is predetermined by adjusting the belt truss location along the building's height. The virtual outrigger in subsequent models is located using the ideal location that has been determined. After that, several models were made using various materials, like steel and concrete, and virtual outriggers positioned in the best possible locations. Next, The outcomes are contrasted with the composite model.

Every storey is three meters high. The soil type is medium, and seismic zones II and V are taken into consideration. The loading for the specified structure consists of live load, seismic load, and dead load according per IS 875 part II, IS 1893-2016, and IS 875 part I, in that order. Analyses are conducted using Response Spectrum Analysis and equivalent static analysis. It is determined the results, including displacement, time period, and base shear. Graphs depicting the data are created after analysis, and they are subsequently studied to make inferences.

V. ANALYTICAL MODELLING

5.1 General

Seismic analysis is used in this work to analyse the lateral load. The analysis approach is determined by the regularity or irregularity of the building's structure, as per the seismic analysis codes. Most codes suggest symmetric buildings and a particular class of regular structures to use linear static analysis. The guideline recommends using dynamic analysis techniques to account for the structures' asymmetrical layouts. The seismic analysis code specifies various techniques for performing lateral load analyses; nevertheless, infill wall effects are typically disregarded during analysis and design. IS 1893-2002 is the seismic analysis code utilised in this paper for the lateral load analysis. Utilising ETABS, the analysis is performed

5.2 Description of the Models that were employed to find the optimum position of virtual outrigger: -

Following are the four models studied in order to pre determine the optimum position of virtual outrigger system to be used in this study.

- Bare frame model + Belt truss at 4th Floor.
- Bare frame model + Belt truss at 8th Floor.
- Bare frame model + Belt truss at 12th Floor.
- Bare frame model + Belt truss at 16th Floor.
- Bare frame model + Belt truss at 20th Floor.

5.3 Description of the Models

The models considered for the present study are as follows

1) Model 1- Conventional RCC building with beams and columns (Bare frame model) in seismic ZONE II.
2) Model 2- Bare frame model + Shear walls at Core location and at corner up to 4th floor + virtual outrigger/ belt truss on 4th floor in seismic ZONE II.
3) Model 3 - Bare frame model + Shear walls at Core location and at corner up to 8th floor + virtual outrigger/ belt truss on 8th floor in seismic ZONE II.
4) Model 4- Bare frame model + Shear walls at Core location and at corner up to 12th floor + virtual outrigger/ belt truss on 12th floor in seismic ZONE II.
5) Model 5- Bare frame model + Shear walls at Core location and at corner up to 16th floor + virtual outrigger/ belt truss on 16th floor in seismic ZONE II.
6) Model 6- Bare frame model + Shear walls at Core location and at corner up to 20th floor + virtual outrigger/ belt truss on 20th floor in seismic ZONE II.
7) Model 7- Conventional RCC building with beams and columns (Bare frame model) in seismic ZONE V.
8) Model 8- Bare frame model + Shear walls at Core location and at corner up to 4th floor + virtual outrigger/ belt truss on 4th floor in seismic ZONE V.
9) Model 9 - Bare frame model + Shear walls at Core location and at corner up to 8th floor + virtual outrigger/ belt truss on 8th floor in seismic ZONE V.
10) Model 10- Bare frame model + Shear walls at Core location and at corner up to 12th floor + virtual outrigger/ belt truss on 12th floor in seismic ZONE V.
11) Model 11- Bare frame model + Shear walls at Core location and at corner up to 16th floor + virtual outrigger/ belt truss on 16th floor in seismic ZONE V.
12) Model 12 - Bare frame model + Shear walls at Core location and at corner up to 20th floor + virtual outrigger/ belt truss on 20th floor in seismic ZONE V.

5.4 Description of the Building:

Table No 1 Building details

Type of building	**Residential Building**
Type of frame	Moment Resisting Frame
No of stories Total height of building	20 stories 64.75 m
Thickness of walls	200mm (main wall) and 100mm (partition wall)
Live load	3KN/m2 – Balcony, Corridor 2KN/m2 – All rooms

Grade of Concrete	M30 for beams and columns
Grade of reinforcing Steel	Fe500
Sizes of columns	C=800mmX800mm
Sizes of beams	B=450X900mm
Thickness of slab	150mm
Zone	II, V
Soil type	II
Importance factor	1.5
Response reduction	5
Seismic zone factor	0.1 for zone II and 0.36 for zone V
Damping ratio	5%
Size of belt truss	ISMB450

VI. RESULTS AND DISCUSSION

6.1 Results of Models used to determine the optimum location Shear Wall & Belt Truss in Zone II.

1) Bare frame model + Shear Wall + Belt truss at 4th Floor.

Table No 2

Particulars	Max Displacement(mm)
EQ X	150.25
EQ Y	150.97
RSM X	134.65
RSM Y	133.93

2) Bare frame model + Shear Wall + Belt truss at 8th Floor

Table No 3

Particulars	Max Displacement(mm)
EQ X	171.25
EQ Y	170.97
RSM X	154.56
RSM Y	154.97

3) Bare frame model + Shear Wall+ Belt truss at 12th Floor.

Table No 4

Particulars	Displacement(mm)
EQ X	135.05
EQ Y	135.87
RSM X	127.61
RSM Y	127.07

4) Bare frame model + Shear Wall+ Belt truss at 16th Floor.

Table No 5

Particulars	Displacement(mm)
EQ X	185.51
EQ Y	185.97
RSM X	177.16
RSM Y	177.87

5) Bare frame model + Shear Wall+ Belt truss at 20th Floor.

Table No 6

Particulars	Displacement(mm)
EQ X	201.45
EQ Y	200.03
RSM X	194.13
RSM Y	194.77

It is evident from the graph that when outrigger was placed at 4th floor of the building the displacement was 150.25mm which got reduced to 135.05 when it was placed at 12th floor. When again the position of outrigger was changed at 16th and 20th floor, the displacement got increased to 185.51mm, 201.45mm respectively. Hence from these results it can be concluded that the optimum position of outrigger to be used in the present study is at 12th floor of the building.

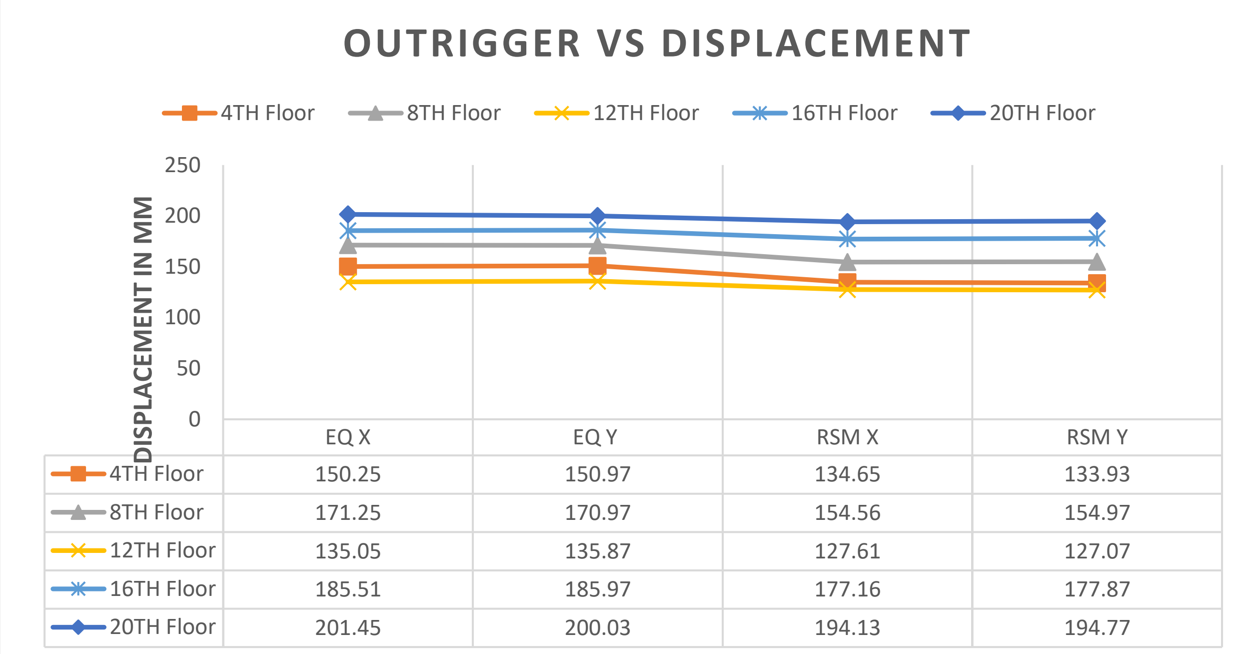
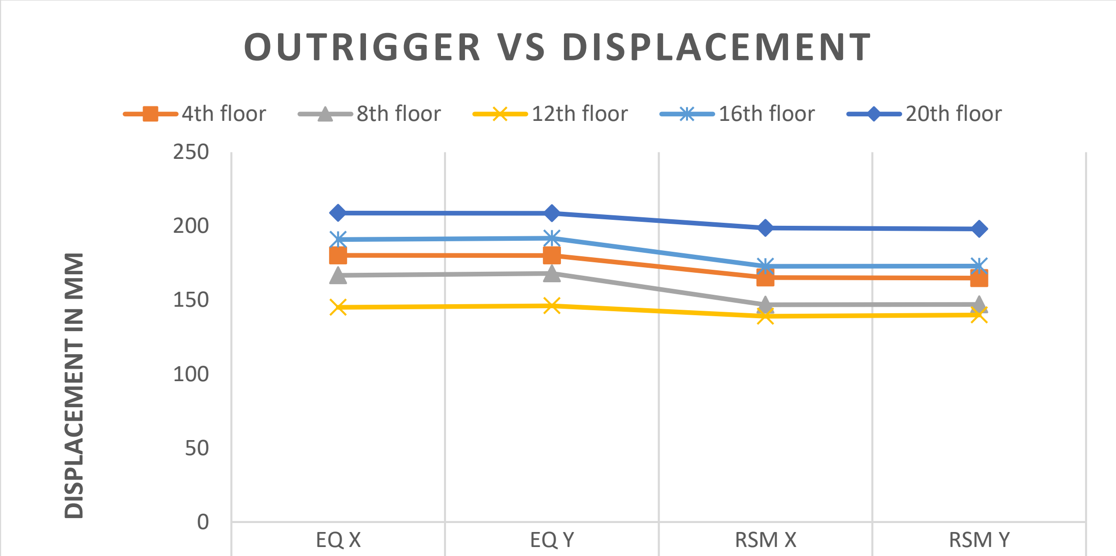


Fig 1 Displacement for various RCC models with different shear wall and outrigger position

6.2 Results of Models used to determine the optimum location Shear Wall & Belt Truss in Zone V.



	EQ X	EQ Y	RSM X	RSM Y
4th floor	180.26	180.14	165.34	164.92
8th floor	166.75	168.04	146.87	147.08
12th floor	145.04	146.14	139.08	139.97
16th floor	191.05	191.84	172.87	173.08
20th floor	208.85	208.77	198.78	198.12

Fig 2 Displacement for various RCC models with different shear wall and outrigger position

It is apparent in the chart that when outrigger was placed at 4^{th} floor of the building the displacement was 180.26mm which got reduced to 145.04 when it was placed at 12^{th} floor. When again the position of outrigger was changed from i.e. 16^{th} and 20^{th} floor, the displacement got increased to 191.05mm, 208.85mm respectively. Hence from these results it can be concluded that the optimum position of outrigger to be used in the present study is at 12^{th} floor of the building.

6.3 BASE SHEAR

The entire lateral force that an earthquake transmits to the foundation is known as base shear. It affects structural design and establishes how a building will react to seismic pressures. Factors affecting base shear include ground motion and building properties. It's crucial for designing the load resisting system. Engineers use analysis methods to calculate base shear. Distribution along the building's height is necessary for stability. It helps determine the size and strength of structural elements.

The design base shear is given by Vb = (Z/2) x(I/R) x (Sa/g) x W

Where, Importance factor I =1.2

Response reduction factor R = 5 as the structure would be designed as OMRF

Sa/g = the structure's normalised response spectrum value, which depends on the foundation soil type and the structure's basic vibrational period.

W= The building's seismic weight will be determined in compliance with IS 1893 (Part 1) 2002, the applicable clause.

6.3.1 VARIATION OF BASE SHEAR OF DIFFERENT RCC MODELS FOR EQUIVALENT STATIC ANALYSIS AND RESPONSE SPECTRUM ANALYSIS

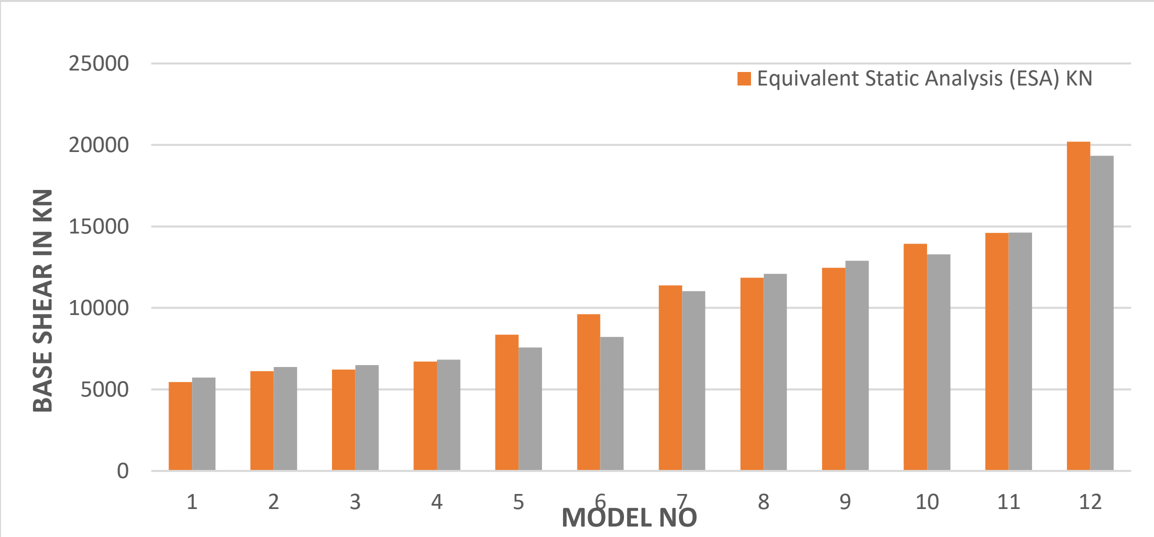


Fig 3 Base shear of all models for ESA and RSA

From the Fig, it is evident that the model 1 has a minimum Base shear value of 5458.23KN and highest value of 6th model i.e. 9615.53KN in zone II. As for zone V model 7 has lowest base shear i.e. 10389.57KN and model 12 has highest base shear i.e. 20195.81KN.

For every case of analytical methodologies, the base shear values rise with the inclusion of a shear wall and the height of the shear wall. When an outrigger is used, the base shear increases because the structure's self-weight increases.

6.3.2 BASE SHEAR

Comparison of base shear of model 6 and models 12 for equivalent static and response spectrum analysis (EQ X and RS X)

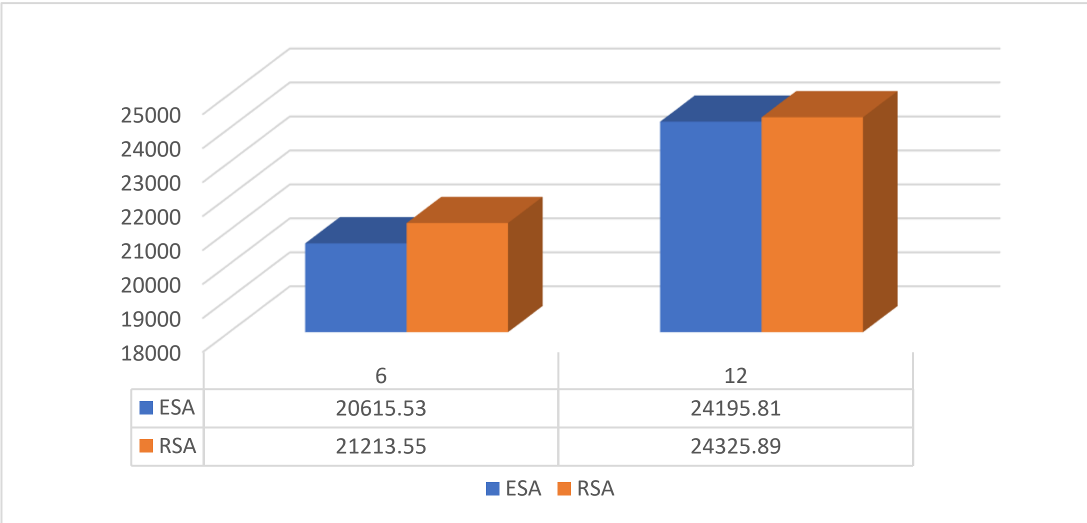


Fig 4 Comparison of Base shear of model 6 and model 12.

From the Fig it is observed that model 6 i.e. bare frame model consisting of shear wall and outrigger in zone II has minimum base shear value compared to model 12 in Equivalent static analysis (ESA) and Response spectrum analysis (RSA), the percentage decrease in Base shear for model 6 is 38.84% for ESA and 38.30% for RSA when compared to model 12.

6.4 STOREY DISPLACEMENTS

The deviation of a single story from the structure's base or ground level is known as storey displacement. Storey displacement is the result of a building's levels or storeys shifting in relation to one another due to seismic waves. Differential displacements where certain floors move more than others may result from this. The degree of storey shift depends on a number of factors, including the power and duration of the earthquake, the characteristics of the soil, and the structural integrity of the building. Using a variety of design techniques, structural engineers attempt to lessen the possible impacts of storey displacement. Using suitable lateral load-resisting systems, like moment frames or shear walls, which can offer strength and rigidity to withstand seismic forces, is one of them. Further detailing methods, like reinforcement detailing and appropriate connection design, are used to guarantee the structural system's ductility and capacity for energy dissipation.

6.4.1 STOREY DISPLACEMENTS OF ALL MODELS ALONG X DIRECTION(EQX) FOR EQUIVALENT STATIC ANALYSIS

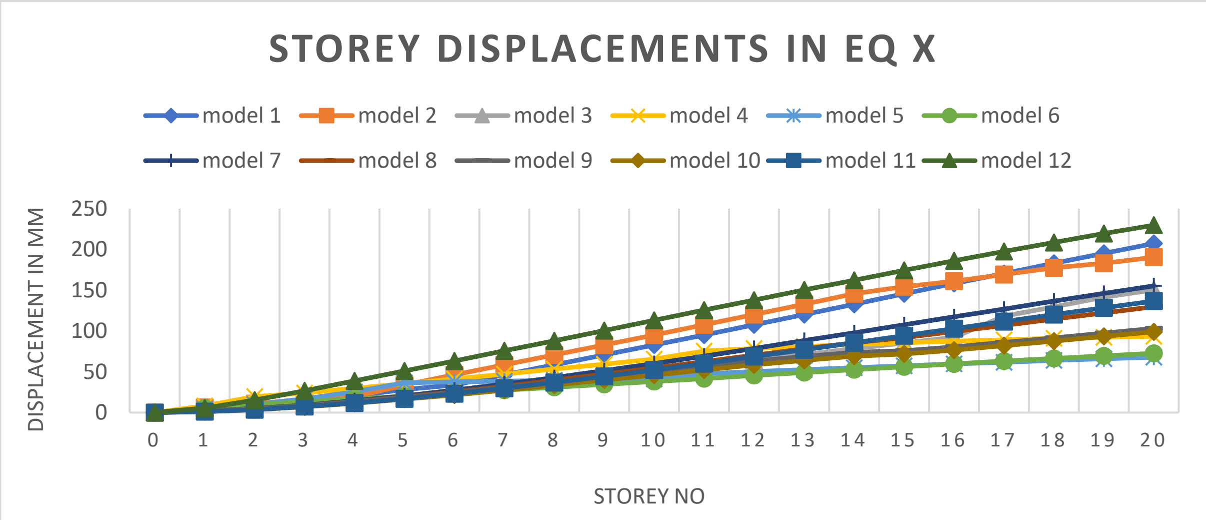


Fig 5 Storey displacement of all models for ESA along X-direction

- From the graph evidently, model 12 has highest storey displacement in both X & Y directions.
- The lowest value of storey displacement is seen in the 5th model.
- Max allowed displacement in a multi-storeyed is Hs/250 (IS 1893 2016) where Hs= building height
- The max allowed displacement for the models utilised in the study= 64.75/250 =0.247m =247mm

6.4.2 STOREY DISPLACEMENTS OF ALL MODELS ALONG Y DIRECTION (EQY) FOR EQUIVALENT STATIC ANALYSIS

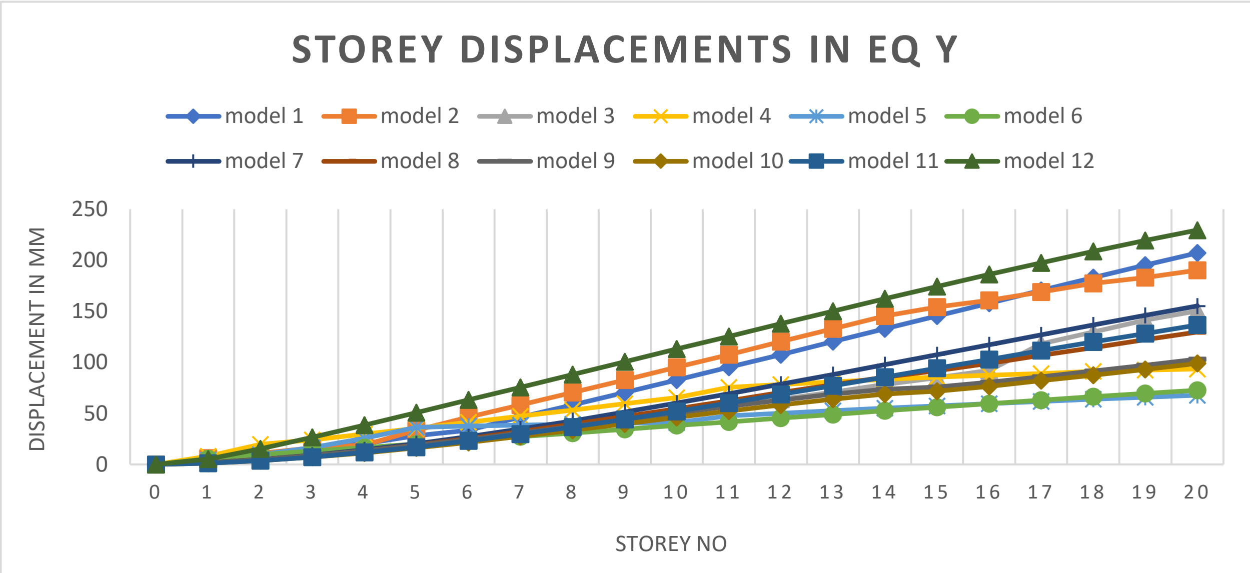


Fig 6 Storey displacement of all models for ESA along Y-direction

6.4.3 STOREY DISPLACEMENTS OF ALL MODELS ALONG X DIRECTION (RSX) FOR RESPONSE SPECTRUM ANALYSIS

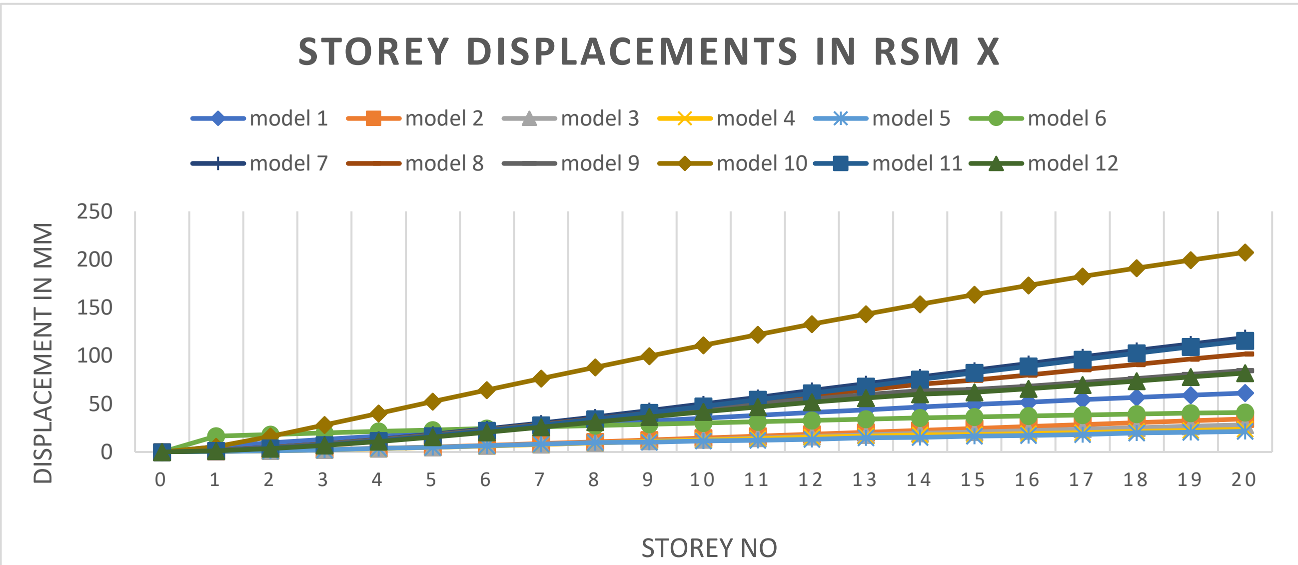


Fig 7 Storey displacement of model 1 to model 12 for RSA along X-direction

6.4.4 STOREY DISPLACEMENTS OF ALL MODELS ALONG Y DIRECTION (RSY) FOR RESPONSE SPECTRUM ANALYSIS

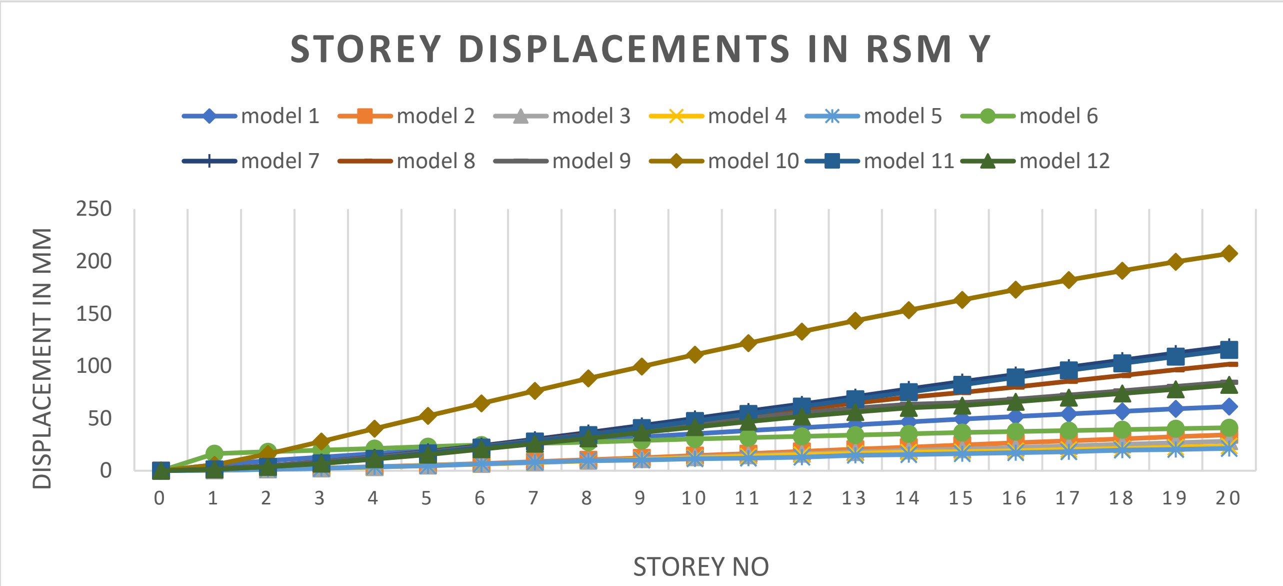


Fig 8 Storey displacement of model 1 to model 12 for RSA along Y-direction

- From the graph it can be seen that model 10 has highest storey displacement in both X & Y directions.
- The lowest value of storey displacement is seen in the 5th model.
- Max allowed displacement in a multi-storeyed is Hs/250 (IS 1893 2016) where Hs= building height
- The max allowed displacement for the models utilised in the study= 64.75/250 =0.247m =247mm

6.5 STOREY DRIFT

A critical factor in building design and seismic analysis is storey drift. Should there be an earthquake, it describes the relative horizontal displacement or movement between neighbouring floors of a building.. It is an important consideration when evaluating the structural performance and safety of the building.

The building experiences lateral stresses from the ground motion during an earthquake, which leads to oscillation and consequent deformation. The amount that each floor travels horizontally in reaction to these seismic pressures is measured by a concept called storey drift. It aids engineers in evaluating the structural integrity of the building and comprehending how it behaves under seismic loads. A number of variables, such as the building's height, flexibility, and stiffness distribution, affect storey drift. Due to higher lateral stresses, taller buildings typically have larger story drifts.

6.5.1 STOREY DRIFT OF ALL MODELS ALONG X DIRECTION (EQX) FOR EQUIVALENT STATIC ANALYSIS

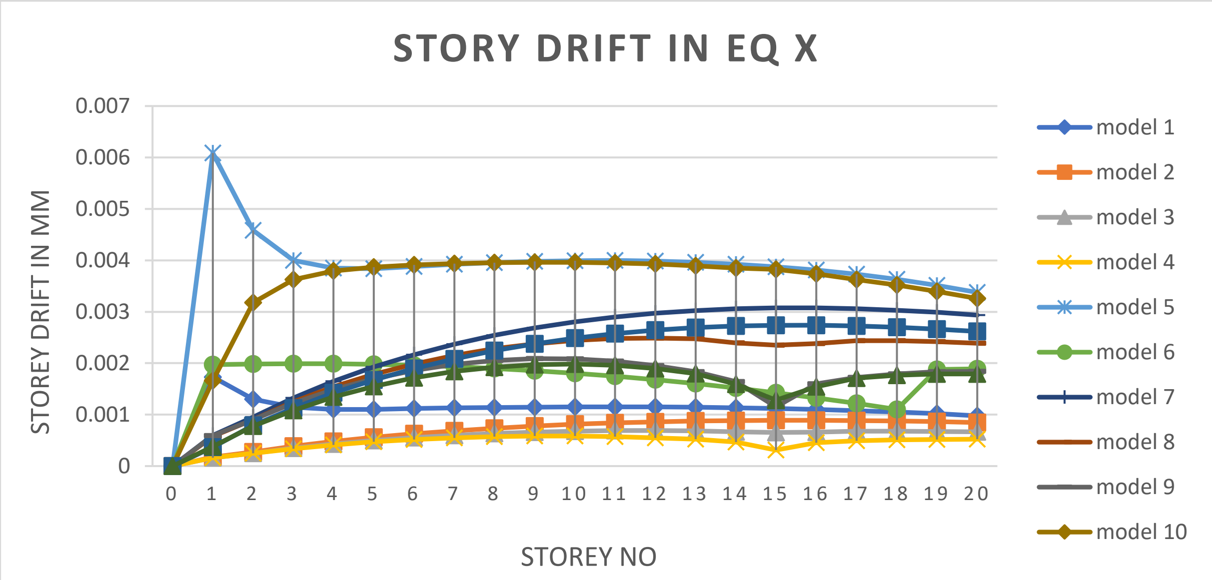


Fig 9 Storey drift of model 1 to model 12 for ESA along X-direction

6.5.2 STORY DRIFTS OF ALL MODELS ALONG Y DIRECTION (EQY) FOR EQUIVALENT STATIC ANALYSIS

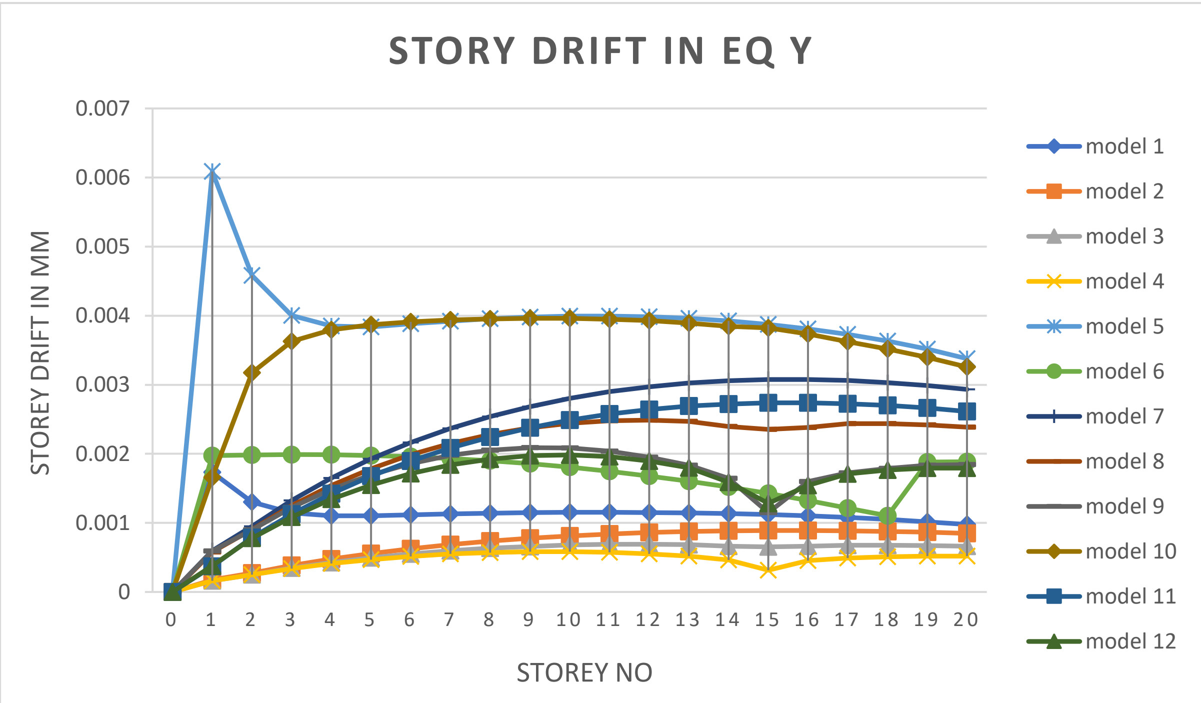


Fig 10 Storey drift of model 1 to model 12 for ESA along Y-direction

- The maximum value of storey drifts is seen in 10th model
- The minimum value of storey drift is seen in the 5th model for both cases of equivalent static analysis.
- A buildings maximum allowed drift is 0.004 X H as per IS 1893 2016 clause 7.11.1, where H= height of one storey
- The max allowed drift = 0.004 X 3 =0.012m=12mm.
- For every model, the storey drift falls within acceptable boundaries.

6.5.3 STORY DRIFTS OF VARIOUS ALL MODELS ALONG X DIRECTION (RSX) FOR RESPONSE SPECTRUM ANALYSIS

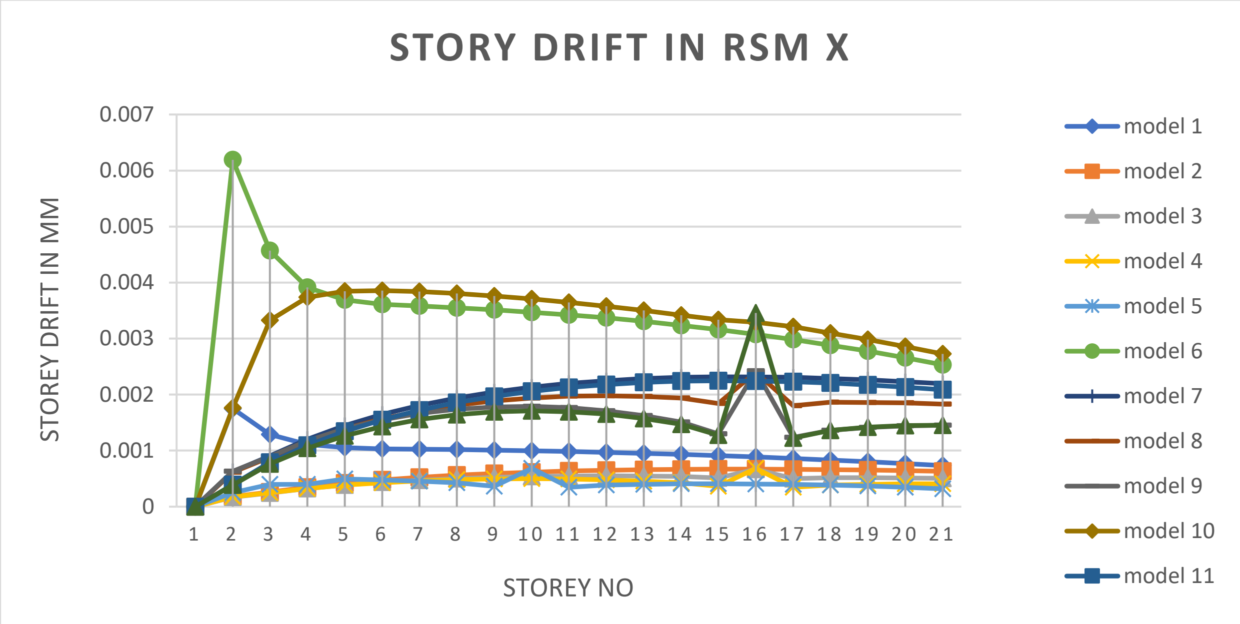


Fig 11 Storey drift of model 1 to model 12 for RSA along X-direction

6.5.4 STORY DRIFTS OF VARIOUS RCC MODELS ALONG Y DIRECTION (RSY) FOR RESPONSE SPECTRUM ANALYSIS

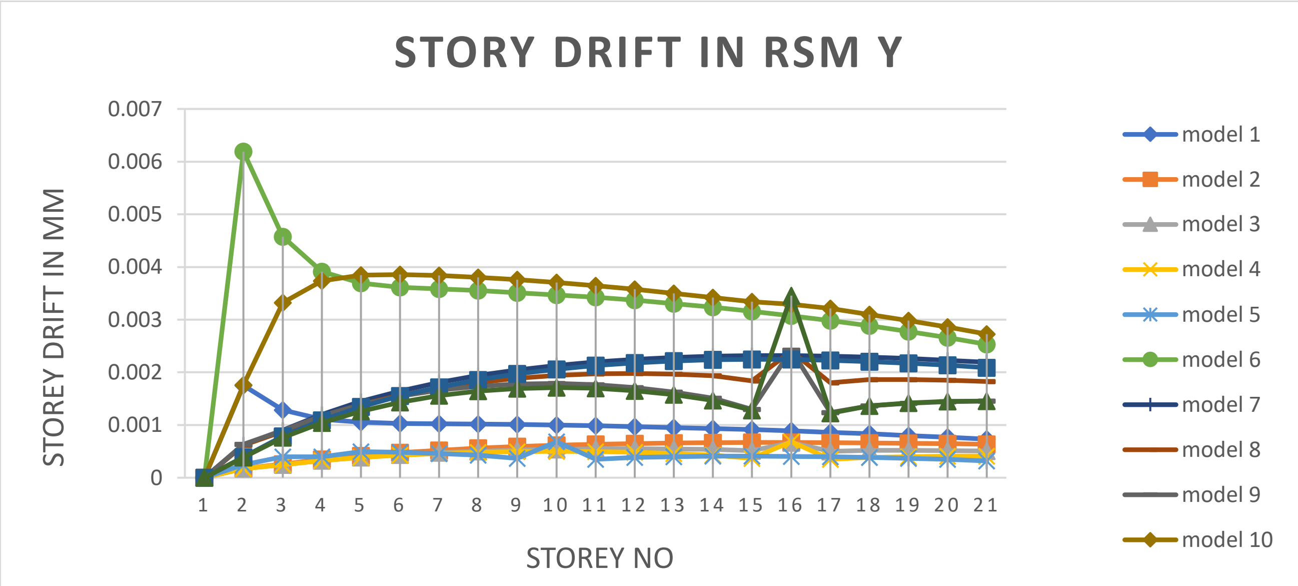


Fig 12 Storey drift of model 1 to model 12 for RSA along Y-direction

- The maximum value of storey drifts is seen in 10th model
- The minimum value of storey drift is seen in the 5th model for both cases of equivalent static analysis.
- A buildings maximum allowed drift is 0.004 X H as per IS 1893 2016 clause 7.11.1, where H= height of one storey
- The max allowed drift = 0.004 X 3 =0.012m=12mm.
- All model's permissible limits for storey drift are met by this one.

Comparison of maximum storey drift for various RCC models in seismic zone V

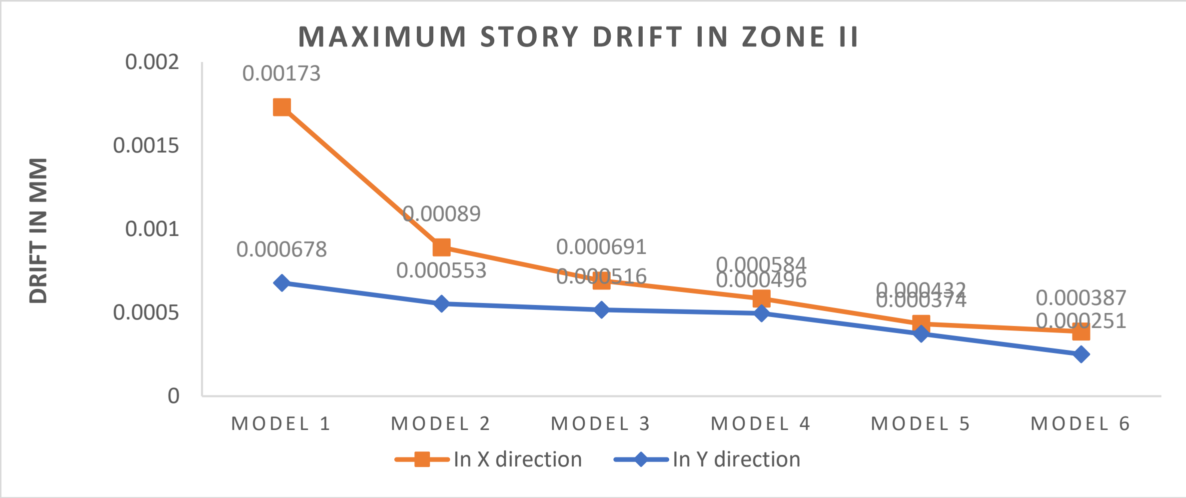


Fig 13 Comparison of maximum storey displacement for various RCC models in seismic zone V

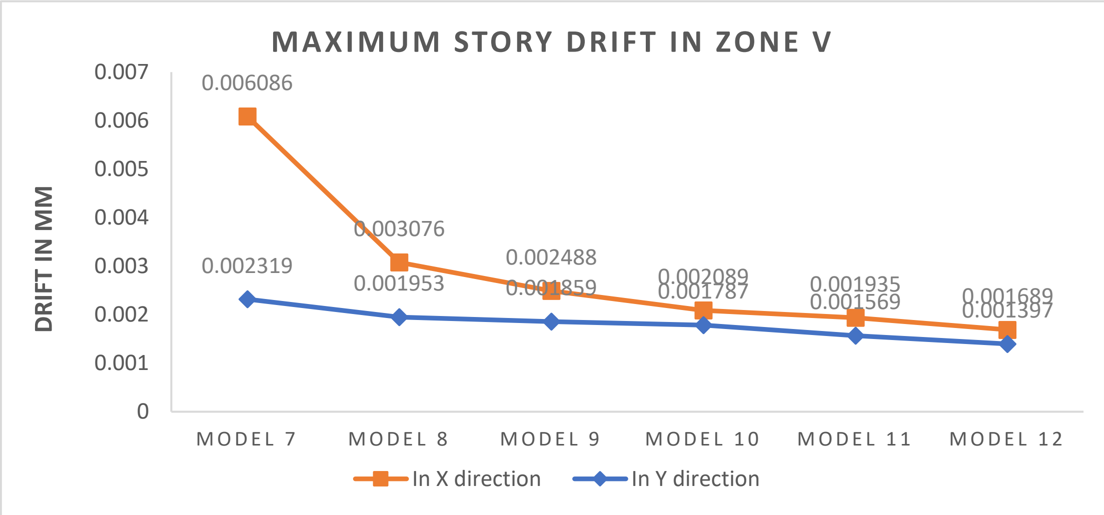


Fig 14 Comparison of maximum storey drift for various RCC models in seismic zone V

It is evident from the accompanying image and table that model 7 has the highest storey drift in both directions. The introduction of a shear wall results in a 49.5% and 15.8% decrease in storey drift in the x and y directions, respectively. In the X and Y directions, Model 7, or the model with the steel outrigger, reduced the drift by 59.2% and 19.8%, respectively. Across all models, Model 8 exhibits the lowest storey drift in both the x and y directions. Using the concrete outrigger model 12, it can be concluded that storey drift can be reduced by up to 72.67% and 27.17% in the X and Y directions, respectively.

6.6 OBSERVATIONS:

1) The Storey displacement is maximum for model 1 and model 7 i.e. RCC basic frame representation in seismic zone II and V with a value of 93.46mm and 323.85mm respectively.
2) If only shear wall is employed the displacement controlled is about 27.46% in zone II and 27.66% in zone V when compared to bare frame model in zone II and zone V i.e. model 1 and model 7 respectively.
3) It is observed that when shear wall along with outrigger and belt truss are employed simultaneously i.e. in model 6, the displacement can be controlled up to 56.54% in X direction and 23.8% in Y direction.
4) The 12th floor of the building, is the ideal location for the virtual outrigger. Given that the outrigger is positioned here, the displacement is minimal.
5) The storey drift is maximum for RCC bare frame model (model 1 and model 7). The maximum decrease in storey drift is seen in model with concrete outrigger i.e. model 1 in zone II and model 7 in zone V. The percentage decreased in storey drift is about 66.47% for model 1 and 65.68% for model 7 when compared with model 2 and model 12 respectively.
6) The base shear is less for composite model when compared to RCC models.
7) The results demonstrates that the model 12 i.e., bare frame model with shear wall and outrigger is best economical model due to reduction in frame sizes, less displacement, less storey drift.

VII. SUMMARY AND CONCLUSIONS

7.1 SUMMARY

The above work is an attempt to study the seismic response of building under the influence of different outrigger and belt truss system located in seismic zone II and zone V. Various models of RCC and composite building are analyzed and compared by using steel and concrete outrigger. The seismic base shear, storey displacement, storey drift and self-weight are compared for RCC and Composite building by performing Equivalent static analysis and Response spectrum analysis. The study leads to the following conclusions.

7.2 CONCLUSIONS

1. The use of shear wall and belt truss system in high rise building increases the stiffness and is most efficient in controlling displacement and drift.
2. Shear wall and belt truss composite construction are seen to be most effective than RCC structure with shear wall and belt truss system.
3. The optimum position of outrigger is at 6th model and 12th model of zone II and zone V respectively.
4. Concrete outrigger along with belt truss is found to be effective in reducing displacement and drift, when compared with steel outriggers.
5. The self-weight of Composite structure is less as compared to RCC structure which helps in reducing the foundation cost.

REFERENCES

1. **Abdul Karim Mulla and Shrinivas B.N** "A Study on Outrigger System in a tall R.C. Structure with steel bracing", International Journal of Engineering Research & Technology (IJERT) Vol. 4 Issue 7, | July – 2015.
2. **Abhishek Arora, Ravi Kumar** "Strengthening of High-Rise Building with Outrigger System", International Journal of Scientific Research in Science, Engineering and Technology, Volume 2 | Issue 3 | 2016, ISSN: 2394-4099 | Page 591-593.
3. **Dr. S. A. Halkude, Mr. C. G. Konapure and Ms. C. A. Mad gundi**: "Effect of Seismicity on Irregular Shape Structure" International Journal of Engineering Research & Technology (IJERT) Vol. 3 Issue 6, June – 2014. ISSN: 2278-0181 | Page 1404-1412.
4. **Kiran Kamath, Shashikumar Rao and Shruthi**: "A Study on Static and Dynamic Behaviour of Outrigger Structural System for Tall Buildings", Bonfring International Journal of Industrial Engineering and Management Science, Vol. 2, No. 4, December 2012, ISSN 2277-5056 | Page 15-20.
5. **M.R Suresh, Pradeep K.M,** "Influence of Outrigger System in RC Structures for Different Seismic Zones" IJSRD- International Journal for Scientific Research & Development, vol.3 Issue 05,2015, ISSN (online) :2321-0613.
6. **P.M.B Raj Kiran Nanduri, Suresh, MD. Ihtesham Hussain** "Optimum Position of Outrigger System for High-Rise Reinforced Concrete Buildings under Wind and Earthquake Loadings"

American Journal of Engineering Research (AJER) e-ISSN: 2320-0847 p-ISSN: 2320-0936 Volume-02, Issue-08, 2013 | pp-76-89.

7. **Po Seng Kian, Frits To rang Siahaan**: "The Use of Outrigger and Belt Truss System for High-Rise Concrete Buildings". DTS, Vol.3, No. 1, ISSN 1410-9530, Maret 2001, Page. 36-41.
8. **Prajyot A. Kakde, Ravindra Desai** "Comparative Study of Outrigger and Belt Truss Structural System for Steel and Concrete Material", International Research Journal of Engineering and Technology (IRJET), Volume: 04 Issue: 05 | May -2017, Page 142-147.Seismic design of outrigger systems for tall buildings by Jeremy Charles Harry Atkinson B.A.Sc., the University of British Columbia, 2013.
9. **Shiva Charan K, Chandrakala S, Karthik N M:** "Optimum Position of Outrigger System for Tall Vertical Irregularity Structures", IOSR Journal of Mechanical and Civil Engineering, Volume 12, Issue 2 Ver. II (Mar - Apr. 2015), PP 54-63.
10. **Shiva Charan k, Chandrakala S, Narayana G, Karthik N M** "Analysis of Outrigger System for Tall Vertical Irregularities Structures Subjected to Lateral Loads", IJRET: International Journal of Research in Engineering and Technology, Volume: 04 Issue: 05 | Page 84-88.
11. **IS: 1893**, "Criteria for earthquake resistant design of structures – general provisions for buildings", Part 1, Bureau of Indian Standards, New Delhi, 2002.
12. **IS: 456**, "Code of practice for plain and reinforced concrete code of practice", Bureau of Indian Standards, New Delhi, 2000.
13. **IS: 875**, "Code of practice for design load (other than earthquake) for buildings and structures" Bureau of Indian Standards, New Delhi, 2002.