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"A STUDY OF TALL STRUCTURES WITH VARIOUS ALIGNMENT OF OUTRIGGERS SUBJECTED TO SEISMIC LOADS"

Syed Ashraf[1], lokesh[2]

[1],M.Tech.(Structural Engineering) ,Veerappa Nisty College Of Engineering Shorapur, Dist -Yadgiri, Karnataka, India,

[2]Professors of M.Tech (Structural Engineering), Veerappa Nisty College Of Engineering Shorapur, Dist -Yadgiri, Karnataka, India ,

ABSTRACT- Recent years have witnessed the rapid development of high rise structures/buildings. Construction of tall structures has introduced new challenges to the structural engineers. Along with gravity loads the most critical loading for tall structures are proved to be lateral loads i.e., wind and seismic loads. With the increase in the height of building the different structural systems are developed correspondingly. In respect of reducing or minimizing the risk of structure, the outrigger is used is as the structural system to reduce the displacement and drifts. The major objective of this thesis is to study the behavior and optimum alignment of outrigger systems with and without belt trusses of a 30-storey three dimensional model subjected to lateral loads. The analysis has been carried out in Etabs 2015 version software for models with different alignment of outriggers. The outcomes have shown that the outriggers system has a considerable effect in minimizing of lateral displacement and storey drift of tall structures.

Keywords: Outriggers, Shear Wall , Displacement , story Drift , Response spectrum method.

I. INTRODUCTION

Human has dependably been entranced by tallness and if we look into history, we have constantly endeavored to achieve the moon allegorically. It can be related since antiquated pyramids to these advanced high rise structures, influence and abundance of a development on a few events breathtaking and amazing structures have been built. Now a days the image of monetary supremacy and administration of high rises. From the early edge with very productive present day structures, the auxiliary specialist's calling has made considerable progress. The ongoing advancement of structure examination and plan programming joined with advance in the limited component strategy has made numerous creative auxiliary and engineering shapes. The expanding reliance on PCs isn't the answer for the difficulties of the calling. The fundamental comprehension of basic conduct while utilizing IT devices are the components that change the way the structures are composed and fabricated. The plan of the high rise is by and large managed by the parallel burdens forced on the structure. Bit by bit, as the structures are greater and more grounded, the basic specialist has progressively been tested to meet the float prerequisites while limiting the effect of the compositional structure. Because of this test, the calling proposed an assortment of side boards, which are currently communicated in expansive structures far and wide. The plan of vast and slim structures is controlled by three affecting variables, quality (material limit), firmness (float) and workableness created by the sidelong load like breeze. As a building ends up bigger and thin, floating contemplations turn out to be more critical.
Without a doubt, the factor that represents plan for an extensive and slim structure more often than not will be not the totally focused on state but rather the float of the building. There are numerous auxiliary sidelong frameworks utilized as a part of the plan
of elevated structures, for example, shear outlines, shear outlines, shear center casings, encircled tubes, trellis tubes, super edges, and so on. Nonetheless, the outriggers and the belt brackets framework is the one that gives essential segments float control and relocation reduction for the building. When outer columns are connected or fixed to the core wall at centre with rigid truss or beams at different levels, than that is to be called as the outrigger system which is utilized as a lateral load resisting system.

OBJECTIVES OF STUDY

To get the best alignment of outriggers and virtual belt truss to oppose the seismic loads in a square RC framed building working by equivalent static analysis method in Etabs software.

- Preparation of 3D models and Analysis of the following different models of 30 storey RC framed building
    - **Model 1**-bare frame with core shear wall
    - **Model 2**-bare frame and core shear wall with virtual belt truss at top and 0.75H in exterior frame
    - **Model 3**- bare frame and core shear wall with centric outriggers at top and 0.75H in exterior frame

- **Model 4**- bare frame and core shear wall with virtual belt truss at top and 0.75H in interior frame
- **Model 5**- bare frame and core shear wall with diagonal outriggers at top and 0.75H in exterior frame
- **Model 6**- bare frame and core shear wall with centric outriggers along with VBT at top and 0.75H in exterior frame
- **Model 7**- bare frame and core shear wall with centric outriggers along with VBT at top and 0.75H in interior frame
- **Model 8**- bare frame and core shear wall with diagonal outriggers along with VBT at top and 0.75H in exterior frame
- **Model 9**- bare frame and core shear wall with diagonal outriggers along with VBT at top and 0.75H in interior frame

➢ To check the displacement, story drift and base shear values for all models.

Comparing base shear, lateral displacement and story drift values of previously mentioned system to decide the best design system for resisting lateral loads.

LITERATURE REVIEW

T. Fatima et al (2011) In their analysis strand7 software was used to analyse the three different models of 28, 42 and 57 floors. The lateral movements and behavior under lateral loads are broke down under different mixes of bracings frameworks (i.e., outriggers, belt truss and core walls).for 28-story building outriggers set under the most favorable conditions result.42-story building outriggers at mid-stature is more wanted area. For 57-story building outrigger set at 2/third is best alternative.

MD. Ihtesham Hussain et al(2013) The goal of this paper is to think about the conduct and find the ideal outrigger position. 1893 (Part-1):2002 and IS 875 (Part 3) are utilized for seismic and wind loads respectively. A 30-story tall structure is taken for instance for the all models considered in study. Outriggers were put at various plans and levels of the building height. They found that 0.5 times the height of building was optimum location for placement of outrigger. The highest displacement was found to be was 50.63mm in structre with only core which was again reduced considerably to 48.20mm by placing outrigger at top and was reduced to 47.63mm along with belt truss. No much considerable changes were found in drift with the belt truss.

M. R. Suresh et al (2014) Rigid Frame, Central Core Shear Wall/ and Wall-Frame Interaction which incorporate "Outrigger" were three framing systems considered in their study. The assumptions and the modeling of all considered models were carried out in Etabs software. Indian standards were used in the design considerations. The model comprises of various stories i.e., G+15, G+30,G+45 and G+60 with height of each story as 3.5m. In their analysis results they found that the maximum storey drifts were found for rigid frame, a bit less in shear wall system and minimum in the outrigger systems. The period was found to be increased with the increase in the height of the building i.e., 45% to 50% increment was seen when added 15 floors each. As the number of stories increases the maximum base shear value of structure also increases. Displacement values were reduced by 50% when used the shear wall system and were reduced by 60% with the outriggers.

DESCRIPTION OF MODEL

i. Plan area = 42m x 42m
ii. Bay spacing in both directions = 6m
iii. Height of each floor= 3.0m
iv. Size of column = 600 x 900 mm
v. Size of beam = 300 x 450 mm
vi. Outrigger bracings = 300x 300mm
vii. No. of stories = 35
viii. Grade of concrete = M35
ix. Total height of structure =90m
x. Thickness of slab= 150mm

Applied Loads

Only external loads are applied on structure neglecting the self weights of members which is calculated automatically by ETABS 2015 software itself. The Shell loads (on Slabs) acting in the Gravity direction are superdead load i.e., floor finish =1.2kN/m2 and Live=3kN/m2. The Frame/wall loads applied uniformly on the beams as Dead=10.8kN/m.

Material Properties

PROPERTIES	VALUES
Young's modulus of concrete	$25X10^6$ kN/m^2
Density of reinforced concrete	25 kN/m^3
Density of steel	76.59 kN/m^3
Poisson's ratio of steel	0.3
Assumed floor finishes	1.2 kN/m^2

Seismic Data

- Zone factor =0.36(Zone V)
- Importance factor = 1.5
- Response reduction factor =5
- Soil type = Type 2 (medium)

DIFFERENT TYPES OF MODELS CONSIDERED FOR PRESENT STUDY

MODEL 1: The building is modeled as a bare frame with core shear wall .

MODEL 2: The building is modeled as bare frame and core shear wall with virtual belt truss at top and 0.75H in exterior frame .

MODEL 3: The building is modeled as bare frame and core shear wall with centric outriggers at top and 0.75H in exterior frame .

MODEL 4: The building is modeled as bare frame and core shear wall with virtual belt truss at top and 0.75H in interior frame .

MODEL 5: The building is modeled as bare frame and core shear wall with diagonal outriggers at top and 0.75H in exterior frame.

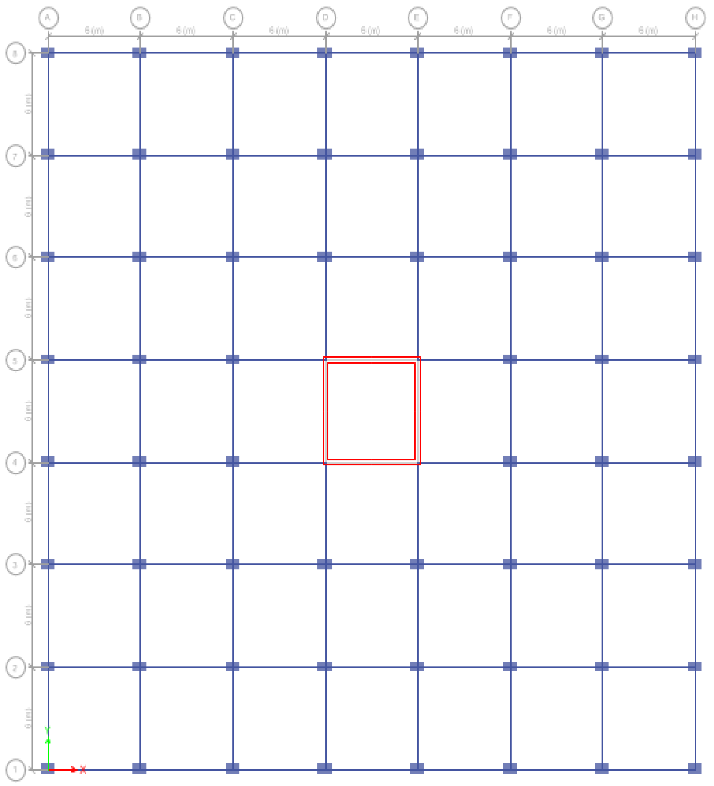
MODEL 6: The building is modeled as bare frame and core shear wall with centric outriggers along with VBT at top and 0.75H in exterior frame.

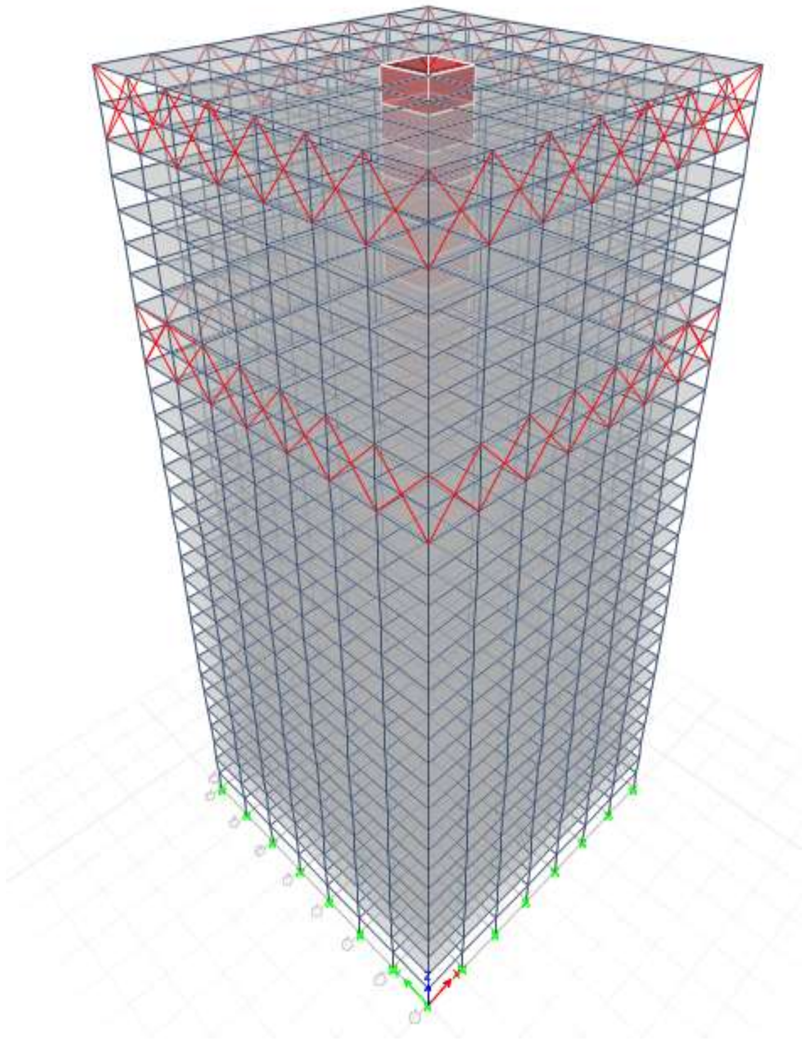
MODEL 7: The building is modeled as bare frame and core shear wall with centric outriggers along with VBT at top and 0.75H in interior frame.

MODEL 8: The building is modeled as bare frame and core shear wall with diagonal outriggers along with VBT at top and 0.75H in exterior frame.

MODEL 9: The building is modeled as bare frame and core shear wall with diagonal outriggers along with VBT at top and 0.75H in interior frame.

PLAN USED IN ANALYSIS





RESULTS AND DISCUSSION

All the different nine models are analysed with equivalent static analysis for the applied seismic loads. The analysis of all the different building models is carried out in ETABs 2015 software. The analysis results such as displacements, story drifts and base shear of all building models are tabulated and compared.

4.1 Displacement

To study the effect of introduction of outriggers in the framing system in respect of increasing the stiffness under the applied seismic loads. The displacement is one of the prime factor in analyzing the building models. The displacements which are likely to happen due to lateral loads are calculated and tabulated for all the models considered.

For all the different models considered the displacements along longitudinal and transverse direction i.e., both X and Y directions are tabulated. The displacements along X and Y directions due to seismic loads are presented in Tables 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8 and 4.9. respectively. Max displacements of all models by Equivalent static analysis are compared in Table 4.19 and a comparison bar chart is represented in chart 4.19.

4.2 Storey Drifts

Story drift is again a factor to be analysed for the performance study of structures. Story drift is calculated as ratio of difference of displacement of two successive stories to the height of that story. For all the different models considered the story drift along longitudinal and transverse direction i.e., both X and Y directions are tabulated. The story drifts along X and Y directions due to seismic loads are presented in Tables 4.10, 4.11, 4.12, 4.13 and 4.14, 4.15, 4.16, 4.17 and 4.18 respectively. Max story drifts of all models by Equivalent static analysis are compared in Table 4.20 and a comparison bar chart is represented in chart 4.20.

RESULTS OF ANALYSIS

Table 4.19 Max displacements for all models

MODEL	MAX DIS IN X-DIRECTION	% REDUCTION COMPARED TO MODEL 1	MAX DIS IN Y-DIRECTION	% REDUCTION COMPARED TO MODEL 1
MODEL 1	238.7	0	245.4	0
MODEL 2	167.3	30	171.8	30
MODEL 3	165	31	169.2	31
MODEL 4	169.6	29	174.1	29
MODEL 5	166.5	30	170.9	30
MODEL 6	154.4	36	158.8	35
MODEL 7	155.9	35	160.2	35
MODEL 8	157.5	34	162	34
MODEL 9	158.2	34	162.7	34

Chart 4.19 Max displacements for all models

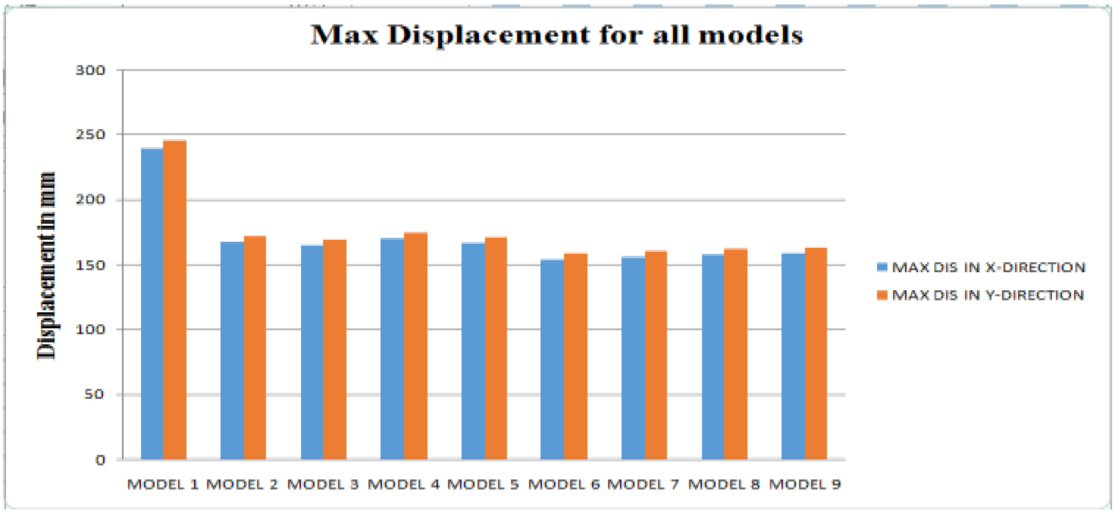


Table 4.20 Max story drifts for all models

MODEL	MAX STORY DRIFT IN X-DIRECTION	% REDUCTION COMPARED TO MODEL 1	MAX STORY DRIFT IN Y-DIRECTION	% REDUCTION COMPARED TO MODEL 1
MODEL 1	0.0033667	0	0.0034333	0
MODEL 2	0.0029000	14	0.0030000	13
MODEL 3	0.0028667	15	0.0029333	15
MODEL 4	0.0029000	14	0.0030000	13
MODEL 5	0.0029000	14	0.0029667	13
MODEL 6	0.0028667	15	0.0029000	16
MODEL 7	0.0028667	15	0.0029000	16
MODEL 8	0.0028667	14	0.0029333	15
MODEL 9	0.0028667	14	0.0029333	15

Chart 4.20 Max story drifts for all models

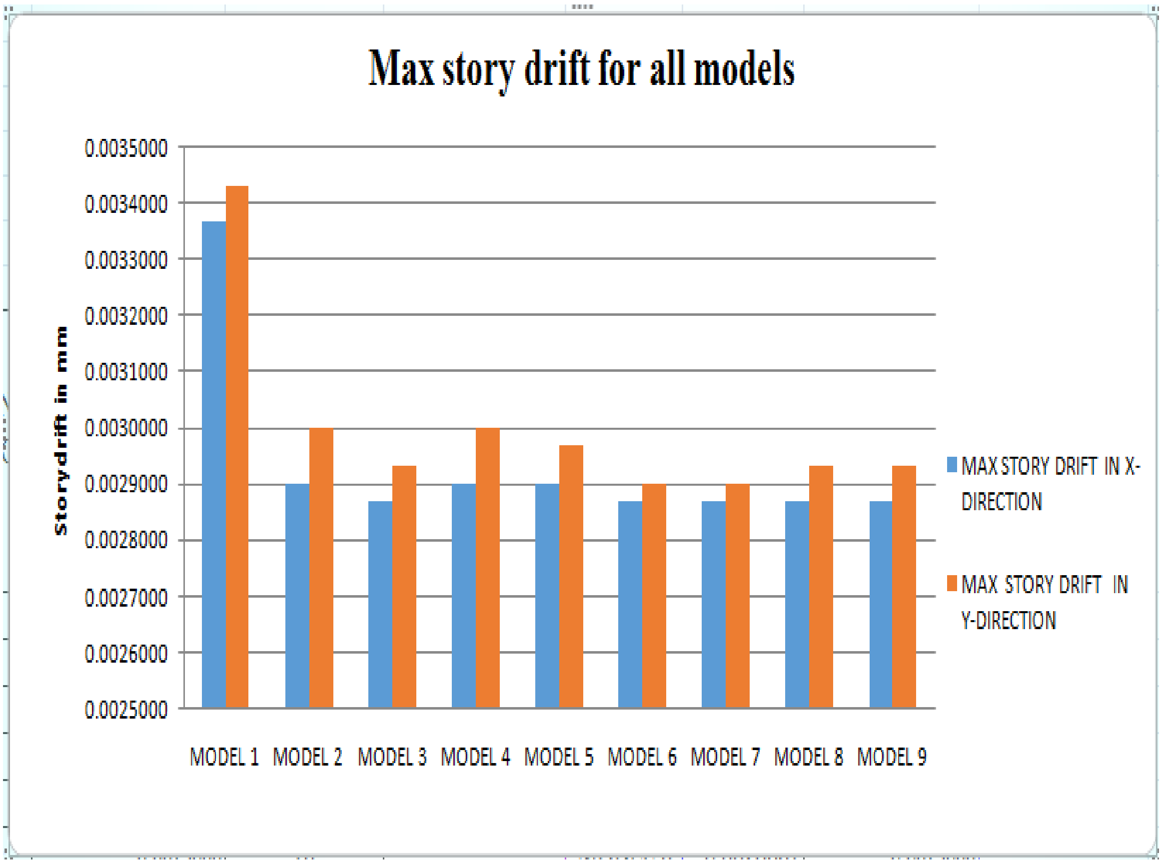
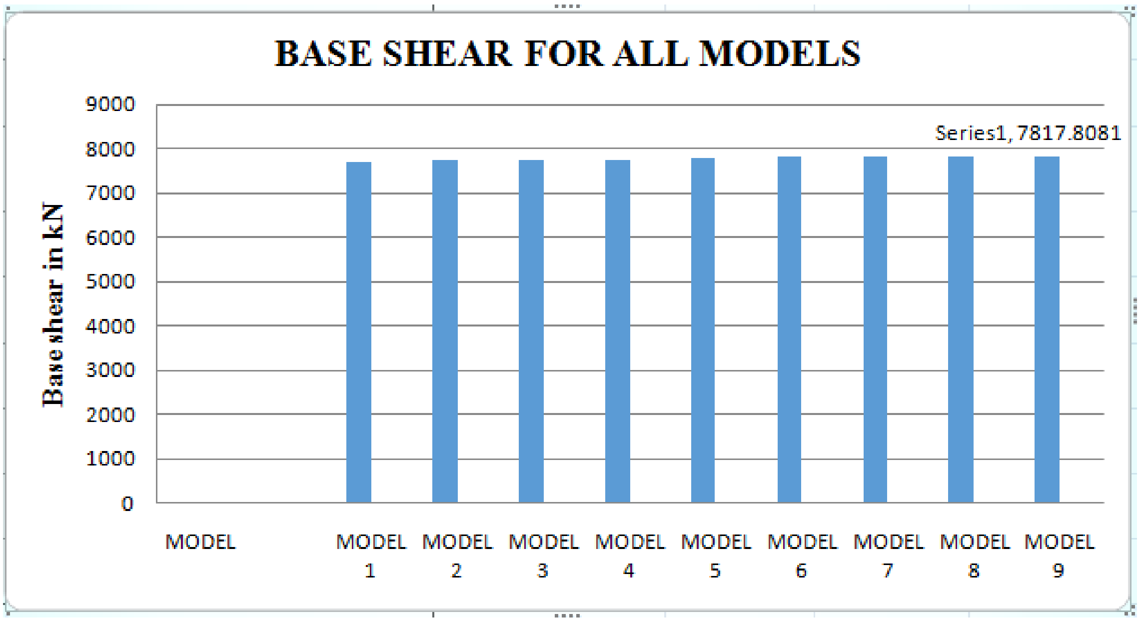


Table 4.21 Base shear values in both directions for all models

MODEL	BASE SHEAR IN X-DIRECTION in kN	BASE SHEAR IN Y-DIRECTION in kN
MODEL 1	7685.3824	7685.3824
MODEL 2	7749.9872	7749.9872
MODEL 3	7740.7579	7740.7579
MODEL 4	7749.9872	7749.9872
MODEL 5	7753.2033	7753.2033
MODEL 6	7805.3628	7805.3628
MODEL 7	7805.3627	7805.3627
MODEL 8	7817.8081	7817.8081
MODEL 9	7817.8081	7817.8081

Chart 4.21 Base shear values in both directions for all models



CONCLUSIONS

- The models 1, 2, 3, 4, 5, 6, 7, 8 and 9 when compared for displacements in X-direction by equivalent static analysis, the displacements of model 2, 3, 4, 5, 6, 7, 8 and 9 are reduced by 30%, 31%, 29%, 30%, 36%, 35%, 34%, and 34% respectively.

- The models 1, 2, 3, 4, 5, 6, 7, 8 and 9 when compared for displacements in Y-direction by equivalent static analysis, the displacements of model 2, 3, 4, 5, 6, 7, 8 and 9 are reduced by 30%, 31%, 29%, 30%, 35%, 35%, 34%, 34% respectively.

- The models 1, 2, 3, 4, 5, 6, 7, 8 and 9 when compared for story drifts in X-direction by equivalent static analysis, the drifts of model 2, 3, 4, 5, 6, 7, 8 and 9 are reduced by 14%, 15%, 14%, 14%, 15%, 15%, 14% and14%, respectively.

- The models 1, 2, 3, 4, 5, 6, 7, 8 and 9 when compared for story drifts in Y-direction by equivalent static analysis, the drifts of model 2, 3, 4, 5, 6, 7, 8 and 9 are reduced by 13%, 15%, 13%, 13%, 16%, 16%, 15% and15%, respectively.

- The introduction of outriggers and belt trusses in different alignments has shown no considerable changes in base shear values .

- The model 6 and model 7 i.e., bare frame and core shear wall with centric outriggers along with VBT at top and 0.75H in exterior frame and in interior frame are found to be efficient in reducing lateral displacements for seismic loads among the all models considered in study.

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