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# The Methodology of mitigation response of the high rise building by using outrigger system

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**Abstract:** The construction of high rise building was beginning from the end of the 19th century with widely spread so that a lot of researchers interested to study the response of high rise building and the methodologies for reducing the response, the most loading effects on the modern high rise building was generated from wind and seismic loads so that using shear wall and core system is one of the solution to resist this effects, they are very helpful to resist and enforce the building against the lateral load but due to increasing of the height building there are necessary to search another effective mitigation mechanism to reduce the response, the development methodology of resistance became the priority for the structure designers to get the most optimization system for resistance the seismic response, so that a lot of researchers had a target to get the best methodology for controlling the response of high rise building, the outrigger system is one of the best solution to mitigate the response of the building and increasing the lateral stability of the building so that the study research direct to get the best position of the outrigger system to mitigate the response, the study focuses on using the outrigger system along the high rise building without specified position to standup the optimization position of the outrigger system, and the study target to compare between the composite material with the steel bracing of the outrigger (the advantages and disadvantages of using different types of material), the research analyzes the response of maximum displacement, story drift, shear overturning moment and base shear due to different position of the outrigger, and compare the difference in results between composite material and steel bracing for the outrigger modeling, in the final studying it can be shown that it illustrates that the results will differ than other researches and not be exactly matching with empirical results which indicates the optimum position will be in the middle of the height which means the outrigger position is effected by the modeling type and the configuration of the building, the results indicate that the increasing the reduction of the lateral displacement in X direction at the outrigger position in Floor 33 with the reduction percentage 14.14%, which means the best position in case of earth quack in X direction at 76.92% of the height of the building and in case of Y direction, the increasing of the reduction of the lateral displacement will be at the outrigger position in Floor 27 with the reduction percentage 35.12%, which means the best position in case of earth quack in Y direction at 63.08% of the height of the building from the bottom level, the reduction percentages in case of overturning moment and the shear are not significant, the model of the outrigger system hasn't big effect in reducing of the overturning moment or shear base, in the final study, the effect of using of composite section instead of steel bracing in the outrigger modeling demonstrates that the using of the composite section has a great effect in reducing the lateral displacement than the steel bracing, this results refer to the increase in the stiffness of the composite section than steel bracing.

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**Keywords:** outrigger models, composite section, response spectrum analysis, optimization

## 1. Introduction

The number of high rise building was increased since 1985, especially due to a large development in the construction material, increasing of high strength material and technology advancement in science and computer software, although the previous mention there are a lot of challenges still faces the development of the high rise building around the world, lateral loads which generate from wind and seismic load are one of the biggest challenges need to resist, increasing the height of the building needs to increase in lateral stability and stiffness, so that the study of different mechanism system for mitigation of the seismic response consider most interesting for the structure design.

High rise building, serviceability, and safety of high rise are the most important factors should take care in the design, so that the design should interest with reducing the lateral displacement effect which results from the earthquake or wind load, lateral displacement increases with the increase of height of the building and to solve these issue there are various structural system can be embedded in the construction of high rise building like as shear wall system, moment – resisting frame, core system, tube in tube, mega core system etc.

Increasing in the cross-section of the moment – resisting frame, shear wall system to construct high rise building lead to uneconomical design, so that the designers search for another structural system like as bundled, braced tube systems m outrigger with belt trusses, the development systems have a role to control of the lateral displacement and story drift [1-7], the outrigger system has a good capability to increase the lateral stability of the building [8-12].

The outrigger system is one of the popular methodologies spread in the world, and the needing in development of the outrigger system to get the best lateral stability is most important to achieve, increasing of the height with increasing of lateral stiffness, using the outrigger, shear wall and core system can be sufficient to resist both of wind and seismic loading, it can help to reduce the story drift which is considered as one of the most important factors should be taken care in the design of the structure especially in the early stage of design, the drift criteria factor is a factor controlling in choosing the appropriate structural element, on the other hand, there are three perspective phases lead us to interest to the drift and lateral displacement [1] structural stability [2] human comfortability [3] architectural requirements [13].

Choosing the best mechanism to reduce the response of high-rise buildings and facing the collapsing of the building due to seismic load especially in the high zone of the seismic area is the most important factor in the structural design and in reducing the cost which is directly related to the optimization design.

The large development in the software phase helps us to developed and represented the outrigger system, and creation the modeling of the outrigger system by finite element modeling which can be created by the software, the software program allows to represent any difficult modeling of the outrigger system in easier way, the using of software as a tool is not only the mean to create and understand the behavior of the structure so that understanding the behavior of the outrigger system by levering of the software program as a tool is considered as our target in the research.

This paper demonstrates the studying the using of the outrigger system in different position along the high of the building with belt truss, Using ETABS 2016 software program for analyzing the three dimensional finite element structure subjected to earthquake in case of dynamic analysis and get the response for all position in the building and comparing the results with the empirical theory to stand up if the empirical theory is validated for all schematic shape of the building or not, and to demonstrate the shape of the building and height effects on the position of the outrigger which indicate that it doesn't the same position in all types of the structure or all height of the building.

On the other side it clarifies that the structure response differs according to their size and shape and not the same in response, the prevailing opinion about the larger structure gives us the identical to the ratio of smaller structure is not correct so that the results about the optimization position of the outrigger system differ from structure to another and this will be clear in our study.

The high rise building with different bracing models is analyzing by using software ETABS. In the analysis, there are focusing on the comparing of seismic analysis of the structure building for different parameters (lateral displacement, story drift, base shear, the capacity moment).

## 2. Literature Review

The basic concept of the outrigger system in the high rise building means the integration between the external columns and internal core in resistance of lateral loads, Using the outrigger system in resistance of lateral load is still one of the governing system, the structural component of the outrigger system comprises the main concrete core connected to exterior column by the stiff outrigger system, the outrigger system can be connected in one direction or in the both direction Fig.1. [14], therefore the using of the core and perimeter column connected with the internal core lead to work together to resist the lateral loads, which means it becomes deeper and stiffer to resist the lateral load.

A various numerical study [15,16,11,17] by using finite element modeling to represent the response of high rise building in case of liner or nonlinear analysis for static and dynamic analysis, in addition, the effects of the position of the outrigger system on the response of the structure.

Using Multi outrigger system to increase the resistance of lateral load induced by seismic loading or wind loading is one of the methodologies to enhance the resistance, a lot of researches studies the different modeling system of outrigger to get the best optimization response of the system.

The response of the system is not difficult to understand, it is easy to analyze, the basic concept of the outrigger system that when the structure subject to lateral load from seismic or wind load the exterior column connected to the core by the outrigger can resist the rotation of the core, reducing the lateral deflections and moment in the core, the overturning moment is not resisted only by the core system but also by using outrigger system connected to the exterior column, it means resistance by the tension and compression of the exterior column Fig.2, using of the exterior column as a constrain for the rotation of the core can be achieved by the connecting the core with the exterior column by using the outrigger.

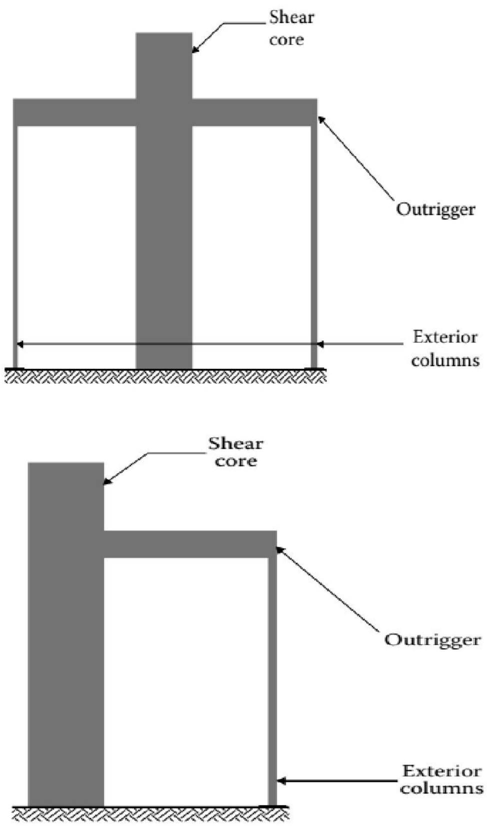


Fig.1. the outrigger system in one direction or in the both direction

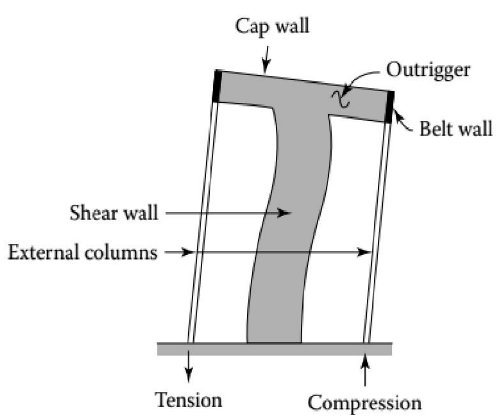


Fig.2. the tension and compression of the exterior column

The floor of outrigger system can be used as mechanical floors or shutter floor, to allow for the engineer to fully utilization of these floor and use these area in the operating system of the building, To full understanding the concept of the outrigger system is that consider the outrigger is strong enough to create moments $M_1$ & $M_2$ as shown in Fig (3) so that $oM_{base}$ will be effected by the reducing moment $M_1$ & $M_2$

$M_{base} = oM_{base} - M_1 - M_2$

Which can be written in another form

$M_{base} = oM_{base} - \sum M_i$

Where Mi is the resistance moment of outrigger i, from the equation and Fig.3. it demonstrates that the base moment reduces by the Mi (resistance moment), although the outrigger moment resistance increase resistance moment, the moment base is close to $oM_{base}$, it obviously also increasing the number of outriggers can increase the value of resistance moment, the big effect of the outrigger system is reducing the displacement and story drift so that it considers as an effective tool to reduce the lateral response.

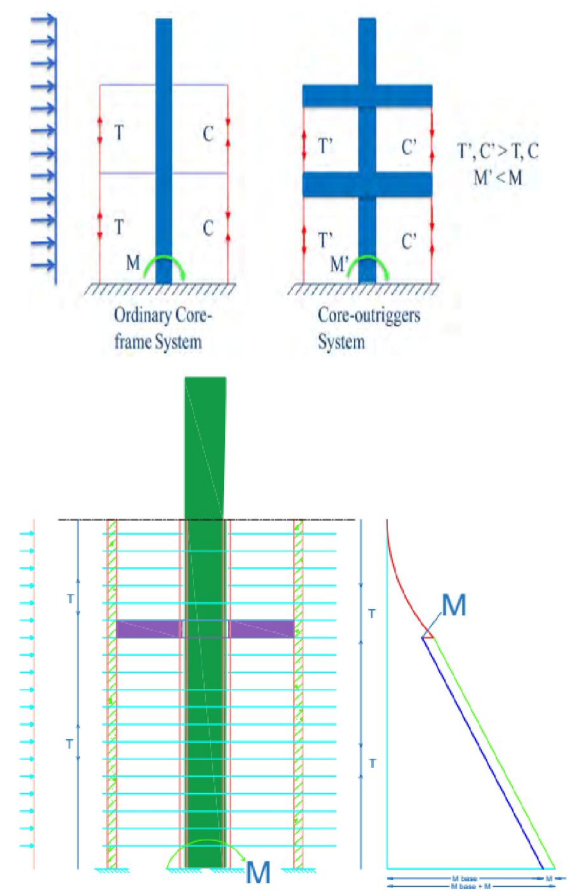


Fig.3. $M_{base}$, $oM_{base}$,$M_1$,$M_2$

Stafford Smith and Salim 1998, Stafford Smith and Coull, 2002 demonstrated that the horizontal deflection behavior can be deduced from the single bending stiffness parameter and they consider the deformation in the concrete wall due to shear forces can be neglected. and the mechanism of the connection between the outrigger, the core, and the column is as shown in Fig.4. which demonstrate that the outrigger system is consider as prismatic member connected rigidly with core and pin connected with the exterior column, these types of connection generate increasing in the effective flexural depth and hence increasing in flexural stiffness, so that the core is supported by the connection the outrigger with the perimeter columns, Using the belt truss to connect the perimeter of exterior column improve the capability of structure to resist the lateral seismic load by distributing the effects equity on the perimeter of the column.

Sinth and Coull 1991; Taranath 1998 determine the optimum position of the outrigger system at 40-60 percent of the building Taranath [8] demonstrated the optimum position of the outrigger in a structure is at 0.455 H from the top (where H: height of the building), and McNabb JW, Muvdi BB [25] Studied using of multi outrigger system to obtain the effective position to reduce the lateral displacement, and indicated the optimum positions are 0.312 H, 0.685 H, and also a various research focused on the optimum position of the outrigger which is considered as an effective methods to resist the lateral displacement with the lowest cost [24,26,27].

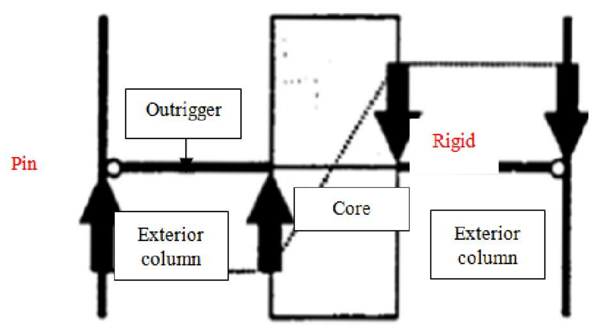


Fig.4. the mechanism of the connection between the outrigger, the core and the column

## 3. Mathematical modeling

Description of the studying high rise building, The present study in the research comprises 42 floor with total height 130 m as shown in Fig.5, Fig.6, the central of core wall dimension indicates in Fig.6, the typical floor height is equal to 3 m expect the first floor with height is equal to 4 m, the system of the structure consists of belt trusses, exterior column, outrigger system and core system, For the analysis of the modeling, it is assumed all sections sizes of column and core are constant regardless the height of high rise building.

Although most of high-rise building built on the basement stories, the representative of the modeling of the building is avoided the basement floor and consider it as an ordinary floor, this is creation in modeling for sake of simplicity in the structural design the demonstrated high rise building models consists of 33.86m in y – direction and 70.95m in x – direction as shown in the configuration plan Fig.5 choosing of the members size to be sufficient with enough accuracy to obtain the a reasonable response for the structure and to indicate the effective of using the outrigger system in the response of the high rise building, the dimension of the cross sec of the elements is consider as a preliminary design process, The dimensions of the exterior columns as shown in Fig.5 are (160 cm x 150 cm), (120 cm x 150 cm), (200 cm x 150 cm), (220 cm x 150 cm), (230 cm x 150 cm), (220 cm x 150 cm), (230 cm x 150 cm), (240 x 150 cm) and (150 cm x 150 cm), the thickness of slabs is equal to 30 cm, the core has thickness equal to 50 cm with dimension 8.2m x 44.6 m, the steel bracing is created by dimensions with height equal to 600 cm and width equal to 300 cm.

The dead loads comprise the self-weigh and the flooring loading, the flooring and roof finishing load is equal to 4 $KN/m^2$, and life load is taken by 2.5 $KN/m^2$ for each floor. The materials were chosen in our studying are C20 for concrete and steel types ST40/60 with constant properties of modulus of elasticity $E = 2.0\times10^8$ $Kn/m^2$, Poisson ratio $\mu = 0.2$, density of concrete = 25 $Kn/m^3$, compressive strength fc = 20000 $Kn/m^2$.

Using ETABS (CSI 2016) software program to analyze the building in three-dimensional analysis and analyze the results by using the software program.

The structural details of building frame are shown in Table 1.

Table 1. Details for frame members

| Member | L (Length cm) | B (width cm) |
|---|---|---|
| **C1** | 220 | 150 |
| **C2** | 240 | 150 |
| **C3** | 230 | 150 |
| **C4** | 230 | 150 |
| **C5** | 230 | 150 |

| | | |
|---|---|---|
| **C6** | 230 | 150 |
| **C7** | 230 | 150 |
| **C8** | 220 | 150 |
| **C9** | 220 | 150 |
| **C10** | 220 | 150 |
| **C11** | 220 | 150 |
| **C12** | 220 | 150 |
| **C13** | 210 | 150 |
| **C14** | 210 | 150 |
| **C15** | 210 | 150 |
| **C16** | 210 | 150 |
| **C17** | 210 | 150 |
| **C18** | 240 | 150 |
| **C19** | 220 | 150 |
| **C20** | 200 | 150 |
| **C21** | 150 | 150 |
| **C22** | 230 | 150 |

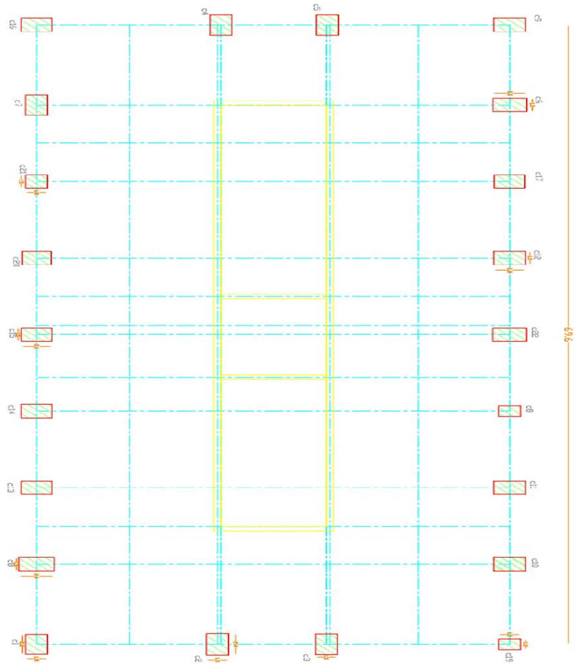
Fig.5. The configuration plan

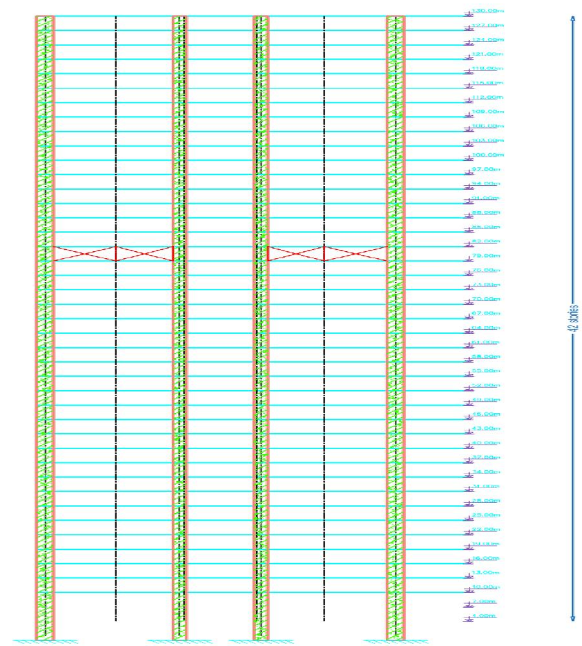
Fig.6. Elevation of the building

## 4. Outrigger Models

Outrigger models comprises all arrangements along the building at each floor level to get fully studying for the effects of the position of the outrigger at each level on the response of the building and to get the deduction about the best position with best response so that the classification of the outrigger position clarify as shown Table 2.

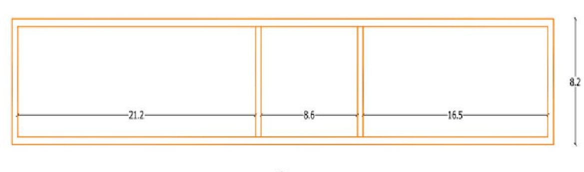

Fig.7 Dimension of the core

Table 2. Outrigger Positions Models

| Ser | The structural model | Outrigger position (Floor Location) | Outrigger code |
|---|---|---|---|
| 1 | Structural Model without outrigger (SMO) | Without outrigger | |
| 2 | Structural Model with one outrigger at the top floor | Floor 42 | SOD 42 |

| | | | |
|---|---|---|---|
| 3 | Structural Model with one outrigger | Floor 41 | SOD 41 |
| 4 | Structural Model with one outrigger | Floor 40 | SOD 40 |
| 5 | Structural Model with one outrigger | Floor 39 | SOD 39 |
| 6 | Structural Model with one outrigger | Floor 38 | SOD 38 |
| 7 | Structural Model with one outrigger | Floor 37 | SOD 37 |
| 8 | Structural Model with one outrigger | Floor 36 | SOD 36 |
| 9 | Structural Model with one outrigger | Floor 35 | SOD 35 |
| 10 | Structural Model with one outrigger | Floor 34 | SOD 34 |
| 11 | Structural Model with one outrigger | Floor 32 | SOD 32 |
| 12 | Structural Model with one outrigger | Floor 31 | SOD 31 |
| 13 | Structural Model with one outrigger | Floor 30 | SOD 30 |
| 14 | Structural Model with one outrigger | Floor 29 | SOD 29 |
| 15 | Structural Model with one outrigger | Floor 28 | SOD 28 |
| 16 | Structural Model with one outrigger | Floor 27 | SOD 27 |
| 17 | Structural Model with one outrigger | Floor 26 | SOD 26 |
| 18 | Structural Model with one outrigger | Floor 25 | SOD 25 |
| 19 | Structural Model with one outrigger | Floor 24 | SOD 24 |
| 20 | Structural Model with one outrigger | Floor 23 | SOD 23 |
| 21 | Structural Model with one outrigger | Floor 22 | SOD 22 |
| 22 | Structural Model with one outrigger | Floor 21 | SOD 21 |
| 23 | Structural Model with one outrigger | Floor 20 | SOD 20 |
| 24 | Structural Model with one outrigger | Floor 19 | SOD 19 |
| 25 | Structural Model with one outrigger | Floor 18 | SOD 18 |
| 26 | Structural Model with one outrigger | Floor 17 | SOD 17 |
| 27 | Structural Model with one outrigger | Floor 16 | SOD 16 |
| 28 | Structural Model with one outrigger | Floor 15 | SOD 15 |
| 29 | Structural Model with one outrigger | Floor 14 | SOD 14 |
| 30 | Structural Model with one outrigger | Floor 13 | SOD 13 |
| 31 | Structural Model with one outrigger | Floor 12 | SOD 12 |
| 32 | Structural Model with one outrigger | Floor 11 | SOD 11 |
| 33 | Structural Model with one outrigger | Floor 10 | SOD 10 |
| 34 | Structural Model with one outrigger | Floor 9 | SOD 9 |
| 35 | Structural Model with one outrigger | Floor 8 | SOD 8 |
| 36 | Structural Model with one outrigger | Floor 7 | SOD 7 |
| 37 | Structural Model with one outrigger | Floor 6 | SOD 6 |
| 38 | Structural Model with one outrigger | Floor 5 | SOD 5 |
| 39 | Structural Model with one outrigger | Floor 4 | SOD 4 |
| 40 | Structural Model with one outrigger | Floor 3 | SOD 3 |
| 41 | Structural Model with one outrigger | Floor 2 | SOD 2 |
| 42 | Structural Model with one outrigger | Floor 1 | SOD 1 |

## 5. Modal response spectrum (RS) method

in the past it has a difficulty to calculate the basic mode superposition method which is considering as a linear elastic analysis to get the complete response of the structure, it has disadvantages due to needs to produce a large amount of information which require the computational effort to produce the complete time history response of joint displacement and forces, But the advantages of using response spectrum method to expect the behavior of the structure under seismic loading and get the displacements and member force, this method includes the max values for each mode which need the computational effort to obtain.

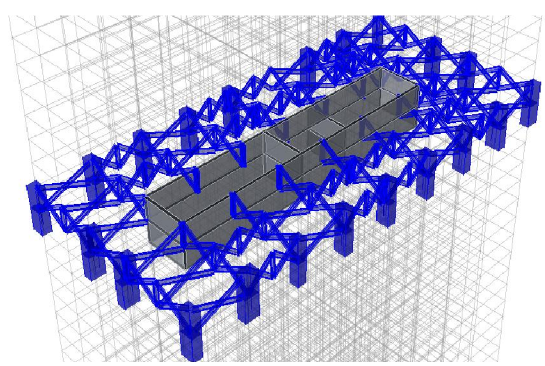

Fig.8 Outrigger Modelling

G. W. Housner had an effective role in spread and acceptance the concept of the earthquake response spectrum which is created by M.A Biot in 1932 as a means to expect the response of the ground motion and its effects on the structures.

At the last century the general concept of earthquake science that the response spectrum gives us the conventional manners to get the peak response of all possible linear SDF system a central concept in earthquake engineering, the response spectrum provides a convenient means to summarize the peak response of all possible linear SDF systems and it can help us to provide the knowledge of structural dynamic to the design and add the concept of the response spectrum in the design codes.

For three-dimensional seismic motion

$$\ddot{y}(t)_n + 2\zeta_n \omega_n \dot{y}(t)_n + \omega_n^2 y(t)_n = p_{nx}\ddot{u}(t)_{gx} + p_{ny}\ddot{u}(t)_{gy} + p_{nz}\ddot{u}(t)_{gz}$$

where the three Mode Participation Factors are defined $p_{ni} = -\Phi_n{}^T M_i$ by in which i is equal to x, y or z.

It can be follow the steps to get the solution and the response of the building under Earthquake, the first step get the maximum peak forces and displacement for each direction and hence get the response for three orthogonal direction, it is necessary to estimate the maximum response from the three components of earthquake motion acting at the same time. The peak response of the response spectrum equation can get from the following:

$$u_o(T_n, \zeta) \equiv \max_t |u(t, T_n, \zeta)|$$

$$\dot{u}_o(T_n, \zeta) \equiv \max_t |\dot{u}(t, T_n, \zeta)|$$

$$\ddot{u}_o^t(T_n, \zeta) \equiv \max_t |\ddot{u}^t(t, T_n, \zeta)|$$

The deformation response spectrum is a plot of uo against Tn for fixed ζ. A similar plot for uo is the relative velocity response spectrum, and for u¨ to is the acceleration response spectrum.

Response-spectrum analysis (RSA) is a linear-dynamic statistical analysis method which can be calculated the maximum seismic response for each natural mode, it can measure pseudo-spectral acceleration, velocity, or displacement as a function of the structural period for given time history and level of damping.

Indeed the concept of the response spectrum is applicable for all types of structures.

The modal participation doesn't lease than 90% to the structure's mass in each orthogonal direction (Kunnath, Kalkan 2004).

The curve of the response spectrum can be shown in Fig.4 and the Egyptian code comprises the damping coefficient in the equation of the response spectrum. The acceleration spectrum is expressed in terms of the peak acceleration (PGA).

The seismic zone considered in this study is zone 3 and the shape of the spectrum is type 3 as per Egyptian zoning system with design ground acceleration ag of 0.15g, the important factor of the modeling γ = 1. The soil class is considered "C" and a soil factor S = 1.5.

The reduction factor, R, is taken considering the vertical loads and the total base shear are totally resisted by the bracing frame structure (R = 5), Tb = 0.1sec, Tc =0.25 sec and Td = 1.2 sec.

Fig.9 demonstrates the response spectrum curve which is used to represent the seismic analysis effecting on the high-rise building.

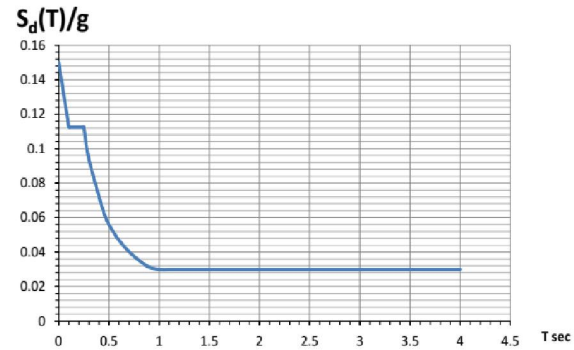


Fig.9. Response Spectrum Curve

## 6. objectives of the Research

The objective of the study is finding the methodology for mitigation of the response of the structure under the seismic load effects by using the outrigger system and the effects of using of the outrigger on the response of high rise building (lateral displacement, story drift, shear overturning moment and base shear due to different position of the outrigger, and compare the difference in results between composite material and steel bracing for the outrigger modeling) compare the results with empirical approach of the optimum position of the outrigger and to demonstrate if the empirical approach for the position is applicable for all shapes and height of the building or applicable for different structure system or not.

In the final research, the advantage and disadvantages of using the composite material instead of steel bracing in the outrigger are investigated.

## 7. Results and Discussion

Using response spectrum analysis to evaluate the displacement, story drift, shear, overturning moment along with the height of the high-rise building.

**The story Displacement**

Table 3. The values of lateral displacement at different positions of the outrigger (In case of earthquake in X-Direction)

| Position of the outrigger | Maximum Displacement value (m) | Percentage reduction (%) |
|---|---|---|
| Bare frame with core (without outrigger) | 0.075 | |
| floor 42 | 0.06642 | 11.4% |
| floor41 | 0.06499 | 13.3% |
| floor40 | 0.06486 | 13.5% |
| floor39 | 0.06475 | 13.67% |
| floor38 | 0.06465 | 13.80% |
| floor37 | 0.06456 | 13.92% |
| floor36 | 0.06449 | 14.01% |
| floor35 | 0.06444 | 14.08% |
| floor34 | 0.06441 | 14.12% |
| floor33 | 0.0644 | 14.14% |
| floor32 | 0.06441 | 14.12% |
| floor31 | 0.06444 | 14.08% |
| floor30 | 0.06449 | 14.01% |
| floor29 | 0.06457 | 13.90% |
| floor28 | 0.06468 | 13.76% |
| floor27 | 0.06481 | 13.58% |
| floor26 | 0.06497 | 13.37% |
| floor25 | 0.06516 | 13.12% |
| floor24 | 0.06537 | 12.84% |
| floor23 | 0.06561 | 12.52% |
| floor22 | 0.06588 | 12.16% |
| floor21 | 0.06616 | 11.78% |
| floor20 | 0.06649 | 11.35% |
| floor19 | 0.06683 | 10.89% |
| floor18 | 0.0672 | 10.40% |
| floor17 | 0.06759 | 9.87% |
| floor16 | 0.068 | 9.32% |
| floor15 | 0.06844 | 8.75% |
| floor14 | 0.06888 | 8.15% |
| floor13 | 0.06935 | 7.54% |
| floor12 | 0.06982 | 6.91% |
| floor11 | 0.0703 | 6.27% |
| floor10 | 0.07078 | 5.63% |
| floor9 | 0.07126 | 4.98% |
| floor8 | 0.07173 | 4.35% |
| floor7 | 0.0722 | 3.73% |
| floor6 | 0.07264 | 3.14% |
| floor5 | 0.07307 | 2.57% |
| floor4 | 0.07345 | 2.07% |
| floor3 | 0.0738 | 1.59% |
| floor2 | 0.07408 | 1.23% |
| floor1 | 0.07433 | 0.89% |

To indicate the best position of the outrigger system to improve the resistance of the high rise building, the research has been demonstrate the difference between the values of the lateral displacement along the height of the building, and not indicate only some chosen position but studied along the height of the building to confirm which position is the best to reduce the lateral displacement, Fig.10, Table.3 indicate the values of lateral displacement at different position of the outrigger at different floor levels in case of earthquake in direction X, it indicates increasing of the reduction of the lateral displacement in X direction at the outrigger position in Floor 33 with the reduction percentage 14.14 %, which means the best position in case of earth quack in X direction at 76.92% of the height of the building, Fig.11 demonstrates the percentage of reduction of the maximum lateral displacement in case of using the different position of the outrigger to indicate the sequence the reduction percentage along with the height of the building in case of an earthquake in direction Y Table.4. Fig.12 indicate also increasing the reduction of the lateral displacement in Y direction at the outrigger position in Floor 27 with the reduction percentage 35.12 %, which means the best position in case of earth quack in Y direction at 63.08% of the height of the building from the bottom level, Fig. 13 shows the biggest reduction in the lateral displacement lies in the Floor 27 and as sequences in the reduction Floors in above and down the floor 27 consider the second choice for reduction, the position of outrigger which give us the max reduction differ according to the direction of earthquake and it does not consider as a constant in all directions.

Table 4. The values of lateral displacement at different positions of the outrigger (In case of earthquake in Y-Direction)

| Position of the outrigger | Maximum Displacement value (m) | Percentage reduction (%) |
|---|---|---|
| Bare frame with core (without outrigger) | 0.709888 | |
| floor 42 | 0.523698 | 26.23% |
| floor41 | 0.510082 | 28.15% |
| floor40 | 0.503446 | 29.08% |
| floor39 | 0.497838 | 29.87% |
| floor38 | 0.492662 | 30.60% |
| floor37 | 0.487761 | 31.29% |
| floor36 | 0.48313 | 31.94% |
| floor35 | 0.478803 | 32.55% |
| floor34 | 0.474825 | 33.11% |
| floor33 | 0.471241 | 33.62% |
| floor32 | 0.468099 | 34.06% |
| floor31 | 0.465446 | 34.43% |
| floor30 | 0.463326 | 34.73% |
| floor29 | 0.461782 | 34.95% |
| floor28 | 0.460854 | 35.08% |
| floor27 | 0.46058 | 35.12% |
| floor26 | 0.460996 | 35.06% |
| floor25 | 0.462133 | 34.90% |
| floor24 | 0.464021 | 34.63% |
| floor23 | 0.466684 | 34.26% |
| floor22 | 0.470144 | 33.77% |
| floor21 | 0.474434 | 33.17% |
| floor20 | 0.47952 | 32.45% |
| floor19 | 0.485458 | 31.61% |
| floor18 | 0.492248 | 30.66% |
| floor17 | 0.499848 | 29.59% |
| floor16 | 0.50829 | 28.40% |
| floor15 | 0.517547 | 27.09% |
| floor14 | 0.527596 | 25.68% |
| floor13 | 0.538407 | 24.16% |
| floor12 | 0.54994 | 22.53% |
| floor11 | 0.562143 | 20.81% |
| floor10 | 0.574952 | 19.01% |
| floor9 | 0.588288 | 17.13% |
| floor8 | 0.602051 | 15.19% |
| floor7 | 0.616123 | 13.21% |
| floor6 | 0.630354 | 11.20% |
| floor5 | 0.644567 | 9.20% |
| floor4 | 0.658532 | 7.23% |
| floor3 | 0.671974 | 5.34% |
| floor2 | 0.684473 | 3.58% |
| floor1 | 0.695569 | 2.02% |

**The story Drift**

The story drift is considered as one of the most important factors should be taken care in design of the structure especially in the early stage of design, the drift criteria factor is a factor controlling in choosing the appropriate structural element, on the other hand there are three perspective phases lead us to interest to the drift and lateral displacement [1] structural stability [2] human comfortability [3] architectural requirements [13]

To study the story drift, it should be identifying the concept of the story drift and methodology of calculation of the story drift, to determine the story drift it can easily be computed by the difference between the deflection at the center of mass at top and bottom story [ASCE] as shown in Fig.14.

In case of the center of mass is not align verticality, it will be led to deflection at the bottom, and the deflection at the bottom is calculated based on the vertical projection, the design story drift is computed as the largest difference between the deflection at the top and bottom of the story.

Studying the story drift in case of earthquake in X and Y direction, to stand up which position of the outrigger lead to the minimum response in the story drift, first in case of earthquake in X - Direction Table.6 indicates the max story drift calculation for different location along the height of the building, it can obviously that minimizing the story drift will be in case of the outrigger in floor level 34, and the reduction percentage will be 16.7%.

Fig.15 demonstrates the relationship between the max story drift and the position of the outrigger system to stand up the sequence of the reduction percentage for different positions of the outrigger system.

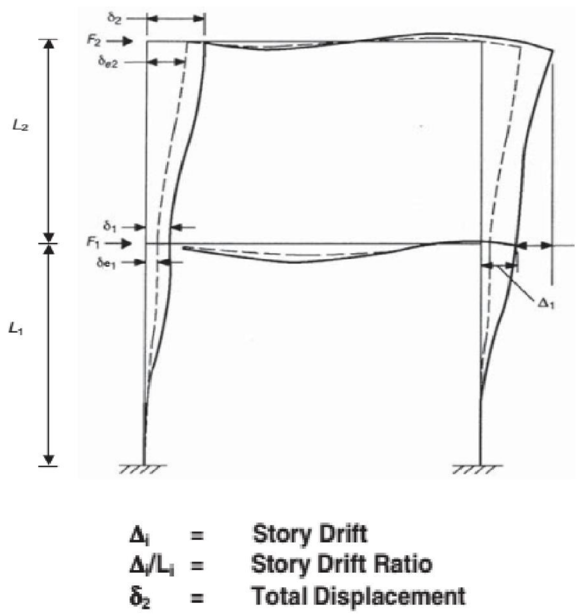


Fig.14 Story Drift

Table 6. The values of story Drift at different positions of the outrigger (In case of earthquake in X- Direction)

| **Position of the outrigger** | **Maximum Story Drift value (m)** | **Percentage reduction (%)** |
|---|---|---|
| Bare frame with core (without outrigger) | 0.00064 | |
| floor 42 | 0.00054 | 15.0% |
| floor41 | 0.00054 | 15.3% |
| floor40 | 0.00054 | 15.5% |
| floor39 | 0.00054 | 15.6% |
| floor38 | 0.00054 | 15.9% |
| floor37 | 0.00054 | 16.1% |
| floor36 | 0.00054 | 16.3% |
| floor35 | 0.00053 | 16.6% |
| floor34 | 0.00053 | 16.7% |
| floor33 | 0.00054 | 15.9% |
| floor32 | 0.00054 | 15.5% |
| floor31 | 0.00054 | 15.0% |
| floor30 | 0.00055 | 14.5% |
| floor29 | 0.00055 | 14.2% |
| floor28 | 0.00055 | 14.1% |
| floor27 | 0.00055 | 13.9% |
| floor26 | 0.00055 | 13.6% |
| floor25 | 0.00056 | 13.3% |
| floor24 | 0.00056 | 13.0% |
| floor23 | 0.00056 | 13.0% |
| floor22 | 0.00056 | 13.0% |

| | | |
|---|---|---|
| floor21 | 0.00056 | 13.1% |
| floor20 | 0.00056 | 12.8% |
| floor19 | 0.00056 | 12.0% |
| floor18 | 0.00057 | 11.4% |
| floor17 | 0.00057 | 10.6% |
| floor16 | 0.00058 | 9.8% |
| floor15 | 0.00058 | 9.1% |
| floor14 | 0.00059 | 8.3% |
| floor13 | 0.00059 | 7.5% |
| floor12 | 0.0006 | 6.7% |
| floor11 | 0.0006 | 5.9% |
| floor10 | 0.00061 | 5.3% |
| floor9 | 0.00061 | 4.5% |
| floor8 | 0.00062 | 3.9% |
| floor7 | 0.00062 | 3.3% |
| floor6 | 0.00062 | 2.7% |
| floor5 | 0.00063 | 2.2% |
| floor4 | 0.00063 | 1.7% |
| floor3 | 0.00063 | 1.3% |
| floor2 | 0.00063 | 0.9% |
| floor1 | 0.00064 | 0.6% |

On the other hand, Table.7 illustrates the max story drift of high rise building in case of different position of the outrigger system in case of earthquake in the Y direction, according to the results, the max reduction percentage of the story drift will lie in case of outrigger position in Floor level 24 with reduction percentage 37.14% so that it can consider the using of outrigger system can effect on reducing the story drift response in the high rise building, and it can help the designers to reduce un comfortability due to large story drift.

Table 7. The values of story Drift at different positions of the outrigger (In case of earthquake in Y- Direction

| **Position of the outrigger** | **Maximum Story Drift value (m)** | **Percentage reduction (%)** |
|---|---|---|
| Bare frame with core (without outrigger) | 0.00672 | |
| floor 42 | 0.00525 | 21.94% |
| floor41 | 0.00515 | 23.36% |
| floor40 | 0.0051 | 24.12% |
| floor39 | 0.00505 | 24.84% |
| floor38 | 0.00501 | 25.52% |
| floor37 | 0.00496 | 26.23% |
| floor36 | 0.00491 | 26.96% |
| floor35 | 0.00486 | 27.74% |
| floor34 | 0.00481 | 28.52% |
| floor33 | 0.00475 | 29.34% |
| floor32 | 0.0047 | 30.15% |
| floor31 | 0.00464 | 30.98% |
| floor30 | 0.00458 | 31.83% |
| floor29 | 0.00453 | 32.70% |
| floor28 | 0.00447 | 33.58% |
| floor27 | 0.00441 | 34.43% |
| floor26 | 0.00435 | 35.32% |
| floor25 | 0.00429 | 36.24% |
| floor24 | 0.00423 | 37.14% |
| floor23 | 0.00429 | 36.14% |
| floor22 | 0.00439 | 34.65% |
| floor21 | 0.0045 | 33.12% |

| | | |
|---|---|---|
| floor20 | 0.0046 | 31.57% |
| floor19 | 0.00471 | 29.98% |
| floor18 | 0.00482 | 28.35% |
| floor17 | 0.00493 | 26.67% |
| floor16 | 0.00505 | 24.97% |
| floor15 | 0.00516 | 23.26% |
| floor14 | 0.00528 | 21.52% |
| floor13 | 0.0054 | 19.77% |
| floor12 | 0.00552 | 17.98% |
| floor11 | 0.00563 | 16.21% |
| floor10 | 0.00575 | 14.46% |
| floor9 | 0.00587 | 12.72% |
| floor8 | 0.00599 | 10.98% |
| floor7 | 0.0061 | 9.28% |
| floor6 | 0.00621 | 7.64% |
| floor5 | 0.00632 | 6.08% |
| floor4 | 0.00641 | 4.61% |
| floor3 | 0.00651 | 3.26% |
| floor2 | 0.00659 | 2.05% |
| floor1 | 0.00665 | 1.06% |

Fig.16 indicates the relationship between the max story drift for different positions of the outrigger to get the sequence of the outrigger position along with the height of the building and it indicates the best position for reducing story drift will be between floor 28 until floor 21.

**The overturning moment**

The outrigger system contributes in reducing the overturning moment not eliminate but the percentage of reducing is differed according to the configuration plan of the system or the structure system, the studying modeling comprises only the core without inner columns and it contains the exterior column and the core system only so that it differs in response than the previously studied structure system.

In case of the earthquake in X -direction, the percentage of reduction of the max overturning due to using the outrigger system is very low reach around 0.26%, it is the very lowest value, these means the effects of using outrigger system in reducing the overturning moment with the largest value is not achieved in the model, Figs (18 & 19), Table.8 indicates the reduction percentage for different position of the outrigger, but really the value of reduction is very low.

And also, in the case of studying Eq in Y direction, the same deduction which achieved in the case of Earthquake in the X direction, Table.9. Figs (20 & 21) demonstrate the results of the effects of using outrigger in the overturning moment.

Table 8. The values of overturning moment for different positions of the outrigger (In case of earthquake in X-Direction)

| Position of the outrigger | Maximum Overturning Moment value My (t.m) | Percentage reduction (%) |
|---|---|---|
| Bare frame with core (without outrigger) | -433294 | |
| floor 42 | -434439 | 0.26% |
| floor41 | -434351 | 0.24% |
| floor40 | -434270 | 0.23% |
| floor39 | -434192 | 0.21% |
| floor38 | -434116 | 0.19% |
| floor37 | -434043 | 0.17% |
| floor36 | -433973 | 0.16% |
| floor35 | -433906 | 0.14% |
| floor34 | -433843 | 0.13% |
| floor33 | -433782 | 0.11% |
| floor32 | -433726 | 0.10% |
| floor31 | -433673 | 0.09% |
| floor30 | -433623 | 0.08% |

| | | |
|---|---|---|
| floor29 | -433578 | 0.07% |
| floor28 | -433537 | 0.06% |
| floor27 | -433499 | 0.05% |
| floor26 | -433466 | 0.04% |
| floor25 | -433438 | 0.03% |
| floor24 | -433414 | 0.03% |
| floor23 | -433394 | 0.02% |
| floor22 | -433379 | 0.02% |
| floor21 | -433379 | 0.02% |
| floor20 | -433363 | 0.02% |
| floor19 | -433362 | 0.02% |
| floor18 | -433376 | 0.02% |
| floor17 | -433375 | 0.02% |
| floor16 | -433389 | 0.02% |
| floor15 | -433407 | 0.03% |
| floor14 | -433430 | 0.03% |
| floor13 | -433458 | 0.04% |
| floor12 | -433490 | 0.05% |
| floor11 | -433526 | 0.05% |
| floor10 | -433566 | 0.06% |
| floor9 | -433609 | 0.07% |
| floor8 | -433656 | 0.08% |
| floor7 | -433706 | 0.10% |
| floor6 | -433757 | 0.11% |
| floor5 | -433811 | 0.12% |
| floor4 | -433865 | 0.13% |
| floor3 | -433921 | 0.14% |
| floor2 | -433973 | 0.16% |
| floor1 | -434027 | 0.17% |

Table 9. The values of overturning moment for different positions of the outrigger (In case of earthquake in Y-Direction)

| Position of the outrigger | Maximum Overturning Moment value Mx (t.m) | Percentage reduction (%) |
|---|---|---|
| Bare frame with core (without outrigger) | 478820 | |
| floor 42 | 470966 | 1.6% |
| floor41 | 470147 | 1.8% |
| floor40 | 469669 | 1.9% |
| floor39 | 469223 | 2.0% |
| floor38 | 468780 | 2.1% |
| floor37 | 468332 | 2.2% |
| floor36 | 467882 | 2.3% |
| floor35 | 467432 | 2.4% |
| floor34 | 466984 | 2.5% |
| floor33 | 466544 | 2.6% |
| floor32 | 466115 | 2.7% |
| floor31 | 465702 | 2.7% |
| floor30 | 465308 | 2.8% |
| floor29 | 464938 | 2.9% |
| floor28 | 464598 | 3.0% |
| floor27 | 464290 | 3.0% |
| floor26 | 464022 | 3.1% |
| floor25 | 463796 | 3.1% |
| floor24 | 463619 | 3.2% |
| floor23 | 463494 | 3.2% |

| | | |
|---|---|---|
| floor22 | 463426 | 3.2% |
| floor21 | 463432 | 3.2% |
| floor20 | 463479 | 3.2% |
| floor19 | 463609 | 3.2% |
| floor18 | 463824 | 3.1% |
| floor17 | 464092 | 3.1% |
| floor16 | 464452 | 3.0% |
| floor15 | 464894 | 2.9% |
| floor14 | 465420 | 2.8% |
| floor13 | 466030 | 2.7% |
| floor12 | 466725 | 2.5% |
| floor11 | 467503 | 2.4% |
| floor10 | 468363 | 2.2% |
| floor9 | 469299 | 2.0% |
| floor8 | 470307 | 1.8% |
| floor7 | 471377 | 1.6% |
| floor6 | 472500 | 1.3% |
| floor5 | 473660 | 1.1% |
| floor4 | 474839 | 0.8% |
| floor3 | 476013 | 0.6% |
| floor2 | 477146 | 0.3% |
| floor1 | 478194 | 0.1% |

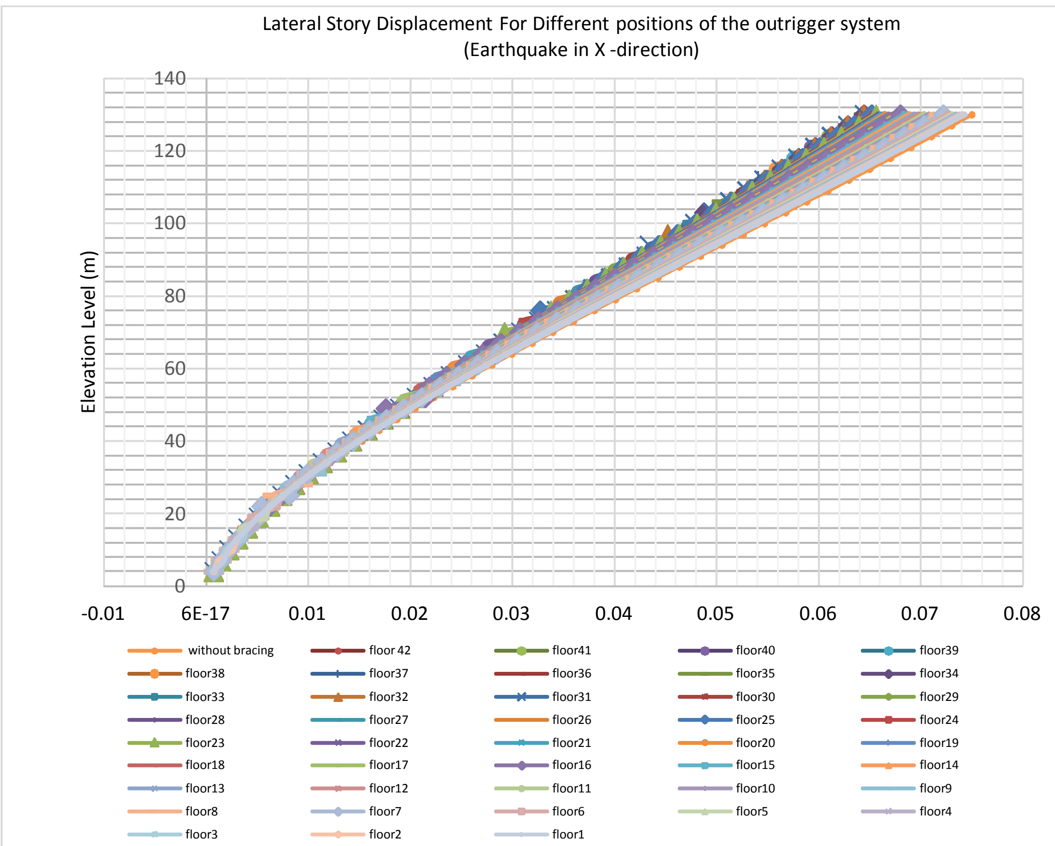


Fig.10 Lateral Story Displacement for Different positions of the outrigger system (Earthquake in X -direction)

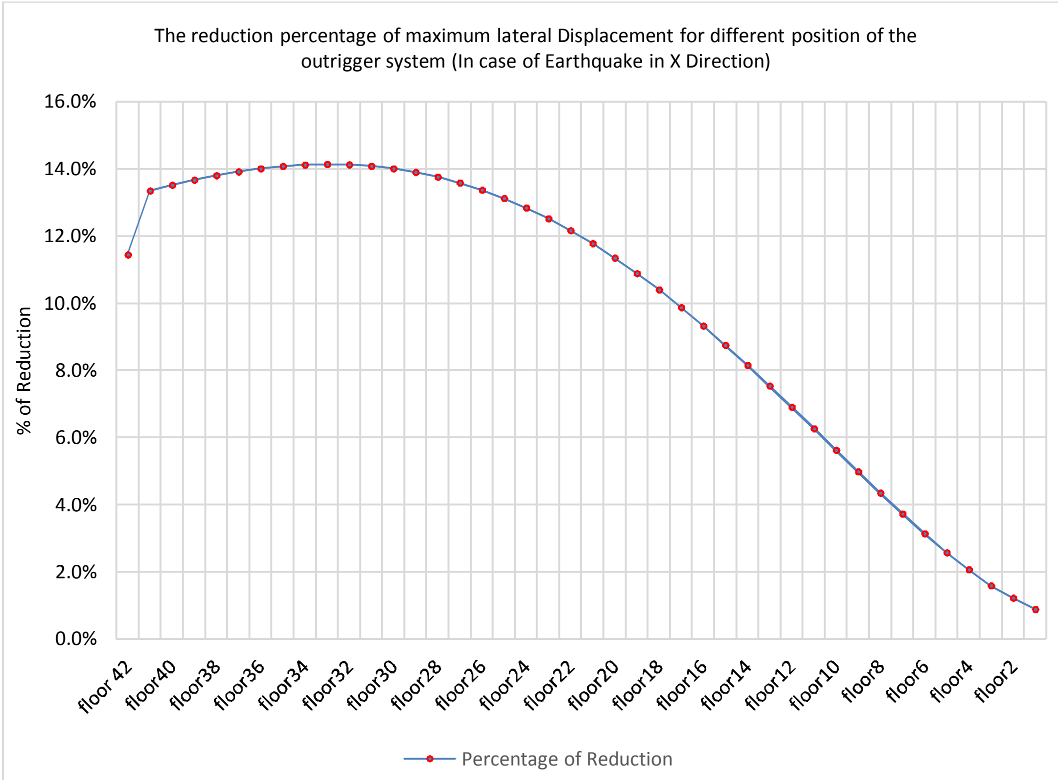


Fig.11 The reduction percentage of maximum lateral Displacement for different position of the outrigger system (In case of Earthquake in X Direction)

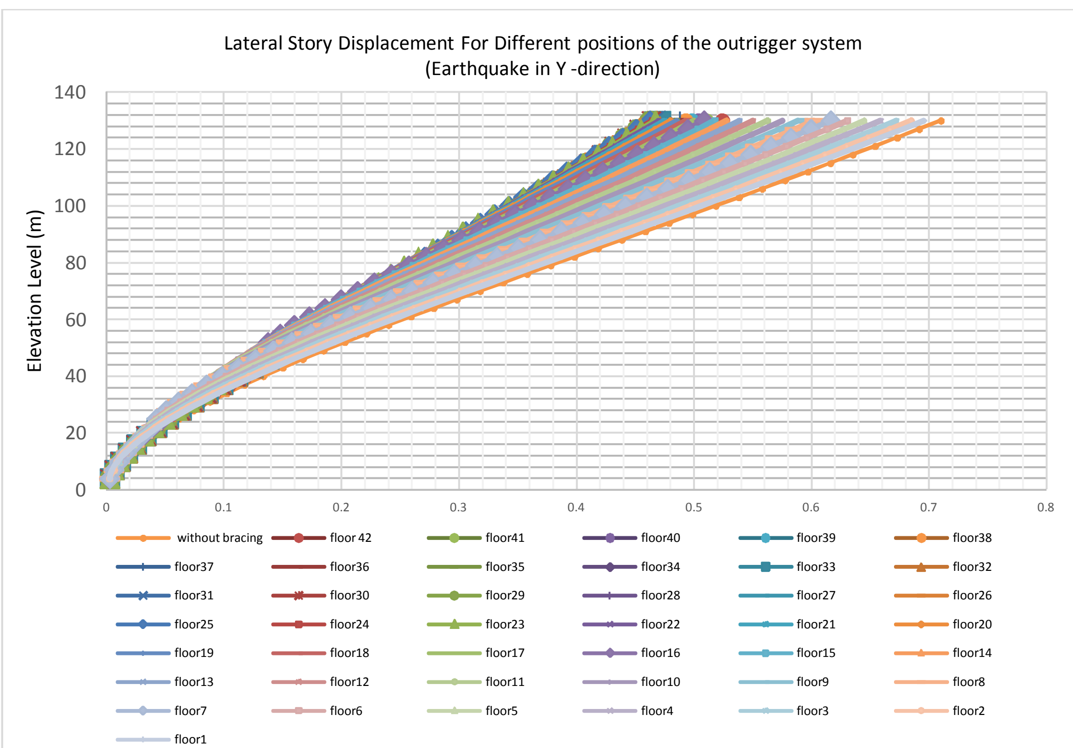


Fig.12 Lateral Story Displacement for Different positions of the outrigger system (Earthquake in Y -direction)

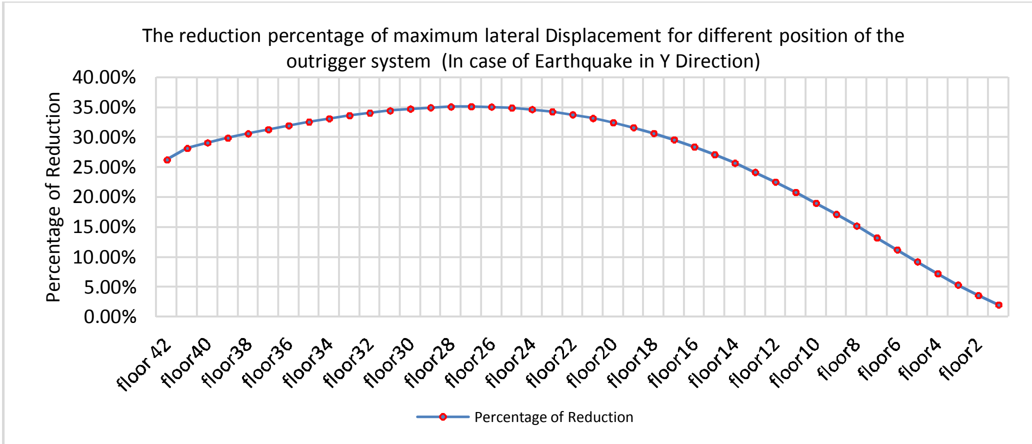


Fig.13 The reduction percentage of maximum lateral Displacement for different position of the outrigger system (In case of Earthquake in Y Direction)

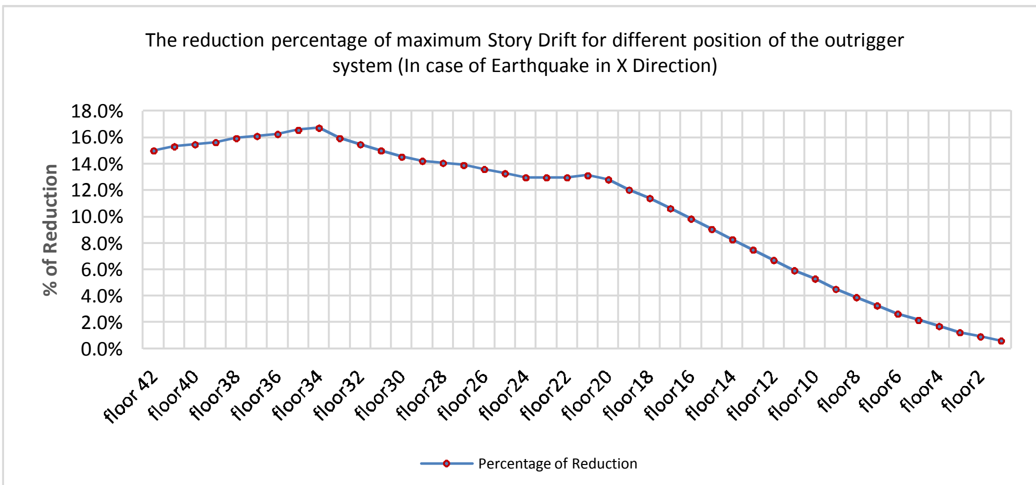


Fig.15 The reduction percentage of maximum Story Drift for different position of the outrigger system (In case of Earthquake in X Direction)

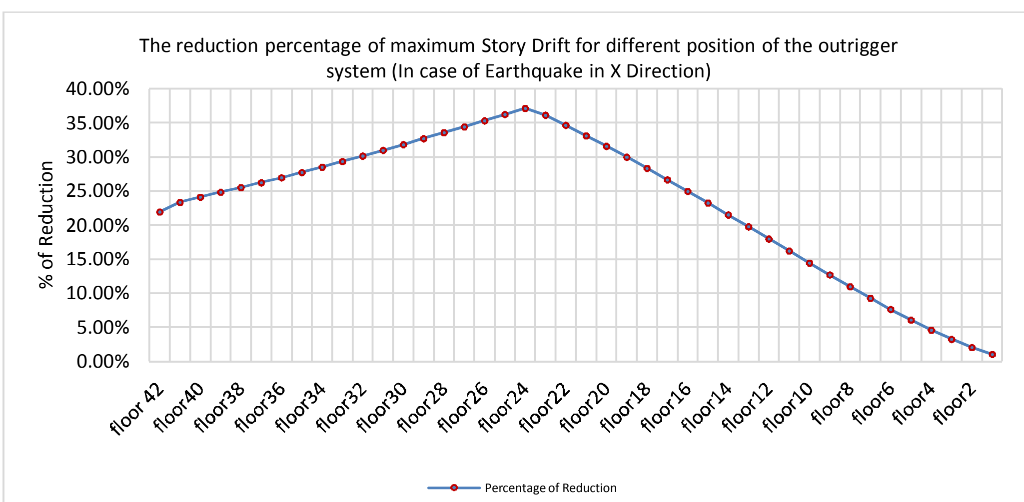


Fig.16 The reduction percentage of maximum Story Drift for different position of the outrigger system (In case of Earthquake in Y Direction)

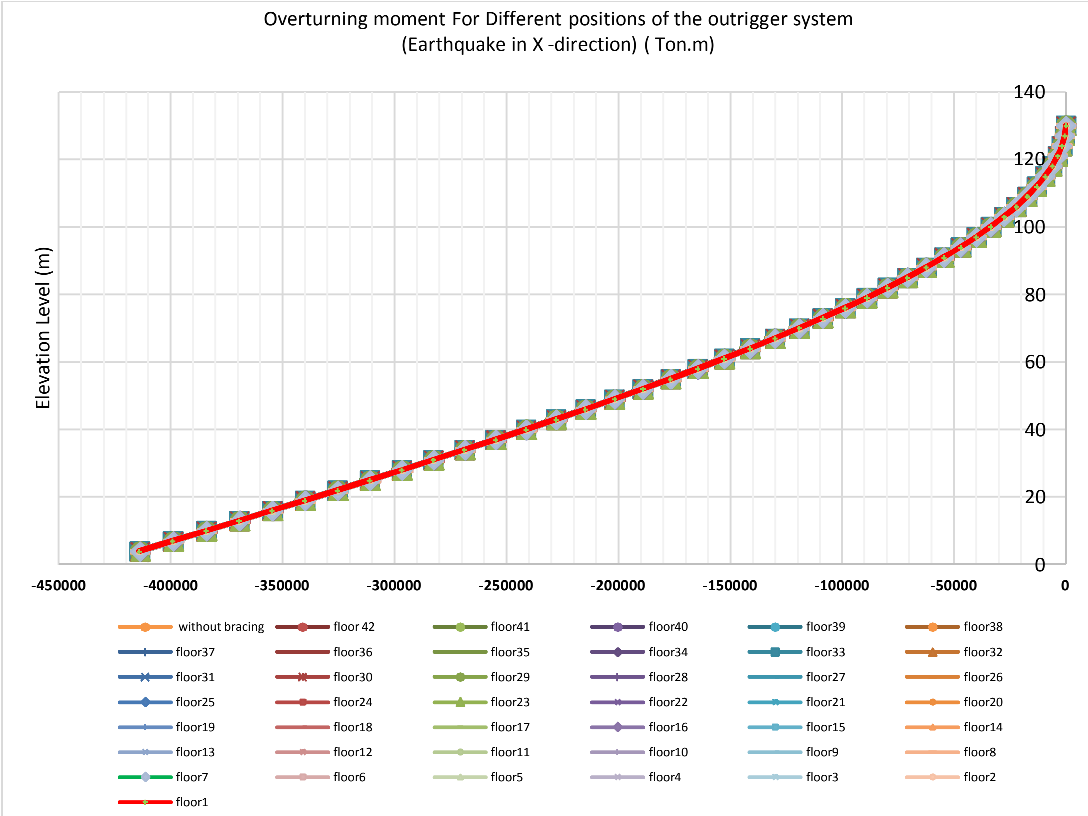


Fig. 17 Overturning moment For Different positions of the outrigger system (Earthquake in X -direction) (Ton.m)

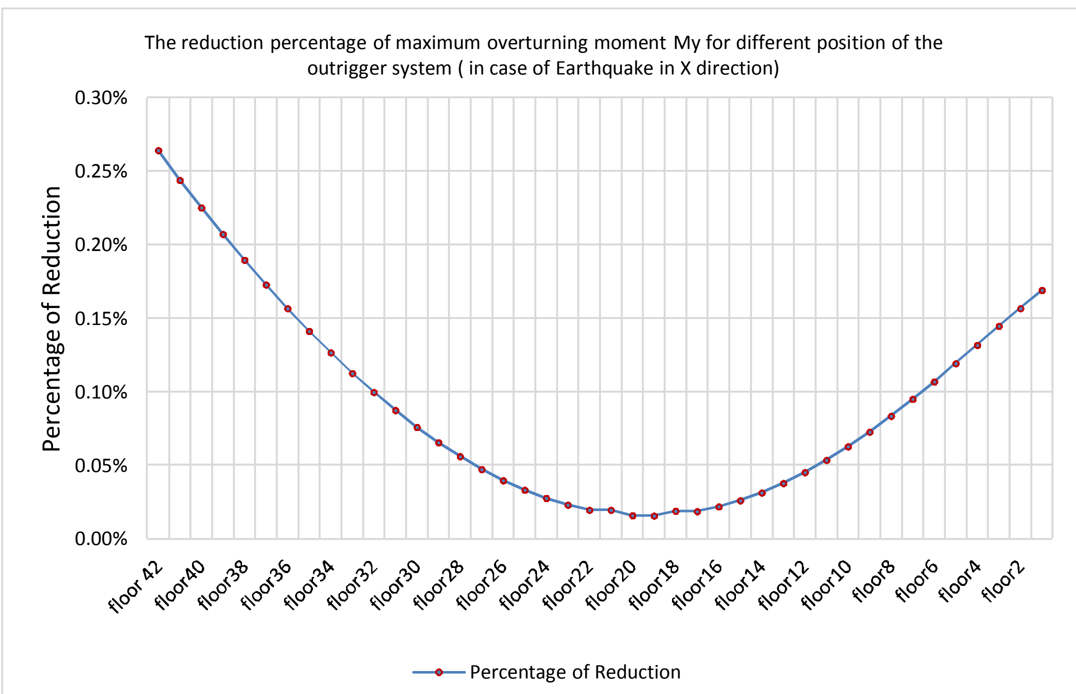


Fig.18 The reduction percentage of maximum overturning moment My for different position of the outrigger system (in case of Earthquake in X direction)

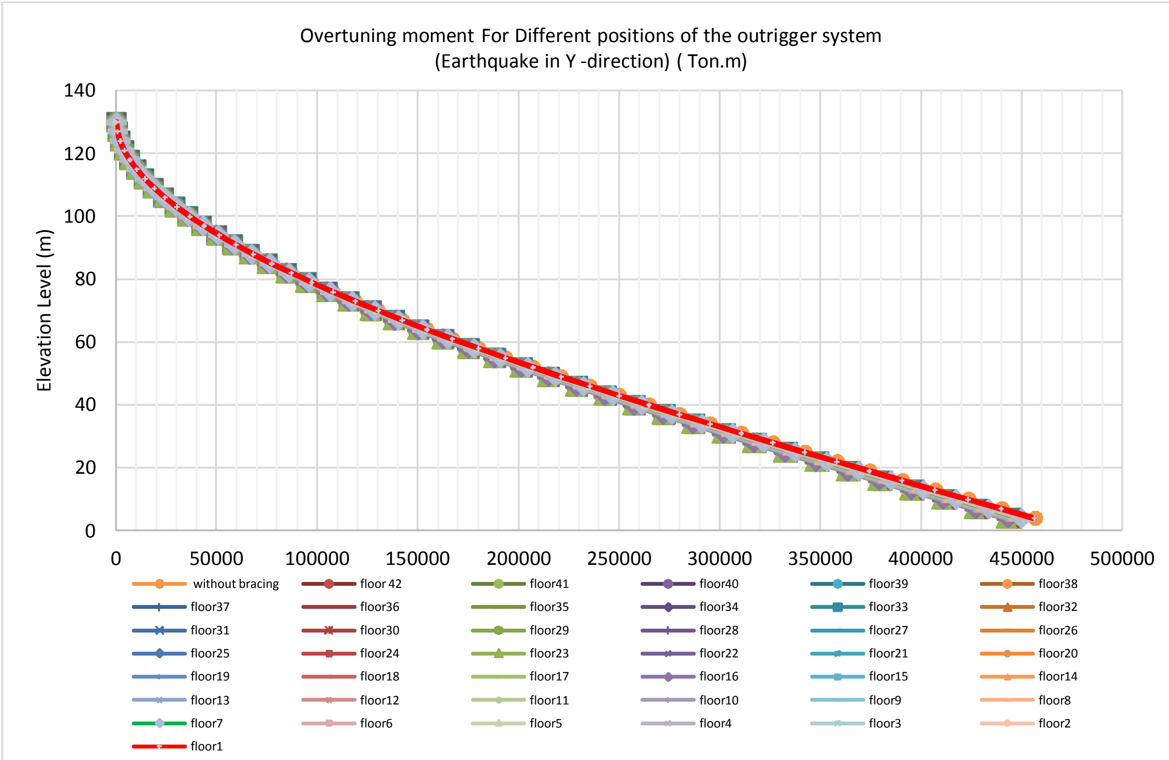

Fig.19 Overturning moment For Different positions of the outrigger system (Earthquake in X -direction) (Ton.m)

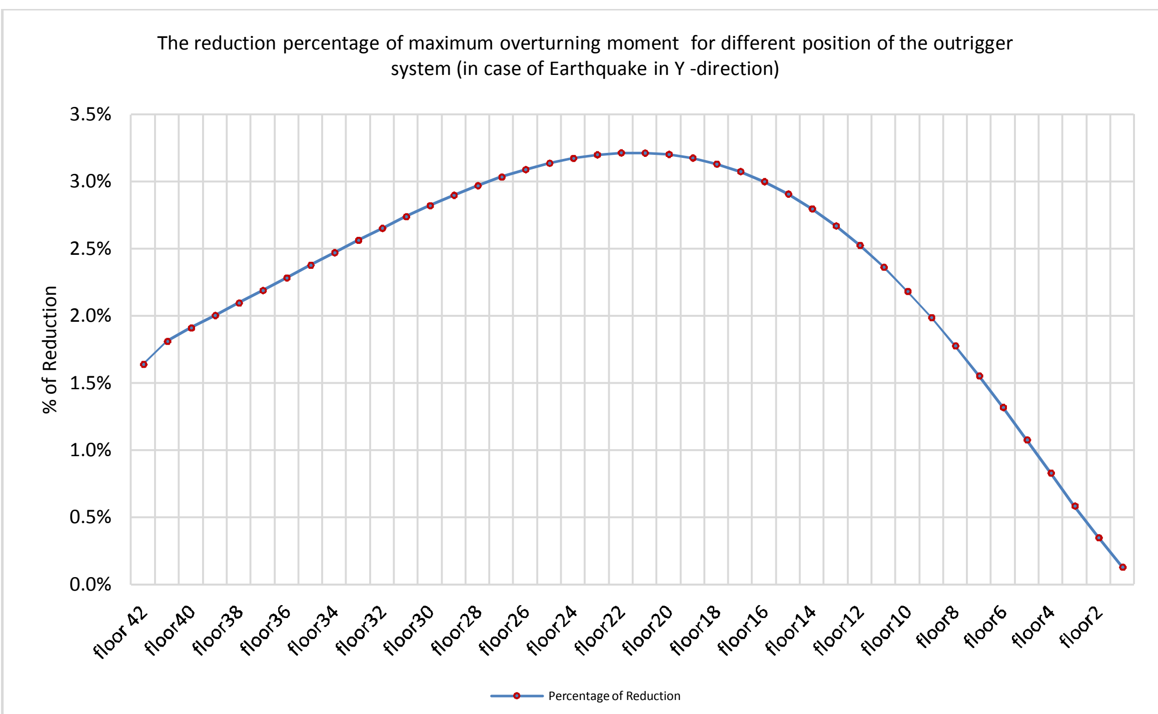

Fig.20 The reduction percentage of maximum overturning moment for different position of the outrigger system (in case of Earthquake in Y -direction)

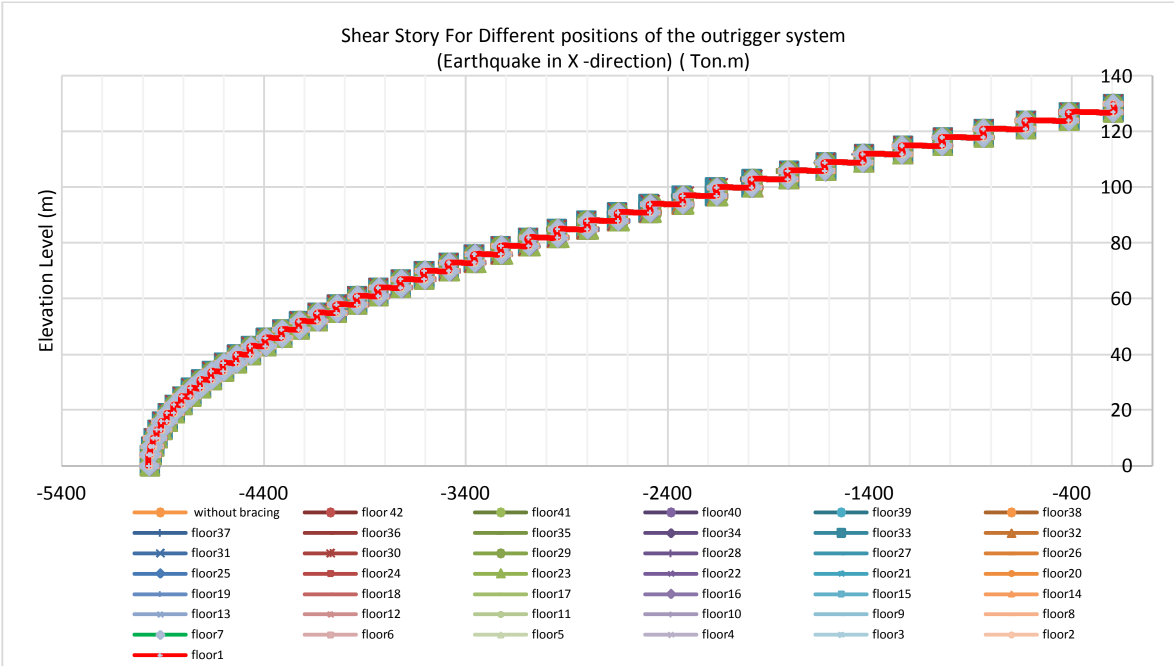


Fig.21 Shear Story For Different positions of the outrigger system (Earthquake in X -direction) (Ton.m)

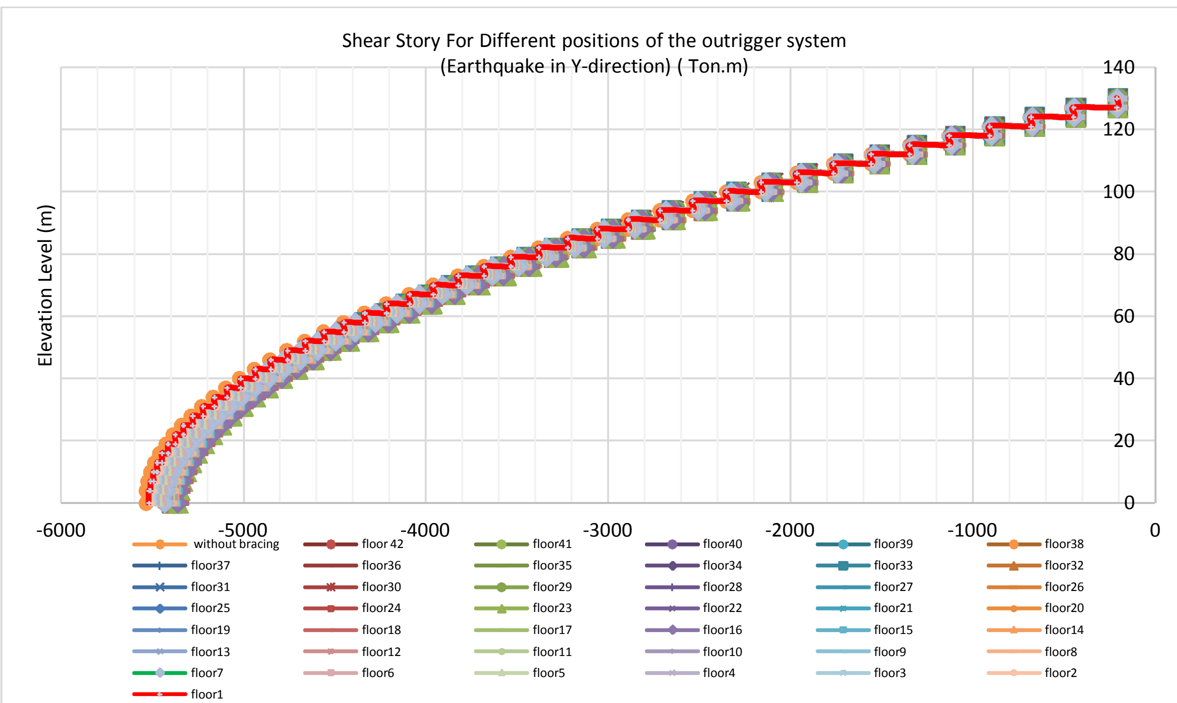


Fig.22 Shear Story For Different positions of the outrigger system (Earthquake in Y-direction) (Ton.m)

**The shear Response**

On the other hand, the research focus also on the shear response due to using the outrigger system, Table 10, Fig 22 indicate also the reduction in the shear response in case of Earthquake in X direction due to using different outrigger system along the height of the building, it can obviously nearly no effect on the shear response due to using the outrigger system. To completely studying of the shear response the behavior of the shear in case of Earthquake in Y direction, it can also obviously the smallest reduction of the shear due to the additional outrigger system, the max reduction of the shear reached 3.27% in case of outrigger in Floor 20.

**The composite section in the outrigger system:**

**The story lateral displacement**

To complete the studying of effects using of the outrigger system on the seismic response, using the composite material in the outrigger instead of steel bracing which it considers preferring choosing in some case, the composite material used in the studying as Fig.23, using the composite section leads to increasing stiffness which will be effective on the response of the high rise building so that, it is important to create comparison between composite section and steel bracing to get the optimization response, the comparison will execute Using of composite structure has a big effect in reducing the value of lateral displacement so that the comparison between the reduction of lateral displacement due to using of steel bracing and the composite structure demonstrate the reduction of lateral response in case of Earthquake in X direction due to the composite structure is 21.18% and due to using steel bracing is 13.58% as shown in Table.10, Fig.23 shows the reduction of lateral displacement due to the composite section in the outrigger and steel bracing, it illustrates the reduction occurs in the floor 27 between the composite section and steel bracing in the optimum position (in floor position 27).

Table 10. the comparison of max story displacement between composite section bracing and steel bracing At the outrigger position in floor 27 (Earthquake in X Direction)

| Position of the outrigger | Maximum Story Displacement value (m) | Percentage reduction (%) |
|---|---|---|
| Bare frame with core (without outrigger) | 0.074997 | |
| Composite section Bracing | 0.059109 | 21.18% |
| Steel Bracing | 0.064811 | 13.58% |

Otherwise, In the case of Earthquake in Y direction, the reduction percentage due to using composite structure is 41.82% and in the case of steel bracing is 35.12% as shown in Table 11, Fig.24 demonstrates the effects of using outrigger system in case of composite section and steel bracing.

Table 11. the comparison of max story displacement between composite section bracing and steel bracing At the outrigger position in floor 27 (Earthquake in Y Direction)

| Position of the outrigger | Maximum Story Displacement value (m) | Percentage reduction (%) |
|---|---|---|
| Bare frame with core (without outrigger) | 0.709888 | |
| Composite section Bracing | 0.413036 | 41.82% |
| Steel Bracing | 0.46058 | 35.12% |

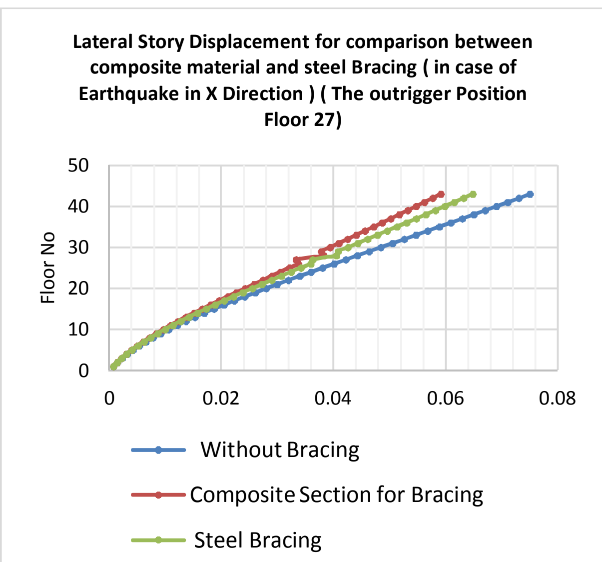


Fig.23 Lateral Story Displacement for comparison between composite material and steel Bracing (in case of Earthquake in X Direction)

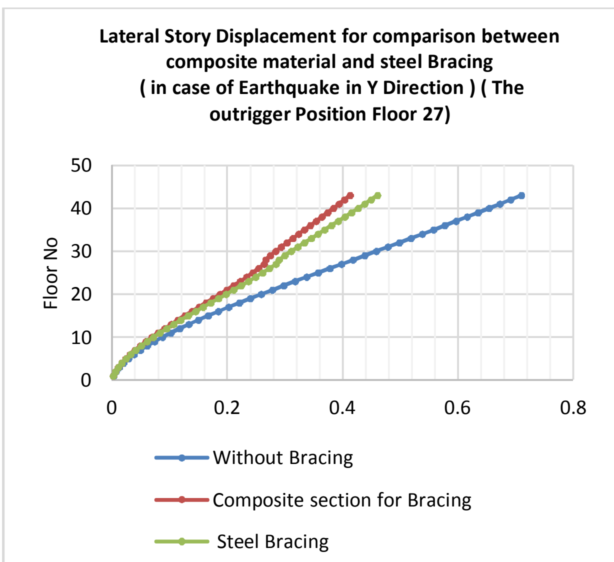


Fig.24 Lateral Story Displacement for comparison between composite material and steel Bracing (in case of Earthquake in X Direction)

**The story Drift**

Using the composite material in reducing the lateral displacement instead of using steel bracing is very useful also in reducing the story drift, so that the designers should direct to using the composite structure to control the story drift, in case of Earthquake in direction X, the reduction percentage in case of composite section is 22.03%, and in case of steel bracing is 13.91% as shown in Table.12, Fig.25 shows the story drifts along the height of the building in case of using composite section and steel bracing

Table 12. The comparison of max story Drift between composite section bracing and steel bracing At the outrigger position in floor 27 (Earthquake in X Direction)

| Position of the outrigger | Maximum Story Drift value (m) | Percentage reduction (%) |
|---|---|---|
| Bare frame with core (without outrigger) | 0.00064 | |
| Composite section Bracing | 0.000499 | 22.03% |
| Steel Bracing | 0.000551 | 13.91% |

On other hands in case of earthquake in Y direction, the percentage of reduction in the composite section is bigger than in the case of steel bracing, the percentage of reduction is 39.37% in case of composite and in the case of steel bracing is 34.43 %, as shown in Table 13, Fig.26 shows the drop in story drift due to using the outrigger system

Table 13. The comparison of max story Drift between composite section bracing and steel bracing At the outrigger position in floor 27 (Earthquake in Y Direction)

| Position of the outrigger | Maximum Story Drift value (m) | Percentage reduction (%) |
|---|---|---|
| Bare frame with core (without outrigger) | 0.006724 | |
| Composite section Bracing | 0.004077 | 39.37% |
| Steel Bracing | 0.004409 | 34.43% |

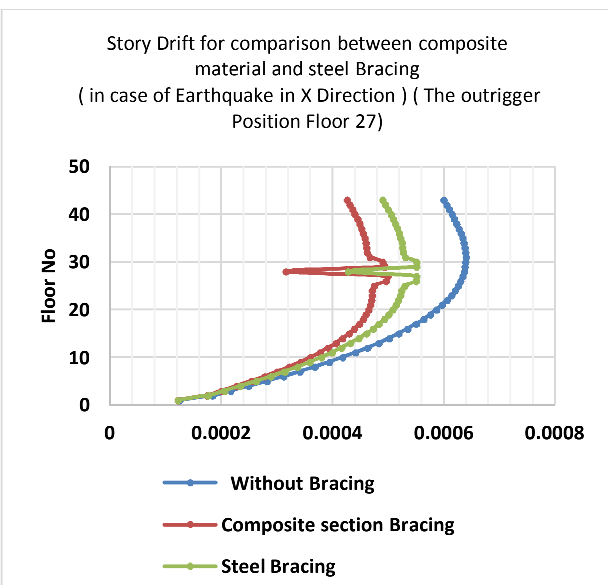


Fig.25 Story Drift for comparison between composite material and steel Bracing (in case of Earthquake in X Direction) (The outrigger Position Floor 27)

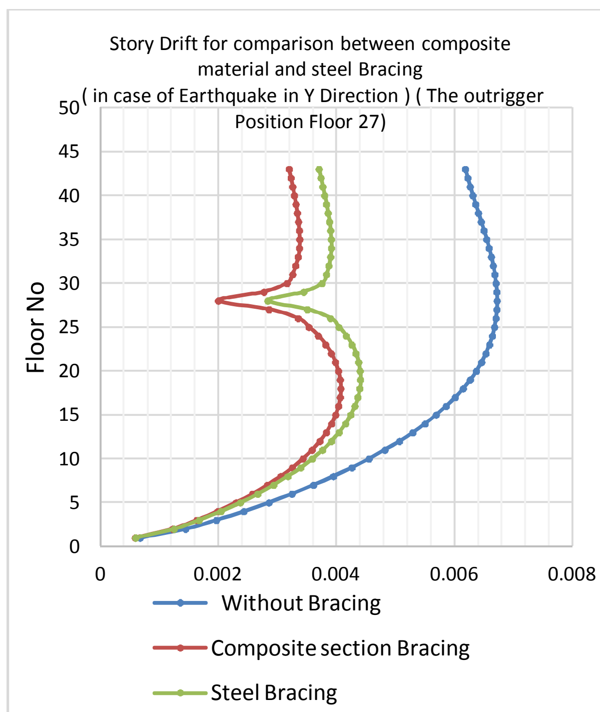


Fig.26 Story Drift for comparison between composite material and steel Bracing (in case of Earthquake in Y Direction) (The outrigger Position Floor 27)

**The overturning moment**

Nearly no difference between the effects of using a composite section or steel bracing of the outrigger system to reduce the overturning moment response, the percentages of reduction in case of composite section and steel bracing are 1.16% & 0.05% as shown in Table.14. Fig.27 shows the close of the moment response in the case of a composite section and steel bracing.

Table.14 the comparison of max overturning moment between composite section bracing and steel bracing At the outrigger position in floor 27 (Earthquake in X Direction)

| Position of the outrigger | Maximum overturning moment value (t.m) | Percentage reduction (%) |
|---|---|---|
| Bare frame with core (without outrigger) | -433294 | |
| Composite section Bracing | -438299 | 1.16% |
| Steel Bracing | -433499 | 0.05% |

In the case of Earthquake in the Y direction, the percentages of reduction in the case of composite section and steel bracing are 2.47% & 3.03% as shown in Table 15, Fig.28 shows the overturning moment along with the height of the building in case of using composite and steel outrigger.

Table.15 the comparison of max overturning moment between composite section bracing and steel bracing At the outrigger position in floor 27 (Earthquake in Y Direction)

| Position of the outrigger | Maximum overturning moment value (t.m) | Percentage reduction (%) |
|---|---|---|
| Bare frame with core (without outrigger) | 478820 | |
| Composite section Bracing | 466992.2 | 2.47% |
| Steel Bracing | 464290.5 | 3.03% |

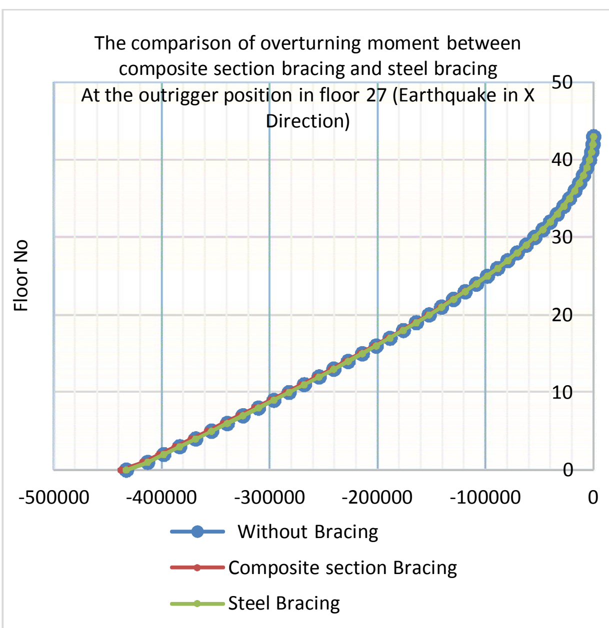


Fig.27 The comparison of overturning moment between composite section bracing and steel bracing At the outrigger position in floor 27 (Earthquake in X Direction)

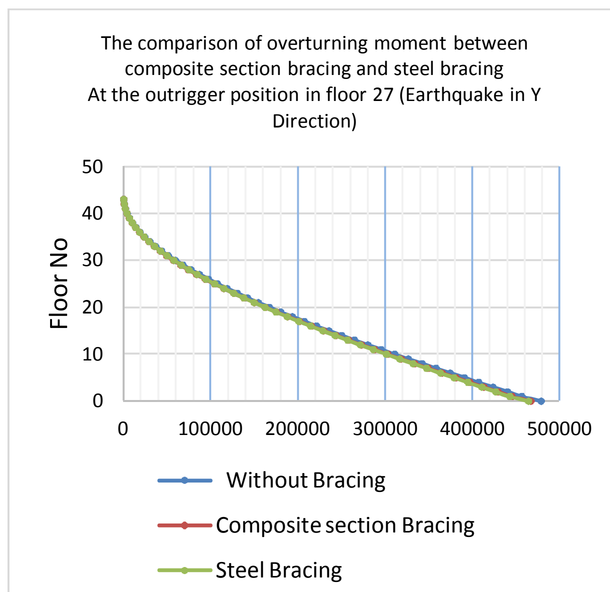


Fig.28 The comparison of overturning moment between composite section bracing and steel bracing At the outrigger position in floor 27 (Earthquake in Y Direction)

**The story shears**

Small effects for story shears in using of the composite structure instead of steel bracing, these response illustrates in both Fig.29 and Fig 30 for seismic loading in X and Y direction, the percentage of reduction in Y direction reached as 2.39% and 3.03% only.

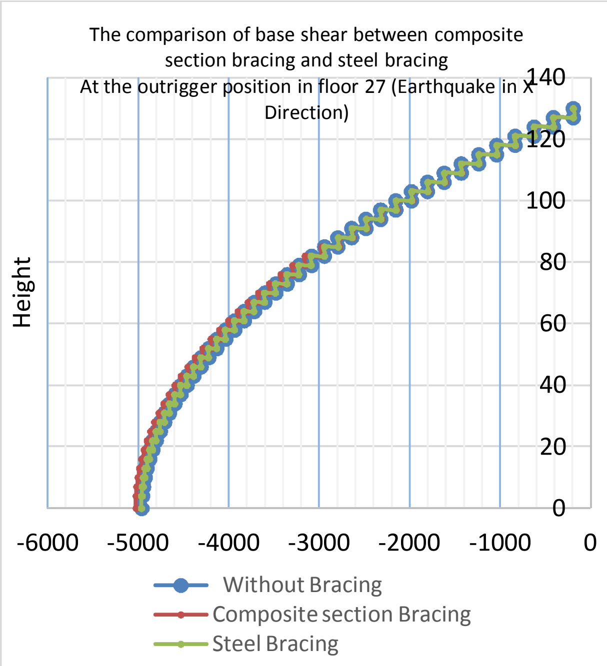


Fig.29 The comparison of base shear between composite section bracing and steel bracing At the outrigger position in floor 27 (Earthquake in X Direction)

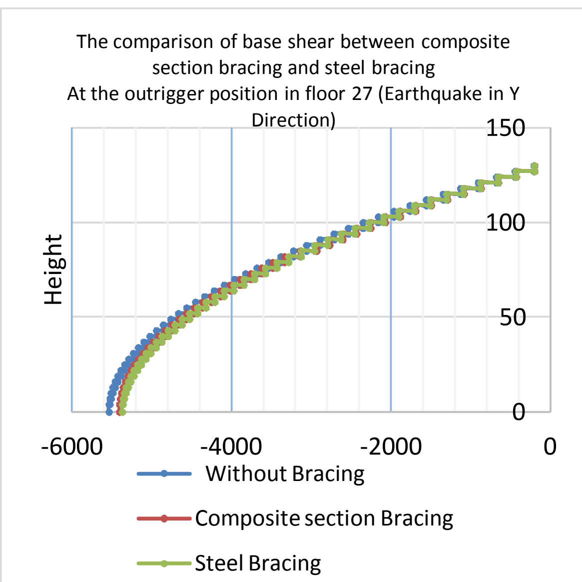


Fig.30 The comparison of base shear between composite section bracing and steel bracing At the outrigger position in floor 27 (Earthquake in Y Direction)

**Conclusion**

In this paper, Using the outrigger system contributes in reducing the response of the high rise building, the study focuses on the effects of using outrigger system in mitigation response and demonstrate which floor level gives the optimization response, compare with results from previous studying, it demonstrates the optimization response in case of the model without inner columns comprises only the exterior column with belt trusses and in the final conclusion if illustrates the results will differ than other researches and not be exactly matching with empirical results which indicates the optimum position will be in the middle of the height which means the outrigger position is effected by the modeling type and the configuration of the building a the outrigger system which differs than other models, the calculation of the modeling deduced from using the ETABS software program it can be illustrated that:

1. it indicates increasing the reduction of the lateral displacement in X direction at the outrigger position in Floor 33 with the reduction percentage 14.14%, which means the best position in case of earth quack in X direction at 76.92% of the height of the building and in case of Y direction, the increasing of the reduction of the lateral displacement will be at the outrigger position in Floor 27 with the reduction percentage 35.12%, which means the best position in case of earth quack in Y direction at 63.08% of the height of the building from the bottom level,

2. The direction of seismic loading effects on the position of the optimization outrigger system, for the model in case of X-direction the optimization, lies in the Floor 33 and in Y direction the optimization is in floor 27.

3. in case of earthquake in X - Direction it can obviously that minimizing the story drift will in case of the outrigger in floor level 34, and the reduction percentage will be 16.7%, in case of earthquake in Y direction, the max reduction percentage of the story drift will lie in case of outrigger position in Floor level 24 with reduction percentage 37.14% so that it can consider the using of outrigger system can affect also on reducing the story drift response in the high rise building, and it can help the designers to reduce un comfortability due to large story drift, From the results, it can be indicated that the best position for reducing will be between floor 28 until floor 21.

4. In case of the earthquake in X -direction, the percentage of reduction of the max overturning due to using the outrigger system is very low reach around 0.26%, it is the very lowest value, these means the effects of using outrigger system in reducing the overturning moment with the largest value is not achievable in this model, And also in case of studying Eq in Y direction so that it can't consider eliminating or reducing the overturning moment in all modeling system, it will reduce but not in the biggest percentages.

5. it can obviously nearly no effect on the shear response due to using the outrigger system in case of an earthquake in X direction and also in case of Earthquake in Y direction, it can obviously the smallest reduction of the shear due to the additional outrigger system, the maximum reduction of the shear reached 3.27% in case of outrigger in Floor 20.

6. To complete the studying, the effects of using composite section which spread in the construction industry in the outrigger system instead of using the steel bracing system, the comparison between steel bracing in Floor 27 (optimization position) and the composite structure in the same level of the floor.

a. Lateral displacement: the composite section demonstrates the reduction of lateral response in case of Earthquake in X direction due to the composite structure is 21.18% and due to using steel bracing is 13.58%, In the case of Earthquake in the Y direction, the reduction percentage due to using composite structure is 41.82% and in case of steel bracing is 35.12% which means that the using of the composite section has a great effect in reducing the lateral displacement than the steel bracing, this results refer to the increase in the stiffness of the composite section than steel bracing.

b. The story Drift: Using the composite structure in reducing the lateral displacement instead of using steel bracing is very useful in reducing the story drift, so that the designers should direct to using the composite structure to control the story drift, in case of Earthquake in direction X, the reduction percentage in case of composite section is 22.03%, and in case of steel bracing is 13.91 %, in case of an earthquake in Y direction, the percentage of reduction in composite section is bigger than in the case of steel bracing, the percentage of reduction is 39.37 % in case of composite and in the case of steel bracing is 34.43%.

c. The overturning moment: Nearly no difference between the effects of using a composite section or steel bracing of the outrigger system in overturning moment response.

d. The story shear: Small effects for story shears in using of the composite structure instead of steel bracing, the percentage of reduction in case of an earthquake in Y direction reached as 2.39% and 3.03% only for composite section and steel bracing respectively.

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