The Effect of Shear Walls Positions and Dimensions Variation on the Analysis of Multi-Story Building

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Abstract: ***Nowadays all regions over the world are exposed to earthquake hazard. So, it is very essential to take the lateral loads effect into consideration in the design of the multi-story and high-rise buildings. Lateral loads obtained by wind and earthquakes cause high stresses, develop sway movement and cause great damage to the structure. It is very significant for the structure to have an adequate strength to resist vertical loads simultaneously with adequate stiffness against lateral forces. Therefore, Shear walls are one of the most common structural elements used for stabilization of the building structures against lateral forces. Providing the shear walls in buildings can increase the lateral stability to resist the seismic lateral load. In this present study, a comparative investigation on regular multi-story reinforced concrete building that consisting of twenty stories is presented to study the behavior of building by varying the positions, shapes, and dimensions of shear walls in the plan. To study the performance of shear walls at different positions during the seismic analysis, both Equivalent Static Load Method (Simplified Modal Response Spectrum Method) and Response Spectrum Analysis are performed. The seismic analysis is performed by using ETABs v. 16.2 software program to study the seismic parameters of the building such as story displacement, story drift, and Base shear. From the below studies, it has been found that the values of story drifts are within the Limits as per the Egyptian Code (ECL 201/2012).***

Keywords: Shear wall, Multi-story, Seismic analysis, Equivalent Static Load Method, Response Spectrum Method, ETABs, Drift

1. Introduction

The stability of earth is always confused because of the internal forces which cause jerks in the earth's crust called an earthquake. The Earthquake is a natural disaster that is destructive and unpredictable. During this hazard, seismic waves are generated that cause many oscillations to the structure's base in various directions causing lateral forces on the building. When the dynamic force subjects structure, it vibrates causing the structure's displacement **[1]**. Recently, the structures that constructed with good mechanism and machines have exposed to immense loss of life and property damage due to earthquakes. Therefore, there are many reinforced concrete systems used for earthquake resistance to improve their earthquake resistance behavior. Selection of the type of lateral force resisting systems is depending on some factors such as the architectural design, the structure behavior, the geometry of the structural constraints of building codes, amount of lateral force, loading composition and maximum displacement **[2]**. Reinforced concrete shear walls are used as one of the most common lateral force resisting system in multi-story and high rise buildings **[3]**. Some previous researches have been conducted to investigate the seismic behavior of the shear wall system **[2]-[6], [9]-[24]**. The performance of the shear wall system is much better than that of the frame system. They have the required ductility, high stiffness, and large strength that can withstand the large horizontal load and support the gravity loads simultaneously **[4]**. Provision of the shear walls in the building is found to be effective in enhancing the overall seismic capacity characteristics of the structure and made them the most vulnerable type of construction in the earthquake-prone areas **[5]**. The locations of shear walls in the building are dependent on functional requirements, structural planning, building sites, and architectural interests. Provision of structural walls as the lateral load resisting system reduces the overall displacement of buildings and natural periods of oscillation. Also, they cause a reduction in shear and moment demands on beams and columns of the building **[6]**. To design the structures and evaluate the effect of the change in the building rigidity to resist earthquakes, there are essentially four different methods for seismic response of the structure classified as: linear static analysis using the Equivalent Lateral Load (ESL), nonlinear static analysis known as Pushover Analysis (POA), linear dynamic analysis by the means of the Response Spectrum Analysis (RSA), and the nonlinear dynamic analysis by the means of Time History Analysis (THA) **[3], [5]**. According to the results obtained from previous researches, the Response Spectrum Analysis (RSA) is more exact than Equivalent Static Load. Also, (RSA) is more convenient than the Time History Analysis (THA). Although, time history method is considered to be an exact solution for the buildings that represent any change in the building properties **[4]**. In this present study, twenty multi-story reinforced concrete buildings subjected to earthquake excitations in El-Mansoura city, Egypt are used to evaluate the accuracy of the Equivalent Static Analysis and the Response Spectrum Analysis procedure as per (ECP 203/2017) and (ECL 201/2012) codes respectively using ETABs v.16.2 **[7], [8]**. Shear walls with different thicknesses are considered in the comparative investigation. The Egyptian code (ECP 203/2017) indicates that the thickness of the wall shall not be less than 0.04 of the effective height of the wall or of the length of the wall section whichever is lower and shall not be less than 120 mm in any case **[7]**. The behavior of regular eight models of the building under seismic loads has been investigated for different locations, shapes, and dimensions of

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shear walls. Linear static and Linear Dynamic are presented to provide a comparison of the seismic response of multi-story buildings in terms of story displacement, story drift, and story shear **[9]**. To obtain the required strength and stiffness to withstand the lateral load in the building, the cross-sectional element of the slabs and the vertical elements such as the columns and the walls have the same value in the eight models.

2. Literature Review

Er. Raman Kumar, et.al **[10]** provision of the shear wall at the internal frame decreased the axial forces, the average displacement, and the story drift. The Maximum decrease of shear forces and bending moments for the building were observed for corner columns when shear walls located at external frames.

Arafa Elhelloty **[11]** performed a comparative study to evaluate the effect of lateral loads resisting systems on the response of steel frame buildings subjected to dynamic loads using ANSYS16 program.

Vikas Govalkar, et.al **[12]** investigated the effectiveness of reinforced concrete shear wall with different position of shear wall considering bare frame structural system and in-filled Frame structural system. The analysis was performed by program "STADD V.8i". The in-filled frame type structural system became economical as compared to the Bare Frame structural system. Also, Provision of the shear wall at the corner on each side the structure gives a better result than the all position.

J. Tarigan, et.al **[13]** performed the seismic analysis using the response spectrum method for different models of structures by comparing the displacement and story drift. Providing shear wall at the core of structure symmetrically gives the best performance to reduce the displacement and story-drift.

Mr. Muralidhar G.B, et.al **[14]** investigated the seismic performance of R.C Building with a flat plate influenced by a shear wall by a linear dynamic method using "ETABs.15" to study the seismic parameters. Concluded that the provision of shear walls at a diagonal corner increases the stiffness of the building and thereby decreases the values of the time period, the displacement and the story drift.

Rupali Goud, et.al **[15]** analyzed the structural behavior of multi-story building with different location of lift core shear wall was performed by an Equivalent static procedure using "STAAD" program. Concluded that the lift core should be provided at the edge of the building to serve its function efficiently and control the deflection during the earthquake. Providing lift core at corners or at the edge of the building have a better drift reduction factor as compared to the core at the center of the building.

Syed Khasim Mutwalli, et.al **[16]** studied the seismic performance of high rise building considering the effect of concrete core wall and shear wall at different positions. Linear static, linear dynamic and pushover analysis have been performed using structural analysis program " ETABS " The model of a bare frame with a shear wall at corners plus lift core wall shows better performance for minimum values of structural displacement and roof displacement, also maximum values of structural acceleration and base shear as compared to other models.

3. Objective of the Work

The main objectives of this study that has been carried out are as follows:

- Determine the seismic parameters of the structure such as story displacement, story drift, and base Shear.
- Evaluate the performance of the R.C. wall system using a linear Equivalent Static Load analysis and Response Spectrum Method.
- Obtain the optimum position of the shear wall with uniform thickness throughout the eight different models presented in this study **[17]**.

4. Structural Modeling

4.1 Site Location and Structural System

A regular residential multi-story building in the plan was selected with twenty stories with R.C. structural wall system. Considering the location of the suggested building is in El-Mansoura, Egypt with a Seismic Zone (2). The maximum dimension is 28 m. in Global-X direction and 22.50 m. in Global-Y direction. The overall height of the building is 60 m with a typical story height of 3 m. The concrete used for slabs, columns, and walls is M40. The cross-sectional elements used for the comparative are stated in the table (1).

Modeling and analysis of the proposed building are carried out using program ETABs v.16.2 with certain assumptions for various loading. All supports of R.C. structural walls and columns are considered as fixed at the base. The symmetrical building is the best choice to avoid damage during earthquakes as it has very small torsional moments. Figures (1) and (2) shows a typical floor plan and a three dimensional of the proposed building respectively.

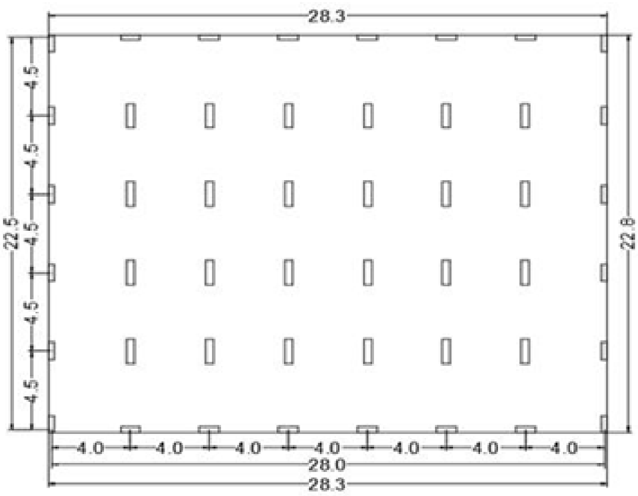

Figure 1: Plan of the proposed building **[4]**

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Model (0) Building with columns and no shear walls

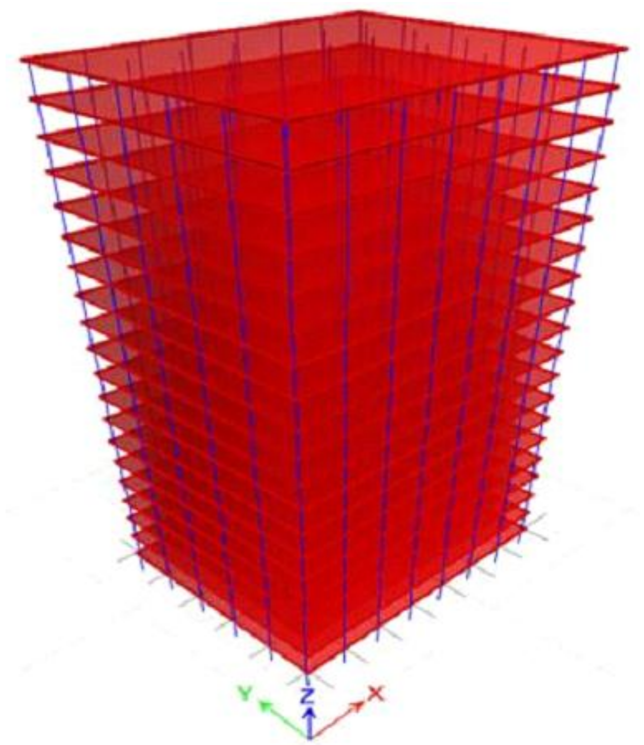

Figure 2: Three Dimensional of the Proposed Building **[4]**

Table 1: Section Properties

Cross Section	Dimension
Slab thickness	200 mm
Shear Wall thickness	200 mm, 300 mm, 400 mm
Columns	300*600 , 300*800 , 300*1000 , 300*1100 , 400*1400 , 400*1600 mm

4.2 Material Properties

The structural strength is strongly affected by the strength of the material **[4]**. It is specified in the analysis of the structure and is assigned according to (ECP 203/2017).

4.3 Models Considered for the Analysis

The Building of twenty stories in the plan was modeled as a fixed base building. Eight regular symmetrical models in the plan, as well as the elevation, are analyzed with soft computing program ETABs v.16.2 using the Equivalent Static analysis and the response spectrum analysis and compared to model (0) with only column and no shear walls in the layout. In this study, the eight models are constructed with different contributions and shapes of shear walls. The cross-sectional elements of the slabs and the vertical elements such as columns and walls have the same values in the eight models in order to make a fair comparison and good results. Also, the material properties, loading and other data for seismic forces are the same in the eight models. The eight models are analyzed for different thicknesses of the shear wall. The eight models of the building separately for a comparison of story displacement, story drift, and base shear are as following:

a) Model (1):

Building with shear walls placed at the central core.

b) Model (2):

Building with (L-shape) shear walls at corners.

c) Model (3):

Building with shear walls at the center of the exterior perimeter.

d) Model (4):

Building with shear walls at the exterior perimeter parallel to Y-direction.

e) Model (5):

Building with shear walls at the exterior perimeter parallel to X- and Y-directions.

f) Model (6):

Building with shear walls at corners as well as the center of the exterior perimeter.

g) Model (7):

Building with shear walls at the central core as well as the center of the exterior perimeter.

h) Model (8):

Building with (U-Shape) shear walls at corners.

Models 1, 2, 3, 4, 5, 6, 7 and 8 are shown in figures (3), (4), (5), (6), (7), (8), (9) and (10) respectively.

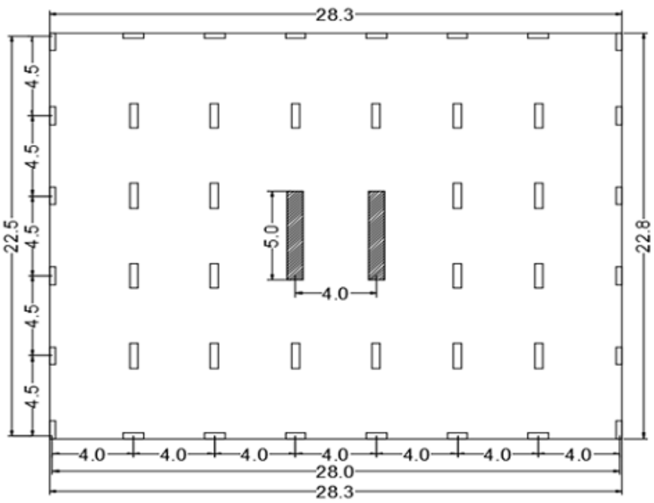

Figure 3: Model (1) Building with Central Walls

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ISSN (Online): 2347-3878
Impact Factor (2018): 5.426

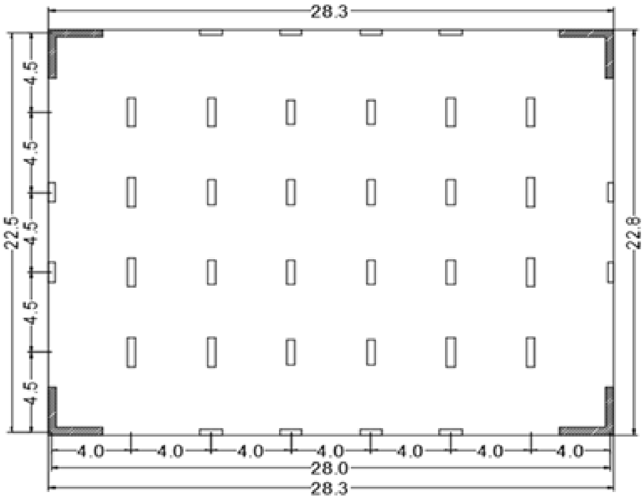

Figure 4: Model (2) Building with (L-shape) shear walls at Corners

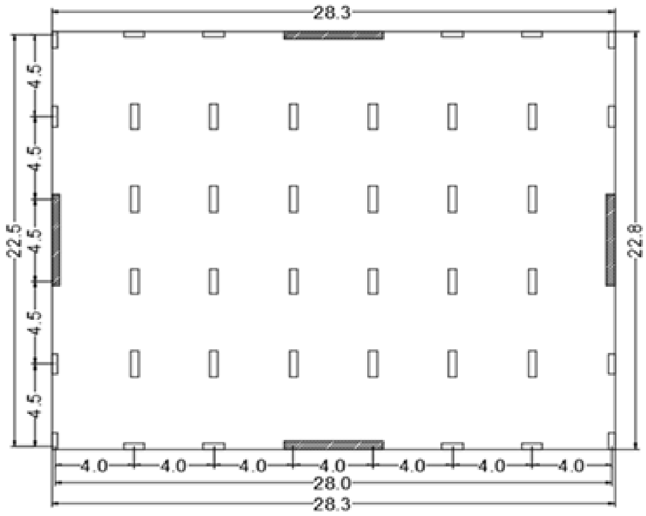

Figure 5: Model (3) Building with Shear Walls at the center of exterior perimeter

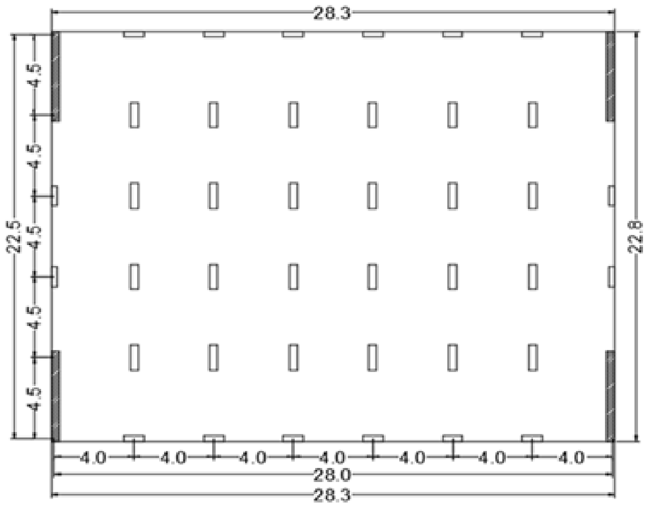

Figure 6: Model (4) Building with Shear Walls at exterior perimeter parallel to Y-direction.

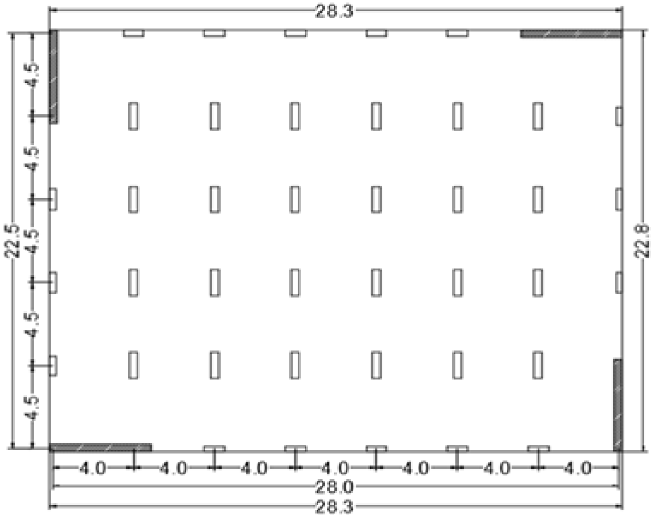

Figure 7: Model (5) Building with Shear Walls at exterior perimeter parallel to X-&Y- direction.

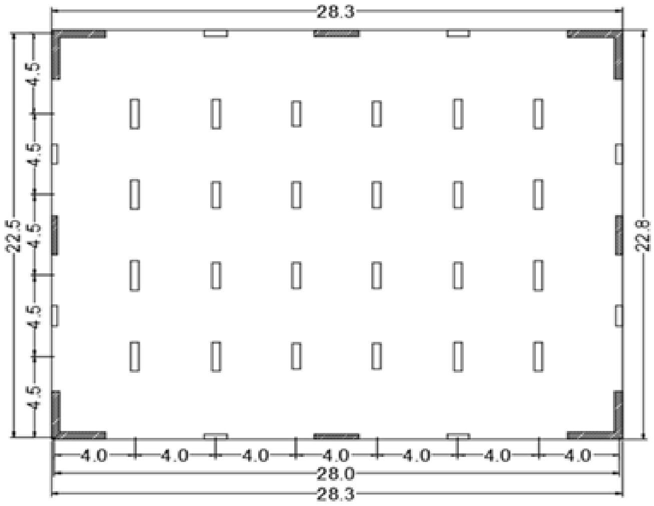

Figure 8: Model (6) Building with Shear Walls at Corners as well as the center of the exterior perimeter

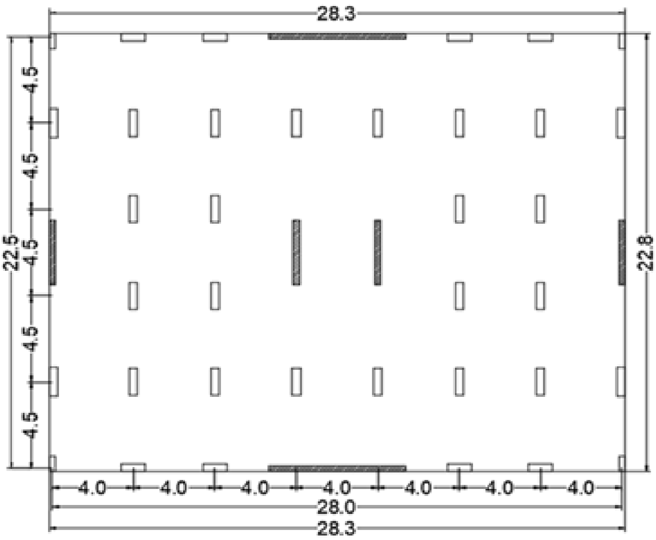

Figure 9: Model (7) Building with Shear Walls at the center as well as the center of the exterior perimeter

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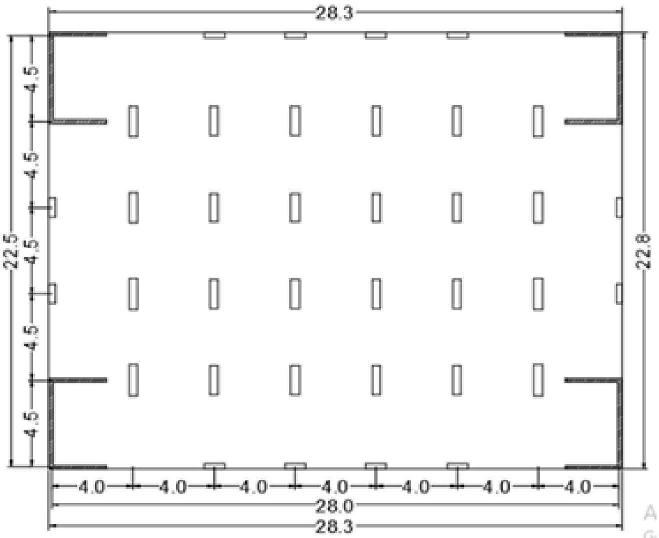

Figure 10: Model (8) Building with (U-Shape) Shear Walls at corners

4.4 Loading considerations

A. Gravity Loads

The gravity loads on the structure considered in this analysis include dead loads and live loads. The Self-weight of the structural elements are calculated automatically by the ETABs program itself. The wall loads are assigned as uniform area loads on slab elements.

Live loads are assigned as uniform area loads as per the Egyptian Code for Loads (ECL 201/2012).

A. Earthquake Load

In recent years, earthquake loads of the high-rise buildings have been a significant concern for designers owing to the development and the construction. The lateral load of the earthquake load is calculated according to the Egyptian Code for Loads (ECL 201/2012).

B. Load Combinations

When calculating the loads on the building, the loading cases shall be considered to give maximum effect on the structural elements. Egyptian Code (ECP 203/2017) states that there are numbers of load combinations which are used in the structural analysis.

C. Analysis of the Structure

For determining seismic design lateral forces, evaluating (ECL 201/2012) and the effect of the change in the building rigidity on seismic actions, the Egyptian code recommended using different types of earthquake analysis methods.

- **Static Analysis**

Equivalent Static Analysis (Linear Static)

- **Dynamic Analysis**

The Response Spectrum Analysis (Linear Dynamic)

Time History Analysis (Non-Linear Dynamic)

In this present study, the Equivalent Static Load analysis and the Response Spectrum Analysis are carried out for the determination of seismic parameters of the building.

All designs against earthquake effects must take the dynamic nature of the load into consideration. However, Equivalent static analysis cannot be used if the structure is irregular in terms of mass distribution, stiffness, strength, and elements with large ductility or the lateral force resisting system is non-orthogonal. The Egyptian code for loads (ECL201/2012) recommends that detailed dynamic analysis should be carried out depending on the importance of the problems. Also, it recommends the use of model analysis using the Equivalent Static Load method and the Response Spectrum Analysis method for building of height less than 60m in all seismic zones as safe.

In (ESL) procedure, the distribution of seismic lateral force on the building depends on the fundamental period of the structure with some modifiers. The base shear shall be computed, and then be distributed along the height of the buildings based on simple formulas for buildings with regular distribution of stiffness and mass. However, the distribution of seismic lateral force on the building in the (RSA) is based on the deformed shapes of natural modes of vibration, which are obtained from the distribution of mass and stiffness of the structure **[18]**.

5. Analysis Results

In this context, the analysis output of all models of twenty stories reinforced concrete building containing the different shapes, dimensions, and locations of shear walls are considered. The analysis has been performed by the Equivalent Static Load and Response Spectrum Analysis as per the Egyptian Code for Loads (ECL 201/2012) for each model using ETABs v.16.2 software. Lateral load values and its distribution along the height have done. The seismic weight is calculated in (ESL) analysis using the full dead load plus 25% of the live load. However, the base shear in (RSA) is scaled to be equal to 85% of the base shear value calculated using the (ESL) Method. The Results have represented in comparison forms according to the following seismic parameters for different stories. These parameters are story displacement, story drift, and base shear.

5.1 Maximum Story Displacement

Story displacement means the displacement which occurred at each story level according to the various loading pattern. The comparative study of the story displacements for each model along the two directions was represented in the figures (11)-(23) using the Equivalent Static Load Method and the Response Spectrum Method respectively.

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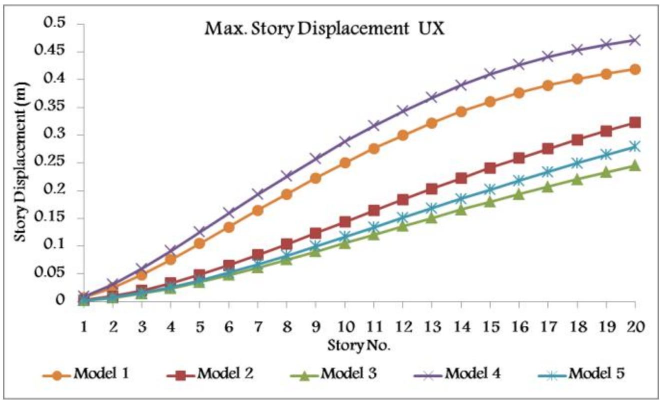

Figure 11: Lateral Maximum Story Displacement in X-dir. (Equivalent Static Load Method) - (tw =400mm)

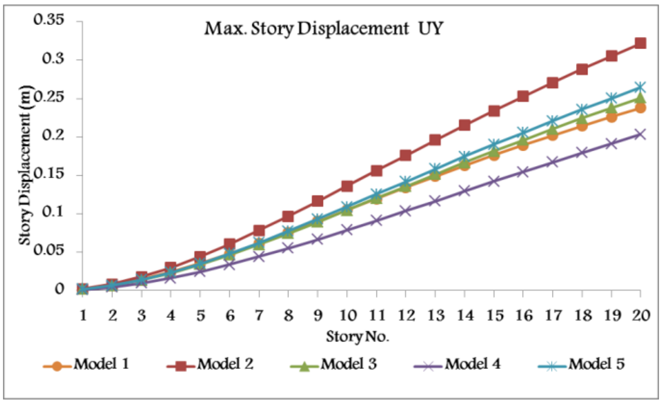

Figure 12: Lateral Maximum Story Displacement in Y-dir. (Equivalent Static Load Method) - (tw =400mm)

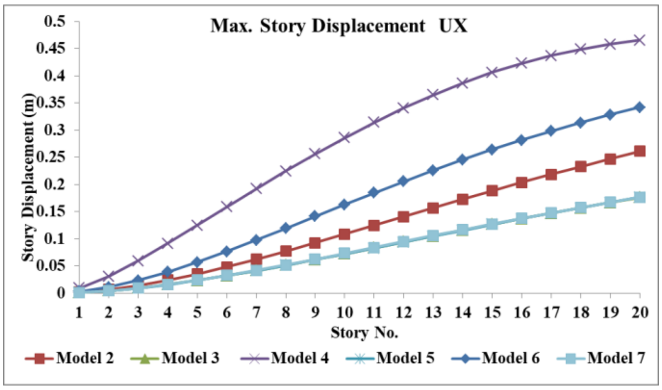

Figure 13: Lateral Maximum Story Displacement in X-dir. (Equivalent Static Load Method) - (tw =300mm)

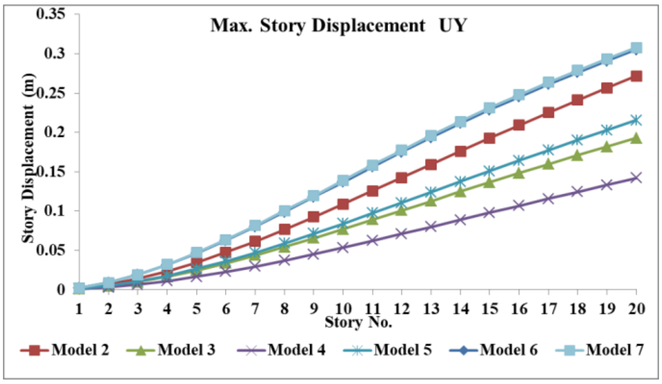

Figure 14: Lateral Maximum Story Displacement in Y-dir. (Equivalent Static Load Method) - (tw =300mm)

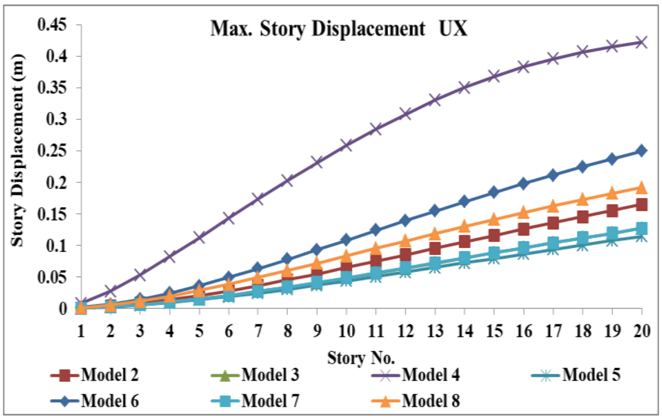

Figure 15: Lateral Maximum Story Displacement in X-dir. (Equivalent Static Load Method) - (tw =200mm)

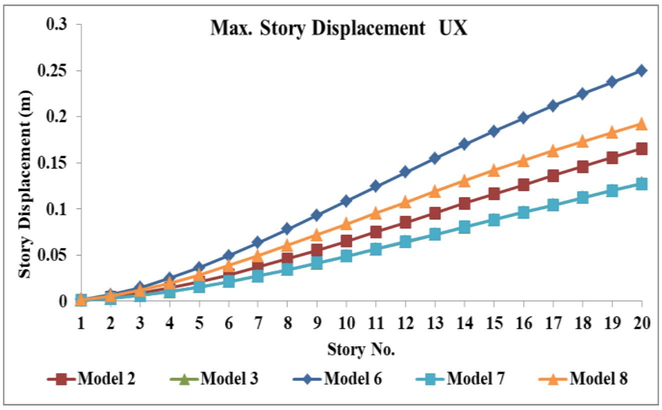

Figure 16: Lateral Maximum Story Displacement in X-dir. (Equivalent Static Load Method) - (tw =200mm)

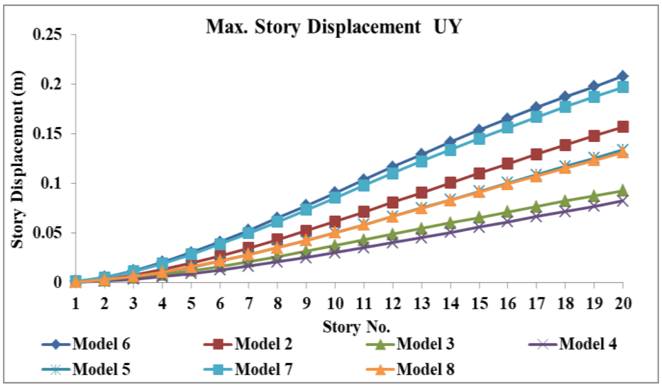

Figure 17: Lateral Maximum Story Displacement in Y-dir. (Equivalent Static Load Method) - (tw =200mm)

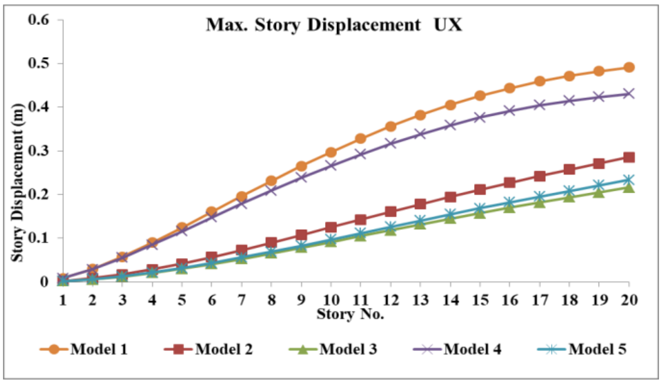

Figure 18: Lateral Maximum Story Displacement in X-dir. (Response Spectrum Method) - (tw =400mm)

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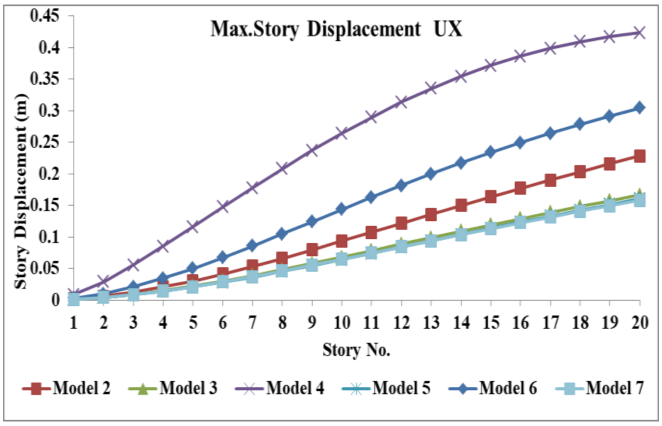

Figure 19: Lateral Maximum Story Displacement in X-dir. (Response Spectrum Method) - (tw =300mm)

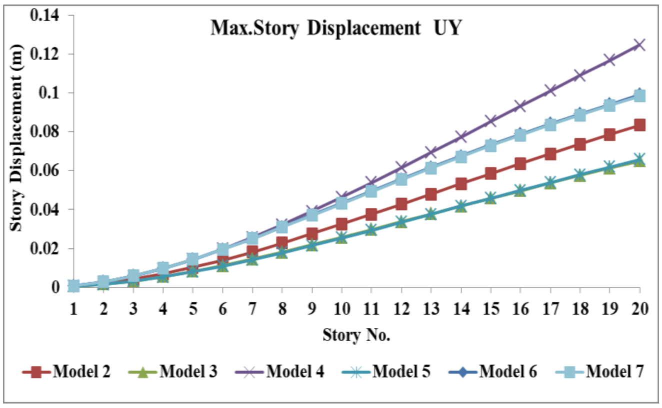

Figure 20: Lateral Maximum Story Displacement in Y-dir. (Response Spectrum Method) - (tw =300mm)

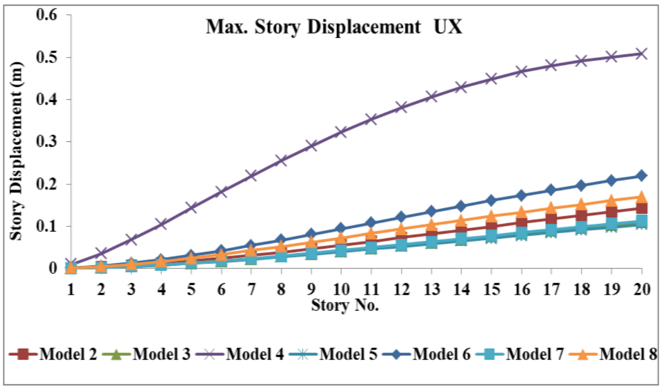

Figure 21: Lateral Maximum Story Displacement in X-dir. (Response Spectrum Method) - (tw =200mm)

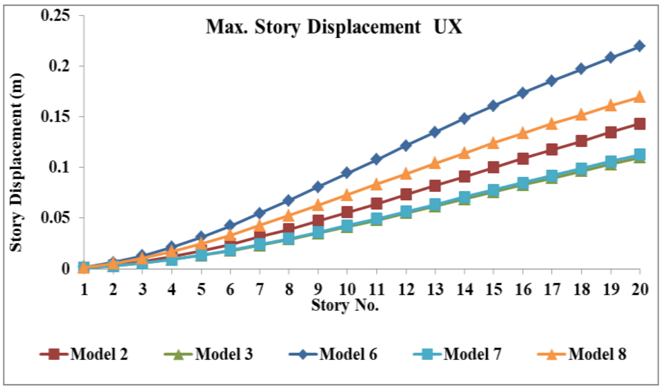

Figure 22: Lateral Maximum Story Displacement in X-dir. (Response Spectrum Method) - (tw =200mm)

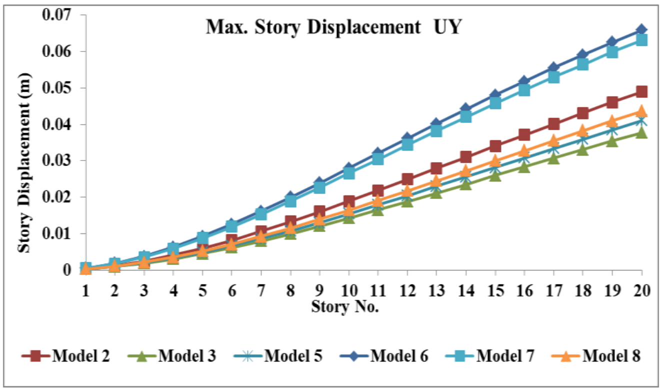

Figure 23: Lateral Maximum Story Displacement in Y-dir. (Response Spectrum Method) - (tw =200mm)

By comparing the displacement values obtained from the Equivalent Static Method for all models for the shear wall thickness of 200 mm, it has been found that model (2), model (3), model (4), model (5), model (6), model (7), and model (8) has 65.14%, 73.1%, 10.94%, 75.8% , 47.3%, 73.12% and 59.4% respectively less displacement values as compared to the model (0) in X- direction and in Y- direction model (2), model (3), model (4), model (5), model (6), model (7), and model (8) has 61.19% , 77.08% , 79.66% , 66.97% , 48.65%, 51.36%, and 67.56% respectively less displacement values as compared to the model (0) . For the shear wall thickness of 300 mm, model (2), model (3), model (4), model (5), model (6), and model (7) has 44.96%, 62.84%, 1.99% , 62.8% , 27.89%, and 62.75% respectively less displacement values as compared to the bare frame model (0) in X- direction and in Y- direction model (2), model (3), model (4), model (5), model (6) and model (7) has 32.95 % , 52.46 % , 64.98%, 46.83%, 24.7%, and 24.14% respectively less displacement values as compared to the model (0).

In the Response Spectrum Analysis, it has been found that model (2), model (3), model (4), model (5), model (6), model (7) and model (8) has 77.7%, 82.9%, 20.9%, 83.8%, 65.9 %, 82.4% and 73.6% respectively less displacement values as compared to the model (0) in X- direction for shear wall thickness of 200 mm. For thickness for shear wall of 300 mm, model (2), model (3), model (4), model (5), model (6), and model (7) has 64.5%, 74.05% , 34.05%, 75.08%, 52.6% and75.4% respectively less displacement values as compared to the model (0) in X- direction.

5.2 Maximum Story Drift

Story drift is the relative displacement between any two levels of the story between the floor above and below the under consideration (Story drift is the lateral displacement of one level relative to the level above or below it).

Story drift ratio = difference between the displacement of two

Stories / height of one story **[19]**

As per (ECL 201/2012), the story drifts in any story due to the specified design lateral force shall not exceed the permissible inter-story drift that is limited to 0.005 times the story height.

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Figures (24)-(33) illustrate the comparison of story drift along X- and Y- directions for all models using Equivalent Static Method and Response Spectrum Method respectively.

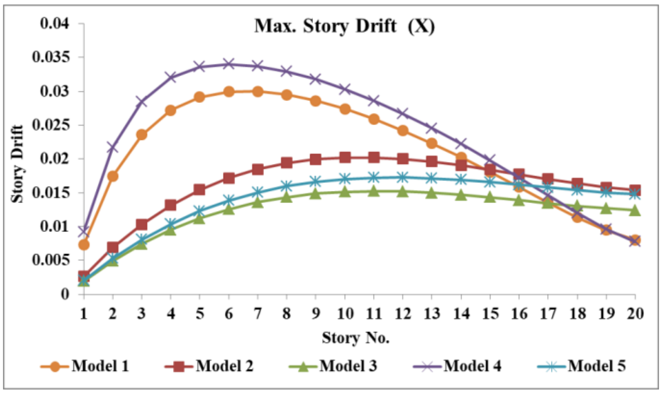

Figure 24: Maximum Story Drift in X-direction. (Equivalent Static Load Method) - (tw =400mm)

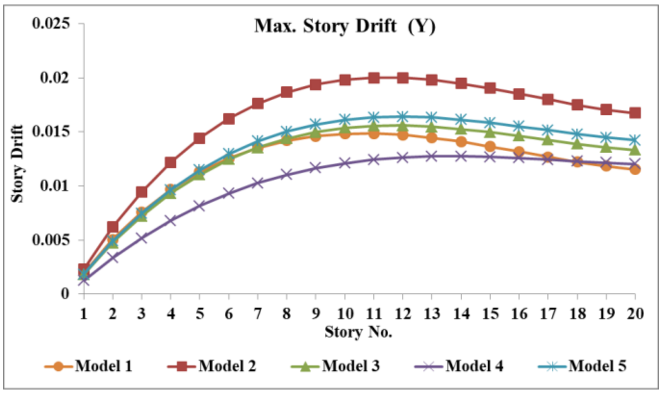

Figure 25: Maximum Story Drift in Y-direction. (Equivalent Static Load Method) – (tw =400mm)

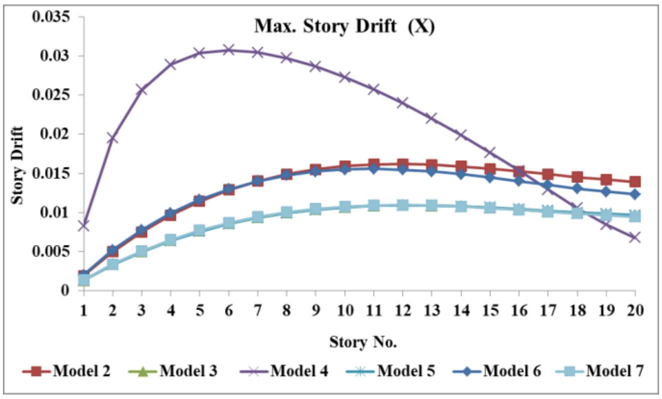

Figure 26: Maximum Story Drift in X-direction. (Equivalent Static Load Method) - (tw =300mm)

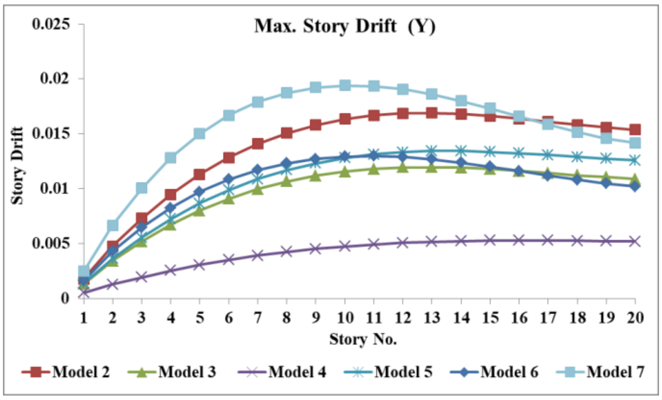

Figure 27: Maximum Story Drift in Y-direction. (Equivalent Static Load Method) - (tw =300mm)

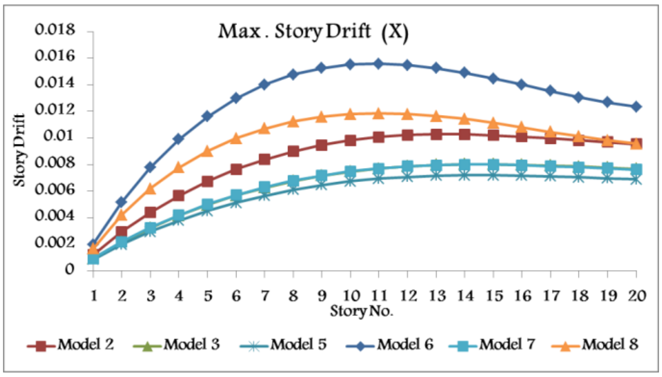

Figure 28: Maximum Story Drift in X-direction. (Equivalent Static Load Method) - (tw =200mm)

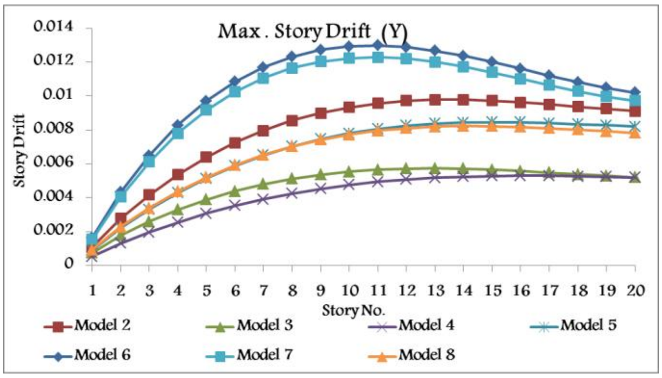

Figure 29: Maximum Story Drift in Y-direction. (Equivalent Static Load Method) - (tw =200mm)

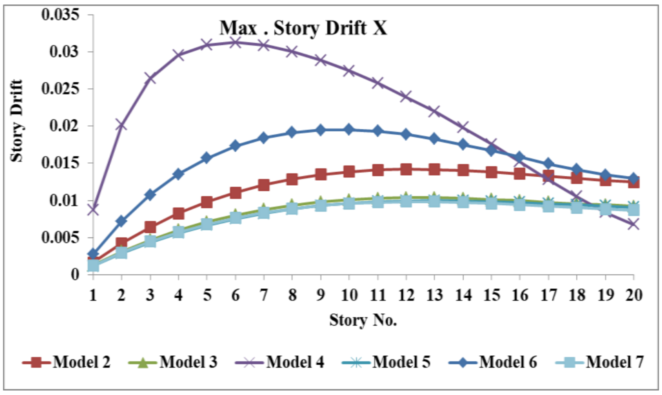

Figure 30: Maximum Story Drift in X-direction. (Response Spectrum Method) - (tw =300mm)

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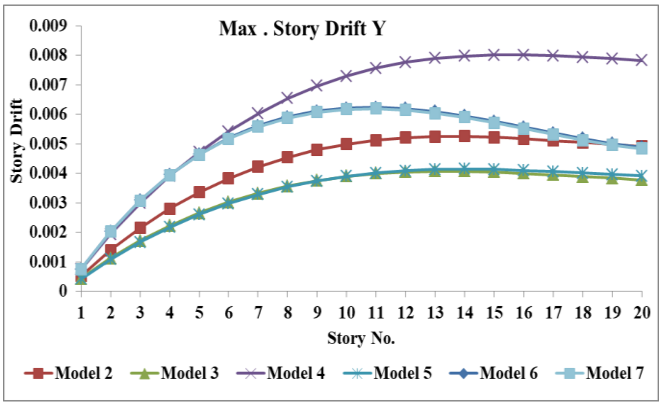

Figure 31: Maximum Story Drift in Y-direction. (Response Spectrum Method) - (tw =300mm)

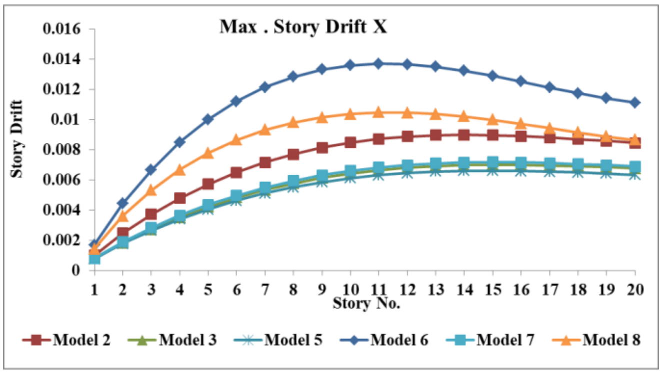

Figure 32: Maximum Story Drift in X-direction. (Response Spectrum Method) - (tw =200mm)

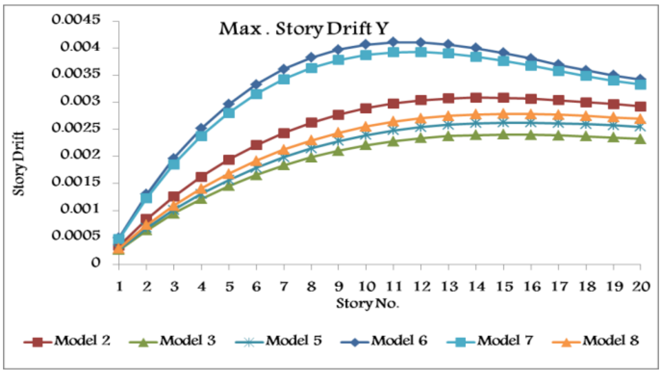

Figure 33: Maximum Story Drift in Y-direction. (Response Spectrum Method) - (tw =200mm)

From the figures (24)–(33), it can be noticed that when decreasing the thickness of shear walls, the story drifts of all models can achieve the permitted value as specified by code (ECL 201/ 2012). The maximum permitted drift is 0.005 times the height of the story equal 0.015 m.

From the above comparison, the increase in the height of the building increased the story drift. It is worth mentioning that the story drift is low in bottom stories, high in the middle stories and finally reduces towards the upper stories.

By comparing the drift values obtained from the Equivalent Static Method for all models for the shear wall thickness of 200 mm, it has been found that model (2), model (3), model (4), model (5), model (6), model (7), and model (8) has 16.23 %, 32.56 %, 40.33%, 39.59%, -8.32%, 33.06%, and 16.03% respectively less drift values as compared to the model (0) in X- direction and in Y- direction model (2), model (3), model (4), model (5), model (6), model (7), and model (8) has 30.7%, 60.5% , 60.44%, 37.7%, 22.39%, 26.08%, and 40.47% respectively less drift values as compared to the model (0) . For the shear wall thickness of 300 mm, model (3), model (4), model (5) and model (7) has 16.35%, 35.59 %, 15.36%, and 16.97% respectively less drift values as compared to the model (0) in X- direction and in Y- direction model (2), model (3), model (4), model (5), model (6), and model (7) has -16.72%, 17.22%, 33.83%, 4.23%, 22.39%, and -7.74% respectively less drift values as compared to the model (0).

In the Response Spectrum Analysis, it has been found that model (2), model (3), model (4), model (5), model (6), model (7) and model (8) has 49.94 %, 59.92%, 54.46% , 62.47%, 34.13%, 59.08%, and 48.69% respectively less drift values as compared to the model (0) in X- direction for shear wall thickness of 200 mm. For thickness for shear wall of 300 mm, model (2), model (3), model (4), model (5), model (6), and model (7) has 25.98%, 45.47%, 60 %, 46.2 %, 23.28%, and 48.6% respectively less drift values as compared to the model (0) in X- direction.

Finally, from the above results, it could be seen that the maximum reduction in story drift values was obtained for Models (3), (5), and (7) when compared to that model with columns only.

5.3 Base Shear

Base shear is the maximum predictable lateral force that will happen due to seismic ground motion at the base of the structure. For the analysis, the codes required the use of the equivalent static force procedure and a dynamic lateral force procedure. Hence, the base shear calculated from the dynamic analysis should be reduced to a certain percentage of the base shear obtained from the static force procedure **[25]**. Base shear scaling is a procedure required that the minimum strength of a structure designed using the Response Spectrum Analysis method (RSA) is similar to that strength if the structure was designed using the Equivalent Static Load method (ESL) **[26]**. As per code (ECL 201/2012), using the (RSA) method reduced the value of the base shear to be equal to 85% of the value calculated using the (ESL) Method.

From the below table (2) which represents the comparison of seismic base shear for various models obtained from ESL and RSA, it can be observed that all of the models approximately have the same values of the base shear in Equivalent Static Load Analysis. The same values of the base shear are the result of the same weight of the cross-sectional element in any model. Also, it can be observed that the Equivalent Static Load Analysis yields the largest values of base shear as compared to that the Response Spectrum Analysis. RSA yielded more effective base shear values when compared to ESL.

The base shear for each model is plotted in the figure (34) using Equivalent Static Load Method (ESL) and Response Spectrum Method (RSA) respectively.

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Table 2: Base Shear (KN)

Model	Base Shear [KN]			
	Linear Static Analysis		Linear Dynamic Analysis	
	Vx	Vy	Vx	Vy
M 2	4996.5	4996.5	4271.9	4317.1
M 3	4996.5	4996.5	4420.5	4520
M 4	4996.0	4996	4643.5	4445.1
M 5	4996.6	4996.6	4467.6	4461.8
M 6	4996.5	4996.5	4254.7	4301.2
M 7	4936.6	4936.6	4383	4254.5
M 8	4995.1	4995.1	4271.8	4429.4

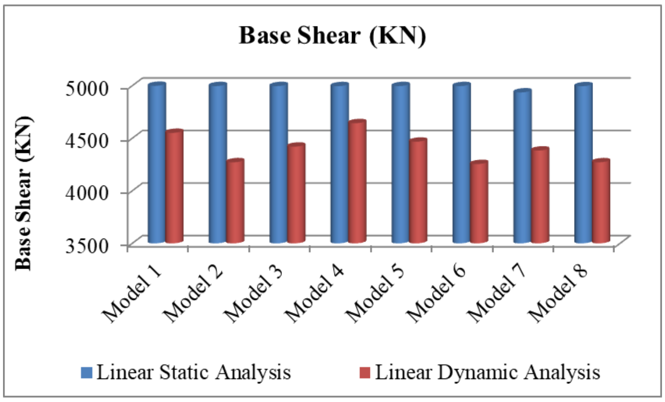

Figure 34: Base Shear

6. Conclusion

This study has investigated the performance of reinforced concrete multi-story building with twenty stories influenced by shear walls. The parametric study is carried out for eight models for the various arrangement of the shear wall in the plan configuration. In this study, the analysis of models is carried out using ETABs v.16.2 software. Shear walls are provided for lateral stability of the reinforced concrete structures. The seismic behavior is evaluated for the various seismic parameters such as story displacement, story drift, and base shear. So based on the results conclusions were drawn:

1) The shear walls should be provided in both directions of buildings in plan configuration not only in one direction because the behavior of the structure is good in that direction, but it has no considerable effect in the other direction as shown in models (1) and (4) in the longitudinal and transverse directions.
2) Providing the shear wall away from C.G decreases the displacement and story drift and vice versa when the shear wall is near C.G, the displacement and story drift is increasing as in model (1) when compared to other models.
3) From the comparison, providing shear walls at the exterior perimeter; model (3), or at the exterior perimeter of the building parallel to longitudinal and transverse directions; model (5) or at central core as well as the center of the exterior perimeter; model (7), shows the preference for the seismic parameters as it improves the behavior of the structure by decreasing the values of the displacements and the story drifts when compared to that model (0) with columns only and no shear walls.
4) The story drifts are within the permissible limits as specified by code (ECL 201/2012) in both ESL and RSA.
5) Model with (U-shape) shear wall in corners was observed to have more inter-story drift when compared to that model in which shear walls are central core as well as the center of the exterior perimeter; model (7).
6) The results of the Response Spectrum Analysis provided a more realistic behavior of structure response than the Equivalent Static Load method.
7) The RSA method yields more effective base shear values compared to The ESL method.

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