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Comparative Analysis of Different Lateral Load Resisting System for Geometrically Irregular Shaped High-Rise Building

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Abstract*— As the population is increasing tremendously with every passing year and the land available for use of habitation is the same as it was a decade ago. So, the only solution to the problem is vertical growth. Now this need for the increase in the vertical height of the buildings has made the buildings tall and slender. Since buildings are getting taller and slender the primary concern of design engineers is shifting from gravity loads to lateral loads. The effect of lateral forces becomes more and more dominant as the building becomes taller and taller. Thus, to boost the performance of the structure under various lateral loading such as in wind or earthquake, lateral load resisting structural system plays very efficient role. In present paper an investigation has been focused on performance of different lateral load resisting structural system in geometrically irregular shaped high-rise building. Here, in this present work a particular 50 storey C shaped plan irregular building with different lateral load resisting systems are considered and four models are developed in ETABS software with codal provisions. These models are analysed for Static and dynamic behavior. Wind analysis and Response spectrum method is carried out. The Parameters discussed in this paper include Storey Displacement, Storey Drift, Base shear, Base moment, Time period and Torsion for static and dynamic behaviour of different lateral load resisting configurations.

Keywords*— Lateral Load Resisting System, Response Spectrum Method, Wind Analysis, Geometrically Irregular, High-Rise Building.

I. INTRODUCTION

As the population is increasing tremendously with every passing year and the land available for use of habitation is the same as it was a decade ago. There has been an increase in the density of population in the urban area, since population from rural areas is migrating in large numbers to metro cities. Due to this, metro cities are getting densely populated day by day. So, the only solution to the problem is for vertical growth. Now this need for the increase in the vertical height of the buildings has made the building become tall and slender. Thus, height of the building has now become the primary point of focus of today's world.

Since buildings are getting taller and slender the primary concern of design engineers is shifting from gravity loads to lateral loads. The effect of lateral forces becomes more and more dominant as the building becomes taller and taller. These lateral forces can produce critical stresses in the structure, induce undesirable stresses and vibrations or cause excessive lateral sway of the structure. This has brought more challenges for the engineers to satisfy both gravities load as well as lateral loads, earlier buildings were designed for the gravity loads but now because of tall height and seismic zone the engineers have taken care of lateral loads due to earthquake and wind forces. So, to cater all the lateral forces, we have to design the structure very uniquely so that the structure can withstand for the maximum time period without causing any harm to the society. The Engineers and professional in the structural designing fields have found out many ways to tackle this problem. Traditional simple framed structures have now been replaced by complex yet more effective structural systems that perform better in case of lateral load

A. Structural System

In the past years, structural members were assumed to carry primarily the gravity loads. However, by the advancement in structural system has made buildings taller and slender. The effect of lateral forces due to wind and earthquake becomes more and more dominant as the building becomes taller and taller. There are many structural systems that can be used for lateral resistance of tall buildings.

The various structural systems commonly used for the design of tall buildings are:

1. Rigid frame structure.
2. Braced frame structure.
3. Shear wall frame structure.
4. Braced frame and shear wall frame structure.
5. Outrigger structure.
6. Frame tube structure.
7. Braced tube structure.
8. Bundled tube structure.

9. Trussed tube.
10. Diagrid system

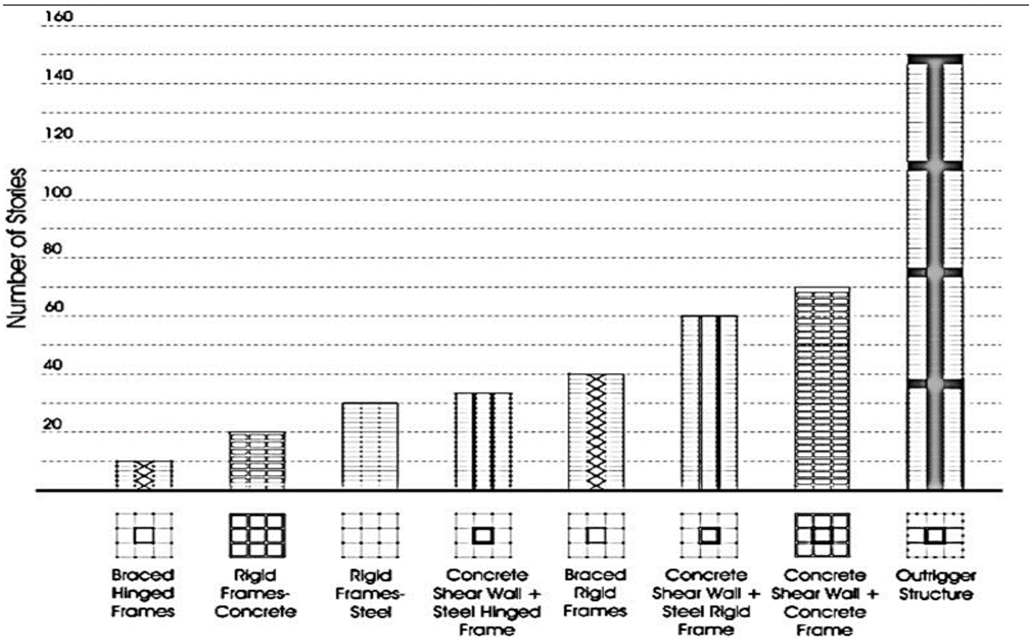


Fig. 1. OUTRIGGER STRUCTURAL SYSTEM

B. Overview of a Few Structural Systems

1. Rigid Frame Structure

A rigid frame in structural engineering is the load-resisting skeleton constructed with straight or curved members interconnected by mostly rigid connections which resist movements induced at the joints of members. Its members can take bending moment, shear, and axial loads.

A rigid-frame high-rise structure typically comprises of parallel or orthogonally arranged bents consisting of columns and girders with moment-resistant joints. The continuity of the frame also increases resistance to gravity loading by reducing the positive moments in the girders. The advantages of a rigid frame are the simplicity and convenience of its rectangular form. Rigid frames are considered economical for buildings of up to about 25 stories, above which their drift resistance is costly to control.

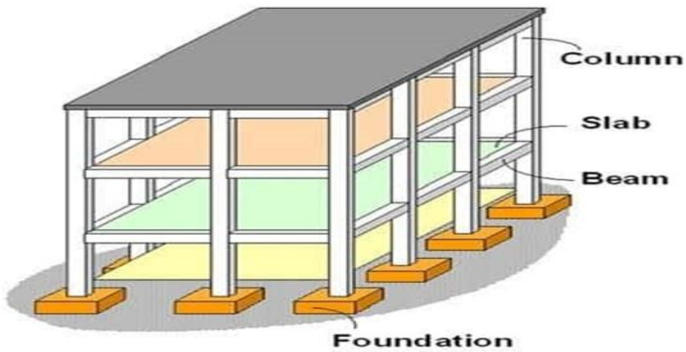


Fig. 2. TYPICAL RIGID FRAME STRUCTURE

2. Shear Wall Frame System

Continuous concrete vertical wall serves both architecturally as partition and structurally to carry gravity and lateral loads. Shear walls are used in building to resist lateral force due to wind and earthquakes. Very high plane stiffness and strength makes shear walls ideally suited for tall buildings. Shear wall generally starts at foundation level and are continued throughout the building height. They act as vertical cantilevers in the form of separate planar walls and as non-planar assemblies of connected walls around elevator, stair and service shafts. Shear walls in buildings must be symmetrically located in plan to reduce ill-effects of twist in buildings.

When shear walls are situated in advantageous positions in the building, they can form an efficient lateral force resisting system by reducing lateral displacements under earthquake loads. Therefore, it is very necessary to determine effective, efficient and ideal location of shear wall. The figure 3. (A) shows Symmetrical location of shear wall located at the centre of the building and Figure 3. (B) shows unsymmetrical location of shear wall placed at periphery and intermediate position of the building. The placement of the shear walls at the centre may not be common for all type of building. In some situations, their location will be bought to the ends of the plan. In case of difficulty in deciding the best location, analysis of different positions is done and the best is chosen.

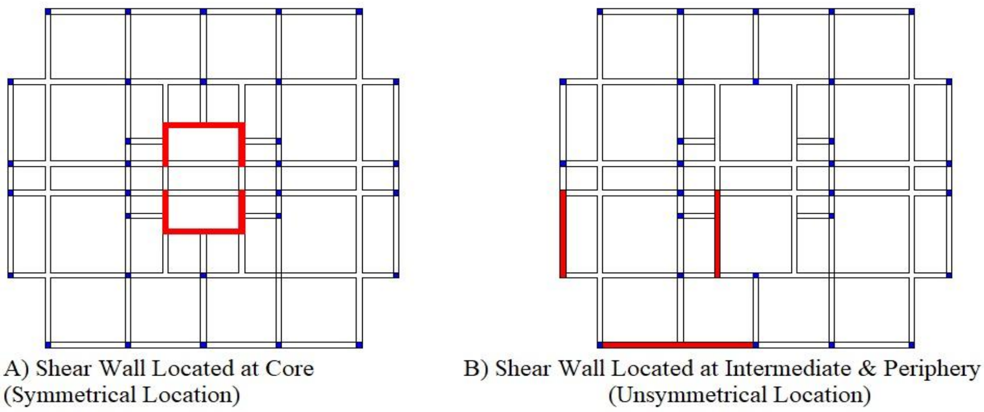


Fig. 3. SYMMETRICAL AND UNSYMMETRICAL LOCATION OF SHEAR WALLS

3. Braced Frame System

A braced frame is a structural system commonly used in structures to resist the lateral forces due to wind and earthquake. The members in a braced frame are generally made of structural steel, which can work effectively both in tension and compression. The beams and columns that form the frame carry vertical loads, and the bracing system carries the lateral loads. The positioning of braces, however, can be problematic as they can interfere with the design of the facade and the position of openings. Buildings adopting high-tech or post-modernist styles have responded to this by expressing bracing as an internal or external design feature.

Bracing is generally regarded as an exclusively steel system but nowadays steel bracings are also used in reinforced concrete frames. The efficiency of bracing is being able to produce laterally very stiff structure for a minimum of additional material makes it an economical structural form for any height of building. A major disadvantage of diagonal bracing is that it obstructs the internal planning and the location of door and windows. For this reason, bracings are usually placed along wall and partition lines and especially around elevators, stairs and service shafts. Recently bracings are not only used to produce highly efficient structures but aesthetically attractive buildings.

Generally, braces are of two types, concentric and eccentric. Concentric braces connect at the beam column intersection, whereas eccentric braces connect to the beam at some distance away from the beam column intersection. Also, bracings are categorized as vertical bracings and horizontal bracings system depending upon the path of transferring load. Vertical bracing is placed in the form of diagonals between column lines in vertical planes to transfer horizontal forces to ground level, whereas horizontal bracing system is provided in horizontal planes at each floor level, to transfer horizontal forces to the vertical bracings.

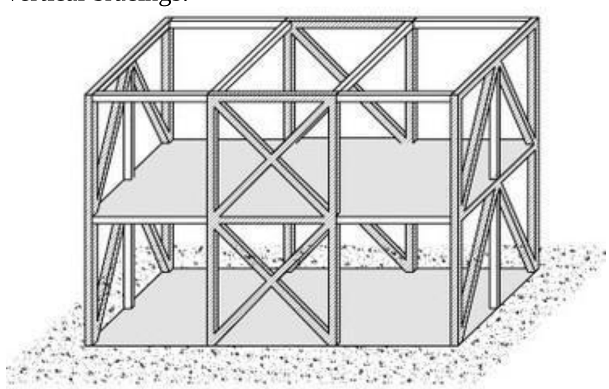
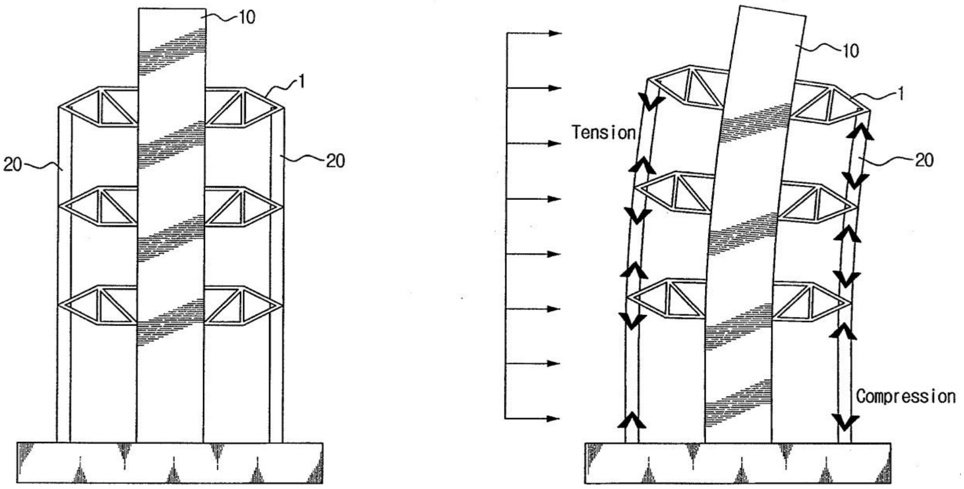


Fig. 4. BRACING SYSTEM

4. Outrigger Structural System

Outriggers are very stiff horizontal arm like structures that are designed to improve the buildings resistance to overturning and strength by connecting the core to distant columns. The concept of Outrigger is not new to us as Outriggers have been used in sailing vessels in the mast of the sail to improve the stability. Despite being such and old technology, it has been recently introduced in the structural framework of the buildings. The basic working of the Outrigger is explained in figure 5 it has very stiff trusses in a selected floor which are made out of trusses like structures having diagonal, vertical and horizontal members. This Outriggers are rigidly tied to the central core of the building.

When the lateral forces due to wind and earthquake acts on the building the building gains acceleration in a particular direction. As the core stiffness is very high as compared to the other columns it attracts maximum lateral forces and try to bend. As the Outrigger arms are very stiff and they have a rigid connection to the core, this bending of the core tries to rotate the Outrigger thus inducing the above tension-compression couple on the peripheral columns as shown in figure 5.



(a) Under normal condition (b) Under lateral load

Fig. 5. BASIC WORKING OF OUTRIGGER SYSTEM

Types of Outrigger Truss System

On the basis of connectivity of core to exterior columns, this system may be divided as in two types

- *Conventional Outrigger Concept*

In the conventional outrigger concept, the outrigger trusses or girders are connected directly to shear walls or braced frames at the core and to columns located outboard of the core

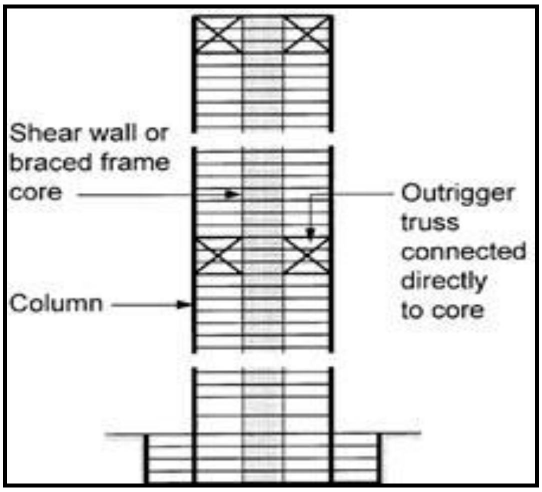


Fig. 6. CONVENTIONAL OUTRIGGER STRUCTURAL SYSTEM

- *Virtual Outrigger Concept*

In the "virtual" outrigger, the same transfer of overturning from the core to elements outboard of the core is achieved, but without a direct connection between the outrigger trusses and the core. The basic idea behind the virtual outrigger concept is to use floor diaphragms, which are typically very stiff and strong in their own plane. Virtual Outrigger is also called as belt truss system.

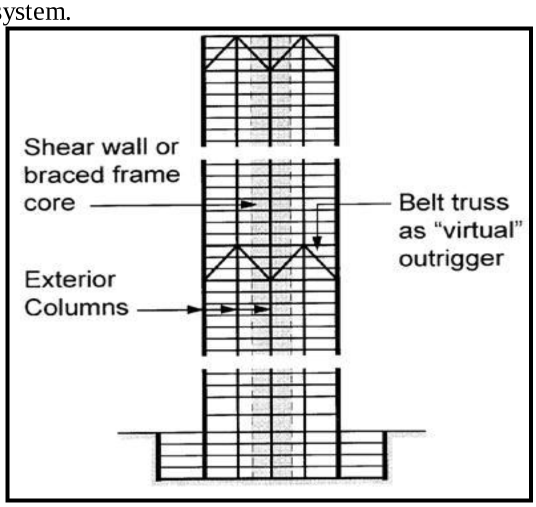


Fig. 7. VIRTUAL OUTRIGGER STRUCTURAL SYSTEM

II. OBJECTIVE OF RESEARCH

1) Finite Element models of reinforced concrete multi-storeyed building with G+50 storey geometrically irregular C shaped plan layouts with different lateral load resisting configurations i.e. Braced framed structure, Shear wall structure, Outrigger structure and Bare frame structure are modelled in ETABS.
2) The main aim of this project is to compare the Braced framed structure, Shear wall structure and Outrigger structure with Bare frame structure based on the performance under lateral loads i.e. wind and earthquake that may occur during the lifespan of the building.
3) To perform Static analysis of geometrically irregular C shaped building models for earthquake analysis as per IS 1893 (Part 1) 2016.
4) To perform Dynamic analysis of geometrically irregular C shaped building models by response spectrum method using software ETABS.
5) To perform Static Wind analysis of geometrically irregular C shaped building models for wind load as per IS 875 (Part 3) 2015.
6) To perform a parametric study which include Storey Displacement, Storey Drift, Base Shear, Base Moment, Time Period and Torsion.
7) To provide a logical and meaningful conclusion for future study considering the safety and economy of the buildings.

III. MODELS CONSIDERED FOR ANALYSIS

In current study, three-dimensional G+50 storied building with plan dimension 48 m x 38m are modelled (Fig 4). The typical floor height is 3.5m giving a total height of 178.5m. The beams, columns and shear walls are modelled as RC elements. Bracings and outrigger is modelled as structural steel truss. Column and beam sizes considered in the analysis are 1000mm x 1000mm and 700mm x 400mm respectively. Shear wall 300mm thick, Steel tube 400mm x 400mm x 60mm are considered for bracings and outrigger. Grade of Concrete considered is M70 for Columns and M35 for Shear wall and for Beams and Floors. Grade of Rebar and Structural Steel considered is FE415 and FE490 respectively.

A total 4 different lateral load resisting system configurations has been modelled and analysed.

1) M1 Bare Frame structure
2) M2 Braced Framed Structure (with X type Bracings)
3) M3 Shear Wall Structure (with L shaped Shear wall are placed at Corners)
4) M4 Outrigger Structure (Conventional outrigger with Belt truss system is provided at top and mid-height)

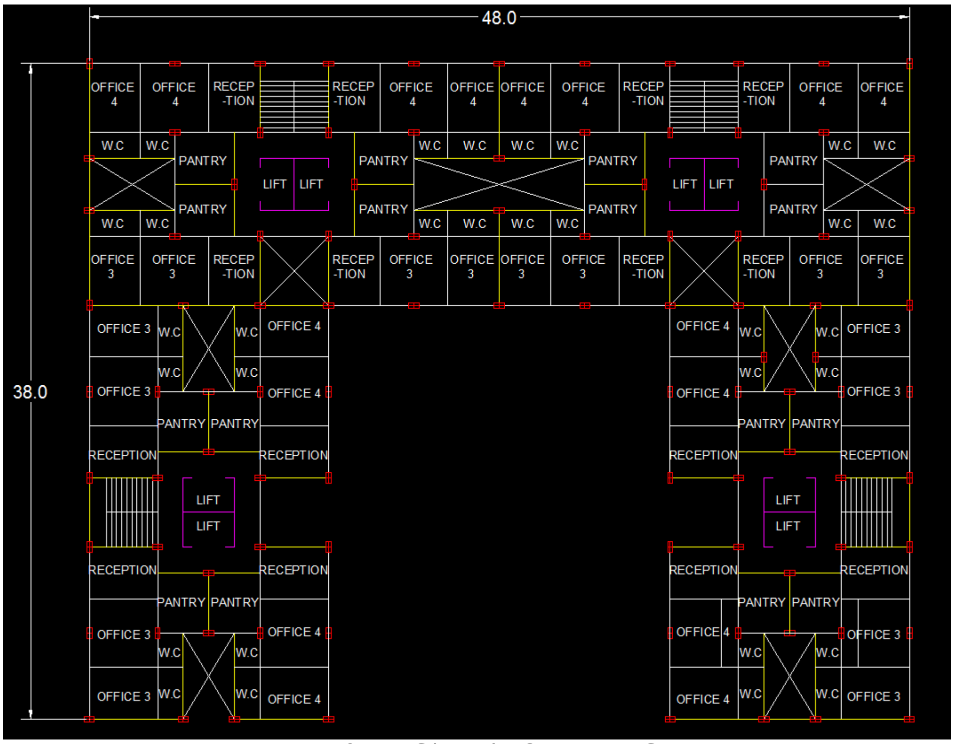


Fig. 8. TYPICAL PLAN OF BUILDING

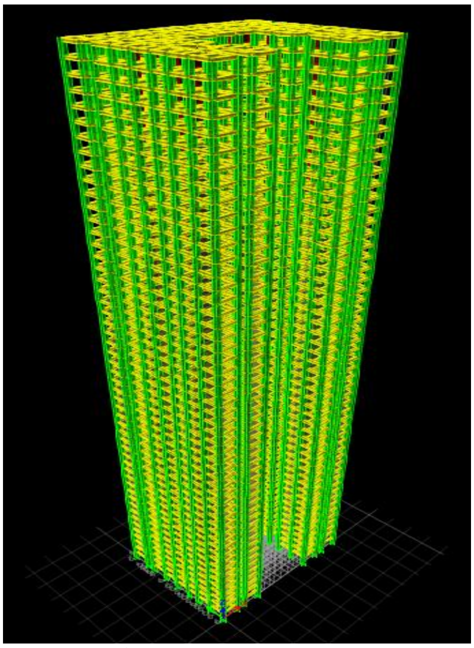


Fig. 9. ELEVATION (MODEL NO 1 - BARE FRAME STRUCTURE)

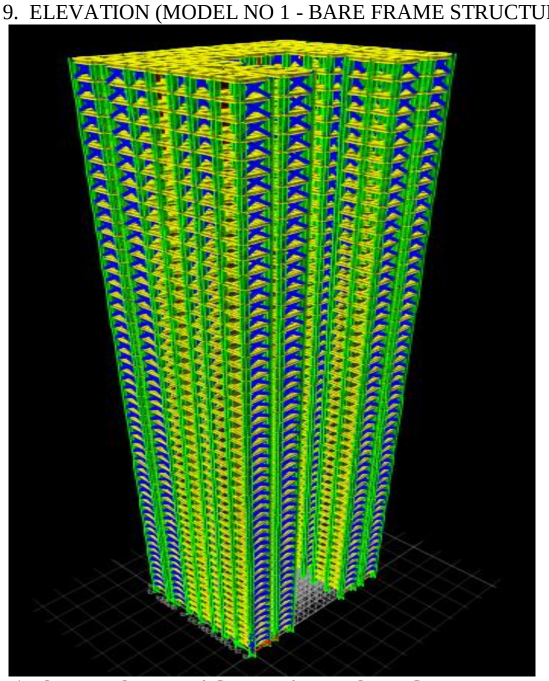


FIG. 10. ELEVATION (MODEL NO 2 - BRACED FRAMED STRUCTURE WITH X TYPE BRACINGS)

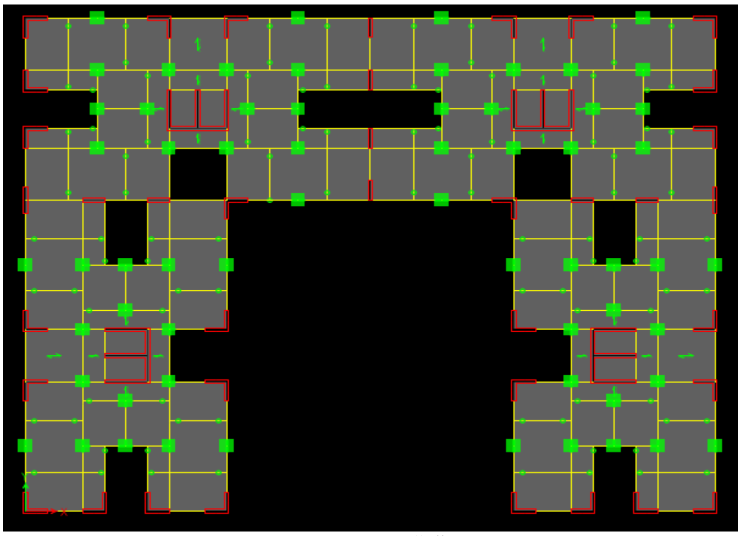


FIG. 11. PLAN (MODEL NO 3 - SHEAR WALL STRUCTURE WITH "L" SHAPED SHEAR WALL ARE PLACED AT CORNERS)

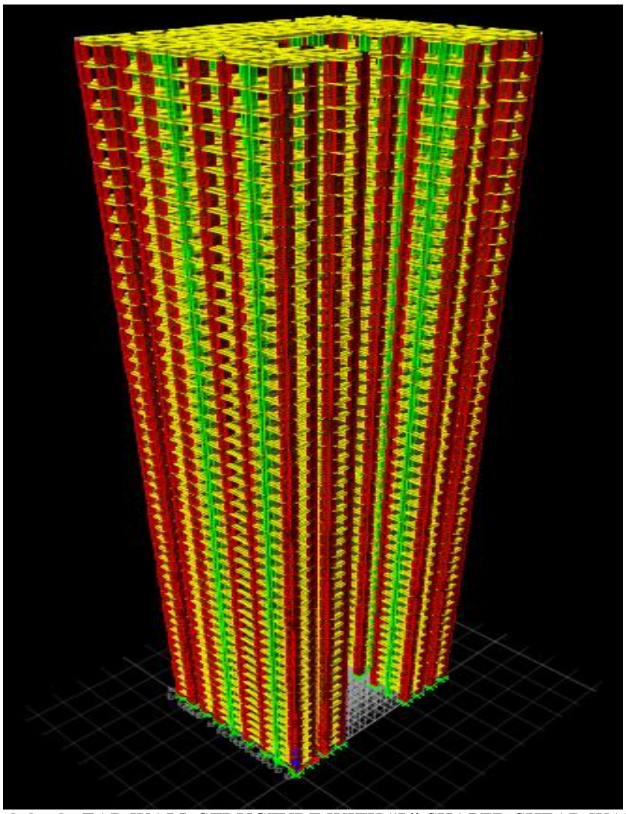


FIG. 11. ELEVATION (MODEL NO 3 - SHEAR WALL STRUCTURE WITH "L" SHAPED SHEAR WALL ARE PLACED AT CORNERS)

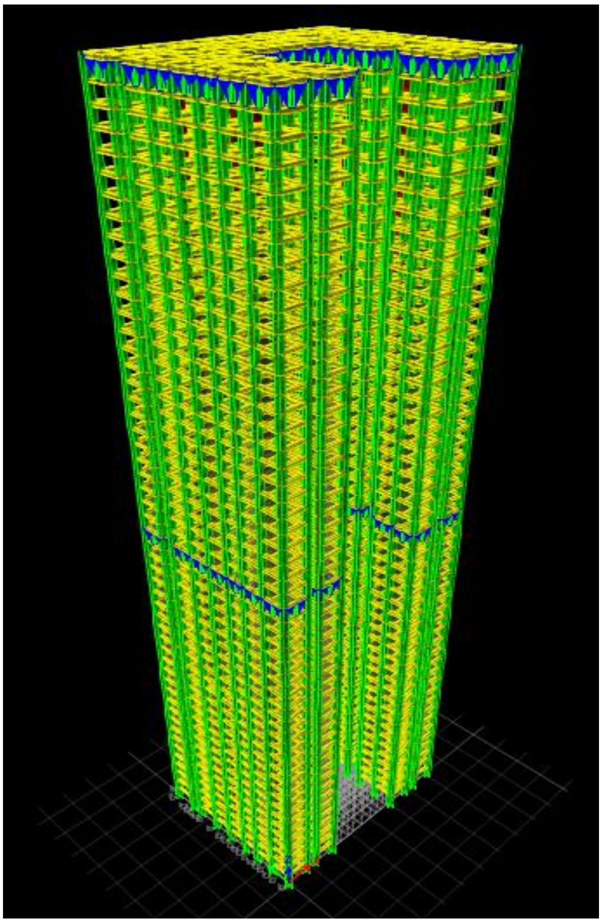


Fig. 5. ELEVATION (MODEL NO 4 - OUTRIGGER AT TOP & 0.5H i.e. HEIGHT OF BUILDING)

The assumptions behind modelling this system are that the connection between shear wall core and foundation is rigid. The outrigger truss rigidly connected to the stiff core on one side and simply supported on the peripheral column other side and bracings are connected in between two columns. Simple support condition is achieved through releasing major and minor moments (M33 & M22) of truss element at the peripheral column junction such that bending moments are not transferred and only axial thrust is exerted to the columns. The columns are sized and shall be designed such that it can safely carry the extra axial force (compression or tension) caused due to outriggers and bracings. The material behavior for analysis is considered to be linearly elastic.

IV. LOAD CONSIDERATION & ANALYSIS OF THE FRAME

Equivalent static analysis method as per IS code is employed for assessing the static behavior of the models. Response spectrum and Wind analysis methods are employed to assess the linear dynamic behavior of the models. Basic wind speed is selected from wind data of Mumbai region.

Finite element software ETABS is used to carry out the above-mentioned analysis. In ETABS, shear walls and slabs are modelled as four nodded thin shell elements with default auto meshing. Beams, columns and truss elements are modelled as two nodded line elements. In addition, the truss members are released for moments on both of its ends to get exclusive axial brace behavior. Semi rigid diaphragm is assigned to all the floor elements to engage all columns in resisting lateral forces.

Loading:

- For slabs, of 1.5kN/m^2 floor finish load and 4kN/ m^2 of live load is considered as per IS-875 (PART-2) for commercial buildings.
- For beams, uniform load of 15kN/m, 10kN/m, and 6 kN/m load is considered for exterior, interior and parapet walls respectively made up of bricks.
- From IS 1893 (PART-1) 2016 seismic load and from IS 875 (PART-3) wind load is considered. The following parameters have been considered for seismic analysis-

  Seismic Zone = Zone III (Z= 0.16)
  Importance Factor = 1.2
  Type of Soil = Medium Soil (Soil Type II)
  Response Reduction Factor = 4
  Damping Ratio = 5%
  Wind speed = 44 m/s
  Diaphragm = Semi Rigid

As per IS: 875 (part 5), load combinations are considered and structure is analysed

1.5(DL + LL)
1.2(DL + LL + EQX)
1.2(DL + LL - EQX)
1.2(DL + LL + EQY)
1.2(DL + LL - EQY)
1.5(DL+ EQX)
1.5(DL - EQX)
1.5(DL+ EQY)
1.5(DL - EQY)
0.9DL + 1.5EQX
0.9DL - 1.5EQX
0.9DL + 1.5EQY
0.9DL - 1.5EQY

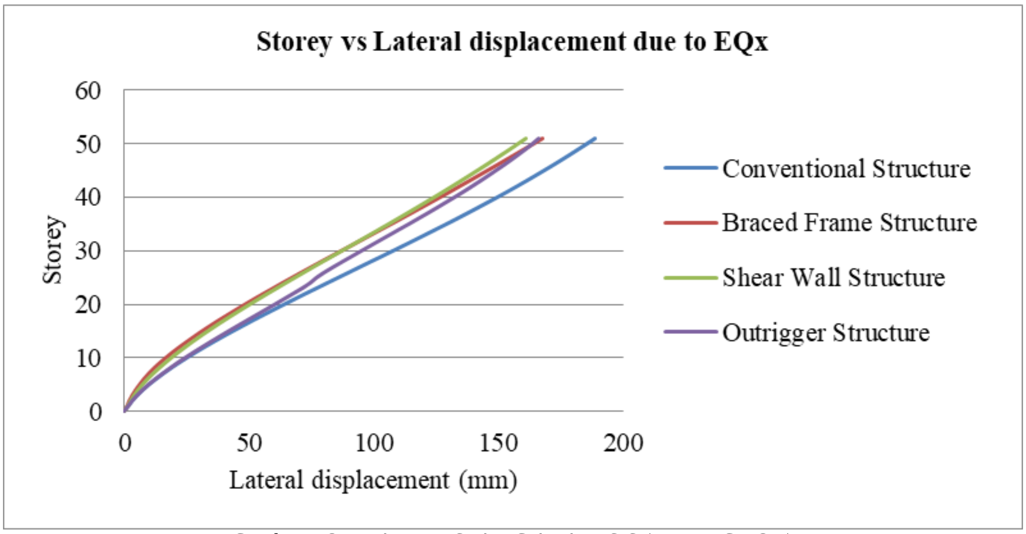
V. RESULTS AND DISCUSSIONS

G+50 storey building is studied and following parameters are discussed which includes variation of Storey Displacement, Storey Drift, Base shear, Base moment, Time period and Torsion for static and dynamic behaviour of different outrigger configurations.

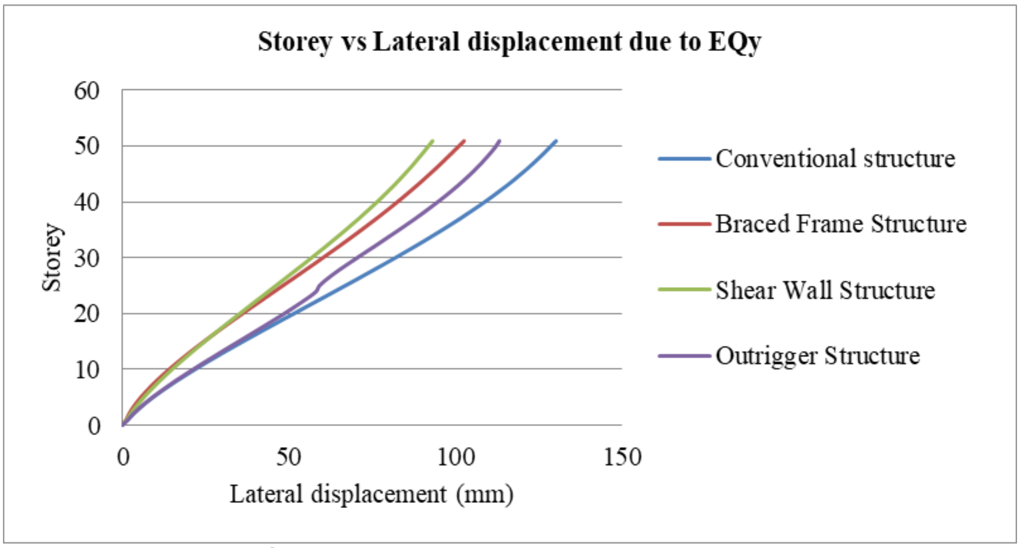
A. Storey Displacement

Graph 1 to 6 shows profiles for variation in storey displacement as well as graph 7 shows variation of top storey displacement in different lateral load resisting configurations for equivalent static analysis, response spectrum analysis and wind analysis. From result obtained in Table no.1 maximum percentage reduction is observed for M3 model i.e. shear wall structure for earthquake forces and M2 model i.e. Braced frame structure for wind forces. The percentage reduction in top storey displacement observed is as follow

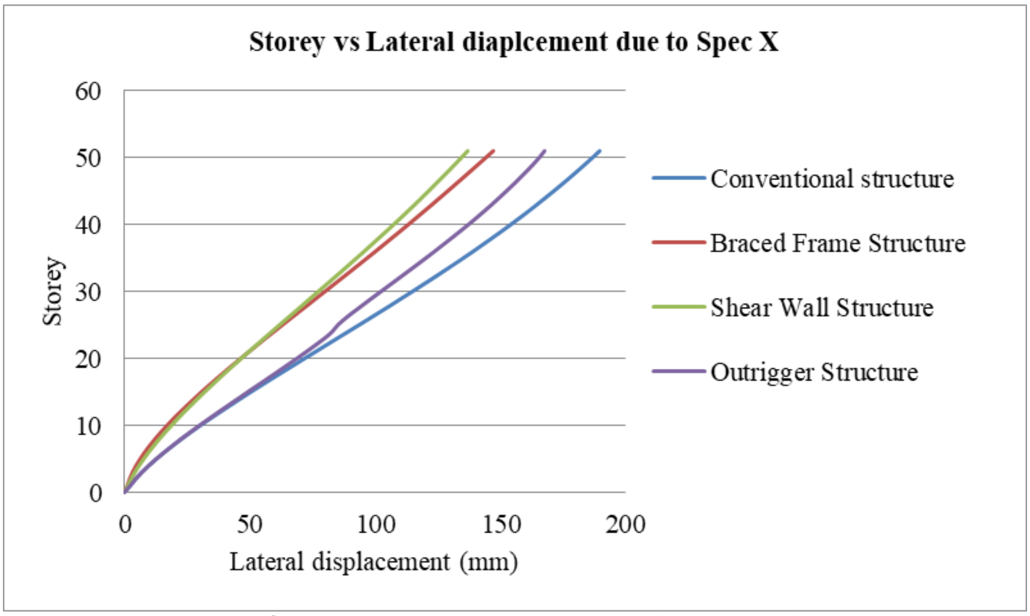
1. In M3 model 14.74% in X-direction and 28.71% in Y-direction for Equivalent Static analysis.
2. In M3 model 27.57% in X-direction and 32.69% in Y-direction for Response Spectrum analysis
3. In M2 model 20.73% in X-direction and 29.04% in Y-direction for Wind analysis



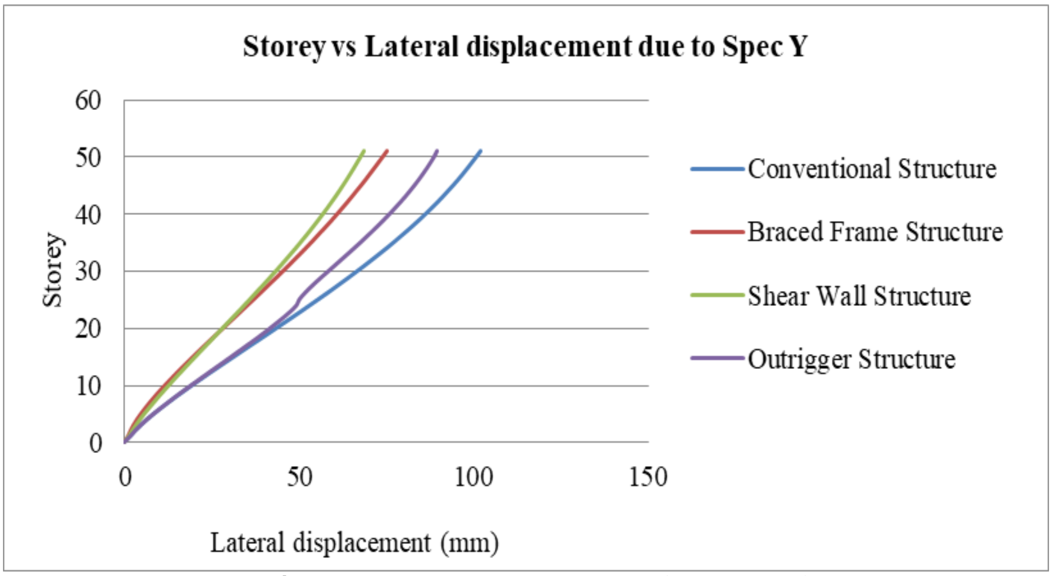
Graph 1. EQUIVALENT STATIC ANALYSIS (X DIRECTION)



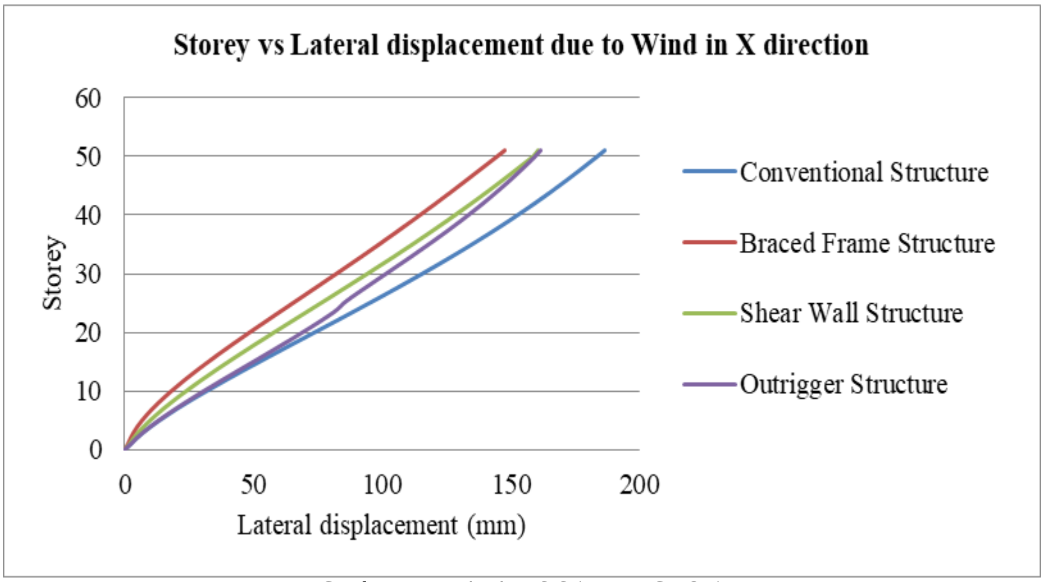
Graph 2. EQUIVALENT STATIC ANALYSIS (Y DIRECTION)



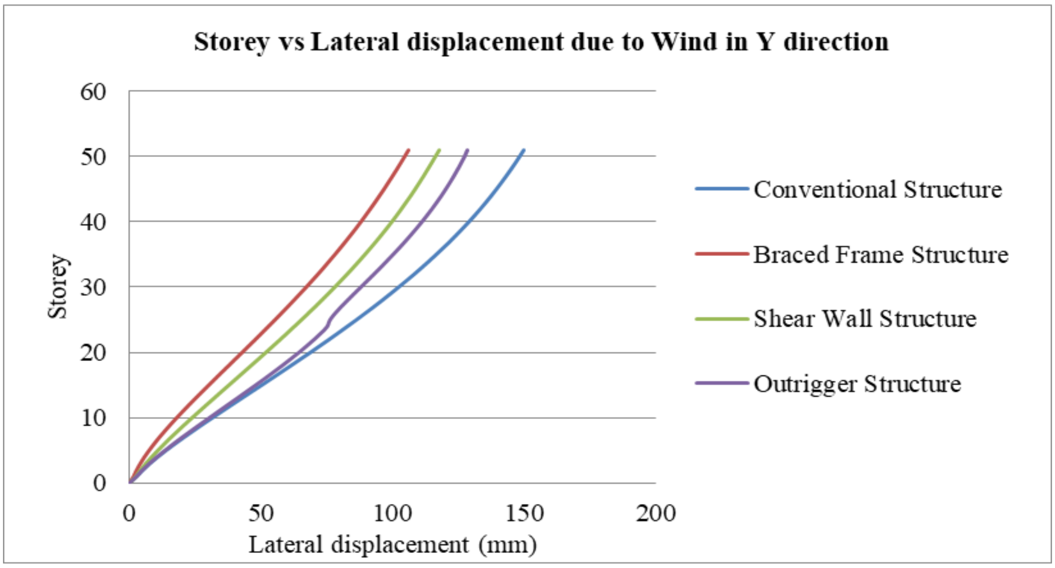
Graph 3. RESPONSE SPECTRUM ANALYSIS (X DIRECTION)



Graph 4. RESPONSE SPECTRUM ANALYSIS (Y DIRECTION)



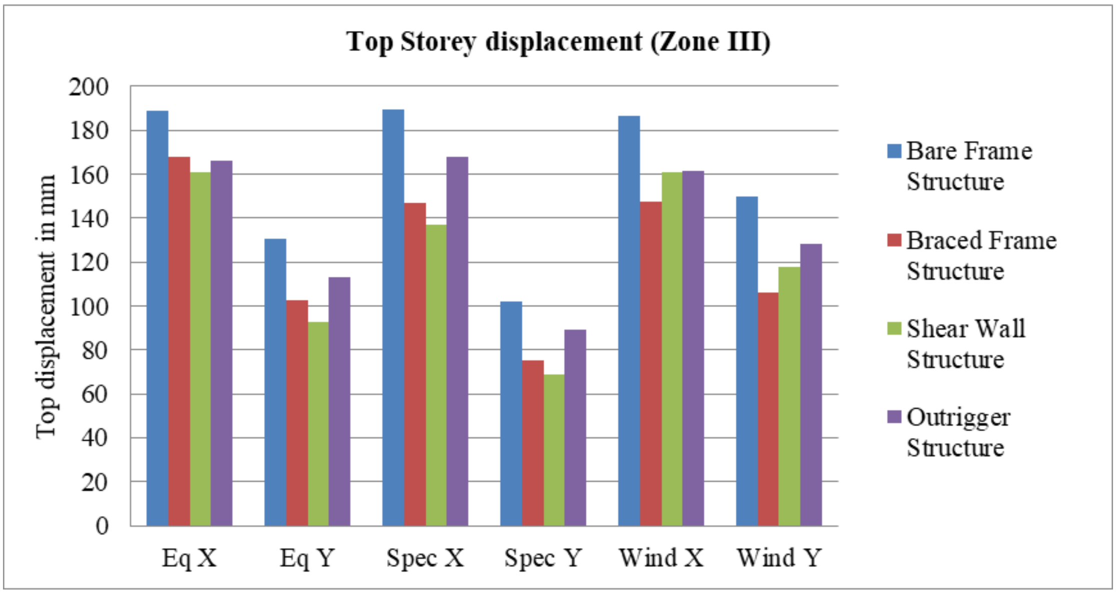
Graph 5. WIND ANALYSIS (X DIRECTION)



Graph 6. WIND ANALYSIS (Y DIRECTION)

TABLE -1: PERCENTAGE REDUCTION IN TOP STOREY DISPLACEMENT WITH DIFFERENT OUTRIGGER CONFIGURATION (EQUIVALENT STATIC ANALYSIS, RESPONSE SPECTRUM ANALYSIS, WIND ANALYSIS AND GUST FACTOR ANALYSIS IN X AND Y DIRECTION)

Top Storey Displacement (Zone III)				
	Bare Frame Structure	Braced Frame Structure	Shear Wall Structure	Outrigger Structure
Eq X	188.831	167.943	160.992	166.461
Eq Y	130.375	102.575	92.941	113.341
Spec X	189.348	147.011	137.153	167.754
Spec Y	101.936	75.073	68.616	89.398
Wind X	186.422	147.772	160.822	161.414
Wind Y	149.833	106.327	117.847	128.582
% Reduction in Top Storey Displacement	Eq X	11.06 %	14.74 %	11.85 %
	Eq Y	21.32 %	28.71 %	13.07 %
	Spec X	22.36 %	27.57 %	11.40 %
	Spec Y	26.35 %	32.69 %	12.30 %
	Wind X	20.73 %	13.73 %	13.41 %
	Wind Y	29.0 4%	21.35 %	14.18 %

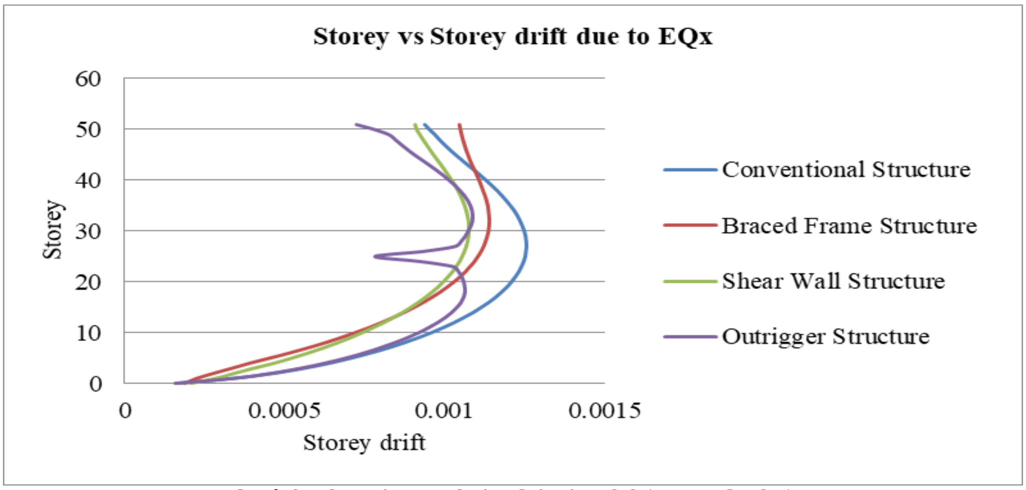


Graph 7. TOP STOREY DISPLACEMENT TOP STOREY DRIFT (EQUIVALENT STATIC ANALYSIS, RESPONSE SPECTRUM ANALYSIS, WIND ANALYSIS AND GUST FACTOR ANALYSIS IN X AND Y DIRECTION)

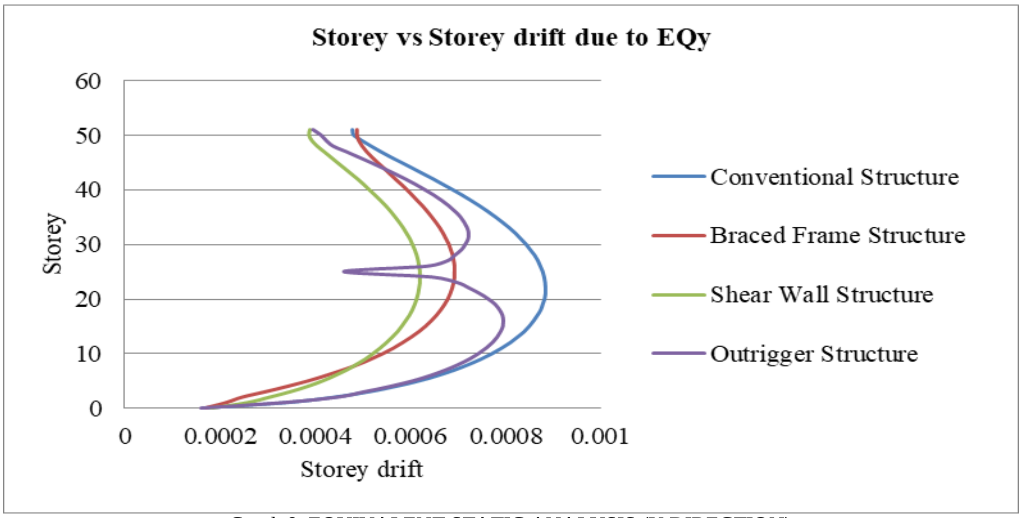
B. Storey Drift

Graph 8 to 13 shows profiles for variation in storey drift as well as graph 14 shows variation of maximum storey drift in different lateral load resisting configurations for equivalent static analysis, response spectrum analysis and wind analysis. It can be observed from graphs below that there is sudden change or drop in story drift at the outrigger stories due to presence of conventional outriggers with belt truss which restricts rotation of walls. From result obtained in Table no.2 maximum percentage reduction is observed for M3 model i.e. shear wall structure for earthquake forces and M2 model i.e. Braced frame structure for wind forces. The reduction in maximum storey drift observed is as follow

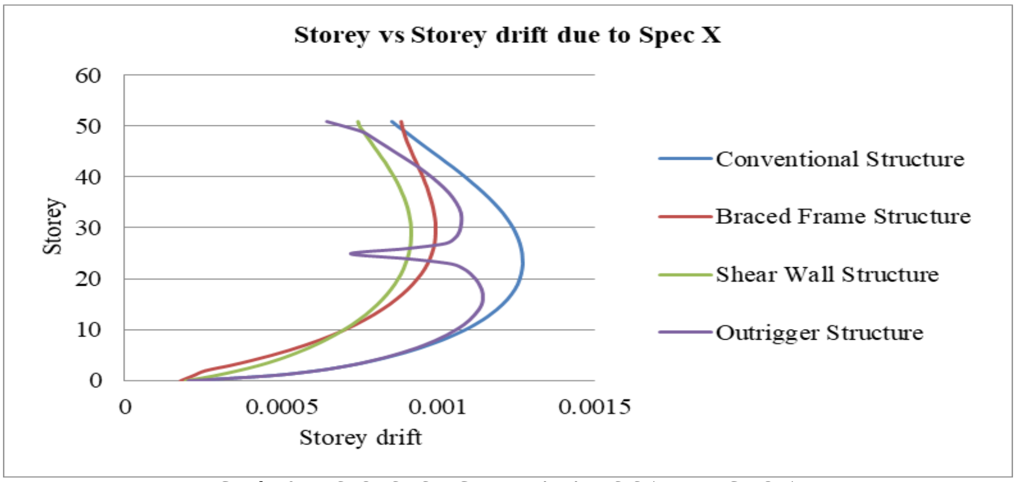
1. In M3 model 14.26% in X-direction and 29.98% in Y-direction for Equivalent Static analysis.
2. In M3 model 27.76% in X-direction and 34.59% in Y-direction for Response Spectrum analysis
3. In M2 model 21.07% in X-direction and 32.00% in Y-direction for Wind analysis



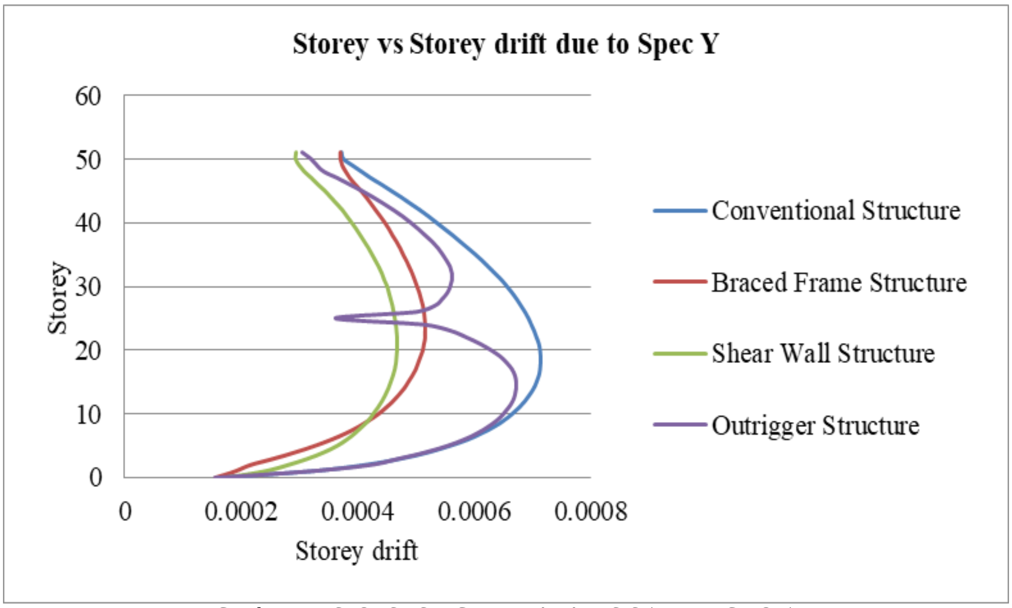
Graph 8. EQUIVALENT STATIC ANALYSIS (X DIRECTION)



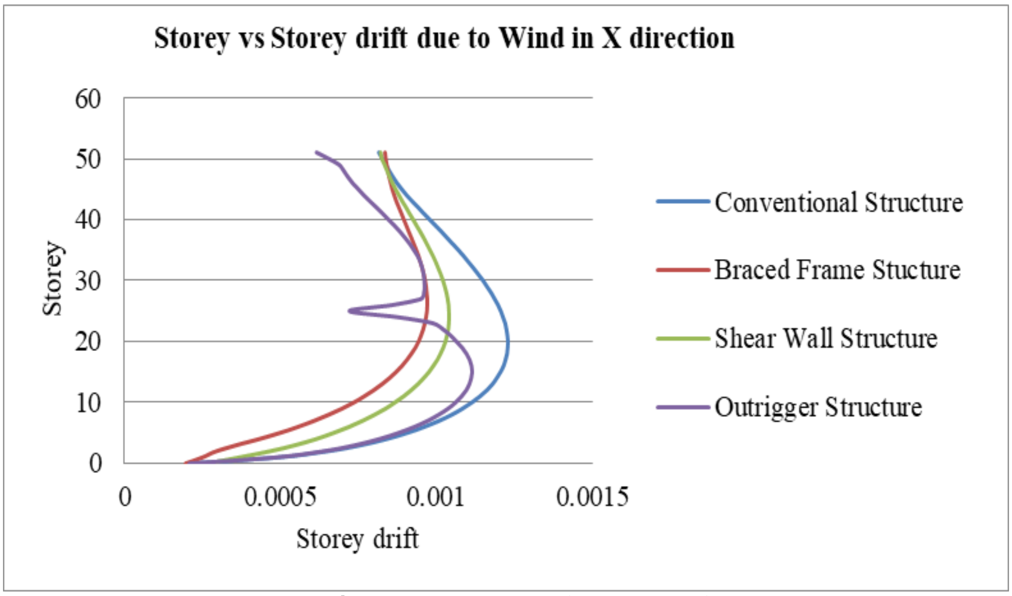
Graph 9. EQUIVALENT STATIC ANALYSIS (Y DIRECTION)



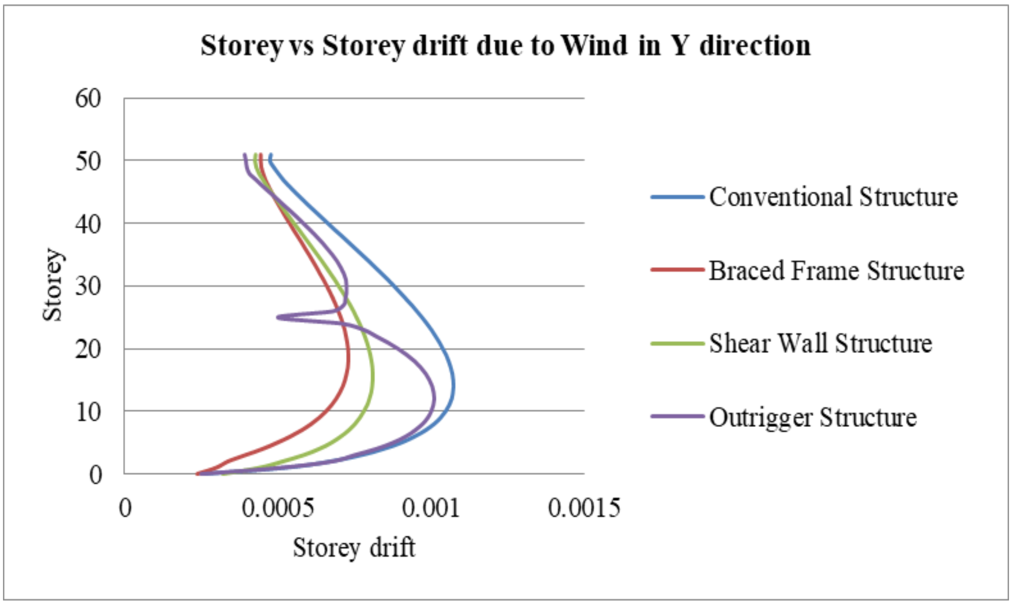
Graph 10. RESPONSE SPECTRUM ANALYSIS (X DIRECTION)



Graph 11. RESPONSE SPECTRUM ANALYSIS (Y DIRECTION)



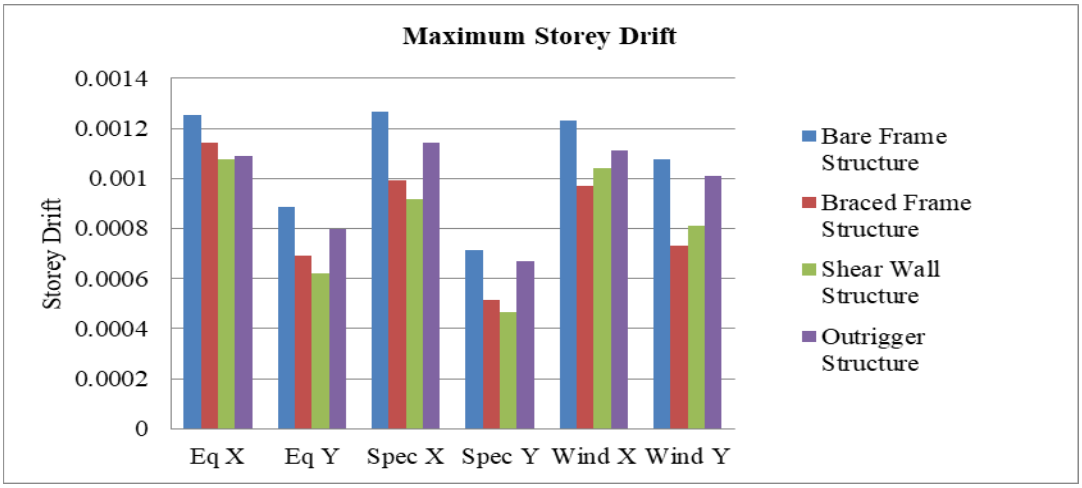
Graph 12. WIND ANALYSIS (X DIRECTION)



Graph 13. WIND ANALYSIS (Y DIRECTION)

TABLE -2: PERCENTAGE REDUCTION IN MAXIMUM STOREY DRIFT WITH DIFFERENT OUTRIGGER CONFIGURATION (EQUIVALENT STATIC ANALYSIS, RESPONSE SPECTRUM ANALYSIS, WIND ANALYSIS AND GUST FACTOR ANALYSIS IN X AND Y DIRECTION)

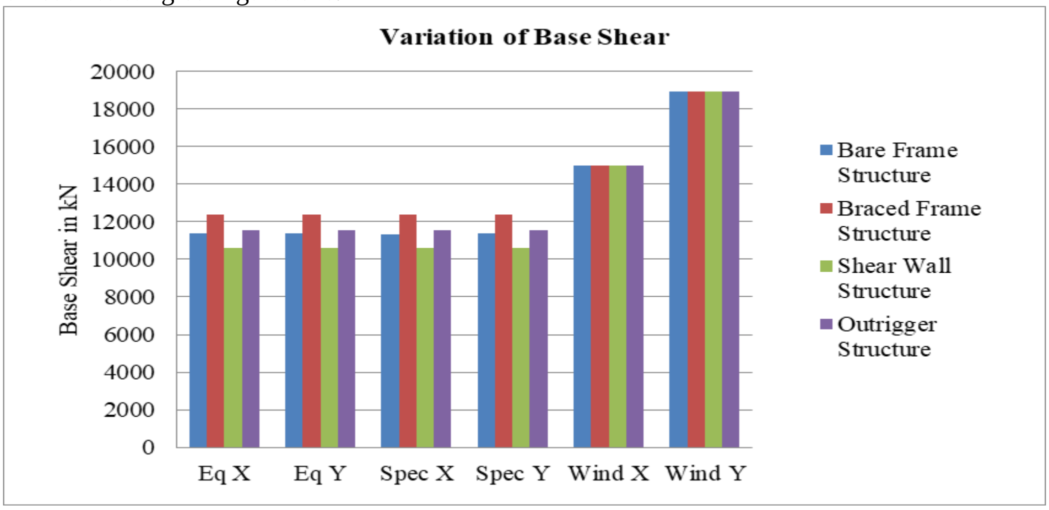
Maximum Storey Drift				
	Bare Frame Structure	Braced Frame Structure	Shear Wall Structure	Outrigger Structure
Eq X	0.001255	0.001141	0.001076	0.001088
Eq Y	0.000884	0.000693	0.000619	0.000796
Spec X	0.001268	0.000993	0.000916	0.001144
Spec Y	0.000714	0.000515	0.000467	0.000671
Wind X	0.001229	0.00097	0.001043	0.001113
Wind Y	0.001075	0.000731	0.00081	0.001011
% Reduction in Maximum Storey Drift	Eq X	9.08 %	14.26 %	13.31 %
	Eq Y	21.61 %	29.98 %	9.95 %
	Spec X	21.69 %	27.76 %	9.78 %
	Spec Y	27.87 %	34.59 %	6.02 %
	Wind X	21.07 %	15.13 %	9.44 %
	Wind Y	32.00 %	24.65 %	5.95 %



Graph 14. TOP STOREY DRIFT (EQUIVALENT STATIC ANALYSIS, RESPONSE SPECTRUM ANALYSIS AND WIND ANALYSIS IN X AND Y DIRECTION)

C. Base Shear

Graph 15 and table No.3 shows variation of base shear in different lateral load resisting configurations for Equivalent static analysis, Response Spectrum analysis and Wind analysis in X and Y Direction. From Graph 19 marginal reduction of base shear values is observed in M3 model i.e. Shear Wall Structure for Equivalent static analysis, Response Spectrum analysis and for Wind analysis it is observed that there is no significant variation of base shear values with provision of different lateral load resisting configurations.



Graph 15. BASE SHEAR GRAPH WITH DIFFERENT OUTRIGGER CONFIGURATION (EQUIVALENT STATIC ANALYSIS, RESPONSE SPECTRUM ANALYSIS WIND ANALYSIS AND GUST FACTOR ANALYSIS - X & Y DIRECTION)

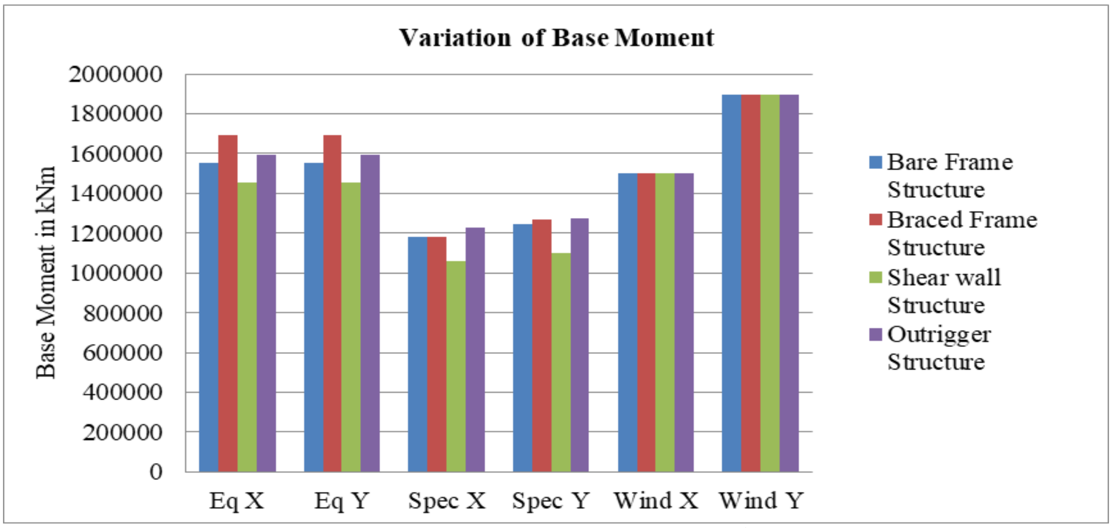
TABLE 3. BASE REACTIONS (IN KN) FOR DIFFERENT OUTRIGGER CONFIGURATION (EQUIVALENT STATIC ANALYSIS, RESPONSE SPECTRUM ANALYSIS, WIND ANALYSIS AND GUST FACTOR ANALYSIS- X &Y DIRECTION)

Base Shear (Zone III)				
	Bare Frame Structure kN	Braced Frame Structure kN	Shear Wall Structure kN	Outrigger Structure kN
Eq X	11365	12380	10626	11565
Eq Y	11365	12380	10626	11565
Spec X	11348	12381	10626	11565
Spec Y	11362	12381	10627	11566
Wind X	14966	14966	14966	14966
Wind Y	18904	18904	18904	18904

Above graphs indicate that, there is marginal reduction in base shear values for shear wall structure. Although, maximum base shear is observed in models with mega column, models with bracings and models with double outrigger. Reason behind that is, the Shear wall structure doesn't significantly increase the seismic weight of the building while Mega Columns, Bracings, Double outriggers increases the seismic weight and as per the codal philosophies the seismic inertial forces are directly proportional to the weight of the building. So, no increase in weight results in no increase in base shears.

D. Base Moments

Graph 16 and table No.4 shows variation of base moments in different lateral load resisting configurations for Equivalent static analysis, Response Spectrum analysis and Wind analysis in X and Y Direction. From Graph 16 marginal reduction of base moment values is observed in M3 model i.e. Shear Wall Structure for Equivalent static analysis, Response Spectrum analysis and for Wind analysis it is observed that there is no significant variation of base moment values with provision of different lateral load resisting configurations.



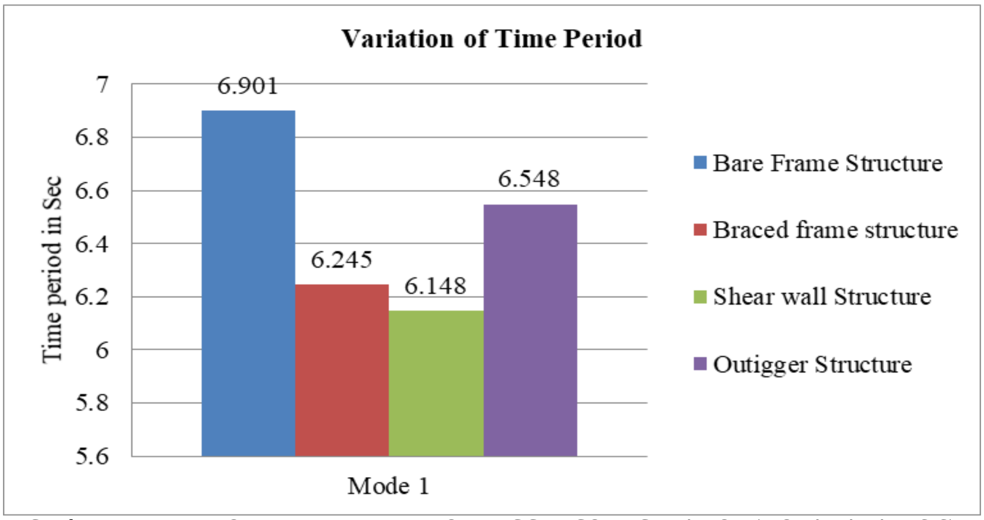
Graph 16. BASE MOMENT GRAPH WITH DIFFERENT OUTRIGGER CONFIGURATION (EQUIVALENT STATIC ANALYSIS, RESPONSE SPECTRUM ANALYSIS WIND ANALYSIS AND GUST FACTOR ANALYSIS - X & Y DIRECTION)

TABLE 4. BASE MOMENT (IN KN) FOR DIFFERENT OUTRIGGER CONFIGURATION (EQUIVALENT STATIC ANALYSIS, RESPONSE SPECTRUM ANALYSIS, WIND ANALYSIS AND GUST FACTOR ANALYSIS- X &Y DIRECTION)

Base Moment (Zone III)				
	Bare Frame Structure kNm	Braced Frame Structure kNm	Shear wall Structure kNm	Outrigger Structure kNm
Eq X	1555722	1693957	1454676	1592458
Eq Y	1555722	1693957	1454676	1592458
Spec X	1183260	1183525	1059976	1224921
Spec Y	1242924	1271257	1099110	1276994
Wind X	1500001	1500001	1500001	1500001
Wind Y	1894738	1894738	1894738	1894738

E. Time Period

Graph 17 and table No.5 shows graph for variation of time period in different lateral load resisting configuration for modal analysis and it is found that there is maximum reduction in time period is observed in M3 model i.e. Shear wall structure.



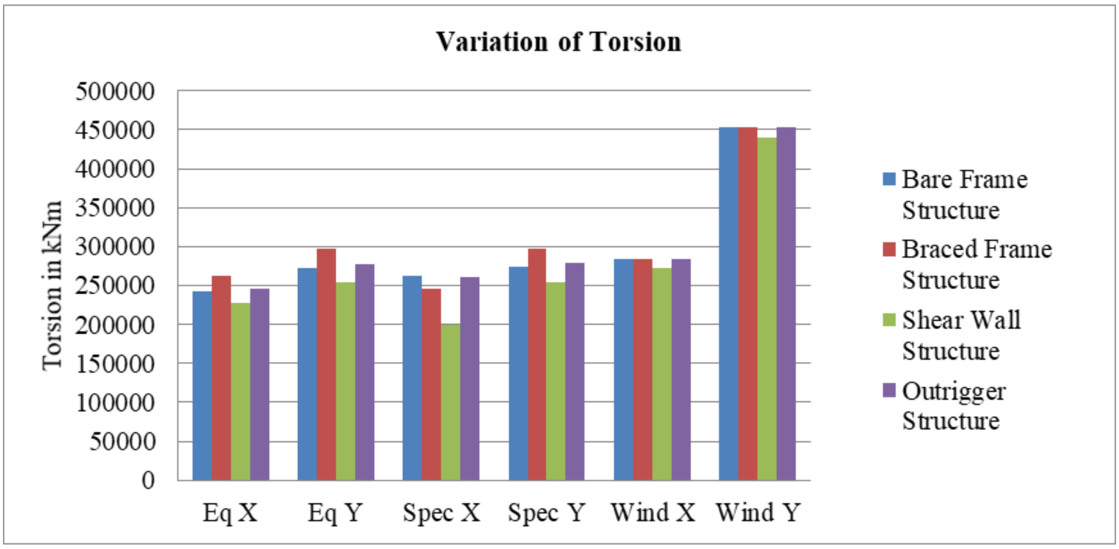
Graph 17. TIME PERIOD WITH DIFFERENT OUTRIGGER CONFIGURATION (MODAL ANALYSIS)

TABLE 5. PERCENTAGE REDUCTION IN TIME PERIOD WITH DIFFERENT OUTRIGGER CONFIGURATIONS (MODAL ANALYSIS)

Time Period (G+60 Zone III)				
	Bare Frame Structure	Braced Frame Structure	Shear Wall Structure	Outrigger Structure
Mode 1 (in Sec)	6.901	6.245	6.148	6.548
% Reduction in time period	Mode 1	10.50 %	10.91 %	5.12 %

F. Torsion

Graph 18 and table No.6 shows variation of torsion in different lateral load resisting configurations for Equivalent static analysis, Response Spectrum analysis and Wind analysis in X and Y Direction. From Graph 18 reduction of torsion values is observed in M3 model i.e. Shear Wall Structure.



Graph 18. TORSION GRAPH WITH DIFFERENT OUTRIGGER CONFIGURATION (EQUIVALENT STATIC ANALYSIS, RESPONSE SPECTRUM ANALYSIS WIND ANALYSIS AND GUST FACTOR ANALYSIS - X & Y DIRECTION)

TABLE 6. TORSION (IN KNM) FOR DIFFERENT OUTRIGGER CONFIGURATION (EQUIVALENT STATIC ANALYSIS, RESPONSE SPECTRUM ANALYSIS, WIND ANALYSIS AND GUST FACTOR ANALYSIS- X &Y DIRECTION)

Torsion (Zone III)				
	Bare Frame Structure kNm	Braced Frame Structure kNm	Shear Wall Structure kNm	Outrigger Structure kNm
Eq X	241942	263250	227863	246030
Eq Y	273231	297154	254972	277479
Spec X	262777	245400	199509	260890
Spec Y	274009	297210	253332	279433
Wind X	284354	284354	273129	284354
Wind Y	453706	453706	439528	453706

VI. CONCLUSIONS

The most effective and deciding basic parameter studied during this whole analysis was drift and displacement of the structure. The result section shows the variation of drift and displacement of the structure with different lateral load resisting system.

The following conclusions are made from the present study

1. The use of lateral load resisting system i.e. shear walls, bracings and outrigger system in tall structure increases the stiffness and makes the structure more efficient under seismic and wind loading
2. Considering effective parameters i.e. displacement and drift it can be concluded that Braced frame structure behaves better for wind forces and Shear wall structure behaves better for earthquake forces.
3. The reduction in displacement is up to 32% for shear wall structure and up to 29% for braced frame structure.
4. The reduction in drift is up to 32% for shear wall structure and up to 29% for braced frame structure.
5. The most visible effect of outrigger is observed in story drift graph, were huge kink in graphs are observed at outrigger stories thus outrigger behaves as high drift controller.
6. In parametric study of base shear and base moment, reduction is observed for model M3 i.e. shear wall structure in all static, dynamic and wind load cases. Thus, reducing economy and steel consumption which advantageous for the structural engineers
7. In geometrically irregular structure it is very challenging task to control the torsion. Therefore, as per parametric study of different lateral load resisting system maximum reduction in torsion is observed in model M3 i.e. shear wall structure, and it is advantageous for the structural engineers.
8. Modal time period decreases for different lateral load resisting configurations. Least modal time period is observed in model M3 i.e. shear wall structure
9. Thus, conclusion is drawn that Shear wall structure provides better performance compared to Braced frame structure and Outrigger structure in terms of all the parameters discussed above.

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REFERENCES

[1] Khuzaim J. Sheikh, Krutharth S. Patel, Bijal Chuadhari, "A Comparative Study of Lateral Load Resisting System in Tall Structures," International Journal of Advanced Engineering and Research Development, Volume 5, Issue 04, April 2018.
[2] A.P. Nagendra Babu, S. Jain Shahab, "Comparative Study of Shear Wall in Multi-Stored R.C. Building," International Journal & Magazine of Engineering, Technology, Management and Research, Volume 04, Issue 05, May 2017
[3] Arathi Thamarakshan, Arunima S., "Analytical Study of Knee Braced Frame with Different Bracing Configuration," International Research Journal of Engineering and Technology, Volume 04, Issue: 04, April 2017.
[4] Janakkumar M. Mehta, Hitesh K. Dhameliya, "Comparative Study on Lateral Load Resisting System in High-Rise Building Using ETABS," International Journal Engineering Trends and Technology, Volume 47, May 2017.
[5] Prajyot A. Kakde, Ravindra Desai, "Comparative Study of Outrigger and Belt Truss Structural System for Steel and Concrete Material," International Research Journal of Engineering and Technology, Volume 04, Issue 05, May 2017.
[6] Shubham P. Dhoke, Bhavini V. Ukey, Amol V. Gorle, "Comparative Analysis of Different Lateral Load Resisting System for RCC Structure," International Journal of Innovative Research in Science, Engineering and Technology, Volume 6, Issue 4, (April 2017)
[7] Ajinkya Prashant Gadkari, N.G. Gore, "Review on Behaviour of Outrigger Structural System in High-Rise Building," International Journal of Engineering Development and Research Volume 4, Issue 2, 2016.

[8] Dr. H.M. Somasekharaiah, Mr. Madhu Sudhana Y B, Mr. Md Muddasar Basha S, “A Comparative Study on Lateral Force Resisting System for Seismic Loads,” International Research Journal of Engineering and Technology, Volume 03, Issue 08, (August 2016)

[9] K. B. Mohankumar and Vinayak Vijapur, “Seismic Response of RC Building with Different Types of Bracings and Shear Wall in Different Seismic Zones,” Bonfring International Journal of Man Machine Interface, Volume 4, 2016.

[10] Piyush Gupta, Dr. Neeraja, “Analysis of Various RCC Lateral Force Resisting Systems and Their Comparison Using ETABS,” International Journal of Innovative of Latest Trends in Engineering and Technology, Volume 6, Issue 4, 2016

[11] Rasool Owais & Tantray Manzoor Ahmad “Comparative Analysis Between Different Commonly Used Lateral Load Resisting Systems in Reinforced Concrete Buildings,” Global Journal of Research in Engineering, Volume 16, Issue 1, 2016

[12] Abdul Karim Mulla, Srinivas B. N., “A Study on Outrigger System in Tall RC Structure with Steel Bracing,” International Journal of Engineering Research & Technology. Volume 4, Issue 07, 2015.

[13] R. Bharath Reddy, S. Sai Gopi Nihal, A. S. Taneja and J. S. Kalyana Rama, “Comparative study on lateral load resistance of Multi-Storied Structure with Bracing systems,” Indian Journal of Science and Technology, Volume 8, December 2015.

[14] R. S. Mishra, V. Kushwaha, S. Kumar, “A Comparative Study of Different Configuration of Shear Wall Location in Soft Storey Building Subjected to Seismic Load,” International Research Journal of Engineering and Technology, Volume 02, Issue 07, October 2015.

[15] Srinivas Suresh Kogilgeri, Beryl Shanthapriya, “A Study of Outrigger System on High Rise Steel Structure by Varying Outrigger Depth,” International Journal of Research in Engineering and Technology, Volume 04, Issue 07, July 2015

[16] Thejaswini R. M. And Rashmi A.R., “Analysis and Comparison of Different Lateral Load Resisting Structural Forms,” International Journal of Engineering Research & Technology, Vol. 4 Issue 7, July 2015

[17] Vijaya Kumari Gowda M. R., Manohar B. C., “A Study on Dynamic Analysis of Tall Structure with Belt Truss Systems for Different Seismic Zones,” International Journal of Engineering and Research and Technology, Volume 4, Issue 08, August 2015

[18] Abhijeet Baikerikar, Kanchan Kanagali, “Study of Lateral Load Resisting System of Variable Heights in All Soil Types of High Seismic Zone,” International Journal of Research in Engineering and Technology, Volume 03, Issue 10, October 2014.

[19] Shruti Badami and M. R. Suresh, “A Study on Behavior of Structural Systems for Tall Buildings Subjected to Lateral Loads,” International Journal of Engineering Research & Technology (IJERT) Volume 3, Issue 7, July 2014

[20] P.M.B. Raj Kiran Nanduri, B. Suresh, MD Ihtesham Hussain, “Optimum Position of Outrigger System for High-Rise Reinforced Concrete Buildings Under Wind and Earthquake Loadings,” American Journal of Engineering Research, Volume 02, Issue 08, 2013.