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Optimization of Multistory Building with Multi-Outrigger System and Belts Truss

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Abstract : **Multistory structures is one of the most used for the influence control of excessive drift, efficient and stiffness when subjected to lateral load is as the outrigger system. During the earthquake or wind load, the damage of non- structural and structural form can be minimized. This paper studies "OPTIMIZATION OF MULTISTORY BUILDING WITH MULTI-OUTRIGGER SYSTEM AND BELTS TRUSS"is the three dimensional model of 25 storey building have to bring into existence for analysis and design using ETABS software. To study the effect of outrigger system varying with different storey height of the building is perform as one, two, three and four outrigger level. This analysis of model is using method of linear static method (equivalent static method) and liner dynamic method (response spectrum method). The characteristics of efficiency and stiffness is to calculate the lateral displacement, base shear, story drift, story force and fundamental natural time period for different types model with and without outrigger system. So this case the reductions of displacement and drift are to minimized as compared to model of without outrigger system.**

I. INTRODUCTION

In structural engineering practice ,one of the ranking above all others requirements is for the engineer and architect to share in something in conceptional stages of the project in order to come up with economical building. It is both interesting and necessary to research the idea of different structural systems and their shared by impact on the economy and the high rise structures. In this category, the study will focus on certain number characteristics to be considered of the exterior column such as their size, location, environmental, numbers, and effect on interior layout of the structures.

In case of vertical load that is lateral load effects on building structures are simple variables and increase load with increases in height that is when subjected to lateral load , the overturning moments at base of building varies in proportional to the square of the building height and lateral deflection height or as equal . According to high rise structures they are major factors are considered as strength,stability, and rigidity. High rise building consists of elements such as walls, floors, columns and braces.

During the last few decades lots of buildings have been built using the belt truss and outrigger systems subjected for a lateral load. This system for tall building is used in conjunction with composite structures is very effectively.

Here the outriggers system for structures consists of reinforced concrete or braced frames with shear wall that is main core connecting to the exterior column with very stiff horizontal members at one or more level stories. When the horizontal load acting on the building , the column will restrained outriggers to dispute the rotation of the core (shear wall) , causing the lateral moments and displacements in the core wall to be smaller than without outriggers system. The external moment is not bending when resisted to the core alone, but also by axial tension and compression of exterior column connected to the outriggers system.In this method, a lateral load of an intensity increasing linearly with height of building structures. Let assumed as 25 stories height, the assumptions are as follows

(a) The structures is linear.
(b) The outriggers arms are connected to the exteriors and interiors column, its results as caused of axial forces in column.
(c) The physical property of outriggers is joined to the core and the core is joined to the foundation base.
(d) The sectional properties of columns, core (shearwall) , outriggers system are uniform.
(e) The core is fully fixed at the base and exterior column is hinged at base.

For medium high rise structures is used to provide truss at core or shear wall at core is to added the lateral resistant by possibility of moment connected frames at other accessible plan Fig(a). Now when building are taller than 30 floors or so , the shear wall will kept in homogeneous with vertical types of mechanical requirement.

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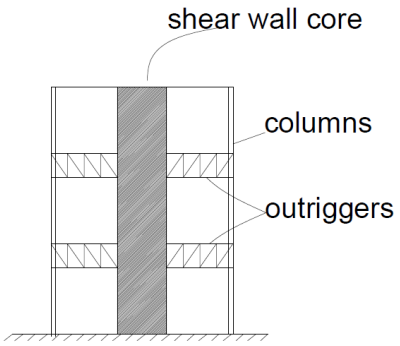

Fig (a)

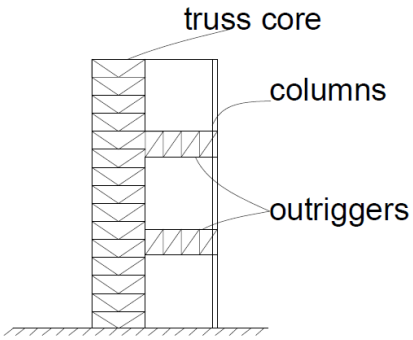

Fig (b)

Placement of truss at top of the building structures get rid of differential movement of exterior and interior column to provide compression when columns are restraint in tension and to provide expansion when column are restraint to compressive as shown in Fig (b). In additional the system resist the lateral load offers a good benefit of equalizing differential of columns resulting from temperature and instability of axial load between shear wall and exterior column.Now to Explain about the behavior of outrigger systems when fix at top results as the shear wall provide lateral bracing and braced shear wall would be similar to free cantilever types. So the core is free cantilever which no longer free to rotate at top of system.

Now let us consider location of belt truss at different types of height storey, which influences the magnitude of drift. In this case the exterior columns to the shear wall core is a functions of different features as,

(a) The physical property of inflexible of the equivalent spring.
(b) When external loads acting at spring location which resist magnitude of rotation at cantilever location.

In above case (a) means stiffness is maximum when located at the bottom base and minimum when at the top of the structures, and case (b) means at cantilever location of the spring which strain energy can be stored which as function of stiffness and rotation. These systems are more efficiently than the system of braced frames. The determination of providing more than one trusses which as increase in stiffness of system of structures and strength and also provide stiffness point of resistance. The building system can used in one, two, three or more belt truss, the more system used give a better integration of the shear wall and the interior and exterior columns. Here usually outriggers arerestrained to mechanical level like a installation of Air Conditioning or others types of mechanical units. Here they are least numbers are used has the outriggers are restrain with mechanical level at every one third , one half , or three quarter height of the building as shown in Fig (c)

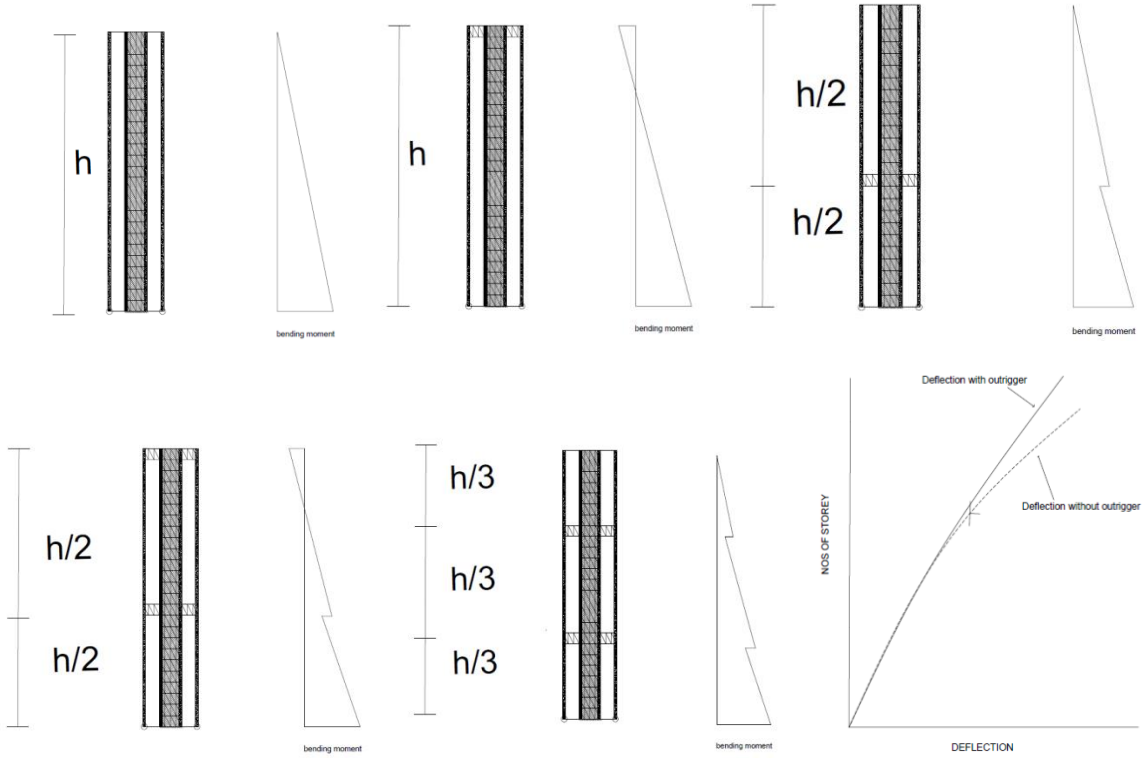

Fig (c)

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At each outrigger system is restrained from rotation which pulls the moment diagram at that level. According to bending moment at the base of the building is most encourage reduced because of translation of lateral load to axial forces. As in case of single truss which give one number of reduced stiffness at the component of structures and if two or more truss are provided which give many numbers of reducing stiffness of bending moment diagrams at components of structures.

Now the analysis is carried out on building varying with different types of level outriggers, with or without outriggers and without shear wall by using ETABS software in different methods that equivalent static method (linear static method) and response spectrum method (linear dynamic method) is adapted. There is comparison for displacement, storey drifts, base shear and storey forces at different types of modeling structures.

II. LITERATURE REVIEWS

2.1. General:

The literature review is the most important which has the similar studies give on focus from recent parts of outrigger system of reinforced concrete frames to determine the research work using high seismic zone wind analyzed. The concept of modeling and analysis used for purpose of improvement technique and economically.

2.2. Reviews:

Po SengKian and Frits TorangSiahaan, [1], this has studies the use of **outrigger and belt truss system for high rise concrete building.** Here the outrigger system for building are subjected to lateral load for sixty (60) storey of three dimensional model are subjected to lateral load , analyzed and comparison of lateral displacement reduction with and without outrigger system. For the three dimensional 60 storey structural model subjected to lateral load that is earthquake load is about 18 % reduction in maximum displacement at top of the storey building and also they are reduced a storey drift.

S. Fawzia and T. Fatima [2], this has studies **the deflection control in composite building by using Belt truss and outrigger system** .This stated the design and analysis of high rise structures is more frequently to determine the serviceability than strength. These are investigation of deflection control by efficient use of belt truss and outrigger system of 60 storey building subjected to lateral load. According to this three dimensional analysis is performed with one, two, three outrigger level which give the reduction as compared to without outrigger are 34%, 42%, and 51%.

Abdul Kareem Mulla[3], he has studies **the study on outrigger system in a tall R.C structure with steel bracing**. The outrigger is the new introducing challenges that the height of the building increases that will reduced the stiffness in performance under the lateral load of seismic loading. In this case it contain comparative study on irregular and regular building with and without outrigger system with centrally shear wall and steel bracing using ETABS software for analysis and design. The analysis is carried out by equivalent static method and response spectrum method used to find the displacement,drift , base shear , and natural period. The result of this case the displacement of regular and irregular building with outrigger is less than without outrigger. It observed that the displacement of that structure is resisted to 18 % for both irregular and regular building by equivalent static method and in case of response spectrum method is resisted to 6% as compared to without outrigger.

III. METHODS OF ANALYSIS

Most of the building structures were not designed to resist major and moderate types of seismic by using manually, in fact it usually by gravity loading and lateral load which make susceptible to attack the building during the event of earthquake. So its uses to consider the seismic loads by using the ETABS software, it is to improve hazard life and capability of essential facilities after an earthquake. The ETABS software is also to create three dimensional models and to carry out the design and analysis

The method of analysis consists are as follows

(1) *Linear Static Method***: -** The static analysis is used to find the equivalent static loading to correspond the action of dynamic earthquake on the structures. The static method is sufficient for analysis of structures by using formula as given in the INDIAN STANDARD code for the distribution of displacement, drift, and base shear is calculated. So this method is used to finding design lateral forces known as equivalent force method or seismic coefficient method

(2) *Linear Dynamic Method:* **-** This method is also known as response spectrum method. Spectrum method is to determining the behaviorof structures during an earthquake like a vibration problem using dynamic analysis, its calculate the amplitude of the deformation. It establish from spectrum method of single degree of freedom on characteristics of ground motion. And this method is applicable to design and analysis of response spectrum of structures which are irregularity shape, asymmetrical etc. This method also called as modal method.

IV. MODELLING DESCRIPTIONS

According to this three dimensional analysis is necessary for typical floor structural model for the study. Here in, method is based on simplifying assumption which determined optimum locations of belt truss .Lets the plan dimension of building and arrangements of core, outriggers, and belt truss. A lateral load is linearly increased with height of building. The model is as 25 storeys reinforced concrete consisting of frames, Core wall & outriggers.

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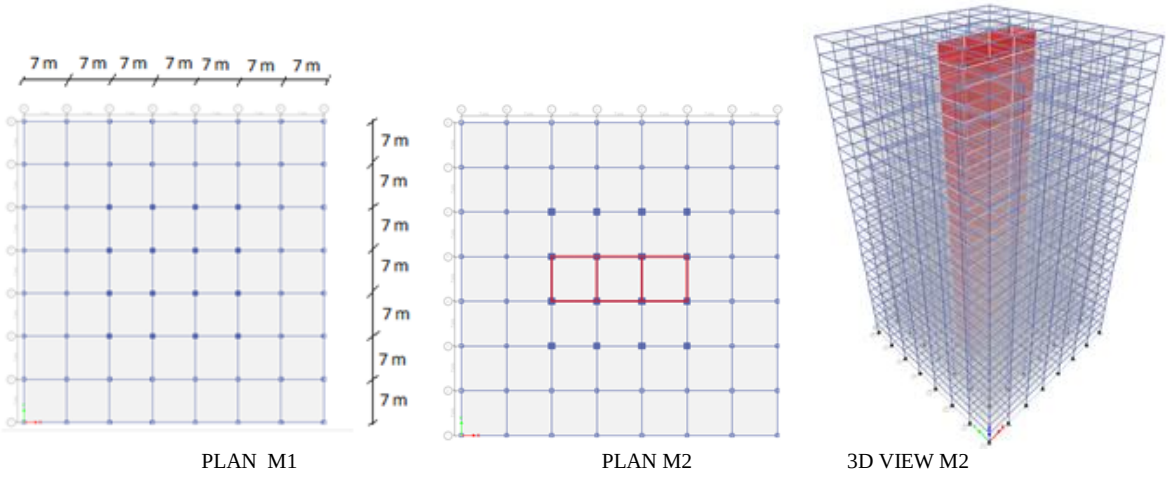
4.1. Model data

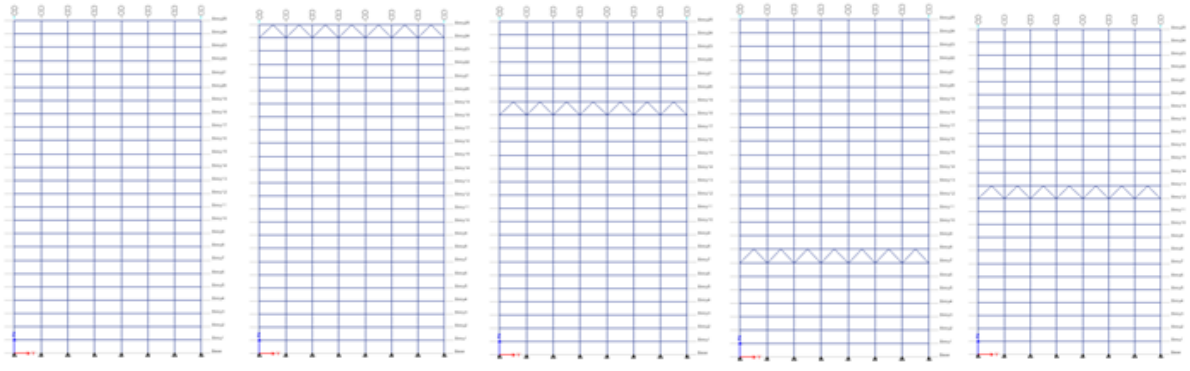
1. Structure- SMRF
2. No. of stories- G+25
3. Storey height – 3.5m
4. Seismic zone – 5th (0.36)
5. Soil type – 2nd (medium)
6. Important factors – 1.5
7. Response Reduction Factors – 5
8. Concrete column – 1.0 x 1.0 m
9. Concrete beam – 0.45 x 0.75 m
10. Composite column – 0.6 x 0.6 m
11. Grade of concrete – M30
12. Steel outrigger brace – ISA 150x150x10 mm Fe 345

The outrigger systems are analysis for the different structural forms as follows,

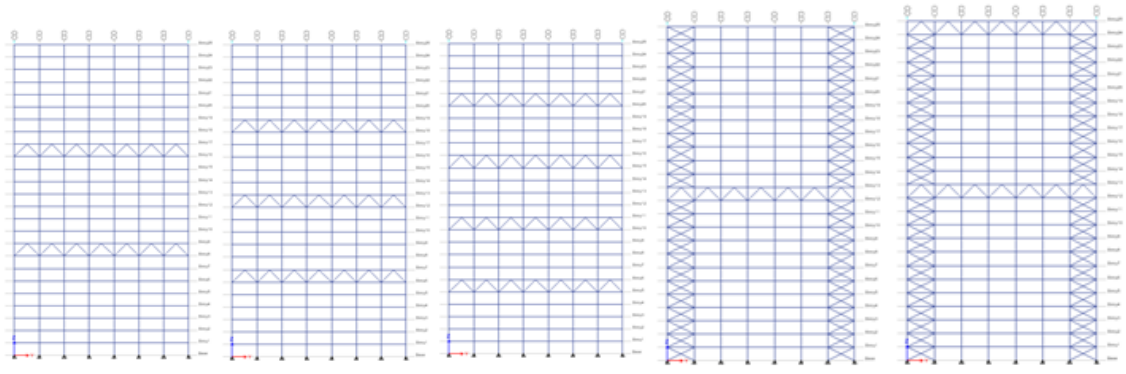
Model 1: Withoutcore wall & without outriggers.
Model 2: With core wall & without outriggers.
Model 3: Core wall & with outriggers at top.
Model 4: Core wall & with outriggers @ quarter height from top.
Model 5: Core wall & with outriggers @ quarter height from bottom.
Model 6: Core wall & with outriggers @ mid span.
Model 7: Core wall & with Two outriggers @ h/3 & 2h/3.
Model 8: Core wall & with Three outriggers @ h/4 , h/2 , 3h/4.
Model 9: Core wall & with outriggers @ h/5 , 2h/5 , 3h/5 , & 4h/5.
Model 10: Core wall & with outriggers @ mid span & bracing @ corners.
Model 11: Core wall & with outriggers @ top & mid span & bracing @ corners.



PLAN M1 PLAN M2 3D VIEW M2



ELEVATION M2 M3 M4 M5 M6



M7 M8 M9 M10 M11

Fig.(d)

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V. RESULTS AND DISCUSSION

5.1. Lateral Displacement

After the analysis results, the maximum displacement values have been shown in a Charts 1& 2 from the methods of linear static analysis and linear dynamic analysis. This methods shown is for both the transverse & the longitudinal directions of that model. According to this, the displacement is maximum at highest top of the level structure and minimum at the base level. Thus the storey height increase with lateral displacement also increases. It observed that, the displacement values of model 9 outrigger system are less than without outrigger system. So this are reduces to 10.5% as compared to without outrigger systems.

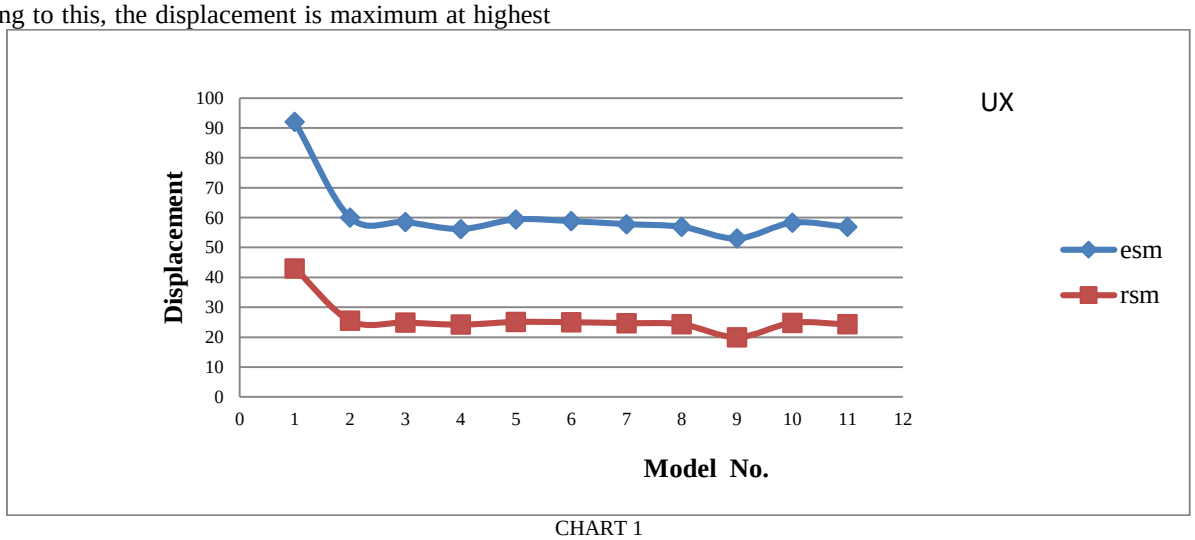

CHART 1

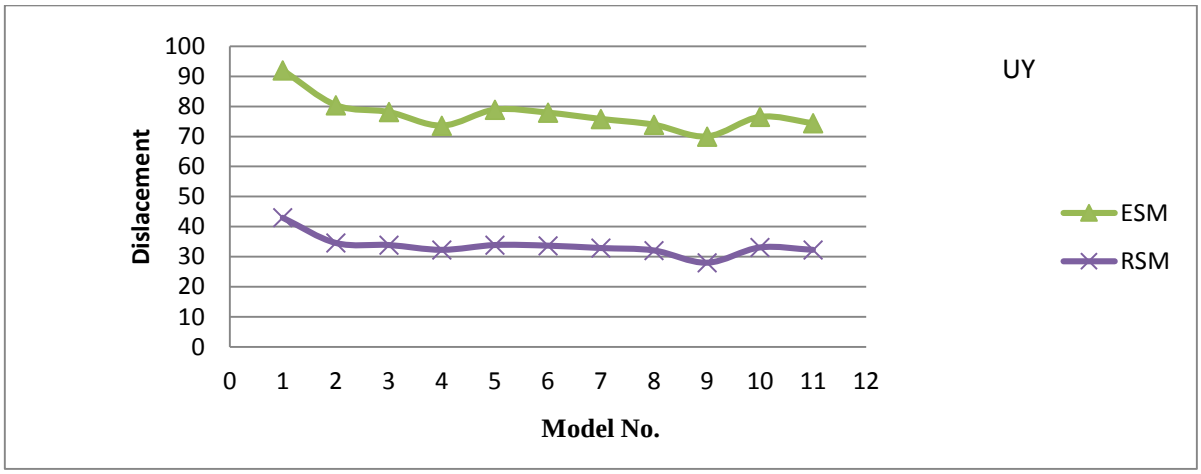

CHART 2

5.2. Storey Drift

After analysis results the minimum story drift have been shown in represent a Charts 3 & 4 from that method for both the direction of transverse and longitudinal. According to story drift concept, the drift is minimum at the base & top, and the maximum at center of story structure. So this method of outrigger system, the drift is also minimum whenevery outrigger system is at the storey height level , this are reduces as 15% minimum drift compared to without outrigger as shown in graphs below.

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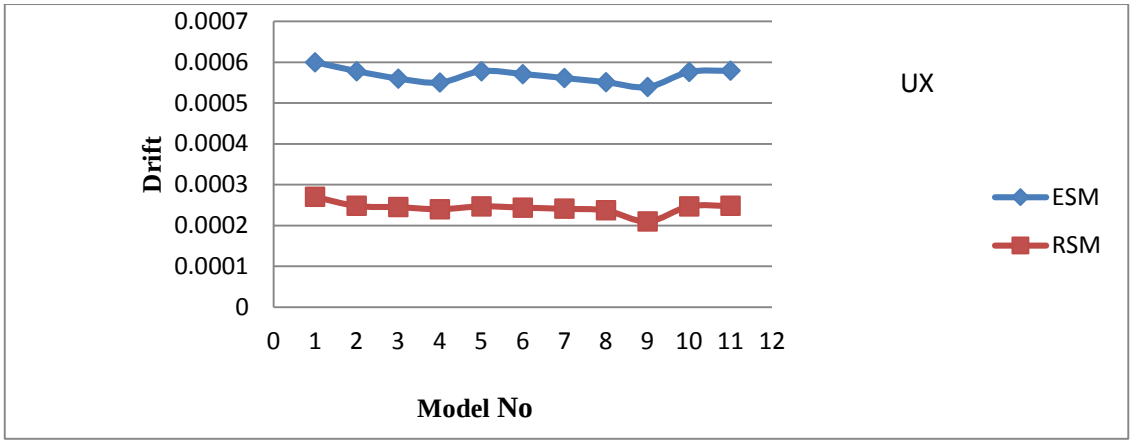

CHART 3

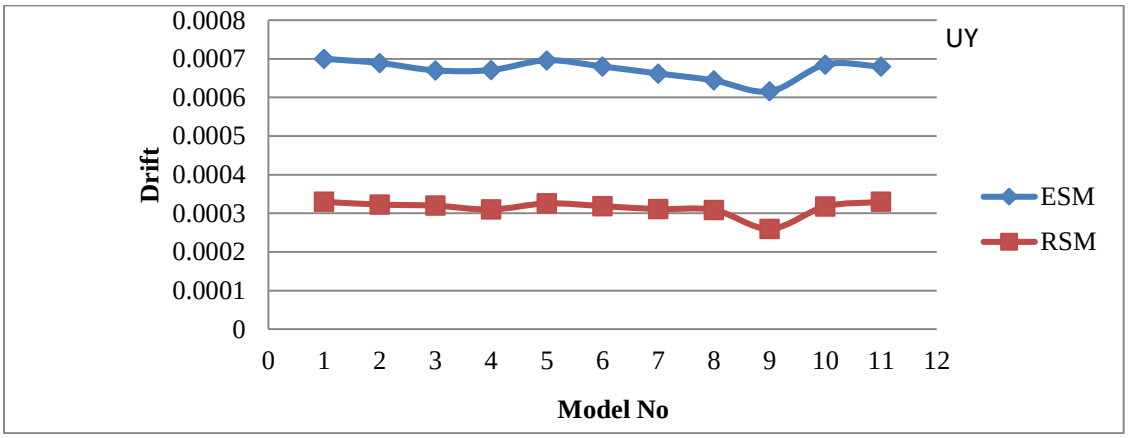

CHART 4

5.3. Base Shear

Base shear is an maximum lateral forces at the base of the building when subjected to seismic load or wind load. The values of base shear is as shown in represent a charts5 & 6 with different models 1 to 11 as compared to without outrigger system of model 2

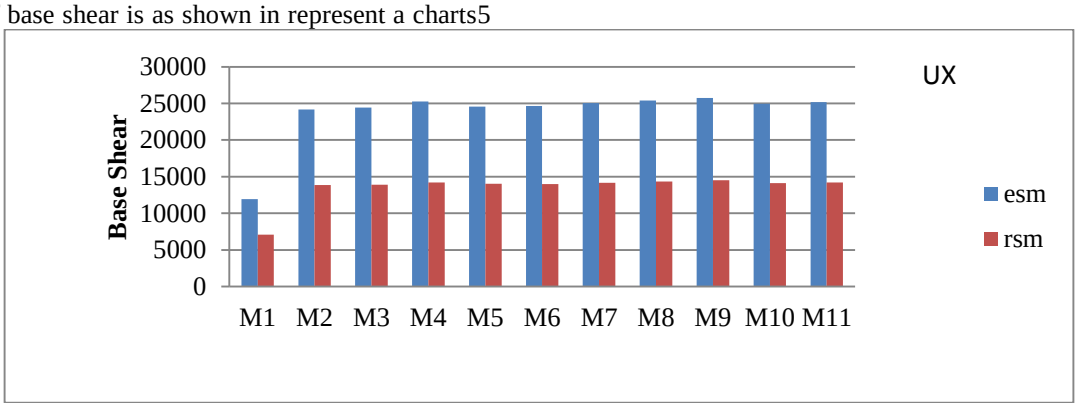

CHART 5

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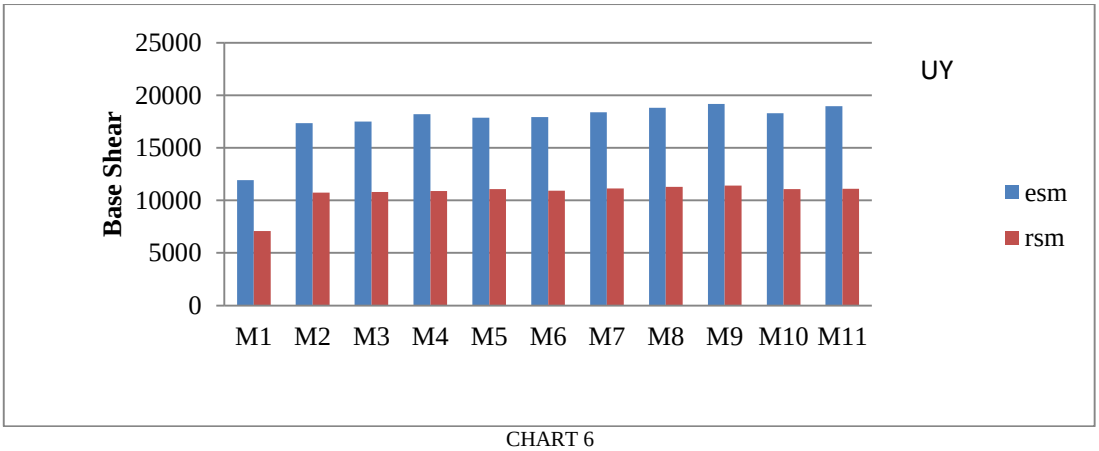

CHART 6

5.4. Fundamental Natural Period

After the analysis, the time period will show the values time in seconds which during its take to swing toward backwards and away forwards at the ground of seismic waves. The tables of minimum time period in seconds as shown in Charts7.

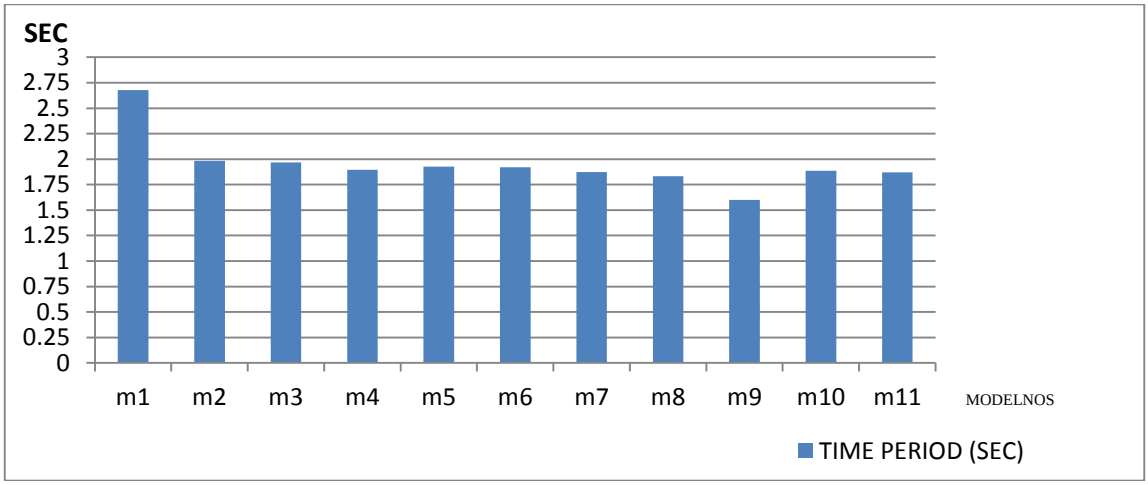

CHART 7

5.5. Bending Moments

The outrigger system is most useful which on focus of bending moments, It's reducing the stiffness and efficiency. The maximum bending moments will at the base of structures as shown in charts8 as comparison of model 2,3,7,9.

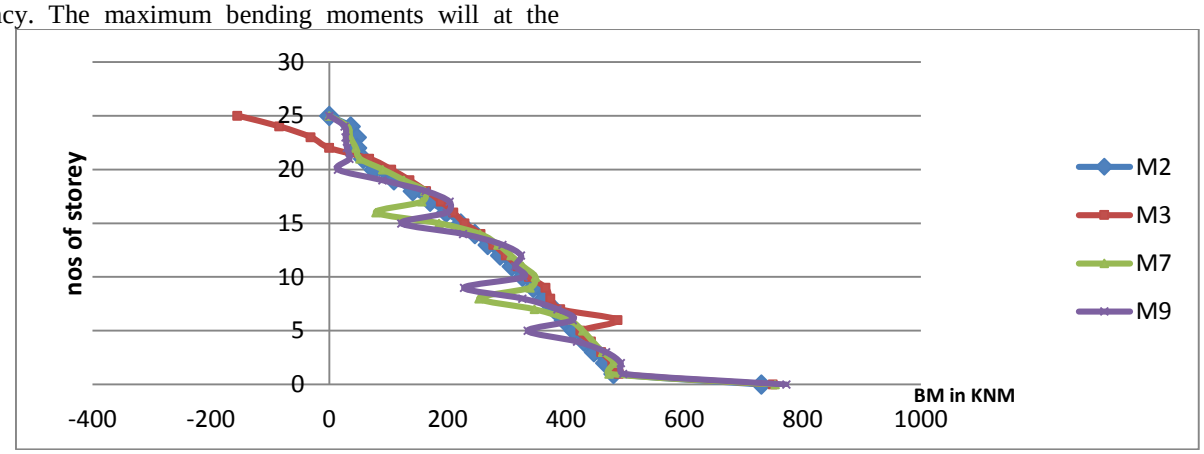

CHART (8)

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VI. CONCLUSIONS

1. In high rise structures, the outrigger system and belt truss which give increase in stiffness and increases in efficient when subjected to wind load or earthquake load.
2. For use of outrigger system, the lateral deflection or displacement is much minimum at top of the level structure than without outrigger system of the structures.
3. Due to this minimum deflection because of stipulated condition of shear wall at center of the structure when located an outrigger system to control less movement conditions.
4. Instability of used of one outrigger level is better to control less displacement than without outrigger system, but when its more than one, two, three, four or more which has more reduction stiffness than all of structures.
5. 25 storeys structures model outrigger systems subjected to lateral load that is earthquake is about 10.5% reduction in maximum lateral displacement, 15% in storey drift.
6. The outrigger system of structures can be used up to 50 story building.
7. The load resisting capacity of tall structures increases by providing outrigger due to its characteristic of strength.

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