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COMPARATIVE STUDY ON OUTRIGGER STRUCTURE AND CONVENTIONAL STRUCTURE

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Abstract: In recent trends, the construction development has been rapidly increasing towards tall building structures. The system has been evaluated based on new structural concept with newly adopted high strength materials and construction methods, that are bracing system, tubular system, outrigger system, diagrid systems etc., This paper attempts to illuminate the behavior of the most effective structural system that is Outrigger Structural systems. Provision of outrigger system is benefited to give adequate stiffness to the structure against such lateral forces. This study presents the comparative results of outrigger and conventional structure (bare frame structure) of steel structure for high rise buildings subjected to lateral loads in zone III using ETABS software. The analysis has been made to consider both equivalent static method and respond spectrum method to outrigger and conventional structural system. Results are tabulated and comparison of parameters namely storey displacement, storey drift, base shear and time period is made among the structures in both equivalent static method and respond spectrum method.

***Index Terms* – Outrigger Structure, Conventional Structure.**

1. INTRODUCTION

Tall buildings have essentially become a need of the current population trends in the world, which led to increase in the demand of the tall structures. High rise buildings have been known to possess a high risk towards lateral loads due to its slender nature which has inspired structural engineers to come up with innovative solutions to these effects. Since then, many structural systems have been developed namely Rigid frame structure, Braced frame structure, Shear wall frame structure, Outrigger structure, tubular structure, Bundled tube structure, Diagrid system etc. Out of these structures this structural systems our paper focuses on the performance of Outrigger and tubular structural systems.

1.1 Outrigger Structural System

The outrigger structural system is a lateral load resisting system in which in this system the belt truss ties all the outside columns on the outskirts of the structure and the outriggers interface these belt trusses to the central core of the structure thus restraining the exterior columns from rotation. This structural system is usually utilized as the structural systems to effectively control lateral load, the danger of structural and non-structural harm is limited during little or medium horizontal load due to one or the other breeze or earthquake.

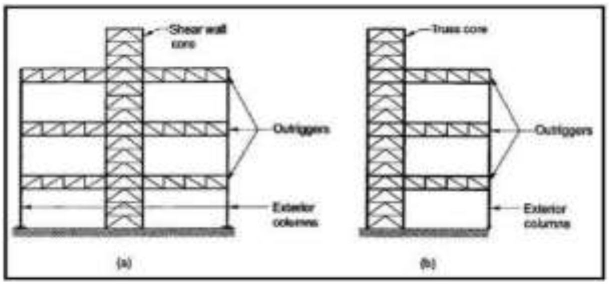

Fig. 1.1 (a) Outrigger with a central core (b) Outrigger system with offset core

2. METHODOLOGY

In this project ETABS software is used to model and analyse steel structures with G+30 storey of area 30X30m, namely outrigger structure and conventional structure for seismic zone III as per the code IS-1893:2002. Comparison is made for outrigger structural system, conventional structural in both equivalent static method and response spectrum method. Parameters such as storey displacement, storey drift, base shear and time period in outrigger and conventional structure are compared. To find out what will be the difference in a structure with and without outrigger structure and to tabulate the results.

2.1 Structural parameters

1. Plan of the building -30mX30m
2. Seismic Zone factor(Z) - 0.16
3. Importance Factor (I) -1
4. Response Reduction Factor (R) - 5
5. Damping Ratio - 0.05
6. Soil type - Medium Soil (Type II)
7. Height of the building
   - For outrigger structure- 92.4m
   - For conventional structure - 94.8m
8. Storey to storey height – 3.2m
   - For outrigger storey height- 2m
9. Span Length- 10m
10. Column dimension- 1000X1000mm;1300X1300mm
11. Beam dimension- ISWB600-1, ISMB600
12. Bracings as core- ISWB600-1, ISWB600-2
13. Bracings as outrigger and belt- ISWB550
14. Slab thickness- 150mm
15. Floor Finish- 1kN/m^2
16. Live load- 3kN/m^2
17. Grade of concrete(fck)-M20
18. Grade of steel(fy)- Fe345

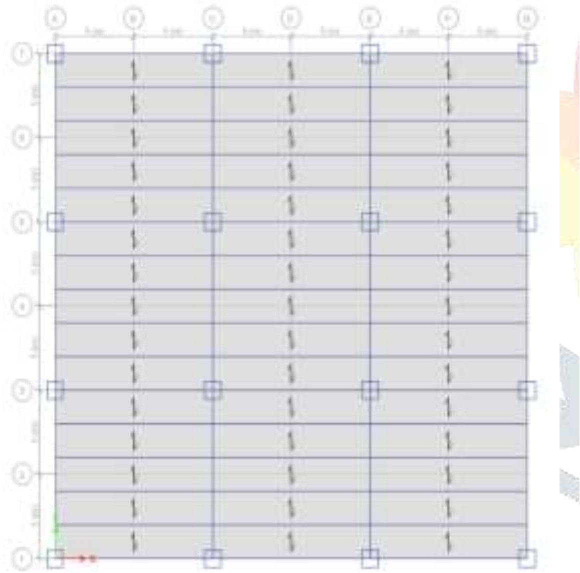

Fig2.1(a) Plan of Outrigger structure

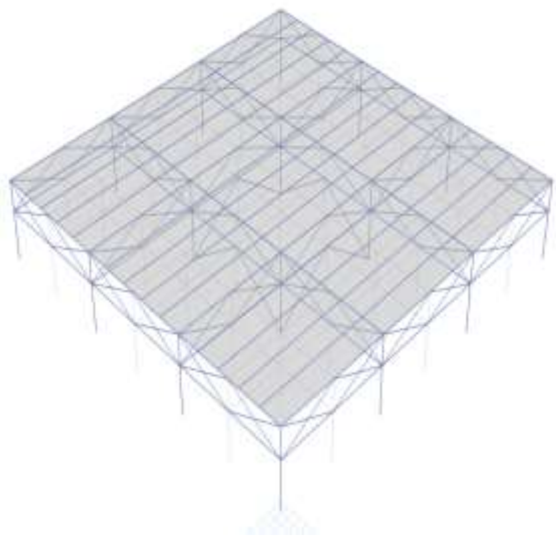

Fig2.1(b) Placement of outriggers

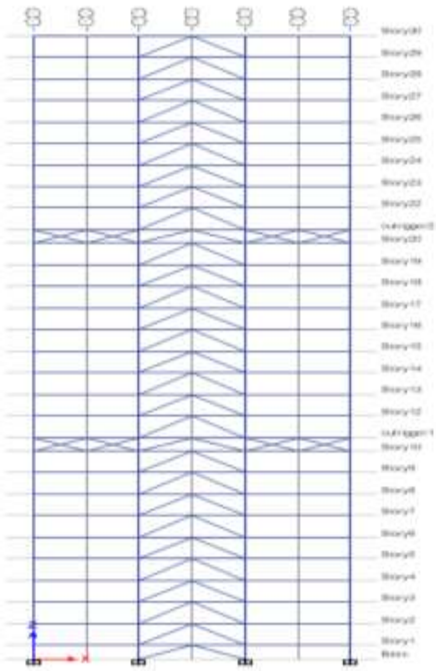

Fig2.1(c) Elevation of outrigger structure

Fig2.1(d) Elevation of conventional structure

3. RESULTS AND DISCUSSION

In this analysis of Outrigger structure and conventional structure in seismic zone III, comparison of parameters namely storey displacement, storey drift, base shear and time period in both equivalent static and responds spectrum method.

3.1 EQUIVALENT STATIC ANALYSIS IN ZONE III:

3.1.1 Storey Displacement

It is the displacement of a storey with respect to the base of a structure.

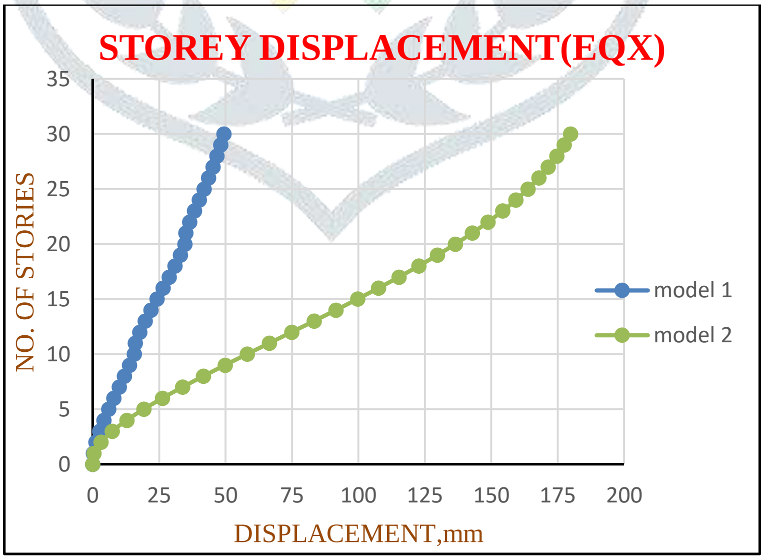

Fig 3.1.1(a) Storey displacement vs no.of stories graph (EQX)

Above figure shows the graph of displacement versus no. of stories (EQX) in equivalent static analysis in zone III. The maximum storey displacement in model 1(outrigger structure) is 49.44mm in storey 30 and in model 2 (conventional structure) the maximum storey displacement is 179.8mm.

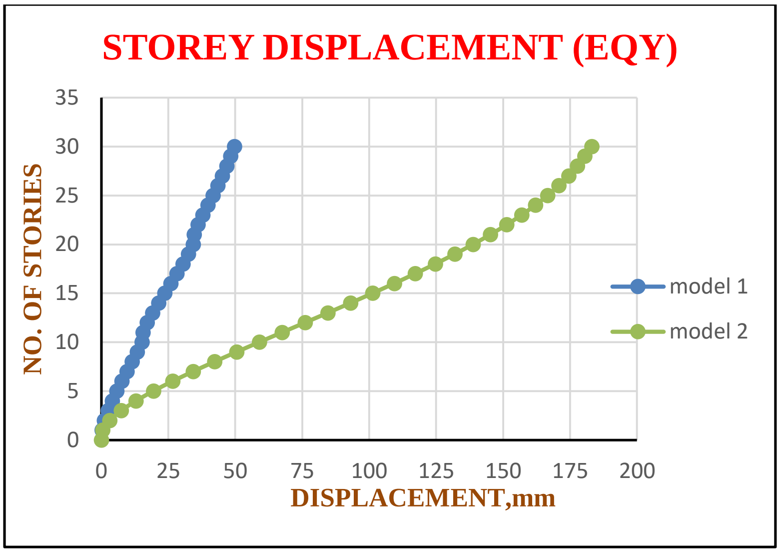

Fig 3.1.1(b) Storey displacement vs no. of stories graph (EQY)

Above figure shows the graph of displacement versus no. of stories (EQY) in equivalent static analysis in zone III. The maximum storey displacement in model 1(outrigger structure) is 49.702mm in storey 30, in model 2 (conventional structure) the maximum storey displacement is 183.107mm

3.1.2 STOREY DRIFT

It is the displacement of one storey with respect to the other storey.

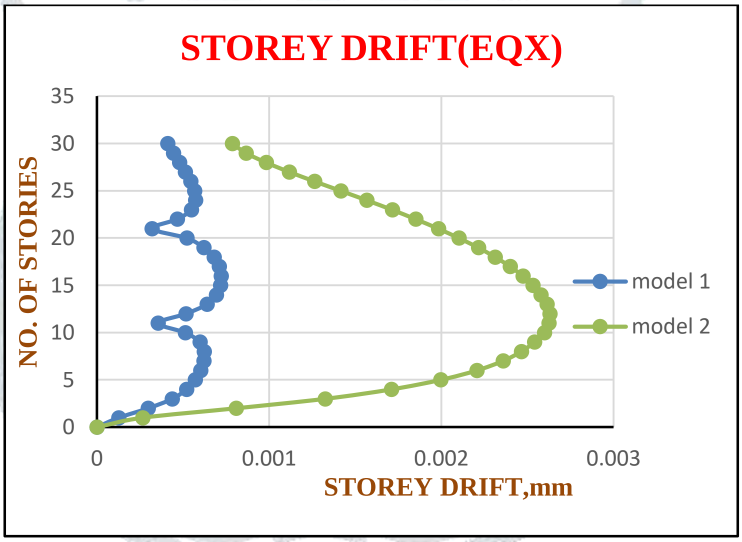

Fig 3.1.2(a) Storey Drift vs no.of stories graph (EQX)

Above figure shows the graph of drift versus no. of stories (EQX) in equivalent static analysis in zone III. The maximum storey drift in model 1(outrigger structure) is 0.000721 in between storey 15 and 18 and in model 2 (conventional structure) the maximum storey drift is 0.00263 in storey 12.

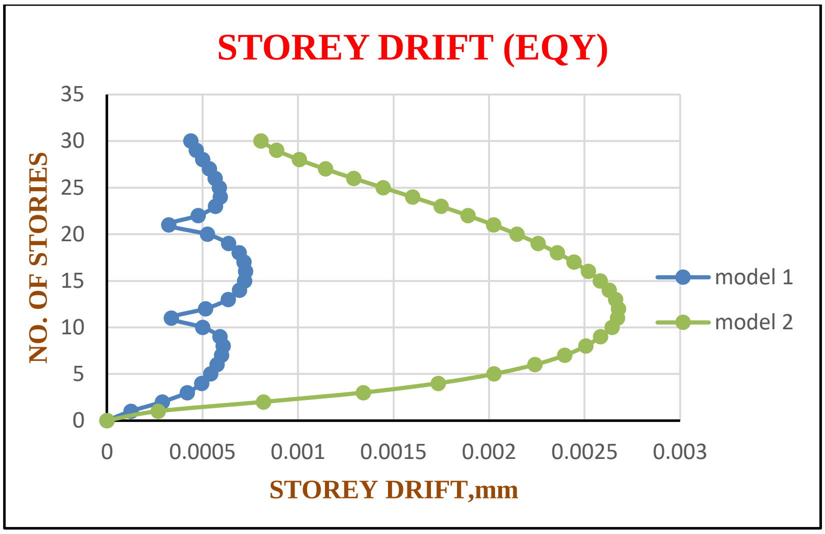

Fig 3.1.2(a) Storey drift vs no.of storey (EQY)

Above figure shows the graph of drift versus no. of stories (EQX) in equivalent static analysis in zone III. The maximum storey drift in model 1(outrigger structure) is 0.000725 in between storey 15 and 18, in model 2 (conventional structure) the maximum storey drift is 0.002677 in storey 12.

3.1.3 BASE SHEAR

Base shear is an estimate of the maximum expected lateral force on the base of the structure due to seismic activity. The base shear results in zone III of outrigger structure (MODEL 1) and conventional structure (MODEL 2) in equivalent static analysis.

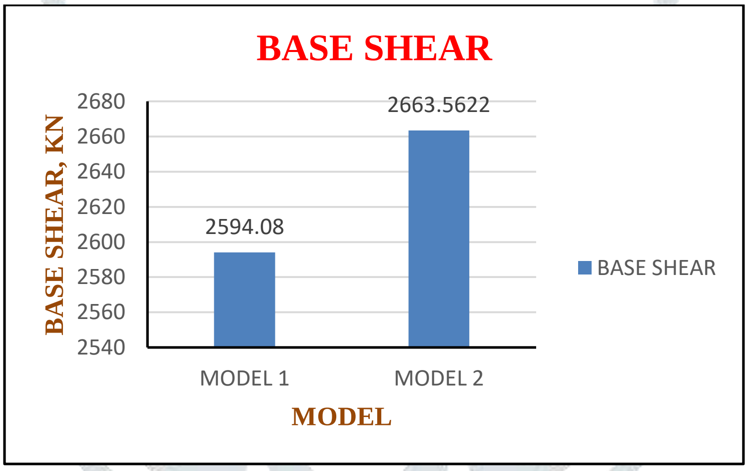

Fig 3.1.3(a) Base shear graph

3.1.4 TIME PERIOD

A Time period (T) is the time taken for 1 complete cycle of vibration to pass a given point. As the frequency of a wave increases, the time period of the wave decrease. The time period results in zone III of outrigger structure (MODEL 1) and conventional structure (MODEL 2) in equivalent static.

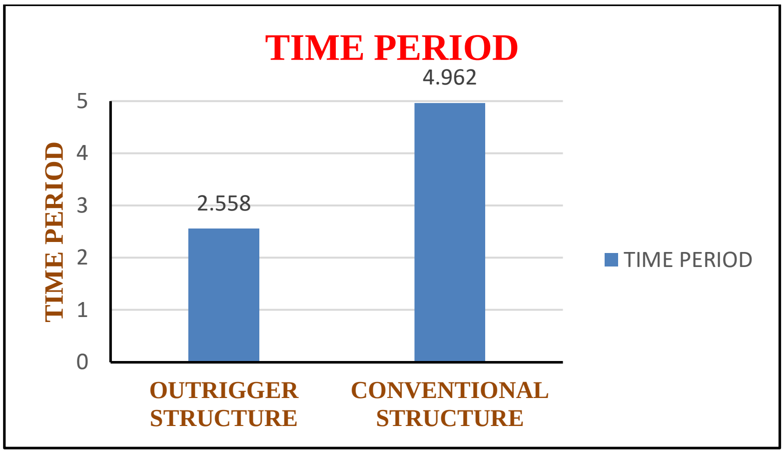

Fig 3.1.4 Time Period graph

3.2 RESPONDS SPECTRUM ANALYSIS IN ZONE III

3.2.1 Storey Displacement

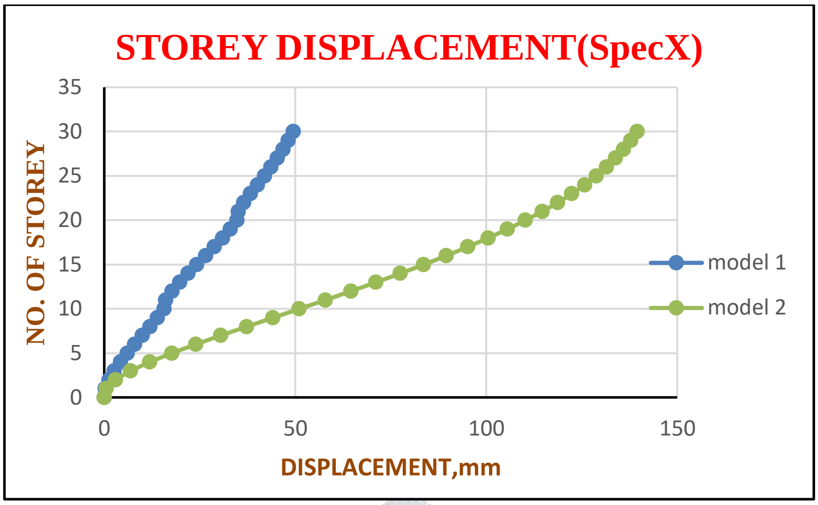

Fig 3.2.1(a) Storey displacement vs no. of stories graph (SpecX)

Above figure shows the graph of displacement versus no. of stories (SpecX) in response spectrum analysis in zone III. The maximum storey displacement in model 1(outrigger structure) is 49.444mm in storey 30 and in model 2 (conventional structure) the maximum storey displacement is 139.5mm.

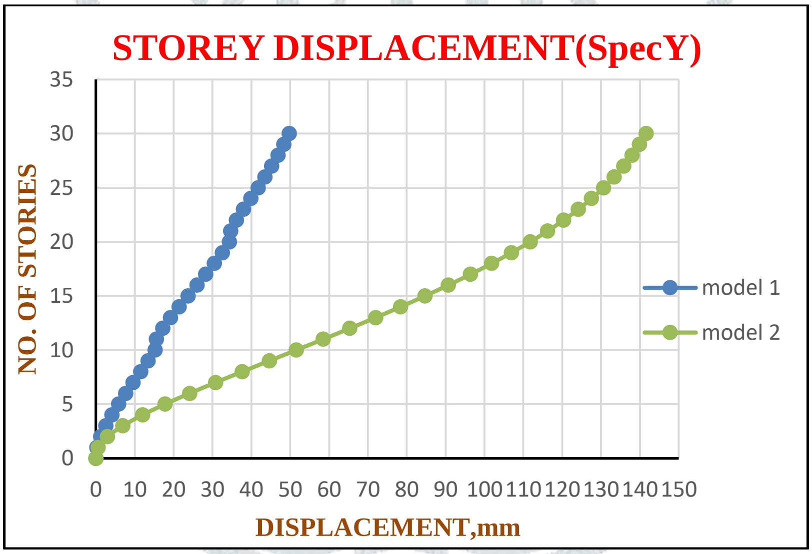

Fig 3.2.1(b) Storey displacement vs no.of stories graph(SpecY)

Above figure shows the graph of displacement versus no. of stories (SpecY) in response spectrum analysis in zone III. The maximum storey displacement in model 1(outrigger structure) is 49.702mm in storey 30 and in model 2 (conventional structure) the maximum storey displacement is 141.598mm.

3.2.2 STOREY DRIFT

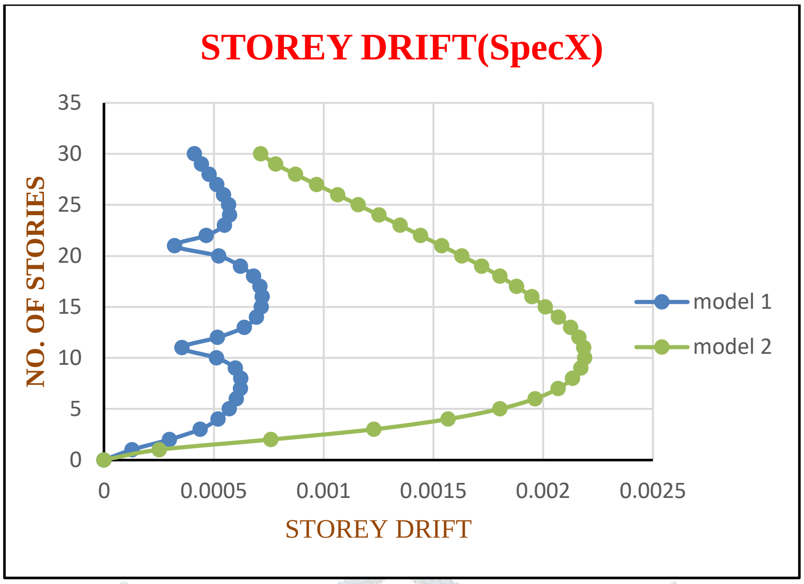

Fig 3.1.2(a) Storey drift vs no.of stories graph (SpecX)

Above figure shows the graph of drift versus no. of stories (SpecX) in response spectrum analysis in zone III. The maximum storey drift in model 1(outrigger structure) is 0.000549 in between storey 15 and 18 and in model 2 (conventional structure) the maximum storey drift is 0.00219 in between 9 and 12.

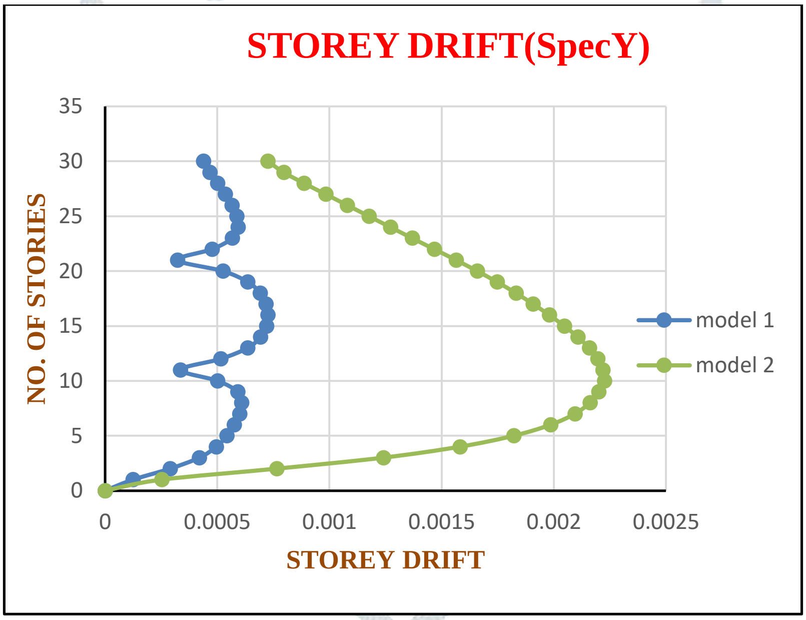

Fig 3.1.2(b) Storey drift vs no. of stories (SpecY)

Above figure shows the graph of drift versus no. of stories (SpecY) in response spectrum analysis in zone III. The maximum storey drift in model 1(outrigger structure) is 0.000544 in between storey 15 and 18 and in model 2 (conventional structure) the maximum storey drift is 0.002225 in between 9 and 12.

3.2.3 BASE SHEAR

The base shear results in zone III of outrigger structure (MODEL 1) and conventional structure (MODEL 2) in Response spectrum analysis.

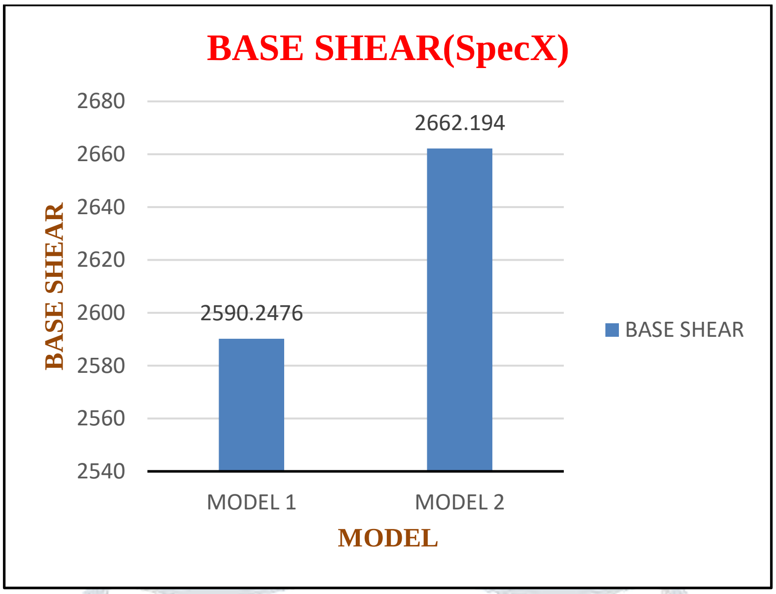

Fig 3.2.3 Base shear graph

4. CONCLUSIONS

In the present work, G+30 storey building is modelled and analysed. The analysis is carried out by equivalent static method of analysis and Responds spectrum method of analysis and the models are compared for parameters such as displacement, drift, base shear and time period.

Based on the results and analysis following conclusions were drawn:

- From the overall analysis it is found that model with conventional structure get overstressed and maximum number of beams and columns tend to fail in zone III, as a result Outrigger were introduced to the model.
- Models designed using outrigger performed well in zone III.
- It is found that the model with outrigger gave better results for all the parameters.

EQUIVALENT STATIC ANALYSIS:

- In equivalent static analysis, conventional structure in zone III showed maximum displacements compared with the other. Model with outrigger reduces displacement effectively. The reduction is around 73% in both X-direction and Y-direction.
- After introducing outriggers to the structure, it is found that there is constant decrease in zone III.
- In case of maximum storey drift, conventional structure showed maximum drift values, while outrigger structure showed least drift value. The reduction is around 72% in both x-direction and y-direction respectively in zone III.
- Base reactions are maximum for conventional structure, this is due to increase in the stiffness of the structure.
- Time period is maximum for models with conventional structure and least for models with outriggers because of the increase in the rigidity.

RESPONSE SPECTRUM METHOD OF ANALYSIS:

- In response spectrum analysis, conventional structure showed maximum displacements compared with the other. Models with outrigger reduces displacement effectively. The reduction is around 65% in both x-direction and in y-direction in zone III.
- In case of maximum storey drift, conventional structure showed maximum drift values. While model with outrigger structure showed least drift values. The reduction is around 75% both in x-direction and y-direction respectively in zone III.
- Base reaction is maximum for conventional structure, this is due to increase in the stiffness of the structure.
- Time period is same for both Equivalent static method and dynamic response spectrum method.

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