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SEISMIC BEHAVIOUR OF STEEL BARE FRAME BUILDING WITH OUTRIGGER AND BRACING WITH OUTRIGGER STRUCTURES

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Abstract - *The advancement of technology and development of economy of the word have brought a new era of tall building, High-rise structures are mostly affected by lateral loads and seismic forces. Earthquake is one of the most devastating natural calamities known to man. Most earthquake related deaths are caused by the collapse of structures. The structural configuration plays a role of paramount importance in reducing the death toll in an earthquake. In this study, the response of various structural configuration regular structure with Bare frame-regular building, outrigger and bracing with outrigger system are evaluated. For the analysis, 30 storey building is considered. The analytical methods used in this work are equivalent static method and response spectrum method. The seismic parameters for earthquake loads and functions are set as per IS1893-2002. The FEA software ETABS v15 is used for analysis, In this work, various parameters like storey drift, storey displacement, time period, frequency and base shear, are obtained for all the models and have been compared.*

Key Words: **ETABS, outrigger, bracing, Seismic Forces, Storey displacement, frequency, base shear…., etc**

1. INTRODUCTION

The primary purpose of all kind of structural system used in multi storey buildings is to transfer gravity load efficiently. Rather than vertical load buildings are also subjected to lateral load they are wind, earthquake loads …, etc. The main way forward towards the resistant towards earthquake design is to improve the lateral stability of structure. The stability in the form of deformability, ductility capacity and limited damage to the structure with no collapse. The reinforcement detailing is main responsible for the elastic behaviour to avoid any brittle failure. Hence, the primary task of an engineer is to design the structure to withstand for earthquake and exhibit higher ductility to withstand the same. The structure has to withstand for the design period stably.

1.1 BRACING

The Lateral forces are resisted by using bracing systems. To happen triangulations, the diagonal members are used in a rectangular area. This system will reduce the bending of columns along with beams and increases its stiffness. The lateral forces can be resisted by 2 different bracing systems

Vertical bracing

Bracing is a member which transfer the load especially horizontal load to the ground. These kind of bracings are provided between the columns. For a framed building, minimum there is a need for 3 direction to provide vertical bracings to resist the vertical members from twisting.

Horizontal bracing

Horizontal bracing provides a load path for transfer of lateral loads to the ground easily. It has to be provided in each floor level. However, the floor itself acts like a lateral resisting system

1.2 OUTRIGGER

The system consists of main concrete core, which will be stiff and stable. The outrigger is the structural member which connects the exterior columns from centre core, which will be up to 2 floors deep. These outriggers are placed parallel along both directions. The structural system is quite normal. The outrigger is stiffer arm which is extending from central core to outer columns. Then under lateral loads, the central core will try to tilt and outer columns attached with outrigger will induced with compression. This will avoid the structure from twisting. This is due to increase in the effective depth of the structure across the lateral force direction by increase in the leaver arm.

2. LITERATURE REVIEW

[**Tejesh R et al.., 2018**] In the present study 15 storey steel structure of height 45m (3m each storey) was considered. The structure was designed as per IS 800:2007 code with dead load, live load earthquake load combinations and wind load combinations. Dynamic analysis (response spectra) was performed using ETABS software assuming response reduction factor as 5, importance factor as 1, seismic zone II and type of soil is 2. The analysis was performed according to IS 1893.The analysis was performed for building without bracing, with X bracing and V-bracing. The results were compared and studied. It was found that displacement of the structure was more in the structure without bracing than other models. It was also observed that lateral loads were more in the case of X-bracing. Finally, it can be concluded that X-bracing is better for wind loading and V-bracing is better for earthquake loading

[**Reza Kamgar et al..,2018**] **l**, in this present paper, for maximizing the efficiency of the outrigger belt truss system, a methodology is proposed here and also an attempt is made based on finding the optimum location of outrigger system is evolved. Here a tall building is modelled with a hybrid pattern by including framed tube, shear core and outrigger system. In this approach, box sections are used for tube systems. The optimum location of outrigger is calculated manually by applying loads in 3 different patterns viz, UDL, trianglulated loading and concentrated loading at top of structure. And the accuracy is also checked by considering various examples and it is found that proposed method is accurate.

[**Remy Morsy Elkholy, 2017**] the real engineering challenges are succeeded when the structures are designed for most prominent natural calamities like earthquake, wind. It is very difficult to find the exact pattern of loading on the structure. It will be real burden for structural engineers to find the exact loads and stresses and to find solution to match perfect structural system to increase its stability and resistance towards the loads. In this study, an investigation is carried out to check the column beam joint and proposed a system called strong column weak beam concept. Finally, it is concluded the present system can be adopted in high rise structures, cable briges with long spans.

3. ANALYSIS

3.1 EQUIVALENT STATIC ANALYSIS

The equivalent static analysis or linear static analysis is bit simple technique, which will substitute to the response spectrum method. In this work, the time period considered will be negligible and forces are applied in a linear format.

The procedure involves:

- The design lateral forces are calculated based on seismic weight and seismic co-efficient method.
- The forces shall be distributed at different levels by standard procedure based on height.

3.2 RESPONSE SPECTRUM ANALYSIS

Response spectrum analysis is a linear dynamic analysis. In the analysis the mode shapes and modal mass participation factors are considered in the analysis and hence it will be treated as practical. All the building or structures will not respond to earthquake out of its frequency of vibration. These frequencies of the structure are called as eigenvalues and the shape of each mode generates which is known as eigenvector. In general, starting 3 modes are important to consider. And as per code it should cover a factor of 90% of modal mass participation.

4. MODELING OF STELL STRUCTURAL SYSTEM

Modelling of G+29 storey building is considered for the analysis in ETABS software. The structure considered here is a regular building with plan dimension of 42m x 42m with a bay length of 6m on both sides. In the present study, a G+29 storeys stell structure with bare frame, bracing system, diagrid system are considered. .

4.1 TYPES OF MODELS FOR ANALYSIS

In the present work five models were considered and analysed they are viz.

Model - 1- Bare frame - regular building
Model - 3- outrigger system
Model- 5 - Bracing with outrigger System.

4.2 MATERIAL PROPERTY

The material considered for analysis RC is M-40 grade concrete and Fe-500 grade reinforcing steel:

Young's- Modulus - steel, Es = 2, 10,000 MPa

Young's - Modulus - concrete, EC =31622.7 MPa

Characteristic strength of concrete, fck = 40 MPa

Yield stress for steel, fy = 500 MPa

Table.3.1 Specification of models

Member	Specification
Beam	ISMB500
Column	Built up ISHB 450
Bracings	ISMB150

The above sections are assigned based on economical design depending on height of the building

4.2 MODEL GEOMETRY

The Building is 30-storied, seven bays along X-dir. and seven bays along Y- dir., Steel frame with properties as specified below. The floors are modelled as rigid deck slab section. The details of the model are given as follows:

Number of stories = 30

Number of bays along X Dir. = 7 Bay, Y-Dir. = 7 Bay

Storey height = 3.0 meters at Ground Floor,

Remaining Floors.

Bay width along X Dir.= 6 m, Y Dir. = 6 m.

4.3 MODELING

Figure .1 indicates the plan of the symmetrical structure. The figure.2 shows the elevation of the model

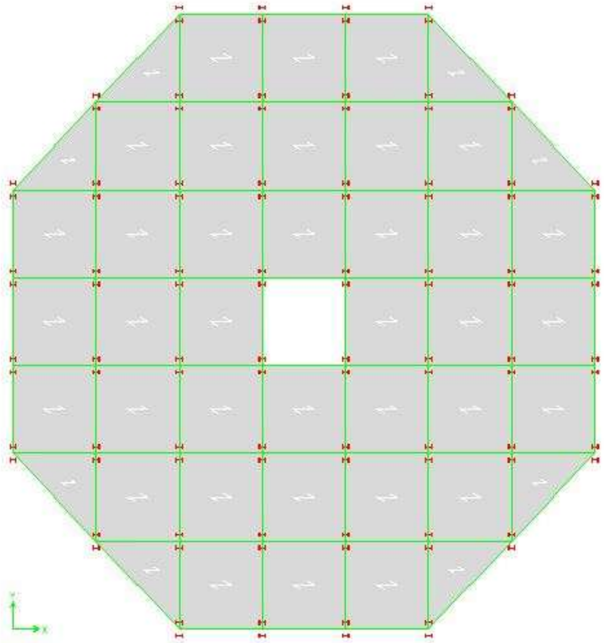

Fig. 1 Plan of the buildings

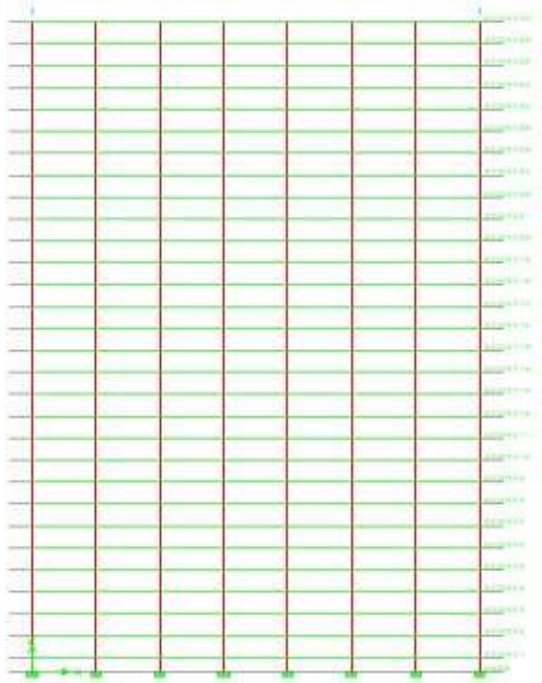

Fig. 2 Elevation View

5. RESULTS

This chapter describes the results and discussion of the models analyzed in ETABS by linear analysis

5.1 STOREY DISPLACEMENT

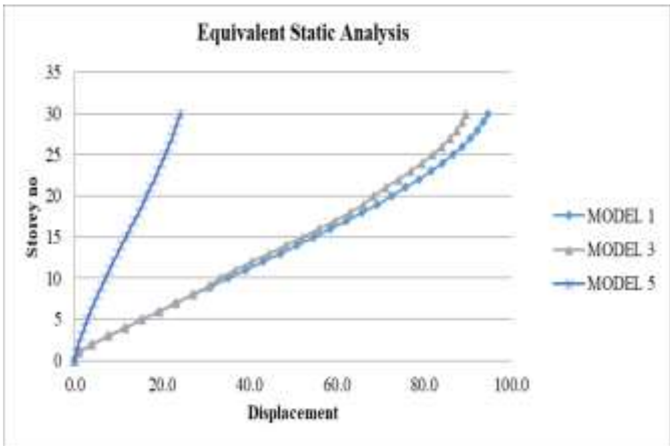

Fig. 3 Comparison of story v/s displacement for 30 storey different models in x-direction

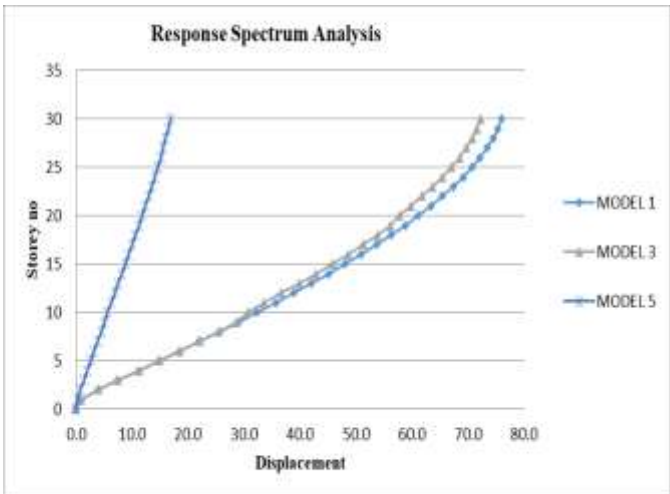

Fig. 4 Comparison of story v/s displacement for 30 storey different models in x-direction

The displacement in the conventional building seems to be high compared to all other structures. This is due to lack of stiffness or capability to resist lateral loads. However, the structure bracing with outrigger(model 5) is the stiffer compared to all other models and is very much significant in terms of displacement. The model 1, and model 3 are having displacement with minimal variations

5.2 STOREY DRIFT

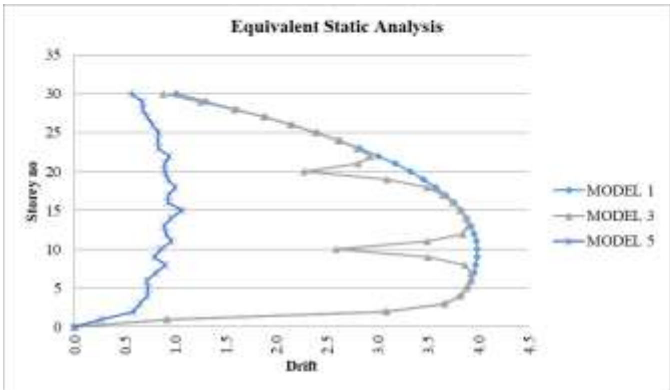

Fig. 5 Comparison of storey v/s storey drifts for 30 story different models in x-direction

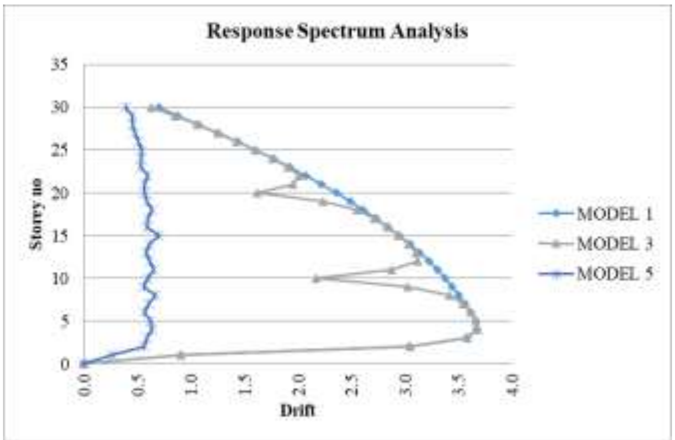

Fig. 6 Comparison of storey v/s storey drifts for 30 story different models in x-direction

The drift values are the difference in the displacement values. From the graphs, it is clear that the drift values are significantly less in the structure bracing with outrigger(model 5), The smooth variations are found in the model 3 and 1. The model 3 indicates few dips in the curve,

5.3 TIME PERIOD

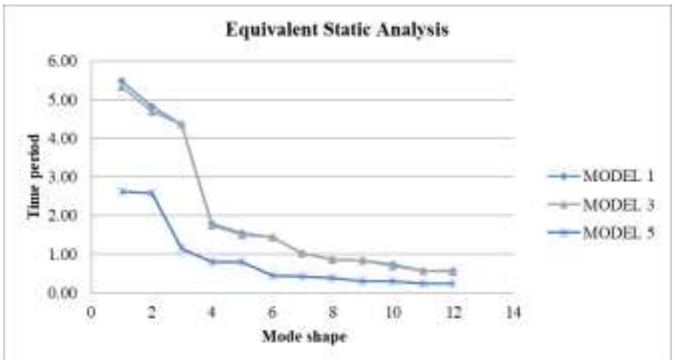

Fig. 7 Comparison of mode numbers v/s time period for 30 storey different models

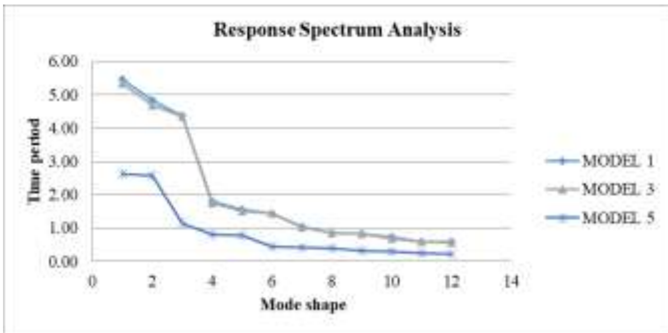

Fig. 8 Comparison of mode numbers v/s time period for 30 storey different models

Regular conventional model is having higher time period and hence the higher flexibility. The flexibility of the structure bracing with outrigger reduced in the time period due to lesser time period. The time period of models1 and model3 are almost same due to same flexibility.

5.4 FREQUENCY

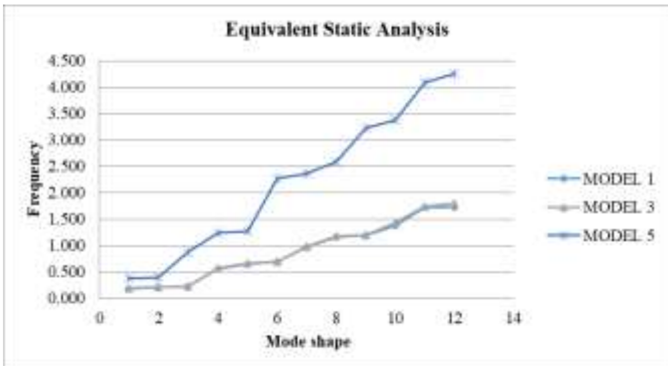

Fig. 9 Comparison of mode numbers v/s frequency for 30 storey different models

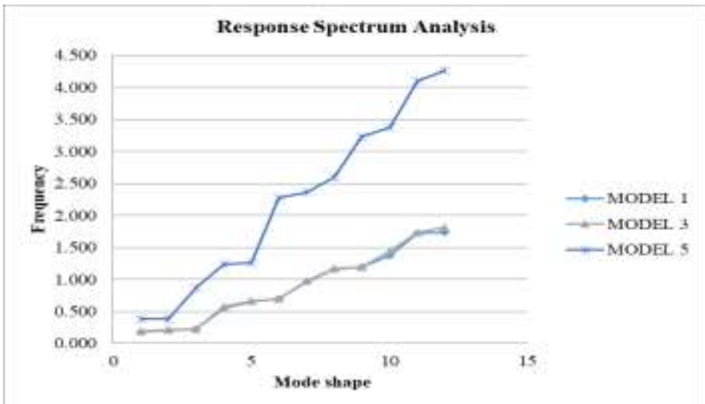

Fig. 10 Comparison of mode numbers v/s frequency for 30 storey different models

Since, the frequency is inversely dependent on the time period, the values are in line with time period values. However, the frequency will be more for structure bracing with outrigger(model 5) when compared to other models. The Regular model is having lesser frequency because of longer time period.

6. CONCLUSIONS

The following conclusions are being made by the results obtained from the present study:

1. The displacement of model1, conventional structure is having higher displacement compared with outrigger structure and bracing with outrigger. The bracing with outrigger structure (module 5) is the stiffer compared to all other models and is very much significant in terms of displacement. The model 1 and model 3 are having displacement with minimal variations.

2. The difference between conventional and outrigger are almost similar comparatively. However, the inclusion of bracing and outrigger in a single model yields lesser displacement value and are significant in value.

3. The drift values are in concurrence with the displacement values, however the difference in terms of percentage values will remain same.

4. The time period of the structure depends on its flexibility. From the results regular conventional building is having greater flexibility than other models. The structure bracing with outrigger in a single module shows lesser time period due to its brittle behaviour.

5. There is no much difference in the base shear values between the models. Since all the models process similar load and height, the base shear parameter is not a matter of considerations.
6. The difference between equivalent static and response spectrum analysis is noticed from the results. It is found that, Equivalent static giving higher displacement values than Response spectrum. However, the time period and base shear values will be not varying for different analysis.

7. The time period and base shear values will not vary for the type of analysis. Since it is depending on the building geometry and its dynamics.

REFERENCES

[1] Akshay A. Khanorkar, S. V. Denge, 2016, “Belt Truss as Lateral Load Resisting Structural System for Tall Building: A Review", International Journal of Science Technology & Engineering, Volume 2, Issue 10, April 2016

[2] Kian P.S, Outrigger And Belt Truss System For High-Rise Concrete Buildings / DTS, Vol. 3, No. 1, Maret 2001, Hal. 36-41

[3]Karthik A L, Geetha K “Dynamic Analysis of Bundled Tube Steel Structure With Belt-Truss and Mega Bracings”International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 03 Issue: 07 | July-2016

[4]Ramy Horsy Elkholy,”Structural System to Resist Seishmic Loads on High Rise Reinforced Concrete Structure s”Scientific Research Publication(SRP),june-2017

[5]Rezakamgar, Reihaneh Tavakoli, Reza Rahgozar, ”The Best Location of Best Truss System in Tall Building Using Multiple Criteria Subjected to Blast Loading”-civil engineering Journal”,Volume-4|June-2018

[6] Tejesh.R, Ummer Farooq Pasha, Latrral Stability of High Rise Steel Building using ETABS”International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 05 Issue: 01 | July-2018, Page no(607-611)

[7] IS 1893 (Part1): 2002, “Criteria for Earthquake Resistant Design of Structures”, Part 1 General Provisions and Buildings, Fifth Edition, Bureau of Indian Standards.

BIOGRAPHIES

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