

# Effect of Wind Load on Structural Performance of Dimensionally Regular & Irregular High rise Buildings with different Outrigger Systems

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## ABSTRACT

Outriggers system is used as one of the best way of increasing the lateral stiffness and has been generally utilized in tall building structures. The outrigger system is very effective in increasing structure's flexural stiffness. It is likewise viable in decreasing the horizontal top deflection and bending moments in the core of high-rise frame-core structures. This study presents the detailed analysis on how the top drift, inter-story drift, base moment in the core are influenced by the outriggers stiffness, outriggers optimum locations, columns axial stiffness and foundations flexibility. outrigger braced structures can strengthen a structure without disturbing its aesthetic appearance and this is a significant advantage over other lateral load resisting systems. The thesis compare between many outriggers systems including both concrete & steel Outriggers. The Rectangular shape & L- shaped building structures are taken for analysis. The study also presents simplified procedure to optimize the location of the outriggers that will result in a maximum reduction in the lateral displacement at the top of the building. The modeling of the structure is done using "ETABS" program. The investigation of the model is completed by comparable static technique. Finally, the thesis proposed a simplified analysis for outriggers structures with core for both regular and irregular high rise building.

**Keywords**— Tall Buildings, Outriggers, Wind Load, Etabs

## I. INTRODUCTION

Urban communities around the globe are seen an expansion in taller and progressively thin structures due to improved building technology, analysis techniques, material science, architectural and special constraints, and prestige. Simultaneously, it is desirable to diminish the size of basic components to maximize useable space. The improvement in tall buildings has advanced quickly in recent years. Population from country territory is migrating in enormous numbers to metro cities. Because of this, metro urban communities are getting thickly populated step by step. As populace is getting denser the accessibility of land is reducing and cost is additionally expanding. So tall structure idea is approached to satisfy the requests of public & it is solution for the land shortage. Present day tall

structures in Canada and the United States are for the most part conspired to utilize a centralized core to resist lateral demands from wind and earthquake. The core additionally contains the lifts and stairs. The core is frequently an interconnected arrangement of strengthened solid shear walls which oppose lateral loads. An auxiliary casing framework can likewise be utilized to give extra drift control. Shear walls with or without auxiliary casing frameworks allows practical design up to around 70 stories. To push beyond this tallness with a economical design, the outrigger framework can be used.

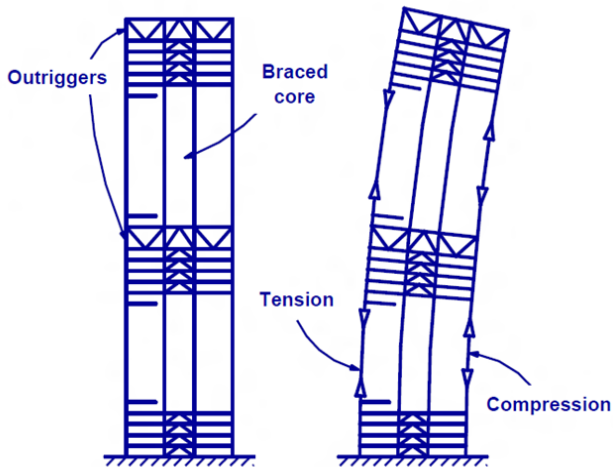
### 1. Objectives

- To Study the effect of Outriggers in Symmetrical & Asymmetrical Buildings under Wind load on Lateral Displacement.
- To Compare the lateral deflection, Story drift of both Symmetrical & Asymmetrical Building.
- To Study the Static Response of Building i.e. Find out most Vulnerable Model & Suggest Optimum Position of Outrigger in High rise Building.
- To have Comparative Study on Steel & Concrete Outriggers.
- To suggest the suitable Outrigger system for high rise regular & irregular Building.

### Structural System

In the previous years, structural individuals were expected to convey essentially the gravity loads. Today, however, by the advances in structural design/systems and high strength materials, building weight has diminished, thus expanding the thinness, which requires considering significantly the lateral loads, for example, wind and earthquake. Specifically for the tall structures, as the slimness, and flexibility increases, structures are harshly affected from the lateral loads resulting from wind and earthquake. Consequently, it turns out to be progressively important to recognize the best possible structural system for resisting the lateral loads relying on the tallness of the structure. The utilization of outriggers in tall structures is certainly not new concept. Truth be told, outriggers have been effectively utilized in tall structures for more than 50 years.

In modern tall buildings, lateral loads induced by wind are often resisted by a system of coupled shear walls. But when the building increases in height, the stiffness of the structure becomes more significant and presentation of outrigger beams between the shear walls and outer columns is frequently used to provide sufficient lateral stiffness to the structure. There are various techniques One among the various methods to resist the lateral force is the Outrigger system.



## II. METHODOLOGY

### *Equivalent Static Analysis Method*

The static nature of the load must be considered as when planning against wind loads. The equivalent linear static method is sufficient for analysis for simple regular structure by utilizing formula given in the IS code, the dissemination and estimate of base shear is calculated. Tall buildings with second and higher modes can be important with torsion effects are less reasonable for this technique and require progressively complex strategy to be utilized in these conditions. Equivalent static Analysis strategy is utilized for estimation of structural displacement demands. The horizontal force shall be applied at the vertical center of the superstructure mass and is distributed horizontally in proportion for mass distribution.

The strategy for investigation of the previously mentioned framework is based up on the assumptions that the outriggers are rigidly attached to the core; The core is rigidly joined to the foundation; The sectional properties of the core, beams and columns are uniform throughout the height; Tensional impacts are not considered; Material conduct is in direct versatile range; The Outrigger Beams are flexurally unbending and induce only axial forces in the columns; The lateral load opposition is given uniquely by the bending resistance of the core and the tie down action of

the exterior columns connected to the outrigger; The rotation of the core because of the shear deformation is negligible.

### *Code Based Wind Analysis*

Designed based on IS-875 part –III. It is very important to analyse reinforced cement concrete High rise buildings properly against horizontal forces. The present study has been planned to check the severity of wind forces with height of the High rise building having different shapes located in Darbhanga, Bihar, having maximum wind speed i.e (55m/s) in India. It is very important to analyse reinforced cement concrete High rise buildings properly against horizontal forces. The present study has been planned to check the severity of wind forces with height of the High rise building having different shapes located in Darbhanga, Bihar, having maximum wind speed i.e (55m/s) in India. The examination is completed utilizing ETABS programming according to IS 875 (Part 3)

Design wind speed ( $V_z$ ):

It can be mathematically expressed as follows.

$$V_z = V_b * k_1 * k_2 * k_3$$

Design wind pressure ( $P_z$ ):

The design wind pressure at any height above mean ground level acquired by the accompanying connection between wind pressure and wind velocity.

$$P_z = 0.6 V_z^2$$

## III. NUMERICAL SIMULATION OF THE HIGH RISE BUILDINGS

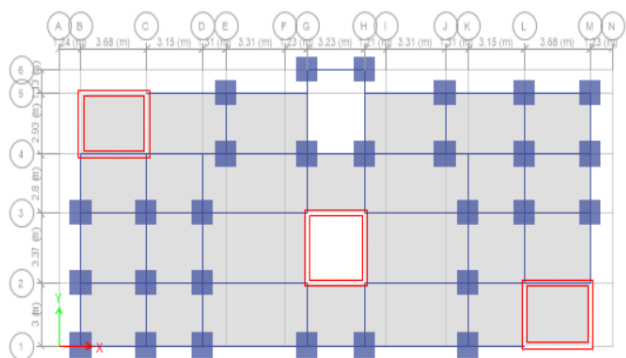
The present examination is done on two unique states of structures and made the comparison of the structure, so we can get the difference between the results. A similar material properties are utilized for the both the structure. Just as for both the structures the various kinds of steel and solid outriggers frameworks are given, so the models get safe against the wind speed. By using the different outriggers at different locations in the model ,the better resistant, decreasing lateral displacement & story drift such kind of results giving outrigger system we are going to find out through this project. There are six no. of models are examined for both regular and irregular structure. They are as per the following,

- Model 1- Bay frame.
- Model 2 - Bay frame with Concrete core with steel outriggers (X braced).
- Model 3 - Bay frame with Concrete core with steel outriggers (V braced).
- Model 4 - Bay frame with Concrete core with Concrete outriggers (X braced).
- Model 5 - Bay frame with Concrete core with steel outriggers (X braced) and belt truss.

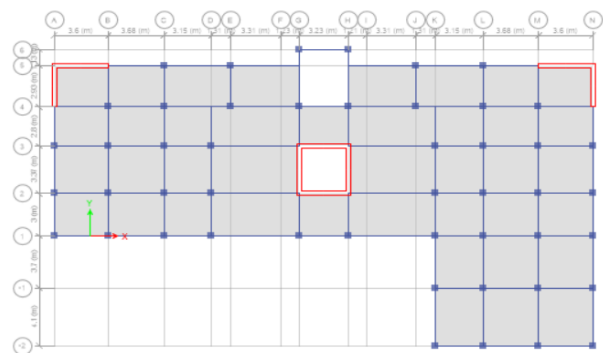
- Model 6 - Bay frame with Concrete core with concrete outrigger (X bracings) and Belt truss

**Material Properties**

Story Height	3.0m
No. of Stories	40
Structure	SMRF
Grade of concrete	M40
Grade of Steel	Fe 550
Soil type	II
Beam Size	0.30mx0.45m, 0.30mx0.60m
Column Size	1.2mx1.2m, 1.0mx1.0m, 0.9mx0.9m, 0.75mx0.75m, 0.60mx0.60m, 0.45x0.45m
Importance Factor	1
Live Load	2 kN/m <sup>2</sup>
Dead Load	1 kN/m <sup>2</sup>
Concrete outrigger	0.45X0.45 m, M40
Steel outrigger	ISMB 500



**Fig. Plan of Rectangular building**



**Fig. Plan of L- shaped building**

**Outrigger Configurations**

The Outriggers are provided in + position in symmetrical building, i.e they are associated with the central core of the structure. They are on the line of 2 & 3

in the underneath rectangular picture in X-dir. Likewise in the in Y-dir they are on the line of G & H of following fig. At different level of structure they are given in order to locate the better position for the outrigger system where he can oppose increasingly lateral load.

The Outriggers are provided in +, I position in asymmetrical building, i.e they are associated with the central core of the structure. They are on the line of 2 & 3 in the L-shaped building in X- dir. Also in the in Y- dir they are on the line of G, H & L, M on the L-shaped building. There should be give the outriggers on the L and M line. When it isn't given it indicates more displacement in the Y-dir. So to control some displacement the outriggers are given on it. At different levels of structure outriggers are given to find the better position for the outrigger system where he can resist more lateral load.

**IV. RESULT & DISCUSSIONS**

**Rectangular Building**

The below table shows the displacement of rectangular building in all the six models. The main model is exposed edge in which the structure demonstrates the higher lateral displacement i. e. in X- dir it is 315 mm and in Y- dir. It is 270.9 mm. After providing the outriggers systems to the model the varies results are found & that are shown in graph. The Concrete outrigger shows the better results than than the steel outriggers. When the concrete outriggers are provided with the belt truss at top floor the least deflection we have get than all the other models.

**Table 1- Result for Lateral Displacement in X- dir & Y-dir**

MODELS	X-DIR (MM)	Y-DIR(MM)
BARE FRAME	315	270.9
STEEL OUT. V	251	259
STEEL OUT. X	213	225
CONC OUT. X	169.9	210.32
STEEL OUT. & BELT TRUSS	202	222
CONC OUT. & BELT TRUSSS	160.43	205.92

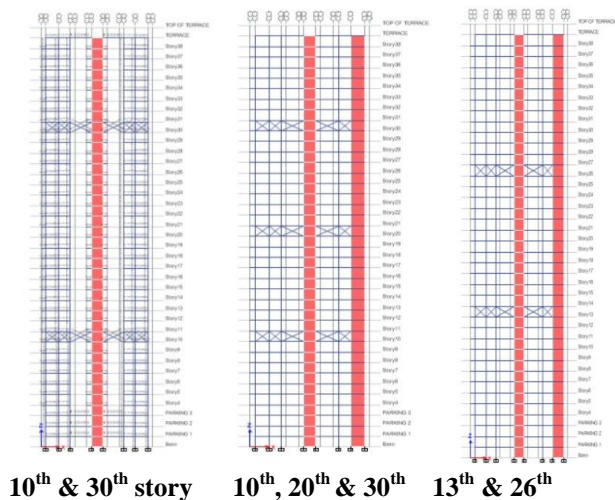
**L-Shaped Building**

The below table shows the displacement of L-shaped building in all the six models. The first model is bare frame is exposed in which the structure demonstrates

the higher lateral displacement i. e. in X- dir it is 294 mm and in Y- dir. It is 320 mm. After providing the outriggers systems to the model the varies results are found & that are shown in graph. The Concrete outrigger shows the better results than than the steel outriggers. When the concrete outriggers are provided with the belt truss at top floor the least deflection we have get than all the other models. The shear wall location is also play important role in the sustain stability of the building. Irregular building shows large displacement when shear wall locations are changed.

**Table 2- Result for Lateral Displacement in X- dir & Y-dir**

MODELS	X-DIR (MM)	Y-DIR(MM)
BARE FRAME	294	320
STEEL OUT. V	227	287
STEEL OUT. X	199	262
CONC OUT. X	174	252
STEEL OUT. & BELT TRUSS	192	256
CONC OUT. & BELT TRUSSS	168	244



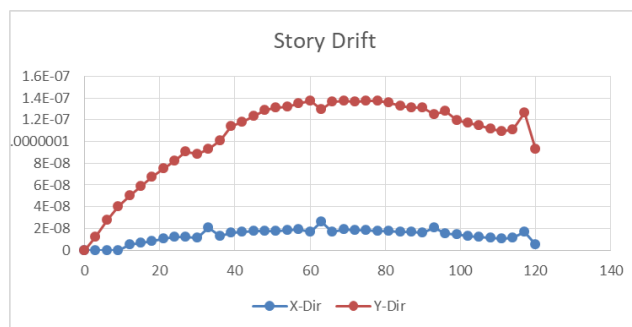
**Fig. Outrigger locations in Rectangular building**

When the concrete outriggers are provided with the belt truss at top floor the least deflection we have get than all the other models. The outriggers are provided at 10<sup>th</sup>, 20<sup>th</sup>, 30<sup>th</sup> story shows the minimum deflection i.e 1/5<sup>th</sup>, 2/5<sup>th</sup>, 3/5<sup>th</sup> ht. of building than it is provided at 1/3<sup>rd</sup>, 2/3<sup>rd</sup> &

1/4<sup>rd</sup>, 3/4<sup>th</sup> height of building for both symmetrical & asymmetrical models.

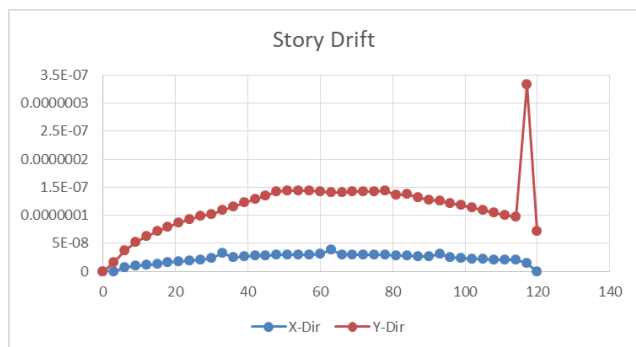
The total story drift is as shown in below graph. The Conc. Out with belt truss model shows minimum deflection so their story drift graph is shown. The Story drift is maximum is occurred at thr 16<sup>th</sup> to 20<sup>th</sup> story in the rectangular building.

**Story Drift in Rectangular Building**



The story drift of each model is different but the least story drift is shown by the conc. Outrigger with belt truss model so it is been compared with the building without outrigger system. The total story drift is as shown in below graph. The Story drift is maximum is occurred at thr 36<sup>th</sup> to 40<sup>th</sup> story in the asymmetrical building.

**Story Drift in L- shaped Building**



**V. CONCLUSIONS**

1. The Results shows that the symmetrical building shows the more resistant to lateral deflection & story drift than the asymmetrical building. The displacement reduction at the top floor of the building is less compared to the outrigger provided at middle floors.
2. The concrete outrigger is more efficient in reducing the lateral storey displacement than the steel outrigger (X-bracing) in the tall RC building. The outriggers which are X shaped braced showed lesser displacement when compared to that V shaped braced outriggers.



3. The size of the outrigger members increases, the displacement in the tall building structural system decreases. Provision of shear wall at the central core with outrigger in the building decreases the forces in the core.
4. The usage of outrigger system in the building increases the efficiency of the building when compared to building without outrigger under the action of lateral loads.
5. The Story Drift of the regular building is less than the Story Drift of irregular building. By providing the outriggers it shows lesser story drift in both the buildings.
6. The outriggers are provided at 10<sup>th</sup>, 20<sup>th</sup>, 30<sup>th</sup> story shows the minimum deflection i.e 1/5<sup>th</sup>, 2/5<sup>th</sup>, 3/5<sup>th</sup> ht. of building than it is provided at 1/3<sup>rd</sup>, 2/3<sup>rd</sup> & 1/4<sup>rd</sup>, 3/4<sup>th</sup> height of building for both symmetrical & asymmetrical models. So for G+40 story structure the outriggers are provided at 1(n+1) H, 2(n+1) H... n(n+1) this positions is very effective position.
7. From economical and displacement point of view the concrete outriggers are better than the steel outriggers. So the conc. Outrigger with Belt Truss is the system is most effective outrigger system than the others, below that only Conc. Outriggers system is liable.

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