# Analysis of Multistory RCC Structure with and Without Outrigger Beam System

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***Abstract***— As now a days in most multi-storied buildings the lateral loads is resisted by the outrigger beam systems. An outrigger beam is a very stiff beam it connects with the shear wall to the exterior column and with this it reduces the lateral load and overturning moment. the system also help to resists the rotation of the core. In this paper the G+15 storey building with shear wall and outrigger beam is analyzed. the drift and avg. displacement of each model is observed and compared with bare frame model (BF). the outrigger beam (OT) is provided at 5th, 10th and 15th floor, for each provision of outrigger beam different models are made. The deep beam and I-beam is used in the analysis for different model.

***Keywords****- Bare Frame model (BF), Outrigger beam (OT), Drift and Avg. Displacement.*

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## I. Introduction

Nowadays overall development of tall buildings has been increased rapidly. Populations from rural areas are migrating more and more day by day to bigger cities due to the increase in job employment and infrastructure facilities. Thus cities become densely populated and cost of land also goes on increasing which leads to the use of multi-storied building. Now as the height of the building increases the effect of lateral loads on multi-storied building increases, height is directly proportional to the effect of lateral loads. There are numerous structural lateral systems used in high-rise building such as shear frames, shear trusses, frames with shear core, framed tubes, trussed tubes etc. However, the outriggers beams and shear wall are the systems used for providing significant drift control. Outriggers systems are rigid horizontal structures designed to improve buildings stability and strengthen it by connecting the building at distant columns, in a way of an outrigger to prevent from over turning. Outrigger systems when provided to whole building, structural behavior of that building are much better than those of the normal component system building. The benefits of an outrigger system lies in the fact that deformation resulting from the overturning moments gets reduced as well as greater efficiency is achieved in resisting forces.

The analysis and design of complete outrigger system is not that easy and simple. Distribution of forces between the core and outrigger system depends on relative stiffness of each element. One cannot assign forces arbitrarily to the core and outrigger columns. Belts improve the lateral system efficiency. With the help of belt truss and the outriggers system, the overall efficiency of the entire system increases.

## ADVANTAGES OF OUTRIGGER SYSTEMS

1. Reduction in deformation: A building with central core braced frame or a shear wall, in this type of structure with an outrigger system built perimeter columns to efficiently reduce the building deformations from the overturning moments and the resulting lateral displacements at higher floors. A tall building structure which is built with an outrigger system will definitely experience a reduction in core overturning moments.

2. Greater efficient Structure: For efficient structure, systems with belt trusses that surround all perimeter columns, it already sized for different loadings and capable of resisting outrigger forces with minimal changes in size or in the reinforcement. Different load factors are applied to the design combination with or without lateral loads. Outrigger system provides and permits optimization of the overall building system. For lower limits on core it requires strength and stiffness.

## II. LITERATURE REVIEW

1. **N. Herath, N. Haritos, T. Ngo & P. Mendis**, In this paper the author propose the study which shows the global behavior of outrigger braced building under earthquake loads in this study he found behavior of the structure under earthquake load is different from earthquake to earthquake. He also mentions that location of the outrigger beam has tremendous effect on the results.

2. **Anju Akbar And Sadic Azeez**, In this paper the author propose the study which shows the overall behavior of irregular building under the lateral loads with a multiple outrigger system with outriggers at top, bottom, and ¾ th of the building and the results were compared with the same building without outrigger system. He found significant reduction in lateral displacement, drift and overturning moment.
3. **Hi Sunchio, Goman Ho, Leonard Joseph and Neville Mathias**, In this paper the author propose the design guides which provide the overview of outrigger system including historical background, design considerations, design recommendations and contemporary examples on the outrigger system.
4. **Ajinkya Prashant Gadkari, N. G. Gore**, In this paper the author propose the study which shows the Outrigger and Belt trussed system is the one of the lateral load resisting systems that can provide significant drift control for tall buildings. The objective of this paper is to study, the performance of outrigger structural system in high-rise building subjected to seismic load and Wind Load.
5. **S. Fawzia, A. Nasir and T. Fatima,** In this paper the author propose the study which shows the paper conducted a study keeping in view the challenging nature of high-rise construction with no generic rules for deflection minimizations and frequency control. The above investigation comes to the conclusion that rigidity/stiffness of composite high-rise building is inversely proportional to its height i.e. the lateral stiffness decreases with increase in height of structure while keeping the other variable constant. Therefore introduction of additional bracing system is required to keep up with the serviceability limits.
6. **Abbas Haghollahi, Mohsen Besharat Ferdous, Mehdi Kasiri**, In this paper the author propose the study which shows when the outrigger beams are used in building design, their location in the optimum position for an economic design is necessary. The aim of this paper is to compare optimum outrigger locations obtained by response spectrum and nonlinear time-history analysis. Two models of 20 and 25 storey models have been investigated and response spectrum and time-history analyses have been carried out against seven ground motions. The finding of this study shows that the optimized location of outrigger with nonlinear time-history is different from response spectrum analyses and it has been located in upper levels.
7. **P.M.B. Raj Kiran Nanduri, B.Suresh, MD. Ihtesham Hussain**, The objective of this thesis is to study the behavior of outrigger and, outrigger location optimization and the efficiency of each outrigger when three outriggers are used in the structure. In Nine 30−storey three dimensional models of outrigger and belt truss system are subjected to wind and earthquake load, analyzed and compared to find the lateral displacement reduction related to the outrigger and belt truss system location. For 30−storey model, 23% maximum displacement reduction can be achieved by providing first outrigger at the top and second outrigger in the structure height. The influence of second outrigger system is studied and important results are tabulated and drawn.
8. **Christian Sandelin, Evgenij Budajev**, This thesis examines the effectiveness of the Tubed mega frame compared to other structural systems. Using Finite Element Method (FEM-) programs studies on previously used structural systems along with the Tubed mega frame has been made. The tubed mega frame shows to require a large amount of concrete compare to other systems at lower heights, because of its geometry. As the height increases it does show an increase in effectiveness and by the time it reaches 480 meters it is using less materials and still achieving greater stiffness than other systems. Since the geometry of the Tubed mega frame is so flexible a conclusion is also made that the stiffness can be increased by sacrificing façade area or creating longer outriggers.
9. **Z. Bayati, M. Mahdikhani, and A. Rahaei**, In this paper the author propose the study which shows techniques which are used in belt trusses and basements as outriggers in tall buildings have been proposed. Belt trusses used as virtual outriggers offer many benefits. However, with the same outrigger column sizes and locations, virtual outriggers will be less effective than conventional direct outriggers because of the reduced stiffness of the indirect force transfer mechanism. In the lateral load analysis of a building with the proposed outrigger system, the in-plane stiffness of the floors that transfer horizontal forces from the core to the outriggers should be modeled accurately. These floors cannot reasonably be idealized as rigid diaphragms.

## III. MODELING AND ANALYSIS

In this study the RCC model of multi-storey building G+15 is created. the RCC multistory building is analyzed for earthquake and the behavior of building under seismic effect is studied. Each model have the outrigger beam of at different level and building is also provided with shear wall at the corners of each building. The Different Model of Multistory Building is Analyzed By Using STAAD PRO Software. Following are the tabulated parameter selected for analysis.

| PARAMETER | DIMENSIONS |
|---|---|
| SIZE OF COLUMN | 400 X 500 MM |
| SIZE OF BEAM | 300 X 400 MM |
| LIVE LOAD | 3 KN/M^2 |
| SLAB THICKNESS | 100 MM |
| BAY ALONG X-DIR. | 5 |
| BAY ALONG Z - DIR | 5 |
| FLOOR FINISH | 1 KN/M^2 |
| STOREY HT. | 3 M |
| SPACING OF COL. | 4M |

| | |
|---|---|
| DEPTH OF FOUNDATION | 3 M |
| DENSITY OF CONCRETE | 25 KN/M^2 |
| DENSITY OF BRICK | 19 KN/M^2 |
| THICKNESS OF INTERNAL WALL | 115MM |
| THICKNESS OF EX. WALL | 230 MM |
| PARA. WALL HT. | 1M |
| ZONE | III |
| SOIL TYPE | MEDIUM SOIL |
| IMPORTANCE FACTOR | 1.5 |
| STRUCTURE TYPE | CONCRETE STRUCTURE |
| LOAD COMBINATION | 1.5 (DL+LL)<br>1.2(DL+LL+_ EQ)<br>1.5(DL+_EQ)<br>0.9DL+_1.5EQ |
| SUPPORT TYPE | FIXED TYPE |
| SIZE OF BUILDING | 20 X 20 M |

**Table no. 1 Parameter for Modeling**

The building of G+15 is modeled as per tabulated parameter in table. the model of G+15 is created and analyzed without shear wall and outrigger beam, the model is Named as Bare frame(BF). in BF model results of Avg. Displacement and Drift is observed.

For outrigger model the two different beam is consider one with deep beam and another with I-beam. The outrigger beam is provided at various levels 5th, 10th and 15th floor. The outrigger beam model is provided with shear wall at all four corners in L-shape

| SHEAR WALL SHAPE | DIMENSION |
|---|---|
| L - SHAPE | 4M LENGTH IN X & Z DIRECTION |

**Table no. 2 Parameter for Modeling of shear wall**

| SECTION | PARAMETER |
|---|---|
| DEEP BEAM ( D ) | 450MM X 1M |
| I-BEAM ( I ) | FLANGE WIDTH = 750 MM, WEB THICKNESS = 220MM, DEPTH OF BEAM = 700MM, THICKNESS OF FLANGE = 145MM |

**Table no. 3 Parameter for different Beam sections**

| MODEL NAME | DENOTATION |
|---|---|
| BF | BARE FRAME MODEL |
| OT- 5D | OUTRIGGER BEAM AT 5TH FLOOR AS DEEP BEAM |
| OT- 10D | OUTRIGGER BEAM AT 10TH FLOOR AS DEEP BEAM |
| OT- 15D | OUTRIGGER BEAM AT 15TH FLOOR AS DEEP BEAM |
| OT- 5I | OUTRIGGER BEAM AT 5TH FLOOR AS I-BEAM |
| OT- 10I | OUTRIGGER BEAM AT 10TH FLOOR AS I-BEAM |
| OT- 15I | OUTRIGGER BEAM AT 15TH FLOOR AS I-BEAM |

**Table no. 4 Model Name**

As per IS 1893:2002 the zone of earthquake in India is divided in four zones as follows, (Clause 6. 4. 2, Table 2, Pg. 16)

| ZONE | II | III | IV | V |
|---|---|---|---|---|
| INTENSITY | 0.10 | 0.16 | 0.24 | 0.36 |

**Table no. 5 Intensity of Zones**

As per Clause 6. 4. 2, the design horizontal seismic coefficient ($A_h$)

$$A_h = \frac{Z}{2} \; \frac{I}{R} \; \frac{Sa}{g}$$

The Response Reduction Factor (R) as Per IS1893:2002 Clause 6. 4. 2, Table No.7

| SYSTEM | R |
|---|---|
| SMRF | 3 |
| OMRF | 5 |

**Table no. 6 Response reduction factor**

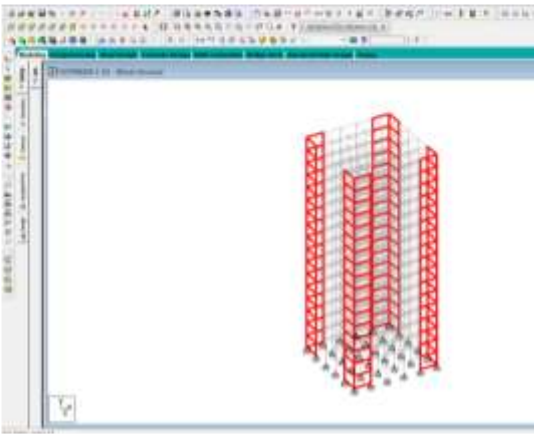


**Fig. no. 1 STAAD PRO model of Outrigger model (shear wall )**

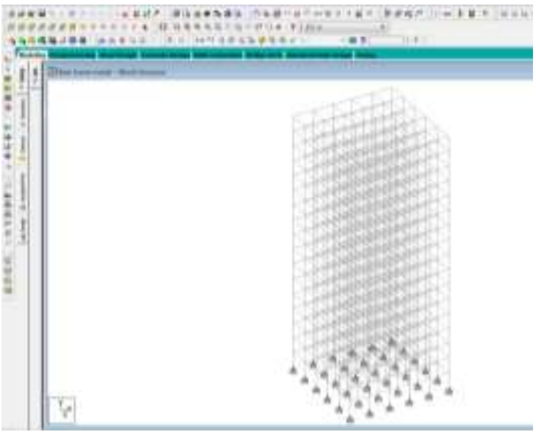


**Fig. no. 2 STAAD PRO model of Bare Frame model**

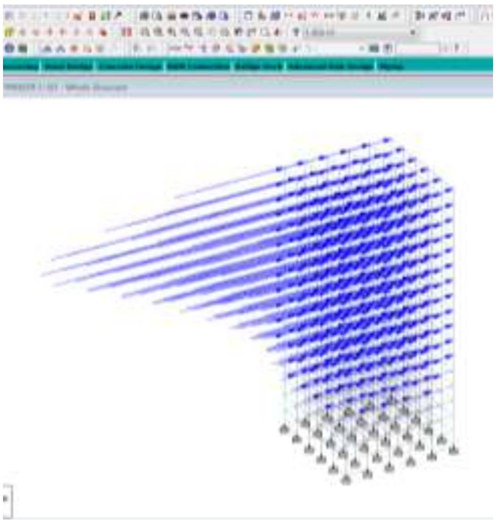
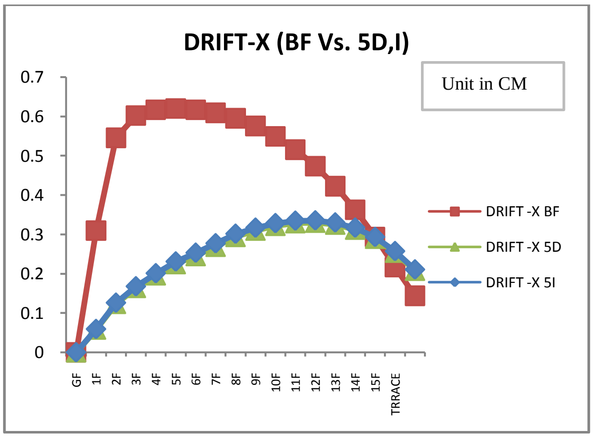
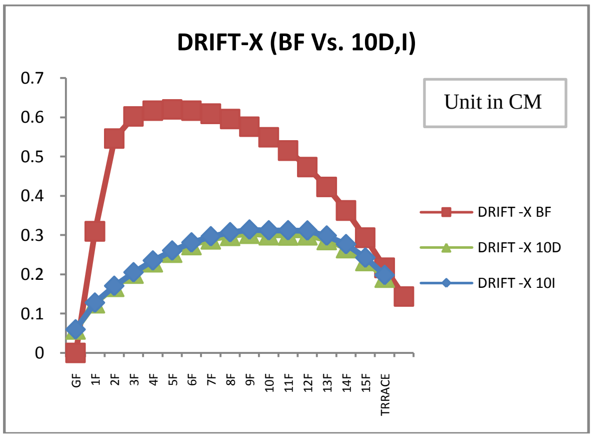


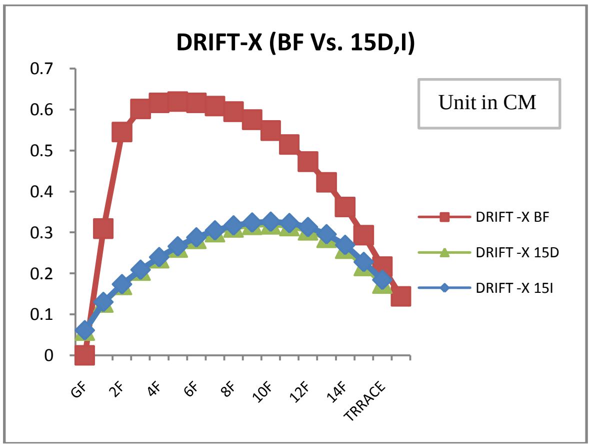
**Fig. no. 3 STAAD PRO model show EQ +X force**



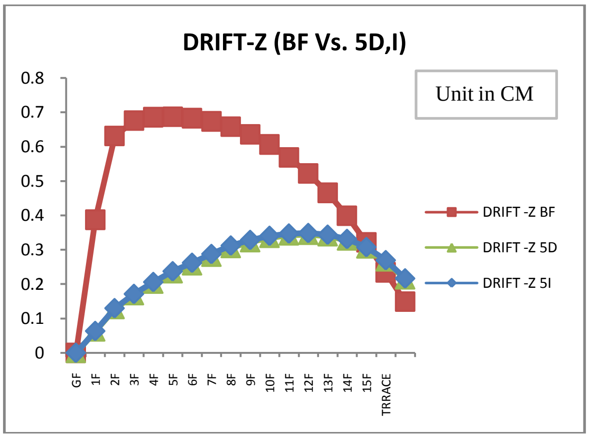

**Graph no. 1 Drift along x direction (BF vs 5D,I)**



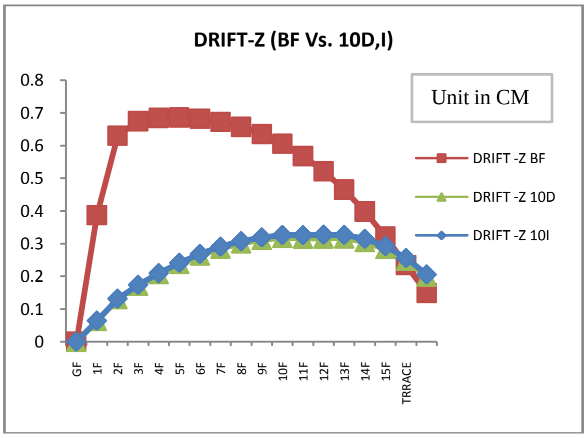

**Graph no. 2 Drift along x direction (BF vs 10D,I)**



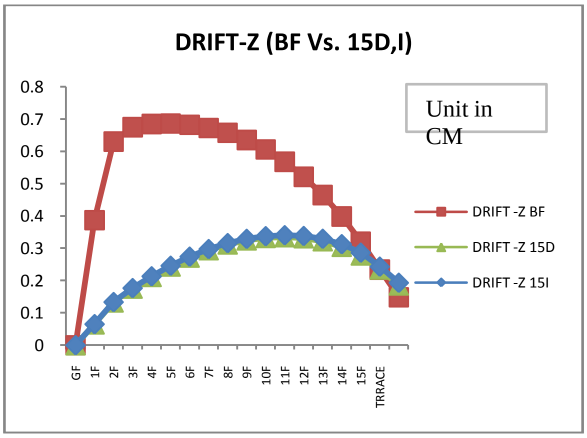

**Graph no. 3 Drift along x direction (BF vs 15D,I)**



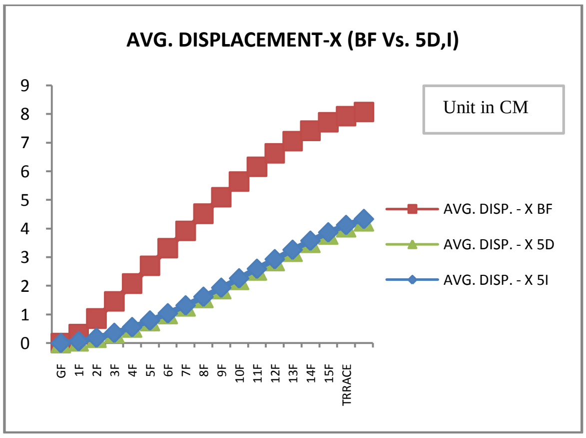

**Graph no. 4 Drift along z direction (BF vs 5D,I)**



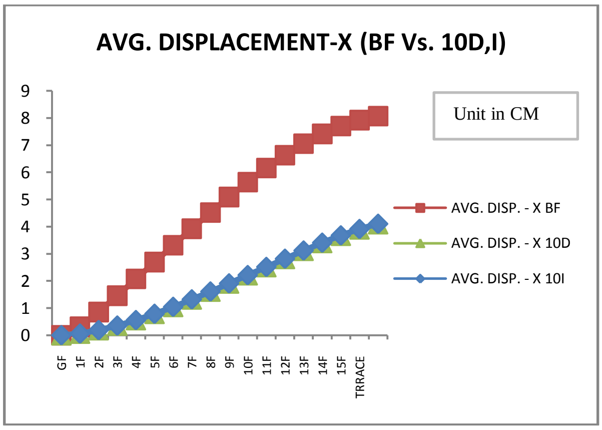

**Graph no. 5 Drift along z direction (BF vs 10D,I)**



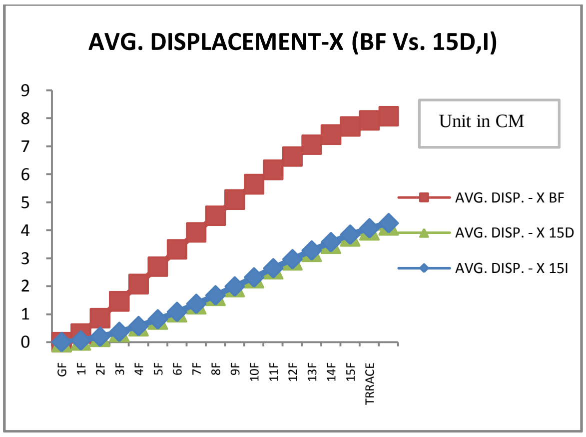

**Graph no. 6 Drift along z direction (BF vs 15D,I)**



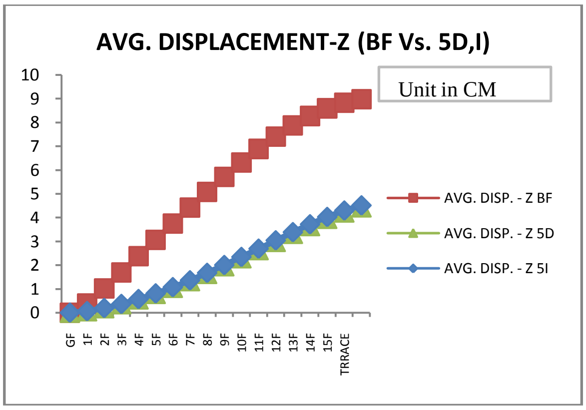

**Graph no. 7 Avg. Displacement along x direction (BF vs 5D,I)**



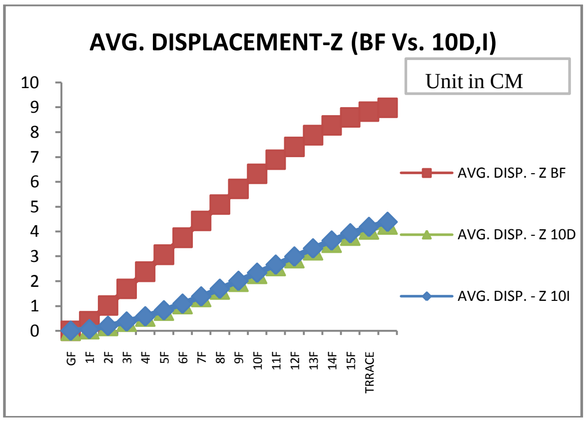

**Graph no. 8 Avg. Displacement along x direction (BF vs 10D,I)**



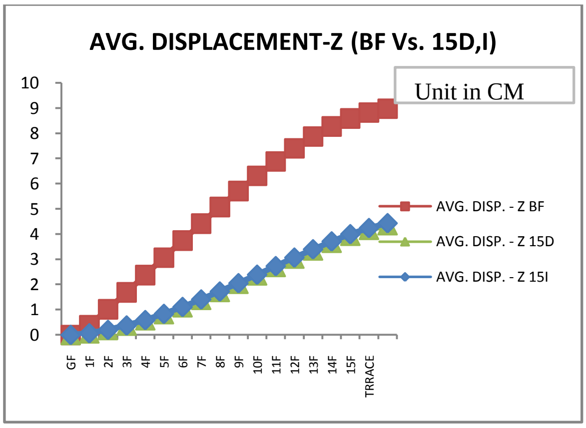

**Graph no. 9 Avg. Displacement along x direction (BF vs 15D,I)**




**Graph no. 10 Avg. Displacement along z direction (BF vs 5D,I)**




**Graph no. 11 Avg. Displacement along z direction (BF vs 10D,I)**




**Graph no. 12 Avg. Displacement along z direction (BF vs 15D,I)**

## IV. CONCLUSION

The Drift And Avg. Displacement of Models is Calculated. The Different Outrigger Models results are Compared With Bare Frame Model (BF).

1. The analyzed bare frame model shows the maximum drift and maximum avg. Displacement.
2. The deep beam outrigger beam and I-beam outrigger beam at 5th, 10th and 15th with shear wall reduces the storey drift up to 53%(approx.) When compared with bare frame model.
3. The I-beam model shows the slightly high storey drift when compared to deep beam model for 5th, 10th and 15th floor multistory building.
4. The deep beam outrigger beam and I-beam outrigger beam at 5th, 10th and 15th with shear wall reduces the avg. Displacement up to 50%(approx.) When compared with bare frame model.
5. The avg. Displacement of I-beam model is more when compared with deep beam model.
6. The avg. Displacement and drift of I-beam is 5%(approx) more than deep beam but the depth of I-beam is less when compared with deep beam.

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