A Comparative Study of Tall R.C. Building with Outriggers and Shear Wall.

[1]Nitin Patel, [2]Chetan Machhi

[1]Student M.tech., [2]Asst. Professor
[1]Post-Graduation (Structural Engineering) Department,
[1]Sardar Patel College of Engineering, Anand, India

***Abstract**:* Now, a day's tall structure and building are mostly need for human being in urban areas. and tall structure are mostly build with central core (comprising of shear wall or braced frame) at the center of building.
The central core consumes a large part of area of floor space and so that less space are profitable for use for residential and commercial use of building. At some height of building the central core would not be sufficient to keep structure stable. Now a day's seismic resistant design is mostly used for tall structure and outrigger system to resist lateral force of building, so that it needs to be connected with outrigger system. From Analytical study, we will be observed that among various configuration, outrigger system offers better resistance to applied lateral loads. And so that we will analysis the structure without outrigger (shear wall or braced frame) and outrigger system and study the behaviour of tall building. The three sets of outrigger models, same models but at different height of building are subjected to earthquake load and analysis for G+29 storey tall reinforced building and compared to find storey displacement, storey drift, base shear. The dynamic analysis is carried out based on Indian standard code IS-875(PART 3), Earthquake load using Response spectrum method by IS-1893 PART1(2016). the analysis will be done for zone 3 and zone 5, The location of outrigger will be used for three optimum position G+9 storey height, G+19 storey height, and G+29 storey height of same building. ETABS computer software will be used for analysis.

Keywords – Outrigger system, tall building, storey drift, Storey displacement, base shear, ETABS.

1. INTRODUCTION

When the building is narrow and specifically in case of shear wall buildings that, your core wall is generally located in the center and it gets huge overturning moments either because of wind or earthquake and it kind of acts like the first image that I showed of a person standing on one leg without any support. It is sensitive and unstable. Image shown below shows the amount of forces that a shear wall resists and the behavior of the shear wall under these tremendous forces.

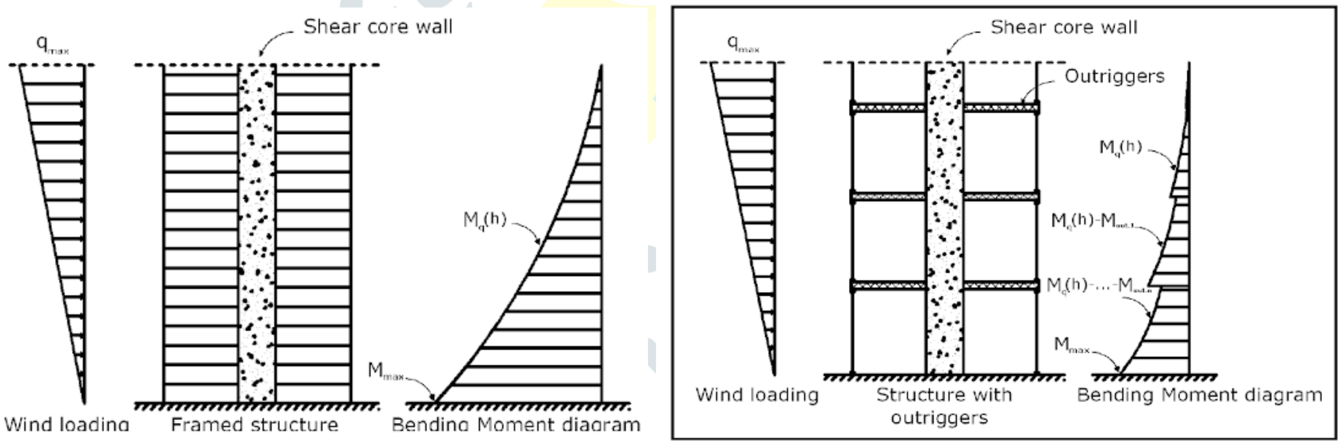


Fig 1.1 Reduction in bending moments because of outriggers

The floor space is usually free of columns and is between the core and the external columns, thus increasing the functional efficiency of the building. Exterior columns restrained the core wall from free rotation through outrigger arms. Outrigger and belt trusses, connect planar vertical trusses and exterior frame columns. Outrigger system can lead to very efficient use of structural materials by mobilizing the axial strength and stiffness of exterior columns.

1.2 TYPES OF OUTRIGGER TRUSS SYSTEM

1.2.1 Conventional Outrigger Concept

In the conventional outrigger concept, the outrigger trusses or girders are connected directly to shear walls or braced frames at the core and to columns located outboard of the core. Typically (but not necessarily), the columns are at the outer edges of the building.

1.2.2. Virtual Outrigger Concept

In the "virtual" outrigger, the same transfer of overturning from the core to elements outboard of the core is achieved, but without a direct connection between the outrigger trusses and the core. The basic idea behind the virtual outrigger concept is to use floor diaphragms, which are typically very stiff and strong in their own plane.

1.2.3. Belt Trusses as Virtual Outriggers

The use of belt trusses as virtual outriggers avoids many of the problems associated with the use of conventional outriggers. The principle is the same as when belt trusses are used as virtual outriggers. Some fraction of the moment in the core is converted into a horizontal couple in the floors at the top and the bottom of the basement.

1.3 TYPES OF OUTRIGGERS AS PER MATERIAL

There are several different types of outrigger system, such as steel outriggers, concrete outriggers, and hybrid outrigger (using both concrete and steel material). Among them, steel outriggers are most conventional type outriggers. The famous examples are: Twin Tower (collapsed in the 9/11 attack) and the Shard in London. Concrete outriggers are used in some tall buildings. One of the famous examples is 432 Park Avenue building in New York. With the development of the construction technology, new types. of outriggers such as hybrid outriggers and damped outriggers have emerged in the construction projects.

1.3.1 Concrete Outrigger

The benefit of concrete outrigger system verses steel is high stiffness and low cost. Under wind load cases, the outrigger system needs to be of stiff concrete deep beam or of concrete wall which can be easily achieved by this fig shows a typical outrigger using concrete. This type of system is more common in a concrete structure rather than in a steel frame structure.

FIG 1.2. Concrete outrigger

1.3.2 Steel Outrigger

Steel outrigger systems are extensively used in a lot of tall buildings as most of tall buildings are either steel or composite structural system. In the conventional design, the outrigger is designed to be a story height truss.

FIG 1.3 Steel outrigger

1.3.3 Hybrid Outrigger

The steel outrigger is not as stiff as concrete outrigger. However, a pure concrete outrigger system is very brittle. An innovative type of steel-concrete hybrid outrigger truss was developed in two 370-m tall mega-high-rise towers in Raffles City Chongqing, in which the steel truss is embedded into the reinforced concrete outrigger wall as shown in fig. Both the steel truss and the concrete outrigger wall work compositely to enhance the overall structural performance of the tower structures under extreme loads.

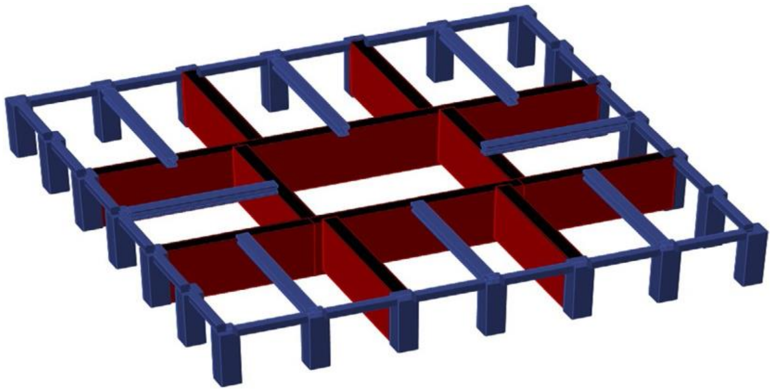


Fig. 1.4 A typical outrigger using concrete wall modeled using ETABS.

1.4 SHEAR WALL

1.4.1. What are Shear Walls?

Shear wall is a structural member used to resist lateral forces i.e. parallel to the plane of the wall. For slender walls where the bending deformation is more, Shear wall resists the loads due to Cantilever Action. In other words, Shear walls are vertical elements of the horizontal force resisting system.

In building construction, a rigid vertical diaphragm capable of transferring lateral forces from exterior walls, floors, and roofs to the ground foundation in a direction parallel to their planes. Examples are the reinforced-concrete wall. Lateral forces caused by wind, earthquake, and uneven settlement loads, in addition to the weight of structure and occupants, create powerful twisting (torsional) forces. This leads to the failure of the structures by shear.

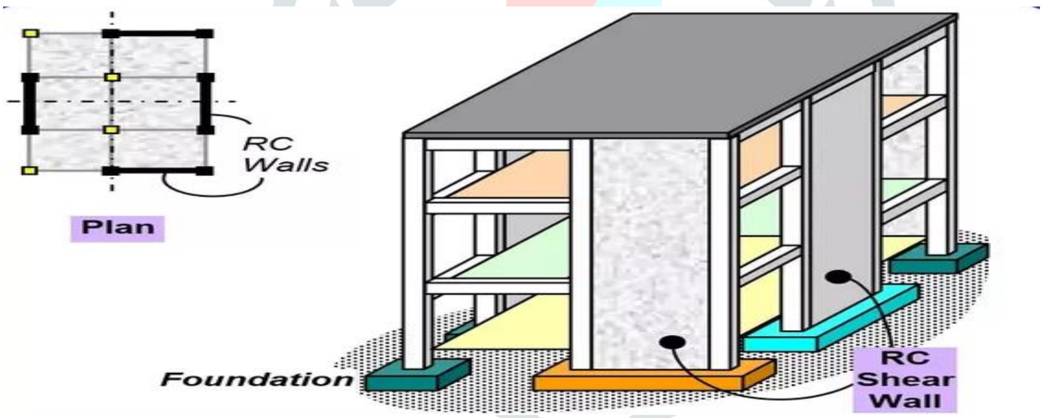


Fig 1.5 Shear Wall in R.C. Structure

Shear walls are especially important in high-rise buildings subject to lateral wind and seismic forces. Generally, shear walls are either plane or flanged in section, while core walls consist of channel sections. They also provide adequate strength and stiffness to control lateral displacements.

2. MODELLING AND ANALYSIS

2.1 MODEL CONFIGURATION

Table 2.1: Model Configuration

No of stories	G+29
floor height	3 m
Total height of building	90 m
Plan area	35 m x35 m
Column size (1-10 Storey)	600 x900 mm
Column size (11-20 Storey)	600 x600 mm
Column size (21-30 Storey)	450 x450 mm
Beam size (1-10 Storey)	450 x600 mm
Beam size (11-30 Storey)	450 x450 mm
Slab Thickness	150 mm
Concrete grade	M 30
Outrigger size	ISA 200X150X15
Shear wall thickness	150 mm
Dead load	1.5 KN/m^2
Live load	4 KN/m^2
Location	Ahmedabad & Bhuj

Models are as follows:

Model A: Frame model of G+29

Model B: R.C. Building with center core

Model C: R.C. Building with shear wall

Model D: outrigger at G+9 Story

Model E: outrigger at G+19 Story

Model F: outrigger at G+29 Story

Model G: outrigger at G+9, G+19 and G+29 Story

Model H: shear wall and outrigger at G+9 Story

Model I: shear wall and outrigger at G+19 Story

Model J: shear wall and outrigger at G+29 Story

Model K: shear wall and outrigger at G+9, G+19 and G+29 Story

ZONE: III (Ahmedabad) and V (Bhuj)

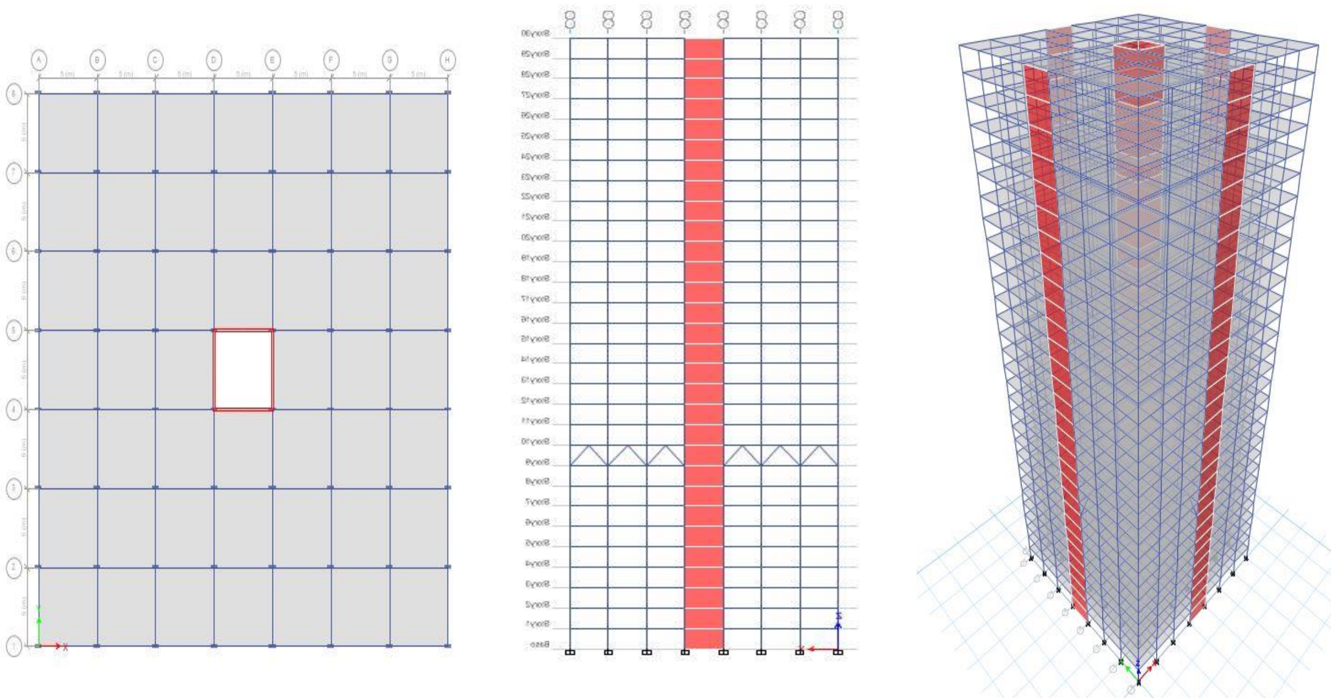
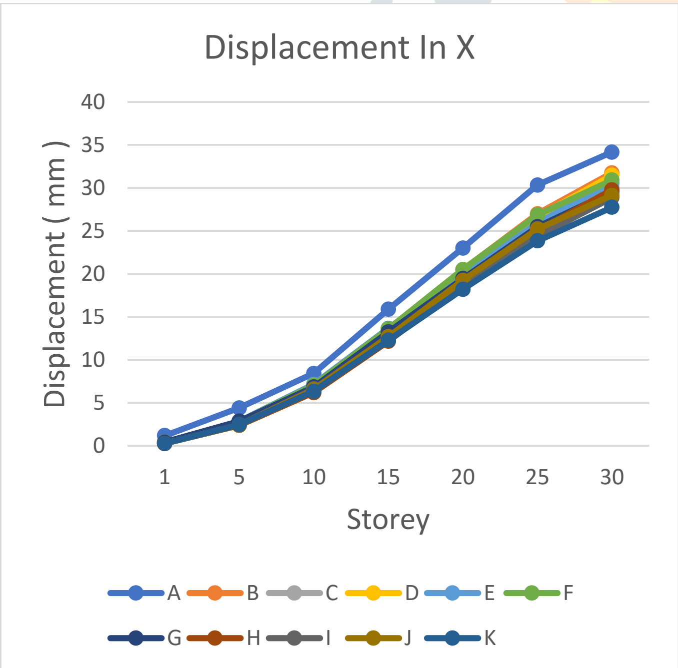


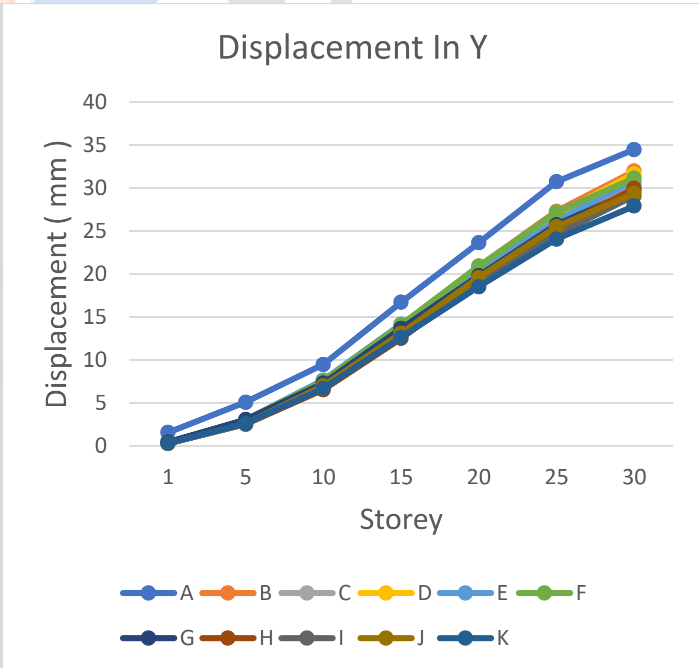
Fig 2.1 Plan & Elevation of Outrigger and Shear Wall At G+9 Building.

3. RESULTS:

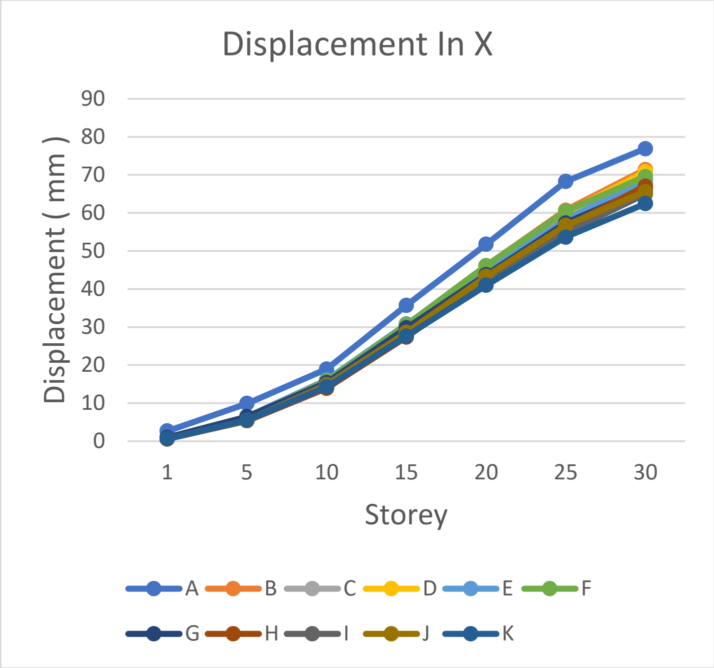
3.1 STOREY DISPLACEMENT

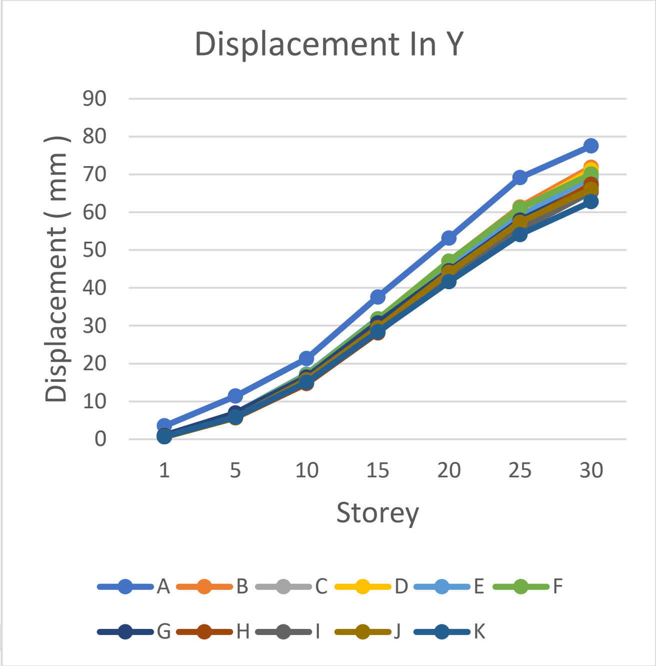
Model: Z-0.16





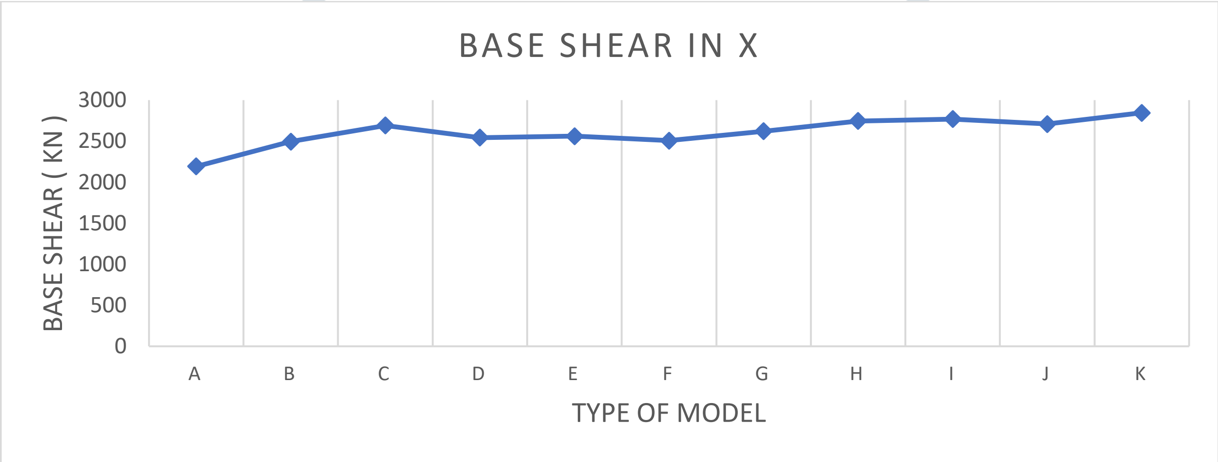
Model: Z-0.36

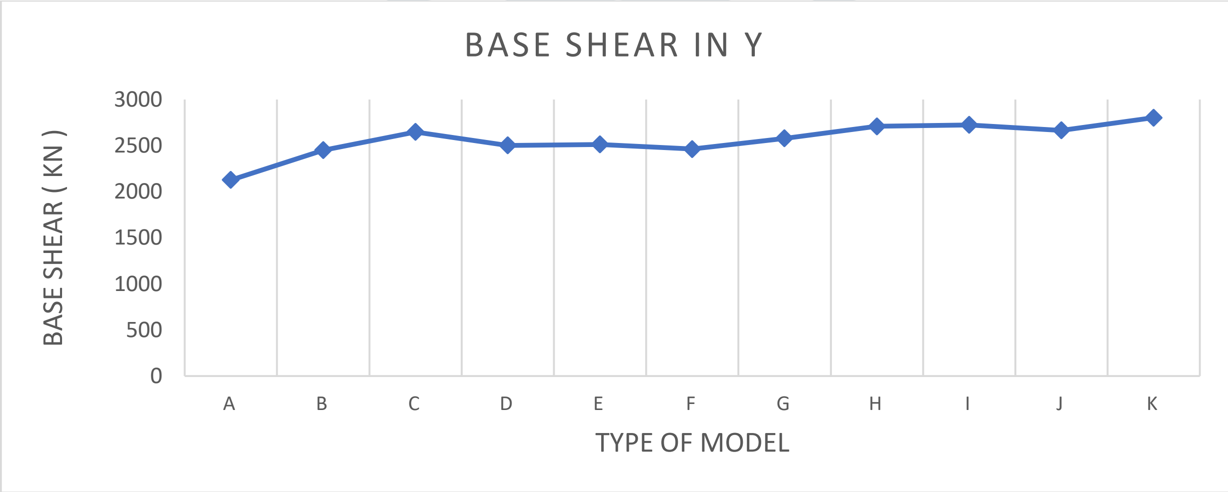




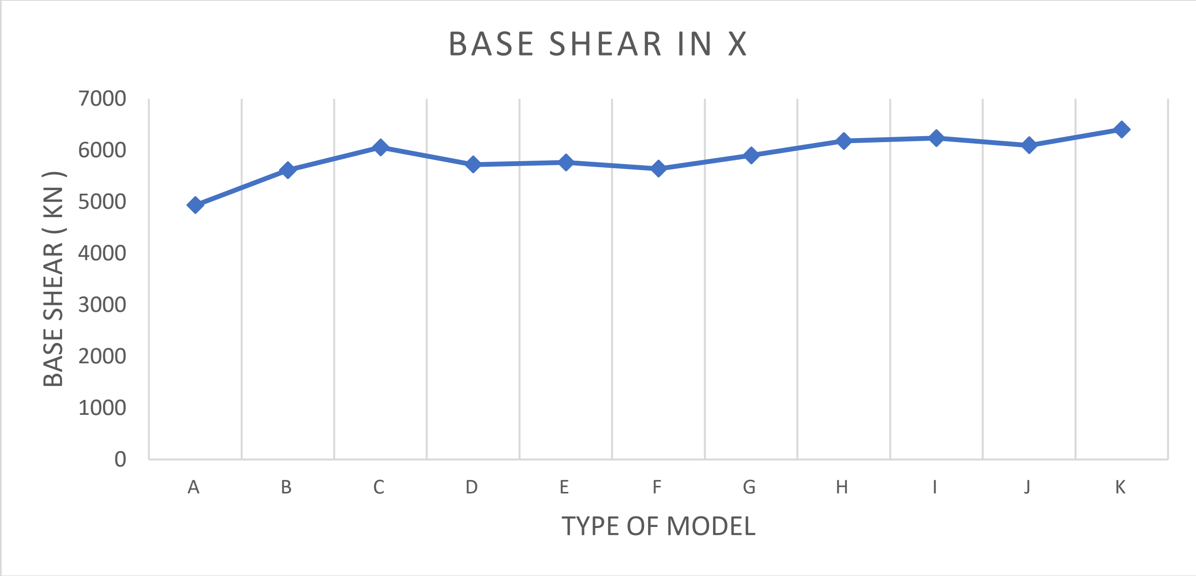
3.2 BASE SHEAR

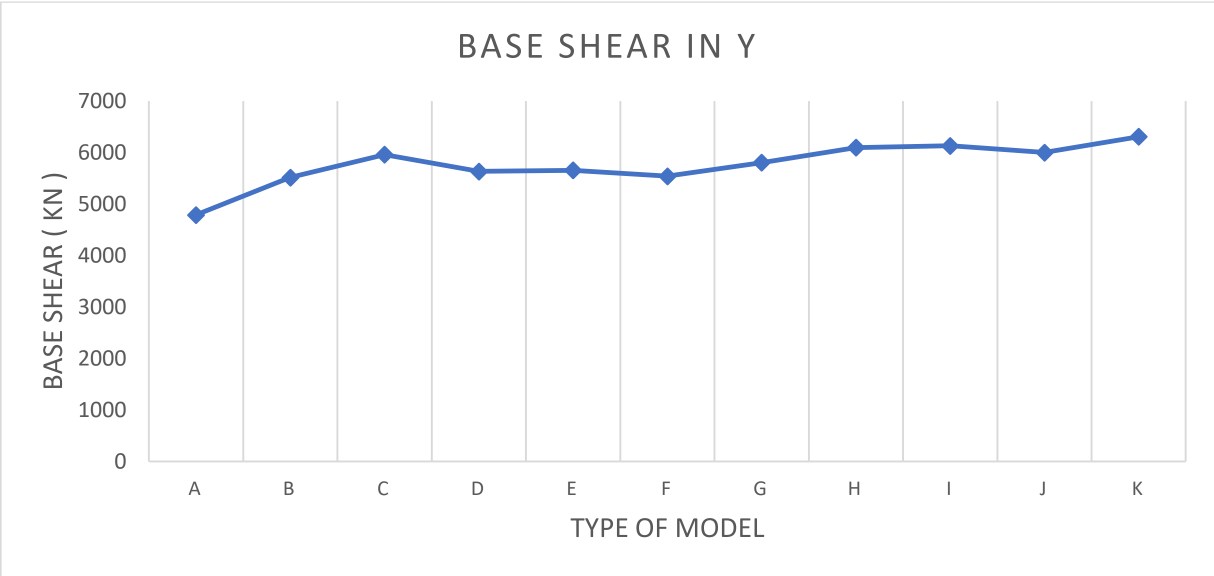
Model: Z-0.16





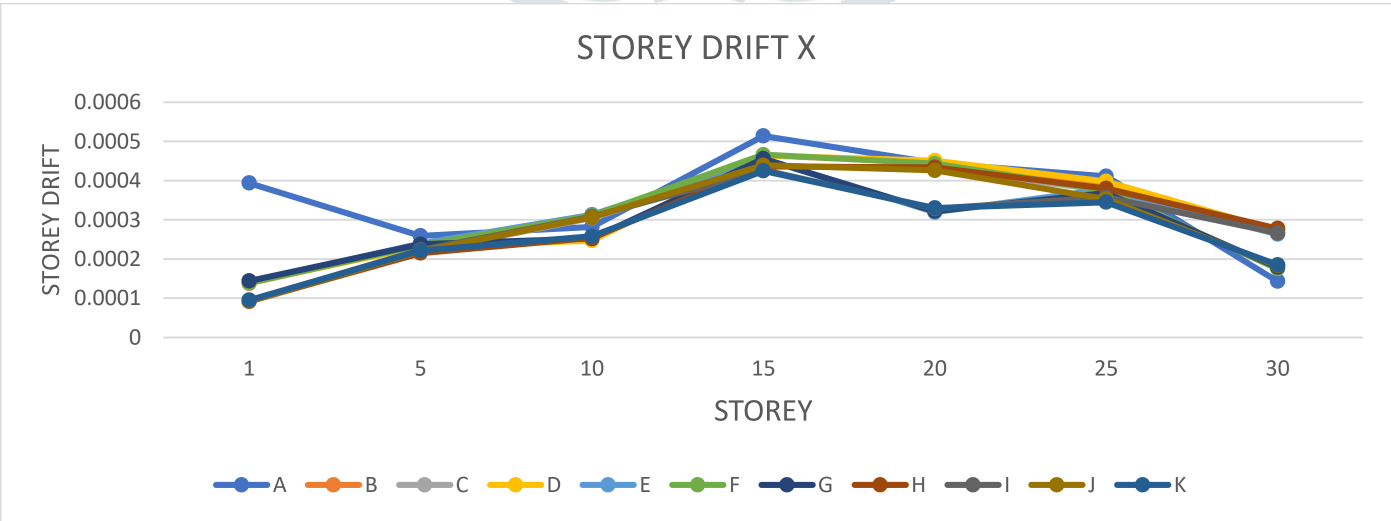
Model: Z-0.36

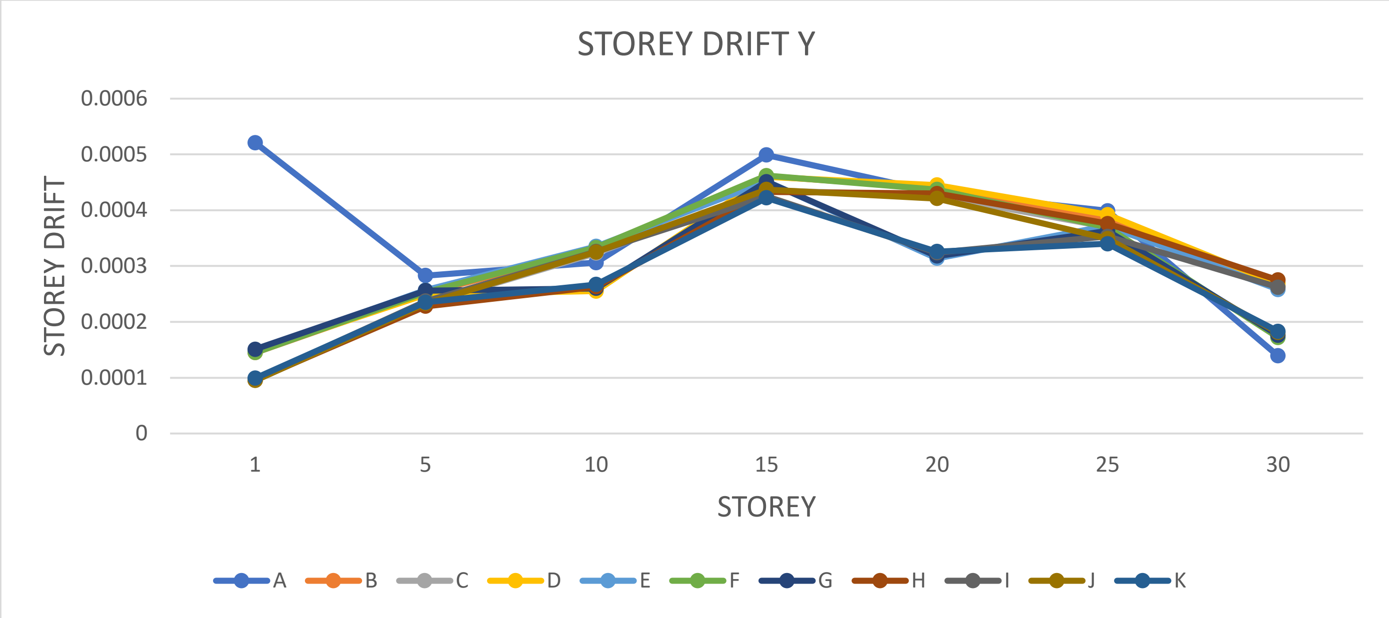




3.3 STOREY DRIFT

Model: Z-0.16

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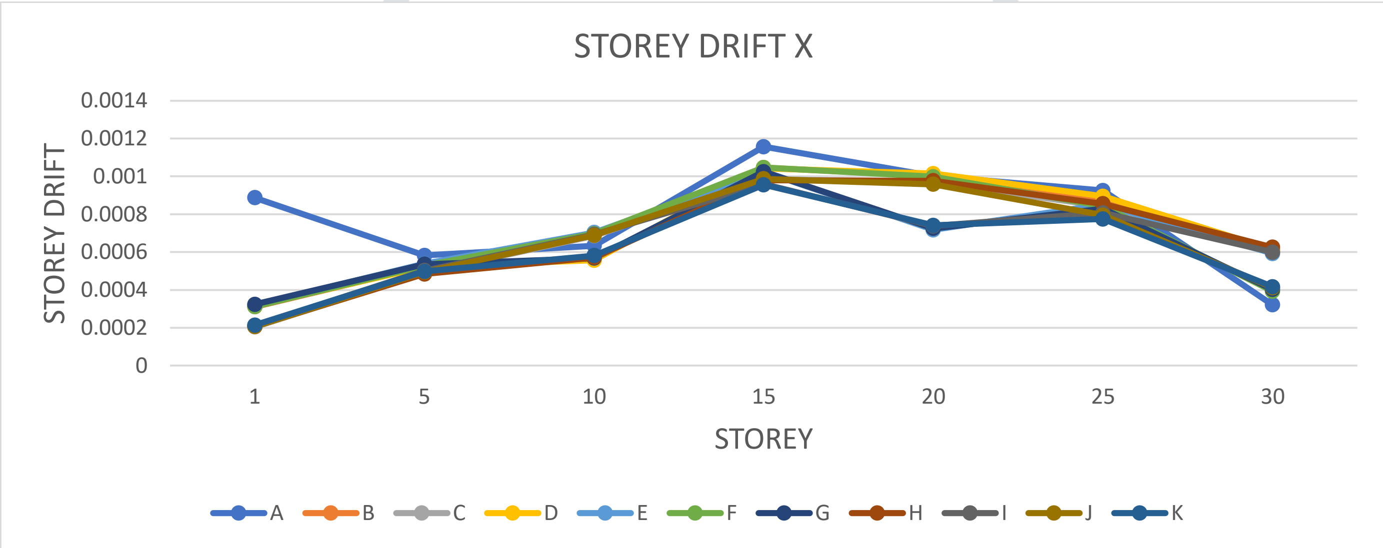
Model: Z-0.36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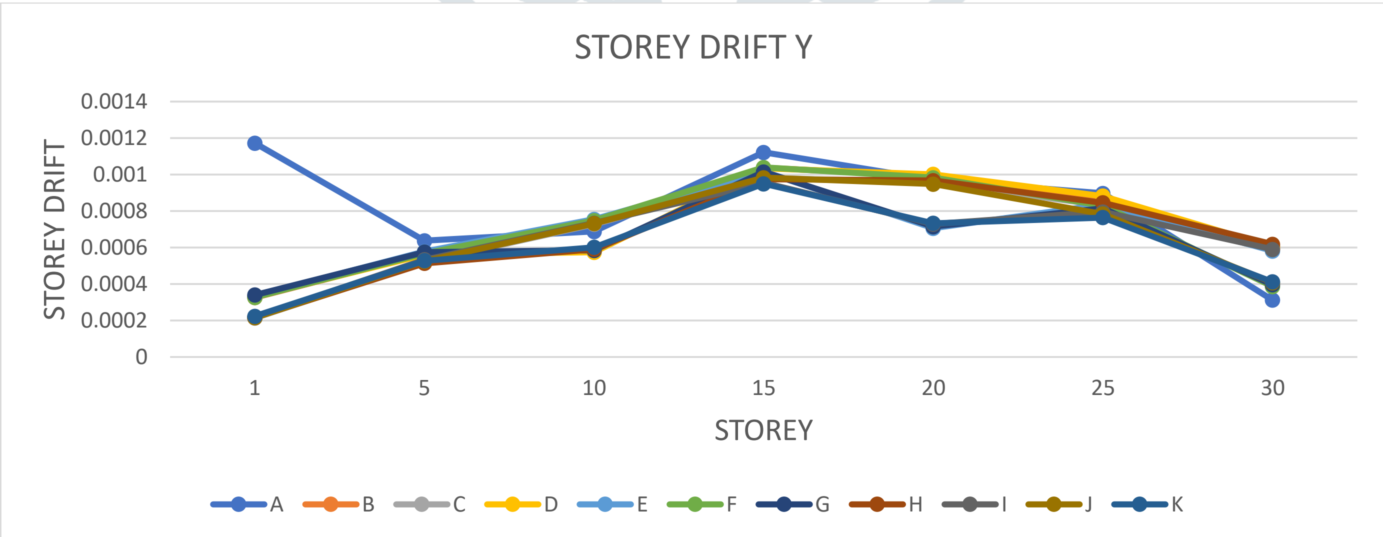
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Conclusion:

- Using the shear wall and outrigger both in building reduces the storey displacement compare to shear wall and outrigger indivisual.
- Optimum location of outrigger is found at G+19 of building to better reduction of storey displacement and storey shear.
- The outrigger system is better than shear wall is found from observation.
- It is observed from analysis that outrigger of all three set G+9, G+19 and G+29 in building are better than shear wall to reduce storey displacement and storey drifts.
- It is also observed that shear wall with outrigger in same building are better than only outrigger in building.

References

- NIKHIL NISHANT And MAMATHA A “OPTIMUM POSITION OF AN OUTRIGGER SYSTEM IN A HIGH RISE REINFORCED CONCRETE BUILDING’’ **International Journal of Recent Trends in Engineering & Research (IJRTER)** Volume 04, Issue 06; June - 2018 [ISSN: 2455-1457]
- JUNAIS AHMED AK, YAMINI SREEVALLI “Application of Outrigger In Slender High Rise Buildings To Reduce Fundamental Time Period” International Journal of Mechanical And Production Engineering, ISSN: 2320-2092, Volume-2, Issue-7, July-2014
- Shivacharan k, Chandrakala S, Narayana G, Karthik N M “Analysis Of Outrigger System For Tall Vertical Irregularities Structures Subjected To Lateral Loads” **IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308**
- P.M.B. Raj Kiran Nanduri, B. Suresh, MD. Ihtesham Hussain “Optimum Position of Outrigger System for High-Rise Reinforced Concrete Buildings Under Wind and Earthquake Loadings” **American Journal of Engineering Research (AJER)** e-ISSN: 2320-0847 p-ISSN: 2320-0936 Volume-02, Issue-08, pp-76-89
- Dhanaraj M. Patil, Keshav K. Sangle” Seismic behaviour of outrigger braced systems in high rise 2-D steel buildings” Reference: ISTRUC 133, doi: 0.1016/j.istruc.2016.07.005
- Kidong Park, Daeyoung Kim, Donghyun Yang, Daeki Joung, Inho Ha and Sangdae Kim“A Comparison Study of Conventional Construction Methods and Outrigger Damper System for the Compensation of Differential Column Shortening in High-rise Buildings” International Journal of Steel Structure December 2010, Vol 10, No 4, 317-324
- Srinivas Suresh Kogilgeri1, Beryl Shanthapriya “A Study on Behaviour Of Outrigger System on High Rise Steel Structure by Varying Outrigger Depth” IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308
- S. K. Madan, R. S. Malik, V. K. Sehgal “Seismic Evaluation with Shear Walls and Braces for Buildings” World Academy of Science, Engineering and Technology International Journal of Computer and Information Engineering Vol:9, No:2, 2015
- P. P. Chandurkar, Dr. P. S. Pajgade “Seismic Analysis of RCC Building with and Without Shear Wall’’ International Journal of Modern Engineering Research (IJMER) www.ijmer.com Vol. 3, Issue. 3, May - June 2013 pp-1805-1810
- IS 1893 (Part1):2002 Indian Standard, “Criteria for earthquake resistant design of structure General provision and buildings”, Bureau of Indian Standard, New Delhi.
- IS-456:2000, “Plain and reinforced concrete-code of practice” by Bureau of Indian Standard, New Delhi.
- IS-456, “Code of practice for plain and reinforced concrete code of practice”, Bureau of Indian Standards, New Delhi, 2000.
- IS-875:1987, “Code for Wind load design of structures- general provisions for buildings”, Part III, Bureau of Indian Standards”, New Delhi.