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ANALYSIS OF HIGH-RISE BUILDING USING RCC VIRTUAL OUTRIGGER SYSTEM

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Abstract— **The development of high-rise buildings has progressed rapidly in recent years, especially in metropolitan cities, mainly to tackle the problem of acute housing shortage caused due to the enormous growth of population. Also, the rapid developments in the modern construction materials, technological innovations in the construction sector and structural systems have given rise to increased use of high-rise buildings. The high-rise building should be design with lateral load resisting system to resist earthquake and wind forces. To address these challenges outrigger system is proved efficient technique than other lateral load resisting technique. In this paper behavior of RCC high-rise building is studied with and without using RCC virtual outrigger at different locations. The 42-storeid RCC high-rise building is analyze using response spectrum method in ETABS2018 software and earthquake responses namely storey displacement, base shear and storey drift for individual model. It is observed that, the providing outrigger reduces the storey displacement significantly. In addition, the optimum location of outrigger is also obtained by comparative study of earthquake responses.**

Keywords— **High-Rise Building, RCC Virtual Outrigger, Response Spectrum Method, ETABS2018.**

I. INTRODUCTION

The rapid developments in the modern construction materials, technological innovations in the construction sector and structural systems have given rise to increased use of high-rise building. In India, like any other developed country, high rise buildings are emerging due to increase in population density. As most of the part of India is susceptible to damaging levels of seismic hazards, high rise structures need to be designed earthquake resistant to minimize the lateral displacement.

There are various lateral load resisting systems employed in high-rise buildings as earthquake or wind forces create complexities. These lateral forces can produce critical stresses and undesirable vibrations and may cause excessive lateral sway of the structure. To address these problems or challenges, the existing techniques such as bracing, isolation, dampers and outriggers etc. perform well to safeguard the structures against wind and seismic forces “Bhati et al” (2016). However, the outriggers system has proved to be a dominant lateral load resisting system in high-rise buildings for minimizing the vibrations and lateral displacement; and improves the stiffness. The outriggers are deep and rigid horizontal beam/truss elements designed to enhance building’s overturning stiffness and strength by connecting the core shear wall.

The present paper focuses on the basic information of outrigger system, incorporation of RCC virtual outrigger system in high-rise building, behavior of high-rise building due to the effect of outrigger system and determine the optimum location of outrigger system by analyzing outriggers provided at different location.

II. OUTRIGGER SYSTEM

The outriggers are deep and rigid horizontal beam/truss elements designed to enhance building’s strength and overturning stiffness by connecting the core shear wall from external column. It is used in both types of building namely RCC or Steel and is generally made up of steel, concrete or composites. The outrigger system is generally classified as conventional outrigger system and virtual outrigger system. In the conventional system, external columns are linked to the core wall of building with very stiff outriggers. But in the virtual system, the outriggers are used to engage the peripheral columns of the building with each other “Mithbhakare et al” (2020). The both these systems can be used as structural systems to reduce the displacements produced by lateral loads. Hence, during wind or earthquake load, the use of outrigger or belt truss system reduces the possibility of structural and non-structural damages “Gadkari et al” (2016).

III. OBJECTIVES

The following are the main objectives of the project work:-

1. To analyze 42 Storied RCC high-rise building provided with and without RCC virtual outriggers system for seismic loading using ETABS software.

2. To carry out behavioral study of RCC virtual outriggers in high-rise building under consideration for responses namely storey drift, base shear and lateral displacement.

3. To determine optimum locations of RCC virtual outrigger system provided to the high-rise RCC buildings

IV. MODELLING CASES OF HIGH-RISE BUILDING

Modeling and analysis of building with and without an outrigger structural system is done by using ETABS2018 software. In this paper, RCC concrete virtual outriggers are provided at different locations. The model cases of the building under consideration with and without the outriggers are as given below:
A) Model 1- RCC building frame model without outriggers.
B) Model 2- Structural Model with one RCC Outrigger at the top floor and another at 3/4th height of the building i.e. 42th and 32th storey (Figure 2).
C) Model 3- Structural Model with one RCC Outrigger at the top floor and another at 1/2th height of the building i.e. 42th and 21th storey (Figure 3).
D) Model 4- Structural Model with one RCC Outrigger at the top floor and another at 1/4th height of the building i.e. 42th and 11th storey (Figure 4).

V. DETAILED MODELLING AND ANALYSIS OF 42-STOREY HIGH-RISE RCC BUILDING

A 42 storey RCC model has been considered for seismic analysis. The response spectrum method is used and earthquake responses namely storey displacement, base shear, storey drift is obtained for each individual model. The software used for analysis is ETABS2018.
The geometrical data for building is given below in Table 1 and plan of the building shown in Fig. 1.

Table -1 Geometrical data of building

1	Number of Bays in X-direction	5
2	Number of Bays in Y-direction	5
3	Dimension of building (LX B)	25 X 25 m
4	Typical Storey Height(h)	3m
5	Bottom Storey Height	3.2m
6	Total Height of Building(H)	129.2m

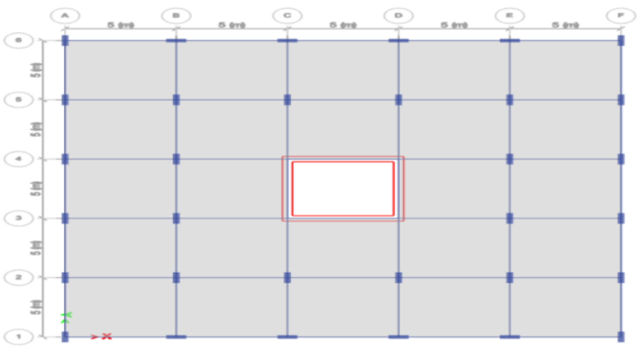

Fig. 1. Plan of building

The component details of the building considered for software analysis is shown in Table 2.

Table -2 Component details of building

Sr. No.	Component	Dimensions	Grade of concrete	Remark
1	Slab	125mm Thick	M25	
2	Central Shear wall Core	450mm Thick	M40	Lift Core
3	Beams	300X650 mm	M30	For all Floors
4	Column	A) 300X900mm	M40	31-42 floor
		B) 425X1200mm	M40	Base to 30th floor
5	Outrigger	3m deep	M40	As per Case

A. Loading Details

The following loading are considered for analysis of building,

1. Self-weight Calculated by ETABS 2016.
2. Live Load: 3 KN/m²
3. Earthquake Load: Auto generated as per IS 1893 (Part 1).

Parameters of seismic loading as per IS 1893 (Part-1): 2016

a. Seismic zone: III Seismic zone factor, Z: 0.16
b. Importance factor, I: 1
c. Response reduction factor, R: 5
d. Soil Type: II (Medium)

4. Wind load: Auto generated as per IS 875 (Part 3) - 2015

5. Response Spectrum: Auto generated as per IS 1893 (Part 1) - 2016

B. Modelling in ETABS

The following Figs. 2-3-4 shows the 42-storey high-rise building with RCC virtual outriggers are at different locations with respect to total height of Building (H). The building with outriggers is modelled as per the modelling cases of building given in section 4.

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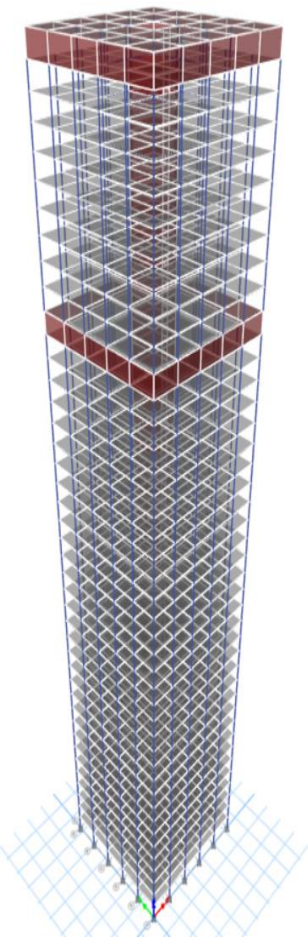

Fig. 2. Outrigger at top and 3/4H

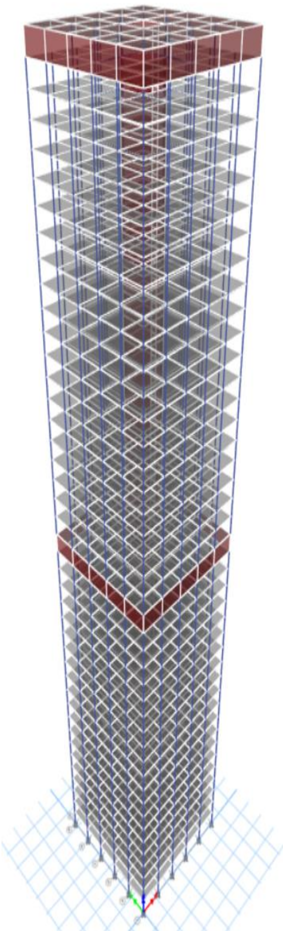

Fig. 3. Outrigger at top and 1/2H.

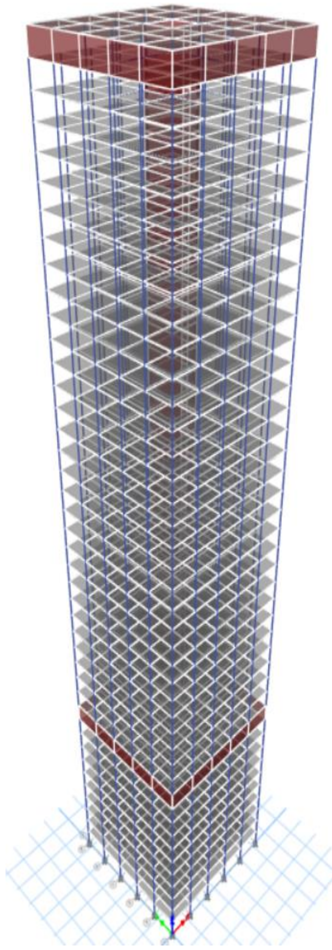

Fig. 4. Outrigger at top and 1/4H

VI. RESULT AND DISCUSSION

The results of the software analysis for responses namely storey displacements, base shear and storey drift at different storey levels of the structural model are presented in the following section.

A. Storey Displacement

The storey displacement is the displacement of a storey with respect to the base of a structure. Figure 5 show variation of lateral displacement of all model at the top storey level. The maximum storey displacement in obtains 115.224mm for building model without providing the outrigger system. Maximum permissible storey displacement is calculated from IS: 456 – 2007.

Maximum permissible storey displacement is limited to H/500.

Where, H – total height of the building.

(IS 456:2007, Clause 20.3, Page No. 33)

For this 42 storey, RCC building maximum displacement is calculated below.

Height of building (H) = 129.2 m.

Maximum storey displacement = H/500.

(IS456:2007, Cl. 20.3, pp. 33)

So maximum displacement = 129.2/500 = 0.2584m i.e. 258.4mm.

Then 115.224mm < 258.4mm.

Hence building is safe for maximum storey displacement limit.

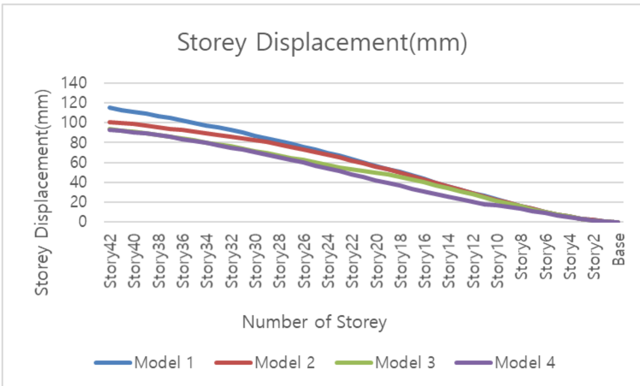

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Fig. 5. Variations in Storey Displacement

B. Base Shear

The base Shear is an estimate of the maximum expected lateral force on the base of the structure due to seismic activity. If it is calculated for the particular storey then the sum of design lateral forces at all levels above the storey under consideration. It depends on the seismic zone, soil material and lateral force equation in IS 1893:2016. The base shear in ETABS calculated by providing all seismic data. The obtained base shear value for all models shown in below figure 6.

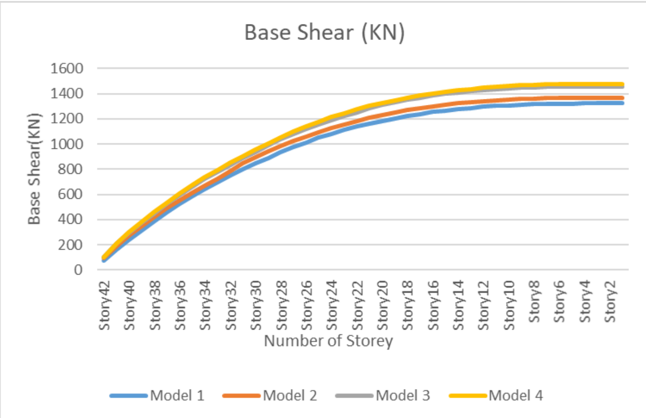

Fig. 6. Variations in Base Shear.

C. Storey Drift

Storey drift is defined as ratio of displacement of two consecutive floors to height of that floor. The ETABS give the design storey drift which is ratio of relative floor displacement to the height of that floor. The maximum Storey drift obtain is 0.00116.
As the storey drift value increases, the damage to the building is increased. Therefore, IS code 1893:2016 (part-1) set a limitation for maximum storey drift value.

Allowable Storey Drift= 0.004h
(IS code 1893: 2016-part 1, Clause 7.11.1, pp-26)
Where, h is the Height of Storey.
Allowable Storey drift= 0.004X3= 0.012 > Max. Storey drift of model = 0.00116.
Hence building is safe.
The obtained Storey drift value for all models shown in below figure 7.

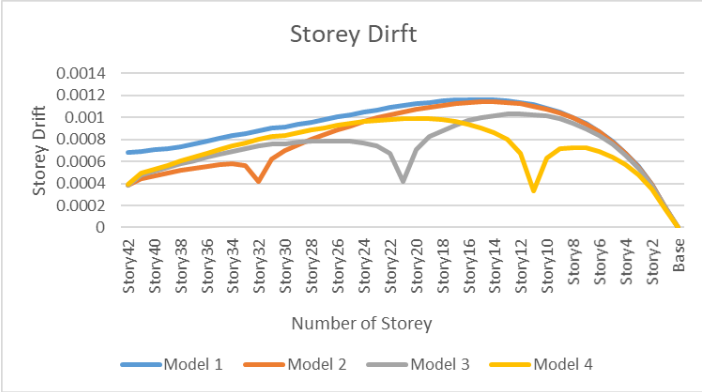

Fig. 7. Variations in Storey Drift.

In following table 3 comparative study of all seismic responses is given. The comparative study helps to drawn the conclusion and determine the optimum location of RCC virtual outrigger in 42 storey high-rise Building.

Table -3. Comparative Study of Earthquake Responses

Model No.	Maximum displacement at top storey (mm)	Maximum Base Shear(KN)	Maximum Drift
Model 1	115.224	1323.258	0.00116
Model 2	101.129	1368.745	0.00114
Model 3	93.579	1457.767	0.00103
Model 4	93.328	1478.491	0.00099

VII. CONCLUSION

1. From software analysis, it is observed that providing outrigger in a high-rise building can reduce the displacement of the model up to 19.01%. Hence it is concluded that RCC outriggers are efficient in reducing displacement.
2. The incorporation of the outrigger system in RCC high-rise building increases the base shear of building up to 10.52%. No significant change in the base shear values are observed as the weight of outriggers is far less compared to the building structure. Hence it doesn't affect the safety over service period life of the building.
3. The storey drift value is reduced by 14.66% by providing the outrigger system for high rise building and less than the IS code maximum allowable limit.
4. The maximum reduction in storey displacement, Storey drift and minimum increase in base shear value gives the optimum location of the outrigger system. It is observed that, the structural model with RCC Outrigger at the top floor and another at 1/2th height of the building i.e. 42th and 21th Storey shows the optimum location of RCC virtual outrigger system.

VIII. REFERENCE

[1] Bhati S., Dode P., and Barbude P.,(2016) "Analysis of high rise building with outrigger structural system," IJCTER, Vol. 2, Issue. 5, (pp. 421 – 433).

[2] Mithbhakare N., Kumbhar P. (2020) "Review on Behavior of Outrigger System in High Rise Building," IRJET, Vol. 07, Issue. 04, (pp. 1-5).

[3] Gadkari A., and Gore N.,(2016) "Review on behavior of outrigger structural system in high-rise building", IJEDR, Vol. 4, Issue. 2, (pp. 2065-2073).

[4] Nanduri P., Suresh B.,, (2013)"Optimum position of system for high-rise reinforced concrete buildings under wind and earthquake load", AJER, Vol.02, Issue 08, (pp. 76-89).

[5] Khade R. and Kulkarni P.,(2019) "Effect of wind load on structural performance of dimensionally regular & irregular high rise buildings with different outrigger systems," IJEMR, Vol. 9, Issue. 4, (pp. 25-29).

[6] Kamgar R. and Rahgozar R.,(2015), "Determination of optimum location for flexible outrigger systems in non-unifrom tall buildings using energy method", IJOCE, vol.5, Issue. 4, (pp. 433-444).

[7] Sathyanarayanan K., and Vijay A., (2012) "Feasibility studies on the use of outrigger system for RC core frames". IJAITI, vol. 1, Issue. 3, (pp.1-9).

[8] Bayati (2008), "Optimized use of multi-outriggers system to stiffen tall buildings". Structural Engineering and Mechanics, Vol. 64, Issue. 2, (pp. 183-194).

[9] Willford M., Smith R., (2008) "Performance-based seismic and wind engineering for 60story twin towers in manila". The 14th World Conference on Earthquake Engineering, Beijing, China.

[10] Herath N., Haritos N.,(2009) "Behaviour of Outrigger Beams in High rise Buildings under Earthquake Loads". Conference: Australian Earthquake Engineering Society Conference.