International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 03 | Mar 2021 www.irjet.net p-ISSN: 2395-0072

Comparative Dynamic Analysis of High Rise Building using Outrigger System and Flag Wall System

Sarwan Gupta[1], V.P. Bhusare[2], Dr. N.V. Khadake[3]

[1]P.G Student, Dept. of Civil Engineering, JSPM's Imperial College of Engineering and Research, Maharashtra, India
[2]Assistant Professor, Dept. of Civil Engineering, JSPM's Imperial College of Engineering and Research, Maharashtra, India
[3]Head of Department, Dept. of Civil Engineering, JSPM's Imperial College of Engineering and Research, Maharashtra, India

---***---

Abstract - *There is tremendous development in the construction of high-rise building in India, especially in metropolitan cities like Mumbai, Bangalore, etc. Often it is observed that, land restriction problem arises for the development of metropolitan cities requiring high rise construction. It is very challenging job for structural engineers to work out the designs for those high-rise projects. These buildings are subjected to various lateral dynamic loads, in which wind load is dominant case for designing the same. To resist these loads, various lateral resisting systems are developed. Outrigger system is one such lateral resisting system. This system involves the usage of trusses in the mechanical floors. The disadvantage of this method is that it uses the whole rentable space. In order to overcome this drawback, an alternative system known as flag wall system is used. In this system, RC walls are used in the mechanical floor. This system can be helpful as it uses less rentable space compared to outrigger system. The main objective of this paper is to study and compare the structural behavior between Outrigger System and Flag Wall System of a 50 storey building. The three-dimensional model is analyzed in ETABS software under the influence of seismic loads, as per IS code provisions.*

***Key Words*: outrigger, belt truss, flag wall, high rise, lateral loads**

1. INTRODUCTION

The growth of real estate and infrastructure plays a vital role in the economic development of any country. As India being a rapidly developing nation, commercial and speedy construction practices are in need to curb the ever-growing demand in the construction industry. Although specific laws and restrictions are needed in order to maintain the balance economically as well as environmentally. Hence here, the need for creative and efficient civil engineers who can maximize the utilization of available land to the utmost benefit is crucial. The three influencing factors, strength, stiffness and serviceability controls the design of high-rise buildings subjected to lateral loads like wind and earthquakes. As the structure is slender and tall, drift becomes an important aspect of the design. Improving the structural systems of high-rise buildings can control their dynamic response parameter in the study. Designing a high-rise building includes many problems such as the number of columns or the size and shape of concrete core, or even the basic dimensions of the building itself. Mostly the factor that affects the design of high-rise buildings is drift, displacement and time period. Lateral drift at the top of building is one of the most important criteria for selection of structural system for high rise building. However, as building increases in height, stiffness of core wall only is not sufficient to resist the seismic and wind load. This difficulty creates the need of innovation of various modern structural systems. There are many structural lateral systems used in the design of high-rise buildings such as moment resisting frame systems, shear frames, shear core frames, framed tubes, tubular system, space frame, etc. However, the outriggers and the belt truss system are the one that provides important components drift control and displacement reduction for the buildings. It increases the effective depth of the structure and significantly improves the stiffness under lateral load.

1.1 OUTRIGGER SYSTEM

The lateral forces which act on the structure can be either because of the wind blowing against the structure or because of the inertia forces such as earthquake load to cut them (shear) and push it on the bending. Therefore, it is necessary to have a lateral load resisting system to resist shear and bend. In the elimination of shear forces, the building must not go beyond the limit of elastic recovery. The basic idea of the outrigger system is to couple both, the perimeter columns with the inner core of the building, to act as a whole monolithic unit. Outriggers increase the stiffness of the building by converting the lateral forces into compression and tension in the perimeter columns.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 03 | Mar 2021 www.irjet.net p-ISSN: 2395-0072

1.2 FLAG WALL SYSTEM

Flag walls are nothing but the concrete walls (RC walls) provided in the selected floors, not reaching the foundation. Flag walls provide additional stiffness, strength and ductility to the whole structure and can be effective in reducing overall lateral drifts and building periods similar to the buildings in which the outriggers are provided. The main advantage of using flag wall is that they do not utilize the space for the operations. Conventional outrigger system utilizes the whole space. In order to overcome this, isolated RC walls i.e., flag walls can be used. The connection between concrete core and steel truss becomes difficult during construction. In flag walls the RC walls are connected to core and columns through coupling beam.

2. OBJECTIVES OF THE STUDY

1. To study the seismic behavior of outrigger system in high rise buildings with different locations of outriggers,
2. To evaluate the performance of outrigger systems under the applications of different lateral loads for Response Spectrum Analysis.
3. To evaluate the seismic performance of flag wall system as an alternative for outrigger system.

3. METHODOLOGY

A 50-storey high-rise rectangular shaped building was considered in this study. The models were analyzed using ETABS software. Typical floor plan and elevation is shown below.

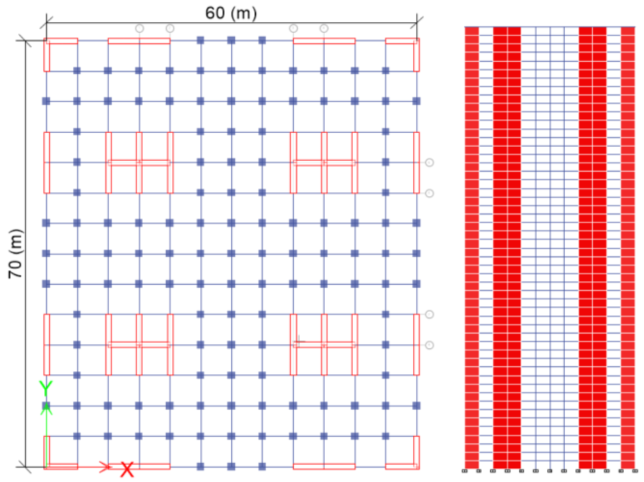

Fig -1: Plan and Elevation of model

4. INPUT PARAMETERS

A G+50 high-rise structure with rectangular plan is modeled in this study. Material Properties of each element are discussed below. Three models were analyzed and effect due to static and dynamic earthquake load and was determined. A SMRF (Special Moment Resisting Frame) system having core wall system, flag walls placed at three locations (0.4 h ,0.7 h and top) and outriggers placed at three locations (0.4 h ,0.7 h and top).

Table -1: Input Parameters

Particulars	Dimensions
Beam Size	600mmx600mm
Column Size	1200mmx1200mm
Spacing between the frame	5m
Floor Dimension in X direction	60m
Floor Dimension in Y direction	70m

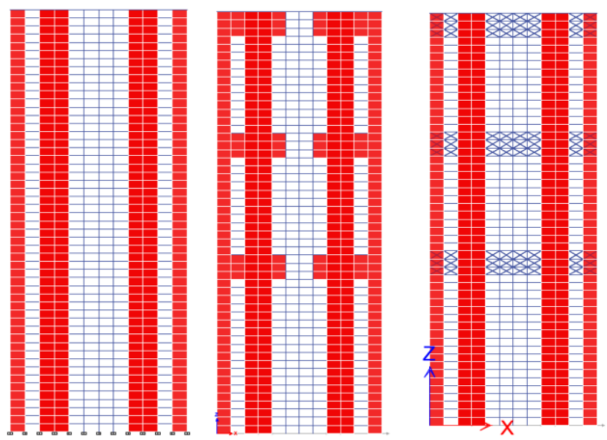

Fig -2: Elevation of models considered in this study

Table -2: Loading conditions

Load Type	Value
Live Load on Floor	2 kN/m2
Live load on Terrace	1.5 kN/m2
Floor Finish	1.5 kN/m2
Water Proofing on Terrace	3 kN/m2
Wall load on Beams, 230 mm Thickness wall	7.5 kN/m

Table -3: Seismic parameters

Load Type	Value
Seismic Zone	V

Zone Factor	0.36
Response Reduction Factor, R	4
Soil type	II, Medium
Importance Factor	1.2

5. RESULTS AND DISCUSSION

Three parameters are compared in this study. Mainly time period, storey displacement and storey drift are compared for all the models.

A. Time Period

Application of Outrigger and Flag wall reduces the time period as compared to SMRF (Special Moment Resisting Frame) system. In mode 1 the time period observed was 4.695 sec, 3.809 sec and 3.211 sec for the conventional system, flag wall system and outrigger system respectively.

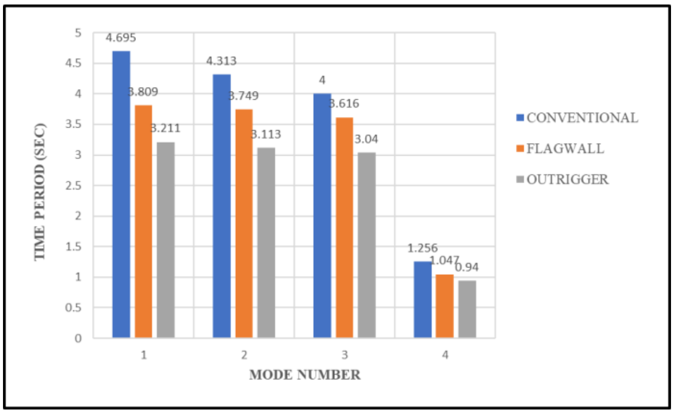

Chart -1: Variation of Time Period

B. LATERAL STOREY DISPLACEMENT

From the G+50 storey, models are subjected to dynamic earthquake in X-direction and observed that the maximum top storey displacement of structure with conventional SMRF system is observed to be 97.233 mm while the structure with flag walls and outriggers, the displacement reduces to 80.423 mm and 62.061 mm respectively.

Chart -2: Variation of storey displacement along X-direction

Also, the top displacement when the models are subjected to dynamic earthquake in Y-direction the results observed are 105.89 mm, 75.022 mm and 59.211 mm for the conventional system, flag wall system and outrigger system respectively.

Chart -3: Variation of storey displacement along Y-direction

C. LATERAL STOREY DRIFT

The G+50 storey is subjected to dynamic seismic load along X-axis and it can be noted that storey drift at 21st storey is 0.000767 for conventional system, 0.000591 for flagwall system and 0.000437 for outrigger system.

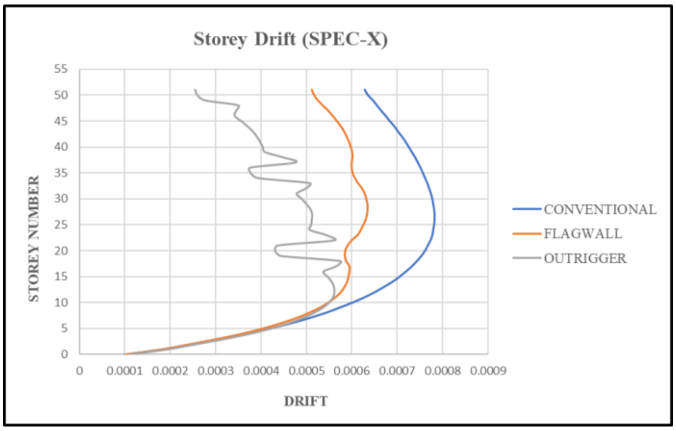

Chart -4: Variation of storey drift along X-direction

Also, the storey drift for the dynamic seismic load along Y-direction for the 21st storey is found out to be 0.000885 for conventional system, 0.000505 for flagwall system and 0.000394 for the outrigger system.

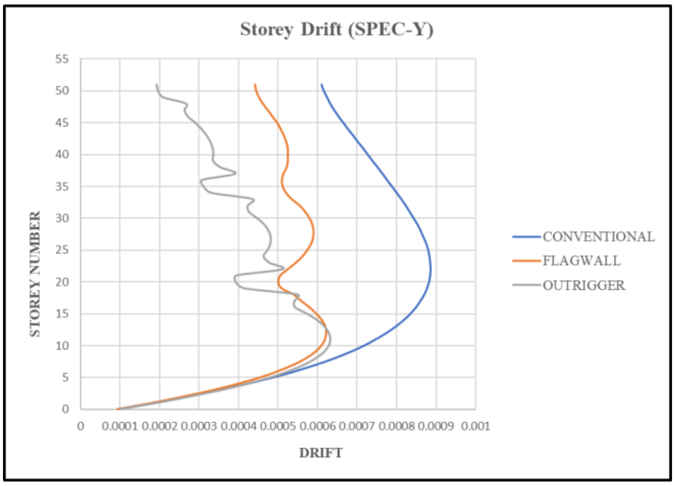

Chart -5: Variation of storey drift along Y-direction

6. CONCLUSIONS

The following conclusions were made from the present study:

- Time period considerably decreased by 18.87% by the introduction of flag walls as compared to the conventional SMRF system.
- Time period considerably decreased by 31.61% by the introduction of outriggers as compared to the conventional SMRF system.
- Maximum reduction in storey displacement of 17.29% in X-direction and 29.15% in Y-direction is achieved when the flagwalls are placed at 0.4h, 0.7h and at top as compared to conventional SMRF system when the structure is subjected to dynamic seismic analysis.
- Maximum reduction in storey displacement of 36.17% in X-direction and 44.08% in Y-direction is achieved when the outriggers are placed at 0.4h, 0.7h and at top as compared to conventional SMRF system when the structure is subjected to dynamic seismic analysis.
- Maximum reduction in storey drift of 22.95% in X-direction and 42.94% in Y-direction is achieved when the flagwalls are placed at 0.4h, 0.7h and at top as compared to conventional SMRF system when the structure is subjected to dynamic seismic analysis.
- Maximum reduction in storey drift of 43.02% in X-direction and 55.48% in Y-direction is achieved when the outriggers are placed at 0.4h, 0.7h and at top as compared to conventional SMRF system when the structure is subjected to dynamic seismic analysis.
- From the results it can be found out that the outrigger system is much effective as compared to flag wall system.

REFERENCES

[1] Akbar.A, Azeez.S "Effect of outrigger system in a multi-storied irregular building" International Journal of Modern Trends in Engineering and Research, Vol-03, Issue 07, pp.197-203(2016)

[2] Badami. S. Suresh M.R "A Study on Behavior of Structural System of Tall Buildings Subjected to Lateral Loads" International Journal of Engineering Research and Technology (IJERT), Vol-3, Issue 7, pp. 989-994(2014)

[3] Bayati. Z, Mahdikhani. M, Rahaei. A "Optimized use of multi-outriggers system to stiffen tall buildings", The 14th world conference on Earthquake Engineering October 12-17, 2008, Beijing, China (2008)

[4] Kian P. O, Siahaan F. T "The Use of Outrigger and Belt Truss System for High-Rise Concrete Buildings" DTS, Vol. 3, No. 1,2, pp. 36-41 (2001)

[5] Mistry K.Z, Dhyani D.J "Optimum Outrigger location in Outrigger Structural System for High-Rise Building" International Journal of Advance Engineering and Research Development vo-2, Issue 5, pp. 266-2755 (2015)

[6] Moon K. S "Optimal Configuration of Structural System for Tall Buildings" American Society of Civil Engineers, pp. 300-309(2016)

[7] Nanduri R. K, Suresh B, Hussain. I, "Optimum Position of Outrigger System for High-Rise Reinforced Concrete Buildings under Wind and Earthquake Loadings" American Journal of Engineering Research (AJER), Vol-02, Issue-08, pp-76-89

[8] Shivacharan K, Chandrakala S, Narayana G, Karthik N "Analysis of outrigger system for tall vertical irregularities structures subjected to lateral loads" International Journal of Research in Engineering and Technology, Vol-04, Issue: 05 pp. 82-88(2015)

[9] Patil D.M, Sangle K.S "Seismic Behavior of Different Bracing Systems in High Rise 2 -D Steel Buildings" Structures, Vol-3, pp. 282–305 (2016).

[10] Reddy. S. A., Anwar. N. "Performance Evaluation of High-Rise Building with RC Flag Wall System", Eleventh U.S. National Conference on Earthquake Engineering, June 25-29, (2018)

[11] Akash K., Madhuri M., Indrajeet J. "The use of outrigger and belt truss system for high rise building", International Journal of Civil Engineering and Technology (IJCIET) Vol-8 pp. 1125-1129 (2017)

[12] Hemant B.D., Imran M., Azghar M. "Optimum Position of Outrigger Systems in Tall Building by Using Reinforced Concrete Shear Walls and Braces" International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET) Vol-8, Issue-5, pp. 2319-8753, pp. 2347-6710 (2019)

[13] Lekshmi S., Sreedevi L. "Comparative Study of Outriggers with Braced Frame Core and Shear Core in High Rise Buildings" International Journal of Engineering Research & Technology (IJERT) Vol-6, Issue-6, pp. 2278-0181 (2017)

[14] Manoj P., Roshni J. "Performance Evaluation of High-Rise Building with Reinforced Concrete Flag walls under Seismic Load" International Journal of Scientific & Engineering Research Vol-10, Issue-5, pp. 2229-5518 (2019)

[15] Fawzia S., Fatima T. "Deflection Control in Composite Building by Using Belt Truss and Outriggers Systems" World Academy of Science, Engineering and Technology (2010)

[16] Nehal M.A., Agamy M. "Non-linear seismic analysis of high raised RC buildings with outrigger systems" International Journal of Scientific & Engineering Research Vol-10, Issue-1, pp. 2229-5518 (2019)

[17] Sandesh K.S., Raghu P., Amarnath K. "Study of Behavior of Outriggers in a High Rise Building under Seismic loading" International Research Journal of Engineering and Technology (IRJET) Vol-3, Issue-8, pp. 2395 -0056, pp. 2395-0072 (2016)

[18] Zahid M., Gurpreet S. "Analytical Study on Outrigger and Hexagrid System in High-Rise Buildings" International Journal of Innovative Technology and Exploring Engineering (IJITEE), Vol-8, Issue-7, pp. 2278-3075 (2019)

[19] IS 1893 (Part-I): 2016: Criteria for Earthquake Resistance Design of Structures, New Delhi, India.