IJEAST

IJEAST

INTERNATIONAL JOURNAL OF ENGINEERING APPLIED SCIENCE AND TECHNOLOGY

VOLUME : 5 ISSUE : 3 Print / Issue Publication Date: 15-Sep-2020

ISSN : 2455-2143

DOI : 10.33564/IJEAST.2020.v05i03.103

Indexed In

WWW.IJEAST.COM

editor@ijeast.com

International Journal of Engineering Applied Sciences and Technology, 2020
Vol. 5, Issue 3, ISSN No. 2455-2143, Pages 600-602
Published Online July 2020 in IJEAST (http://www.ijeast.com)

A REVIEW: BEHAVIOUR OF HIGH RISE BUILDING APPLYING OUTRIGGER AND BELT TRUSS SYSTEM FOR SEISMIC AND WIND FORCES

Sarwan Ashok Gupta
PG Student
Department of Civil Engineering
JSPM's Imperial College of Engineering and Research,
Wagholi, Maharashtra, India

Prof. V. P. Bhusare
Assistant Professor
Department of Civil Engineering
JSPM's Imperial College of Engineering and Research,
Wagholi, Maharashtra, India

Dr. N.V. Khadake
Head of Department
Department of Civil Engineering
JSPM's Imperial College of Engineering and Research,
Wagholi, Maharashtra, India

Abstract— **As a developing nation, India has seen tremendous growth in the construction of high-rise buildings. In metropolitan cities like Mumbai, Bangalore, etc. it is observed that, land restriction problems arise in the development requiring construction of high-rise buildings. It is a 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. The outrigger and belt truss system is the most common lateral load resistance system in high-rise buildings. The widespread use of this system is the result of its efficiency, which has been studied and proven through a large number of studies considering all aspects of the outrigger and belt truss system. Therefore, combining the main goals and conclusions of previous research is essential to provide guidance to researchers, especially those who are new to the research field. Therefore, this article can be regarded as the focus of research in order to establish a detailed understanding of the system.**

Keywords— **outrigger, belt truss, high rise building, lateral load**

I. 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 factors strength, stiffness and usability control the design of high-rise buildings when they are subjected to lateral loads such as wind and earthquakes. Due to the slender and tall structure, drift plays a vital role in the design. Improving the structural system of high-rise buildings can control its dynamic response parameters. Many problems are encountered when designing high-rise buildings, such as the number and size of columns, shape of the concrete core, and even the basic building dimensions. The main factors affecting the design of high-rise buildings are drift, displacement and time period. The most important criterion for selecting the structural system of a high-rise building is the lateral displacement of the top. However, as the height of the building increases, the rigidity of the core wall alone is insufficient to resist earthquake and wind loads. This difficulty leads to the need to innovate various modern structural systems. Many horizontal structural systems are used in the design of high-rise buildings, such as curved frame systems, shear frames, shear core frames, frame tubes, tubular systems, space frames, etc. However, the outrigger and belt truss system is an important part of a tool that provides building drift control and reduces displacement. It increases the effective depth of the structure and significantly improves the stiffness under lateral loads

II. LITERATURE REVIEW

Bayati et al. (2008) studied the performance of multi-outrigger systems under wind and earthquakes to determine the best position of the outriggers. A case study of a sample structure consisting of an 80-story high steel frame office building in Vanah Parkth in Tehran was investigated. They concluded that by using an optimized multi-outrigger system, the seismic response of the building was effectively reduced.

The results show that compared with the virtual outrigger system, the performance of the traditional outrigger is better.

Shivacharan K. et al. (2015) analyzed a 30 story building, taking into account different levels of vertical irregularities. The analysis is performed using a bare frame, which consists of an outrigger system and a belt truss system, used in different positions (0.25, 0.33, 0.5, 0.67, 0.75 and top). It was observed that by providing outriggers with a height of 0.67, the displacement was reduced by 29.8% compared to the bare frame, and by 36.9% in the case of drift. By using 0.67 and 0.5 belt trusses, 45.1% deflection and 40% drift control have been achieved.

Badami S. et al. (2014) studied the performance of various structural systems that resist lateral loads in high-rise buildings. The main goal is to select the best structural system for a specific building height. Different types of structural systems are studied, such as rigid frame systems, rigid frames with shear wall systems, and shear wall systems with openings and outrigger systems. For the analysis, ETABS software and IS specification terms were used. A comparative analysis was performed to check the structural efficiency. Conclusions are as follows:

Height	**Suggested system**
10 stories (35 m)	Rigid frame, shear wall
20 stories (70 m)	Shear wall. Outrigger
30 stories (105 m)	Rigid frame with shear wall, outrigger
40 stories (140 m)	Rigid frame with shear wall. Outrigger
50 stories (175 m)	Outrigger
60 stories (210 m)	Outrigger

Thejaswini R.M and Rashmi A.R (2015) analyzed different anti-lateral load systems to understand their performance under earthquake and wind loads. They used ETABS software to analyze the model of a G+14-story RCC building with different anti-lateral load systems, such as rigid frame systems, core wall systems, shear wall structures, tube structures and structures with cantilevered arms. They concluded that the tube structure and the L-shaped shear wall structure are more stable structures under earthquake action.

Dahake H. et al. (2019) used ETABS software to analyze a commercial building with G + 24 floors. The best position of the outrigger is determined by changing the position of the outrigger over the entire structure height. The best type of outriggers found were buildings with external X-shaped brackets on the 8, 16 and 24 floors. Compared with buildings without outrigger systems, the displacement was reduced by 9.5%.

Mistry K. et al. (2015) considered a model of a 40-story high-rise building with a height of 150 m. The different positions of outriggers are adopted and analyzed. They concluded that when the outriggers were placed on the middle of the building at 0.5h, the displacement and shear force were significantly reduced.

Shirole S.K. et al. (2016) studied the behavior of outriggers in high-rise buildings. The outrigger system effectively resists lateral seismic forces. In this study, a 30-story model was modeled using ETABS software. Without the use of outriggers, the floor stiffness increased by 2.25 times the building floor stiffness. It is found that the best position of the outrigger is 0.66 times the height from the bottom.

Zahid Manzoor et al (2019) studied the behavior of 38 storey building having a total height of 133 m. The analysis was done by ETABS software by using Response Spectrum and Static wind analysis. This paper concluded that the model with outrigger at h/4 from top shows minimum storey drift under seismic load while as the model with two outriggers one at h/3 and the other at 2h/3 shows minimum drift under wind load.

Lekshmi Soman et al (2017) carried out a study to check the behavior of G+40 storey RC frame building using ETABS software by Response Spectrum analysis. The optimum location of outriggers is determined by varying the location of outriggers throughout the height of the structure. They concluded that the building with outrigger at 0.75h is good in terms of base shear and story drift.

Akbar A. & Azeez S. (2016) studied the effect of outrigger on a 40 storey building with outriggers at top, bottom and $3/4^{th}$ of building. They concluded that the lateral displacement with multiple outriggers with belt truss has reduction of 50% on storey 1, 27.9% reduction at storey 20 and 35.4% reduction at storey 40 and the story drift has 26.69% reduction at storey 1, 32.11% reduction at storey 20 and 51.25% reduction at storey 40.

Nehal M. Ayash & Mohamed H. Agamy (2019) carried out a study on a G+55 storey RC building having outrigger system. The optimum location for single or double internal outriggers with cap outrigger is studied. The optimum location for single internal outrigger with cap one is at 0.67, 1H and for double internal outrigger with cap one is at 0.67, 0.75, 1H i.e. closely spaced to each other and closely to top of building.

Kala Akash et al (2017) aimed to identify the optimum outrigger location in high rise RC building under horizontal load. A 60 storey RC building is studied in order to determine the optimum location of outrigger to minimize the drift due to wind load using ETABS software. Results from the location to construct the outriggers is one third of the height of the building i.e. at the 20th storey which reduces the maximum drift to 385 mm.

Goman Wai-Ming Ho, Arup (2016) represents a state-of-the-art review of the outrigger system in tall building along with the history and applications of outrigger system in structure. They studied new applications of outrigger systems. Initially outriggers provided additional stiffness to reduce drift and deflection during wind loading. They presented a wide choice of outrigger system that can be used in the structure. Also optimum topology, design and construction considerations are also discussed.

Patil Dhanaraj et al. (2016) studied the seismic performance of outrigger supporting buildings to find the best position of outriggers in high-rise two-dimensional steel structure buildings. Non-linear subduction analysis was carried out on high steel structure buildings with different outriggers supporting 20 stories, 25 stories, 30 stories and 35 stories to capture the seismic response. The conclusion of this paper is that adding outriggers to the top story significantly increases the base shear force while reducing roof displacement. In addition, adding outriggers at 0.3H to 0.6H can increase stiffness and help resist greater forces during seismic excitation, so it is considered the best position.

III. CONCLUSION

The main contributions of this paper are as follows:

1. The detailed study of outrigger system behavior is carried out based on previous research, and a clear illustration of the parameters which affect the system performance is presented in this study.
2. The optimum location of the first outrigger was at the top of the building and for the second outrigger it was at the middle level of the building.
3. In comparison of outrigger at top storey as a cap truss with and without the belt truss, there was not much reduction in drift with the belt truss.
4. Tube structure and shear wall structural system are not as effective as outrigger system for buildings having height more than 50 stories.
5. The stiffness of the building increases if the outriggers are placed close to each other.

IV. REFERENCE

[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] 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)

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

[6] 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)

[7] 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).

[8] Kala A., 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)

[9] 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)

[10] 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)

[11] 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)

[12] 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)

[13] 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)

IJEAST

INTERNATIONAL JOURNAL OF ENGINEERING APPLIED SCIENCE AND TECHNOLOGY

ABOUT IJEAST

International Journal of Engineering Applied Science and Technology (IJEAST) is a peer-reviewed, open access journal that publishes high-quality research papers in the field of Engineering, Applied Science and Technology.

IJEAST aims to provide a platform for researchers, academicians, and professionals to share their innovative ideas, research findings, and practical experiences with the global scientific community.

FOCUS AREAS

- Engineering
- Applied Science
- Technology
- Innovation & Development
- Interdisciplinary Studies

PEER REVIEWED

All submissions are rigorously peer reviewed to ensure quality.

OPEN ACCESS

Free and unrestricted access to research for all.

GLOBAL REACH

Connecting researchers and professionals worldwide.

TIMELY PUBLICATION

We ensure a swift and efficient publication process.

For more information, visit our website

www.ijeast.com

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE
AND TECHNOLOGY

editor@ijeast.com

www.ijeast.com

India

2455-2143