AN INVESTIGATION ON STRUCTURAL PERFORMANCE OF TALL BUILDING EMBEDDED WITH CORE & OUTRIGGER SYSTEM

ATUL S. KURZEKAR, VIVEK. D. JAYALE, SAGAR. W. DHENGARE & JAYANT. M. RAUT

Assistant Professor, Department of Civil, YCC, Maharashtra, India

ABSTRACT

The core and outrigger system which is mostly used in tall building, this method can be used to control the extreme drift due to horizontal load as per previous research. One more advantage by using this method is that it minimize the effect of structural harm due to horizontal loading, wind load and earthquake load also it reduce pounding effects in building. In this current work, a twenty storied RC building with and without outrigger at different position were analyzed & design. The aims of study is to find out the best position of outrigger, story drift, story displacement, stiffness, base shear and time period for outrigger corresponding to core & compare variation in displacement when outrigger is provided at different position. Also in this study we discuss efficiency of outrigger at different story height and static behaviour of RC building under horizontal loading.

KEYWORDS: *Outrigger, Wind Load, Earthquake Load, Lateral Displacement*

Received: Apr 21, 2020; **Accepted:** May 12, 2020; **Published:** Jun 30, 2020; **Paper Id.:** IJMPERDJUN2020191

INTRODUCTION

Increasing infrastructure development in most parts of the world, especially in developing countries like India, People in urban areas is travelling to metro cities. Because of this reason metro cities are getting heavily populated. As the population is increased day by day it adversely effect on land which is available for farming and other need purpose and therefore the cost of land is increases and due to this there is a huge demand of tall buildings, the buildings, particularly in seismic zone, this system can be select as an appropriate structure.

In seismic active zone, structural performance of conventional RC building is reduced, which shows increasing time period and excessive drifts when subjected to horizontal forces. These issues can be solved by providing horizontal load resisting element such as outrigger system at different elevation of building. In India, particularly in seismic zone 3, high-rise buildings are affected due to horizontal force made by earthquake or winds are often resisted by a sum of all force of coupled shear walls. And when the height of building is more, the stiffness of the structure becomes more important, it is necessary to decrease the effect of wind and earthquake by making or providing external provision, for that purpose we want more and more unconventional and capable structural systems. One such system is Outrigger System. The mechanical reaction of a core and outrigger system is totally based on compression, tension couple induced in the external columns. This system acts as a rigid arm fetching external columns and principal core. The horizontal force when tempted in the central core is relocated to marginal columns through outriggers and the overturning moment decreased. The best example of outrigger system that is to be used in Taipei Tower, Taiwan China and Plaza Rakyat Tower, kuala ,Malaysia.

Figure 1: Taipei 101 Tower, Taiwan.

Figure 2: Plaza Rakyat Tower, Kuala.

SUMMARY OF LITERATURE REVIEW

Researchers in past have explicated that by making use of outriggers as a stiff beam to connect core wall and the exterior column will strengthen the building against the lateral loads acting over the building. Many studies were concluded on the position of outrigger, which will have maximum effect on the behaviour of the tall building. Optimally positioning of outrigger will have good resistance against the overturning moments, bending stiffness, inter storey drift, lateral displacement and other parameters.

MODELING OF STRUCTURES

Regular Frame Structure

Specification of Structure:-

- Height of Structure = 60 m
- No of Stories = 20

- Width of Structure = 25m
- Length of Structure = 25m
- Height of each storey=3m
- Software used ETABS 2016.
- Column = 600mm x 600mm
- Beam = 230mm x 600mm
- Outrigger= ISLB 300

Figure 3: Conventional RC Frame Building & Structural Model with Core and One Outrigger.

ANALYSIS OF STRUCTURE

All the models with and without outrigger system has been analysed by static analysis method in ETABS 2016 for seismic zone three and basic wind speed 43 to 44 m/s as per IS 1893 (part I):2002 and IS 875 (part III):1987. The analysis has been done for fundamental time period of vibration, storey displacement, storey drift, base shear and stiffness of structure.

Comparison has been done by considering different parameters

Table 1: Data for Analysis

S. No.	Data	Property
1	Concrete Grade	M30
2	Steel Grade	Fe 415
3	Grade of steel outrigger	Fe 345
4	Seismic Zone	III
5	Height of building	60 M
6	Live weight	3 KN/m ²
7	Roof weight	1.5 KN/m ²

Figure 4: Storey Drift of Five Different Model.

Figure 5: Shear Force Produce in Five Different Model.

Figure 6 : Base shear

Figure 6: Base Shear.

RESULTS & DISCUSSION

The building model with core & outrigger system at top story, the story displacement is about 20% - 30% less when compare to conventional RC frame structure.

The deflection is more at the top of story i.e. around 49.33 mm and this is reduces up to 23.28 mm by providing 1st outrigger at upper story and 2nd at the mid height of structure i.e. 47 % deflection reduces in basic Model with One Outrigger at the upper story and another two third height of the building than conventional RC frame structure

After analysis and design of twenty story building it is found that storey displacement is decreased by 47 % and time period is decreased up to 64% when this system is provided at top of the building and at the two third of building.

Stiffness is 34% – 38% higher for structure having core and outrigger than the conventional frame structure

CONCLUSIONS

- The stiffness is increases in tall building which makes the structure effective against horizontal loading by using outrigger mechanical systems.
- Core and outrigger system is not only control the overall horizontal displacement but also very capable of reducing the inter story drifts in tall building.
- From the observations optimum location of outrigger is found in mechanical model with one Outrigger at the upper floor and another at two third height of the building as it gives minimum values of storey drift, storey displacement, and time period and gives maximum stiffness and base shear to the structure.
- As core and outrigger can effectively reduce horizontal deflection of building, inner storey drift and also increases stiffness of structure so it can be used as good horizontal force resisting structural system.
- As related to conventional frame structure the time period is reduces for the structure having core and outrigger system.

REFERENCES

1. Po Seng Kian, Frits Torang Siahaan, (2001) "The use of outrigger and belt truss system for high-rise concrete buildings " *Dimensi Teknik Sipil*, Vol. 3, No. 1, 36-41 ISSN 1410-9530 .
2. Z. Bayati , M. Mahdikhani and A. Rahaei, (2008) "Optimized use of multi-outriggers system to stiffen tall buildings" *The 14th world conference on earthquake engineering* October 12-17, Beijing, China.
3. Gerasimidis S., Efstathiou E. & Baniotopoulos C. C, (1990). "Optimum outrigger locations of high-rise steel buildings for wind loading" vol. 36, issues 1-3, pages 235-244.
4. Dr. K.S. Sathyanarayanan, A. Vijay, S. Balachandar, (2012), "Feasibility Studies on the Use of Outrigger System for RC Core Frames" *Volume 1 Number 3 (May/June 2012)* ISSN: 2277-1891.
5. Richard J. Balling, S.E.; and Jacob S. Lee, (2015) "Simplified Model for Analysis and Optimization of Skyscrapers with Outrigger and Belt Trusses" *J. Struct. Eng.*, 141(9): 04014231).
6. Reza Kamgar, Mohammad Mehdi Saadatpour, (2012) "A simple mathematical model for free vibration analysis of combined system consisting of framed tube, shear core, belt truss and outrigger system" *ELSEVIER, Engineering structures* 364918-4930.
7. P.M.B. Raj Kiran Nanduri, B.Suresh, M D. Ihtesham Hussain, (2008) "Optimum Position of Outrigger System for High-Rise Reinforced Concrete Buildings under Wind and Earthquake Loadings" *Volume-02*, pp-76-89.
8. N. Herath, N. Haritos, T. Ngo & P. Mendis,n, (2009) "Behaviour of Outrigger Beams in High rise Buildings under Earthquake Loads" *Australian Earthquake Engineering Society Conference*.
9. Jianguo Nie and Ran Ding, (2013) "Experimental research on seismic performance of K-style steel outrigger truss to concrete core tube wall joints" *Structures Congress* © ASCE 2013.

10. Dhanaraj M. Patila, Keshav K. Sangleb, (2015) "Seismic behavior of outrigger braced systems in high rise 2-D steel buildings" Vol. 3, pp. 282-305.
11. J. R. WU and Q. S. LI, (2003) "Structural performance of multi-outrigger braced tall buildings" *Struct. Design Tall Spec. Build.* 12, 155–176
12. Soobum Lee, Andres Tover, (2014) "Outrigger placement in tall building using topology optimization" *ELSEVIER, Engineering structures* 74 122-129.
13. P. Tan, C.J. Fang, C.M. Chang, B.F. Spencer, F.I. Zhou, (2015) "Dynamic characteristics of novel energy dissipation system with damped outriggers" *ELSEVIER, Engineering structures* 98-128-140.
14. Akash Kala, 2Madhuri Mangulkar, 3Indrajeet Jain, (2016) "Optimum position of outrigger with belt truss in tall building under horizontal load" *ISSN (Online): 2347 - 2812, Volume-4, Issue -3.*
15. Hyo Seon Park, Eunseok Lee, Se Woon Choi, Byung Kwan Oh, Tongjun Cho, Yousok Kim, (2016) "Genetic-algorithm-based minimum weight design of an outrigger system for high-rise buildings" *Engineering Structures* 117- 496–505.
16. Y. Chen, D. M. McFarland, Z. Wang, (2010) "Analysis of Tall Buildings with Damped Outriggers" *J. Struct. Eng., ASCE*, 136(11): 1435-1443.
17. A Griezic, W. D. Cook, (2001) "SEISMIC BEHAVIOR AND RETROFIT OF OUTRIGGER BEAM-COLUMN FRAMES" *J. Bridge Eng., © ASCE*, 6(5): 340-348.
18. Alex Coull and Otto Lau. W.H, (1989) "Multi Outrigger Braced Structures", *Journal of Structural Engineering, ASCE*, Vol. 115, No. 7.
19. Bahram M. Shahrooz, Jeremy T. Deason, (2004) "Outrigger Beam–Wall Connections. I: Component Testing and Development of Design Model" © ASCE *J. Struct. Eng.* 130:253-261.
20. Takehiko Asai, Chia-Ming Chang, (2013) "Real-time hybrid simulation of a smart outrigger damping system for high-rise buildings" *ELSEVIER, Engineering Structures* 57-177–188.
21. Hasan, Raad Abed Al-Jallal. "Behaviour of beam and wall outrigger in high-rise building and their comparison." *International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD)* 6.1 (2016): 19-30.
22. Reddy, P. Surendra, G. Kiran Kumar, and A. Venkataravindra. "Wind Load Analysis of Solar Farm Using Computational Fluid Dynamics." *International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)* 9.6 (2019):485–498
23. Awchat, G D, and Yamini N. Deshmukh. "Seismic Response of Tall Building with Underground Storey Using Dampers." *International Journal of Civil Engineering (IJCE)* 6.4 (2017):57-66
24. Suriansyah, I., M. Afifuddin, and M. Hasan. "Performance of Asymmetric Building Structure with Base Isolator Using Pushover Analysis." *International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD)* 10.2 (2020):1–8
25. Abou-Rayyan, Ashraf M., Nader N. Khalil, And Mohamed S. Afify. "Dynamic Characteristics of Three Different Tlp's Supporting 5-Mw Wind Turbines under Multi-Directional Random and Regular Waves." *International Journal of Civil Engineering (IJCE)* 5.3 (2016):37-48