BEHAVIOUR OF OUTRIGGER SYSTEM ON HIGH RISE STRUCTURE BY VARYING OUTRIGGER DEPTH

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Abstract*— Tall building development has been rapidly increasing worldwide introducing new challenges that need to be met through engineering judgment. In modern tall buildings, lateral loads induced by wind or earthquake are often resisted by a system of coupled shear walls. But when the building increases in height, the stiffness of the structure becomes more important and introduction of outrigger beams between the shear walls and external columns is often used to provide sufficient lateral stiffness to the structure. The outrigger and is commonly used as one of the structural system to effectively control the excessive drift due to lateral load, so that, during small or medium lateral load due to either wind or earthquake load, the risk of structural and non-structural damage can be minimized. For high-rise buildings, particularly in seismic active zone or wind load dominant, this system can be chosen as an appropriate structure. The objective is to study the behavior of outrigger and, optimization of outrigger depth.

I. INTRODUCTION

The design of tall and slender structures is controlled by three governing factors, strength (material capacity), stiffness (drift) and serviceability (motion perception and accelerations), produced by the action of lateral loading, such as wind. The overall geometry of a building often dictates which factor governs the overall design. As a building becomes taller and slenderer, drift considerations become more significant. Proportioning member efficiency based on maximum lateral displacement supersedes design based on allowable stress criteria.

Through the design of a high-rise structure, numerous problems appear such as the number of columns or size and shape of concrete core or even basic dimensions of the structure itself. Having constraints for the building immediately defines and solves part of the unknown variables but it is the geometry of the structural system inside these basic parameters that identifies an efficient design.

The factor that governs the design for a tall and slender structure most of the times is not the fully stressed state but the drift of the building. There are numerous structural lateral systems used in high-rise building design such as: shear frames, shear trusses, frames with shear core, framed tubes, trussed tubes, super frames etc. However, the outriggers and belt trusses system is the one providing significant drift control for the building.

II. LITRETURE REVIEW

[1] Abhishek Arora and Ravi Kumar presented in their research paper 'A Strengthening of High Rise Building with Outrigger System' that Drift decreased with provision of outrigger and increased with reducing outrigger depth.

[2]S. Fawzia et al presented that provision of outriggers and belt truss was more efficient in deflection minimization then the required value achieved from fundamental frequency of vibration. Composite buildings usually had structural steel bracings truss which did not have appreciable locally stiffness rather it could be very useful in providing a tie down effects between shear walls and columns.

[3] Hi sun choi et al presented research in 'Outrigger System Design Considerations' and concluded that Building core-and-outrigger systems have been used for half a century, but have kept evolving and reflected changes in preferred materials, building proportions, analysis methods and design approaches. They concluded the outrigger design was not amenable to a standardize procedure due to variety of challenge posed, solutions used and new concepts being developed.

[4] Kiran Kamath et al researched 3D models using ETABS software for reinforced concrete structure with central core wall with outrigger and without outrigger by varying the relative flexural rigidity from 0.25 to 2.0 with step of 0.25. They concluded that when the criterion considered was lateral displacement then the optimum position of the outriggers was at mid height for both static and dynamic behavior for the structure considered. When the criterion for design was peak acceleration the optimum position of outrigger was at top where it was reduced up to 30%.

[5] M.R Suresh et al researched in their paper by providing the outrigger system at different levels along the height of the building by varying the relative stiffness and represented that the percentage reduction of lateral displacement and inter- story drift with respect to bare frame varied for different model configuration. however, the variation was not significant when compared between different seismic zones. Maximum inter-story drift was observed at building height in the range of 5 to 15m.

[6] N. Herath, et al. presented in 'Behavior of Outrigger Beams in High Rise Buildings under Earthquake Loads' that the behavior of a structure under earthquake load was different from earthquake to earthquake. The location of the outrigger beam had a critical influence on the lateral behavior of the structure under earthquake load and the optimum outrigger locations of the building had to be carefully selected in the building design. The optimum outrigger location of a high rise building under the action of earthquake load was between 0.44-0.48 times the height of the building (from the bottom of the building), which was consistent with the optimal location associated with wind loading.

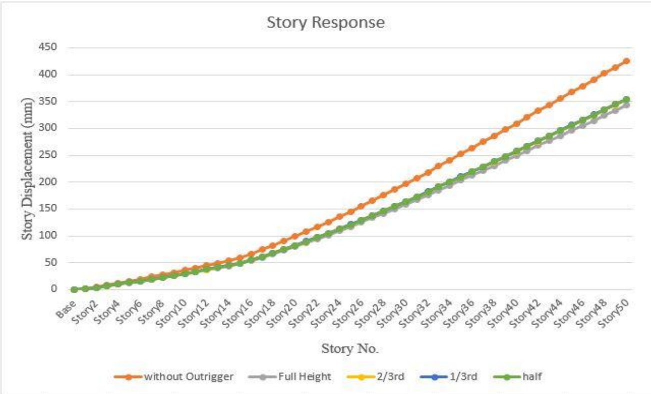
[7] P.M.B. Raj Kiran Nanduri, et.al researched, in their research paper Optimum Position of Outrigger System for High-Rise Reinforced Concrete Buildings under Wind and Earthquake Loadings thatthe maximum drift at the top of structure when only core was employed was around 50.63 mm and this was reduced by suitably selecting the lateral system. The placing of outrigger at top story as a cap truss was 48.20 mm and 47.63 mm with and without belt truss respectively. Hence there were not much reductions in drift with belt truss. Using second outrigger with cap truss gave the reduction of 18.55% and 23.01% with and without belt truss. The optimum location of second outrigger was middle height of the building.

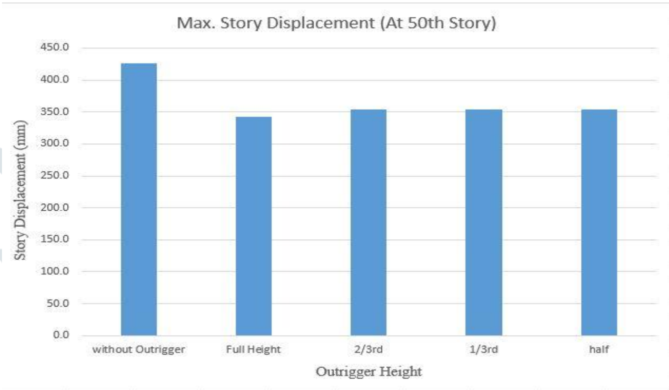
[8] Shruti B. Sukhdeve et analyzed tall building and found that the optimum position of outrigger system using lateral loads and concluded that the maximum deflection at the top of structure when only flat slab with core was employed was around 625.7mm and that was reduced up to 411.18mm by when first outrigger provided at mid height of structure i.e. 29.45% deflection reduction occurred for first position of outrigger. The maximum deflection at top of structure reduced up to 335.15mm when provided with second outrigger at 3/4th height of structure.

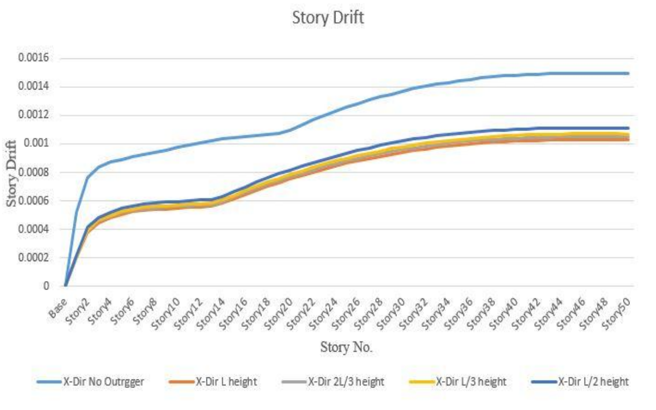
III. METHEDOLOGY

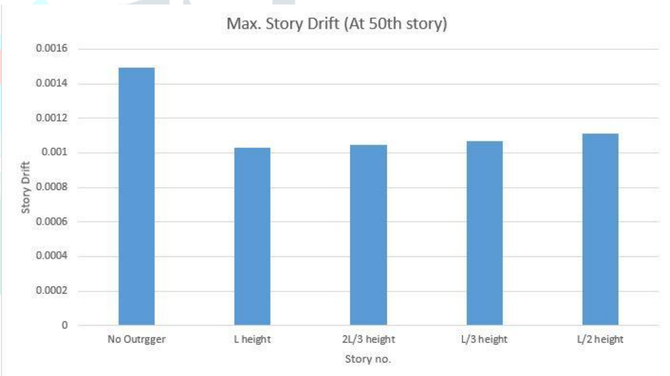
Plan Dimension = 50 m x 40 m (grid)
No of Storey of Building = 50 Storey
Typical Storey Height = 3 m

Column Details = Length – 1800 mm, Width – 900 mm
Beam Details = Breadth – 230 mm, Depth – 450 mm
Slab Details = Thickness – 150 mm
Column to Column Clear Distance = 5 m









IV. CONCLUSION FROM ANALYSIS

For 50 story building Story Displacement reduces from **425mm**without outrigger to **342mm** for After providing L height further decrease in height of outrigger slightly increases story displacement.

For 50 story building decrease in the depth of the outrigger to 2/3rd., 1/3rd. and 1/2 of the story height reduces the percentage reduction of lateral displacement and story drift up-to 3% – 4% and 5% - 6% respectively in comparison with outrigger depth of full story height. Hence, Drift increases with reduction of depth of outrigger.

For different outrigger depth there is not much difference in displacement up to some height of the building (up to 16 story) then it increases slightly.

Outrigger of full story height at top. So, displacement reduces up to **19.42%** for outrigger of L height.

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