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A REVIEW ON STUDY OF LATERAL LOAD RESISTING SYSTEMS IN TALL STRUCTURES

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Abstract — *In the early structures at the beginning of the 20th century, structural members were assumed to carry primarily the gravity loads. Today, however, by the advances in structural design and high-strength materials, building weight is reduced, and slenderness is increased, which necessitates taking into consideration mainly the lateral loads such as wind and earthquake. Understandably, especially for the tall buildings, as the slenderness, and so the flexibility increases, buildings suffer from the lateral loads resulting from wind and earthquake more and more. As a general rule, when other things being equal, the taller the building, the more necessary it is to identify the proper structural system for resisting the lateral loads. The objective of this papers to study, the performance of structural system in high-rise building subjected to seismic and wind load. Study of the literature is reviewed in this paper on various aspects of structural system as; behaviour of high- rise structure was assessed by overall building drift, story drift, displacement, base shear.*

Keywords*-Tall buildings, Structural system ,Displacement, Drift, Base shear, Seismic force, Wind force*

I. INTRODUCTION

Buildings are complex and multiple systems. Hence, at the planning stage itself, architects and structural engineers must work together to ensure that unfavorable features are avoided and good building configuration is chosen. If we have a poor configuration to start with, all that engineers can do is to provide a band-aid i.e. Improve a basically poor solution as best as they can. Conversely, if we start with a good configuration and reasonable framing system, even a poor engineer cannot harm its ultimate performance too much.[4]

The resistance of tall buildings to wind as well as to earthquakes is the main determinant in the formulation of new structural systems that evolve by the continuous efforts of structural engineers to increase building height while keeping the deflection within acceptable limits and minimizing the amount of materials. Thanks to the sophisticated computer technology, modern materials and innovative structural concepts, structural systems have gone beyond the traditional frame construction. Basically, there are three main types of buildings: steel buildings, reinforced concrete buildings, and composite buildings. Concrete and steel systems evolved independently of each other until 1969, the year in which the composite construction, basically described as a steel frame stabilized by reinforced concrete, of a 20-storey building was done by Dr. Fazlur Khan. All tall buildings can be considered as composite buildings since it is impossible to construct a functional building by using only steel or concrete. That is, in a critical sense, using mild steel reinforcement can make a concrete building a composite structure, and in the same way, reinforced concrete slabs can make a steel building a composite building.[1]

Structural development of tall buildings has been a continuously evolving process. There is a distinct structural history of tall buildings similar to the history of their architectural styles in terms of skyscraper ages (Ali & Armstrong, 1995; Huxtable, 1984). These stages range from the rigid frame, tube, core-outrigger to diagrid systems. A brief account of past developments in tall buildings is presented below.[2]

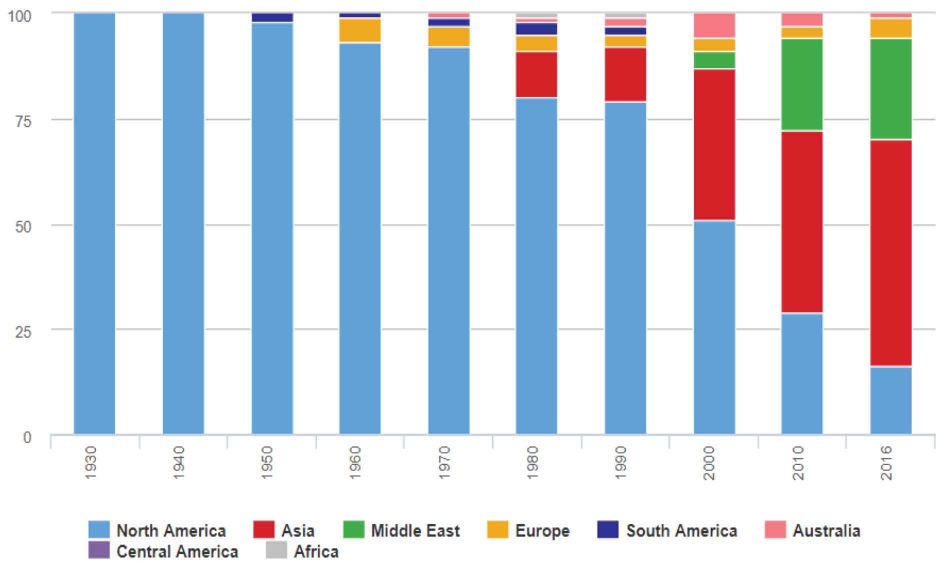

Figure 1. Tall Buildings in Regions as per CTBUH (COUNCIL ON TALL BUILDING AND URBAN HABITAT)

II. LITERATURE REVIEW

A. M. Halis Gunel, H. Emre Ilgin; ''A proposal for the classified the structural system for tall buildings" Building and Environment, 42 (2007) 2667–2675, 04 July-2006

M. Halis Gunel, H. Emre Ilgin[1]; "A proposal classified the structural system for tall buildings" In this study, structural systems that can be used for the lateral resistance of tall buildings are classified based on the basic reaction mechanism/structural behavior for resisting the lateral loads. In this research the following classification is proposed for the structural systems of tall buildings for all the types namely steel buildings, reinforced concrete buildings and composite buildings.

Rigid Frame Systems
Braced Frame And Shear-walled Frame Systems
Outrigger Systems
Framed-tube Systems
Braced-tube Systems
Bundled-tube Systems

At the end authors concluded that advancements in concrete technology, such as manufacturing ultra-high-strength concrete, except ‘outrigger systems’, all the structural systems classified above can be applied in reinforced concrete. And tall buildings with new structural classification which can be called as ‘mixed systems’ will be introduced. ‘Mixed systems’ use the combination of two or more of the above six different systems.

B. Mir M. Ali and Kyoung Sun Moon; "Structural Developments in Tall Buildings Current Trends and Future Prospects" Architectural Science Review, Volume 50.3, 13 June-2007

Mir M. Ali and Kyoung Sun Moon[2]; "Structural Developments in Tall Buildings Current Trends and Future Prospects" This paper gives depth classification of structural system as, Interior Structures and Exterior Structures. They also suggests the Structural System Efficient for different story height And also give some brief idea on Damping Strategies for Structural Systems.

Interior Structures	**Exterior Structures**
Rigid Frames	Tube
Braced Hinged Frames	Diagrid
Shear Wall / Hinged Frames	Space Truss Structures
Shear Wall - Frame Interaction System	Super frames
Outrigger Structures	Exo-skeleton

They conclude that exterior structural systems which are technically more efficient. More research is needed for exterior system. However, placing structural frames on the perimeter has some drawbacks from an architectural point of view. Structural solutions to overcome these problems are very much needed. And major challenge for multi-use tall structures is to make them adaptive to possible changes in occupancy at different floor levels responding to the demands of the prevailing real estate market.

C. Osama Ahmed Mohamed, Omar Najm "Outrigger System to mitigate Disproportion Collapse in Building Structures" Procedia Engineering 161 (2016) 839-844, june-16

Osama Ahmed Mohamed and Omar Najm[3]; "Outrigger system to mitigate disproportionate collapse in building structures" This Study give us a study on outrigger as follow Outrigger Systems are often used to transfer lateral forces to the foundation. They are particularly designed to control drift in tall buildings due to wind and seismic forces. The paper discusses how outrigger systems may mitigate toppling of building of building structures. As per papers when outrigger systems are unitized to resist lateral forces, vertical elements on the perimeter are naturally design to resist tension under lateral forces, as well as compression. This paper also discusses a case study where, Lateral force resistance was provided using reinforced concrete central core with outriggers extending to 8 mega-columns connected by a perimeter belt system. Outriggers and belt systems are located at the 20th ,40thand 60th story levels. The outriggers at the 60th story are mostly for practical rather than structural purposes. Plan shown below are the Typical plan view showing outrigger location.

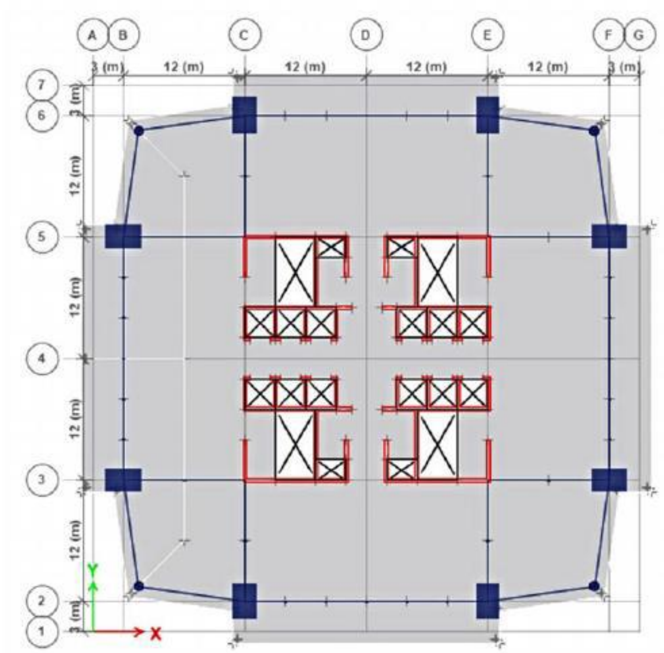

Figure 2. Typical plan view showing outrigger location

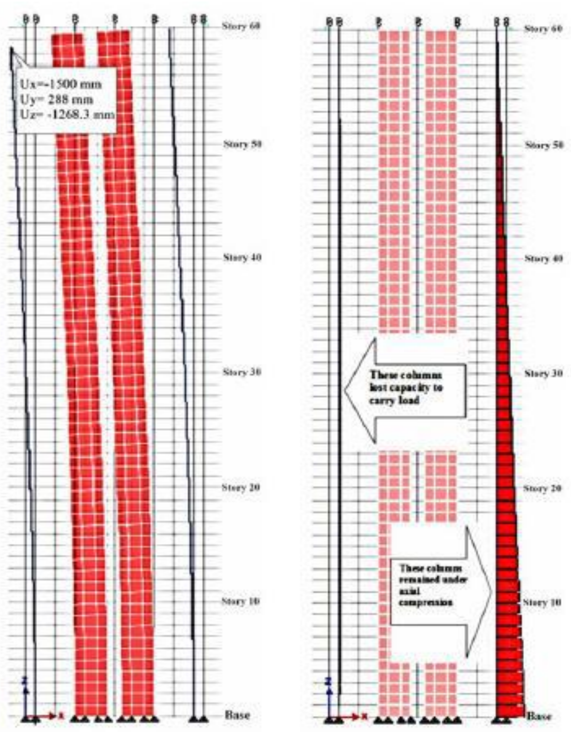

Figure 3. Deflection without Outrigger

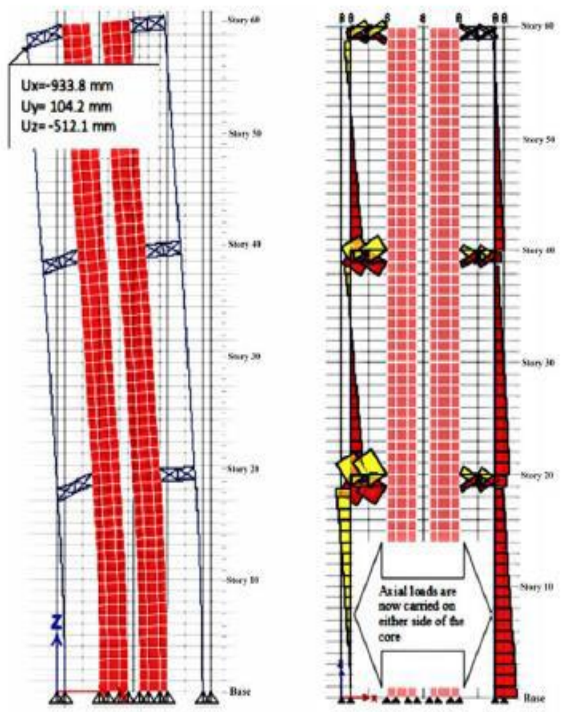

Figure 4. Deflection with outrigger

This paper demonstrated through a case study that stiff outrigger-belt systems connected to a rigid concrete core are capable of reducing the peak deformations due to gravity loads associated with progressive collapse. Redistribution of gravity forces results in reducing the axial compressive stress, compared to the system without outriggers.

D. Hojat Allah Ghasemi "Evaluation Of Seismic Behavior Of Irregular Tube Buildings In Tube Systems" Advance in Science and Technology Research Journal, Vol 10, No. 29, March 2016

Hojat Allah Ghasemi[4]; "evaluation of seismic behavior of irregular tube buildings in tube systems" This study is intended to investigate seismic behavior of irregular building tube in tube systems, for this purpose seismic behavior of 40-story and 60-story reinforced concrete frame building with irregular plan was evaluated, seismic behavior of irregular buildings was assessed by overall building drifts, story drifts and shear lag behavior factors.

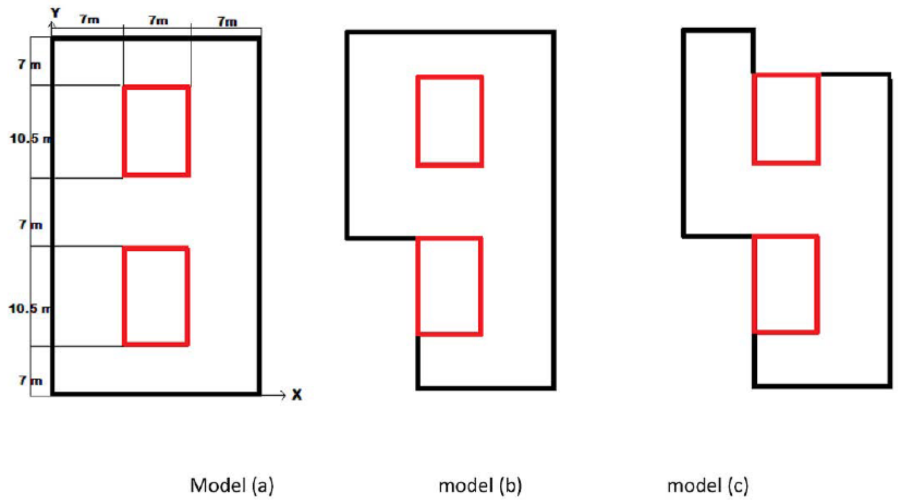

Figure 5. Plans of case study for 40-story and 60-story buildings

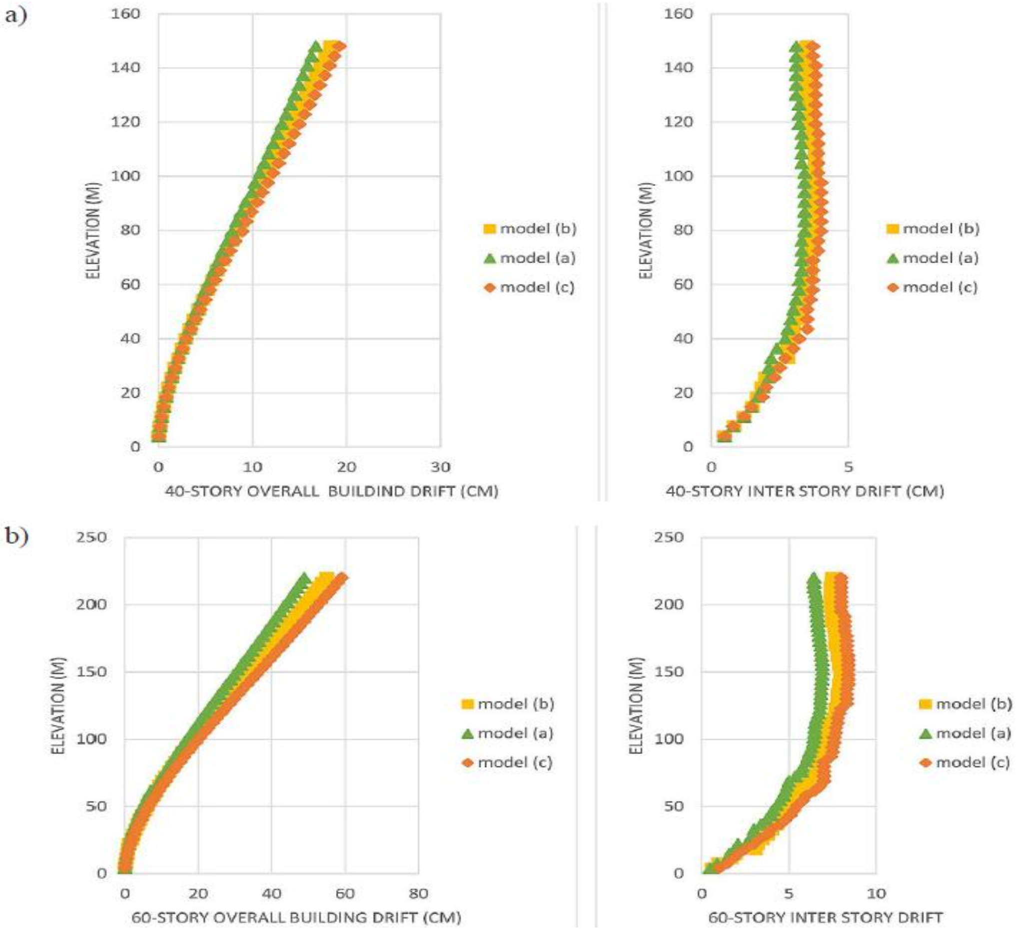

Figure 6. Overall story drift and inter story drift for: a) 40-story building, b) 60-story building

At the end authors concluded that irregular in plan of structure increase overall building drift and inter story drift, in the 60-story building with increase irregular in plan story drifts growth more than the 40-story drift, max difference story drift between regular plan and irregular plan in 40-story building was about 13%, while max difference story drift between regular plan and irregular plan in the 40-story building was about 18%.

E. Shaival J. Patel, Prof. Vishal B. Patel "Comparison of Different Types of Tubular Systems" IJAREST-2016, Volume 3, Issue 4, April 2016

Shaival J. Patel and Prof. Vishal B. Patel[5]; "Comparison of Different Types of Tubular Systems" In this study one steel building of each framed tube system and bundled tube system of optimum section with 64 stories with symmetric plan area and identical loading condition using ETABS. Various parameters like fundamental time period, maximum top story lateral displacement, maximum base shear, steel weight, and maximum story drift are considered in this study.

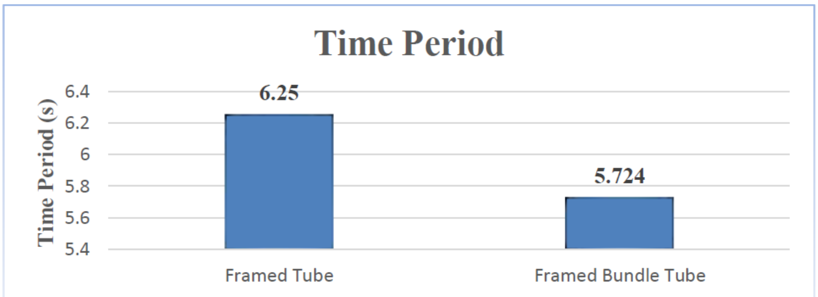

Figure 7. Time Period

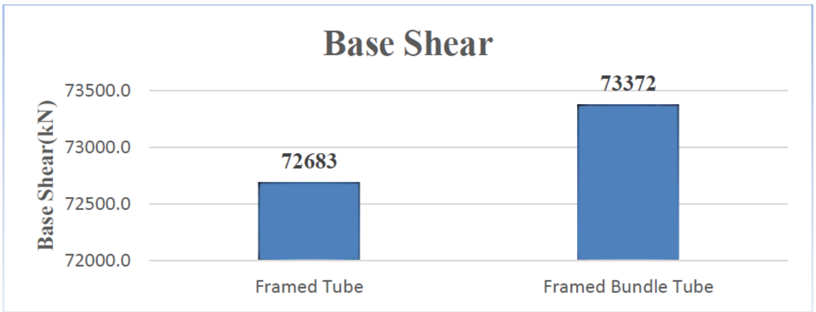

Figure 8. Base Shear

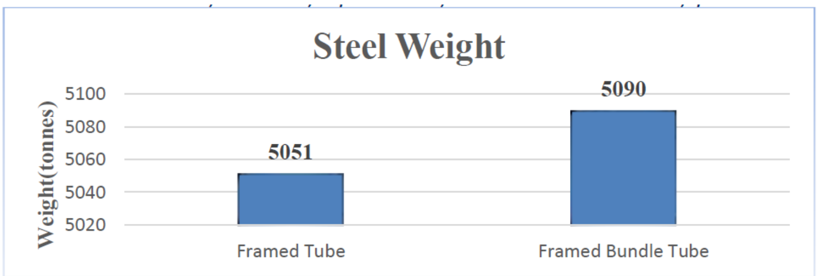

Figure 9. Steel Weight

Bundled Tube structural system has emerged as a better solution for lateral load resisting system in terms of lateral displacements, story drift, base shear and stiffness. It's stiff enough to resist wind forces upto higher heights. This System provide large spacing between exterior column for bundled tube system in compare to framed tube system and also close tube to give attractive view like shears tower.

F. Thejaswini R M and Rashmi AR. "Analysis and Comparison of Different Lateral Load Resisting Structural Forms "International Journal of Engineering Research & Technology, Vol. 4 Issue 07, July-2015

Thejaswini R M and Rashmi A R[6]; "In this study a particular type of irregular building with different structural forms are considered and seven models are developed in Etabs software with codal provisions. These models are analyzed for response spectrum method and wind load. When seismic analysis is considered some of the major factors come into picture like lateral displacement, storey drift, and stability of columns in particular storey due to lateral forces and when the building is in irregular configuration torsion irregularity will also become an important factor.

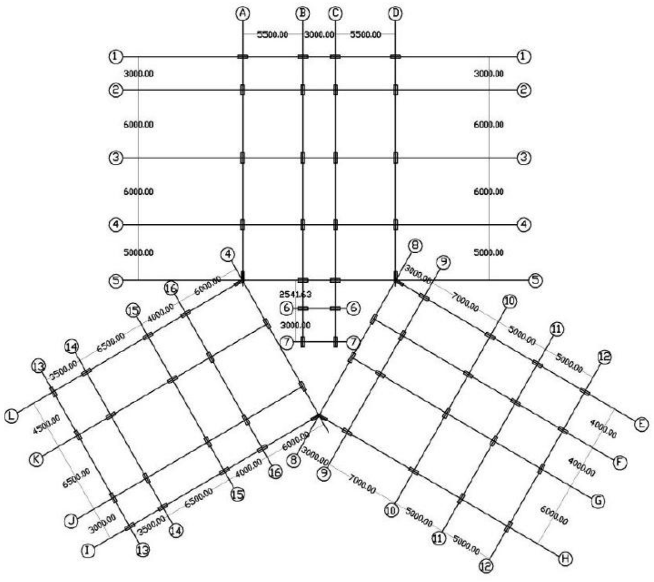

Figure 10. Plan of Considered Model

Models considered:

Model 1	Rigid Frame Structure
Model 2	Core Wall Structure
Model 3	Shear Wall along Width of Each Block
Model 4	Shear Wall along Length of Each Block
Model 5	Shear Wall at Corners of Each Block
Model 6	Tube Structure
Model 7	Outrigger Structure

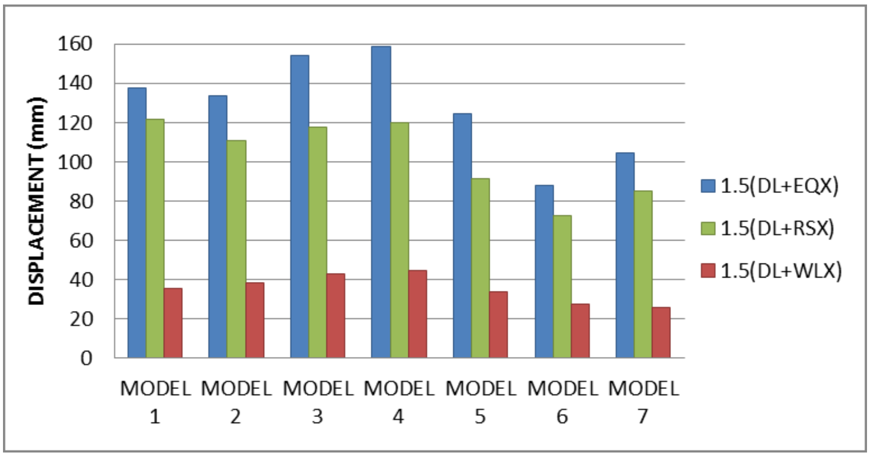

Figure 11. Maximum Displacement in X Direction

It is observed that as the density of column increases along periphery it leads to increase in stiffness and acceleration, resulting in decrease of displacement, Outrigger behaves as high drift controller when provided at storey which has maximum drift, The stability of the structure can be increased and the sway in columns can be avoided by providing tubular structure and 'L' shaped shear walls at corners. And at last Out of all 7 models, Model-6 (tubular structure) is considered as best lateral load resisting system due to lowest displacement, most stable and no torsional irregularity in the building.

III. CONCLUSION

From the above literature we conclude that

1) Paper suggest to use of different structural system based on different height of structure and plan shape.
2) Use of rigid moment resisting structural system becomes inefficient for more than 30 story.
3) In the future, the preference of composite and concrete tall structures will be increased.
4) Farther more, combination of different structural system called hybrid system will be preferred.
5) There cannot be the perfect classification of structural system, it changes from mind to mind of designer.

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