PERFORMANCE OF LATERAL SYSTEMS ON TALL BUILDINGS

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ABSTRACT
The advances in three-dimensional structural analysis and computing resources have allowed the efficient and safe design of increasingly taller structures. These structures are the consequence of increasing urban densification and economic viability. The trend towards progressively taller structures has demanded a shift from the traditional strength based design approach of buildings to a focus on constraining the overall motion of the structure. Structural engineers have responded to this challenge of lateral control with a myriad of systems that achieve motion control while adhering to the overall architectural vision. The present work aims to demonstrate the performance of building considered with outriggers, tube in tube, bundled system. The building studied in this work is a reinforced concrete moment resisting frame (G+40) designed for gravity and seismic using 1893:2002. And is studied using Non-linear time history analysis. These building models are analyzed, using SAP 2000 software, to the action of lateral forces employing non-linear dynamic approaches as per IS 1893 (Part I): 2002. The results of the analyses, in terms of lateral deformations, respective storey drifts and base shears are obtained and the conclusions are drawn thereof. The suitability of the type of lateral system for the buildings is suggested based on the soil type and its location.

Key words: Earthquake loads, Finite element modelling, High-rise, Lateral Displacement, Lateral loads.

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1. INTRODUCTION
Mankind has always had a fascination for height and throughout our history; we have constantly sought to metaphorically reach for the stars. From the ancient pyramids to today’s modern skyscraper, a civilization’s power and wealth has been repeatedly expressed through spectacular and monumental structures. Today, the symbol of economic power and leadership is the skyscraper. There has been a demonstrated competitiveness that exists in mankind to proclaim to have the tallest building in the world.

This undying quest for height has laid out incredible opportunities for the building profession. From the early moment frames to today’s ultra-efficient mega-braced structures, the structural engineering profession has come a long way. Diagrids structural systems are emerging as structurally efficient as well as architecturally significant assemblies for tall buildings. The recent development of structural analysis and design software coupled with advances in the finite element method has allowed the creation of many structural and architecturally innovative forms. However, increased reliance on computer analysis is not the solution to the challenges that lie ahead in the profession. The basic understanding of structural behavior while leveraging on computing tools are the elements that will change the way structures are designed and built.

The design of skyscrapers is usually governed by the lateral loads imposed on the structure. As buildings have taller and narrower, the structural engineer has been increasingly challenged to meet the imposed drift requirements while minimizing the architectural impact of the structure. In response to this challenge, the profession has proposed a multitude of lateral schemes that are now spoken in tall buildings across the globe. This study seeks to understand the evolution of the different lateral systems that have emerged and its associated structural behavior, for each lateral scheme examined, its advantages and disadvantages and performance of tall framed buildings in seismic zone will be looked at.

2. OBJECTIVES
1. To investigate the behaviour of buildings, i.e. Outrigger, bundled; tube in tube and conventional frame with shear wall under the seismic zone V Using the nonlinear time history analysis.
2. To check the reliability of structure with Outrigger system, tube in tube, bundled system and conventional frame with shear.
3. To study various responses such as Base shear, Overturning moment, Shear force, Bending moment, axial force, inter storey drift, storey shear, storey moment etc. of buildings.

3. SCOPE OF STUDY
The present work aims at an objective to investigate the behaviour of buildings, under the seismic zone V. Structural performance of complex shaped tall buildings with structural systems such as braced tube, diagrids and outrigger systems structural performance of each system is studied. For comparison of three buildings under the same seismic zone, the parameter in all the buildings is taken same. The building studied in this section is a reinforced concrete moment resisting framed building designed for gravity loads alone. The structure is evaluated in accordance with seismic code IS 1893:2002 (14) using nonlinear time history analysis in SAP2000 V16 package.

4. METHODOLOGY
4.1. Nonlinear Dynamic Analysis
It is known as Time history analysis. It is an important technique for structural seismic analysis especially when the evaluated structural response is nonlinear. To perform such an analysis, a representative earthquake time history is required for a structure being evaluated. Time history analysis is a step by step analysis of the dynamic response of a structure to a specified loading that may vary with time. Time history analysis is used to determine the seismic response of a structure under dynamic loading of representative earthquake.
4.2. Nonlinear Time History Analysis

NLTHA is one of the methods and the most accurate method available to understand the behavior of structures subjected to earthquake forces. As the name implies, it is the process of finding out the history of responses throughout the life span of the dynamic loading like an earthquake ground acceleration record until the structure reaches a limit state. The dynamic loading consists of applying earthquake ground acceleration record of lateral loads to a model which captures the material non-linearity of an existing or previously designed structure, and monotonically increasing those loads which vary with time so that the peak response of the structure is evaluated.

For this purpose two earthquake ground acceleration records namely N-E Bhuj and N-W Bhuj components of the Bhuj Earthquake record have been selected. Bhuj is a place located in the state of Gujarat which is a high intensity earthquake zone of zone factor 0.36 which comes under the Zone V according to the classification of seismic zones by IS 1893-2002 part-1. The records are defined for the acceleration points with respect to a time interval of 0.005 second. The acceleration record has units of m/sec^2 and has a total number of 26,706 acceleration data coordinates out of which the most critical data points which are of the highest intensity are the first 10,000 acceleration data coordinates have been considered.

![Figure 1 Bhuj-N-E component earthquake ground acceleration record](image)

5. STRUCTURAL MODELLING AND ANALYSIS

The SAP2000 software is able to predict the geometric nonlinear behaviour of space frames under static or dynamic loadings, taking into account both geometric nonlinearity and material inelasticity. In this work 5 buildings of 30 storied are taken and their structural behaviour is compared under seismic zone V using nonlinear time history analysis.

Floor load- 4kN/m^2
Floor finish- 1.25kN/m^2
Beam size- 400x600mm
Column size- 700x700mm
Slab thickness- 150mm
Importance factor- 1.0
Seismic zone factor- 0.36
Response reduction factor- 5
Grade of concrete- M35
Grade of steel- Fe-500
Unit weight of concrete- 25kN/m$^3$

**Figure 1** Plan and Elevation of rcc building

**Figure 2** Plan and Elevation of shear wall building
Figure 3 Plan and Elevation of outrigger frame building

Figure 4 Plan and Elevation of tube in tube building

Figure 5 Bundled tube building
Table 1 Building parameters common to 5 models

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<th>S. No.</th>
<th>Description</th>
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<td>1</td>
<td>Plan size</td>
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<tr>
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<td>Number of storey’s above ground level</td>
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<td>Number of basements below ground</td>
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<td>IS-1893:2002 Clause 7.1</td>
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<td>7</td>
<td>Horizontal floor system</td>
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<tr>
<td>8</td>
<td>Software used</td>
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6. RESULTS AND DISCUSSIONS

The Results obtained are of different parameters such as Storey drifts, Base shear, Modal Periods, Torsion etc. Seismic performance of reinforced concrete moment resisting frame can be evaluated in terms of inter story drift and lateral load resistance. The results obtained by carrying out Non-Linear Time History Analysis for Thirty Storey Buildings as listed.

![Figure 6](http://www.iaeme.com/IJCIET/index.asp) Above graph shows displacement of models
Performance of Lateral Systems on Tall Buildings

**Figure 7** Above graph shows drift of models

**Figure 8** Above graph shows time periods of models

**Figure 11** Above graph shows base shears of models
For high-rise buildings, in order to control the seismic response bundled tube were modelled and the results showed that there is a drastic decrease in storey displacements and storey drifts by 37% and 50.9% compared to RCC symmetric building.

In OUTRIGGER structure the base shear and base moment is reduced by 31% and 25% compare to RCC symmetric building.

The overall results suggested that bundled tube is excellent seismic control for high-rise symmetric Buildings.

7. CONCLUSION

The different parameters such as Storey drifts, Base shear, Modal Periods of five buildings are evaluated using nonlinear time history analysis in SAP2000V16 package.

The use of outrigger structural system increases the stiffness of the structure by connecting the building core to the distant column and makes the whole system to act as a single unit in resisting the lateral load. A framed tube system with internal tubes is analyzed using orthotropic box beam analogy approach which accounts for flexural and shears lag effects. The overall results suggested that bundled tube is excellent seismic control for high-rise symmetric Buildings.

As Time History is realistic method, used for seismic analysis, it provides a better check to the safety of structures analyzed and designed by method specified by IS code.

REFERENCE


