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DESIGN AND ANALYSIS OF HIGH RISE BUILDING

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ABSTRACT - *As cities expand, there is an increasing need for high-rise structures. As a result, the need for tools that assist in the design and analysis of structures in a more efficient manner is also on the rise. The emphasis of this research work is the analysis and design of high-rise buildings using ETABS, which is among the most commonly used analytical tools for building system designs. Because the program can address nonlinearities in geometry and load conditions, it is an effective instrument for designing tall buildings.*

Different loading conditions such as dead load, live load, wind load and seismic load were all considered in the research as the building models where the main objective. ETABS is used to create a 3D living structure model that includes various structural system parts with several elements calculating stiffness, stability, and material characteristics. systems to drown the structure out from responding to lateral loads like the wind and earthquakes. Such as moment-resisting frames, shear walls and bracing systems are designed and further optimised through ETABS for safety and performance of the structure.As part of the design, the vertical level of force application will be determined, along with the dynamic properties of the building in relation to earthquake phenomena and high wind load. For instance, BC Hydro ETABS includes components that allow for advanced building modelling such as pushover analysis and response research. The study also notes that building codes and standards can be unified so that proper safety measures are put in place.From the findings, there is sufficient evidence to support the claim that ETABS is effective in the structural design of skyscrapers because it improves efficiency in structural component design through its load analysis capabilities. This research offers an in-depth approach to engineers and architects in the design of high rise buildings that are safe, effective, and demand less resources and time integrating modern day computational techniques.

Key Words: ETABS, high-rise buildings, structural analysis, load distribution, wind forces, seismic design, lateral load-resisting systems, computational design.

1. INTRODUCTION

A high-rise building, as defined by the National Building Code of India 2005, is any structure taller than 15 meters. These buildings typically use reinforced concrete and steel for their frameworks. In North America, many skyscrapers feature steel frames, while residential buildings often rely on concrete. Although there's no strict distinction between tower blocks and skyscrapers, buildings with fifty or more stories are generally classified as skyscrapers.

High-rise structures present unique design challenges for structural and geotechnical engineers, especially in areas prone to seismic activity or where the underlying soil has risks like high compressibility. Engineers must navigate these complexities to ensure safety and stability, making the design of high-rises a fascinating and demanding field. The sight of tall buildings has turned into a symbol of our new cities - they evidently express economic and technological achievements. However, their construction is full of challenges specifically in the regions that are earthquake-prone.

On top of the list, earthquake-resistance safety and stability of these structures are core, thus, necessitating a global analysis of the target and designing those in a way that can withstand any unforeseen situation. This study is the first one to be undertaken for the throughout examination of the seismic performance of high-rise buildings (G+16) using the best structural analysis and design software, Etabs. High-rise buildings are especially prone to seismic push-pull forces given their altitude and the time-dependent behaviors influencing their responsiveness to ground motion. The main objective of the research is to compare structural systems and different variations of such to decide the best building designs to reduce the seismic hazard. The analysis will take into account a number of factors, including building geometry, material properties, load distribution, mechanisms.

1.1 ANALYTICAL INVESTIGATION

Analytical studies of tall structures include evaluating how they respond to various static and dynamic loads and conditions. This procedure is essential to ensure the performance, stability, and safety of towers, bridges, tall buildings, and other structures. Below is an overview of static and dynamic analysis of tall structures:

The objective is to compare the performance of different methods for static and dynamic analysis of tall structures with regard to the influence of shear lag, bending stiffening and boundary conditions on the static and dynamic behavior of tall structures. The objective is to propose a simple and accurate approximation method for static analysis of high-rise structures that can reduce computational effort and cost, and to validate the proposed method with experimental data and existing literature.

1.2 TYPES OF SEISMIC ANALYSIS

1.2.1 EQUIVALENT STATIC ANALYSIS

The response of a structure to dynamic loads such as earthquakes or wind loads is evaluated in civil engineering using a simplified technique known as equivalent static analysis, which is often used when dynamic analyses such as response spectrum analysis or time history analysis are too complex or when a more rational approach to design is sufficient.

1.2.2 RESPONSE SPECTRUM ANALYSIS

Response spectrum analysis is a method to determine the response of a design to a specific earthquake motion. It is a powerful method to create earthquake-resistant structures, so that they can withstand earthquake forces without collapsing. This is called the earthquake motion response region. First, the designer must select the earthquake motions that are typical of earthquakes that are likely to occur near the site.

1.2.3 PUSH OVER ANALYSIS

For earthquake restoration projects, the Applied Technology Council (ATC) and the Federal Emergency Management Agency (FEMA) developed and recommended nonlinear static analysis, also known as pushover analysis (Documents FEMA-356, FEMA-273, and ATC-40 were among them). A gradually increasing lateral load is pushed over or under a vertical load. The load or displacement on the building frame is applied gradually. Plastic hinge development, stiffness loss, and plastic rotation are tracked. This type of study can identify structural weaknesses. Pushover analysis is a nonlinear static process that uses a truncated estimate of earthquake structural deformation using a nonlinear approach. It is a further development of static analysis to determine force displacements.

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2.1 DEFLECTION OF BUILDINGS:

2.1.1 Along x axis

2.1.2 Along y axis

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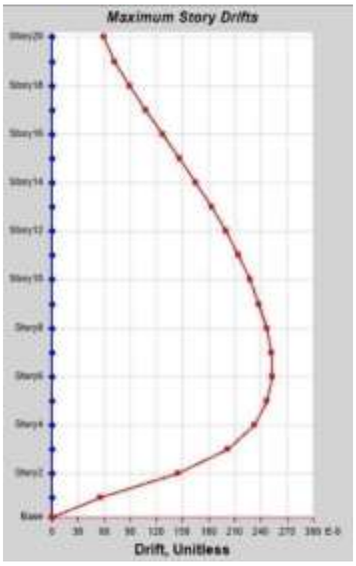
2.1.3 STOREY DRIFT :



3. TYPES OF PUSHOVER ANALYSIS :

There are now two non-linear static analysis methods available: the Capacity Spectrum Method (CSM), documented in ATC-40, and the Deployment Coefficient Method (DCM), documented in FEMA-356. Both approaches rely on variations in lateral load deformation brought about by idealized lateral loading as a result of seismic action and non-linear static analysis under gravity loading. Pushover Analysis is the name given to this analysis.

CAPACITY SPECTRUM METHOD

The Capacity Spectrum Method is a non-linear static analysis technique that intersects the structure's capacity spectrum with the earthquake's response spectrum (demand spectrum) to produce a graphical representation of the projected seismic performance of the structure. The displacement coordinate (dp) of the performance point is the estimated displacement demand on the structure for the given level of seismic danger. The intersection point is referred to as the performance point.

DISPLACEMENT COEFFICIENT METHOD

The displacement coefficient method is a nonlinear static analysis technique that uses a bilinear representation of the capacity curve and a number of modification factors to produce a target displacement to give a numerical methodology for predicting the displacement demand on a structure. The capacity spectrum method's counterpart of the performance point is the point on the capacity curve at target displacement.

4. SAFETY AND STRUCTURAL INTERGRITY

Tall structures are more susceptible to failure than shorter structures due to their increased height and flexibility. As a result, it is essential to perform both static and dynamic analysis to ensure the safety and structural integrity of these structures. Static analysis involves the application of static forces to the structure, such as gravity loads, wind loads, and snow loads. This analysis is used to determine the maximum expected forces that the structure will experience and to design the structure's structural elements to resist those forces. Dynamic analysis involves the study of the structure’s response to dynamic forces, such as earthquake forces. This analysis is used to determine the structure's natural frequency, mode shapes, and damping characteristics. This information is then used to design the structure to withstand dynamic forces without failure. Both static and dynamic analysis are important for ensuring the safety and structural integrity of tall structures. However, dynamic analysis is particularly important for tall structures located in seismic regions.

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4.1 Foundation design: The foundation of a tall structure needs to be strong enough to hold the weight of the building and to withstand the shear pressures and overturning moments that will be applied to it during an earthquake.

4.2 Structural framing system: A tall structure's structural framing system needs to be built with enough rigidity and strength to withstand both static and dynamic forces. Additionally, the system needs to be ductile in order to deform during an earthquake without failing.

4.3 Lateral load resisting system: A tall structure's lateral load resisting system is in charge of fending off wind and earthquake effects. To prevent excessive lateral displacement of the structure, the system must be strong and stiff enough.

4.4 Damping: Damping is a structure's capacity to take in energy and lessen vibrations. In order to lessen the response of tall structures to dynamic forces, damping devices must be incorporated into the structure because tall structures often have low levels of damping.

3.4. Load Consideration

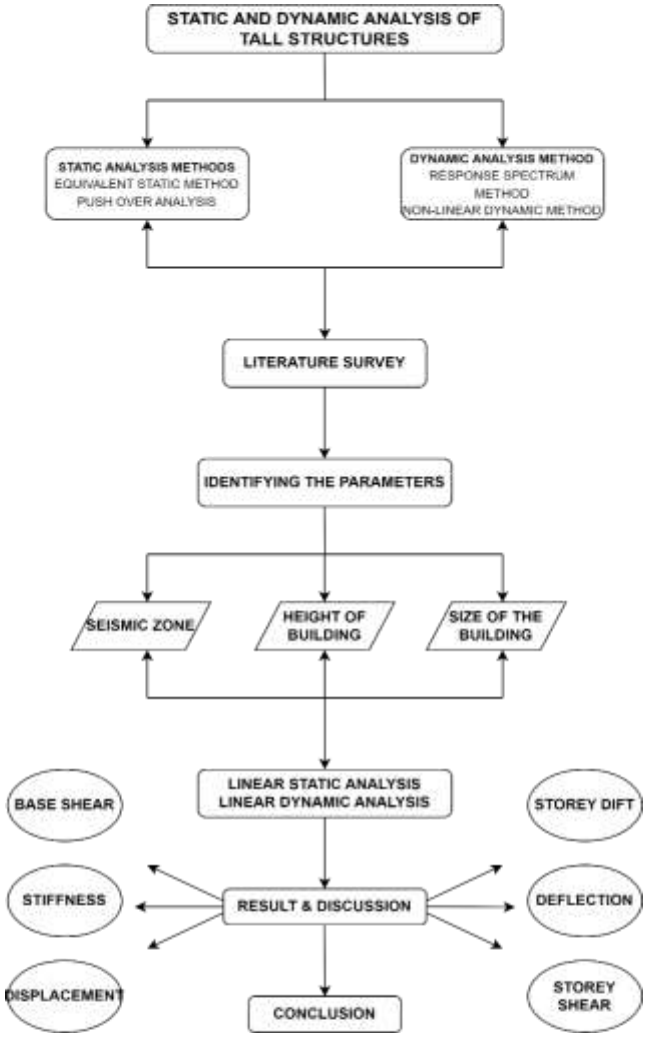
- Dead load - Gravity load
- Live load - Seismic load

1. Zone IV = 1.24 (zone factor)
2. Importance factor = 1
3. Type of structure = SMRF

In the limit state design of reinforced and prestressed concrete structure, the following load combination shall be accounted for as per IS 1893:2002

1. 1.5 (DL + LL)
2. 1.2 (DL+LL+EQX)
3. 1.5(DL+EQX)
4. 0.9 DL+1.5EQX

5. METHODOLOGY



6. CONCLUSION

The analysis and design of high-rise buildings using ETABS is a significant advancement in modern structural engineering, offering an efficient and precise approach to addressing the complexities of tall structures. ETABS, as a specialized software for structural analysis and design, integrates advanced tools to model, analyze, and design buildings with a high degree of accuracy and reliability. High-rise structures are subjected to various complex forces such as gravity, wind, and seismic loads, and ETABS simplifies the process by providing a user-friendly interface and robust analytical capabilities. One of the primary advantages of using ETABS is its ability to automate intricate calculations and produce highly accurate results, thereby reducing the time and effort required for manual computations. This not only accelerates the design process but also ensures better optimization of structural elements, leading to more cost-effective solutions. The software supports a wide range of international design codes, allowing engineers to create structures that comply with regional regulations and standards. This compliance ensures that buildings meet safety and performance requirements while addressing the specific challenges posed by their geographic locations. Another critical aspect is ETABS' capability to perform advanced seismic and wind analysis, which is crucial for the safety and durability of high-rise buildings. The dynamic analysis tools in ETABS help engineers understand the building's behavior under lateral loads and design structures that can withstand extreme conditions without compromising stability. Additionally, the software enables engineers to optimize material usage, which not only reduces costs but also aligns with sustainable construction practices. ETABS also provides detailed insights into structural behavior through its visualization tools, offering better understanding and communication of design decisions. By identifying potential weaknesses in the structure early in the design process, engineers can make necessary adjustments to improve performance. Furthermore, the integration of building information modeling (BIM) in ETABS ensures seamless collaboration among different disciplines involved in the project, fostering better coordination and reducing errors. The software's advanced capabilities make it indispensable for modern high-rise building projects, where efficiency, accuracy, and safety are of paramount importance. In conclusion, ETABS streamlines the process of analyzing and designing high-rise buildings by addressing their unique challenges through its powerful tools and features. It ensures structural efficiency, compliance with safety standards, and optimization of resources, all while saving time and reducing costs. The ability to handle complex loading conditions, such as seismic and wind forces, makes ETABS a preferred choice for engineers worldwide. With its contribution to improving the quality and reliability of high-rise buildings, ETABS plays a pivotal role in advancing the construction industry and meeting the demands of modern urbanization.

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