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Analysis and Design of Code Exceeding Structures Using is 16700

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Abstract- Due to population growth and limited available space in cities, the construction of tall buildings has become a necessity. When designing tall buildings, the focus is often on achieving the required stiffness rather than just strength. Proper selection of the structural system and design is crucial to ensure sufficient lateral stiffness, as tall buildings are primarily affected by lateral loads such as wind and seismic forces. Various factors, including building height, plan aspect ratio, slenderness ratio, geometry, and damping, influence the behavior of high-rise buildings and must be considered during the design process.Analyzing the wind loads and structural behavior of tall buildings can be challenging, especially when dealing with unique aerodynamic shapes or flexible buildings that are prone to motion-induced forces.Different countries develop their own codes and standards for the analysis and design of tall buildings. In India, high-rise constructions have been carried out according to various Indian standards and building codes. However, the existing codes and standards may not adequately address all the specific challenges associated with tall buildings. To address this gap, a new code called IS 16700-2017 "Criteria for Structural Safety of Tall Concrete Buildings" has recently been introduced in India.

Keywords- RCC building, seismic analysis, structural safety, shear wall.

I. INTRODUCTION

The rapid increase in population has resulted in a significant shortage of available space in cities, making it necessary to construct tall or high-rise buildings. Designing tall buildings poses unique challenges compared to low- and mid-rise structures. These buildings are subjected to static and dynamic loads, and their structural integrity is influenced by various factors such as bending, shear, torsion, and drift. It is crucial to consider these effects during the analysis and design process. Different countries develop their own codes and standards for the analysis and design of tall buildings. In India, high-rise constructions have been carried out according to various Indian standards and building codes. However, the existing codes and standards may not adequately address all the specific challenges associated with tall buildings.

To address this gap, a new code called IS 16700-2017 "Criteria for Structural Safety of Tall Concrete Buildings" has recently been introduced in India. This code focuses specifically on the unique aspects and considerations related to tall buildings, aiming to provide comprehensive guidelines for their safe and efficient design. The emergence of tall buildings in Indian cities is a response to the challenges of urbanization and the scarcity of available land. These vertical developments offer a way to accommodate the growing population and meet the demand for residential and commercial spaces. It is important to note that wind load becomes a significant governing factor in the design of tall buildings, unlike in most low-rise structures. Additionally, considering that a significant portion of Indian territory is prone to earthquakes, seismic safety is a crucial aspect that needs to be addressed in the design and construction of tall buildings.

Indian urban communities are seeing massive development because of movement from encompassing towns, prompting endless suburban, housing interest, ascend in expense of land. Numerous residents all over India move to the urban areas for better positions and lifestyle. Enterprises, exchange and business exercises and number of institutions focuses in urban areas pull in gliding populace from all their low populated towns and regions. This has extended the urban areas every which way and all parts of advancement. With an endless suburban of kilometers, these face the issues of clog, contamination, ordinary driving to work place, rivalry, deforestation and so forth.

As India encounters fast turn of events, urban areas will keep on observing tremendous spray in the interest for reasonable lodging and business land, in the metro urban areas as well as in tier 2, 3 and 4 cities. Because of this need, the metropolitan advancement services of the states have expanded the reasonable developed region ashore by methods for increasing Floor Area Ratio (FAR or FSI). Modern cities generally feature new structures that are 15 stories or taller (50 meters+), consuming the available FAR. There were gaps in the conceptualization and design of tall structures, and the structural engineering community nationwide was not prepared for the abrupt rise in building heights.

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In contrast to low-rise buildings, the design of higher structures is influenced by lateral stresses as well, such as wind and earthquake, which play a crucial part in conceiving the design. To ensure proper execution of tall constructions in terms of security and functionality, a standard plan convention was needed. In India, there wasn't really a Standard Code of Practice for the design of tall structures. As a result, a new Standard for Criteria for Structural Safety of Tall Concrete Buildings was developed, and its requirements are prescriptive for RCC solid tall construction plans.

II. OVERVIEW OF IS 16700: 2017

The 2017 edition of the IS 16700: 2017 "Criteria for structural safety of tall concrete buildings" code, published the the Bureau of Indian Standards, addresses the problems with the construction of reinforced concrete (RC) tall buildings. Tall buildings, as defined by this code, are those that range in height from 50 to 250 meters. The key aspects of this standard that it addresses are as follows:

- Many structural designs that may be used.
- General requirements, including the highest structure that may be permitted to be constructed.Plan aspect ratio, lateral drift, storey stiffness and strength, vertical acceleration, floor systems, material qualities, and progressive collapse mechanism are among the several structural systems and seismic zones that need to be considered.
- Loads and load combinations
- Structural design parameters
- Foundation design parameters

Buildings that exceed the requirements of this standard (for instance, those that are taller than 250 m, those that have larger than the height allowed for a specific structural system, or those that use other structural systems not allowed by this standard) and those that are not covered through this standard are referred to as "code exceeding tall buildings." To achieve the specified structural performances, such a building needs a performance-based design methodology. Two processes should be used for all code-exceeding high-rise buildings: structural design reviewer review and expert review panel evaluation.

III. METHODOLOGY

As per is 16700 Annex Aevery Code exceeding tall building shall go through following two process:

1. Review by structural design reviewer
2. Review by expert review panel.
   - Code-exceeding tall The types of buildings covered by this document include:

- Structures whose height exceeds the maximum limitations set out in this standard for the applicable structural system.
- Buildings that are 50 m or taller but are within the maximum height restrictions provided by this standard but contain structural irregularities as described in IS 1893 (Part 1) or this standard.
- Complex structures that contain structural elements not covered by this standard, including linked towers, split levels, considerable gravity transfers, and structural systems.
- Foundational energy-dissipating structures and systems that are separated.
- Buildings that fail to adhere to the IS16700 standard's specifications.
- As per Is16700 Checklist Provided in Clause A 1.3, In this research I have chosen Four irregularity.
- As per IS 16700 clause A 5.2 the Structure is analysed and design accordingly.

This research is focused towards presenting the comparative analysis of a G+30 story structure (Design as per code) the behavior of the structures under the impact of dead load, live load, wind load, or seismic loads with various forms of Code exceeding constructions. In order to determine design level earthquake force demands, linear dynamic response spectrum analysis and time-history analysis must be carried out in accordance with IS 1893 (Part 1). These analyses must account for site-specific and higher mode effects. The horizontal and vertical seismic time history records applied should match the criteria as per the code, and the constraint conditions in the time history analysis must have the same meaning as those in the response spectrum analysis. ETAB software is employed for modeling and analysis, while CSi18 detailing software is used for design details.

IV. STRUCTURE AND MODELLING

The G+30 RC multi storey framed building with shear wall and Fluid viscus damper is considered for analysis to know the realistic behaviour during an earthquake with the general plan and elevation is shown in figure 1. Plan dimensions in X and Y direction are 32.25m and 19.55m respectively.

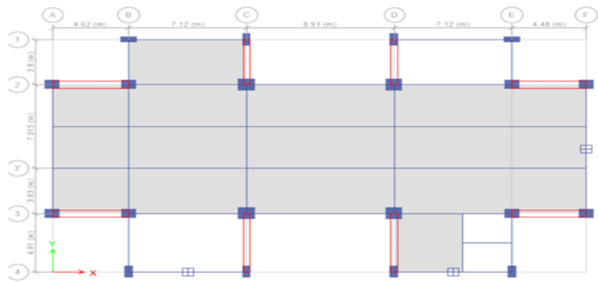

Fig 1. Plan of Base building.

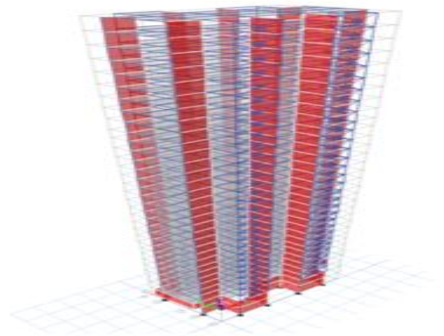

Fig 2. 3D View of Base Building.

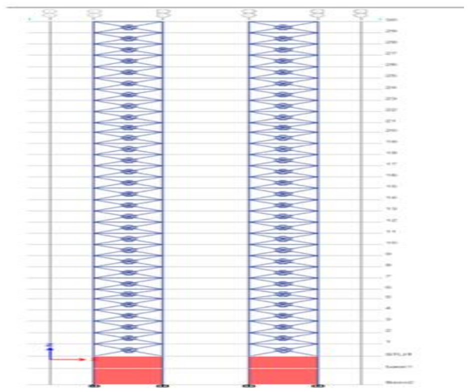

Fig 3. Elevation of base building with friction dampers.

Modal Specifications

Table 1. Geometrical Specifications of the Base Structure.

Geometrical Specification	
Particulars of Item	Properties
Number of Storey	G+30
Total height of Structure	108.25m
Typical Storey height	3.6m
Bottom Storey Height	4m
Floor Diaphragm	Rigid
Number of Grid Lines in X-direction	6
Number of Grid Lines in Y-direction	6
Size of Main Beam	450x900mm
Size of Peripheral Beam	400x750mm
Beam Shape	Rectangular
Column Size C1	500x1000mm
Column Size C2	1000x500mm
Column Size C3	750x900mm
Column Shape	Rectangular
Slab Depth	225mm
Slab Type	Thin Shell
Shear Wall Thickness	600mm
Retaining Wall Thickness	400mm

Table 2. Grades of Material.

Elements	Grade of Concrete	Grade of Steel
Column	M50	Fe500
Beams	M50	Fe500
Shear wall	M50	Fe500
Retaining wall	M35	Fe500
Slabs	M50	Fe500
Structural Steel	-----	Fe250

Table 3. Fluid Viscous Damper Properties

Property	Values
Mass	44 kg
Effective Stiffness	84723 kN/m
Effective damping	12821 kN-s/m
Stiffness	1788048 kN/m
Damping	0.05 kN*(s/m)Exp
Damping exponent	0.3

V. LOADING CONDITION

1. Dead Load:

IS 875 (PART-1) is used to calculate the unit weight of structural materials for dead load calculations.

2. Slab Weight Calculation:

Thickness of slab=0.225m

Density of concrete= 25kN/m3

Self-Weight of slab= Density of concrete x Thickness of slab

= 25x0.225

= 5.625kN/m2

Floor Finish at floor level = 1.5 kN/m2

Total Slab Weight at floor level= 7.125 kN/m2

3. Live Load:

IS 875 (PART-2) is used to calculate the value of floor live load and roof live load.Live Load Intensity specified (Public building) = 4 kN/m2

Live Load at roof level =1.5 kN/m2.

4. Wind load:

IS 875 (Part -3) is used to calculate the value of wind load isn X and Y directions.

Table 3.5 Wind Load Parameters

Parameters	Values
Basic Wind Speed	44kmph
Terrain Category	4
Importance factor	1
Windward coefficient	0.8
Leeward coefficient	0.5
Risk Coefficient(k1)	1
Topography Factor(k3)	1

5. Seismic Load:
Seismic Load is provided in X and Y directions in seismic Zone V as per Is 1893:2016 code.

VI. ANALYSIS AND RESULTS

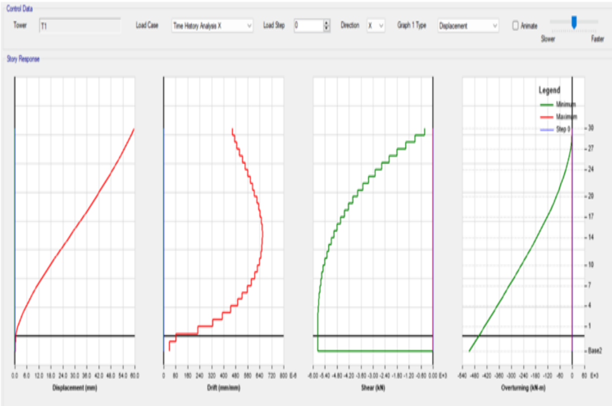

Fig 4. Displacement graph of structure with shear wall 2%.

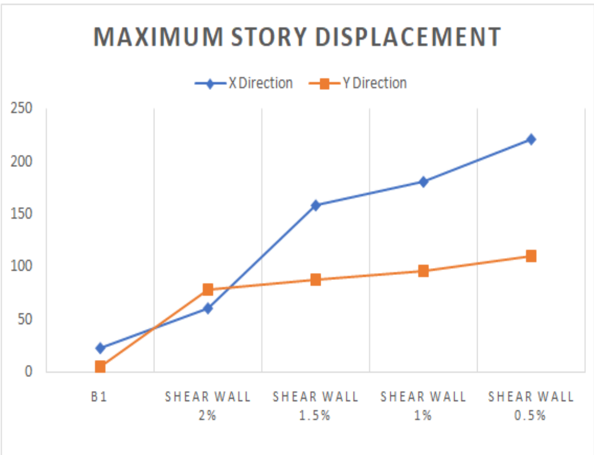

Fig 5. Graph of comparison of maximum story displacement.

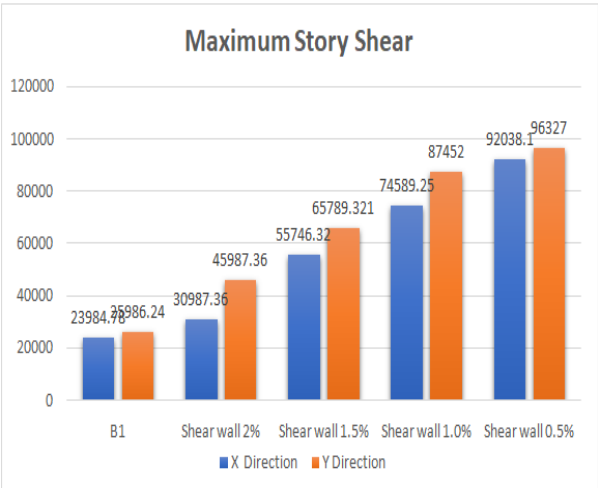

Fig 6. Graph of comparison of maximum story shear.

Building With Exceeding Plan Aspect Ratio
As per code the maximum plan aspect ratio was 5 so I create a building of plan aspect ratio of 6, 7, 8, 9 and analysis the structure.
Building with Plan Aspect Ratio = 6
Length of Building in X direction =117.78m
Length of Building in Y direction =19.55m

V. CONCLUSION

In Case of different shear wall percentage for G+30 building 1% of shear wall is sufficient for structure to be designed. The maximum story drifts values and maximum story displacement values increases significantly when we decrease shear wall percentage. For optimum results and considerable deflection we can provide shear wall percentage to 1.5 percent.

The cost of construction reduced up to 10% when we consider least possible minimum percentage of shear wall. In Case of Slenderness ratio up to slenderness ratio 12 building is safe in lateral displacement but after that it would cross the maximum allowable lateral displacement limit. The height of the structure can be increase w.r.t to their lateral dimensions upto a certain limit keeping other things constant.

In case of building with different plan aspect ratio it would have seen that plan aspect ratio does not have many much impact on maximum story displacement however the base reaction and story drift in y direction increases significantly keeping all other things constant.

Upto Plan aspect ratio 8 the different parametric values like maximum story drift, maximum base reaction and story shear are in limit hence can be designed. In case of building with transfer structure the transfer structure should be adequate strong to transfer the load equally on soil so that there is no differential settlement. Building with transfer structure increases over cost of building up to 20% and designing become cumbersome.

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