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A REVIEW ON "NONLINEAR ANALYTICAL STUDY OF TALL BUILDING USING IS 16700-2017"

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Abstract - *Tall buildings are emerging constructions in Indian cities due to urbanization. In comparison to low and mid-rise buildings the design criteria for tall buildings are different. National building code and other Indian standard codes are not sufficient to adequately address various issues related to tall building. Recently, BIS released the Code IS 16700: 2017 "Criteria for Structural Safety of Tall Concrete Buildings" under CED-38 committee. In present study various aspects studied for tall buildings with reference to IS 16700. In analysis for seismic loads few changes in comparison to IS 1893 part 1: 2016 are also reported. Modelling of the tall building and changes in the design considerations are listed.*

Key Words: Tall Structures, Nonlinear Analysis, Push Over Analysis

1. INTRODUCTION

Shortage of land in cities to accommodate the huge population migrants due to rapid urbanization can be compensated by vertical developments of cities with tall buildings. Tall buildings are the emerging construction practice in the developing countries like India. The design criteria for the tall buildings are different I n comparison to low and medium rise buildings. In general, wind load is not the governing criteria in most of the low-rise buildings, but for tall buildings wind is the governing criteria in most of the cases.

The design of tall buildings essentially involves a conceptual design, approximate analysis, preliminary design and optimization, to safely carry gravity and lateral loads. The design criteria are, strength, serviceability, stability and human comfort.

1.1 WHAT IS MEANT BY HIGH RISE STRUCTURE??

That any building with a height of 30m (nine floors) be categorized as a high rise. This is an increase of 6m from the existing definition (24m or seven floors). But from the structural point of view it can be defined as a building that its height will be affected by lateral forces resulting from earthquakes and wind forces to extent that such forces will play a major role in the process of design. Based on the distribution of the components of the primary lateral load-resisting system over the building, the structural system of high-rise buildings can be broadly classified as

a. Interior Structures Exterior Structures

b. In interior structural system,

The major part of the lateral load-resisting system is located within the interior of the building. Whereas in exterior structural system, the lateral loads resisting system, is located along the building perimeter.

1.2 HIGH RISE STRUCTURES IN INDIA

In India, a building greater than 75ft (23 m), generally 7 to 10 stories, is considered as high-rise. Also a building is considered to be high-rise when it extends higher than the maximum reach available to fire fighters. According to the building code of India, a tall building is one with four floors or more or a high-rise building is one 15 meters or more in height [4].Most of the tall buildings in India are in the commercial capital Mumbai. More than 2500 high-rise buildings are already constructed. In addition more than thousand mid-rises exists already in the city. Mumbai is undergoing a massive construction boom, with thousands of tall buildings and about fifteen high-rise structures are under construction. Delhi and its surrounding regions are witnessing huge construction activities with 1500 already constructed high-rises

2. IS 16700-2017 OVERVIEW

As India experiences rapid development, cities will continue to see huge spurt in the demand for affordable housing and commercial real estate, not just in the metro cities but also in tier 2, 3 and 4 cities. In response to this need, the urban development ministries of the states have increased the allowable built up area on land by means of augmenting Floor Area Ratio (FAR or FSI). Most cities now typically have new buildings of 15 storeys and higher (50m+) to consume the available FAR. The structural engineering community across the country was not geared to the sudden increase in building heights and there were gaps in the conceptualization and design process of tall buildings. Unlike low-rise buildings, design of taller buildings is driven not by gravity loads alone; lateral loads such as wind and earthquake play a defining role in conceptualizing the design. A standardized design protocol to ensure acceptable performance of tall structures in terms of safety and serviceability was needed. Such a Standard Code of Practice did not exist in India for design of tall buildings. Hence a new

Standard for Criteria for Structural Safety of Tall Concrete Buildings was developed. This standard provides prescriptive requirements for design of reinforced concrete tall buildings. The following salient aspects, which are based on the prescriptive approach, are addressed in this standard:

a) Structural systems that can be adopted in tall building;

b) General requirements including;

1) Height limitations of different structural systems,

2) Elevation and plan aspect ratios,

3) lateral drift,

4) Storey stiffness and strength,

5) Density of buildings,

6) Modes of vibration,

7) Floor systems,

8) Materials, and

9) Progressive collapse mechanism;

c) Wind and seismic effects:

1) Load combinations,

2) Acceptable serviceability criteria for lateral accelerations;

d) Methods of structural analysis to be adopted, and section properties (in cracked and uncracked states) of reinforced concrete member to be considered in analysis;

e) Structural design aspects for various applicable structural systems;

f) Issues to be considered in design of foundations; and

g) Systems needed for structural health monitoring. As another first in the country, this code acknowledges that there will be buildings that will not conform to the requirements of the code and there should be a special review process for such "code-exceeding" buildings. For such buildings, the code has recommended detailed guidelines that may be adopted by local authorities which includes formation of a Review Committee and qualifications of constituent members for such a review committee.

3. LITERATURE REVIEW

O. Esmaili and S. Epackachi et. al (2008) In recent decades, shear walls and tube structures are the most appropriate structural forms, which have caused the height of concrete buildings to be soared. So, recent RC tall buildings would have more complicated structural behavior than before. Therefore, studying the structural systems and associated behavior of these types of structures would be very interesting. Here in this paper; we will study the structural aspects of one of the tallest RC buildings, located in the high seismic zone, with 56 stories. In this Tower, shear wall system with irregular openings are utilized under both lateral and gravity loads, and may result some especial issues in the behavior of structural elements such as shear walls, coupling beams and etc. To have a seismic evaluation of the Tower, a lot of non-linear analyses were performed to verify its behavior with the most prevalent retrofitting guidelines like FEMA 356. In this paper; some especial aspects of the tower and the assessment of its seismic load bearing system with considering some important factors will be discussed. Finally after a general study of ductility levels in shear walls; we will conclude the optimality and conceptuality of the tower design. Finally, having some technical information about the structural behavior of the case would be very fascinating and useful for designers.

Rupali Kavilkar and Shweta Patil (2014) —High-rise structures are also called “vertical cities”, having the potential to decongest urban sprawl. Indian cities are witnessing immense demographic expansion due to migration from surrounding villages, leading to urban sprawl, housing demand, rise in cost of land. Housing has developed into an economy generating industry. Given this demand, while high-rise residential structures have become a solution in the metropolitan cities, they remain eluded in tier II cities in India. Low-rise or mid-rise high-density dwelling types have developed in these cities. A study of Pune city’s housing needs, demands, market, and type of structures being built, reveal that tall buildings of 11 floors are being developed on the city’s urban fringe. Most of the high-rise projects remain as proposals. An investigation in this case study reveal that high rise structures are not preferred due to user perception of insecurity in case of fire and high cost of the building. The paper aims at studying the availability and use of fly ash in various proportions, which can be used in Indian high-rise residential buildings. The research paper indicates that fly ash concrete can be used to reduce the cost of construction and has the potential to minimize the damage caused due to high temperature.

Sunil S K , Mahesh Kumar C L et.al (2017) Tall building or Tallness, however, is a relative matter and tall buildings cannot be defined in specific terms related just to height or to the number of floors. The tallness of a building is a matter of a person's or community's circumstance and their consequent perception. From the structural engineer's point of view, however a tall building may be defined as one that. Because of its height, is affected by lateral forces due to wind or earthquake actions to an extent that they play an important role in the structural design. The influence of these actions must therefore be considered from the very beginning of the design process. In this Paper, considering the multi-storey building of G+30 floors. The various loads applied on the building such as Dead load, Live load and Earthquake load. Then analysing the behaviour of structure subjected to combination of the above-mentioned loads using E-tabs software. For the irregularity building considering the equivalent static method for different zones and soil types the clear visible that there is an increasing order in the values obtained for cumulative storey shear, displacement, storey drift and overturning moment are follows in the order of soil-I, soil-II and soil-III types in all zones in X direction. And also, it comes same in the order of zone II, zone III, zone IV, zone V in all soil types in X direction.

Sumit Ghangus, Prof. Sangeet Kumar Gupta (2017) The present analysis for every under developing and developed countries is somewhere based on its infrastructure development. In this 20th century there are many such remarkable examples of skyscrapers in front of world by many of the countries. This is a trend in building construction and going to be increase in future. The thoughts of Engineers and Architects are not stuck off to some limited designs and practices and this is giving birth to the changing scenario in construction. The high price of land in metro cities and home for everyone both can be fulfilled with vertical city concept. These building are not restricted to only tall but the typical structural systems. These structural systems which are described by IS 16700:2017 are explained in this study.

Gangisetty Venkata Krishna and Ratnesh Kumar (2018) Tall buildings are emerging constructions in Indian cities due to urbanization. In comparison to low and mid-rise buildings the design criteria for tall buildings are different. National building code and other Indian standard codes are not sufficient to adequately address various issues related to tall building. Recently, BIS released the Code IS 16700: 2017 "Criteria for Structural Safety of Tall Concrete Buildings" under CED-38 committee. In present paper various aspects and issues related to tall buildings with reference to IS 16700 have been reviewed. The selection of structural system and plan dimension are specified based on structural configuration and seismic zone. In the design of tall building other parameters that need attention are; wind load analysis using wind tunnel test, P-Δ effect, secondary effect like creep & shrinkage, and temperature. In analysis for seismic loads few changes in comparison to IS 1893 part 1: 2016 are also reported. Modelling of the tall building and changes in the design considerations are listed. Criteria for selection of foundations are specified. The importance of non-structural elements is also specified and design guidelines based on the sensitivity of the elements are provided.

Khuzaim J. Sheikh Krutarth S. Patel et.al. (2018) Early structures in the medieval period of twentieth century were assumed to carry only the gravity loads. However, today with the increase in urbanization along with the scantiness of land availability and high price rise, the need of the vertical development arises for fulfilment of various needs of human activities. Owing to these situations, advances have been in the development for the use of high-strength materials, lightweight material along with changes in structural design and establishment of slender buildings. These innovative methods require critical analysis with consideration of lateral loads such as wind and earthquake loads. Presently, numerous structural systems are available which can be utilized for analysis of the lateral resistance of tall buildings. In this way, proper examination is required for undertaking the consideration of proper type of structural system, which can be used to fulfil all our Structural & Architectural parameters along with effective utilization of the material & technology that can be useful for sustainability of the future. The present work, studies the response of the various structural system used in the buildings and its comparison. Four different structural systems were investigated, which includes Structural Wall + Moment Resisting Frame, Structural Wall System, Core Structural Wall system and Outrigger Structural System (Belt Truss System). 39 storey building having typical height 3.65m was considered. Moreover, Response Spectrum analysis and Static wind analysis were also performed and comparison of different structural parameters such as Base Shear, Storey Drift, and Storey Displacement were accomplished.

M.Jesse Leo Pragnan, Anirudh Maddi (2019): The turn of the century saw urbanisation like never before, which has led to the obvious problem of land scarcity and thus, land price spike, among others. To address this inadequacy of space, tall buildings have become commonplace. However, the safety of multi-storied buildings diminishes greatly in areas of moderate - high seismic intensity. The design of such buildings must facilitate the accommodation of loads applied laterally on them. Following the recently released IS code, "Criteria for Structural Safety of Tall Concrete Buildings 1S16700:2017" will ensure the safety of these high rise structures even in zones of high seismic intensity. This latest code lays emphasis on using P-Delta analysis for high-rise buildings, alongside the other conventional seismic analyses (like Equivalent Static Analysis, Linear Dynamic Analysis (Response Spectrum Analysis), Nonlinear Static Analysis (Pushover analysis) and Nonlinear Dynamic Analysis) that were used hitherto. In this study, modelling, analysis and design of a Tall RCC building was done employing IS code16700:2017. ETAB software was used to execute Equivalent static analysis, Response Spectrum analysis and P-Delta analysis in seismic zone-V and medium soil conditions. A variety of seismic parameters, for example, self-weight, displacement, time period, storey drift, base shear and storey shear, were evaluated and analyzed for Response Spectrum analysis and P-Delta analysis making use o the IS16700:2017 code. Although the storey shear was same in both the analyses, the storey drift was considerably more in P-Delta analysis in comparison to Response Spectrum analysis.

Shesalu D. Vadeo | M. V. Waghmare (2019) Earthquakes in the past have shown that a strong mainshock is often followed by aftershocks forming mainshock-aftershock series type of ground motions or multiple earthquakes. Aftershocks could occur after days, months or even years and although they are normally smaller in magnitude, their intensity can be large with different energy content than mainshock and pose a seismic hazard after a mainshock. The general approach of seismic design of structures usually considers a single earthquake but recent studies have shown that the mainshock aftershock records and interaction between these two should be evaluated to determine the likely damage behavior and responses of structure. Due to successive shaking of the ground over a short period of time, the damages in the structure gets accumulated and the structure becomes vulnerable to collapse. To understand the behavior of structure under such repeated ground motions or multiple earthquakes, non-linear time history analysis is carried out. The present study considers a 12 storey reinforced concrete building. The building was analyzed for both linear and nonlinear time history analysis for 5-time history ground motions considering mainshock and mainshock-aftershock sequences. The material and geometric non linearities were accounted in terms of hinges and p-delta effects. It was found that the mainshock-aftershock sequence of ground motion has significant effect on the response of the structure in terms of top displacements and storey drifts. The analysis was carried out by ETABS 2016.

4. AIM AND OBJECTIVE OF PRESENT STUDY

Following are the objectives:

1) To understand the behaviour of structure linear equivalent static method is used.
2) To understand the behaviour of structure non-linear Push Over analysis will be carried out.
3) To compare structural performance in terms of Time Period, Storey Displacement, Storey Drift and Base Shear by Seismic Analysis will used.
4) To study the stiffness modifiers stated in IS 16700 & IS 1893 & its effect.

5. SCOPE OF WORK

Following are the scope of work:

1) The present study considers a 50 storey reinforced concrete building. The building was analyzed for both equivalent static linear and nonlinear push over analysis.
2) The building will be analyzed according to the Indian Standards (IS 16700-2017& IS 1893-2016)
3) Only the superstructure is studied and the goal is to study the various clauses & codal provision stated in IS 16700.

6. PROBLEM STATEMENT

A regular symmetrical floor plan of 20-meter X 20 meter is considered with 50 Storey. Story height are kept 3m for all models. Nonlinear Push over Analysis, P-delta analysis and Stiffness modifiers are studied.

7. METHODOLOGY

7.1 MODELLING STEPS

In this study, the Nonlinear Push over Analysis, P-delta analysis & Stiffness modifiers are studied in terms of storey displacement, storey drift, base shear and fundamental time period.

Following steps are adopted in this study.

Step 1: Selection of site condition and seismic zone.

Step 2: Selection of building geometry and modelling of structural system using ETABS 2017 software for the same plan.

Step 3: Application of loads and load combination to the structural model according to the Standard codes.

Step 4: Analysis of each building frame models.

Step 5: Comparative study of results in terms of time period, storey displacement, storey drift and base shear

Step 6: Analysis of each building frame models.

Step 7: Effect of Parametric changes on model will studied.

7.2 MODELLING DATA

Following data will be used for analytical model by ETABS 2019 to meet the objectives of this study.

Plan dimension 20 meter X 20 meter

Number of Storey 50 Storey

Grade of Concrete M30

Grade of Steel Fe500

Storey Height 3 meter

Size of beam 230mm X 350mm

Size of Column 300mm X 450mm

Shear wall 230 mm

Thickness of Slab 125mm

Dear Load 2KN/m^2

Live Load 3KN/m^2

Wall Load (Frame load) 12.42KN/m^2

Structure Utility Commercial

Seismic Zone III

Seismic Coefficient 0.16

Response Reduction Factor 5

Importance Factor 1.2

Analysis Method

1. Linear Equivalent static method

2. Non Linear Push Over analysis method

IS Codes Used

-IS 456-2000

-IS 1893 Part 1-2016

-IS 16700-2017

8. CONCLUSIONS

This paper ensure that we can carried out the static analysis and nonlinear analysis of Tall structures which suggest by IS 16700-2017 to ensure the structural safety. Further Study of this topic gives outcomes of this study.

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