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Comparative Study: Key Updates of is 16700 (2017) with Its First Revision is 16700 (2023)

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Abstract:
The evolution of urban landscapes and the increasing demand for space in densely populated areas have necessitated a paradigm shift in architectural design towards verticality. Tall buildings stand as iconic symbols of human ingenuity, challenging traditional notions of urban sprawl and land use. This paper explores the imperative for vertical construction, examining the diverse factors that drive the trend towards building skyward.
The primary objective of this research is to analyze the multifaceted requirements driving the design and construction of tall buildings. From economic considerations to environmental sustainability, each aspect contributes to the rationale behind going vertical. The study delves into architectural innovations and engineering advancements that enable the realization of increasingly taller structures while addressing safety, functionality, and aesthetic appeal.
The present study is aimed at bringing the comparative analysis of upgradation of new and old code IS 16700.

Keyword: IS16700 2023, IS 16700 2017, RC Framed Buildings, Tall Buildings

1. Introduction

Cities that are experiencing a shortage of land owing to fast urbanization may be able to make up for it by developing vertically with tall buildings. In developing nations like India, tall buildings are becoming more and more common.
The design requirements for tall buildings differ from those for low- and medium-rise structures. For low-rise buildings, wind load is typically not the determining factor; however, for tall buildings, wind is typically the determining factor, contingent on factors such as geographical locations. The primary goal of this study is to familiarize the reader with the most recent version of IS 16700:2023, "Criteria for Structural Safety of Tall Concrete Buildings,".
Tall buildings are the most intricately constructed buildings because they must incorporate intricate building systems and a multitude of competing criteria. The towering buildings of today are getting thinner and thinner, which could give them greater sway than prior high-rise structures. Therefore, the effects of earthquake and wind forces on them become a crucial component of the design. The dynamic reactivity of tall structures can be managed by optimizing their structural systems.

2. Comparison of IS 16700:2017 and IS 16700:2023

In this first revision, the following changes have been incorporated:

a) Systems with structural walls at core have been dropped. All structural wall systems should have well distributed walls

1. Clause 5.1.1 Structural wall system

Table 1 Maximum values of Height, *H* above Top of Base Level of Buildings with Different Structural Systems, in metre

(*Clause* 5.1.1)

Sl No.	Seismic Zone	Structural System					
		Moment Frame	Structural Wall		Structural Wall + Moment Frame	Structural Wall + Perimeter Frame	Structural Wall + Framed Tube
			Located at Core	Well-Distributed[1]			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	V	NA	100	120	100	120	150
ii)	IV	NA	100	120	100	120	150
iii)	III	60	160	200	160	200	220
iv)	II	80	180	220	180	220	250

[1] Well-distributed shear walls are those walls outside of the core that are capable of carrying at least 25 percent of the lateral loads.

Table 5.1.1 IS 16700 2017

Table 1 Maximum Values of Height *H* above Top of Base Level of Buildings with Different Structural Systems, in metres

(*Clause* 5.1.1)

Sl No.	Seismic Zones	Structural System				
		Moment Frame	Structural Wall Well Distributed[1]	Structural Wall + Moment Frame	Structural Wall + Perimeter Frame	Structural Wall + Framed Tube[2]
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	V	NA	120	150	150	180
ii)	IV	NA	150	200	200	225
iii)	III	60	200	225	225	250
iv)	II	80	250	250	250	250

[1] Structural walls are considered to be well-distributed when structural walls that are outside of the core are capable of carrying at least 25 percent of the lateral loads.

[2] This includes systems covered under **1.5** (g), **1.5** (h) and **1.5** (k).

Table 5.1.1 IS 16700 2023

b) The wind return period of wind for natural drift under wind conditions has been revised

2. Clause 5.4.1 (Lateral Drift)

IS 16700 2017: When design lateral forces are applied on the building, the maximum inter-storey elastic lateral drift ratio (Δmax /hi) under working loads (unfactored wind load combinations with return period of 50 years), which is estimated based on realistic section properties mentioned in 7.2, shall be limited to H/500. For a single storey the drift limit may be relaxed to hi /400. For earthquake load (factored) combinations the drift shall be limited to hi /250.

IS 16700 2023: When design lateral forces are applied on the building, the maximum inter-storey lateral drift ratio (ΔMax/hi) under serviceability loads (including wind load with return period of 20 years), which is estimated based on the sectional properties for serviceability loads mentioned in 7.2, shall be limited to 1/500. Total drift at the topmost usable floor shall be limited to H/500. For a single storey the drift limit may be relaxed to hi/400. For design earthquake force, the maximum inter-story drift shall be hi/250.

3. **Clause 5.6.2.3 (Minimum Width of Floor slab)**

IS 16700 2017: At any storey, the minimum width of floor slab along any section after deduction of openings shall not be less than 5 m and the minimum width of the slab beyond an opening to edge of slab shall not be less than 2 m. Further, the cumulative width of the slab at any location shall not be less than 50 percent of the floor width.

IS 16700 2023: At any storey, the minimum width of floor slab along any section after deduction of openings shall not be less than 5 m, if there is no perimeter beam. Further, the cumulative width of the slab at any location shall preferably not be less than 50 percent of the floor width.

4. **Clause 5.7.2.3 (Lapping of Bars)**

IS 16700 2017: No lapping of bars shall be allowed in RC columns and walls, when diameter of bars is 16 mm or higher; mechanical couplers as per IS 16172 shall be used to extend bars. If lapping of bars is required in exceptional case, relevant clauses of IS 13920 shall apply.

IS 16700 2023: Lapping of longitudinal bars shall be avoided in RC columns and walls that form a part of the lateral load resisting system; when diameter of bars is 20 mm or higher; mechanical couplers as per IS 16172 shall be used to extend bars.

c) **Maximum horizontal acceleration requirement has been revised for residential buildings**

5. **Clause 6.2.3 (Lateral Acceleration)**

IS 16700 2017: From serviceability considerations, under standard wind loads with return period of 10 years, the maximum structural peak combined horizontal acceleration aMax in the building for along and across wind actions at any floor level shall not exceed values given in Table 3, without or with the use of wind dampers in the building.

Table 3 Permissible Peak Combined Acceleration

Sl No	Building Use	Maximum Peak Combined Acceleration, aMax m/s2
1.	Residential	0.15
2.	Mercantile	0.25

IS 16700 2023: From serviceability considerations, under standard wind loads with return period of 10 years, the maximum structural peak combined horizontal acceleration aMax in the building for along and across wind actions at any floor level shall not exceed values given in Table 3, without or with the use of wind dampers in the building.

Table 3 Permissible Peak Combined Acceleration

Sl No	Building Use	Maximum Peak Combined Acceleration, aMax m/s2
1.	Residential	0.18
2.	Mercantile	0.25

6. Clause 6.3.2 (Seismic Effect)

IS 16700 2017: For buildings in seismic zone IV and Zone V, deterministic site-specific design spectra may preferably be estimated and used in design. When site-specific investigations result in higher hazard estimation, site-specific investigation results shall be used.

IS 16700 2023: For buildings in seismic zone V, deterministic site-specific design spectra may preferably be estimated and used in design. When site-specific investigations result in higher hazard estimation, site-specific investigation results shall be used.

d) Requirements for maximum vertical acceleration of floors have been dropped

e) A new expression for estimating the approximate fundamental natural period of buildings over 50 m has been provided

7. Clause 6.3.2 (Fundamental Natural Time Pd)

IS 16700 2023: For buildings of height 50 m and more, the fundamental period, T (in sec) for a structure shall be determined by accounting for all structural properties and inherent stiffness of the building through rigorously validated structural analysis procedures. The fundamental period shall however not exceed the value obtained from the approximate fundamental translational natural period Ta (in s) of oscillation, estimated by following expression:

Ta = 0.0644 H0.9 for concrete moment resisting frame systems; and

Ta = 0.0672 H0.75 for all other concrete structural systems

Load combination has been specified considering P-Δ effects

8. Clause 7.2 (Load combinations in P Delta Effect)

IS 16700 2017: Clause 7.2 (d) P Delta effect not specified

IS 16700 2023: Clause 7.2 (d) P Delta effect specified, The load combination for the initial analysis considering P-Δ effects shall be taken as:

1.2 DL + 0.5 IL ±1.5 EL/WL.

f) An expression for inter storey drift stability coefficient θ has been introduced;

9. Clause 7.3.10 (Inter-storey Drift Stability Coefficient)

IS 16700 2017: In no case, the flexibility of the building shall be such that the value of inter-storey drift stability coefficient T (Pu Delta/H) exceeds 0.20.

IS 16700 2023: The flexibility of the building shall be such that the inter-storey drift stability coefficient satisfies:

$$\theta = \frac{P_i \Delta_i}{V_i h_{i-1} R} \leq 0.2$$

Where
Pi = total design vertical load at level i;
i = design storey drift at level i;
Δ Vi = design shear force at level i;
hi-1 = storey height below level i; and
R = response reduction factor.

g) The minimum requirement for transverse reinforcement in structural walls has been revised

10. Clause 8.5.13 (Special Requirements for Seismic Zones IV and V)

IS 16700 2017: Clause 8.5.13(b) The thickness of structural wall shall not be less than 200 mm;Clause 8.5.13(c) The minimum longitudinal and transverse reinforcements shall not be less than 0.4 percent of gross cross-sectional area in each direction

IS 16700 2023: Clause 8.5.13(b) The minimum longitudinal reinforcement in structural walls shall not be less than 0.4 percent of gross cross-sectional area Clause 8.5.13(c) The minimum transverse reinforcement in Structural walls shall not be less than 0.25 percent of gross cross-sectional area

11. Clause 8.6 (Flat Slab – Structural Wall Systems)

IS 16700 2017: Clause 8.6.1 Structural walls shall carry all lateral loads on the building, and column strips of the flat slab system shall not be included in the lateral load resisting system.

IS 16700 2023: Clause 8.6.1 In structures with flat slab system as gravity load carrying system, structural walls shall carry all lateral loads on the building, and column strips of the flat slab system shall not be included in the lateral load resisting system. All requirements related to structures with flat slabs mentioned in IS 1893 (Part 1) shall be met with.

h) The procedure for approval of buildings that do not conform to the prescriptive requirements of this standard has been revised in Annex B.

12. Clause (ANNEX B)

IS 16700 2023: Guidelines For Building Authority Having Jurisdiction For Approval Process For Design Of Concrete Tall Buildings Not Conforming To The Prescriptive Requirements Of This Standard

3. OBSERVATIONS

1. Systems with structural walls at core have been dropped. All structural wall systems should have well distributed walls
2. The wind return period of wind for natural drift under wind conditions has been revised
3. Maximum horizontal acceleration requirement has been revised for residential buildings
4. Requirements for maximum vertical acceleration of floors have been dropped

5. A new expression for estimating the approximate fundamental natural period of buildings over 50 m has been provided
6. An expression for inter storey drift stability coefficient θ has been introduced
7. The minimum requirement for transverse reinforcement in structural walls has been revised

4. CONCLUSION

The review and comparison of code IS 16700 2023 with IS 16700 2017 has provided valuable insights into its strengths and areas of improvement. Overall, the code demonstrates a solid foundation with clear organization and adherence to coding standards. The use of appropriate variable names, comments, and documentation enhances readability and maintainability.

However, areas were identified for enhancement. These include optimizing algorithms for better performance, ensuring robust error handling and input validation, and addressing potential security vulnerabilities. Additionally, enhancing code modularity and scalability which further will improve its flexibility and ease of maintenance.

Incorporating the changes will not only enhance the efficiency and reliability of the new code but also contribute to the overall quality of the software product. Continuous review and refinement are essential to ensuring that the code remains aligned with evolving requirements and best practices in software development.

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