MODERN INDIAN CITIES

by Ashish Singh

Submission date: 29-May-2025 12:27PM (UTC+0530)
Submission ID: 2687409327
File name: ASHISH_THESIS_FINAL.pdf (2.56M)
Word count: 7493
Character count: 36918

CHAPTER 1
INTRODUCTION

1.1 High Rise Buildings and the Challenge of Wind

Modern Indian cities are rapidly changing, and high-rise buildings have become symbols of economic progress and urban density. Iconic structures like the World Trade Centre in Mumbai and The Imperial in Delhi demonstrate India's progress, but they also present issues, notably in terms of wind resistance. Wind, though invisible, causes significant lateral pressures on tall buildings and must be factored into structural design.

High-rise structures are becoming more and more noticeable in contemporary Indian cities, which are changing quickly. These buildings, like as Delhi's The Imperial and Mumbai's World Trade Centre, not only reshape skylines but also represent urbanisation and economic expansion. But their majestic appearance frequently conceals a weakness—the wind's unseen power.

1.2 A Unique Susceptibility: Elevation, Exposure, and the Dynamics of Wind

High rise structures are more vulnerable to wind than their lower-rise equivalents. Because of their height, they are subject to stronger and more constant wind speeds, which significantly alter their thin profiles. If these forces are not appropriately taken into consideration during the design phase, they may cause sway, vibrations, and even structural instablility. The problem is made more difficult by wind dynamics. Wind is a dynamic force that continuously varies in intensity and direction, in contrast to static loads like gravity.

When wind frequencies coincide with a building's inherent frequencies, a phenomenon known as resonance can occur, intensifying vibrations and perhaps causing structural damage.

1.3 Beyond Beauty: How Wind Affects Comfort and Security

The impact of wind extends beyond structural performance to human comfort and safety. High lateral vibrations can produce nausea and panic in occupants, as well as fatigue damage to structural materials. In severe circumstances, wind has resulted in catastrophic structural collapses, such as the Tacoma Narrows Bridge disaster of 1940.

1.4 Wind Loading Codes Importance: Balancing Safety and Innovation for Indian High-Rises

Wind loading codes serve as vital tools in structural engineering, offering standardized procedures for calculating wind pressures and loads. In India, IS 875 (Part 3) governs wind load calculations. These codes allow engineers to design buildings that are safe, efficient, and capable of withstanding wind-induced effects while still promoting innovation in architecture.

1.5 Understanding the Fundamentals: Key Terms for M.Tech Thesis

To understand the scope of this thesis, a few technical terms are introduced:

- **Wind Loading**: The estimation of wind effects, including pressures and forces.
- **Structural Integrity**: A structure's capacity to withstand loads without breaking.
- **Terrain Categories**: Classifications of land based on roughness that impact wind behaviour.
- **Design Wind Pressure**: Wind pressure used in calculations for designing structural elements.
- **Base Shear**: The total horizontal force acting at the foundation of the building as a result of wind or earthquake loads
- **Gust & Gust Factor**: Sudden increases in wind speed; the gust factor measures the intensity of these gusts compared to average wind speed.

1.6 The Need for Comparative Analysis: An International Scene with an Emphasis on Indian Standards

India's varied topography and climate present particular wind concerns for high-rise structures. Although the Indian wind loading code (IS 875) is essential for their safety, a comparison with international codes such as ASCE 7-22 would be beneficial. In the end, this analysis can improve the development of the Indian code by addressing knowledge gaps in managing wind events, such as cyclones, and identifying best practices for wind load evaluation. India can guarantee strong and flexible design standards for its high-rise projects by concentrating on both localised factors and studying international techniques.

1.7 Scope and Objectives

The study is focused on a comparative evaluation of ASCE 7-22 and IS 875 (Part 3): 2015 for the structural design of tall buildings. It evaluates building response parameters such as design wind pressure, base shear, storey drift, and storey displacement under dynamic wind effects. The ultimate goal is to understand the disparities between the codes and improve the implementation of wind loading provisions, particularly in the Indian context.

1.8 Methodology

The methodology consists of wind analysis using computational modeling in ETABS. Different high-rise buildings of varying shapes and heights (130m and 65m) were modeled. Wind loads were calculated manually based on both IS and ASCE provisions and then applied to the models. The analysis focused on key parameters under terrain category 3.

1.9 Organization of the Thesis

- **Chapter 2**: Literature review on wind loading and comparative studies.
- **Chapter 3 & 4**: Building modelling and wind load calculation as per IS and ASCE.
- **Chapter 5**: Methodology in detail.
- **Chapter 6**: Presentation and discussion of comparative results.
- **Chapter 7**: Conclusions, insights, and recommendations for future work.

CHAPTER 2
LITERATURE REVIEW

2.1- LITERATURE REVIEW

Over the last few decades, various research studies and articles have been undertaken on the responsiveness of important international wind codes and standards. We will present an overview of relevant research studies and papers on this topic.

S. Ahmed, et al. (2017) The study presents a comparison between five major international codes and standards and the Indian standard IS 875 Part-III (2015) with respect to along-wind loads on tall buildings. It also outlines the guidelines for evaluating along-wind response using the Gust Factor Method[1].

Yin Zhou et al. (2013), This paper conducts a comprehensive analysis of the variations among leading international codes and standards in evaluating along-wind effects on tall buildings. It focuses on the differences in methodologies used by these standards despite their common reliance on the Gust Loading Factor (GLF) approach. Notably, significant variations are observed in the predicted wind effects under comparable wind flow conditions. The study examines six key guidelines, including ASCE 7-98 (North America), AS1170.2-89 (Australia), NBC-1995 (Canada), RLB-AIJ-1993 (Japan), and Eurocode-1993 (Europe). Critical aspects analyzed include the definition of wind parameters, mean wind loads, GLF, equivalent static wind loads, and the resulting wind-induced effects. The findings reveal that discrepancies in predicted wind loads primarily stem from inconsistencies in how wind field parameters are defined across different codes and standards [2].

Ahsan Kareem, Dae Kun Kwon (2013), present a detailed comparison of wind loads and their effects on tall structures based on eight major international codes and standards: ASCE 2010 (USA), AS/NZ 2011 (Australia and New Zealand), AIJ 2004 (Japan), CNS 2012 (China), NBCC 2010 (Canada), Eurocode 2010 (Europe), ISO 2009, and IWC 2012 (India). The comparison primarily focuses on serviceability criteria for both along-wind and across-wind directions, as well as provisions for survivability design. Given that most of these codes share a common theoretical basis for calculating dynamic load effects, the fundamental equations are reformulated in a general format to analyze how different factors influence the overall recommendations of the various standards [3].

Gholamreza Amirinia et al. (2017), This study examines the differences between hurricane surface winds and non-hurricane winds, as well as how these differences affect high-rise buildings' along-wind response in open spaces. It focusses on turbulence intensity, turbulence spectra, and mean wind speed profiles. After reviewing recent studies on hurricane boundary layer winds, this paper examines the characteristics of high-rise buildings—such as their aspect ratio and natural frequency—and explores the role of aerodynamic admittance in dynamic analysis. Three representative high-rise structures with different attributes are chosen for an unstable examination of hurricanes' along-wind impacts. According to the findings, hurricane winds cause very high-rise buildings to experience more along-wind forces and responses than typical boundary layer winds; at lower elevations and higher natural frequencies, the disparity diminishes. Measurements from the High-Frequency Force Balance (HFFB) show good agreement with results for typical boundary layer winds, although hurricane winds exhibit higher root-mean-square base moments compared to those recorded by HFFB.

Rakesh Chaudhary et al. (2019), This study conducts a comparison between two prominent international codes—ASCE 7-02 (USA) and AS/NZS1170.2-2011 (Australia and New Zealand)—and the latest Indian wind load standard, IS 875 Part-III (2015), focusing specifically on along-wind loads for high-rise buildings. Wind effects are critical considerations in building design, especially in coastal regions and areas experiencing high average wind speeds. Different countries regulate wind-resistant design through their respective codes. This research uses static analysis to evaluate how various geometric configurations of a 60-meter tall building respond to wind loads. Employing ETABS software, the study investigates parameters such as Base Shear, Story Displacement, and Story Drift, analyzing static wind responses for terrain categories 2 and 3. The main objective is to compare results from different wind load codes with those obtained from the Indian standard.

Himanshu Yadav et al. (2023), The study examined the impacts of interference on wind-induced moments between two adjacent high-rise buildings, highlighting the need of taking aspect ratios, building closeness, and wind incidence angles into account while designing. Researchers can make well-informed decisions during the construction of tall structures by identifying high-pressure zones that result in increased wind loads and low-pressure areas that cause suction effects by examining Cp values. In engineering applications, evaluating structural integrity and load distribution requires an understanding of force components along force vectors on wall zones, emphasising the importance of precisely estimating force coefficients[4].

2.2 SUMMARY OF LITERATURE REVIEW:

The comparative studies on wind load codes for tall buildings reveal significant variations in provisions and predicted effects across different standards. While there is a common theoretical basis, regional differences in wind characteristics and design priorities necessitate diverse approaches. The Indian standard IS 875 Part-III (2015) includes specific provisions that cater to local requirements, while international standards show variability due to differing environmental conditions. The impact of extreme wind events like hurricanes further stresses the importance of tailored wind load assessments. Harmonizing certain aspects of these codes while accommodating regional specifics could improve the predictability and reliability of wind load calculations for tall buildings globally.

CHAPTER 3
RCC FRAMED STRUCTURES

An RCC (Reinforced Cement Concrete) framed structure consists of interconnected slabs, beams, columns, and foundations working together as a unified system. In this system, loads are transferred sequentially—from the slabs to the beams, then to the columns, down through the lower columns, and ultimately to the foundation, which distributes the load into the ground. Compared to load-bearing wall buildings, RCC framed structures typically offer 10 to 12 percent more floor area. Additionally, RCC framing allows for monolithic construction, which enhances the building's ability to resist vibrations, wind forces, and seismic activity more effectively than load-bearing wall systems. Furthermore, RCC framed buildings can be constructed more quickly.

3.1 Assumptions In Design: -

- The partial safety factor for loads is taken as $\Upsilon_t = 1.5$, according to clause 36.4 of IS 456-2000
- As per clause 36.4.2 of IS 456-2000, the partial safety factor for materials is 1.5 for concrete and 1.15 for steel.
- Load combinations are considered using the partial safety factors specified in clause 36.4 of IS 456-2000.

3.2 Load Combination For Limit State Of Collapse As Per IS 456-2000.

1. 1.5 × (Dead Load + Live Load)
2. 1.2 × (Dead Load + Live Load + Wind Load in X direction
3. 1.2 × (Dead Load + Live Load + Wind Load in Y direction
4. 0.9 × Dead Load + 1.5 × Wind Load in X direction
5. 0.9 × Dead Load + 1.5 × Wind Load in Y direction

Total load cases = 5

3.3 Code And Standards Considered In This Project:

In this Thesis we have considered these following codes:-

1. Indian standard 875 (part 3)-2015)
2. American Society for Civil Engineering (ASCE)-7-22

3.4 Wind Load Calculation As Per Indian Standard (IS 875-2015 (Part 3)):

Dynamic Wind Response

To calculate the design wind speed, Vz, at a specific height Z for the chosen structure, the basic wind speed for the site must first be identified and then adjusted to account for the following factors: (a) The degree of risk; (b) the height of the structure and the roughness of the terrain; (c) the local topography; and (d) the significance Wind speed factor specific to cyclonic zones. The following is how it is expressed mathematically:

Hourly Mean Wind Speed

The hourly average wind speed at a height z for different types of terrain can be calculated using the following expression:

$\bar{V}_{z,H} = \bar{k}_{2,i} V_b$

Where ,

$\bar{k}_{2,i}$ = Terrain Category 1 factor for average hourly wind speed

$$= 0.1423 \left[\ln \left(\frac{z}{z_{0,i}} \right) \right] (z_{0,i})^{0.0706}$$

The design hourly mean wind speed at height z can be determined using the following formula:

$$\bar{V}_{z,d} = \bar{V}_{z,H} k_1 \bar{k}_{2,i} k_3 k_4$$

K1 = probability factor (risk coefficient) (5.3.1),

K3 = topography factor (5.3.3)

K4 = importance factor for the cyclonic zone (5.3.4)

$$\mathbf{M_a = \sum F_z . Z}$$

$$\mathbf{F_z = C_{f,z} . A_z . \bar{p}_d . G}$$

F_Z = design peak at any height z along the building's or structure's wind load

A_Z = the building's or structure's effective frontal area at any height z

$\bar{p}_d$ = hourly mean wind pressure design that corresponds to $\bar{V}_{z,d}$ and obtained as

$0.6 V^2_{z,d}$ (N/m^{2})

$\bar{V}_{z,d}$ = design hourly mean wind speed in meters per second at height z

$C_{f,z}$ = the building's or structure's drag force coefficient in relation to area Az

G = Gust Factor, which is provided by.

$$= 1 + r . \sqrt{[g_v^2 . B_s . (1 + \Phi)2 + \frac{H_s . g_r^2 . SE}{\beta}]}$$

r = roughness factor, which doubles the intensity of longitudinal turbulence

g_V = peak factor for fluctuations in upwind velocity,

=3.0 for terrains in categories 1 and 2, and

= 4.0 for terrains in categories 3 and 4,

B_S = The background factor represents the slowly varying component of the fluctuating wind load, which is caused by low-frequency variations in wind

$$= \frac{1}{\left[1 + \frac{\sqrt{0.26.(h-s)^2 + 0.4 b_{sh}^2}}{L_h}\right]}$$

where

b_{sh} = Mean structural width between heights s and h

L_h = the height, h, in meters of the effective turbulence length scale

$$= 85\left(\frac{h}{10}\right)^{0.25} \text{ for terrain category 1 to 3.}$$

$$= 70\left(\frac{h}{10}\right)^{0.25} \text{ for terrain category 4}$$

ϕ= factor to take into consideration the severity of second order turbulence

$I_{h,i}$= Turbulence intensity at height h for terrain category i

H_s = = Resonance response height factor

S = size reduction factor provided by

$$= \frac{1}{\left[1 + \frac{3.5 f_a h}{V_{h,d}}\right]\left[1 + \frac{4 f_a b_{0h}}{V_{h,d}}\right]}$$

Where

b_{0h}= typical building/structure width, ranging from 0 to h.

E = turbulence spectrum in the incoming wind stream

where,

N = effective reduced frequency

$$= \frac{f_a L_h}{V_{h,d}}$$

f_a = First-mode vibration frequency of the building in the windward direction, in Hz

$V_{h,d}$= hourly mean wind speed at height, h, expressed in m/s

4

β = damping coefficient of the building/structure (Table 36)

g_R = peak factor for resonant response

$= \sqrt{[2\ln(3600 f_a)]}$

3.4 WIND LOAD CALCULATION AS PER AMERICAN STANDARD ASCE -7.22 :-

According to ASCE 7-22, fundamental wind speeds are specified based on the geographic location and the designated risk category of the structure. These wind speeds are used to calculate the velocity pressure, which is given by the following expression:

$$qz = 0.00256 K_z K_{zt} K_e V^2 (lb/ft2); V, mi/h \ (26.10-1)$$

K_z= Exposure coefficient for velocity pressure (26.10.1)
K_{zt} = Topography factor, (26.8.2)
K_e = Factor of ground elevation (26.9)
V=Basic wind speed, (26.5)
qz= Velocity pressure at height z.

WIND LOAD ON BUILDINGS: MAIN WIND FORCE RESISTING SYSTEM.

For both rigid and flexible buildings—whether enclosed, partially enclosed, or partially open—the design wind pressures acting on the Main Wind-Force Resisting System (MWFRS) for structures of any height shall be calculated using the following formula, with results expressed in lb/ft² (or N/m²):

$$p = q.K_d.GC_p - q_i.K_d.(GC_{pi}$$

where,

q = qz, for windward walls measured at z altitude;

q = qh, for roofs, sidewalls, and leeward walls assessed at height h

qi = qh, For the design of roofs, sidewalls, leeward walls, and windward walls of enclosed and partially open buildings—as well as for evaluating negative internal pressure in partially enclosed structures

qi = qz, For evaluating positive internal pressure in partially enclosed structures, the height z refers to the elevation of the highest opening in the building that can influence the development of positive internal pressure; The enclosure classification for glazed openings in structures located in wind-borne debris regions must follow Section 26.12.3, and qi can be conservatively assessed at height h (qi = qh) for the evaluation of positive internal pressure;

Kd = factor of wind directionality (see to Section 26.6);

G = The gust-effect factor, denoted as Gf and defined in Section 26.11.5, shall be used in place of G for flexible buildings, in accordance with the provisions of Section 26.11

Cp = coefficient of external pressure as shown in Figures 27.3-1, 27.3-2, and 27.3-3; and

(GCpi) = Table 26.13-1's internal pressure coefficient

Adaptable Structures or Buildings The gust-effect factor for flexible buildings or other structures, as outlined in Section 26.2, must be determined in accordance with the procedures specified in Section 26.11.5.

$$G_f = 0.925\left(\frac{1 + 1.7 I_{\bar{z}}\sqrt{g_Q^2 Q^2 + g_R^2 R^2}}{1 + 1.7 g_v I_{\bar{z}}}\right) \qquad (26.11-10)$$

For flexible buildings or structures specified in Section 26.2, the gust-effect factor must be calculated using the method described in Section 26.11.5.

$$g_R = \sqrt{2 \ln 3{,}600 n_1} + \frac{0.577}{\sqrt{2 \ln 3{,}600 n_1}} \qquad (26.11\text{-}11)$$

Section 26.11.4 defines the intensity of turbulence at height z, IZ, and the background response factor, Q.

$$Q = \sqrt{\frac{1}{1 + 0.63\left(\frac{B+h}{L_{\bar{z}}}\right)^{0.63}}} \qquad (26.11\text{-}8)$$

$$L_{\bar{z}} = \ell\left(\frac{\bar{z}}{33}\right)^{\bar{\epsilon}} \qquad (26.11\text{-}9)$$

$$I_{\bar{z}} = c\left(\frac{33}{\bar{z}}\right)^{1/6} \qquad (26.11\text{-}7)$$

For all building or structure heights h, z is the equivalent height, defined as 0.6h, but not less than Zmin. Table 26.11-1 lists Zmin and c for each exposure.

The resonant response factor is

$$R = \sqrt{\frac{1}{\beta} R_n R_h R_B (0.53 + 0.47 R_L)} \qquad (26.11 - 12)$$

where ß is the damping ratio and proportion of critical (for example, use 0.02 in the calculation for 2%), and n1 is the fundamental natural frequency.

When measured at the structure's natural reduced frequency, N_1, the power spectral density of turbulence at the structure's equivalent height, z^{-}, is

$$R_n = \frac{7.47 N_1}{(1 + 10.3 N_1)^{5/3}}$$

$$N_1 = \frac{n_1 L_{\bar{z}}}{\bar{V}_{\bar{z}}} \qquad (26.11\text{-}14)$$

where Equation (26.11-9) defines L. The building's height, width, and depth are the size effect components that are

$$R_h = \frac{1}{\eta_h} - \frac{1}{2\eta_h^2}(1 - e^{-2\eta_h})$$
$$R_B = \frac{1}{\eta_B} - \frac{1}{2\eta_B^2}(1 - e^{-2\eta_B}) \qquad (26.11\text{-}15a)$$
$$R_L = \frac{1}{\eta_L} - \frac{1}{2\eta_L^2}(1 - e^{-2\eta_L})$$

Consequently, when assessed at the naturally lower frequency, the turbulent coherence (correlation) components in the respective directions are

$$\eta_h = 4.6 n_1 h/\overline{V}_z$$
$$\eta_B = 4.6 n_1 B/\overline{V}_z \qquad (26.11\text{-}15b)$$
$$\eta_L = 15.4 n_1 L/\overline{V}_z$$

At the equivalent structural height, z, the mean hourly wind speed (in feet per second or meters per second) equals

$$\overline{V}_{\bar{z}} = \bar{b}\left(\frac{\bar{z}}{33}\right)^{\bar{\alpha}}\left(\frac{88}{60}\right)V \qquad (26.11\text{-}16)$$

$$\overline{V}_{\bar{z}} = \bar{b}\left(\frac{\bar{z}}{10}\right)^{\bar{\alpha}}V \qquad (26.11\text{-}16.SI)$$

where V is the fundamental wind speed, mi/h (m/s), z is taken from Section 26.11.4, and b and α are constants given in Table 26.11-1.

CHAPTER - 4

DETAILS OF THE MODELS STUDIED

Few sample building models are used to assess the base shear and story displacement between various building shapes. 3D models are created and evaluated using the finite element analysis program ETABS. Every building shape in the plan is subjected to the dynamic wind load analysis in accordance with IS:875 part 3 and ASCE 7-22. The models come in a variety of shapes, including square and octagonal.

4.1 -MODELLING AND ANALYSIS OF MODEL 1(130.4m)

A high-rise residential building with an RCC frame structure that is thought to be **in Delhi** and has no vertical anomalies was the subject of a study. The building has a rectangular cross section (**30 m by 30 m**), a height of **130.4 m** above the ground, and a flat roof. The topography is flat in all directions. The fundamental **wind speed is 47 m/s,** and the wind direction is standard for the 35 m wall face. In both wind codes, the terrain category is divided into three categories.

Table 4.1 -Design parameters of 130.4m height building

No. of storey	G+35
Column	0.6 m x0.6 m
Beam	0.350 m x0.600 m
Slabs	0.15 m
Live load on slab	3 KN/m2
Floor finish	1.2 KN/m2
Grade of concrete in column	M 40
Grade of concrete in beam	M 30
Grade of steel	Fe 500
Total height	130.4 m
Height of ground storey	3.6 m
Height of floor to floor	3.6 m
Spacing of frame along length	5 m
Spacing of frame along width	5 m
Thickness of shear wall	0.30 m
Thickness of wall	0.23 m

PLAN OF 130.4 M HEIGHT BUILDING:

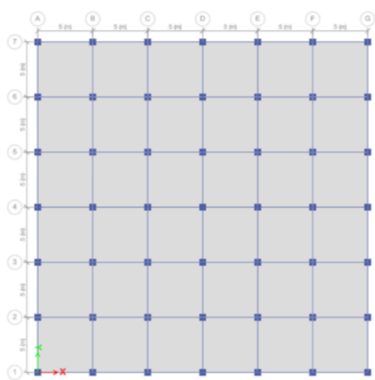

Figure 4.1: Plan of square building

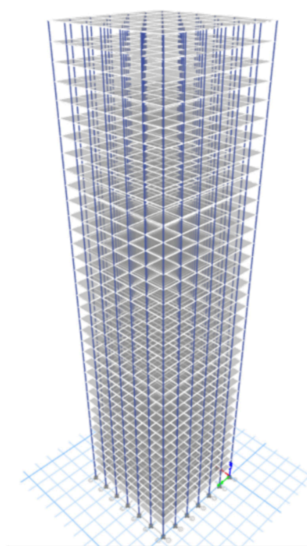

Figure 4.2: 3D view

4.2 MODELLING AND ANALYSIS OF MODEL (65.6m)

The impact of different tall structure shapes under wind excitation is the subject of another investigation. Four distinct 65.6-meter building models have been taken into consideration. These models are taken into consideration in the same location and have the same height and attributes.

Table 4.2 -Design parameters of 65.6m height building

No. of storey	G+17
Column	0.6 m x 0.6m
Beam	0.350 m x0.600 m
Slabs	0.15 m
Live load on slab	3 KN/m2
Floor finish	1.2 KN/m2
Grade of concrete in column	M 40
Grade of concrete in beam	M 40
Grade of steel	Fe 500
Total height	150 m
Height of ground storey	4.4 m
Height of floor to floor	3.6 m
Spacing of frame along length	5m
Spacing of frame along width	5m
Thickness of external wall	.230 m
Thickness of internal wall	.115 m

PLAN OF THE DIFFERENT SHAPES OF BUILDINGS: FIGURE OF 65.6M HEIGHT BUILDING:

SQUARE SHAPE:

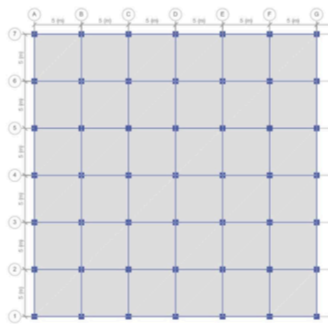

Figure 4.3: Plan of Square building

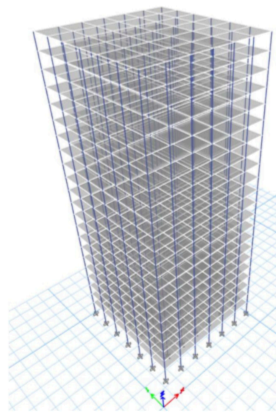

Figure 4.4: 3DVIEW

OCTAGONAL SHAPE:

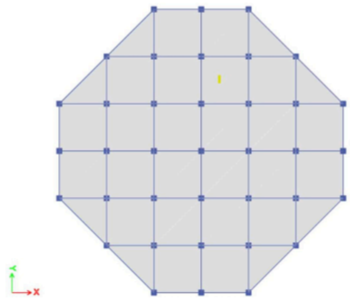

Figure 4.5: Plan of octagonal building

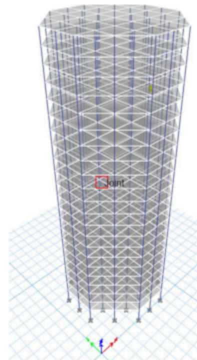

Figure 4.6: 3D View

CHAPTER -5

METHODOLOGY

The methodology adopted for this study involves a structured approach to model, analyze, and interpret the behavior of a building structure using ETABS software. The process is designed to ensure accuracy, adherence to design standards, and clarity in structural performance assessment. The key stages of the methodology are summarized below:

1. Define the Material and Section Properties in ETABS
2. Create Geometry and Assign the Properties
3. Support and Property Assigning
4. Define the Load Patterns
5. Apply the Dead and Live Loads
6. Calculate the Dynamic Wind Load Manually
7. Apply the Manually Calculated Wind Forces in ETABS
8. Analysis
9. Post-Analysis Results Computation

Step 1: Define the Material and Section Properties in ETABS

- Objective: Establish the fundamental building blocks for the structural analysis.
- Actions:
  - Open ETABS software.
  - Navigate to the 'Define' menu and select 'Material Properties'.
  - Input the properties for concrete and steel (e.g., grade of concrete, yield strength of steel).
  - Define the section properties for beams, columns, slabs, and other structural elements.

Step 2: Create Geometry and Assign the Properties

- Objective: Model the physical structure of the building.
- Actions:
  - Use the 'Draw' tools in ETABS to create the geometry of the structure (e.g., floors, beams, columns).
  - Assign the previously defined material and section properties to the respective elements.

Step 3: Supports and Property Assigning

- Objective: Define the boundary conditions and cross-sections.
- Actions:
  - Specify the support conditions at the base of the structure as 'fixed'.
  - Assign material properties and cross-sections to beams, columns, and slabs.
  - Ensure all structural elements are appropriately defined

Step 4: Define the Load Patterns

- Objective: Set up various load conditions for analysis.
- Actions:
  - Navigate to 'Define' > 'Load Patterns'
  - Define the load patterns as Dead Load (DL), Live Load (LL), Wind in X direction (WINDX), and Wind in Y direction (WINDY).

Step 5: Apply the Dead and Live Loads

- Objective: Apply static loads to the structure.
- Actions:
  - Apply Floor Finish(1.2 kN/m²) and Live Load(3 kN/m²)to the appropriate areas of the structure.
  - Use the 'Assign' menu to distribute these loads across the floors and slabs.

Step 6: Calculate the Dynamic Wind Load Manually

- Objective: Determine wind loads according to relevant standards.
- Actions:
  - Use IS Code and ASCE Code to manually calculate the wind loads.

Step 7: Apply the Manually Calculated Wind Forces in ETABS

- Objective: Incorporate dynamic wind loads into the model.

- Actions:
  - Define a user-defined load pattern in ETABS for the wind loads.
  - Apply the calculated wind forces in the X and Y directions to the structure.

Step 8: Analysis

- Objective: Perform structural analysis on the model.
- Actions:
  - Run the analysis in ETABS by clicking 'Run Analysis'.
  - Check for any errors or warnings and resolve them if necessary

Step 9: Post-Analysis Results Computation

- Objective: Interpret the analysis results.
- Actions:
  - Extract results for, story drift, base shear and story displacement from ETABS.
  - Document these results systematically for further discussion and interpretation.

CHAPTER - 6

RESULTS AND DISCUSSION

6.1 Dynamic wind load on 65.6 m Height of building calculated by IS 875 part3 (2015).

6.1.1 Effect of the Shape of The Building on Lateral Displacements:

Table 6.1.1 - Comparison of Lateral Displacements in mm at different height.

Height (m)	Square (mm)	Octagonal (mm)
65.6	196.438	120.111
62	191.797	116.95
58.4	186.313	113.29
54.8	179.988	109.139
51.2	172.828	104.507
47.6	164.842	99.407
44	156.04	93.852
40.4	146.435	87.854
36.8	136.039	81.431
33.2	124.869	74.602
29.6	112.943	67.385
26	100.285	59.802
22.4	86.925	51.879
18.8	72.903	43.644
15.2	58.284	35.129
11.6	43.193	26.375
8	27.928	17.451
4.4	13.223	8.54
0	0	0

- The table compares lateral displacements in millimeters at various building heights for square and octagonal structures.
- Displacements increase with height for both structural shapes.
- Square structures show significantly higher lateral displacements than octagonal ones at all heights.
- At the maximum height of 65.6 m, the square structure has a displacement of 196.438 mm, while the octagonal has 120.111 mm.

6.1.2 Effect of the Shape of the Building on Storey Drifts:

Table 6.1.2 - Comparison of Storey Drifts at Different Heights in mm.

Height (m)	Square (mm)	Octagonal (mm)
65.6	0.001289	0.000878
62	0.001523	0.001017
58.4	0.001757	0.001153
54.8	0.001989	0.001287
51.2	0.002218	0.001417
47.6	0.002445	0.001543
44	0.002668	0.001666
40.4	0.002888	0.001784
36.8	0.003103	0.001897
33.2	0.003313	0.002005
29.6	0.003516	0.002106
26	0.003711	0.002201
22.4	0.003895	0.002288
18.8	0.004061	0.002365
15.2	0.004192	0.002432
11.6	0.00424	0.002479
8	0.004085	0.002475
4.4	0.003005	0.001941
0	0	0

- The table compares storey drift values in millimeters at various building heights for square and octagonal structures.
- Storey drift increases with height for both geometries up to a peak around mid-height and then decreases.
- Square structures consistently exhibit higher drift values than octagonal structures at all levels.
- Maximum drift occurs at 11.6 m for square (0.00424 mm) and 8 m for octagonal (0.002475 mm) structures.

6.1.3 Effect of the Shape of the Building on Storey Base Shear:

Table 6.1.3 - Comparison of Storey Base Shear at Different Heights in KN

Height (m)	Square(mm)	Octagonal (mm)
65.6	-985	-1169
62	-1192	-1415
58.4	-1394	-1655
54.8	-1591	-1889
51.2	-1782	-2116
47.6	-1967	-2337
44	-2146	-2551
40.4	-2319	-2757
36.8	-2485	-2955
33.2	-2644	-3145
29.6	-2796	-3326
26	-2939	-3497
22.4	-3073	-3657
18.8	-3197	-3805
15.2	-3309	-3939
11.6	-3407	-4056
8	-3488	-4153
4.4	-3516	-4187
0	0	0

- The table compares storey base shear in kN at various heights for square and octagonal structures.
- Base shear values are negative, indicating direction, and increase in magnitude as the height decreases.
- At all heights, the octagonal structure experiences higher base shear magnitudes than the square structure.
- Maximum base shear occurs at the base (0 m), with values of -3516 kN for square and -4187 kN for octagonal shapes.

6.2 Dynamic wind load on 65.6 m Height of building calculated by ASCE 7-22.

6.1.4 Effect of the Shape of The Building on Lateral Displacements:

Table 6.2.1 - Comparison of Lateral Displacements in mm at different height.

Height (m)	Square (mm)	Octagonal (mm)
65.6	134.8	82.484
62	131.83	80.476
58.4	128.31	78.144
54.8	124.235	75.488
51.2	119.6	72.511
47.6	114.403	69.213
44	108.641	65.598
40.4	102.312	61.667
36.8	95.415	57.426
33.2	87.949	52.877
29.6	79.916	48.027
26	71.316	42.882
22.4	62.156	37.448
18.8	52.445	31.734
15.2	42.209	25.751
11.6	31.514	19.511
8	20.548	13.045
4.4	9.818	6.462
0	0	0

- This table compares lateral displacements (in mm) at different heights for square and octagonal structures.
- As height increases, both structures show increased lateral displacement.
- Square structures consistently exhibit higher lateral displacement than octagonal ones at all heights.
- At the maximum height of 65.6 m, the square structure has 134.8 mm displacement, while the octagonal has 82.484 mm

6.1.5 Effect of the Shape of the Building on Storey Drifts:

Table 6.2.2 - Comparison of Storey Drifts at Different Heights in mm

Height (m)	Square (mm)	Octagonal (mm)
65.6	0.000825	0.000558
62	0.000978	0.000648
58.4	0.001132	0.000738
54.8	0.001287	0.000827
51.2	0.001444	0.000916
47.6	0.001601	0.001004
44	0.001758	0.001092
40.4	0.001916	0.001178
36.8	0.002074	0.001263
33.2	0.002232	0.001347
29.6	0.002389	0.001429
26	0.002545	0.001509
22.4	0.002697	0.001587
18.8	0.002843	0.001662
15.2	0.002971	0.001733
11.6	0.003046	0.001796
8	0.00298	0.001829
4.4	0.002231	0.001469
0	0	0

- This table presents a comparison of storey drifts (in mm) at various heights for square and octagonal structures.
- Storey drift increases with height for both structural shapes, peaking around mid-height.
- Square structures consistently show higher drift values than octagonal ones across all heights.
- Maximum drift for the square structure is 0.003046 mm at 11.6 m, while the octagonal structure reaches 0.001796 mm at the same height.

6.1.6 Effect of the Shape of the Building on Storey Base Shear:

Table 6.2.3 - Comparison of Base Shear at Different Heights in KN

Height (m)	Square (mm)	Octagonal (mm)
65.6	-623.8398	-731.0064
62	-759.0198	-890.4496
58.4	-892.8293	-1048.6897
54.8	-1025.2066	-1205.6669
51.2	-1156.0828	-1361.3136
47.6	-1285.3802	-1515.5536
44	-1413.0109	-1668.3003
40.4	-1538.8744	-1819.4535
36.8	-1662.854	-1968.8966
33.2	-1784.8126	-2116.4916
29.6	-1904.5864	-2262.0722
26	-2021.9756	-2405.4337
22.4	-2136.7297	-2546.317
18.8	-2248.5234	-2684.3816
15.2	-2356.9137	-2819.1575
11.6	-2461.2521	-2949.9447
8	-2560.4696	-3075.562
4.4	-2664.6071	-3208.799
0	0	

- This table presents a comparison of base shear values at different heights for two distinct structural shapes: Square and Octagonal.
- The height is given in meters, while the base shear values for both shapes are in millimetres.
- All base shear values are negative, indicating a specific direction or type of force.

6.2 COMPARISON OF RESULTS ON 65.6 M BUILDING BY IS 875 PART-3 AND ASCE 7-22

6.1.7 For Square building

6.1.7.1 Comparison of Lateral Displacements in Square Building

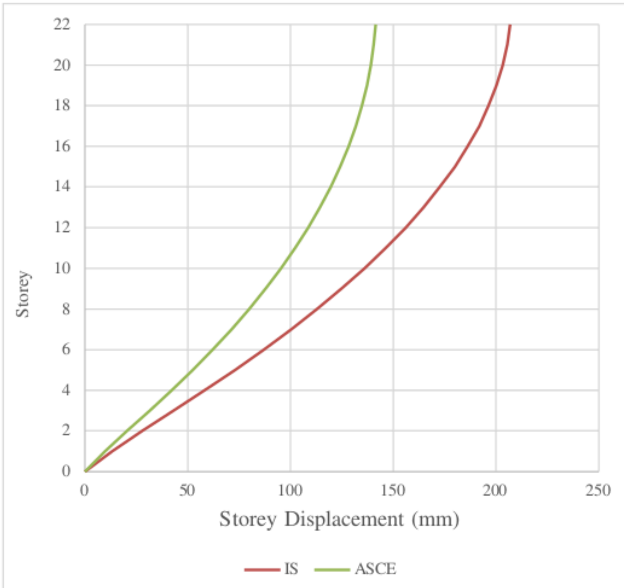

Figure 6.3.1.1: Comparison of Lateral Displacements in Square Building in mm at different Storey .

This graph shows how lateral displacement (in mm) changes with the storey height. Two curves are presented, representing different building codes or design standards: IS (red) and ASCE (green). The ASCE standard generally shows less lateral displacement for a given storey compared to the IS standard, especially at higher storeys.

6.1.7.2 Comparison of Storey Drift Ratio in Square Building

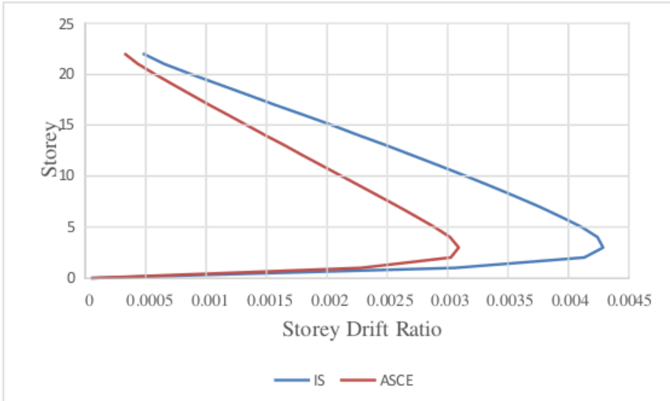

Figure 6.3.1.2: Comparison of story drift ratio in Square Building at different height.

This graph, titled "Comparison of Storey Drift Ratio in Square Building," illustrates the storey drift ratio against the storey height. Two different design standards, IS (blue) and ASCE (red), are compared. Both standards show an increasing drift ratio up to a certain storey, after which it decreases, with ASCE generally showing lower drift ratios for the initial storeys and then higher values at the peak compared to IS.

6.1.7.3 Comparison of Storey Base Shear in Square Building

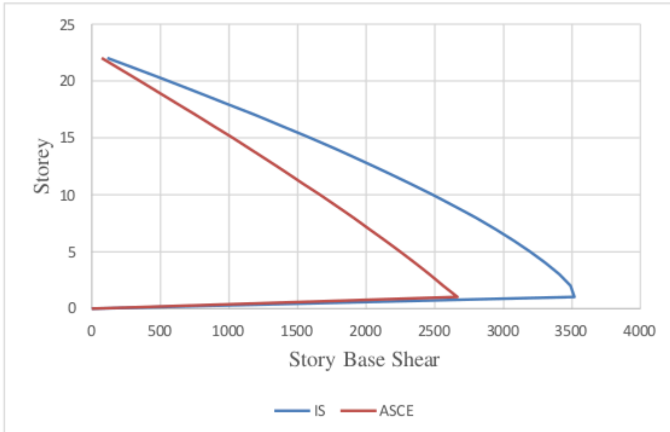

Figure 6.3.1.3: Comparison of story Base Shear (kN) in Square Building at different Storey.

This graph, displays the storey base shear (in kN) in relation to the storey height. It compares two different design standards: IS (blue) and ASCE (red). Both curves show a similar trend, where the base shear is highest at the lower storeys and progressively decreases with increasing height, with the IS standard generally indicating higher base shear values compared to the ASCE standard across most storeys.

6.1.8 For Octagonal Building

6.1.8.1 Comparison of Lateral Displacements in Octagonal Building

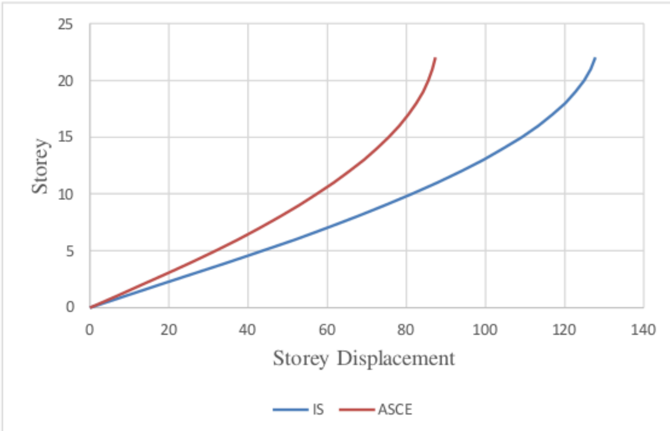

Figure 6.3.2.1: Comparison of Lateral Displacements in Octagonal Building in mm at different Storey

It compares storey displacement against storey level for two different standards: IS (Indian Standards, blue line) and ASCE (American Society of Civil Engineers, red line). The graph indicates that for a given storey, the ASCE standard generally shows less lateral displacement compared to the IS standard, especially at higher storey levels.

6.1.8.2 Comparison of Storey Drift Ratio in Octagonal Building

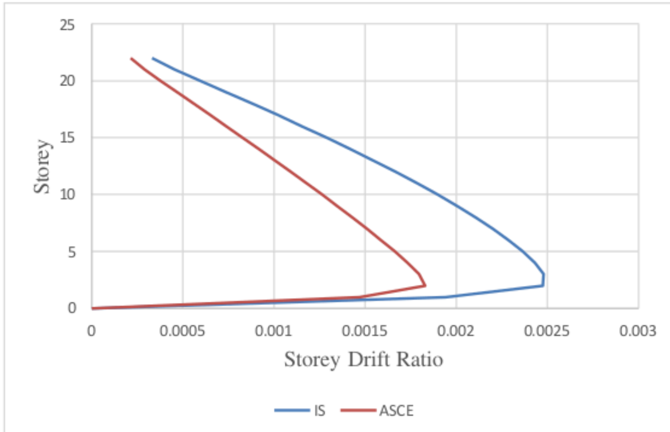

Figure 6.3.2.2: Comparison of story drift ratio in Octagonal Building at different height.

This graph, illustrates the lateral displacement (in mm) as a function of storey height. It compares two design standards: IS (blue) and ASCE (red). The ASCE standard consistently shows higher lateral displacements compared to the IS standard for a given storey, and both curves exhibit an increasing displacement with increasing storey height.

6.1.8.3 Comparison of Storey Base Shear in Octagonal Building

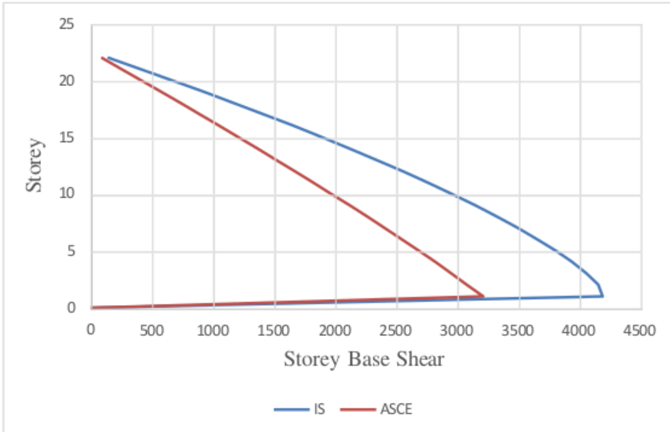

Figure 6.3.2.3: Comparison of story Base Shear(kN) in Octagonal Building at different height.

This graph, depicts the storey base shear (in kN) against the storey height. It compares two design standards: IS (blue) and ASCE (red). Both standards show the base shear decreasing with increasing storey height, with the IS standard generally indicating higher base shear values than the ASCE standard across most storeys.

6.2 RESULTS OF 130.4M HEIGHT OF BUILDING AND WIND LOAD CALCULATED BY IS 875 PART3(2015) AND ASCE 7-22.

Table 6.4.1- Comparison of Lateral Displacements in mm at different height

higher storeys.

STORY	IS 875	ASCE 7-22
35	155.522	122.966
34	149.897	118.56
33	144.247	114.134
32	138.574	109.689
31	132.882	105.228
30	127.175	100.754
29	121.457	96.27
28	115.734	91.78
27	110.013	87.29
26	104.3	82.804
25	98.604	78.328
24	92.933	73.869
23	87.296	69.434
22	81.704	65.031
21	76.169	60.669
20	70.701	56.356
19	65.312	52.101
18	60.016	47.916
17	54.826	43.811
16	49.758	39.797
15	44.825	35.886
14	40.044	32.092
13	35.432	28.426
12	31.006	24.905
11	26.784	21.541
10	22.786	18.35
9	19.03	15.347
8	15.536	12.55
7	12.327	9.976
6	9.425	7.643
5	6.853	5.57
4	4.637	3.779
3	2.805	2.293
2	1.39	1.14
1	0.431	0.356

The table compares lateral displacements in millimeters at various storey levels as per IS 875 and ASCE 7-22 codes. Displacement values are consistently higher under the IS 875 code than under the ASCE 7-22 code. Both codes show an increase in displacement with storey height, reaching a maximum at the top storey. The difference in displacement between the two codes becomes more significant at

Table 6.4.2 - Comparison of story drift in mm at different height.

STORY	IS 875	ASCE 7-22
35	0.001563	0.001224
34	0.00157	0.001229
33	0.001576	0.001235
32	0.001581	0.001239
31	0.001585	0.001243
30	0.001588	0.001246
29	0.00159	0.001247
28	0.001589	0.001247
27	0.001587	0.001246
26	0.001582	0.001243
25	0.001575	0.001239
24	0.001566	0.001232
23	0.001553	0.001223
22	0.001538	0.001212
21	0.001519	0.001198
20	0.001497	0.001182
19	0.001471	0.001163
18	0.001442	0.00114
17	0.001408	0.001115
16	0.00137	0.001086
15	0.001328	0.001054
14	0.001281	0.001018
13	0.001229	0.000978
12	0.001173	0.000934
11	0.001111	0.000886
10	0.001043	0.000834
9	0.00097	0.000777
8	0.000891	0.000715
7	0.000806	0.000648
6	0.000714	0.000576
5	0.000616	0.000498
4	0.000509	0.000413
3	0.000393	0.00032
2	0.000266	0.000218
1	0.00012	9.90E-05

- The table presents a comparison of storey drift values in millimeters for each storey level under IS 875 and ASCE 7-22 codes.
- Drift values are consistently higher in IS 875 compared to ASCE 7-22 across all storeys.
- Both codes show increasing drift with height, peaking around the mid to upper storeys.
- The difference in drift between the two codes is more pronounced at higher levels.

Table 6.4.3 - Comparison of Base Shear in mm at different height

BASE SHEAR		
STORY	**IS 875**	**ASCE**
35	2557	1930.195
34	2883	2181.196
33	3205	2430.552
32	3523	2678.244
31	3837	2924.273
30	4147	3168.638
29	4452	3411.221
28	4753	3651.956
27	5050	3890.842
26	5342	4127.88
25	5630	4362.972
24	5913	4595.973
23	6191	4826.884
22	6464	5055.704
21	6732	5282.377
20	6995	5506.627
19	7253	5728.452
18	7505	5946.239
17	7752	6163.061
16	7993	6378.435
15	8228	6590.189
14	8456	6798.926
13	8678	7004.044
12	8893	7205.663
11	9100	7404.748
10	9299	7600.213
9	9490	7793.266
8	9672	7980.285
7	9844	8161.271
6	10004	8337.431
5	10152	8508.162
4	10285	8672.859
3	10401	8827.422
2	10494	8972.995
1	10554	9039.659

- The table presents a comparison of storey drift values in millimeters for each storey level under IS 875 and ASCE 7-22 codes.
- Drift values are consistently higher in IS 875 compared to ASCE 7-22 across all storeys.
- Both codes show increasing drift with height, peaking around the mid to upper storeys.
- The difference in drift between the two codes is more pronounced at higher levels.

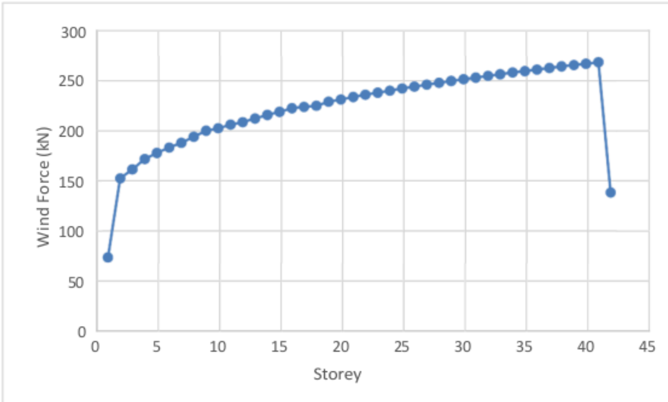

Figure 6.4.1: Wind Force as per IS 875:2015(Part3) in x dir

This graph illustrates the distribution of wind force (kN) across different storeys. The wind force generally increases with storey height, peaking at approximately 40 storeys before showing a significant drop at the highest recorded storey. This suggests that wind force accumulates with height up to a certain point, after which there might be a structural or environmental factor causing a reduction.

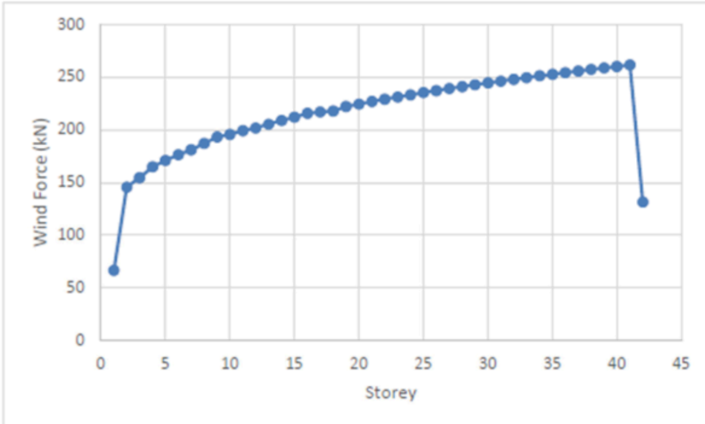

Figure 6.4.2: Wind Force as per ASCE 7-22.

This graph illustrates the wind force (kN) distributed across different storeys. The wind force generally increases with storey height, reaching its maximum around storey 40. After this peak, there is a sharp decrease in wind force at the highest storey shown.

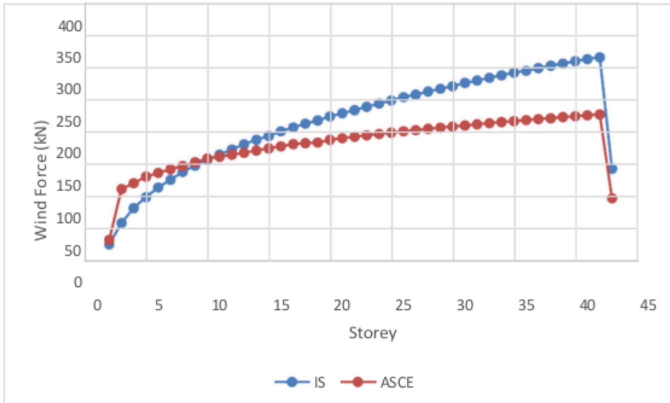

Figure 6.4.3: Comparison of Wind Force at different height.

This graph presents the wind force (kN) as it varies with storey height. It compares two standards: IS (blue) and ASCE (red). Both curves show an increasing trend in wind force with height, peaking around 40 storeys before a sudden drop, with the IS standard consistently indicating higher wind forces than the ASCE standard for most storeys.

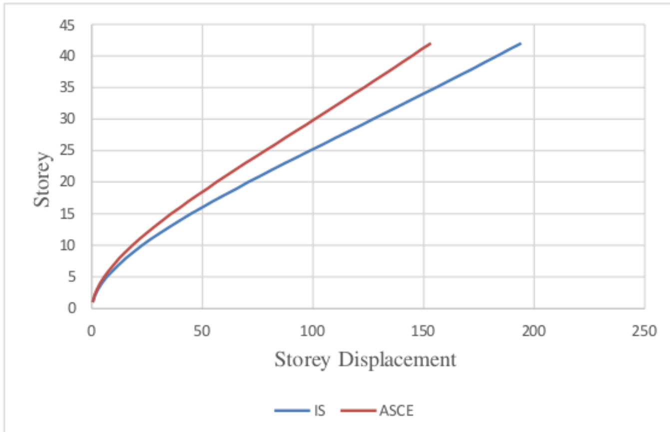

Figure 6.4.4: Comparison of Lateral Displacements in mm at different height.

This graph shows the lateral displacement (in mm) versus storey height. It compares two standards: IS (blue) and ASCE (red). Both curves indicate that lateral displacement increases with storey height, with the ASCE standard showing higher displacements than the IS standard for a given storey.

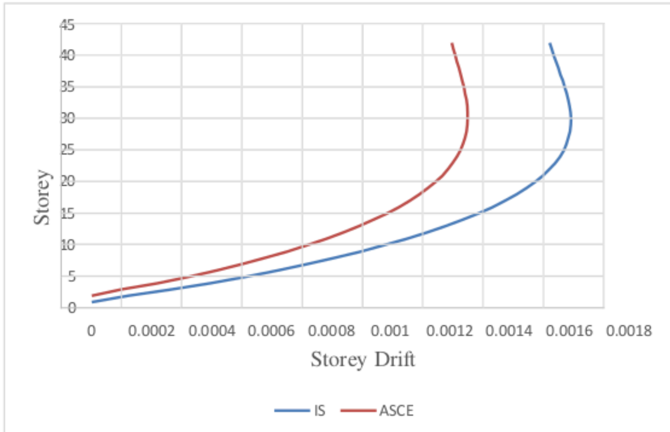

Figure 6.4.5: Comparison of story drift in mm at different height.

This graph illustrates the storey drift against the storey height. It compares two design standards: IS (blue) and ASCE (red). Both standards show an increasing drift up to a certain height, after which the curve bends back, with the ASCE standard generally indicating higher drift values for the same storey compared to the IS standard.

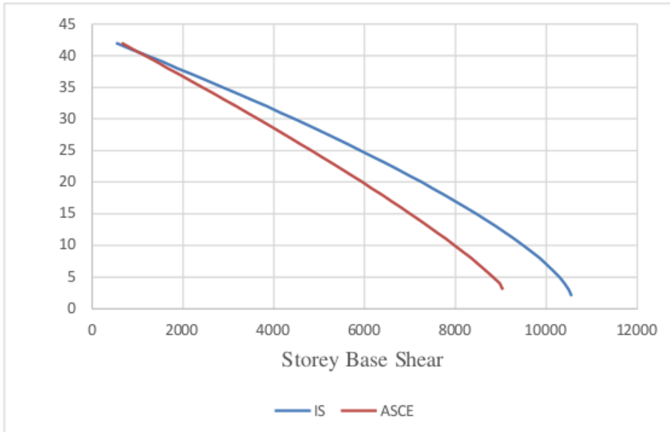

Figure 6.4.6: Comparison of story Base Shear in kN at different height.

The graph compares the distribution of storey base shear across different storey heights as per IS and ASCE codes. Base shear values are higher in the IS code than in the ASCE code at all storey levels. Both curves show a decreasing trend in base shear with increasing storey height.

CHAPTER – 7

CONCLUSION

Dynamic Wind Load on a 65.6 m High Building (IS 875 Part 3 (2015) and ASCE 7-22)

Lateral Displacements

- **Comparison of Standards**:
  - For both IS 875 Part 3 (2015) and ASCE 7-22, lateral displacements decrease as the height decreases.
  - IS 875 Part 3 (2015) generally yields higher values of lateral displacement as compared to ASCE 7-22 for all building shapes.
- **Effect of Shape**:
  - **Octagonal**: Shows the lowest lateral displacement, indicating a higher resistance to wind loads due to its shape.
  - **Square**: lateral displacement at the top storey is significantly higher in square buildings as compared to octagonal shape.

Storey Drifts

- **Comparison of Standards**:
  - Storey drifts follow a similar pattern, with IS 875 Part 3 (2015) generally showing higher drifts compared to ASCE 7-22.
- **Effect of Shape**:
  - **Octagonal**: Exhibits the lowest storey drifts, suggesting a more stable structure under wind loads.
  - **Square**: least stable structure as compared to octagonal shape because it exhibits high storey drifts as compared to octagonal shape.

Storey Base Shear

- **Comparison of Standards**:
  - Base shear values are significantly higher in IS 875 Part 3 (2015) compared to ASCE 7-22.
- **Effect of Shape**:
  - **Octagonal**: Shows the lowest base shear values, indicating better distribution of wind loads.
  - **Square**: The base shear recorded in the square-shaped building was significantly higher than in the octagonal-shaped building.

Dynamic Wind Load on a 130.4 m High Building (IS 875 Part 3 (2015) and ASCE 7-22)

Lateral Displacements

- **Comparison of Standards**:
  - A steady decline in lateral displacement from the top to the bottom stories is evident in both standards.
  - IS 875 Part 3 (2015) results in higher lateral displacements compared to ASCE 7-22 at all story levels.
- **General Observations**:
  - Higher wind loads in IS 875 Part 3 (2015) lead to greater lateral displacements, implying more flexible building behavior under dynamic wind loads.

Storey Drifts

- **Comparison of Standards**:
  - Similar trends in storey drifts are observed, with IS 875 Part 3 (2015) showing slightly higher values than ASCE 7-22.
- **General Observations**:
  - Lower storey drifts in ASCE 7-22 indicate better performance in terms of structural stability and reduced lateral movement.

Storey Base Shear

- **Comparison of Standards**:
  - IS 875 Part 3 (2015) produces significantly higher base shear values compared to ASCE 7-22.
- **General Observations**:
  - Higher base shear values in IS 875 Part 3 (2015) imply greater forces acting at the base of the structure, necessitating more robust foundation design and lateral load resistance mechanisms.

Overall Conclusion

Comparison of Indian (IS 875 Part 3 (2015)) and American (ASCE 7-22) Standards:

- IS 875 Part 3 (2015) generally predicts higher lateral displacements, storey drifts, and base shear values compared to ASCE 7-22.
- This indicates that the Indian standard tends to be more
- conservative, resulting in higher estimates of wind-induced effects on buildings.
- **Effect of Building Shape**:

Octagonal Shape: Best suited for wind-prone regions due to its reduced wind-induced responses. Preferred for high-rise buildings to enhance performance and reduce structural demand.

Square Shape: Acceptable but less efficient in terms of wind resistance. May require additional bracing or member sizing to match the performance of more aerodynamic shapes.

- **Design Implications**:
  - Designers should consider the more conservative estimates of IS 875 Part 3 (2015) for higher safety margins in wind load design.
  - The octagonal shape proves to be the most effective in reducing wind-induced displacements, drifts, and base shear, suggesting a preferred shape for high-rise buildings in wind-prone areas.
  - Comparative results highlight the importance of choosing appropriate building shapes and standards to ensure both safety and cost-efficiency in structural design against dynamic wind effects

MODERN INDIAN CITIES

ORIGINALITY REPORT

11%	7%	10%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	"Minimum Design Loads and Associated Criteria for Buildings and Other Structures", American Society of Civil Engineers (ASCE), 2022 Publication	3%
2	www.researchgate.net Internet Source	2%
3	archive.org Internet Source	1%
4	pusprajbhatt.files.wordpress.com Internet Source	1%
5	downloads.hindawi.com Internet Source	1%
6	dspace.dtu.ac.in:8080 Internet Source	<1%
7	www.sefindia.org Internet Source	<1%
8	Naveen Suthar, Pradeep K. Goyal. "Comparison of response of building against	<1%

wind load as per wind codes [IS 875 – (Part 3) – 1987] and [IS 875 – (Part 3) – 2015]", IOP Conference Series: Earth and Environmental Science, 2021
Publication

9	scholarworks.uttyler.edu Internet Source	<1 %
10	"Minimum Design Loads and Associated Criteria for Buildings and Other Structures", American Society of Civil Engineers (ASCE), 2017 Publication	<1 %
11	Syed Mehdi Ashraf. "Structural Building Design: Wind and Flood Loads", CRC Press, 2018 Publication	<1 %
12	W.F. Chen, E.M. Lui. "Handbook of Structural Engineering", CRC Press, 2019 Publication	<1 %
13	Gholamreza Amirinia, Sungmoon Jung. "Along-Wind Response of High-Rise Buildings Subjected to Hurricane Boundary Layer Winds", Journal of Structural Engineering, 2017 Publication	<1 %
14	Saraç, Yavuz. "Optimum Design of Pın-Jointed 3-D Dome Structures Using Global	<1 %

Optimization Techniques", Middle East Technical University (Turkey), 2024
Publication

15	T. J. Nikose, R. S. Sonparote. "Dynamic along wind response of tall buildings using Artificial Neural Network", Cluster Computing, 2018 Publication	<1%
16	idoc.pub Internet Source	<1%
17	"Minimum Design Loads for Buildings and Other Structures", American Society of Civil Engineers (ASCE), 2013 Publication	<1%
18	atrium.lib.uoguelph.ca Internet Source	<1%
19	www.cqhp.org Internet Source	<1%
20	Alberto Lago, Dario Trabucco, Antony Wood. "Design procedures for tall buildings with dynamic modification devices", Elsevier BV, 2019 Publication	<1%
21	Lu, Qin. "Integrating Surrogate Modeling and Bayesian Updating for Damage Assessment", University of Connecticut, 2024 Publication	<1%

22	www.pubs.asce.org Internet Source	<1 %
23	www.ukessays.com Internet Source	<1 %
24	Somnath Ghosh, Arundeb Gupta. "Design of Wind and Earthquake Resistant Reinforced Concrete Buildings", Routledge, 2021 Publication	<1 %
25	William L. Coulbourne, T. Eric Stafford. "Wind Loads", American Society of Civil Engineers (ASCE), 2020 Publication	<1 %
26	documents.mx Internet Source	<1 %
27	Guo-Qiang Li, Mengde Pang, Feifei Sun, Jian Jiang, Dazhu Hu. "Seismic behavior of coupled shear wall structures with various concrete and steel coupling beams", The Structural Design of Tall and Special Buildings, 2018 Publication	<1 %
28	www.ijsrd.com Internet Source	<1 %
29	Bilgen, Sinan. "Investigation of Aerodynamic and Structural Features of Twisting Tall Buildings.", Middle East Technical University (Turkey), 2024	<1 %

Publication

30	Chhabirani Tudu, Manaswinee Patnaik, Dilip Kumar Bagal. "Assessing the efficacy of tuned mass dampers in mitigating wind-induced vibrations of tall structures", Innovative Infrastructure Solutions, 2024 Publication	<1 %
31	Dominick Pilla. "Elementary Structural Analysis and Design of Buildings - A Guide for Practicing Engineers and Students", CRC Press, 2017 Publication	<1 %
32	Mahtab Abdollahi Sarvi, Siamak Epackachi, Ali Imanpour. "A methodology towards reducing the wind return period in reinforced concrete shear walls considering reserve capacity", Journal of Wind Engineering and Industrial Aerodynamics, 2025 Publication	<1 %
33	Stjepan Lakusic. "Analysis of supported steel frames with rigid and semi-rigid connections", Journal of the Croatian Association of Civil Engineers, 2017 Publication	<1 %
34	T. Eric Stafford, Timothy A. Reinhold. "Wind Loads", American Society of Civil Engineers (ASCE), 2023 Publication	<1 %

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		