

A Comparative Study of Wind Effect on High Rise Building Using American and Indian Wind Standards

A Dissertation submitted in partial fulfilment
of the requirement for the degree of

**Master of Engineering
In
Structural Engineering**

**Submitted by
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JULY 2025

DECLARATION

I hereby declare that the work which is presented in this dissertation entitled “ A Comparative Study of Wind Effect on High Rise Building Using American and Indian Wind Standards” as per the requirement for the award of Master of engineering in Structures, submitted in the Department of civil engineering, Thapar Institute of Engineering & Technology, Patiala is review carried out by me under the guidance of Dr. Arpit Goyal, Assistant Professor, Department of Civil Engineering, Thapar Institute of Engineering & Technology, Patiala and Er.Ayush Gupta, Assistant Structure Engineer, LKT Engineering Consultants Ltd, Ashok Nagar, New Delhi.

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This is to certify that the above declaration made by the student concerned is correct according to the best of my knowledge and belief.



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ABSTRACT

This M.Tech thesis presents a comprehensive comparison of wind loading codes for high-rise buildings, focusing on the American Society of Civil Engineers (ASCE) 7- 22 and the Indian Standard (IS) 875 (2015) - Part 3. The study evaluates the response of buildings to wind loads through dynamic analysis, considering various dynamic wind characteristics. A set of 151.2m high-rise buildings of different shapes were subjected to analysis, alongside an 80m height building for further examination of different building geometries.

The comparative analysis primarily focuses on terrain category 3 for both codes, with a meticulous examination of parameters such as design wind pressure at different heights, base shear, storey drift and storey displacement. The aim of this research is to provide insights into the variations between international wind loading standards, particularly in comparison with the Indian wind loading standard.

Through rigorous analysis and comparison, this study sheds light on the disparities in wind load assessments and their implications on structural design and safety. The findings presented in this thesis contribute to enhancing understanding and improving the application of wind loading codes in the design and construction of tall buildings, facilitating better structural performance and resilience in diverse geographical contexts.

Table of Contents

DECLARATION	i
ACKNOWLEDGEMENT	ii
LIST OF TABLES	vi
LIST OF FIGURES	vii
CHAPTER -1	1
INTRODUCTION	1
1.1 General	1
1.2 High-Rise Buildings and the challenge of wind.....	1
1.3 Wind's Impact on High-rise Buildings	1
1.4 The Crucial Role of Wind Loading Codes.....	2
1.5 Fundamentals Key Terms (IS 875 (2015)-PART-3).....	2
1.6 Scope and Objectives	3
CHAPTER -2.....	4
LITERATURE REVIEW	4
2.1 Comparison of wind effect on buildings with different geometrical shapes using different codes	4
2.2 Quantitative comparison of codes and standards.....	12
2.3 Comparison of wind effect on buildings of different height using different codes	17
2.4 Research Gaps	21
CHAPTER -3.....	22
METHODOLOGY.....	22
3.1 STEP-BY-STEP PROCEDURE OF ETABS MODELING AND ANALYSIS UNDER IS AND ASCE WIND LOAD STANDARDS	22
3.2 ASSUMPTIONS IN DESIGN: -	23
3.3 LOAD COMBINATION TO BE CONSIDERED IN WIND LOAD: -.....	23
An Load combination for limit state of collapse as per IS 456-2000.	23
3.4 A WIND CODES AND STANDARDS CONSIDERED IN THIS THESIS: -.....	23
3.5 WIND LOAD CALCULATION AS PER INDIAN STANDARD (875-2015 (PART 3)).....	24
3.6 WIND LOAD CALCULATION AS PER AMERICAN STANDARD ASCE-7:22:-.....	27
CHAPTER - 4.....	30
DETAILS OF THE MODELS STUDIED	30
4.1 MODELLING AND ANALYSIS OF MODEL 1(151.2m):-.....	30
4.2 MODELLING AND ANALYSIS OF MODEL (80m):-.....	32
CHAPTER – 5	36
RESULTS AND DISCUSSION	36
5.1 Dynamic wind load on 80 m Height of building calculated by IS 875 part3 (2015).	36
5.2 Dynamic wind load on 80 m Height of building calculated by ASCE 7-22.	39
5.3 COMPARISON OF RESULTS ON 80M BUILDING BY IS 875 PART-3 AND ASCE 7-22.....	42
5.4 COMPARISON OF RESULTS ON 151.2M BUILDING BY IS 875 PART-3 AND ASCE 7-22.....	54

CHAPTER – 6.....	61
CONCLUSION.....	61
REFERENCES	62

LIST OF TABLES

Table 2.1 Maximum Storey Displacement.....	5
Table 2.2 Maximum Storey Displacement.....	6
Table 2.3 Comparison of Different Codes and Standards.....	15
Table 2.4 Displacement due to wind loads	18
Table 2.5 Comparison of design parameter as per IS 875 (Part 3)-2015 and AS/NZS (Part-2)-2011	19
Table 4.1.1 Design parameters of 151.2m height building	30
Table 4.2.1 Design parameters of 80m height building	32
Table 5.1.1 Comparison of Lateral Displacements in mm at different height.	36
Table 5.1.2 Comparison of Storey Drifts at Different Heights in m.	37
Table 5.1.3 Comparison of Storey Base Shear at Different height in KN	38
Table 5.2.1 Comparison of Lateral Displacements in mm at different height.	39
Table 5.2.2 Comparison of Storey Drifts at Different Heights in m	40
Table 5.2.3 Comparison of Base Shear at Different Heights in KN	41
Table 5.4.1 Comparison of Lateral Displacements in mm at different height	54
Table 5.4.2 Comparison of story drift at different height.	55
Table 5.4.3 Comparison of Base Shear in KN at different height	56

LIST OF FIGURES

Figure 2.1 Maximum Story Displacement.....	4
Figure 2.2 Base Shear	5
Figure 2.3 Storey Drift.....	5
Figure 2.4 Maximum Storey Displacement	7
Figure 2.5 Storey wise distribution of forces for each model along X and Y-direction	8
Figure 2.6 Displacement in Y-Dir	8
Figure 2.7 Storey Displacement (wog)	9
Figure 2.8 Storey Displacement (wg)	9
Figure 2.9 Storey Drift (wog)	10
Figure 2.10 Storey Drift (wg)	10
Figure 2.11 Storey Shear (wog)	10
Figure 2.12 Storey Shear (wg)	11
Figure 2.13 Wind velocity profile (875-3).....	12
Figure 2.14 Wind velocity profile (CP-2004).....	12
Figure 2.15 Wind velocity profile (AS/NZS 1170.2:2011)	13
Figure 2.16 Wind velocity profile (AIJ-RLB-2004).....	13
Figure 2.17 Pressure distribution along height of the building.....	14
Figure 2.18 Comparison of base bending moment M.....	14
Figure 2.19 Comparison of base shear.....	15
Figure 2.20 Storey Shear for 10 Storey Building.....	17
Figure 2.21 Storey Shear for 20 Storey Building.....	17
Figure 2.22 Comparison of deflection in mm.....	20
Figure 2.23 Comparison of storey drift.....	20
Figure 4.1.1 Plan of square	31
Figure 4.1.2 3D View	31
Figure 4.2.1 Plan of Square Building.....	32
Figure 4.2.2 3D View	32
Figure 4.2.3 Plan of Rectangular Building	33
Figure 4.2.4 3D View	33
Figure 4.2.5 Plan of Octagonal Building	34
Figure 4.2.6 3D View	34
Figure 4.2.7 Plan of Diamond Building.....	35
Figure 4.2.8 3D View	35
Figure 5.3.1.1 Comparison of Lateral Displacements in Rectangular Shape Building in mm at different Storey.....	42
Figure 5.3.1.2 Comparison of storey drift ratio in Rectangular Shape Building at different height.....	43
Figure 5.3.1.3 Comparison of story Base Shear (kN) in Rectangular Shape Building at different height. ..	44
Figure 5.3.2.1 Comparison of Lateral Displacements in Square Shape Building in mm at different Storey.....	45
Figure 5.3.2.2 Comparison of storey drift ratio in Square Shape Building at different height.....	46
Figure 5.3.2.3 Comparison of storey Base Shear (kN) in Square Shape Building at different Storey.	47
Figure 5.3.3.1 Comparison of Lateral Displacements in Diamond Shape Building in mm at different Storey.....	48
Figure 5.3.3.2 Comparison of storey drift ratio in Diamond Shape Building at different height.....	49
Figure 5.3.3.3 Comparison of storey Base Shear (kN) in Diamond Shape Building at.....	50

Figure 5.3.4.1 Comparison of Lateral Displacements in Octagonal Shape Building in mm at different Storey.....51
Figure 5.3.4.2 Comparison of storey drift ratio in Octagonal Shape Building at different storey52
Figure 5.3.4. 3 Comparison of story Base Shear (kN) in Octagonal Shape Building at different storey53

CHAPTER -1

INTRODUCTION

1.1 General

Wind is the movement of air, generally occurring in the horizontal direction, and represents the natural motion of the atmosphere. Vertical or nearly vertical movement of air is referred to as a "current," but near the Earth's surface, air flows in three dimensions, with horizontal motion being the most dominant. While vertical currents are important in meteorology, their influence near the ground is limited. On the other hand, horizontal airflow particularly the gradual reduction in wind speed and the high turbulence close to the ground is of great importance in building engineering. (Yennawar et al., 2018)

Wind load regulations are crucial for high-rise building design, especially in non-seismic regions. Most countries have developed standards and requirements for wind load analysis to effectively analyze structures. Wind refers to the natural horizontal motion of air near the earth's surface, with horizontal motion being larger than vertical. In meteorology, vertical motion is less significant, but horizontal motion is crucial in building engineering. (Maru et al, 2024)

1.2 High-Rise Buildings and the challenge of wind

Modern Indian cities are rapidly transforming, with high-rise buildings becoming increasingly prominent. These structures, like the World Trade Centre Mumbai and The Imperial in Delhi, not only redefine skylines but also symbolize economic growth and a burgeoning urban population. However, their majestic presence often belies a hidden vulnerability – the invisible force of wind. (Chaudhary et al, 2019)

1.3 Wind's Impact on High-rise Buildings

The effects of wind on high-rise buildings extend beyond aesthetics and occupant comfort. Excessive wind-induced vibrations can lead to discomfort, nausea, and even fear for occupants. More importantly, these vibrations can cause fatigue in the structural elements over time, leading to the development of cracks and compromising long-term safety. In extreme cases, wind forces can be strong enough to cause catastrophic failure. (Shaikh et al, 2019).

1.4 The Crucial Role of Wind Loading Codes

To ensure the safety and integrity of high-rise buildings in India, engineers rely on wind loading codes. These codes establish a standardized and systematic approach for evaluating the effects of wind on structures. They provide methodologies, criteria, and standards for analyzing wind pressures, forces, and the dynamic responses of buildings.

By incorporating the provisions of wind loading codes into the design process, engineers can ensure that high-rise buildings are robust enough to withstand wind forces while maintaining their architectural integrity. This allows for the construction of innovative and sustainable high-rises that contribute to India's urban landscape without compromising the safety of occupants. (Ahmed et al, 2017)

1.5 Fundamentals Key Terms (IS 875 (2015)-PART-3)

Some essential terms related to wind engineering and high-rise buildings design:

- **Wind Loading:** The process of assessing the effects of wind on structures, including wind pressures, forces, and resulting dynamic responses.
- **Structural Integrity:** The ability of structure to resist external loads and environmental conditions without experiencing excessive deformation, failure, or compromise in its safety.
- **Terrain Categories:** Classification of terrain types based on their roughness characteristics (open flat terrain, suburban areas, urban centers), which influence wind flow patterns and speeds around buildings.
- **Design Wind Pressure:** The pressure exerted by the wind on a building's surface, used in structural design calculations to determine the required strength and stiffness of building elements. Crucial for Indian standards due to the potential for high wind speeds in some regions.
- **Base Shear:** The total lateral force acting at base of the structure due to wind or seismic loads, which must be resisted by the building's foundation system. This is critical parameter for ensuring the stability of high-rise buildings under wind loads.
- **Gust:** A positive and negative departure of wind speed from its mean value, lasting for more than, say 2 min over a specified interval of time.

- **Gust Factor:** This is a number that tells you how much stronger a gust can be compared to the average wind speed. It is calculated by dividing the peak gust speed (the strongest measured gust) by the sustained wind speed (the average wind speed over a set time, usually 10 or 60 minutes).

1.6 Scope and Objectives

- To compare the lateral displacement, storey drift, and base shear of an 80 m and 151.2 m high-rise building subjected to dynamic wind load using IS 875 Part 3 (2015) and ASCE 7-22 standards.
- To assess the impact of different building shapes rectangular, square, diamond, and octagonal on structural performance under wind loads.
- To identify which code (IS or ASCE) results in higher wind-induced structural responses and understand the implications for safety and design conservatism.
- To determine the most wind-resistant and cost-effective building shape and design code combination for high-rise structures.
- To provide recommendations for selecting suitable building shapes and wind load standards that ensure structural stability, efficiency, and economy in design.

CHAPTER -2

LITERATURE REVIEW

2.1 Comparison of wind effect on buildings with different geometrical shapes using different codes

Chaudhary et al (2019) : conducted a comparative study of the latest Indian wind code, IS 875 (Part 3)-2015, with two prominent international codes: ASCE 7-22 (United States) and AS/NZS 1170.2-2011 (Australia and New Zealand). The study focused on along-wind loads on high-rise buildings, emphasizing the importance of wind in structural design, particularly in regions with high average wind speeds and coastal areas.

The research analysed the response of a 60-meter-high building with various geometrical shapes to wind loads using static analysis. Static wind characteristics for terrain categories 2 and 3 were evaluated using ETABS software, with parameters such as base shear, story displacement, and story drift compared across the codes. The objective was to assess the differences in wind loading standards and their implications for the Indian code.

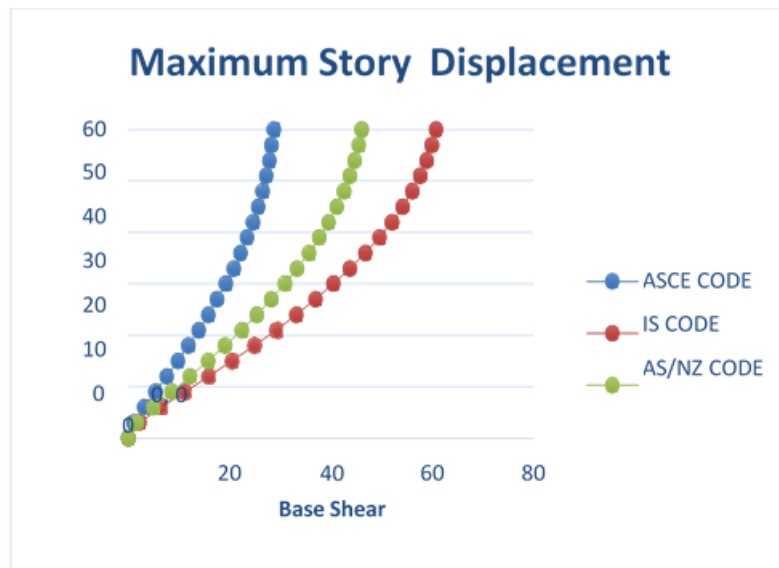


Figure 2.1 Maximum Story Displacement [Chaudhary et al (2019)]

- Figure 2.1 illustrates that the IS code yields higher story displacement values compared to the AS/NZS code, while the AS/NZS code produces higher values than the ASCE code.

Table 2.1 Maximum Storey Displacement

Code	Maximum Displacement(mm)
ASCE Code	28.70
IS Code	60.811
AS/NZS Code	46.111

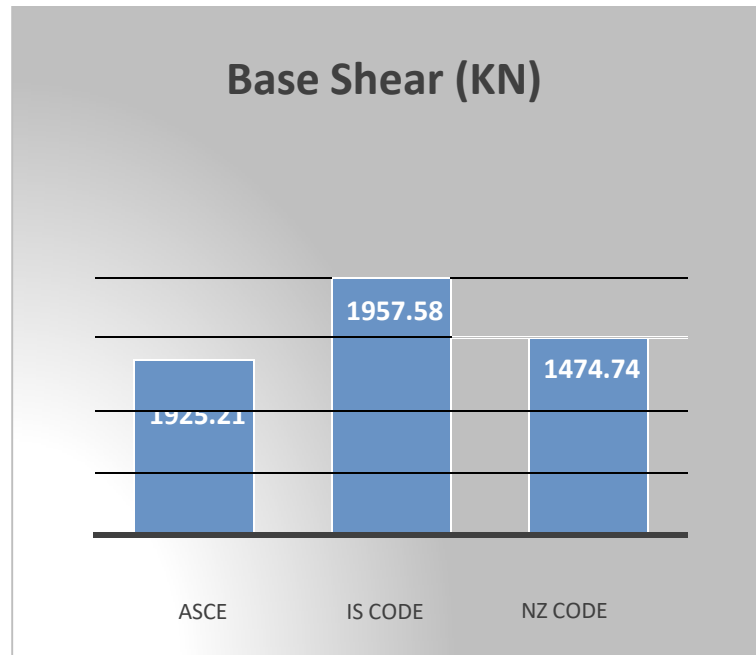


Figure 2.2 Base Shear [Chaudhary et al (2019)]

- Figure 2.2 shows that the IS code results in higher base shear values compared to the AS/NZS and ASCE codes, with the AS/NZS code yielding higher values than the ASCE code.

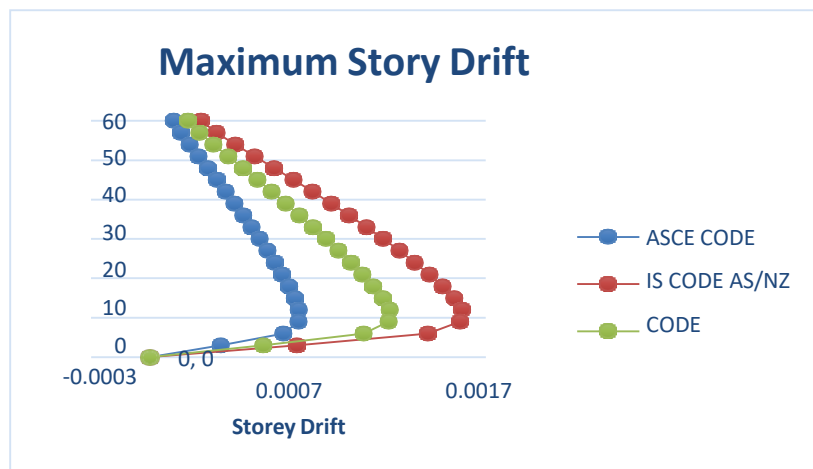


Figure 2.3 Storey Drift [Chaudhary et al (2019)]

- Similarly, Figure 2.3 indicates that the IS code produces higher story drift values compared to both the AS/NZS and ASCE codes, with the AS/NZS code again showing higher values than the ASCE code.
- The storey displacement for the L-shaped building is greater than that of both the C-shaped and rectangular configurations, indicating that the rectangular shape offers the highest stability under wind loads, whereas the L-shape exhibits the least stability.

Maru et al (2019) : A study was carried out to evaluate and compare the structural performance of three structural systems—Braced Frame, Hull-Core, and Shear Wall—under dynamic wind loading, as per five different design codes: Indian (IS 875 Part 3:2015), American (ASCE 7-10), Australian/New Zealand Standard (AS/NZS 1170.2:2011), Canadian Standard (NBCC 2015), and British Standard (BS EN 1991-1-4:2005). The analysis was conducted using ETABS v.16 for structures of varying heights. All structural types demonstrated satisfactory behavior in both open and rough terrain exposure categories. The study focused on comparing dynamic lateral forces, with conclusions drawn based on the maximum storey displacement observed.

Table 2.2 Maximum Storey Displacement

Country Code	Exposure Open			Exposure Rough		
	Braced	Hull-Core	Shear Wall	Braced	Hull-Core	Shear Wall
ASCE	82.469	71.074	85.931	62.88	54.156	65.561
AZ/NZS	114.595	103.26	122.02	72.133	64.871	76.832
EN/BS	360.59	310.57	375.96	221.24	190.23	231.05
INDIA	59.454	51.185	62.013	37.404	32.09	39.147
NBCC	260.066	224.08	271.05	191.98	165.31	200.21

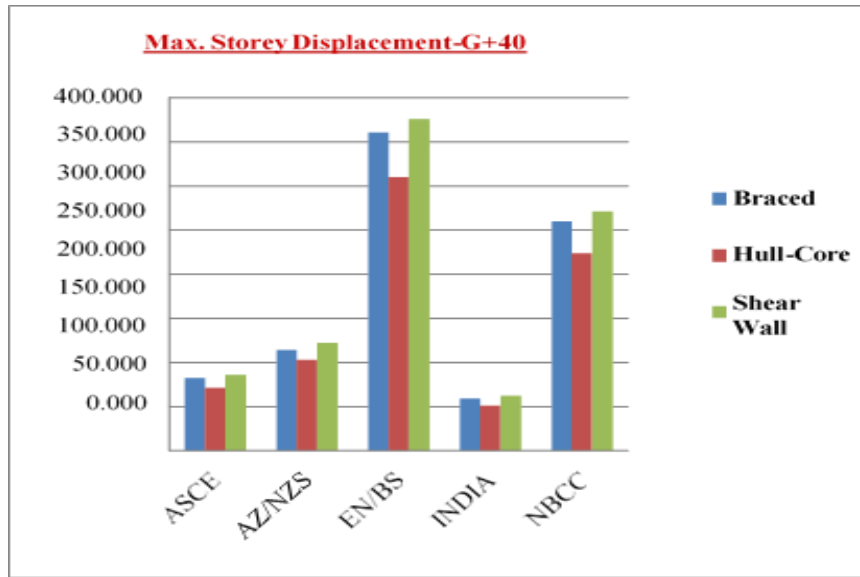


Figure 2.4 Maximum Storey Displacement [Maru et al (2019)]

- From Figure 2.4 and Table 2.1, it is observed that in all cases analyzed using different country codes for dynamic wind loading, the maximum story displacement occurs in the shear wall structure.
- From Figure 2.4 and Table 2.1, it can be seen that the hull-core structure outperformed the other structures, showing the lowest story displacement values in both exposure categories across all structure heights.
- All structures, including braced, hull-core, and shear wall, yielded satisfactory serviceability results, with the exception of EN/BS.

Shaikh et al (2019) : This study aims to examine the provisions of various international standards and compare them with Indian standards, with a specific emphasis on the impact of wind loads on reinforced concrete (RC) buildings. The analysis incorporates key design codes, including IS 875 (Part-3):1987, IS 875 (Part-3):2015, and ASCE 7-05. Special emphasis is placed on the revisions introduced in IS 875 (Part-3):2015, highlighting its advancements and improvements over the earlier 1987 version.

The study investigates buildings with a variety of shapes, encompassing both regular and irregular configurations. Wind load effects, particularly along-wind forces and the gust factor, are evaluated using IS 875 (Part-3):2015, which provides guidelines for determining design loads on structures. Custom spreadsheets were developed to assess the wind effects on different building geometries, and the structural analysis was conducted using ETABS

2016, a finite element software. The analysis focuses on 20-storey buildings, each with a uniform storey height of 4 meters, resulting in a total height of 80 meters. To maintain consistency, the plan areas of the regular shapes square, rectangular, elliptical, circular, and a rectangle with two semicircular ends were kept constant, along with the frame properties.

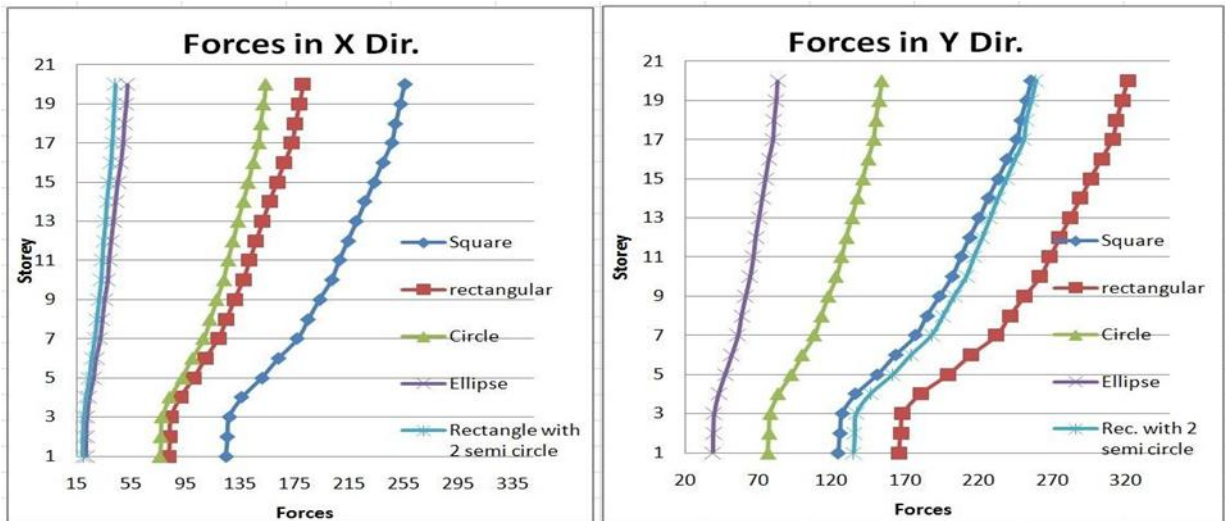


Figure 2.5 Storey-wise force distribution for each structural model in both the X and Y directions. [Shaikh et al (2019)]

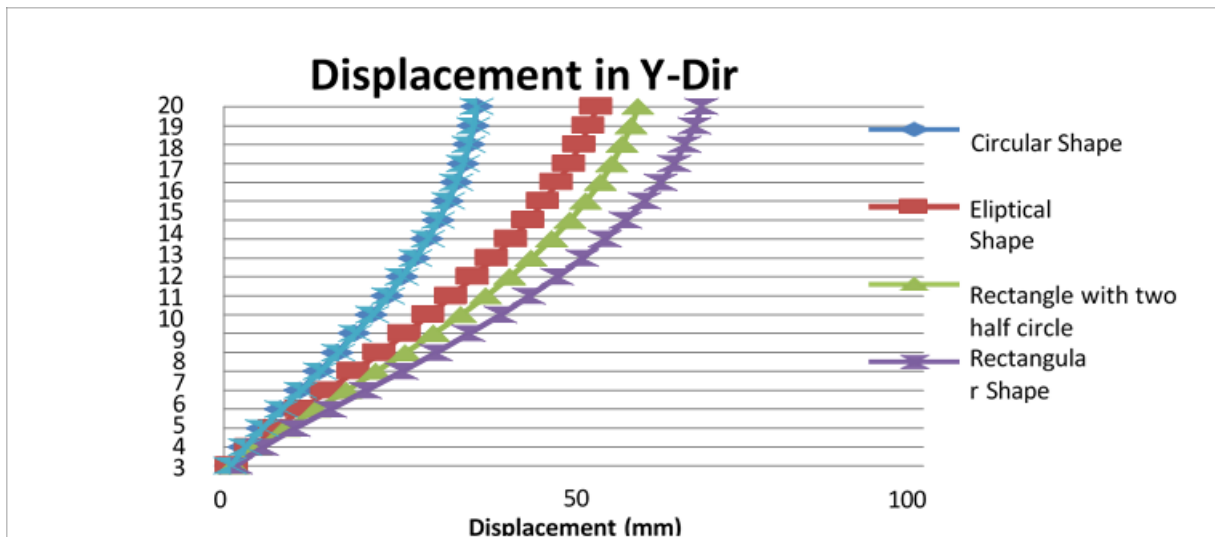


Figure 2. 6 Displacement in Y-Dir [Shaikh et al (2019)]

- Buildings with circular, elliptical, and rectangular plans incorporating semicircular ends present a reduced surface area facing the wind, leading to lower wind pressure compared to square and rectangular plan configurations.
- The rectangle shape building has maximum displacement than other as shown in fig 2.6
- Square buildings face the highest wind forces in the X-direction, while rectangular buildings experience the maximum in the Y-direction. In the X-direction, wind load

reductions for circular, rectangular, rectangular with two semicircular ends, and elliptical buildings are 39.28%, 31.35%, 83.52%, and 80.85%, respectively. In the Y-direction, the reductions for square, circular, rectangular with two semicircular ends, and elliptical buildings are 22.37%, 52.85%, 19.21%, and 75.19%, respectively. These results indicate that, among common building shapes, elliptical forms and rectangular buildings with two semicircular ends are the most effective in reducing wind loads, as illustrated in Figure 2.5.

Gawali et al (2015) :This study involves a detailed analytical assessment of different building shapes using various analysis methods. Building layouts are modeled, and wind loads are calculated in accordance with IS 875 (Part 3):1987, considering cases both with and without the application of the gust factor. The models are evaluated using ETABS v13.1.1 based on key parameters such as storey drift, storey displacement, and storey shear for each building shape. Through this comparative analysis, the building configuration that demonstrates optimal wind resistance and structural efficiency is identified.

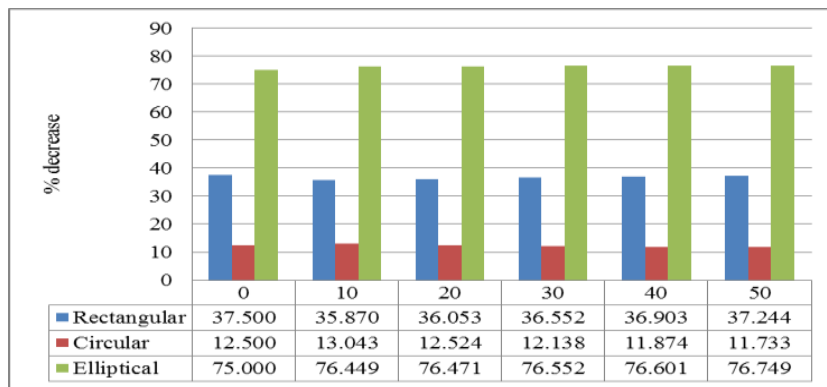


Figure 2.7 Storey Displacement (wog) [Gawali et al (2015)]

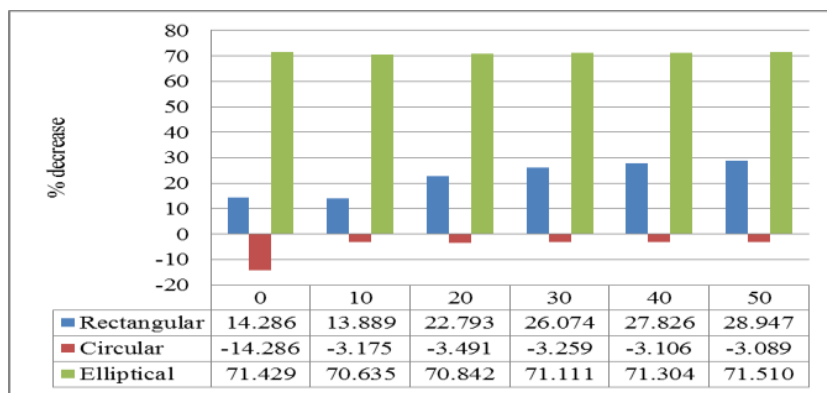


Figure 2.8 Storey Displacement (wg) [Gawali et al (2015)]

- The lateral forces acting on the structure cause displacement at each storey level. The storey displacement values for square, rectangular, circular, and elliptical-shaped buildings are graphically illustrated in Figures 2.7 and 2.8.

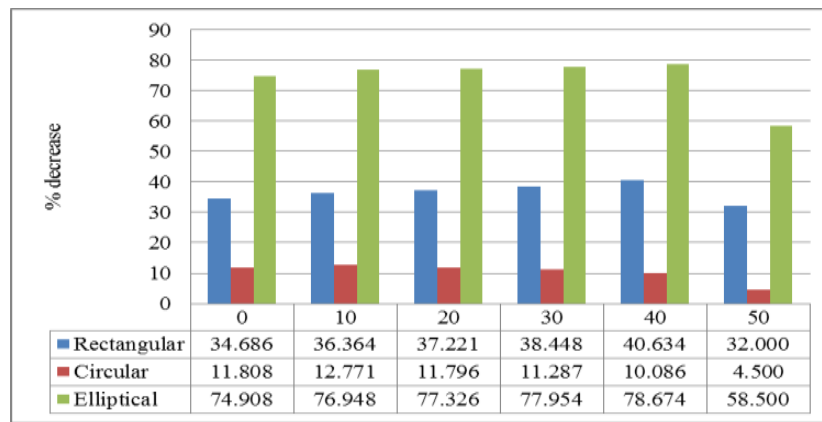


Figure 2.9 Storey Drift (wog) [Gawali et al (2015)]

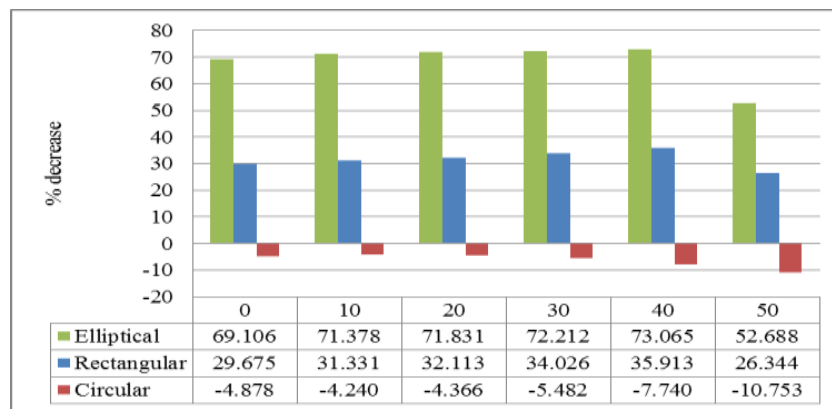


Figure 2.10 Storey Drift (wg) [Gawali et al (2015)]

- Storey drift refers to the displacement of one level relative to the level above or below it. The storey drift values for square, rectangular, circular, and elliptical-shaped buildings are compared and graphically presented in Figures 2.9 and 2.10.

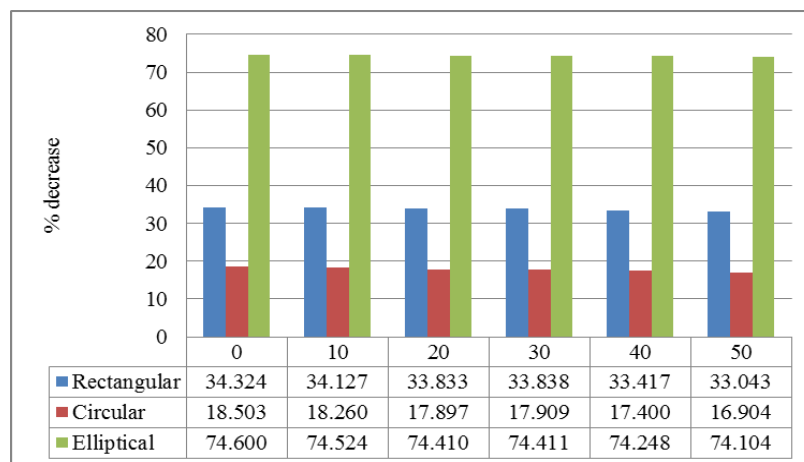


Figure 2.11 Storey Shear (wog) [Gawali et al (2015)]

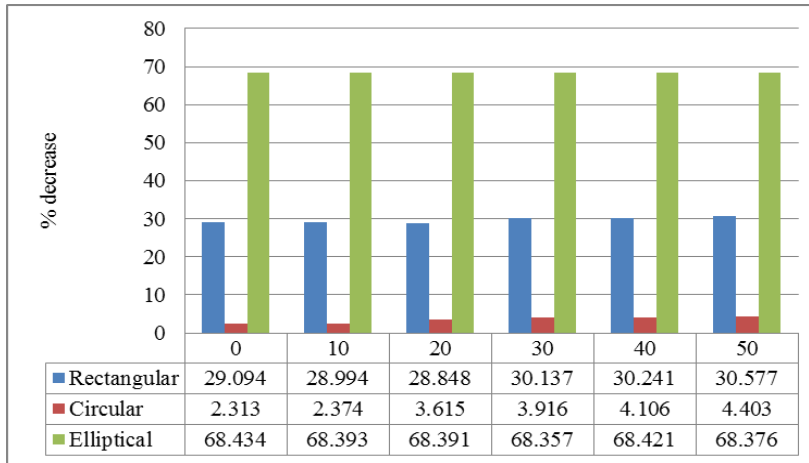


Figure 2.12 Storey Shear (wg) [Gawali et al (2015)]

- Storey shear is defined as the total sum of design lateral forces acting at all levels above the storey being considered. The storey shear values for square, rectangular, circular, and elliptical-shaped buildings are compared and graphically illustrated in Figures 2.11 and 2.12.

2.2 Quantitative comparison of codes and standards.

Verma et al (2016) :used wind loading rules from four different nations to compare how structures responded to wind load. Japan (AIJ-RLB-2004), India (IS 875-3), Hong Kong (CP-2004), and New Zealand (AS/NZS 1170.2:2002) are among the codes employed in this study. The study employed static analysis to examine the static wind properties of a rectangular building that was 200 meters high. The wind loading codes for terrain category 2 were used to compare findings across all nations. Additionally, the study analyzed a number of factors, including base shear, base bending moment, gust factor, and design wind pressure at various heights.

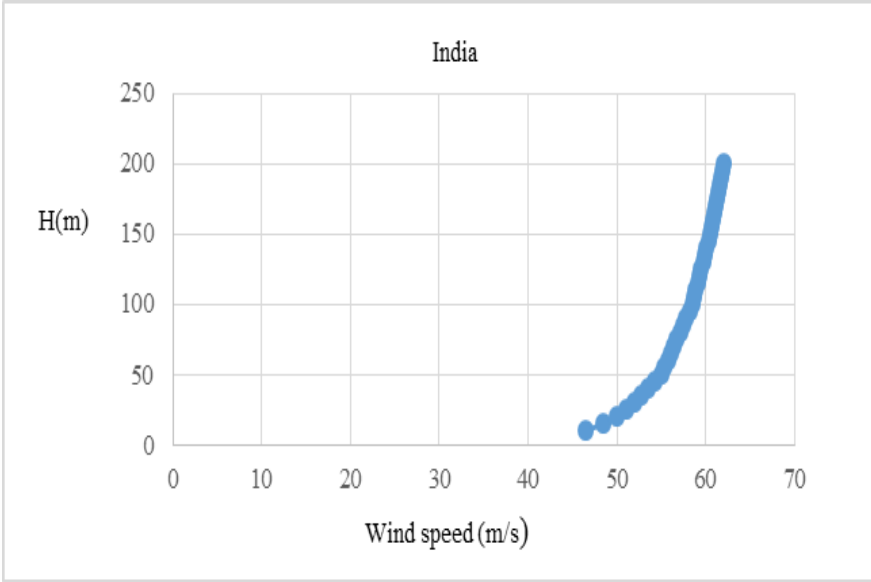


Figure 2.13 Wind speed (875-3) [Verma et al (2016)]

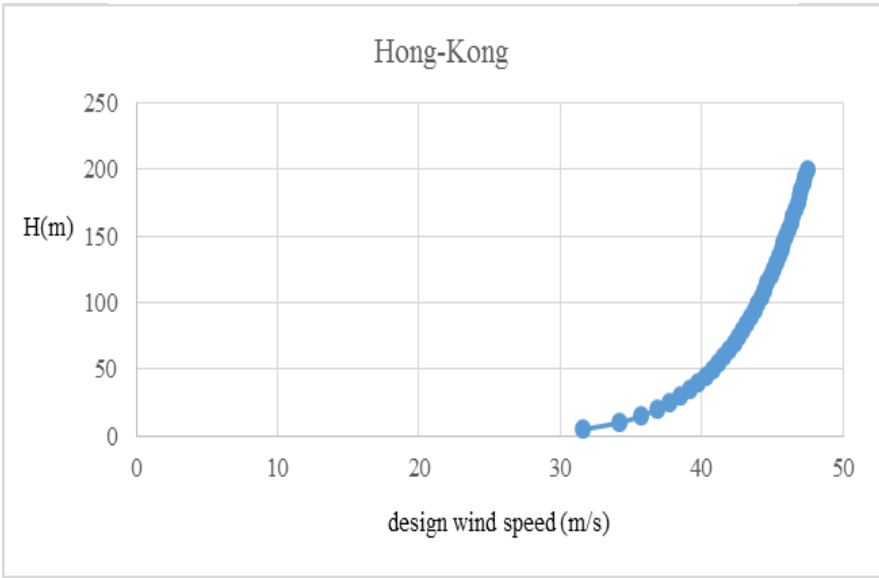


Figure 2.14 wind speed (CP-2004) [Verma et al (2016)]

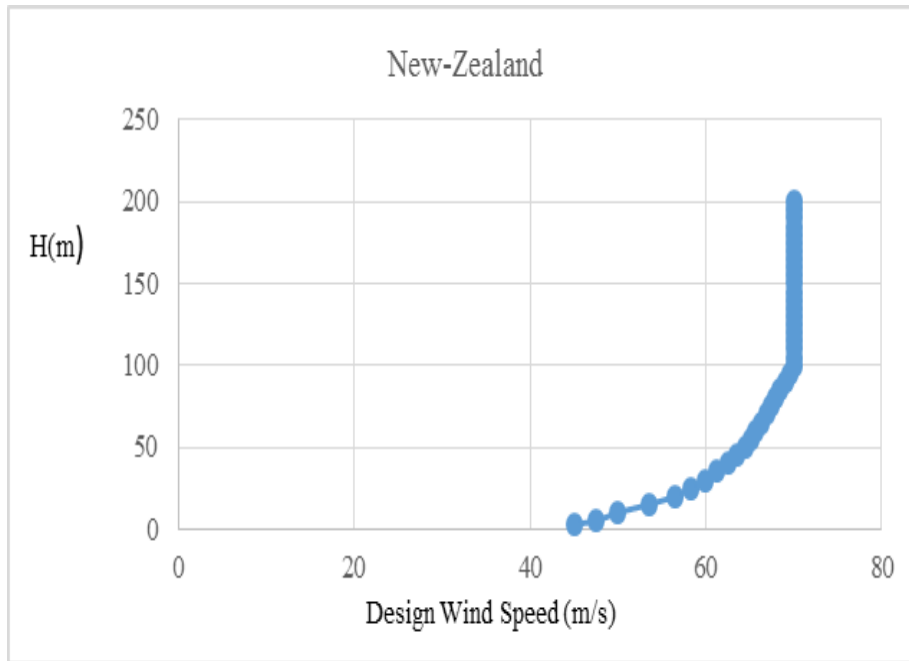


Figure 2.15 Wind Speed (AS/NZS 1170.2:2011) [Verma et al (2016)]

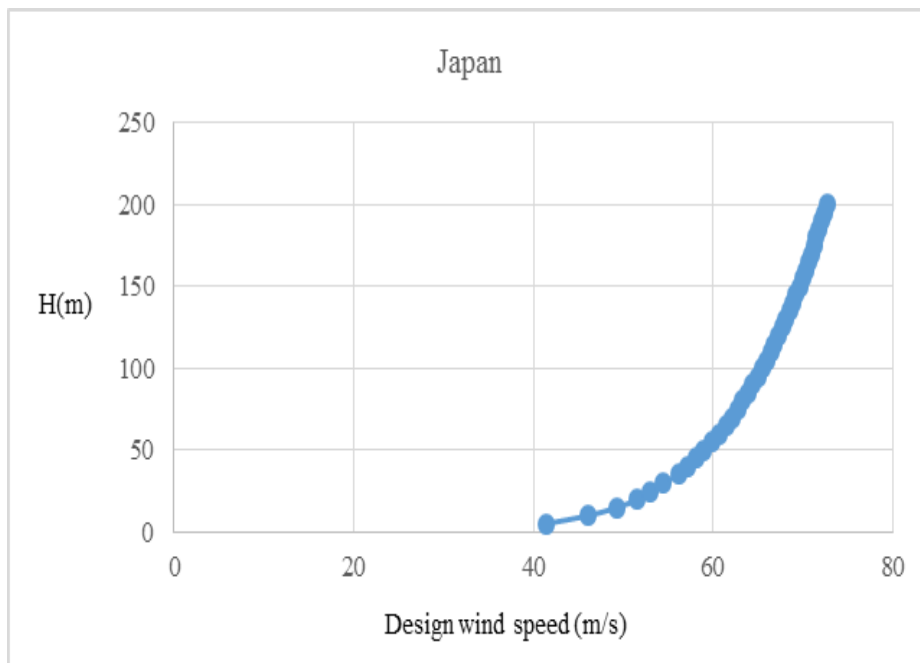


Figure 2.16 Wind speed (AIJ-RLB-2004) [Verma et al (2016)]

The New Zealand standard AS/NZS 1170.2:2011 specifies that wind velocity remains constant between 100 m and 200 m in height. This is because, in Terrain Category 2, the terrain multiplier is 1.40 at 100 m and does not increase for greater heights. This behavior is illustrated in Figures 2.13, 2.14, 2.15, and 2.16.

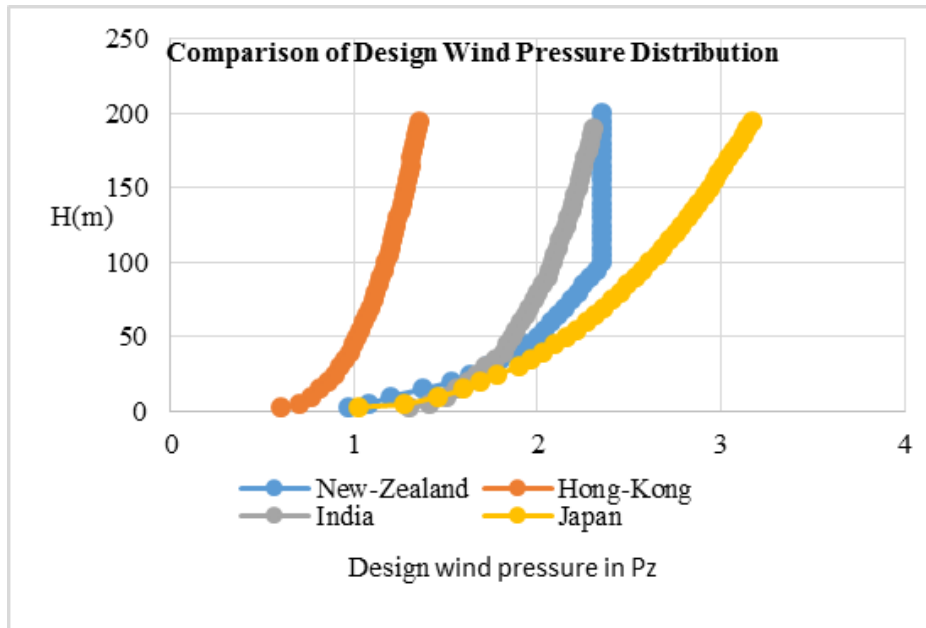


Figure 2.17 Design wind Pressure distribution along height of the building [Verma et al (2016)]

- Figure 2.17 illustrates that design wind pressure distribution values at different building heights are substantially equal for both the Indian and New Zealand codes and standards.

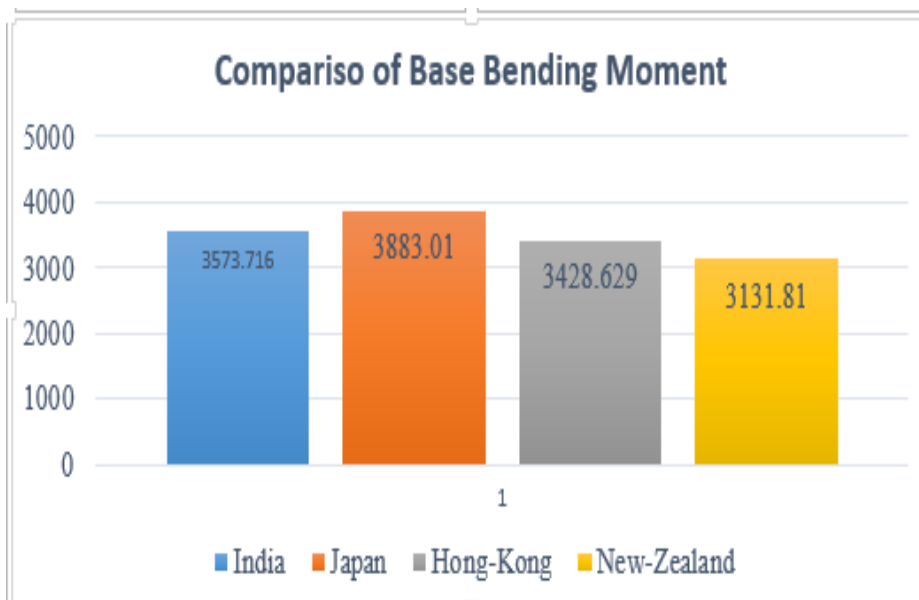


Figure 2.18 Comparison of base bending moment M [Verma et al (2016)]

- Japan has the greatest base bending moment values among wind loading codes, whereas New Zealand has the lowest. Figure 2.18 shows that India and Hong Kong had roughly equal outcomes.

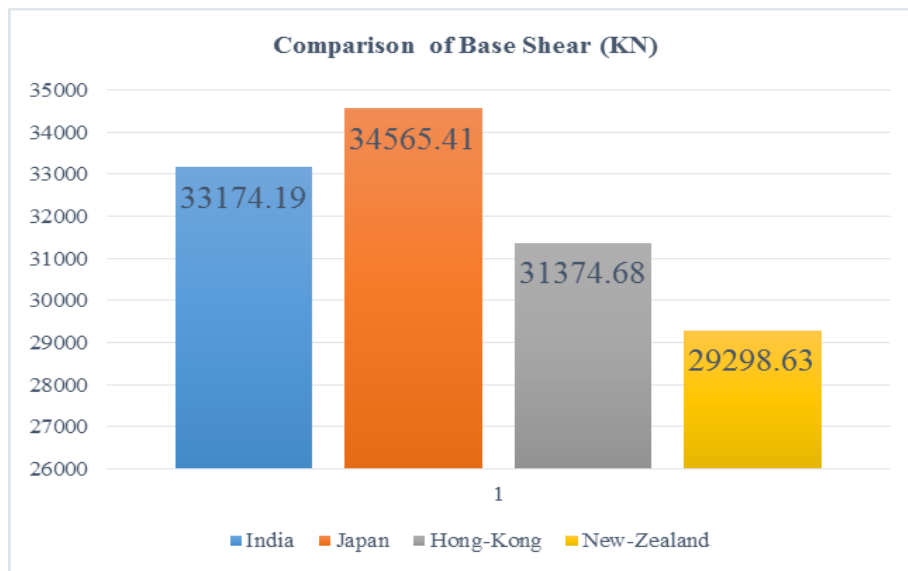


Figure 2.19 Comparison of base shear [Verma et al (2016)]

- Japan has the greatest base shear values among wind loading codes, whereas New Zealand has the lowest. Figure 2.19 shows that India and Hong Kong had roughly equal outcomes.

Ahmed et al (2017) : The Gust Factor Method (GFM) was applied to compare the latest Indian wind load code, IS 875 Part-3 (2015), with five major international wind load codes and standards. The study focused on along-wind loads and related responses in tall buildings. The international codes considered include ASCE 7-98 (USA), AS1170.2-89 (Australia), NBC 1995 (Canada), RLB-AIJ 1993 (Japan), and Eurocode 1-4 (1993). The analysis highlights the application of the Gust Factor Method for evaluating along-wind effects on tall structures.

Table 2.3 Comparison of Different Codes and Standards

	IS 875 Part-III (2015)		ASCE 7 (1998)		AS1107.2(1989)		NBC(1995)		RLB-AIJ(1993)		Eurocode (1993)	
	4(A)	2(C)	4(A)	2(C)	4(A)	2(C)	4(A)	2(C)	4(A)	2(C)	4(A)	2(C)
V_0	26	26	40	40	40	40	26	26	27	27	27	27
z	200	200	120	120	200	200	200	200	200	200	120	120
V_z	33.0	33.8	27.5	38.1	26.7	37.3	32.6	39.5	30.4	42.3	30.7	39.3
L_z	211	211	190	250	2115	2115	1220	1220	1220	258	258	197
B	0.616	0.616	0.583	0.624	0.633	0.633	0.300	0.300	0.582	0.582	0.500	0.529
E	0.054	0.063	0.140	0.144	0.094	0.117	0.170	0.191	0.080	0.100	0.106	0.109
S	0.046	0.064	0.048	0.079	0.080	0.123	0.077	0.101	0.154	0.212	0.087	0.121
R	0.248	0.403	0.525	0.889	0.596	1.138	1.031	1.524	0.967	1.655	0.726	1.039
g	3.5	3.5	3.40	3.40	3.70	3.70	3.759	3.759	3.209	3.209	3.208	3.208
v	3.63	3.63	3.79	3.79	3.63	3.63	3.768	3.768	3.325	3.325	3.225	3.225
g_R												
G	0.965	1.01	2.691	1.854	2.495	2.021	2.833	2.544	2.103	1.868	2.500	2.026

- Table 2.4 shows that ASCE 7 and Eurocode 1-4 (1993) have different definitions of wind characteristic parameters, resulting in different GLF (Gust Loading Factor) estimates.

2.3 Comparison of wind effect on buildings of different height using different codes

Kulkarni et al (2018) : In this study, both wind and earthquake effects are investigated and compared using the Indian Standard Code. This case study will focus on the city of Pune in Maharashtra. The height of a structure might vary depending on its plan. The number of stories in a building varies between 10 and 50. Wind and earthquake loads are applied to buildings in accordance with the Indian Standard Code. The analysis is carried out using ETABS software. Buildings are examined using the linear static approach. The results of wind and earthquake studies are contrasted in terms of storey shear.

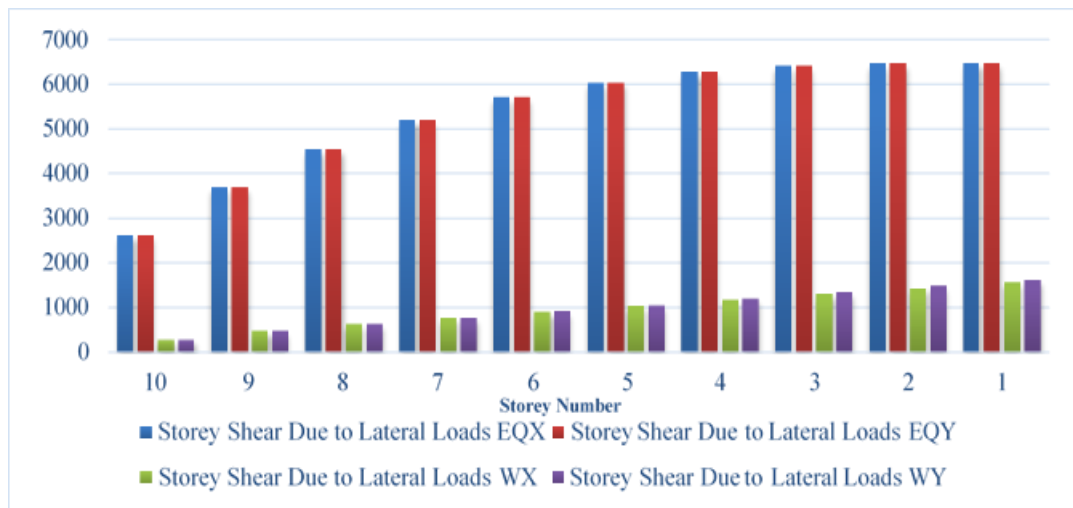


Figure 2.20 Storey Shear for 10 Storey Building [Kulkarni et al (2018)]

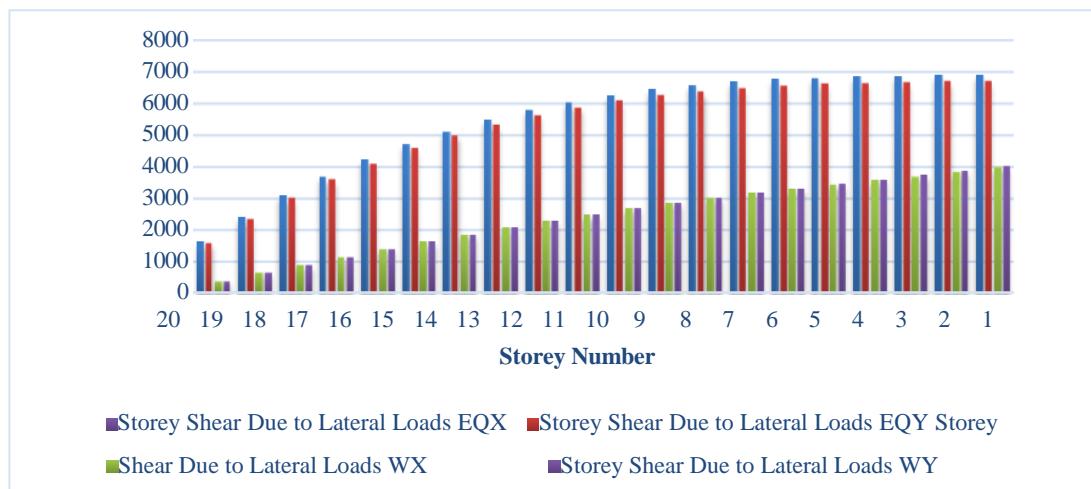


Figure 2.21 Storey Shear for 20 Storey Building [Kulkarni et al (2018)]

- Base shear due to wind in X-direction and Y-direction (WX & WY) is nearly equal at same floor as shown in fig 2.20 and 2.21.
- Base shear due to wind is continuously goes on increasing with decreasing storey number.
- Base shear due to wind is continuously goes on increasing with decreasing storey number.

Daniel C et al (2017) : carried out a study contrasting the American code (ASCE-7:2002) with the Indian code (IS 875:2009 Part 3). Wind load forces were applied to the structure using a variety of load scenarios for different story levels using SAP 2000 software. At angles between 0 and 90 degrees, the lateral loads were taken into account. In relation to wind load, the bending moment and shear force for both codes were compared. According to the study's findings, the American code offers a reduced failure risk than the Indian code, making it more effective for wind load design.

Table 2.4 Displacement due to wind loads

Load case	Story No	UX _{max} (mm)	UY _{max} (mm)	UZ _{max} (mm)	RX _{max} (rad)	RY _{max} (rad)	RZ _{max} (rad)
DL	5	-1.12E-08	-1.28E-08	-2.54E+00	1.50E-04	1.48E-04	0
DL+LL+ WL (Indian) Max	5	0.8E+08	1.72E+01	-3.24E+00	1.58E-04	1.47E-04	0
DL+LL+ WL (Indian) Min	5	-1.38E-08	-1.65E-08	-3.24E+00	-2.46E-03	1.87E-04	0
DL+LL+ WL (American) Max	5	1.72E-04	1.68E+01	-3.24E+00	1.42E-03	0.82E-03	4.12E-04
DL+LL+ WL (American) Min	5	-2.52E+00	-1.13E+01	-3.24E+00	-2.40E-03	-3.42E-04	-4.12E-04

- While the ASCE code allows the use of wind tunnel testing procedures, the IS code does not currently permit this approach. To improve accuracy and reduce potential risks, the Indian code should be updated to incorporate a wider range of methods for determining wind loads, including provisions for wind tunnel testing.
- In comparison to the Indian code, the American code results in lower structural deformation, indicating greater effectiveness in wind load design. Reduced deformation suggests a lower likelihood of structural failure.

Goyal et al (2022) : A comparative research was done to analyze a building's response to wind loads using two distinct standards: AS/NZS 1170 (Part 2):2011 and IS 875 (Part 3):2015. The investigation focused on a 150-meter-tall structure and evaluated wind effects under terrain category 3 for both codes. Key metrics such as design wind pressure, total wind load, lateral deflection, storey drift, storey shear, and storey moment were investigated and compared to better understand the differences in structural performance between codes.

Table 2.5 Comparison of design parameter as per IS 875 (Part 3)-2015 and AS/NZS (Part-2)-2011

IS 875:2015 (part 3)	AS/NZ 1170.2 2011
<p>The design wind speed (V_z) is given by $V_z = V_b K_1 K_2 K_3 K_4$ where V_z is the design wind speed at any height z in m/s V_b is the basic wind speed in m/s, K_1 is the probability factor K_2 is terrain height and structure size factor K_3 is the topography factor, and K_4 is the importance factor for the cyclonic region</p>	<p>The site wind speed is calculated as follows $V_{sit,\beta} = V_R M_d M_{z,cat} M_s M_t$ where V_{sit} is the site wind speeds, V_R is the regional 3 s gust wind speed, in m/s for annual probability M_d is the wind directional multipliers $M_{z,cat}$ is the terrain/height multiplier M_s is the shielding multiplier, and M_t is the topographic multiplier</p>
<p>The basic wind pressure is obtained at height z as $P_z = 0.6 V_z^2$ P_z is the design wind pressure in N/m^2 at height z V_z is the design wind speed at any height z in m/s $P_d = K_d K_a K_c P_z$ where P_d is the design wind pressure in N/m^2 at height z, K_d is the wind directionally factor K_a is the area averaging factor, and K_c is the combination factor</p>	<p>The wind pressures (P) are often determined as $P = 0.5 [V_{des,\theta}]^2 \rho_{air} C_{fig} C_{dyn}$ P is design wind pressure ρ_{air} is the density of air taken as 1.2 kg/m^3 $V_{des,\theta}$ is the building orthogonal design wind speeds C_{fig} is the aerodynamic shape factor, and C_{dyn} is the dynamic factor</p>
<p>The wind load (F) on building or structure is determined by $F = C_f A_e P_d$ where A_e is the effective frontal area P_z is the design wind pressure in N/m^2 C_f is the force coefficient which depends upon shape of element plan size and wind dir.</p>	<p>Design wind force derived from force coefficients $F = 0.5 [V_{des,\theta}]^2 \rho_{air} C_{fig} C_{dyn} A_z$ $F = p A_z$ where A_z is projected area with drag force coefficient (C_d)</p>

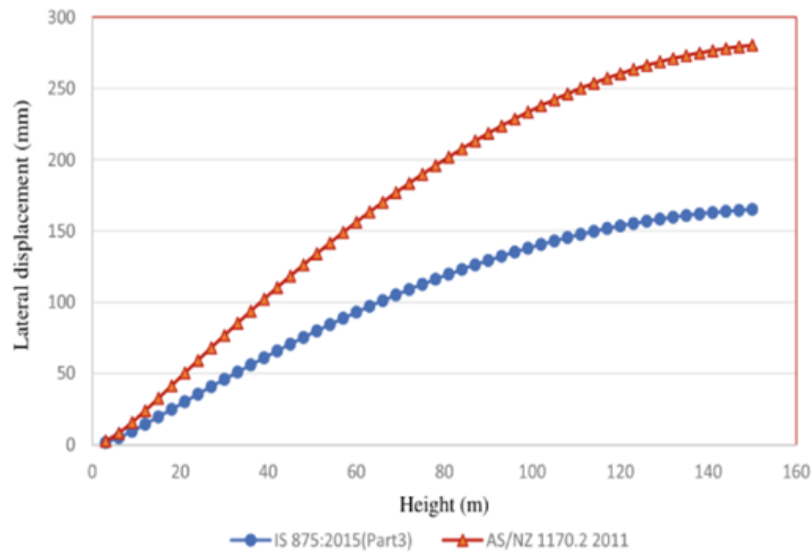


Figure 2.22 Comparison of deflection in mm [Goyal et al (2022)]

- The maximum lateral deflection at the terrace level for a tall building analyzed as per IS 875 (Part 3)-2015 is 145.36 mm, while for a building analyzed as per AS/NZS 1170.2-2011, it is 246.32 mm in the X-direction. Both values are within the permissible limit of 300 mm for a 150-meter-high building, as shown in Figure 2.22.

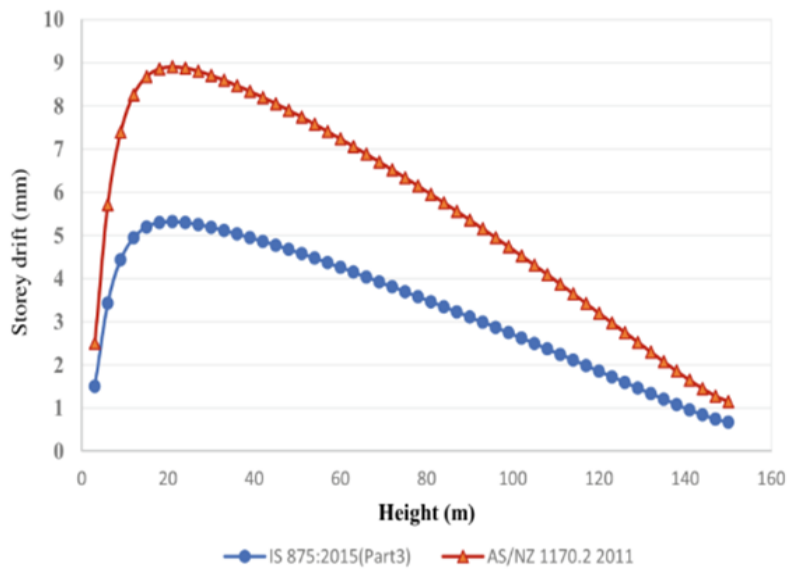


Figure 2.23 Comparison of storey drift [Goyal et al (2022)]

- The story drift limit should not exceed 0.002 times the story height or H/500 in both cases. Story drift calculated using AS/NZS 1170.2-2011 is significantly higher compared to IS 875 (Part 3)-2015 up to a height of 50 meters, as shown in Figure 2.23.

2.4 Research Gaps

- Need for comprehensive comparative studies to understand the differences in wind load predictions and their practical implications on structural design.
- Detailed investigation on how different building shapes perform under each standard, focusing on lateral displacements, storey drifts, and base shear.
- A lack of region-specific guidelines in IS 875 for extreme wind events and resilience planning for high-risk zones.
- IS 875 does not address urban canyon effects or the interference of wind loads due to neighboring buildings, which are common in densely populated urban areas. The need for studies and code updates to incorporate wind flow behavior in urban environments.
- IS 875 does not provide provisions for using advanced methods such as computational fluid dynamics (CFD) or wind tunnel testing for complex structures. Integration of CFD and experimental validation techniques is necessary to improve the accuracy of wind load predictions for high-rise buildings.
- The Indian code needs enhanced provisions for terrain categories, shielding effects, and topographic influences.

CHAPTER -3

METHODOLOGY

3.1 STEP-BY-STEP PROCEDURE OF ETABS MODELING AND ANALYSIS UNDER IS AND ASCE WIND LOAD STANDARDS

Step 1: Define the Material and Section Properties in ETABS

- 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 the Geometry and Assign the Properties

- 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

- 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

- 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: Define the Load Patterns

- Apply Live Load and Floor Finish to the appropriate areas of the structure.
- Use the 'Assign' menu to distribute these loads across the floors and slabs.

Step 6: Apply the Manually Calculated Wind Forces in ETABS

- 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 7: Analysis

- Run the analysis in ETABS by clicking 'Run Analysis'.
- Check for any errors or warnings and resolve them if necessary.

Step 8: Post-Analysis Results Computation

- Extract results for story displacement, story drift, and base shear from ETABS.
- Document these results systematically for further discussion and interpretation.

3.2 ASSUMPTIONS IN DESIGN: -

- Using partial factor of safety for loads in the clause 36.4 of IS-456-2000 $\gamma_t=1.5$.
- Partial factor of safety for material in accordance with clause 36.4.2 is IS- 456- 2000 is taken as 1.5 for concrete and 1.15 for steel.
- Using partial safety factors in the clause 36.4 of IS456- 2000 combination of load.

3.3 LOAD COMBINATION TO BE CONSIDERED IN WIND LOAD: -

An Load combination for limit state of collapse as per IS 456-2000.

1. $1.5(D+L)$
2. $1.2(D+L+W \text{ X dir.})$
3. $1.2(D+L+W \text{ Y dir.})$
4. $0.9 \text{ DL} + 1.5 \text{ W X dir}$
5. $0.9 \text{ DL} + 1.5 \text{ W Ydir}$

Total load cases = 5

3.4 A WIND CODES AND STANDARDS CONSIDERED IN THIS THESIS: -

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

3.5 WIND LOAD CALCULATION AS PER INDIAN STANDARD (875-2015 (PART 3))

Dynamic Wind Response

the essential wind speed for any site shall be obtained and modified to incorporate the subsequent effects to urge design wind speed, V_z at any height, Z for the chosen structure:

(a) Risk level, (b) Terrain roughness and height of structure, (c) Local topography, and (d) Importance factor for the cyclonic region. It is mathematically expressed as follows:

Hourly Mean Wind Speed

The hourly mean wind speed at height z , for different terrains can be obtained as

$$\bar{V}_{z,H} = \bar{K}_{2,i} V_b \quad (3.5.1)$$

Where,

$$\begin{aligned} \bar{K}_{2,i} &= \text{hourly mean wind speed factor for terrain category 1} \\ &= 0.1423 \left[\ln \left(\frac{z}{z_{0,i}} \right) \right] (z_{0,i})^{0.0706} \end{aligned} \quad (3.5.2)$$

The design hourly mean wind speed at height z can be obtained as:

$$\bar{V}_{z,d} = \bar{V}_{z,H} K_1 K_3 K_4 \quad (3.5.3)$$

$$= \bar{V}_b K_1 \bar{K}_{2,i} K_3 K_4 \quad (3.5.4)$$

Where,

K_1 = probability factor (risk coefficient)

K_3 = topography factor

K_4 = importance factor for the cyclonic region

The design peak along wind base bending moment, (M_a) shall be obtained by,

$$M_a = \sum F_z Z \quad (3.5.5)$$

$$F_z = C_{f,z} A_z \bar{P}_d G \quad (3.5.6)$$

Where,

F_z = design peak along wind load on the building/structure at any height z

A_z = the effective frontal area of the building/structure at any height z , in m^2

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

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

$\bar{V}_{z,d}$ = design hourly mean wind speed at height z, in m/s

$C_{f,z}$ = the drag force coefficient of the building/ structure corresponding to the area Az

G = Gust Factor and is given by,

$$= 1 + r \sqrt{\left[g_v^2 B_s (1 + \Phi)^2 + \frac{H_s g_R^2 S E}{\beta} \right]} \quad (3.5.7)$$

Where,

r = roughness factor which is twice the longitudinal turbulence intensity, $I_{h,i}$

g_v = peak factor for upwind velocity fluctuation,

= 3.0 for category 1 and 2 terrains, and

= 4.0 for category 3 and 4 terrains,

B_s = Background factor indicating the measure of slowly varying component fluctuating wind load caused by the lower frequency wind speed variations

$$= \frac{1}{\left[1 + \frac{\sqrt{0.26(h-s)^2 + 0.46b_s^2}}{L_h} \right]} \quad (3.5.8)$$

Where,

bsh = average breadth of the building/structure between heights s and h

L_h = measure of effective turbulence length scale at the height, h, in m

$$= 85 \frac{h^{0.25}}{10} \quad \text{for terrain category 1 to 3.} \quad (3.5.9)$$

$$= 70 \frac{h^{0.25}}{10} \quad \text{for terrain category 4} \quad (3.5.10)$$

Φ = factor to account for the second order turbulence intensity

$$= \frac{g_v I_{h,j} \sqrt{B_s}}{2} \quad (3.5.11)$$

$I_{h,i}$ = turbulence intensity at height h in terrain category i

Hs = height factor for resonance response

$$= 1 + \left(\frac{s}{h}\right)^2 \quad (3.5.12)$$

S = size reduction factor given by:

$$= \frac{1}{\left[1 + \frac{3.5f_a h}{\bar{V}_{h,d}}\right] \left[1 + \frac{4f_a b_{0h}}{\bar{V}_{h,d}}\right]} \quad (3.5.13)$$

Where,

b_{0h} = average breadth of the building/structure between 0 and h.

E = spectrum of turbulence in the approaching wind stream

$$= \frac{\pi N}{(1 + 70.8N^2)^{5/6}} \quad (3.5.14)$$

Where,

N = effective reduced frequency

$$= \frac{f_a L h}{\bar{V}_{h,d}} \quad (3.5.15)$$

f_a = first mode natural frequency of the building/structure in along wind direction, in Hz

$\bar{V}_{h,d}$ = design hourly mean wind speed at height, h in m/s

β = damping coefficient of the building/structure

g_R = peak factor for resonant response

$$= \sqrt{[2 \ln(3600 f_a)]} \quad (3.5.16)$$

3.6 WIND LOAD CALCULATION AS PER AMERICAN STANDARD ASCE-7:22:-

ASCE 7:22 defines the basic wind speeds based on Risk Categories and location which can define Velocity pressure. the Velocity pressure is defined as:

$$q_z = 0.00256 K_z K_{zt} K_d V^2 \quad (\text{lb/ft}^2) \quad (3.6.1)$$

$$q_z = 0.613 K_z K_{zt} K_d V^2 \quad (\text{N/m}^2) \quad (3.6.2)$$

Where,

K_z = Velocity pressure exposure coefficient

K_{zt} = Topographic factor

K_e = Ground elevation factor

V = Basic wind speed

q_z = Velocity pressure at height z .

For enclosed, partially enclosed, and partially open rigid and flexible buildings, the design wind pressures acting on the Main Wind-Force Resisting System (MWFRS) for buildings of all heights, expressed in lb/ft² (N/m²), shall be calculated using the following equation:

$$P = q G_f C_p - q_i (G C_{pi}) \quad (3.6.3)$$

Where,

G = Gust-effect factor (see Section 26.11); For flexible buildings, G_f , determined in accordance with Section 26.11.5, shall be substituted for G ;

C_p = External pressure coefficient

$(G C_{pi})$ = Internal pressure coefficient from Table 26.13-1.

For flexible buildings or structures, as defined in Section 26.2, the gust effect factor must be obtained through analytical calculations.

$$G_f = 0.925 \left(\frac{1 + 1.7 I_z \sqrt{g_Q^2 Q^2 + g_R^2 R^2}}{1 + 1.7 g_v I_z} \right) \quad (3.6.4)$$

The background peak factors g_Q and g_v are taken as 3.4, while the resonant peak factor g_R is determined using following expression:

$$g_R = \sqrt{2 \ln(3600h_1)} + \frac{0.577}{\sqrt{2 \ln(3600h_1)}} \quad (3.6.5)$$

The background response factor, Q , and the intensity of turbulence at height z , I_Z , are defined as

$$Q = \sqrt{\frac{1}{1 + 0.63 \left(\frac{B+h}{L_Z}\right)^{0.63}}} \quad (3.6.6)$$

$$L_Z = l \left(\frac{z}{33}\right)^\varepsilon \quad (3.6.7)$$

$$I_Z = c \left(\frac{33}{z}\right)^{1/6} \quad (3.6.8)$$

z is the equivalent height of the building or structure defined as $0.6h$, but not less than z_{\min} , for all building or structure heights h . z_{\min} and c are listed for each exposure in Table 26.11-1.

The resonant response factor is

$$R = \sqrt{\frac{1}{\beta}} R_h R_B (0.53 + 0.47 R_L) \quad (3.6.9)$$

where n_1 represents the fundamental natural frequency, and β denotes the damping ratio as a fraction of critical (for example, use 0.02 for a 2% damping ratio in the equation).

The power spectral density of turbulence at the equivalent height z of the structure, evaluated at its natural reduced frequency N_l , is expressed as:

$$R_n = \frac{7.47 N_1}{(1 + 10.3 N_1)^{5/3}} \quad (3.6.10)$$

$$N_1 = \frac{n_1 L_z}{V_z} \quad (3.6.11)$$

$$R_l = \frac{1}{\eta} - \frac{1}{2\eta^2} (1 - e^{-2\eta}) \text{ for } \eta > 0 \quad (3.6.12)$$

$$R_l = 1 \text{ for } \eta = 0$$

The size effect factors corresponding to the building's height, breadth, and depth are:

$$R_h = \frac{1}{\eta h} - \frac{1}{2\eta^2 h} (1 - e^{-2\eta h}) \quad (3.6.13)$$

$$R_B = \frac{1}{\eta B} - \frac{1}{2\eta^2 B} (1 - e^{-2\eta B}) \quad (3.6.14)$$

$$R_L = \frac{1}{\eta L} - \frac{1}{2\eta^2 L} (1 - e^{-2\eta L}) \quad (3.6.15)$$

Where the turbulent coherence (or correlation) factors in the respective direction, evaluated at the natural reduced frequency, are defined as:

$$\eta_h = 4.6n_1 h / \bar{V}_z \quad (3.6.16)$$

$$\eta_B = 4.6n_1 B / \bar{V}_z \quad (3.6.17)$$

$$\eta_L = 4.6n_1 L / \bar{V}_z$$

The mean hourly wind speed (in ft/s or m/s) at the equivalent structure height, z , is

$$\bar{V}_z = \bar{b} \left(\frac{z}{33} \right)^{\bar{\alpha}} \left(\frac{88}{60} \right) V \quad (3.6.18)$$

$$\bar{V}_z = \bar{b} \left(\frac{z}{10} \right)^{\bar{\alpha}} V \quad (\text{In SI}) \quad (3.6.19)$$

where \bar{b} and $\bar{\alpha}$ are constants and V is the basic wind speed, mi/h (m/s).

CHAPTER - 4

DETAILS OF THE MODELS STUDIED

Five sample building models are used to analyze story displacement and foundation shear between various building shapes. ETABS, a finite element analysis software, is used to construct and analyze 3D models. The dynamic wind load analysis, as per IS:875 part 3 and ASCE 7-22, is applied to all building types in the plan. The models' forms include square, rectangular, diamond, hexagonal, and octagonal.

4.1 MODELLING AND ANALYSIS OF MODEL 1(151.2m):-

A study was carried out on a high-rise residential building with an RCC frame structure, assumed to be located in Delhi. The building has no vertical irregularities, and the surrounding topography is flat in all directions. It features a rectangular plan measuring 35 m × 35 m, with an overall height of 151.2 m above ground level and a flat roof. Wind is considered to act perpendicular to the 35 m-wide face. The basic wind speed is taken as 50 m/s, and both wind codes categorize the terrain as Category 3.

Table 4.1.1 Design parameters of 151.2m height building

No. of storey	G+41
Column	0.6 m x0.6 m
Beam	0.350 m x0.600 m
Slabs	0.15 m
Live load on slab	3 KN/m ²
Floor finish	1.2 KN/m ²
Grade of concrete in column	M 40
Grade of concrete in beam	M 30
Grade of steel	Fe 500
Total height	151.2m
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 151.2 M HEIGHT BUILDING:

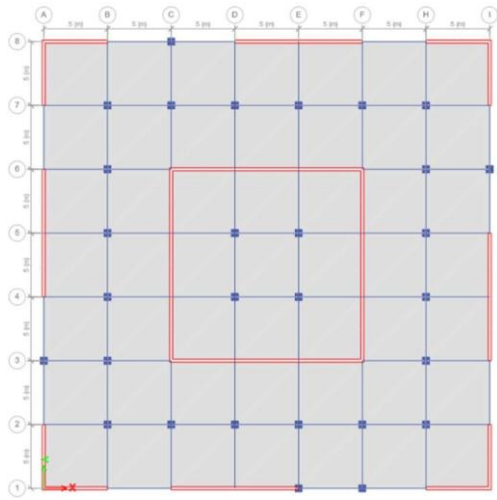


Figure 4.1.2 Plan of square



Figure 4.1.1 3D View

- Figure 4.1.1 shows the plan of a square building with a cross-sectional area of $35 \text{ m} \times 35 \text{ m}$, consisting of beams measuring $0.35 \text{ m} \times 0.6 \text{ m}$, columns measuring $0.6 \text{ m} \times 0.6 \text{ m}$ and shear wall thickness of 0.3 m .
- Figure 4.1.2 illustrates the 3D view of a square-shaped building with a total height of 151.2 meters, comprising a ground floor and 41 additional storeys (G+41).

4.2 MODELLING AND ANALYSIS OF MODEL (80m):-

Another research is carried out to study the effect of various shapes of tall structures subjected to wind excitation. Four different shaped building models of 80m has been considered. These models are same characteristics as same height, and considered in same locality.

Table 4.2.1 Design parameters of 80m height building

No. of storey	G+21
Column	0.6 m x 0.6m
Beam	0.350 m x0.600 m
Slabs	0.15 m
Live load on slab	3 KN/m ²
Floor finish	1.2 KN/m ²
Grade of concrete in column	M 40
Grade of concrete in beam	M 40
Grade of steel	Fe 500
Total height	80 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	0.230 m
Thickness of internal wall	0.115 m

PLAN OF THE DIFFERENT SHAPES OF BUILDINGS: FIGURE OF 80M HEIGHT BUILDING:

SQUARE SHAPE:

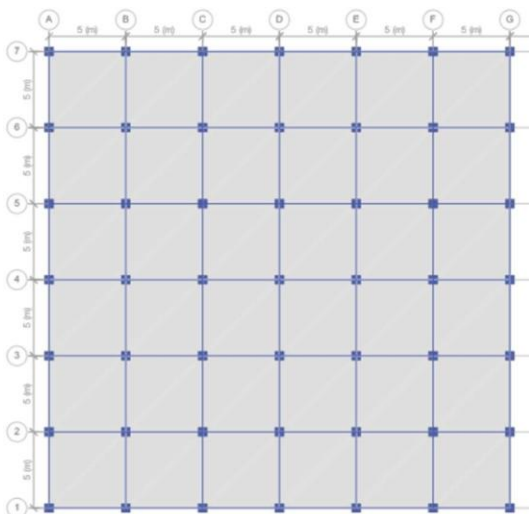


Figure 4.2.2 Plan of Square Building

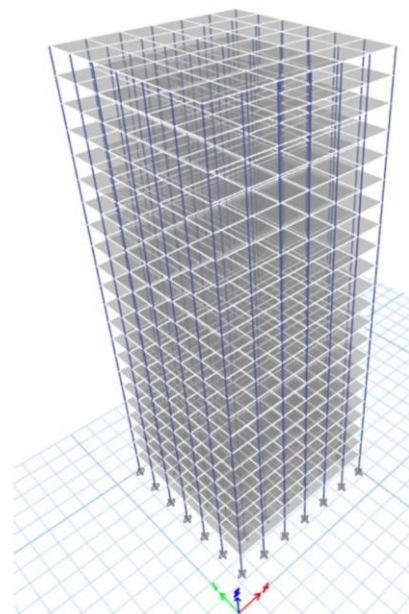


Figure 4.2.1 3D View

- Figure 4.2.1 shows the plan of a square building with a cross-sectional area of $30\text{ m} \times 30\text{ m}$, consisting of beams measuring $0.35\text{ m} \times 0.6\text{ m}$, and columns measuring $0.6\text{ m} \times 0.6\text{ m}$.
- Figure 4.2.2 illustrates the 3D view of a square-shaped building with a total height of 80 meters, comprising a ground floor and 22 additional storeys (G+22).

RECTANGULAR SHAPE:

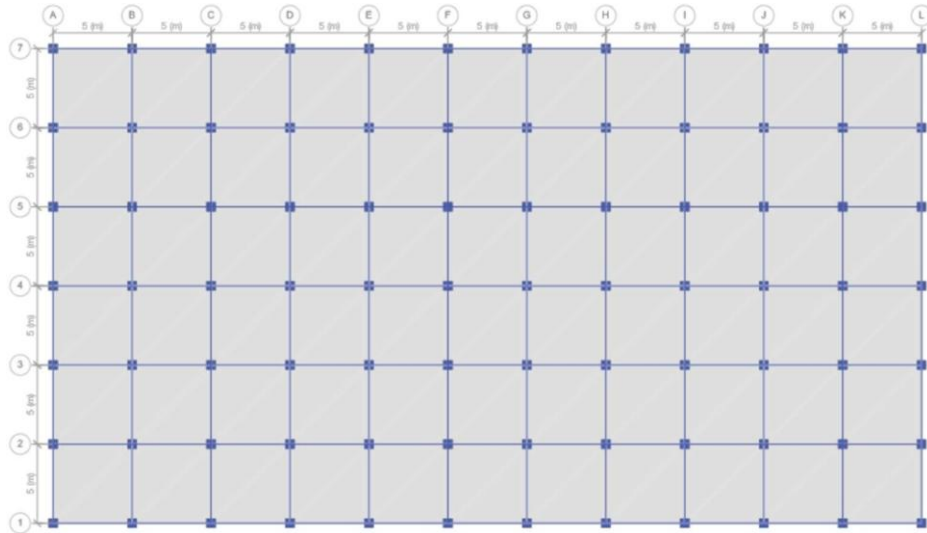


Figure 4.2.3 Plan of Rectangular Building

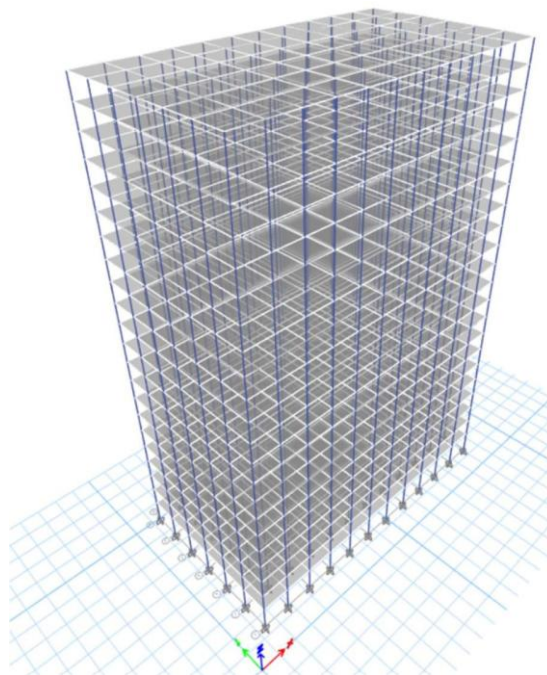


Figure 4.2.4 3D View

- Figure 4.2.3 shows the plan of a rectangular shaped building with a cross-sectional area of $55 \text{ m} \times 30 \text{ m}$, consisting of beams measuring $0.35 \text{ m} \times 0.6 \text{ m}$, and columns measuring $0.6 \text{ m} \times 0.6 \text{ m}$.
- Figure 4.2.4 illustrates the 3D view of a rectangular -shaped building with a total height of 80 meters, comprising a ground floor and 22 additional storeys (G+22).

OCTAGONAL SHAPE:

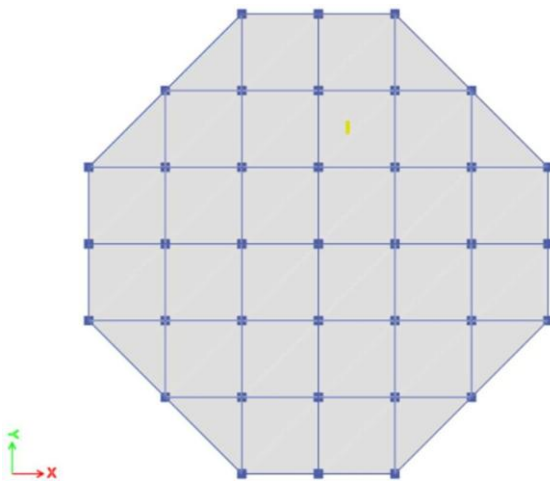


Figure 4.2.5 Plan of Octagonal Building

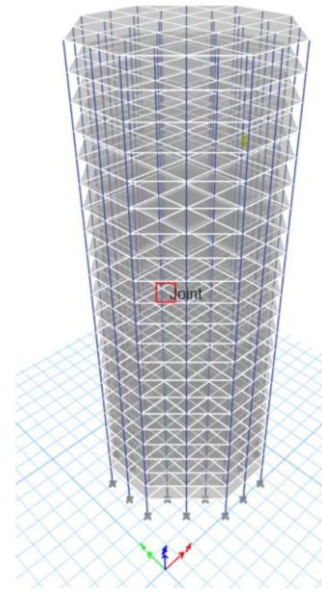


Figure 4.2.6 3D View

- Figure 4.2.5 shows the plan of a octagonal shaped building with a cross-sectional area of $30 \text{ m} \times 30 \text{ m}$, consisting of beams measuring $0.35 \text{ m} \times 0.6 \text{ m}$, and columns measuring $0.6 \text{ m} \times 0.6 \text{ m}$.
- Figure 4.2.6 illustrates the 3D view of a ocatgonal-shaped building with a total height of 80 meters, comprising a ground floor and 22 additional storeys (G+22).

DIAMOND SHAPE:

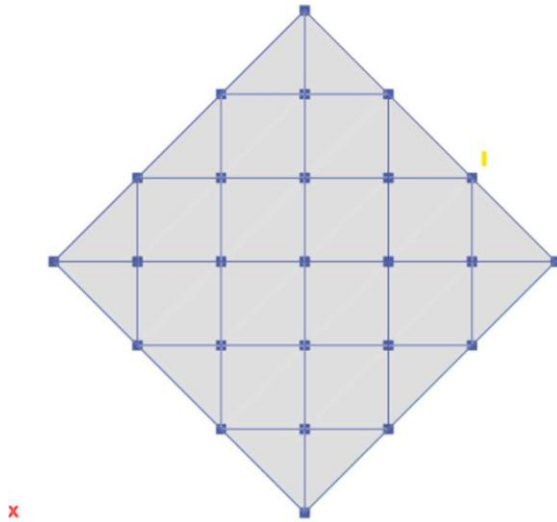


Figure 4.2.5 Plan of Diamond Building

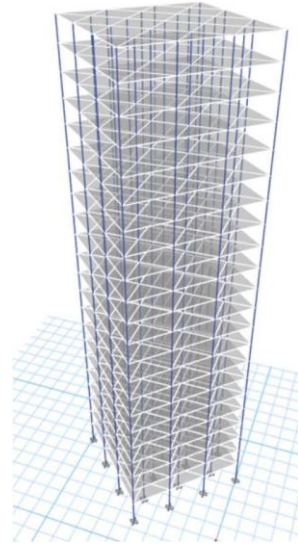


Figure 4.2.6 3D View

- Figure 4.2.7 shows the plan of a diamond shaped building with a cross-sectional area of $30 \text{ m} \times 30 \text{ m}$, consisting of beams measuring $0.35 \text{ m} \times 0.6 \text{ m}$, and columns measuring $0.6 \text{ m} \times 0.6 \text{ m}$.
- Figure 4.2.8 illustrates the 3D view of a diamond-shaped building with a total height of 80 meters, comprising a ground floor and 22 additional storeys (G+22).

CHAPTER – 5

RESULTS AND DISCUSSION

5.1 Dynamic wind load on 80 m Height of building calculated by IS 875 part3 (2015).

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

Table 5.1.1 Comparison of Lateral Displacements in mm at different height.

Height (m)	Rectangular (mm)	Square (mm)	Diamond (mm)	Octagonal (mm)
80	140.022	119.262	125.692	100.081
76.4	138.39	118.072	124.079	99.143
72.8	136.223	116.509	122.046	97.824
69.2	133.439	114.503	119.542	96.07
65.6	130.027	112.034	116.565	93.872
62	126.001	109.094	113.117	91.237
58.4	121.384	105.685	109.203	88.177
54.8	116.202	101.807	104.833	84.706
51.2	110.484	97.467	100.019	80.839
47.6	104.262	92.668	94.770	76.592
44	97.566	87.416	89.098	71.981
40.4	90.429	81.719	83.018	67.024
36.8	82.885	75.584	76.547	61.738
33.2	74.969	69.02	69.701	56.143
29.6	66.719	62.039	62.502	50.256
26	58.171	54.653	54.970	44.1
22.4	49.37	46.88	47.129	37.698
18.8	40.367	38.749	39.013	31.078
15.2	31.234	30.311	30.662	24.282
11.6	22.103	21.681	22.153	17.392
8	13.256	13.137	13.664	10.598
4.4	5.383	5.383	5.722	4.402
0	0	0	0	0

- Table 5.1.1 presents a comparison of lateral displacements (in mm) at different heights for various building shapes, as calculated using IS 875 (2015).
- The maximum storey displacement for the rectangular shape is 140.022 mm, which is the highest among the four shapes. Compared to this, the square shape shows a 14.83% reduction, the diamond shape shows a 10.23% reduction, and the octagonal shape exhibits the greatest reduction in displacement at 28.52%. This indicates that the octagonal shape is the most effective in minimizing wind-induced displacement, while the rectangular shape is the least efficient.

5.1.2 Effect of the Shape of The Building on Storey Drifts:

Table 5.1.2 Comparison of Storey Drifts at Different Heights in m.

Height (m)	Rectangular	Square	Diamond	Octagonal
80	0.000462	0.000425	0.000442	0.000331
76.4	0.00068	0.000604	0.000646	0.000455
72.8	0.000949	0.000824	0.00908	0.000596
69.2	0.001233	0.001055	0.001215	0.000737
65.6	0.001522	0.001289	0.00150	0.000878
62	0.001814	0.001523	0.001781	0.001017
58.4	0.002106	0.001757	0.002008	0.001153
54.8	0.002398	0.001989	0.00223	0.001287
51.2	0.00269	0.002218	0.002446	0.001417
47.6	0.002981	0.002445	0.002657	0.001543
44	0.00327	0.002668	0.002861	0.001666
40.4	0.003556	0.002888	0.003057	0.001784
36.8	0.003839	0.003103	0.003245	0.001897
33.2	0.004118	0.003313	0.003423	0.002005
29.6	0.004391	0.003516	0.00359	0.002106
26	0.004656	0.003711	0.003744	0.002201
22.4	0.004907	0.003895	0.003885	0.002288
18.8	0.005135	0.004061	0.00401	0.002365
15.2	0.00531	0.004192	0.004114	0.002432
11.6	0.005347	0.00424	0.004183	0.002479
8	0.004997	0.004085	0.004162	0.002475
4.4	0.003017	0.003005	0.003207	0.001941
0	0	0	0	0

- Table 5.1.2 presents a comparison of Storey Drift at different heights for various building shapes, as calculated using IS 875 (2015).
- The maximum storey drift in the rectangular building is 0.005347, which is the highest among all the shapes. In comparison, the square shape shows a 20.70% reduction, the diamond shape shows a 21.76% reduction, and the octagonal shape exhibits the greatest improvement with a 53.63% reduction in maximum storey drift. This demonstrates that the octagonal shape is the most effective in minimizing lateral Storey Drift under wind loads.

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

Table 5.1.3 Comparison of Storey Base Shear at Different height in KN

Height (m)	Rectangular (KN)	Square (KN)	Diamond (KN)	Octagonal (KN)
80	-133	-114	-135	-83
76.4	-396	-338	-401	-255
72.8	-656	-558	-662	-413
69.2	-913	-774	-918	-580
65.6	-1166	-985	-1169	-742
62	-1416	-1192	-1415	-896
58.4	-1662	-1394	-1655	-1059
54.8	-1904	-1591	-1889	-1216
51.2	-2142	-1782	-2116	-1371
47.6	-2375	-1967	-2337	-1526
44	-2603	-2146	-2551	-1679
40.4	-2826	-2319	-2757	-1839
36.8	-3043	-2485	-2955	-1989
33.2	-3254	-2644	-3145	-2137
29.6	-3458	-2796	-3326	-2262
26	-3654	-2939	-3497	-2411
22.4	-3841	-3073	-3657	-2546
18.8	-4018	-3197	-3805	-2695
15.2	-4182	-3309	-3939	-2829
11.6	-4331	-3407	-4056	-2960
8	-4459	-3488	-4153	-3099
4.4	-4576	-3516	-4187	-3211
0	0	0	0	0

- Table 5.1.3 presents a comparison of Storey Base Shear at different heights for various building shapes, as calculated using IS 875 (2015).
- The greatest base shear encountered by the rectangular building is 4576 kN, the highest of the shapes evaluated. The square shape shows a 23.21% reduction, the diamond shape shows an 8.51% reduction, and the octagonal shape displays the highest reduction in base shear at 29.85%. This shows that the octagonal structure design is the most effective in reducing wind-induced base shear.

5.2 Dynamic wind load on 80 m Height of building calculated by ASCE 7-22.

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

Table 5.2.1 Comparison of Lateral Displacements in mm at different height.

Height (m)	Rectangular (mm)	Square (mm)	Diamond (mm)	Octagonal (mm)
80	111.448	94.925	100.043	79.658
76.4	110.149	93.978	98.759	78.911
72.8	108.502	92.800	97.210	77.917
69.2	106.365	91.271	95.288	76.578
65.6	103.726	89.372	92.987	74.884
62	100.598	87.099	90.311	72.842
58.4	96.997	84.452	87.263	70.462
54.8	92.940	81.426	83.847	67.749
51.2	88.451	78.030	80.073	64.718
47.6	83.557	74.266	75.950	61.382
44	78.274	70.131	71.481	57.748
40.4	72.635	65.639	66.683	53.836
36.8	66.660	60.788	61.563	49.653
33.2	60.374	55.583	56.132	45.213
29.6	53.806	50.032	50.406	40.530
26	46.991	44.149	44.405	35.624
22.4	39.954	37.939	38.141	30.508
18.8	32.735	31.423	31.637	25.202
15.2	25.386	24.636	24.922	19.736
11.6	18.013	17.669	18.054	14.174
8	10.836	10.739	11.170	8.664
4.4	4.415	4.316	4.693	3.610
0	0	0	0	0

- Table 5.2.1 presents a comparison of lateral displacements (in mm) at different heights for various building shapes, as calculated using ASCE 7-22.
- As per ASCE 7, the rectangular building shows the highest storey displacement (111.448 mm), while the square, diamond, and octagonal shapes reduce it by 14.82%, 10.23%, and 28.52% respectively, making the octagonal shape the most effective in minimizing wind-induced displacement.

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

Table 5.2.2 Comparison of Storey Drifts at Different Heights in m

Height (m)	Rectangular	Square	Diamond	Octagonal
80	0.001194	0.000274	0.000416	0.000214
76.4	0.001223	0.000387	0.000542	0.000290
72.8	0.001289	0.000526	0.000688	0.000378
69.2	0.001363	0.000674	0.000837	0.000468
65.6	0.001438	0.000825	0.000987	0.000558
62	0.001515	0.000978	0.001136	0.000648
58.4	0.001592	0.001132	0.001286	0.000738
54.8	0.001671	0.001287	0.001434	0.000827
51.2	0.001750	0.001444	0.001582	0.000916
47.6	0.001830	0.001601	0.001729	0.001004
44	0.001911	0.001758	0.001874	0.001092
40.4	0.001992	0.001916	0.002017	0.001178
36.8	0.002074	0.002074	0.002158	0.001263
33.2	0.002156	0.002232	0.002296	0.001347
29.6	0.002239	0.002389	0.002430	0.001429
26	0.002321	0.002545	0.002561	0.001509
22.4	0.002404	0.002697	0.002688	0.001587
18.8	0.002484	0.002843	0.002809	0.001662
15.2	0.002560	0.002971	0.002922	0.001733
11.6	0.002620	0.003046	0.003019	0.001796
8	0.002650	0.002980	0.003063	0.001829
4.4	0.002480	0.002231	0.002418	0.001469
0	0	0	0	0

- Table 5.2.2 presents a comparison of Storey Drift at different heights for various building shapes, as calculated using ASCE 7-22.
- As per ASCE 7-22, the maximum storey drift occurs in the rectangular building with a value of 0.002650, while the square, diamond, and octagonal shapes reduce it by 11.32%, 6.77%, and 30.94% respectively, making the octagonal shape the most effective in controlling wind-induced drift.

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

Table 5.2.3 Comparison of Base Shear at Different Heights in KN

Height (m)	Rectangular (KN)	Square (KN)	Diamond (KN)	Octagonal (KN)
80	-86	-70	-82	-62
76.4	-257	-211	-246	-145
72.8	-426	-350	-409	-251
69.2	-595	-487	-570	-361
65.6	-762	-624	-731	-473
62	-929	-759	-890	-691
58.4	-1094	-893	-1049	-705
54.8	-1258	-1025	-1206	-906
51.2	-1420	-1156	-1361	-1070
47.6	-1581	-1285	-1516	-1116
44	-1740	-1413	-1668	-1378
40.4	-1898	-1539	-1819	-1410
36.8	-2054	-1663	-1969	-1558
33.2	-2208	-1785	-2116	-1617
29.6	-2359	-1905	-2262	-1861
26	-2509	-2022	-2405	-1905
22.4	-2656	-2137	-2546	-2056
18.8	-2800	-2249	-2684	-2175
15.2	-2940	-2357	-2819	-2200
11.6	-3077	-2461	-2950	-2340
8	-3208	-2560	-3076	-2464
4.4	-3347	-2665	-3209	-2609
0	0	0	0	0

- Table 5.2.3 presents a comparison of Storey Base Shear at different heights for various building shapes, as calculated using ASCE 7-22.
- The rectangular building has the highest base shear of 3347 kN, whereas the square, diamond, and octagonal shapes reduce it by 20.38%, 4.12%, and 22.05%, respectively, with the octagonal shape being the most effective in minimizing wind-induced base shear according to ASCE 7-22.

5.3 COMPARISON OF RESULTS ON 80M BUILDING BY IS 875 PART-3 AND ASCE 7-22.

5.3.1 For Rectangular Building

5.3.1.1 Comparison of Lateral Displacements in Rectangular Shape Building

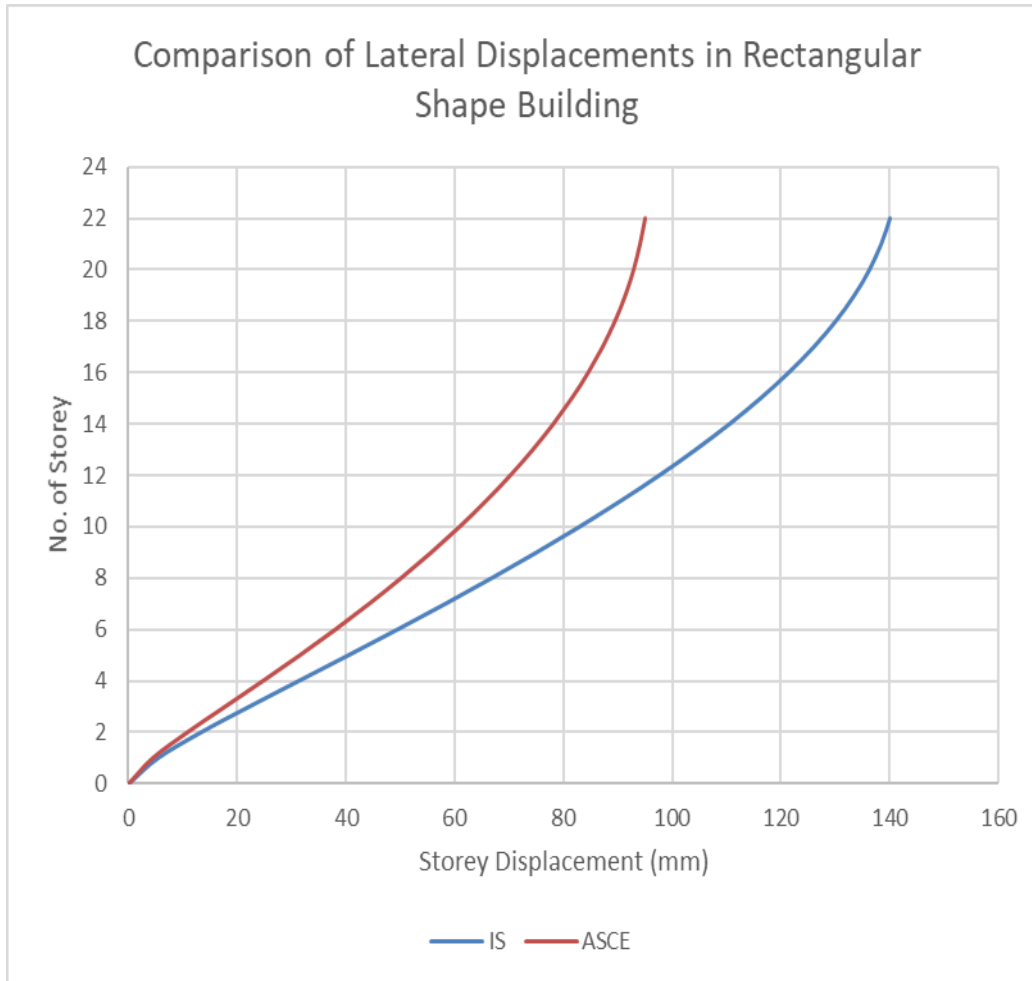


Figure 5.3.1.1 Comparison of Lateral Displacements in Rectangular Shape Building in mm at different Storey.

- Figure 5.3.1.1 illustrates the comparison of lateral displacement (in mm) between IS and ASCE standards for a rectangular-shaped building at various storey levels.
- The maximum lateral displacement of the rectangular building, according to ASCE 7-22, is 111.448 mm, which is 20.40% less than the 140.022 mm computed using the IS -875 code, suggesting that ASCE 7-22 gives a more cautious estimate of Lateral displacement.

5.3.1.2 Comparison of Storey Drift Ratio in Rectangular Shape Building

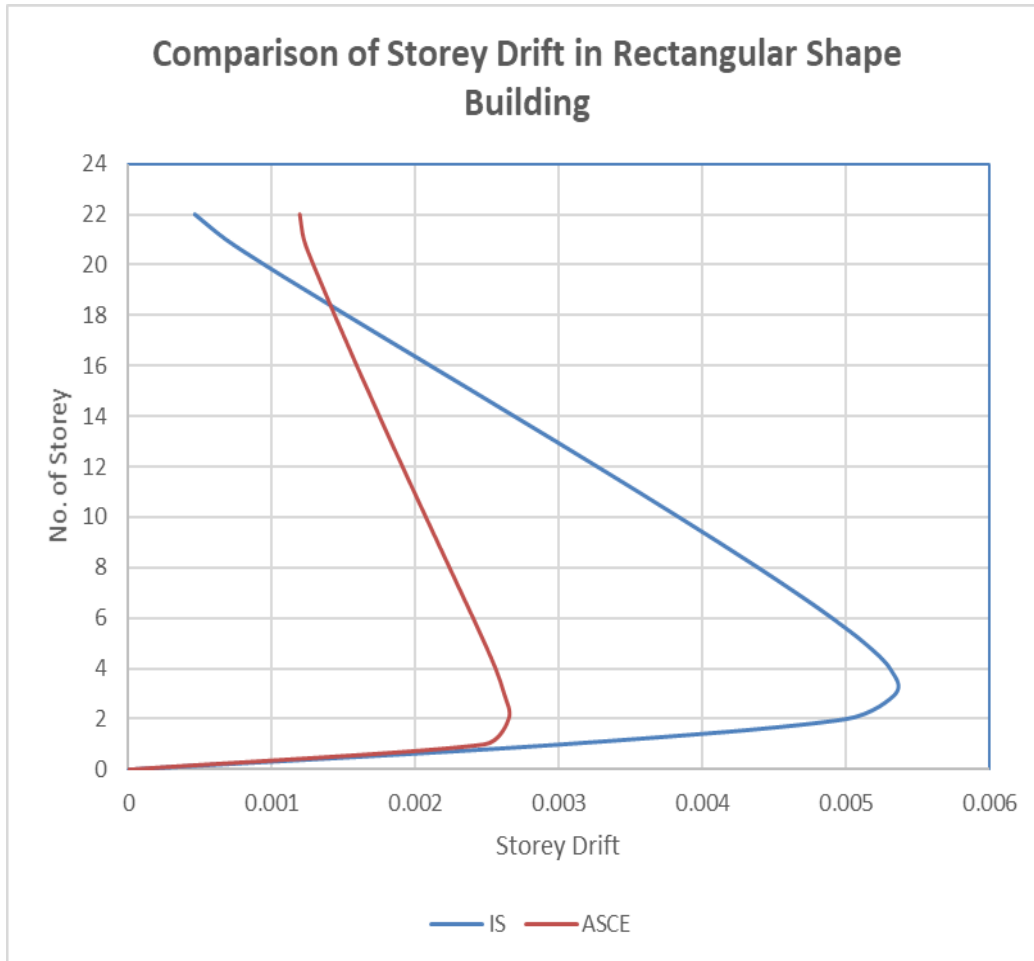


Figure 5.3.1.2 Comparison of storey drift ratio in Rectangular Shape Building at different height.

- Figure 5.3.1.2 illustrates the comparison of storey drift between IS and ASCE standards for a rectangular-shaped building at various storey levels.
- The maximum storey drift of the rectangular building, as per ASCE 7-22, is 0.002650, which is 50.44% lower than the 0.005347 value obtained using the IS-875 code, indicating that ASCE 7-22 predicts significantly lower storey drift for the same building configuration.

5.3.1.3 Comparison of Storey Base Shear in Rectangular Building

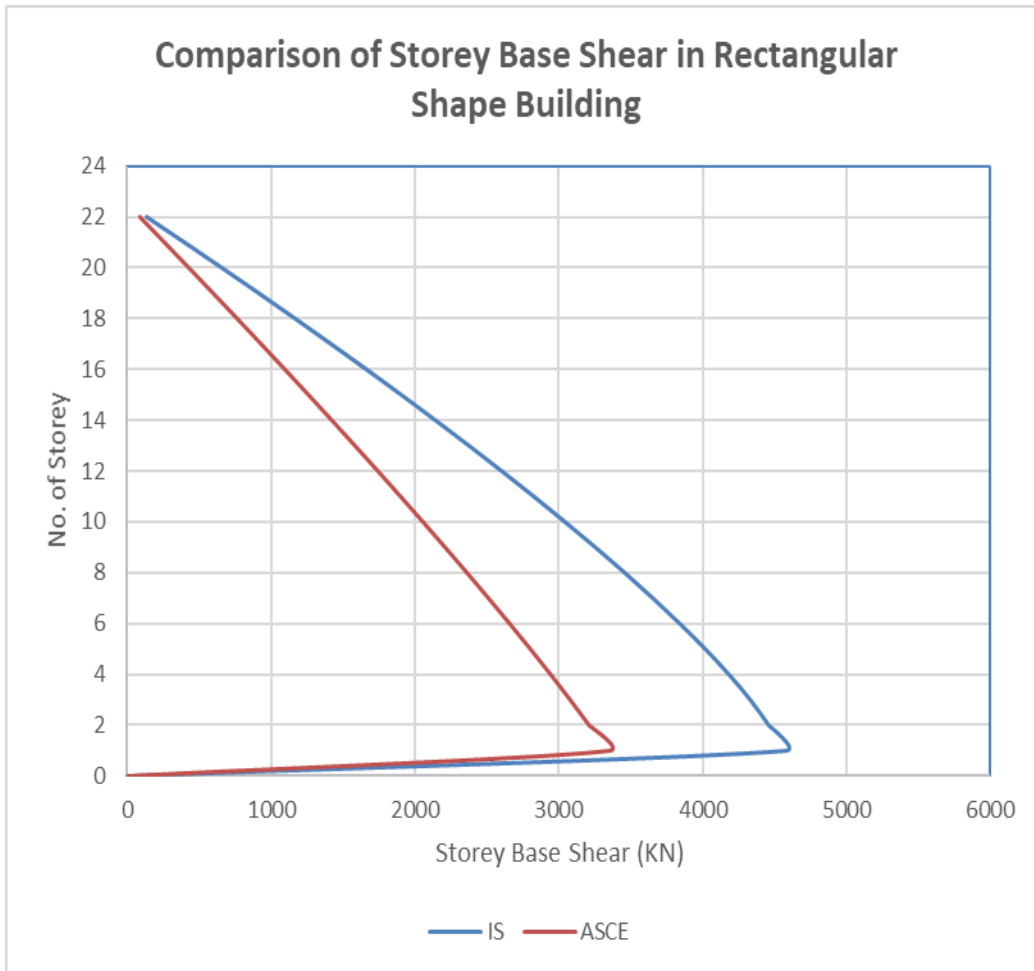


Figure 5.3.1.3 Comparison of story Base Shear (kN) in Rectangular Shape Building at different height.

- Figure 5.3.1.3 illustrates the comparison of storey base shear between IS and ASCE standards for a rectangular-shaped building at various storey levels.
- The maximum base shear for the rectangular building, as per ASCE 7-22, is 3347 kN, which is 26.86% less than the 4576 kN computed using the IS-875 code, indicating that the IS code results in a higher estimate of base shear compared to ASCE 7-22, leading to designs that account for greater lateral forces on the structure.

5.3.2 For Square building

5.3.2.1 Comparison of Lateral Displacements in Square Shape Building

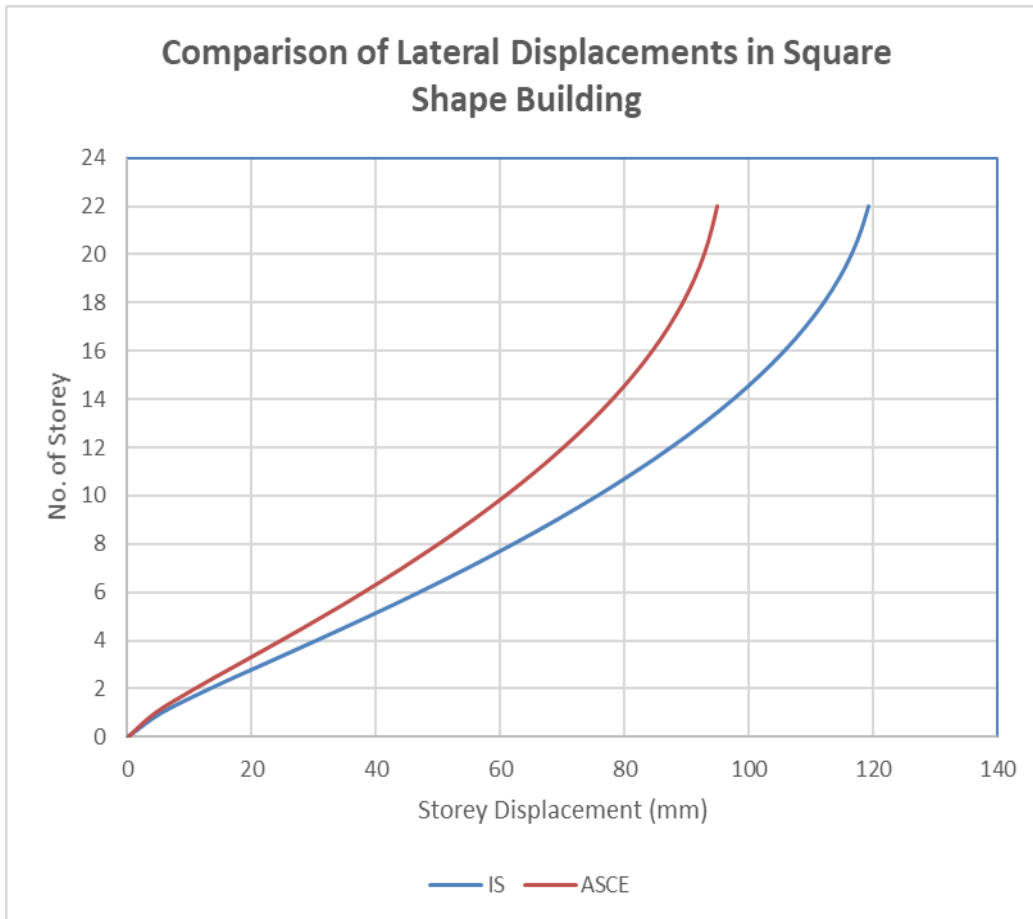


Figure 5.3.2.1 Comparison of Lateral Displacements in Square Shape Building in mm at different Storey.

- Figure 5.3.2.1 illustrates the comparison of lateral displacement between IS and ASCE standards for a square-shaped building at various storey levels.
- The maximum storey displacement of the square-shaped building, as per ASCE 7-22, is 94.925 mm, which is 20.40% lower than the 119.262 mm value obtained using the IS 875 code, indicating that ASCE 7-22 predicts significantly lower storey displacement for the same building configuration.

5.3.2.2 Comparison of Storey Drift Ratio in Square Shape Building

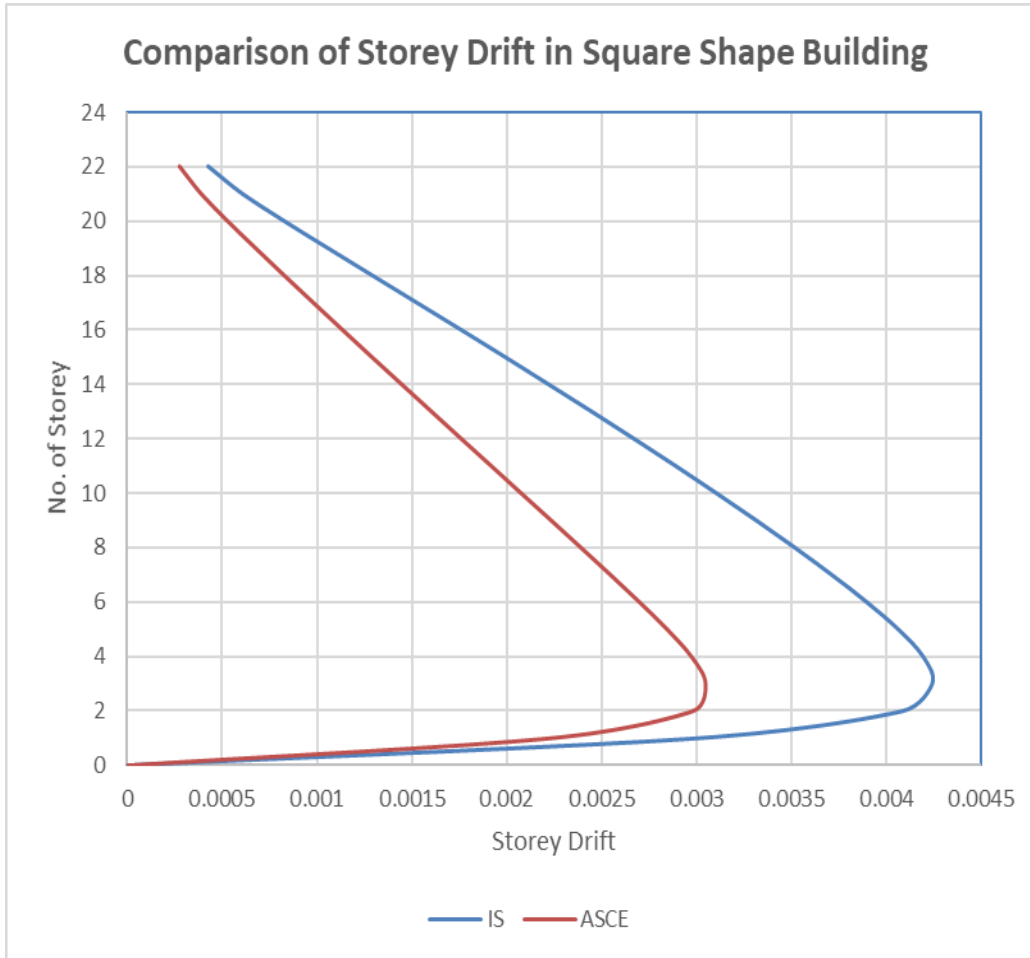


Figure 5.3.2.2 Comparison of storey drift ratio in Square Shape Building at different height.

- Figure 5.3.2.2 illustrates the comparison of storey drift between IS and ASCE standards for a square-shaped building at various storey levels.
- The maximum storey drift of the square-shaped building, as per ASCE 7-22, is 0.003046, which is 28.16% lower than the 0.00424 value obtained using the IS 875 code, indicating that ASCE 7-22 predicts lower storey drift for the same building configuration.

5.3.2.3 Comparison of Storey Base Shear in Square Shape Building

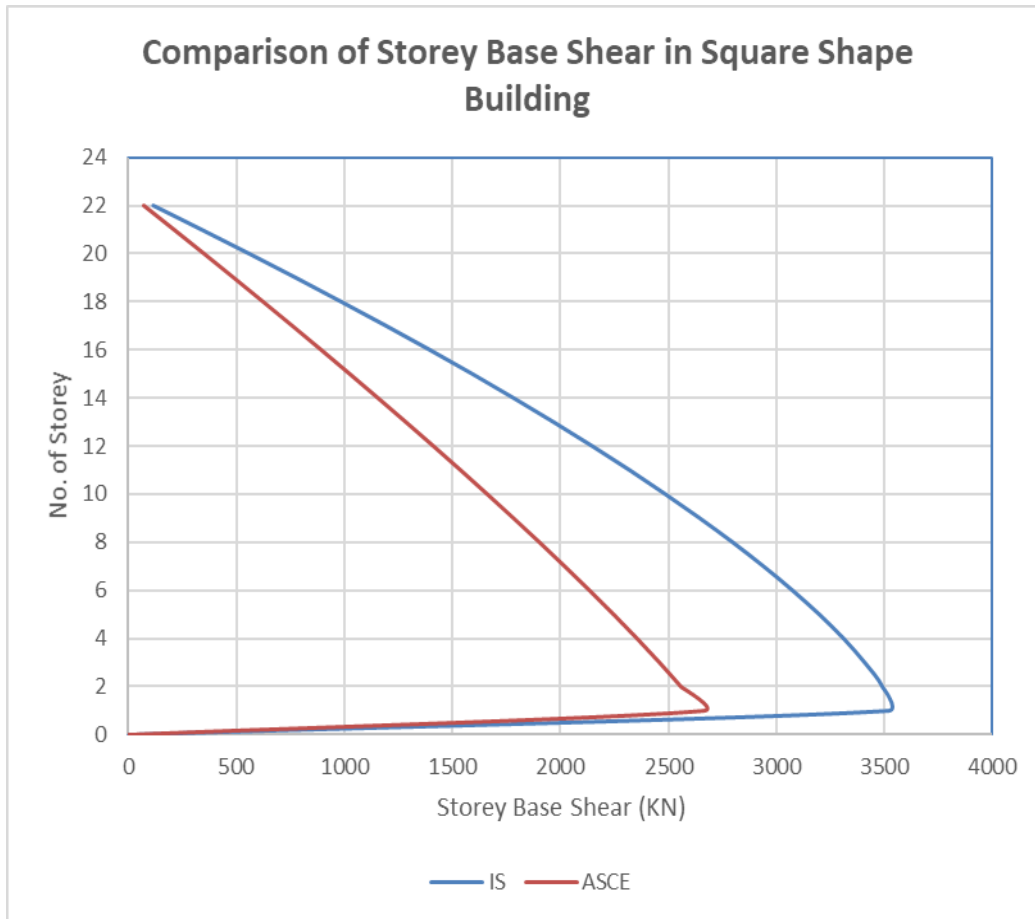


Figure 5.3.2.3 Comparison of storey Base Shear (kN) in Square Shape Building at different Storey.

- Figure 5.3.2.3 illustrates the comparison of storey base shear between IS and ASCE standards for a square-shaped building at various storey levels.
- The maximum base shear for the square-shaped building, as per ASCE 7-22, is 2665 kN, which is 24.20% less than the 3516 kN computed using the IS 875 code, indicating that the IS code yields a higher estimate of base shear, thereby leading to structural designs that consider greater lateral force demands.

5.3.3 For Diamond Shaped Building

5.3.3.1 Comparison of Lateral Displacements in Diamond Shape Building

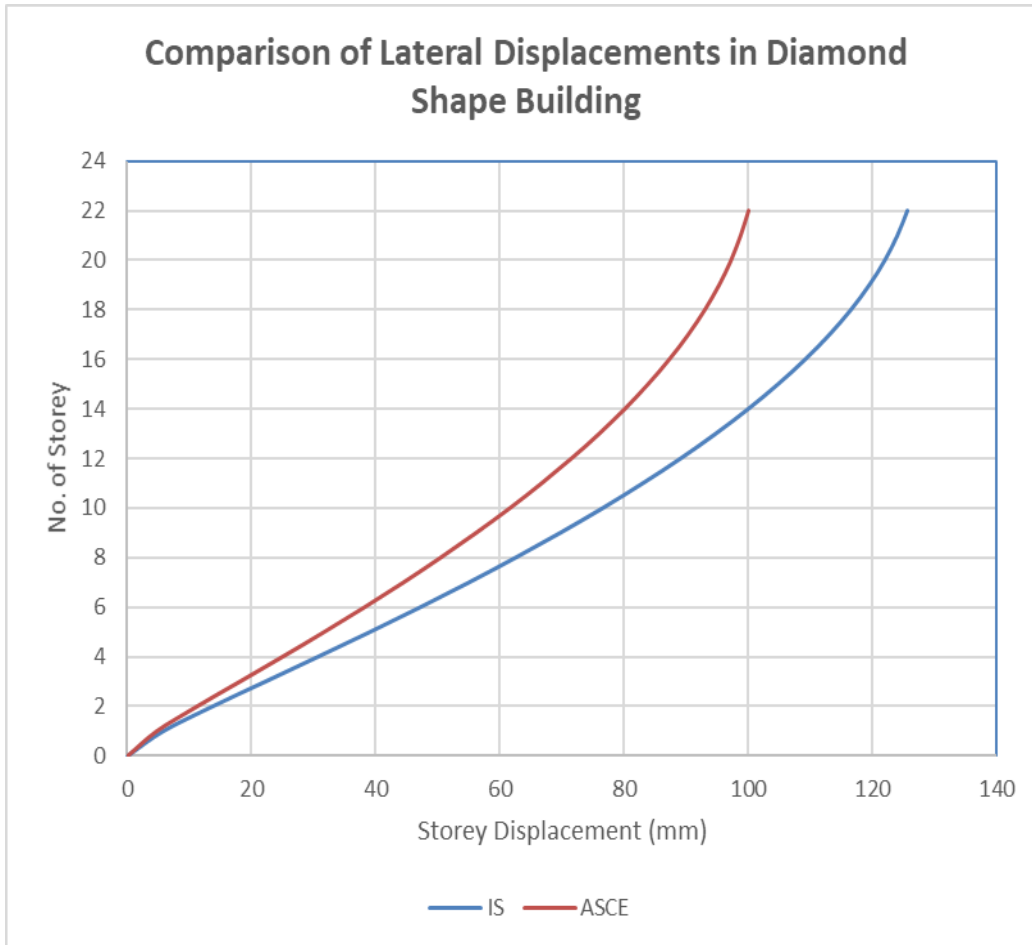


Figure 5.3.3.1 Comparison of Lateral Displacements in Diamond Shape Building in mm at different Storey.

- Figure 5.3.3.1 illustrates the comparison of storey displacement between IS and ASCE standards for a diamond-shaped building at various storey levels.
- The lateral displacement for the diamond-shaped building, as per ASCE 7-22, is 100.043 mm, which is 20.41% lower than the 125.692 mm obtained using the IS code, indicating that ASCE 7-22 predicts reduced lateral displacement for the same structural configuration.

5.3.3.2 Comparison of Storey Drift Ratio in Diamond Shape Building

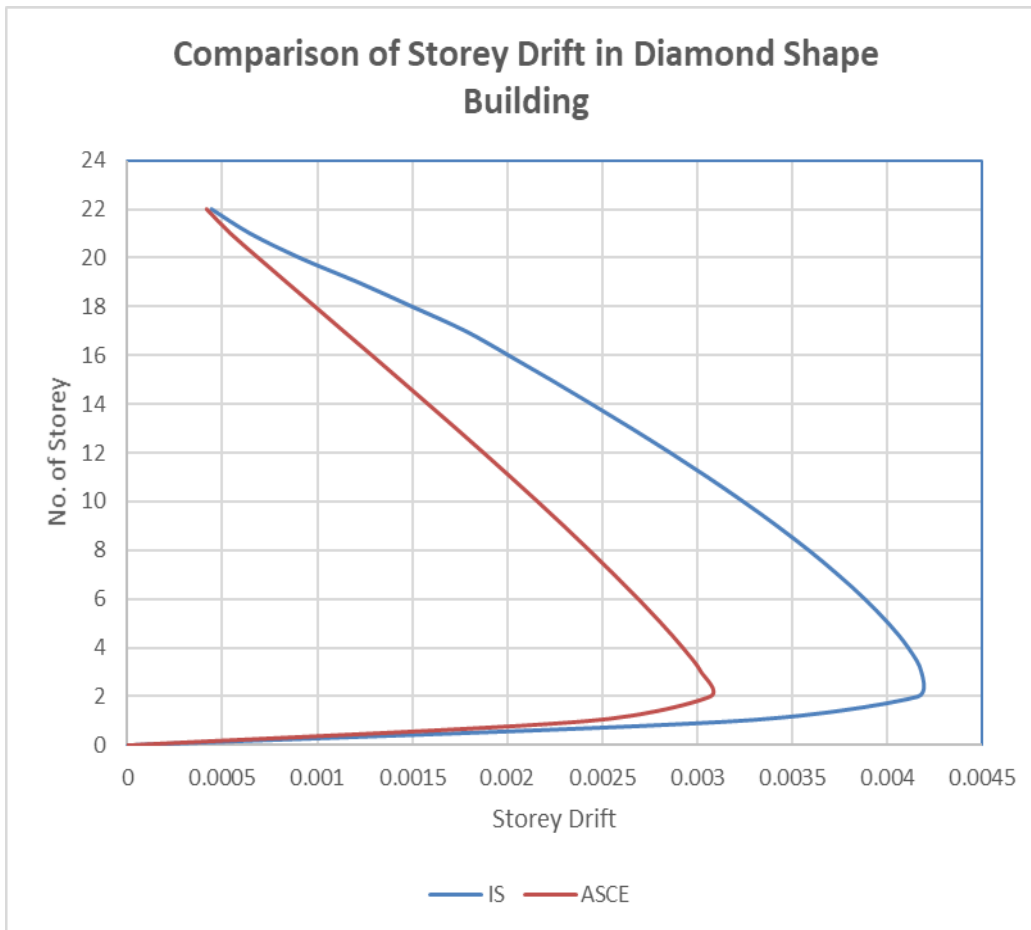


Figure 5.3.3.2 Comparison of story drift ratio in Diamond Shape Building at different height.

- Figure 5.3.3.2 illustrates the comparison of storey drift between IS and ASCE standards for a diamond-shaped building at various storey levels.
- The maximum storey drift of the square-shaped building, as per ASCE 7-22, is 0.003046, which is 28.16% less than the 0.00424 value obtained using the IS 875 code, suggesting that ASCE 7-22 results in a lower lateral deformation estimate for the same structural configuration.

5.3.3.3 Comparison of Storey Base Shear in Diamond Shape Building

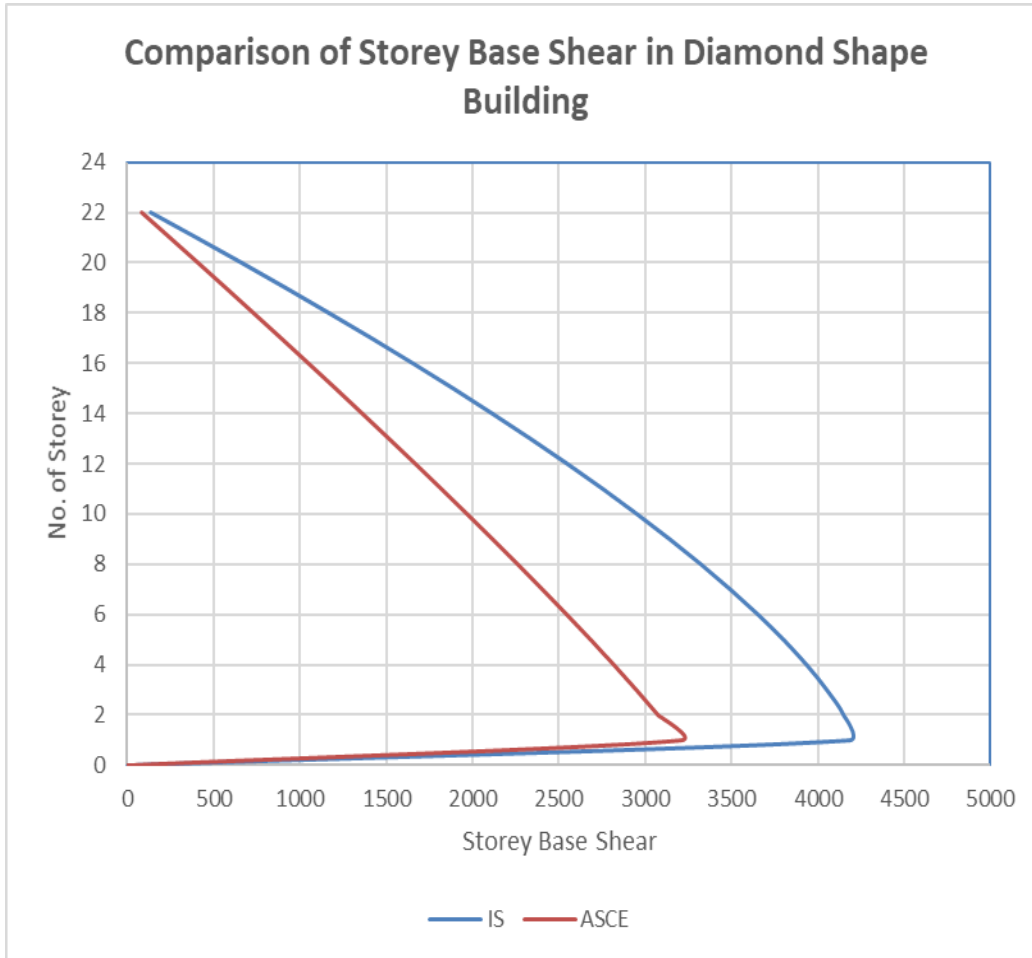


Figure 5.3.3.3 Comparison of storey Base Shear (kN) in Diamond Shape Building at different height.

- Figure 5.3.3.3 illustrates the comparison of storey Base Shear between IS and ASCE standards for a diamond-shaped building at various storey levels.
- The maximum storey shear for the diamond-shaped building, as per ASCE 7-22, is 3209 kN, which is 23.35% lower than the 4187 kN computed using the IS 875 code, indicating that ASCE 7-22 predicts reduced lateral force demand for the same structural configuration.

5.3.4 For Octagonal Building

5.3.4.1 Comparison of Lateral Displacements in Octagonal Shape Building

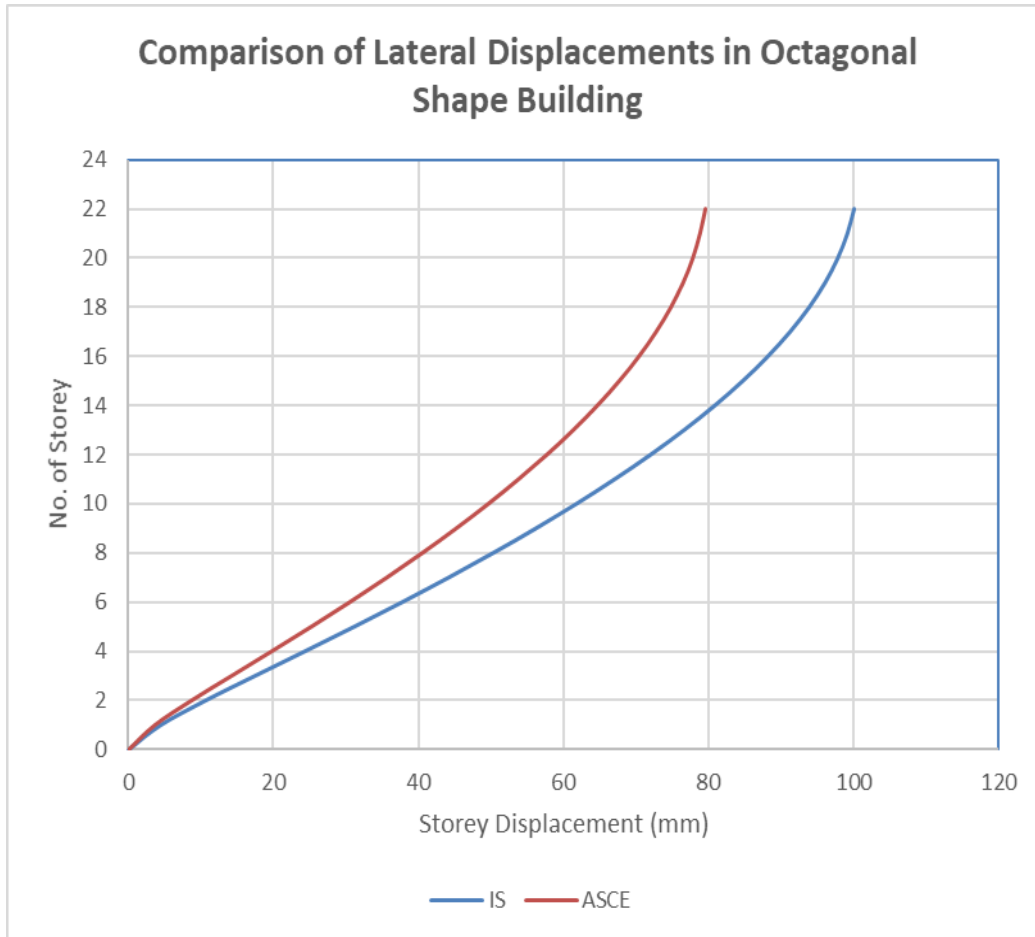


Figure 5.3.4.1 Comparison of Lateral Displacements in Octagonal Shape Building in mm at different Storey.

Figure 5.3.4.2 Comparison of Lateral Displacements in Octagonal Shape Building in mm at different Storey.

- Figure 5.3.4.1 illustrates the comparison of lateral displacement between IS and ASCE standards for an octagonal-shaped building at various storey levels.
- The maximum storey displacement for the octagonal-shaped building, as per ASCE 7-22, is 79.658 mm, which is 20.40% lower than the 100.081 mm obtained using the IS 875 code, indicating that ASCE 7-22 predicts reduced lateral displacement for the same structural configuration.

5.3.4.2 Comparison of Storey Drift Ratio in Octagonal Shape Building

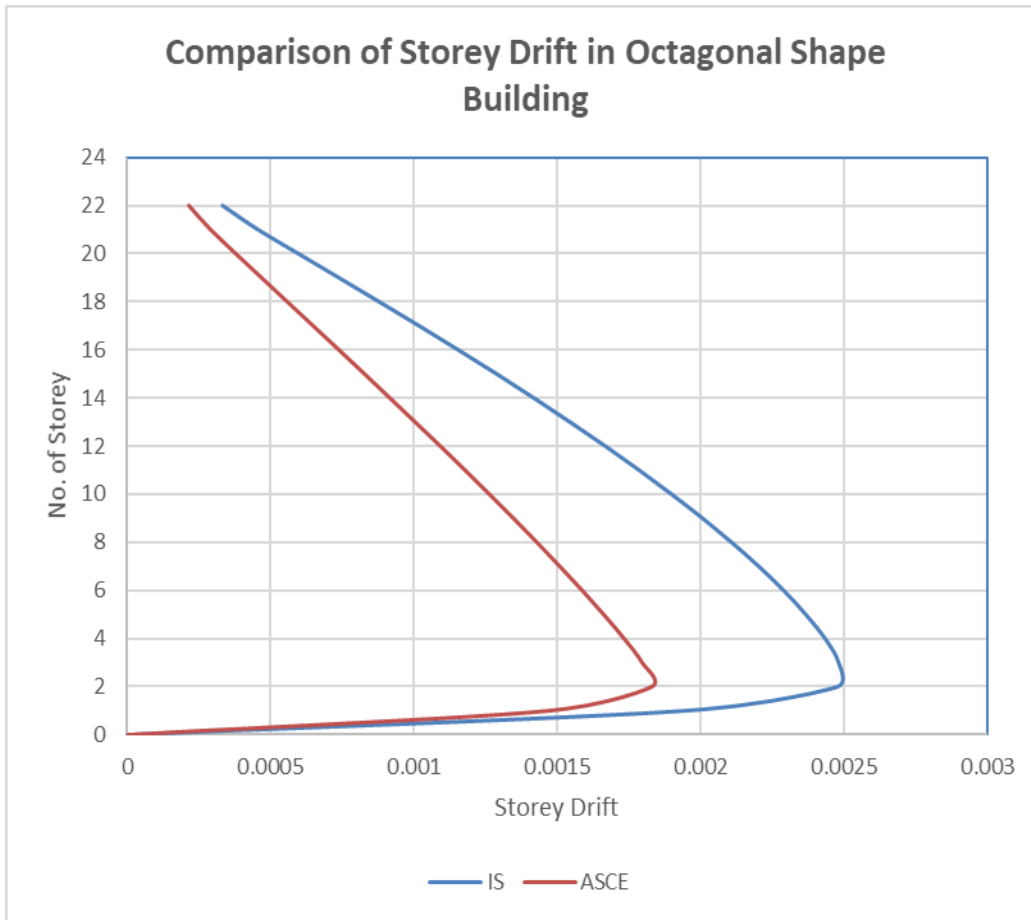


Figure 5.3.4.3 Comparison of storey drift ratio in Octagonal Shape Building at different height

- Figure 5.3.4.2 illustrates the comparison of storey drift between IS and ASCE standards for a octagonal-shaped building at various storey levels.
- The maximum storey drift for the octagonal-shaped building, according to ASCE 7-22, is 0.001829, which is 26.22% less than the 0.002479 value calculated using the IS 875 code, suggesting that ASCE 7-22 estimates a lower drift for the identical building configuration.

5.3.4.3 Comparison of Storey Base Shear in Octagonal Building

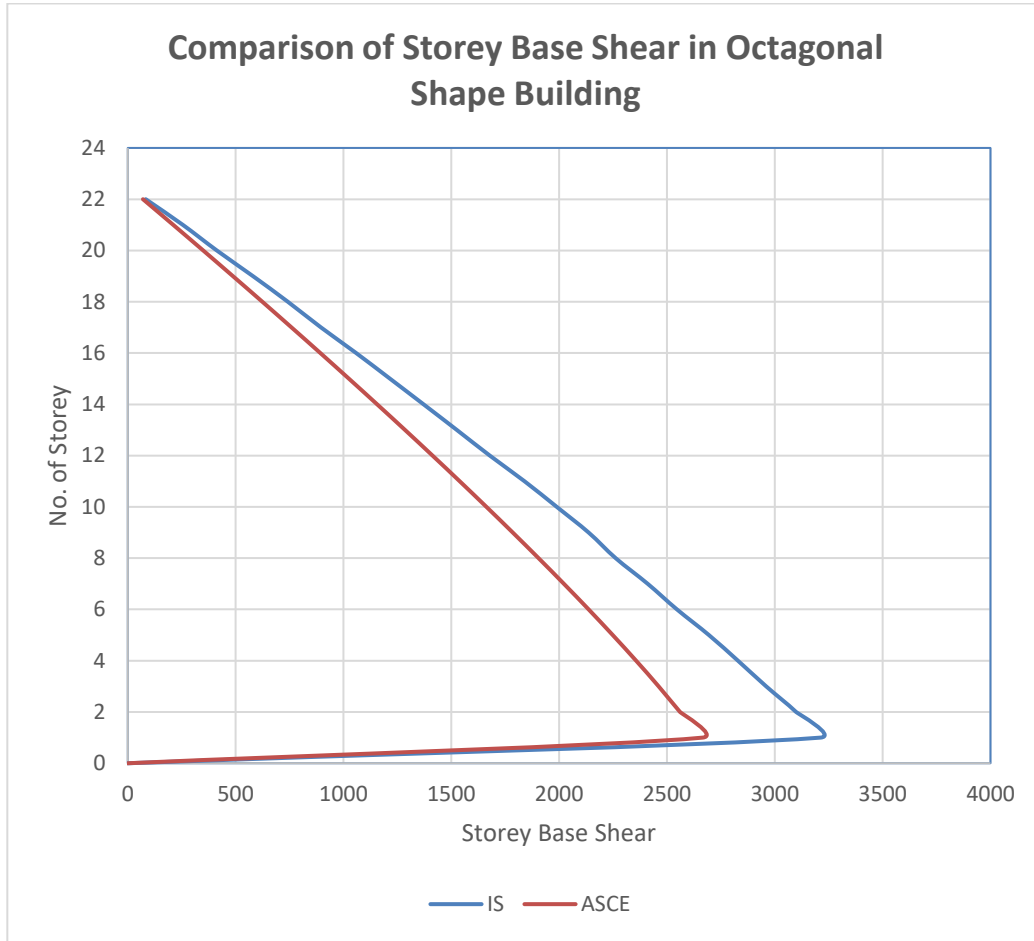


Figure 5.3.4. 4 Comparison of story Base Shear (kN) in Octagonal Shape Building at different height.

- Figure 5.3.4.3 illustrates the comparison of storey Base Shear between IS 875 and ASCE 7-22 standards for a octagonal-shaped building at various storey levels.
- The maximum storey shear for the diamond-shaped building, as per ASCE 7-22, is 2609 kN, which is 18.75% lower than the 3211 kN computed using the IS 875 code, indicating that ASCE 7-22 predicts reduced lateral force demand for the same structural configuration.

5.4 COMPARISON OF RESULTS ON 151.2M BUILDING BY IS 875 PART-3 AND ASCE 7-22.

Table 5.4.1 Comparison of Lateral Displacements in mm at different height

STOREY	IS 875	ASCE 7-22
42	194.165	153.229
41	188.717	148.962
40	183.246	144.677
39	177.753	140.375
38	172.236	136.055
37	166.692	131.713
36	161.121	127.350
35	155.522	122.966
34	149.897	118.560
33	144.247	114.134
32	138.574	109.689
31	132.882	105.228
30	127.175	100.754
29	121.457	96.270
28	115.734	91.780
27	110.013	87.290
26	104.300	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	19.030	15.347
8	15.536	12.550
7	12.327	9.976

6	9.425	7.643
5	6.853	5.570
4	4.637	3.779
3	2.805	2.293
2	1.390	1.140
1	0.431	0.356

- Table 5.4.1 presents a comparison of lateral displacement for a 151.2 m tall building as per IS 875 and ASCE 7-22 standards.
- The IS code gives a higher value of lateral displacement for the 151.2 m tall building compared to the ASCE 7-22 code.

Table 5.4.2 Comparison of story drift at different height.

STOREY	IS 875	ASCE 7-22
42	0.001513	0.001185
41	0.001520	0.001190
40	0.001526	0.001195
39	0.001533	0.001200
38	0.001540	0.001206
37	0.001548	0.001212
36	0.001555	0.001218
35	0.001563	0.001224
34	0.001570	0.001229
33	0.001576	0.001235
32	0.001581	0.001239
31	0.001585	0.001243
30	0.001588	0.001246
29	0.001590	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	0.001140
17	0.001408	0.001115
16	0.001370	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	0.000970	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	0.000320
2	0.000266	0.000218
1	0.00012	9.90E-05

- Table 5.4.2 presents a comparison of storey drift for a 151.2 m tall building as per IS 875 and ASCE 7-22 standards.
- The IS code gives a higher value of storey drift for the 151.2 m tall building compared to the ASCE 7-22 code.

Table 5.4.3 Comparison of Base Shear in KN at different height

BASE SHEAR		
STOREY	IS	ASCE
42	177	131
41	527	393
40	874	653
39	1218	911
38	1558	1168
37	1895	1424
36	2228	1678
35	2557	1930
34	2883	2181
33	3205	2431
32	3523	2678
31	3837	2924
30	4147	3169
29	4452	3411
28	4753	3652
27	5050	3891
26	5342	4128
25	5630	4363
24	5913	4596
23	6191	4827
22	6464	5056
21	6732	5282
20	6995	5507
19	7253	5728

18	7505	5946
17	7752	6163
16	7993	6378
15	8228	6590
14	8456	6799
13	8678	7004
12	8893	7206
11	9100	7405
10	9299	7600
9	9490	7793
8	9672	7980
7	9844	8161
6	10004	8337
5	10152	8508
4	10285	8673
3	10401	8827
2	10494	8973
1	10554	9040

- Table 5.4.2 presents a comparison of storey Base Shear for a 151.2 m tall building as per IS 875 and ASCE 7-22 standards.
- The IS code gives a higher value of storey Base Shear for the 151.2 m tall building compared to the ASCE 7-22 code.



Figure 5.4.1 Comparison of Lateral Displacements in mm at different height

- Figure 5.4.1 illustrates the comparison of lateral displacement between IS and ASCE standards for a 151.2 m tall building.
- The maximum storey displacement for the 151.2 m tall building, as per ASCE 7-22, is 153.229 mm, which is 21.08% lower than the 194.165 mm obtained using the IS 875 code, indicating that ASCE 7-22 predicts reduced lateral displacement for the same structural height and configuration.



Figure 5.4.2 Comparison of storey drift at different height.

- Figure 5.4.2 illustrates the comparison of storey drift between IS and ASCE standards for a 151.2 m tall building.
- The maximum storey drift for the 151.2 m tall building, as per ASCE 7-22, is 0.001247, which is 21.57% less than the 0.00159 value calculated using the IS 875 code, suggesting that ASCE 7-22 estimates a lower drift for the same building configuration.

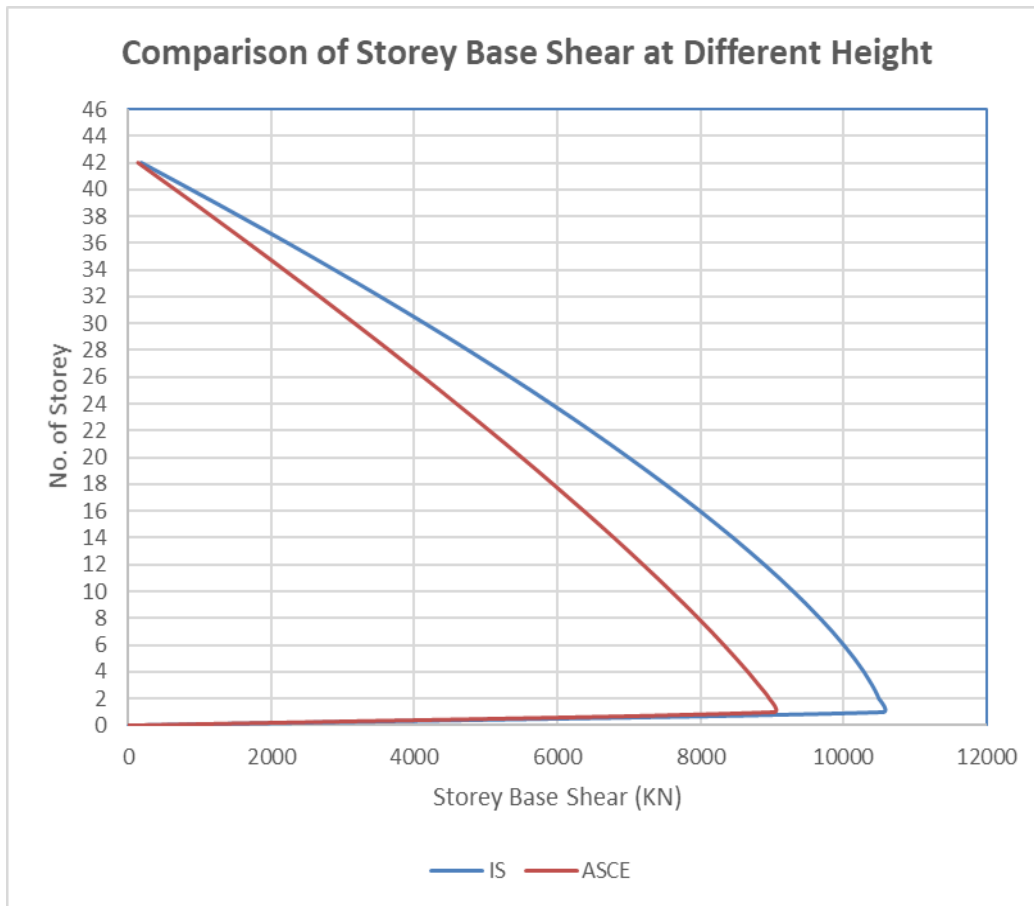


Figure 5.4.3 Comparison of story Base Shear in kN at different height.

- Figure 5.4.3 illustrates the comparison of storey Base Shear between IS and ASCE standards for a 151.2 m tall building.
- The maximum storey base shear for the 151.2 m tall building, as per ASCE 7-22, is 9040 kN, which is 14.34% lower than the 10554 kN calculated using the IS 875 code, indicating that ASCE 7-22 results in a reduced estimate of lateral force for the same building configuration.

CHAPTER – 6

CONCLUSION

- Across all building shapes rectangular, square, diamond, and octagonal as well as for the 151.2 m tall building, the ASCE 7-22 code consistently predicts approximately 20–21% lower maximum lateral displacement compared to the IS 875 code. This difference reflects ASCE refined dynamic wind load procedures, particularly its incorporation of the gust effect factor, which better captures the influence of building flexibility and wind turbulence. Consequently, ASCE 7-22 provides a more precise and performance-oriented estimate of lateral response, enabling more efficient and structurally optimized designs.
- ASCE 7-22 consistently estimates lower maximum storey drift for all building shapes rectangular, square, diamond, and octagonal as well as for the 151.2 m tall structure, with reductions ranging from 21.57% to 50.44% compared to IS 875. This reflects ASCE’s refined dynamic approach. The consistent drift reduction across these configurations suggests better control of lateral deformation. Thus, ASCE 7-22 enables more efficient, drift-compliant structural designs.
- ASCE 7-22 predicts 14% to 27% lower base shear values than IS 875 for all building shapes (rectangular, square, diamond, and the 151.2 m tall structure), indicating that IS 875 yields more conservative lateral force estimates. ASCE 7-22 takes a performance-based approach that considers dynamic wind effects and structural characteristics.
- The analysis shows that IS 875 (Part 3):2015 yields the highest values, while ASCE 7-22 gives the lowest. ASCE 7-22 is thus the more cost-effective option for designing wind-resistant buildings.
- Considering both ASCE 7-22 and IS 875 codes, the octagonal-shaped building consistently exhibits the lowest storey displacement, drift, and base shear, highlighting its aerodynamic efficiency and superior performance in minimizing wind-induced effects across both ASCE 7-22 and IS-875 wind loading standards.
- 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.

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