Comparison of Wind Response on Building According to Different Wind Loading Codes

A DISSERTATION

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE AWARD OF THE DEGREE

OF

MASTER OF TECHNOLOGY
IN

STRUCTURAL ENGINEERING

Submitted

by

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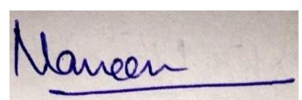
<u>CANDIDATE’S DECLARATION</u>

I , **Naveen Suthar** , **2K18/STE/19** of MTech (structural engineering), hereby declare that the project Dissertation titled “**comparison of wind response on building according to different wind loading codes**” which is submitted by me to the **Department of Civil engineering**, Delhi Technological University, Delhi in partial fulfilment of the requirements for the award of the degree of Master of Technology, is original and not copied from any source with proper citation. This work has not previously formed the basis for the award of the Degree, Diploma Associateship, Fellowship or other similar title or recognition.



Place: DELHI **Naveen Suthar**

Date: 31-08-2020 (**2K18/STE/19)**

CERTIFICATE

I hereby certify that the Project Dissertation titled **"comparison of wind load on building according to different wind loading codes"** which is submitted by **Naveen Suthar (2K18/STE/19)**, **Department of Civil engineering**, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: Delhi **Dr. Pradeep K. Goyal**

Date: 31-07-2020 **(Associate Professor)**

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I, **Naveen Suthar** wish to express my profound gratitude and indebtedness to **Dr. P. K. GOYAL,** Department of Civil, Delhi Technological University, Delhi for introducing the present topic and for his inspiring guidance, constructive criticism and valuable suggestion throughout the project work. And my sincere thanks to all our friends who have patiently extended all sorts of help for accomplishing this undertaking.

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ABSTRACT

All the International wind loading codes and standards provide guidelines and procedure for evaluation of wind load and effect of wind on tall buildings. This project presents a comparison of response of building due to wind load by two countries' wind loading code. The different codes used in this present study in AS/NZS 1170(Part 2)-2011and Indian (IS 875 (2015)-part 3). The study was conducted on 150m high rise different shape buildings for static wind characteristics i.e. static analysis and another study also conducted on a 36m height building for the comparison of different shapes of the building by the both codes. The comparative results are obtained from the different international wind loading codes and standards for terrain category 3 for both codes. Different perimeter like design wind pressure at different height, base shear and base bending moment also compare. The aim of this project is comparing the results of various wind loading codes and standards with Indian wind loading code and standard. The difference in these parameters have been given in this report.

CHAPTER - 1
INTRODUCTION

1.1- GENERAL

The wind is an important factor in the design of high-rise building. The wind is more important than the earthquake and other important loads. The terrain category is defined according to the roughness and the smoothness of the surface. The wind load is affecting many parameters like construction cost, building strength and another parameter of the building. As per the results which help in the selection of different parameter of the building. Standard codes from different countries use their different terrain categories for the calculation the wind load and they depend on the surface conditions. All the standard wind load codes have their approach to calculate the wind load. they have different formulas and conditions in their map for the calculation of the wind load. For the analysis of wind load, the terrain category 3 has taken for the different wind load and the comparative analysis. The results of the response of the different building using different code will compare with each other. the excitation the building against wind load is compared with different shape of the structure analysed from the different code. In this project, we use the static analysis in the calculation of the response of the building. And we take the different wind loading codes for the analysis of the wind. In professional practice throughout the planet, design wind loads for a huge majority of structures are evaluated on the idea of wind load provisions laid out in standards and codes. For design of high-rise structures wind load is a critical parameter especially for taller structures constructed in non-seismic area. For the analysis of wind load most of the countries as developed its own standards and related specification for effective analysis and design of structures. Wind is that the term used for air in motion and is typically applied to the natural horizontal motion of the atmosphere. Motion during a vertical or nearly vertical direction is named a current. Movement of air near the surface of the world is three-dimensional, with horizontal motion much greater than the vertical motion. Vertical air motion is of importance in meteorology but is of less importance near the bottom surface. On the opposite hand, the horizontal motion of air, particularly the gradual retardation of wind speed and therefore the high turbulence that happens near the bottom surface, are of importance in building engineering. The height of the tallest building changes year by year because skyscrapers are constructed constantly worldwide. With this development that buildings are rising, there will be a larger awareness of occupant's comfort due to wind induced acceleration in the top floors of a high-rise structure. So, when the height of structure increases then the consideration of lateral load and other factors are very much important. For that the lateral load resisting system becomes more important than the structural system that only resists the gravitational loads. Wind effects on structures are often classified as "static" and "dynamic". Because of the static wind bending and twisting occur in the structure. we use dynamic analysis for tall and long and slender structure., Wind gusts cause changing forces on the structure which induce large dynamic motions, including fluctuations.

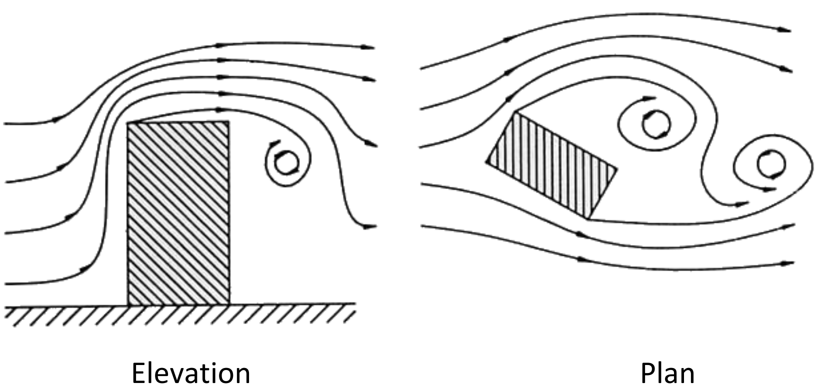


Figure: 1.1 wind load interaction against building

Wind load on the structure are generally dynamic in nature. On the topographical condition and surface condition wind depends. Wind plays an important role in the design of the tall structure because it exerts a load on the structures. For any high-rise vertical construction, wind is more significant ratio than the earthquake and gravity load. Calculated results can be used in the selection of the design parameter of the building.

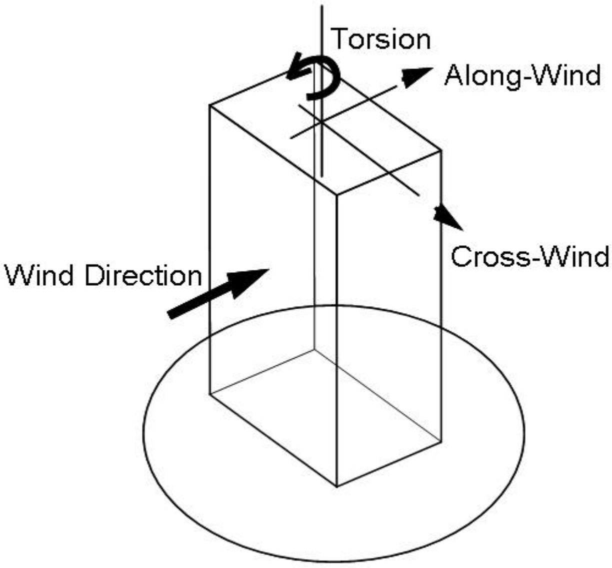


Figure 1.2: Wind Response Directions

As we know that if the load increases this will affect most of parameters of design such as dimensions of structural members, strength of material, and quantity of material and cost of the construction. Terrain category define because the surface condition of approach flow (smooth or rough). Different wind loading codes considered different terrain condition from terrain category one to terrain category five where terrain category one to five indicate smoother to rougher condition.

1.2 - OBJECTIVES:

This study will focus on effect of wind on the G+11 storey building, with the modelling by use of finite element method. and also, the comparison between different shapes of structure which are of same height and wind force acting on it.

And another study will be carried out of wind by different standard wind load on 50 storey building, with the modelling by use of finite element method the comparison between different international wind codes on building which are having same height and wind force acting on it.

- To study and compare results of big structures with various non circular shape configuration in plan using STAAD software.
- To investigate behaviour of various structural systems under wind load according to the IS:875 (Part 3)2015 and (AS/NZS1170(part 2):2011).
- To carry out study such as story drifts, lateral displacement, wind intensity etc. by modelling structures subjected to wind load calculated by different standard international code.

1.3 - TERMINOLOGIES USED IN WIND LOAD ANALYSIS

Developed height: Developed height is that the height of upward penetration of the speed profile during a new terrain. At large fetch lengths, such penetration reaches the gradient height, above which the wind speed could also be taken to be constant. At lesser fetch lengths, a velocity profile of a smaller height but almost like that of the fully developed profile of that terrain category has got to be taken, with the additional provision that the speed at the highest of this shorter profile equals that of the unpenetrated earlier velocity profile at that height.

Effective Frontal Area: The projected area of the structure normal to the direction of the wind Element of Surface Area: the world of surface over which the pressure coefficient is taken to be constant

Force Coefficient: A non-dimensional coefficient such the entire wind force on a body is that the product of the force coefficient, the dynamic pressure of the incident design wind speed and the force is required over the reference area.

Ground Roughness: The nature of the earth's surface as affected by small scale obstacles such as trees and buildings (as distinct from topography) is called ground roughness.

Gust: Positive or negative departures of wind speed from its mean, lasting for less than, say, 2 minutes over a specified interval of your time.

Peak Gust: Peak gust or peak gust speed is that the wind speed related to the utmost amplitude.

Gradient Height: Gradient height is that the height above the mean ground level at which the gradient wind blows as a result of balance among pressure gradient force, carioles force and force. For the aim of this code, the gradient height is taken because the height above the mean ground level, above which the variation of wind speed with height need not be considered.

Mean Ground Level: The mean ground level is that the average horizontal plane of the world enclosed by the boundaries of the structure.

Pressure Coefficient: Pressure coefficient is that the ratio of the difference between the pressure working at some extent on a surface and therefore the static pressure of the incident wind to the planning wind pressure, where the static and style wind pressures are determined at the peak of the purpose considered after taking under consideration the geographical location, terrain conditions and shielding effect. The pressure coefficient is also equal to $[1-\left(\frac{Vp}{VZ}\right)^2]$, where Vp is the actual wind speed at any point on the structure at a height corresponding to that of Vz.

Terrain Category: Terrain category means the characteristics of the surface irregularities of a neighbourhood which arise from natural or constructed features. The categories are numbered in increasing order of roughness.

Topography: The nature of the earth's surface as influenced the hill and valley arrangements.

Building Enclosed: A building that doesn't suits for open or partially enclosed buildings

Building Envelope: Cladding, roofing, exterior walls, glazing, door assemblies, window assemblies, skylight assemblies, and other components enclosing the structure.

1.4 - VARIATION OF WIND VELOCITY WITH HEIGHT

The viscosity of air reduces its velocity adjacent to earth's surface to almost zero, A retarding effect occurs in the wind layers near the ground and these inner layers successively slow the outer layers. The slowing down is reduced at each layer because the height increases, and eventually becomes negligibly small. The height at which velocity ceases to extend is named the gradient height, and therefore the corresponding velocity, the gradient velocity. This characteristic of variation of wind velocity with height may be a well-understood phenomenon, as evidenced by complex design pressures specified at higher raises in most structure codes.

MEAN WIND PROFILES FOR DIFFERENT TERRAINS

The variation of wind speed with height is additionally dependent upon the bottom roughness and is thus different for every terrain category, as are often visualized from Fig. Wind blows at a given height, with lesser speed in rougher terrains and with higher speeds in smoother terrains. Further, in any terrain, wind speed increases along the height up to the gradient height and the values of the gradient heights are higher for rougher terrains. By definition, wind speeds beyond gradient heights altogether terrains are equal. At any height during a given terrain, the magnitude of wind speed depends on the averaging time. Shorter the averaging time, the upper is that the mean wind speed. Also, it takes quite a distance, called fetch length, for wind to travel over a typical terrain to fully develop a stable velocity profile idealized for that terrain category. The viscosity of air reduces its velocity adjacent to earth's surface to almost zero, as shown in fig. near the ground the retarding effect occur and these the outer layers successively slow by inner layers. As the height increases slowing down is reduced at each and every level and become negligibly small. The height at which velocity ceases to increase is called the gradient height, and the corresponding velocity, the gradient velocity. This characteristic of variation of wind velocity with height is a well-understood phenomenon, as evidenced by higher design pressures specified at higher raises in most structure codes.

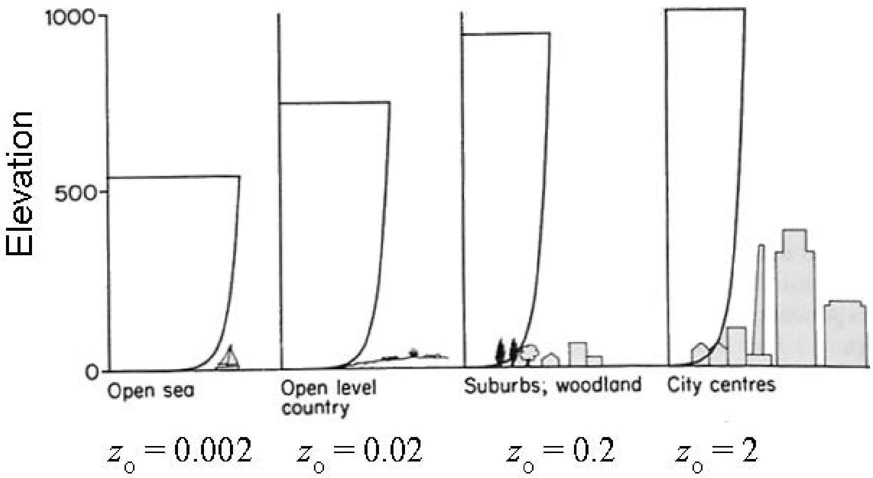


Figure 1.3: Mean wind profiles for different terrains

The variation of wind speed with height is also dependent upon the ground roughness and is thus different for each terrain category, as can be visualized from Fig. Wind blows at a given height, with lesser speed in rougher terrains and with higher speeds in smoother terrains. Further, in any terrain, wind speed increases along the height up to the gradient height and the values of the gradient heights are higher for rougher terrains. By definition, in all terrains are equal, wind speeds beyond gradient heights. At any height in a given terrain, the magnitude of wind speed depends on the averaging time. the higher is the mean wind speed, Shorter the averaging time. Also, it takes quite a distance, called fetch length, for wind to travel over a typical terrain to fully develop a stable velocity profile idealized for that terrain category.

CHAPTER 2
LITERATURE REVIEW

2.1- LITERATURE REVIEWED

This chapter is all about the previous study done by so many scholars across the worlds. Substantial amount of work on this aspect have been carried out by great number of scholars in India and foreign. Some contribution in this direction in recent past have been made by researchers are presenting-

- **K. Suresh Kumar (2011)** This paper elaborates on how well the Indian Standard for wind loads (IS:875) predicts the wind induced local loads also as overall structural loads on tall buildings in conjunction with reality. For this investigation, the structure results from a typical CAARC building model have been utilized for comparing against the IS:875 predictions. Further, predictions from other international codes of practice and from few Indian projects are also included in this paper for comparison purposes. Based on this study, preliminary recommendations have been made.

- **Megha Kalra et.al., (2011)** this paper says that the direction of wind is horizontal relative to the surface of earth. The primary generating force behind wind is that the constant rotational movement of earth and terrestrial radiations of varying intensity. The radiation results in the convection currents in two directions -upwards or downwards. The nature of wind is very unpredictable, even for the same locality the wind speeds are extremely different, one may experience the effect of gusts lasting for few seconds. The effect of wind on a building thus depends on many factors like its geographical location and obstructions near the building which may cause any variation in air flow and the characteristics of the building itself. Plus, shape and Non-uniform shape were the foremost stable shapes whereas L-shape and U-shape was the smallest amount stable of all the shapes. More the stiffness of the building more are going to be its stability.

- **Khaled M. Heiza and Magdy A. Tayel (2012)**, it is very important to consider the effects of wind and earthquakes load in the design of reinforced concrete structures, especially for tall buildings. The Egyptian Code of Practice for calculating loads and forces in Structural and Building Works, 1993 and 2003 proposed methods for determining such loads. The codes are reviewed for wind and earthquake analysis and discussed to point out all factors affecting the planning. A computer virus is developed to analyze the structural buildings behaviour under wind pressure defined also as equivalent static loads for earthquakes considering all factors within the codes.

- **Dr. B. Dean Kumar and Dr. B.L. P Swami (2012),** In this paper, the proposed draft is studied and compared with the existing code i.e.IS: 875(Part1)-1987. Both the static and dynamic methods studied in the code are used for analysing the multi-story frames of 20 to 100 stories. The study includes the wind effects on structures located on the coastal belt of the country and in the interior part of the country. Depending on the study, important conclusions and shortcomings in the existing code and proposed draft is pointed out. Also, the importance of dynamic method is studied and acknowledged after a comparison with the static method.

- **M.R Suresh, Pradeep K.M(2012)**, Aim of this paper to review the effect and performance of outrigger system in 30-story building. The outrigger system is provided at different levels along the height of the building by varying the relative stiffness. Loads are considered as per Indian Standards IS: 875(Part1)-1987 and IS: 1893(Part-1) - 2002. The analysis is completed with Equivalent static method for various seismic zones. The modelling and analysis were performed using the finite element software ETABS 9.7.4. It is inferring that, with the increase in relative stiffness of the outrigger system, there is a decrease in lateral displacement and inter-story drift. Further there's increase in base shear of the structure with higher relative stiffness altogether seismic zones.

- **Kiran Kamath and N. Divya, Asha U Rao(2012)**, within the paper an investigation has been performed to work out the behaviour of varied alternative 3D models using ETABS software for reinforced concrete structure, we can use structure by varying its relative rigidity 0.25 to 2.0 of structure with outrigger or without outrigger and with the central wall. Also, the position of outrigger has been varied along the peak of the building by considering a parameter relative height of outrigger from 0.975 to 0.4. in this paper include the main parameter in the comparative study of variation of bending moments, shear force, lateral deflection, peak acceleration of the core. Inter storey drifts for static and dynamic analysis for a 3-D model for several values of relative rigidity and relative height. From the analysis of the results obtained it's been found that performance of the outrigger is most effective for relative height of the outrigger adequate to 0.5.

- **Prof. Sarita Singla et al., (2012)** this paper deals with buildings which are designed for utilization by the people as shelter for living. As nowadays there is shortage of land for building, the vertical construction is given due importance. A designer is curious about storey wise horizontal forces for analysis and style of structural frames. Hence, priority is given to compute the storey wise lateral forces due to wind on building. In the present study, a building of different shapes Square, Hexagonal and Octagonal, having similar plan area has been analyzed. Based upon the study, it's concluded that shape of the structure plays a crucial role in resisting wind loads. Octagonal shaped building performed the simplest followed by hexagonal shaped and square shaped building.

- **P.M.B. Raj Kiran Nanduri and B. Suresh and MD. Ihtesham Hussain (2013),** The objective of this paper is to review the behaviour of outrigger and, outrigger location optimization and therefore, the efficiency of every outrigger when three outriggers are utilized in the structure. In 30 storey 3D models of an outrigger and belt truss system are subjected to wind and earthquake load, analyzed and compared the reduction of lateral displacement at the location of belt truss system and outrigger. For 30 storey model, maximum reduction of lateral displacement up to 23% can achieved by use of first outrigger at top of the building and second outrigger within the building.

- **Tupat (2014),** In this paper present a comparative study of lateral load i.e. Wind and earthquake loads to decide the design loads of a multi-storey building. The importance of this work is to calculate the design loads of a structure which is subjected to wind and earthquake loads in a particular region. The wind loads so obtained on the building are compared thereupon of earthquake loads. Finally, it's found the wind loads are more critical than the earthquake loads in most of the cases. Based on the results obtained the following conclusions are made. The wind and earthquake load increase with height of structure. Wind loads are more critical for tall structures than the earthquake loads. For the critical forces of wind and earthquake building should be designed against the loads obtained in both directions independently.

- **Mohit Sharma et.al (2014)** carried out dynamic analysis band on Indian standard Code and STAAD.Pro. A G+30 building was taken for this study and the response spectrum, loading and deflection diagrams with application of lateral loads were recorded. Axial forces, torsion, movement and displacement were compared for two different zones.

- **S. Mahesh et.al., (2014)** studied the behavior of G+11 building using STAAD.Pro and ETABS, assuming the materials property as linear static. Dynamic analysis was carried out based on different seismic zones and different soil types. Comparing both software, STAAD.Pro gives higher results with respect to base shear storey drift and area of steel.

- **U. Weerasuriya and M.T.R. Jayasinghe (2014)** A high-rise building of height – 183 m was employed to gauge similarities and differences of wind load calculations done by using five major wind codes and standards. Evaluation was wiped out both ultimate and serviceability limit conditions. Member forces in columns, and beams, compressive stress in shear walls and support reactions obtained from finite element modelling was wont to assess building responses in ultimate limit condition. Along and across wind, accelerations and drift indices were involved to estimate serviceability limit state performances of the structure. Presented 3 second gust wind speeds are converted into mean hourly and 10-minute average wind speeds to estimate wind loads on structure. Wind speeds with 5 years return period was utilized in building acceleration calculation. The simultaneous use of upper terrain-height multiplier and importance factor could also be cause over design, even in cyclone prone areas. The use of post disaster wind speed doesn't exceed the drift limit but exceeds threshold acceleration value in across insert wind acceleration.

- **M. R. Wakchaure and Sayali Gawali (2015)**, In this study, analytical investigation of different shapes of buildings are taken as an example and various analytical approaches are performed on the building. These plans are modelled and wind loads are found out according to I.S 875(part 3)-1987 by taking gust factor and without taking gust factor. These models are compared in several aspects like storey drift, storey displacement, storey shear, etc. for different shapes of buildings by using the finite element software package ETAB‟s 13.1.1v. Among these results, which shape of building provides sound wind loading to the structure also because the structural efficiency would be selected.

- **Muftha A. Abdusemed and Ashok K. Ahuja (2015)**, Present paper describes the experimental study carried out on the models of high-rise buildings with varying cross-sectional shapes under both stand-alone condition and interference condition. The models are tested in a circuit boundary layer wind tunnel. Twisting moment developed because of wind is measured additionally based shear and base moment in along-wind direction also as across-wind direction. The effect of wind angle of incidence on wind loads is studied just in case of isolated condition. Study of the interference condition we consider effect of distance between structure and interference structure on wind load.

- **Anupam Rajmani et.al (2015)**, says that wind is one of the most powerful force affecting tall buildings. Tall buildings are attached to the ground; they bend and sway in the wind. This is known as wind drift, should be kept under acceptable limits. For a properly designed building, the wind drift should not be higher than the height of the building divided by 500. Wind loads on structures increase considerably with the increase in structure heights. In respect to nodal shape triangle shape performs better than other shapes.

- **Prof. M. R. Wakchaure et al (2016)**, this paper shows the buildings having same area, but constructed with different shapes and each of them are compared. Wind loads are determined based on gust effectiveness factor method. The critical gust loads for design are determined. Circular or elliptical buildings have a smaller surface perpendicular to the wind direction, the wind pressure is less than in prismatic buildings, square shaped buildings are less stable against wind load than elliptical buildings. Hence it is concluded that wind load is reduced with an elliptical plan.

- **Rohan Kulkarni et.al (2016**), The most prominent buildings are called high-rise buildings in most countries from the structural design point of view, it is simpler to consider a building as tall when its structural analysis and style are in how suffering from the lateral loads i.e., wind or seismic and particularly the sway caused by such lateral loads. As the height of building increases the wind loads starts to dominate. Therefore, structural framework for high rise structures is developed all around concepts associated entirely with resistance to turbulent effect of wind. Circular and elliptical plan shape of buildings is far better compared to the opposite plan shape of building in reducing of both wind Pressure Coefficient also as

Total Drag Force on Building.

- **P.V. Sreedharan (2016)** analyzed the wind and seismic loads for four different shaped structures and three tracing systems are analyzed for concentrated the forces. The analysis is carried using ETABS software. The research findings showcase the effect of plan irregularities and tracing system towards the wind and seismic loads.

- **V. Rajesh et.al., (2016)** aims at devising an economical section based on geometry, cross section supports and stability of multi storey structure. Effect of loads on the members is analyzed using RUN analysis and finally designed. The study finds that, the deflection and shear is the more at wind loads compared to seismic loads. It insists in providing more reinforcement at higher sections to counteract the lateral force.

- **B. S. Mashalkar et al., (2017)** this deals with the event of buildings which are susceptible to wind action. To design the high-rise buildings in a much effective way, better understanding of interaction between building and wind is required. This paper gives comparative study of effect of wind on plans with a spread irregular shape as I, C, T and L. The wind load is estimated based on basic wind speed for that region the outcome of the study gives the calculation of wind loads for structural frame with different plan shapes and therefore the permissible drifts of individual buildings and located that wind load on the building is maximum when it's maximum exposed area.

- **Daniel C, Levin Daniel and Joel Shelton and Arun Raj and Vincent Sam Jebadurai S and Hemalata G (2017)** In the recent past many tall buildings are being inbuilt India. The impact of wind loads is to be considered for the planning of tall multistoried buildings. Several failures of structures have occurred in India thanks to wind. In this paper comparison of the two international wind codes first Indian code (IS 875:2009 Part 3) and second American code (ASCE-7:2002). Using SAP 2000 software all wind load forces data added to the structure with various load cases for various storey was analyzed. The lateral load to stories was 0-degree (along the building in x direction) and 90-degree (across the building in y direction) degree. Comparison of Bending moment and shear force according to different wind loading codes. American code is simpler for designing for wind loads because it gives less chance of failure as compared to Indian code.

- **Shams Ahmed and Prof. S Mandal (2017)** The research paper discusses a comparative study of 5 major international codes and standards with the newest Indian Code for wind load i.e. IS 875 part-3 2015 for along wind loads on high rise structures and other provisions for along and across wind response on high rise building by Gust Factor Method. The major international codes and standards of wind loads included within the scope of this research paper are ASCE-7-98 (United States), AS1170.2-89 (Australia), NBC-1995 (Canada), RLB-AIJ-1993 (Japan), Eurocode 1-4 (1993). The research work is basically a presence of latest Indian Code IS 875 Part 3 (2015) in the comparative study and this study published by Yin Zhou, Tracy Kijewski and Ahsan Kareem. Major emphasis is put on the gust factor method approach for estimating along wind loads on tall buildings. A detailed example is also solved at the end so as to facilitate quantitative comparison.

2.2 SUMMARY OF LITERATURE REVIEW:

From literature survey it is observed that most of the paper have compared the international wind codes with Indian codes and to design the building in much effective way and better interaction between building and wind is required. From the structural point of view the interaction between building and wind either along and across the direction. Therefore, structural framework for high rise structures is developed all around concepts associated entirely with resistance to turbulent effect of wind. However, it is seems that there is no one worked on the comparison of wind response different shapes of the building according to the different international codes and this study is related to the comparison of the wind response on the building according to the different wind loading codes. in this we consider different shapes of the building.

CHAPTER-3

RCC FRAME STRUCTURES

An RCC framed structure is essentially an assembly of slabs, beams, columns and foundation inter -connected to every other as a unit. The load transfer, in such a structure takes place from the slabs to the beams, from the beams to the columns then to the lower columns and eventually to the foundation which successively transfers it to the soil. The floor area of a R.C.C framed structure building is 10 to 12 percent quite that of a load bearing walled building. Monolithic construction is achievable with R.C.C framed structures. monolithic buildings can easily resist vibrations, wind loading, earthquake more effectively than load bearing walled buildings. Speed of building for RCC framed structures is speedier.

3.1 - ASSUMPTIONS IN DESIGN: -

• Using partial factor of safety for loads in the clause 36.4 of IS-456-2000 Υt=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.

3.2 - LOAD COMBINATION TO BE CONSIDERED IN WIND LOAD: -

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

1. 1.5(D+L)
2. 1.2(D+L+W X dir.)
3. 1.2(D+L+W Z dir.)

Total load cases = 3

3.3 - CODE AND STANDARDS CONSIDERED IN THIS PROJECT:

1. Indian standard (875(part 3)-2015)

2. Australian/New Zealand standard (AS/NZS1170(part 2):2011)

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

the essential wind speed for any site shall be obtained and modified to incorporate the subsequent effects to urge design wind speed, Vz 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:

$V_z=V_b\times K_1\times K_2\times K_3\times K_4$,

Where,

V_z = design wind speed at any height z in m/s,

K_1 = probability factor (risk coefficient) (5.3.1),

K_2 = terrain roughness and height factor (5.3.2),

K_3 = topography factor (5.3.3),

K_4 = importance factor for the cyclonic region (5.3.4).

The wind pressure at any height above mean ground level shall be obtained by the subsequent relationship between wind pressure and wind speed,

$P_z=0.6\times(V_z)^2$

Where,

P_z = wind pressure in N/m^2 at height z,

V_z = design wind speed in m/s at height z. the planning wind pressure Pd is obtained as,

$P_d = K_d \times K_a \times K_c \times P_z$

Where,

P_d = design wind pressure in N/m^2 at height z,

K_d = Wind directionality factor

K_a = Area averaging factor

K_c = Combination factor

Wind force during a Building (F) Wind force during a Building

$F = C_f \times P_d \times$area exposed

C_f may be a force coefficient depends upon shape of element plan size & wind dir.

WIND LOAD CALCULATION AS PER AUSTRALIAN/NEW ZEALAND STANDARD AS/NZS 1170 PART 2(2011):

Australian/New Zealand standard AS/NZS 1170 part 2 defines the location wind speeds which can define design wind speed. the location wind speed are often calculated as follows:

$V_{site,\beta} = V_R \times M_d \times M_{z,cat} \times M_s \times M_t$

Where,

V_R = regional 3 s gust wind speed for Australia and New Zealand sites.

M_d = wind directional multipliers

$M_{z,cat}$ = is terrain/height multiplier.

M_s = shielding multiplier.

M_t is topographic multiplier. the planning wind pressures (P) consistent with AS/NZS 1172 part 2 are often determined for pressure vessel or tank as follows:

$p=0.5[V_{des,\theta}]^2\times\rho_{air}\times C_{fig}\times C_{dyn}$

Where,

$p=0.5[V_{des,\theta}]^2\times\rho_{air}\times C_{fig}\times C_{dyn}$

p =Design wind pressure

ρ_{air} = density of air=$1.2kg/m^3$

$V_{des,\theta}$ = building orthogonal design wind speeds

C_{fig} = aerodynamic shape factor

C_{dyn} = dynamic factor

Design wind force derived from force coefficients:

$F=0.5\times[V_{des,\theta}]^2\times\rho_{air}\times C_{fig}\times C_{dyn}\times A_z$

$F=p\times A_z$

Where, A_z is projected Area with drag force coefficient C_{dyn},

3.3 - COMPARISON OF IMPORTANT PARAMETERS

Comparison of important parameters from international standards with Indian standard is given in table below. The table shows the variation of parameters like design wind speed, design wind pressures, pressure coefficients and gust loading factor.

Comparison of building codes with reference to wind force determination;

IS 875:2015(Part3)	AS/NZ 1170.2 2011
$V_z=V_b \times K_1 \times K_2 \times K_3 \times K_4$, Where, V_z = design wind speed at any height z in m/s, K_1 = probability factor (risk coefficient), K_2 = terrain roughness and height factor, K_3 = topography factor, K_4 = importance factor for the cyclonic region.	$V_{site,\beta} = V_R \times M_d \times M_{z,cat} \times M_s \times M_t$ Where, V_R = regional 3 s gust wind speed for Australia and New Zealand sites. M_d = wind directional multipliers $M_{z,cat}$ = is terrain/height multiplier. M_s = shielding multiplier.

$P_z=0.6 \times (V_z)^2$ Where, P_z = wind pressure in N/m^2 at height z, V_z = design wind speed in m/s at height z. the planning wind pressure Pd is obtained as, $P_d=K_d \times K_a \times K_c \times P_z$ Where, P_d = design wind pressure in N/m^2 at height z, K_d = Wind directionality factor	$p=0.5[V_{des,\theta}]^2 \times \rho_{air} \times C_{fig} \times C_{dyn}$ Where, $p=0.5[V_{des,\theta}]^2 \times \rho_{air} \times C_{fig} \times C_{dyn}$ p =Design wind pressure ρ_{air} = density of air=$1.2 kg/m^3$ $V_{des,\theta}$ = building orthogonal design wind speeds C_{fig} = aerodynamic shape factor C_{dyn} = dynamic factor

K_a = Area averaging factor K_c = Combination factor	

CHAPTER - 4

DETAILS OF THE MODELS STUDIED

In order to evaluate the story displacement and base shear between different shapes of buildings, five sample building models are adopted which plan area is 36x36 for all the shape. The finite element analysis software STAAD is used to create 3D model and analysed. The wind load analysis as per IS:875 part 3 is completed on all the form of building in plan. The various shapes models are square, rectangular, diamond, hexagonal, octagonal.

4.1 - MODELLING AND ANALYSIS

To study the effect of various shapes of tall structures subjected to wind excitation. four different shaped building models has been considered. These models are same characteristics as same height, same area in plan, and also considered in same locality.

Table 4.1 -Design parameters of 36m height building

No. of storey	G+11
Column	0.350 m x0.350 m
Beam	0.300 m x0.500 m
Slabs	0.15 m
Live load on slab	3 KN/m2
Floor finish	3 KN/m2
Grade of concrete in column	M 25
Grade of concrete in beam	M 25
Grade of steel	Fe 500
Total height	36 m
Height of ground storey	3 m
Height of floor to floor	3 m
Spacing of frame along length	4 m
Spacing of frame along width	4 m
Thickness of external wall	.230 m
Thickness of internal wall	.115 m

A another study carried out on a high rise building which is a RCC frame structure residential type building assumed to be located in a Delhi and there is no vertical irregularities .topography is flat in all direction building is rectangular in cross section (50m by 70m), building having height above ground surface is 150m. roof is flat. Wind dir. is normal to the 70m wall face basic wind speed is 47m/s. terrain category is considered 3 categories in both the wind codes.

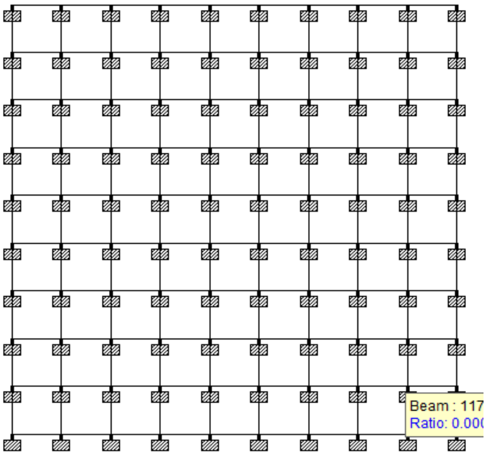
Table4.2 -Design parameters of 150m height building

No. of storey	50
Column	1 m x1m
Beam	0.300 m x0.600 m
Slabs	0.15 m
Live load on slab	3 KN/m2
Floor finish	3 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	3 m
Height of floor to floor	3 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

4.2 - PLAN OF THE DIFFERENT SHAPES OF BUILDINGS:

FIGURE OF 36M HEIGHT BUILDING:

SQUARE SHAPE:



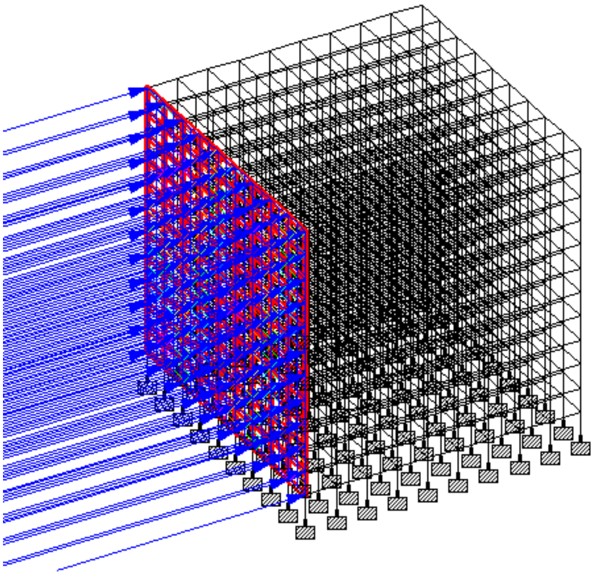
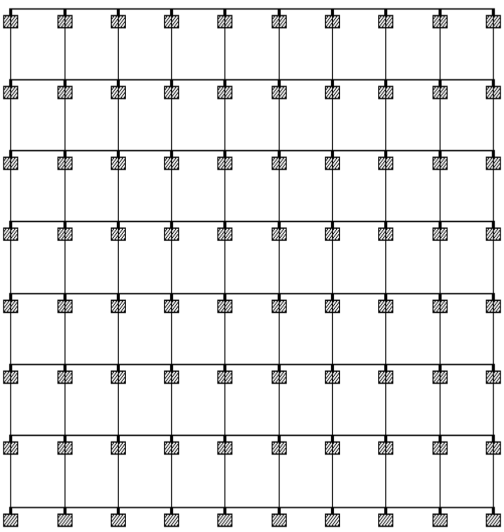


Figure 4.1: Plan of square building **Figure 4.2:** wind load in X dir

RECTANGULAR SHAPE:



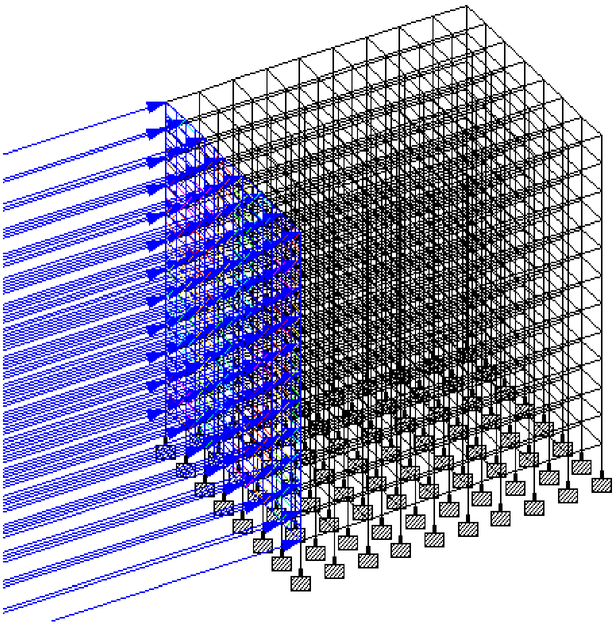


Figure 4.3: Plan of rectangular building **Figure 4.4:** wind load in X dir

DIAMOND SHAPE:

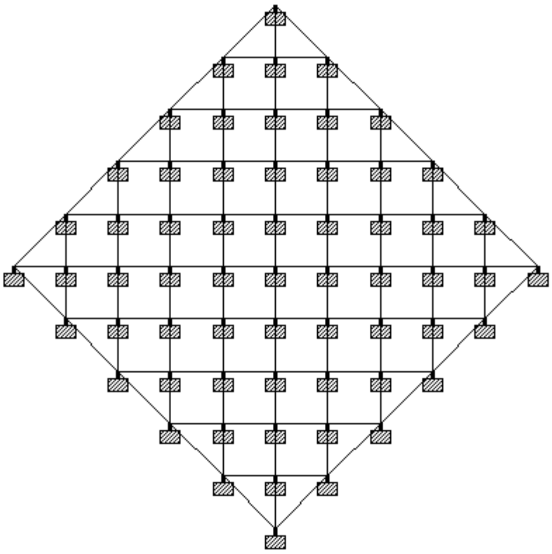


Figure 4.5: Plan of diamond building

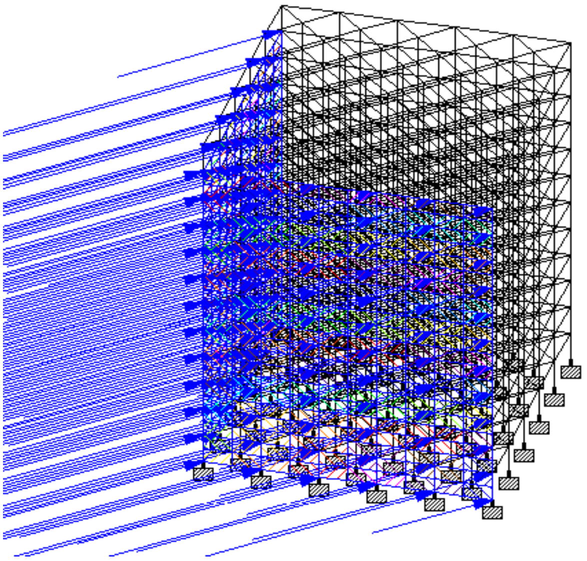


Figure 4.6: wind load in X dir

OCTAGONAL SHAPE:

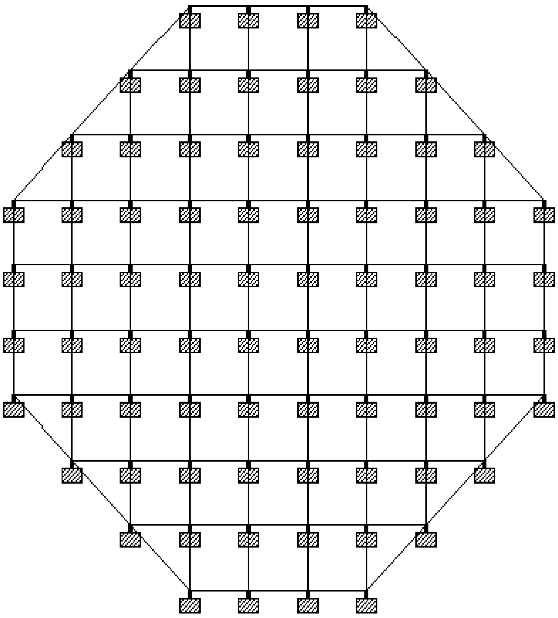


Figure 4.7: Plan of octagonal building

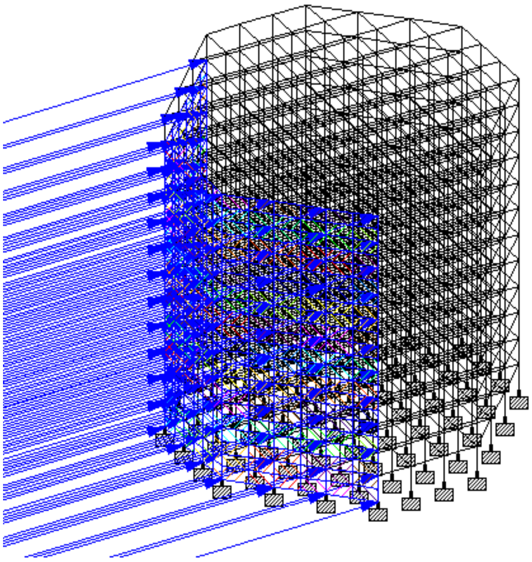
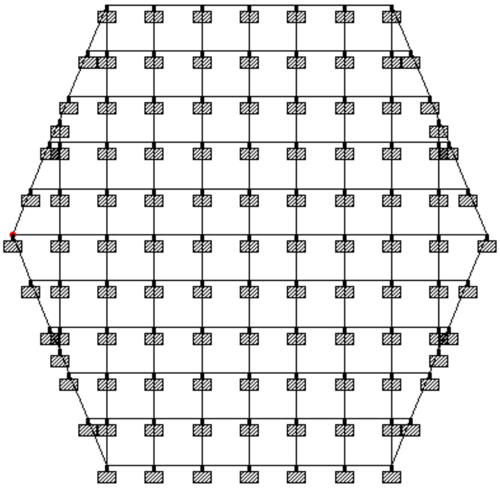


Figure 4.8: wind load in X dir

HEXAGONAL BUILDING:



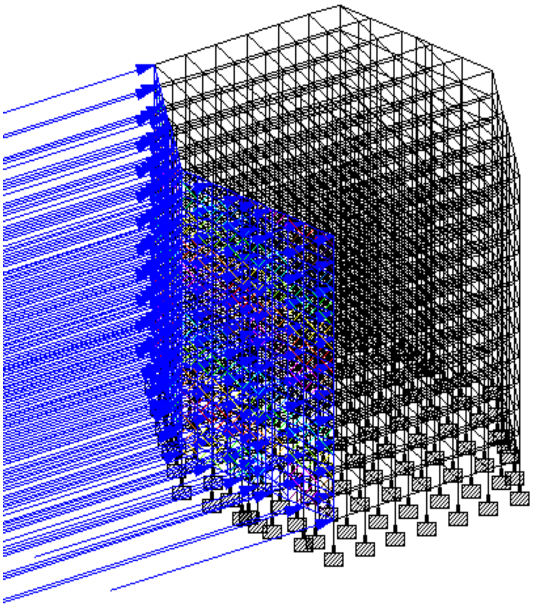
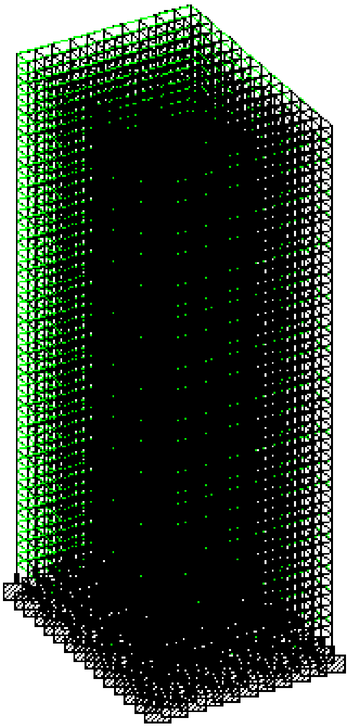


Figure 4.9: Plan of hexagonal building **Figure 4.10:**wind load in X dir

FIGURE OF 150M HEIGHT BUILDING:



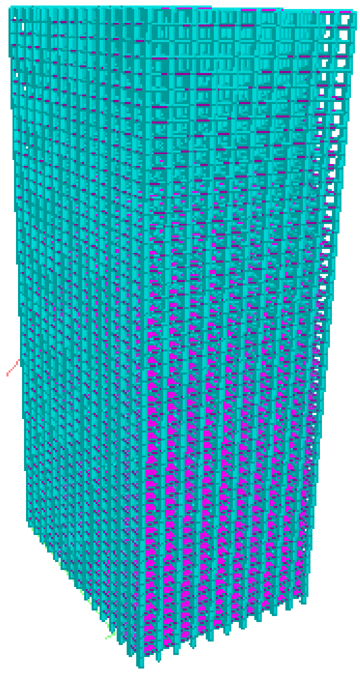


Figure 4.11: 3d view **Figure 4.12:** 3d rendering view

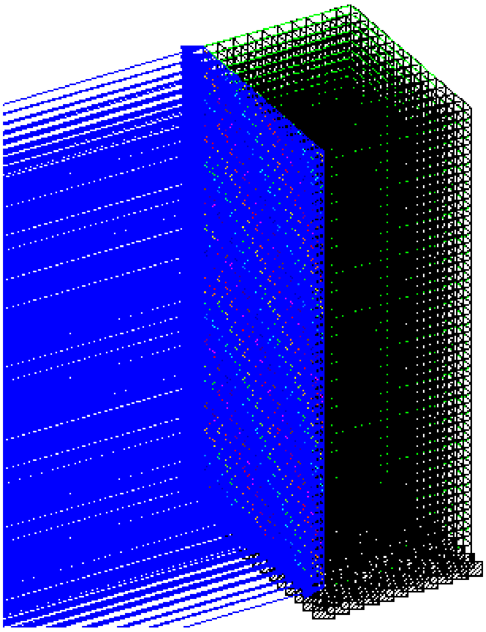


Figure 4.13: wind in x dir

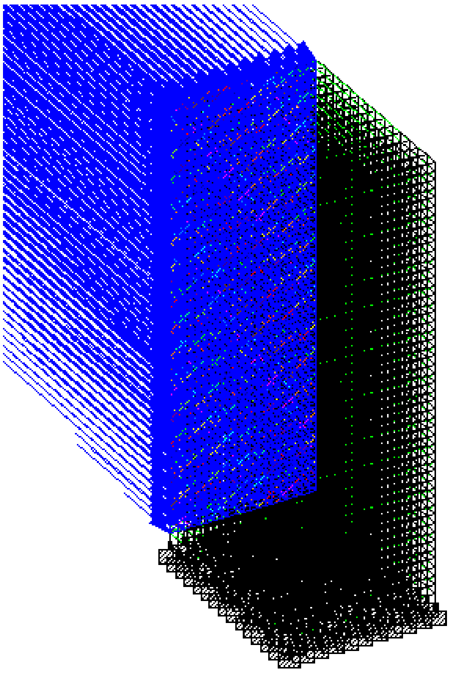


Figure 4.14: wind in z dir

4.3 - WIND LOAD CALCULATION:

36M HEIGHT OF BUILDING:

DEAD LOAD CALCULATION AS PER IS 875 PART 1:

Self-weight of beam and column (as per staad pro)

Floor load: Load intensity on slab = $0.150 \times 25 = 3.75\ KN/m^2$

Floor finisher = 3 KN/m^2

Total floor load = $6.75\ KN/m^2$

Member load: -

External wall = $.230 \times 1 \times 3 \times 19 = 13.12\ KN/m^2$

Internal wall = $.115 \times 1 \times 3 \times 19 = 6.56\ KN/m^2$

LIVE LOAD CALCULATION AS PER IS 875 PART 2:

Live load = 3 KN/m^2 for every floor

WIND LOAD CALCULATION AS PER IS 875 PART3 (2015): -

SQUARE SHAPE:

$V_z = V_b \times K_1 \times K_2 \times K_3 \times K_4$,

Where,

V_z = design wind speed at any height z in m/s,

K_1 = probability factor (risk coefficient) (5.3.1),

K_2 = terrain roughness and height factor (5.3.2),

K_3 = topography factor (5.3.3),

K_4 = importance factor for the cyclonic region (5.3.4).

Vb, wind speed $= 47\ m/sec$ for Delhi (zone 4)

K_1= 1

K_2= For Terrain category III

Height in meter	K_2
10	0.91
15	0.97
20	1.01
30	1.06
50	1.12

K_3=1 for plain category.

K_4=1 for a non-cyclonic region

$V_z = 47 \times 1 \times K2 \times 1.0 = 47\ K2$

$P_z = 0.6 \times Vz^2$

Where,

P_z = wind pressure in N/m2 at height z,

V_z = design wind speed in m/s at height z.

$P_d = K_d \times K_a \times K_c \times P_z$

Where,

P_d =design wind pressure in N/m2 at height z,

K_d = wind directionally factor

K_d = 0.9 for rectangular / square / triangular

K_a = area averaging factor

K_a = 0.986 for (tributary area in x dir & z dir are same =4x3=12)

K_c = Combination factor

K_c = 0.9 (frame with roof)

$P_d = 0.9 \times 0.986 \times 0.9 \times Pz = 0.798\, Pz$

The coefficient Cf is found from Figure 4A ($\frac{36}{36} = 1$) of IS 875-Part 3

$\frac{a}{b}$ = Width of Building/Length of Building= $\frac{36}{36} = 1$

$\frac{h}{a}$ =Height of Building/ Width of building= $\frac{36}{36} = 1$

$\frac{h}{b}$ = Height of Building/length of Building=$\frac{36}{36} = 1$

For $\frac{h}{a} = 1$ Cf= 1.25 in X direction in STAAD

For $\frac{h}{b} = 1$ Cf= 1.25 in Z direction in STAAD

Wind force in a Building (F) = $C_f \times P_d \times$ area exposed.

C_f is a force coefficient depends upon shape of element plan size & wind dir.

The values are tabulated as follows:

height	K_2	$V_z=V_b\times K_1\times K_2\times K_3\times K_4$	$P_z=0.6\times Vz^2$ N/m^2	$P_d=K_d\times K_a\times K_c\times P_z$ N/m^2	$P_i=C_f\ P_d$ KN/m^2	
					X dir.	Y dir.
10	0.91	42.77	1097.56	875.85	1.09	1.09
15	0.97	45.59	1247.06	983.93	1.22	1.22
20	1.01	47.47	1352.04	1080.52	1.35	1.35
30	1.06	49.82	1489.21	1188.38	1.48	1.48
50	1.12	52.64	1662.58	1326.73	1.65	1.65

RECTANGULAR SHAPE:

$V_z=V_b\times K_1\times K_2\times K_3\times K_4$,

Where,

V_z = design wind speed at any height z in m/s,

K_1 = probability factor (risk coefficient) (5.3.1),

K_2 = terrain roughness and height factor (5.3.2),

K_3 = topography factor (5.3.3),

K_4 = importance factor for the cyclonic region (5.3.4).

$K_1 = 1$

K_2 = For Terrain category III

Height in meter	K_2
10	0.91
15	0.97
20	1.01
30	1.06
50	1.12

K_3 =1 for plain category.

K_4=1 for a non-cyclonic region

V_z = 47×1×K_2×1.0= 47 K_2

P_z=0.6×Vz^2

Where,

P_z = wind pressure in N/m2 at height z,

V_z = design wind speed in m/s at height z.

P_d=K_d×K_a×K_c×P_z

Where,

P_d =design wind pressure in N/m2 at height z,

K_d= wind directionally factor

K_d= 0.9 for rectangular / square / triangular

K_a= area averaging factor

K_a= 0.986 for (tributary area in x dir & z dir are same =4×3=12)

K_c = Combination factor

K_c= 0.9 (frame with roof)

P_d = 0.9×0.986×0.9×P_z = 0.798P_z

The coefficient C_f is found from Figure 4A ($\frac{36}{36} = 1$) of IS 875-Part 3

$\frac{a}{b} =$ Width of Building/Length of Building= $\frac{36}{28} = 1.285$

$\frac{h}{a}$ =Height of Building/ Width of building= $\frac{36}{28} = 1.285$

$\frac{h}{b} =$ Height of Building/length of Building=$\frac{36}{36} = 1$

For $\frac{h}{b} = 1.285$,C_f= 1.25 in X direction in STAAD

For $\frac{h}{b} = 1,$ C_f= 1.2 in Z direction in STAAD

Wind force in a Building (F) = $C_f \times P_d \times$ area exposed.

C_f is a force coefficient depends upon shape of element plan size & wind dir.

The values are tabulated as follows:

height	K_2	$V_z=V_b\times K_1\times K_2\times K_3\times K_4$	$P_z=0.6\times Vz^2$ N/m^2	$P_d=K_d\times K_a\times K_c\times P_z$ N/m^2	$P_i=C_fP_d$ KN/m^2	
					X dir.	Y dir.
10	0.91	42.77	1097.56	875.85	1.10	1.01
15	0.97	45.59	1247.06	983.93	1.23	1.13
20	1.01	47.47	1352.04	1080.52	1.35	1.24
30	1.06	49.82	1489.21	1188.38	1.485	1.37
50	1.12	52.64	1662.58	1326.73	1.66	1.53

DIAMOND SHAPE:

$V_z=V_b\times K_1\times K_2\times K_3\times K_4$,

Where,

V_z = design wind speed at any height z in m/s,

K_1 = probability factor (risk coefficient) (5.3.1),

K_2 = terrain roughness and height factor (5.3.2),

K_3 = topography factor (5.3.3),

K_4 = importance factor for the cyclonic region (5.3.4)

V_b, wind speed $= 47\ m/sec$ for Delhi (zone 4)

K_1= 1

K_2= For Terrain category III

Height in meter	K_2
10	0.91
15	0.97
20	1.01
30	1.06

50	1.12

K_3 =1 for plain category.

K_4=1 for a non-cyclonic region

V_z = 47×1×K2×1.0= 47 K2

$P_d = K_d \times K_a \times K_c \times P_z$

K_d = 0.9

K_a = 0.986

K_c= 0.9 (frame with roof)

P_d = 0.9×0.986×0.9×P_z = 0.798 P_z

The coefficient C_f is found from Table no. 29

$\frac{h}{b}$ =Height of Building/ Width of building $= \frac{36}{20} = 1.8$

coefficient C_f is 0.88

Wind force in a Building (F) = $C_f \times P_d \times$area exposed.

C_f is a force coefficient depends upon shape of element plan size & wind dir.

The values are tabulated as follows:

height	K_2	$V_z=V_b \times K_1 \times K_2 \times K_3 \times K_4$	$P_z=0.6 \times Vz^2$ N/m^2	$P_d=K_d \times K_a \times K_c \times P_z$ N/m^2	$P_i=C_f P_d$ KN/m^2	
					X dir.	Y dir.
10	0.91	42.77	1097.56	875.85	0.770	0.770
15	0.97	45.59	1247.06	983.93	0.865	0.865
20	1.01	47.47	1352.04	1080.52	0.950	0.950
30	1.06	49.82	1489.21	1188.38	1.045	1.045
50	1.12	52.64	1662.58	1326.73	1.167	1.167

HEXAGONAL SHAPE:

$V_z=V_b\times K_1\times K_2\times K_3\times K_4$,

Where,

V_z = design wind speed at any height z in m/s,

K_1 = probability factor (risk coefficient) (5.3.1),

K_2 = terrain roughness and height factor (5.3.2),

K_3 = topography factor (5.3.3),

K_4 = importance factor for the cyclonic region (5.3.4)

V_b, wind speed =47 m/sec for Delhi (zone 4)

K_1= 1

K_2= For Terrain category III

Height in meter	K2
10	0.91
15	0.97
20	1.01
30	1.06
50	1.12

K_3 =1 for plain category.

K_4=1 for a non-cyclonic region

$V_z = 47\times1\times K_2\times1.0= 47\ K_2$

$P_d=K_d\times K_a\times K_c\times P_z$

$K_d = 0.9$

$K_a = 0.986$ for

$K_c = 0.9$ (frame with roof)

$P_d = 0.9\times0.986\times0.9\times P_z = 0.798\ P_z$

The coefficient C_f is found from Table no. 29

$\frac{h}{b}$ =Height of Building/ Width of building= $\frac{36}{36} = 1$

coefficient C_f is 1.1

Wind force in a Building (F) = $C_f \times P_d \times$area exposed.

C_f is a force coefficient depends upon shape of element plan size & wind dir.

The values are tabulated as follows:

height	K_2	$V_z=V_b\times K_1\times K_2\times K_3\times K_4$	$P_z=0.6\times Vz^2$ N/m^2	$P_d=K_d\times K_a\times K_c\times P_z$ N/m^2	$P_i=C_f$ P_d KN/m^2	
					X dir.	Y dir.
10	0.91	42.77	1097.56	875.85	0.96	0.96
15	0.97	45.59	1247.06	983.93	1.08	1.08
20	1.01	47.47	1352.04	1080.52	1.19	1.19
30	1.06	49.82	1489.21	1188.38	1.31	1.31
50	1.12	52.64	1662.58	1326.73	1.46	1.46

OCTAGONAL SHAPE:

$V_z=V_b\times K_1\times K_2\times K_3\times K_4$,

Where,

V_z = design wind speed at any height z in m/s,

K_1 = probability factor (risk coefficient) (5.3.1),

K_2 = terrain roughness and height factor (5.3.2),

K_3 = topography factor (5.3.3),

K_4 = importance factor for the cyclonic region (5.3.4)

V_b, wind speed =47 m/sec for Delhi (zone 4)

K_1= 1

K_2= For Terrain category III

Height in meter	K_2
10	0.91
15	0.97

20	1.01
30	1.06
50	1.12

K_3 =1 for plain category.

K_4 =1 for a non-cyclonic region

V_z= 47×1×K_2×1.0= 47 K2

$P_d = K_d \times K_a \times K_c \times P_z$

K_d = 0.9

K_a = 0.986 for

K_c = 0.9 (frame with roof)

P_d = 0.9 x 0.986 x 0.9x P_z = 0.798P_z

The coefficient C_f is found from Table no. 29

$\frac{h}{b}$ =Height of Building/ Width of building= $\frac{36}{36} = 1$

coefficient C_f is 1

Wind force in a Building (F) = $C_f \times P_d \times$area exposed.

C_f is a force coefficient depends upon shape of element plan size & wind dir.

The values are tabulated as follows:

height	K_2	$V_z=V_b \times K_1 \times K_2 \times K_3 \times K_4$	$P_z=0.6 \times Vz^2$ N/m^2	$P_d=K_d \times K_a \times K_c \times P_z$ N/m^2	$P_i=C_f$ P_d KN/m^2	
					X dir.	Y dir.
10	0.91	42.77	1097.56	875.85	0.88	0.88
15	0.97	45.59	1247.06	983.93	0.98	0.98
20	1.01	47.47	1352.04	1080.52	1.10	1.10
30	1.06	49.82	1489.21	1188.38	1.20	1.20
50	1.12	52.64	1662.58	1326.73	1.33	1.33

WIND LOAD CALCULATION AS PER AS/NZ 1170.2 (2011) – RECTANGULAR SHAPE:

$V_{site,\beta} = V_R \times M_d \times M_{z,cat} \times M_s \times M_t$

Where,

V_R = regional 3 s gust wind speed for Australia and New Zealand sites.

M_d = wind directional multipliers

$M_{z,cat}$ = is terrain/height multiplier.

M_s = shielding multiplier.

M_t = topographic multiplier

V_R, wind speed =47 m/sec

M_d= 1

$M_{z,cat}$ =For Terrain category III Height in meter

height	M_{zcat}
3	.83
5	.83
10	.83
15	.89
20	.94
30	1
40	1.04

M_s=1

M_t=1

$V_{sit} = 47 \times 1 \times M_{zcat} \times 1.0 = 47\ M_{zcat}$

$p=0.5[V_{des,\theta}]^2 \times \rho_{air} \times C_{fig} \times C_{dyn}$

Where,

P=Design wind pressure

ρ_{air} =1.2 kg/m^3, density of air

$V_{des,\theta}$ = 47 Mzcat, building orthogonal design wind speeds

C_{dyn} =1, dynamic factor

C_{fig} =aerodynamic shape factor

$C_{fig}=K_{ar}\times K_i\times C_f$ along member's x-axis (major axis)

$C_{fig}=K_{ar}\times K_i\times C_f$, along member's y-axis (minor axis)

K_{ar} =0.7 for the $\frac{l}{b}$ ratio = 8

aspect ratio correction factor for individual member forces, as given in Table E I

K_i = 1.0, when the wind is normal to the member

The coefficient C_{fig} is found from

Figure E2(A) or Figure E2(B)

$\frac{d}{b} = Width\ of\ Building/Length\ of\ Building = \frac{28}{36} = 0.778$

For $\frac{d}{b}$ = 0.778, C_f= 2.70 in X direction in STAAD

For $\frac{d}{b}$ = 0.778, C_f=1.08 in Z direction in STAAD

C_{fig}=1×0.7×2.70=1.89 in X direction in STAAD

C_{fig}=1×0.7×1.08=0.75 in Z direction in STAAD

$P = 0.5 \times 1.2\times(47\times M_{zcat})^2 \times C_{fig} \times 1 = 1325.4\ (M_{zcat})^2\ C_{fig}$

Wind force in a Building (F) = P × area exposed.

C_f is a force coefficient depends upon shape of element plan size & wind dir.

The values are tabulated as follows:

height	$M_{z,cat}$	$V_{site,\beta}=V_R\times M_d\times M_{z,cat}\times M_s\times M_t$ m/sec	$p=0.5[V_{des,\theta}]^2\times\rho_{air}\times C_{fig}\times C_{dyn}$ N/m^2	P in KN/m^2	
				X dir	Y dir
3	0.83	39.01	913.06xCfig	1.72	0.68
5	0.83	39.01	913.06xCfig	1.72	0.68
10	0.83	39.01	913.06xCfig	1.72	0.68
15	0.89	41.83	1049.84xCfig	1.98	0.78

20	0.94	44.18	1171.12xCfig	2.21	0.87
30	1	47	1325.40xCfig	2.42	0.99
40	1.04	48.88	1433.55xCfig	2.70	1.07

SQUARE SHAPE:

$V_{site,\beta} = V_R \times M_d \times M_{z,cat} \times M_s \times M_t$

Where,

V_R = regional 3 s gust wind speed for Australia and New Zealand sites.

M_d = wind directional multipliers

$M_{z,cat}$ = is terrain/height multiplier.

M_s = shielding multiplier.

M_t = topographic multiplier

V_R, wind speed $= 47\ m/sec$

$M_d = 1$

M_{zcat} = For Terrain category III Height in meter

height	M_{zcat}
3	0.83
5	0.83
10	0.83
15	0.89
20	0.94
30	1.01
40	1.04

M_s=1

M_t=1

V_{sit} = 47 x 1 x M_{zcat} x 1.0 = 47 M_{zcat}

$p=0.5[V_{des,\theta}]^2 \times \rho_{air} \times C_{fig} \times C_{dyn}$

where,

P=Design wind pressure

ρ_{air} =1.2 kg/m3, density of air

$V_{des,\theta}$ = 47 Mzcat, building orthogonal design wind speeds

C_{dyn} =1, dynamic factor

C_{fig} =aerodynamic shape factor

C_{fig}= K_{ar}×K_i×C_f (x dir.),

K_{ar} =0.7 for the $\frac{l}{b}$ ratio =8

aspect ratio correction factor for individual member forces, as given in Table E I

K_i= 1.0, when the wind is normal to the member

The coefficient C_f is found from Table E4 C_f =2.2

C_{fig}=2.2×0.7×1=1.54

P = 0.5 ×1.2×(47×M_{zcat})^2×C_{fig}×1 = 1325.4 M_{zcat}^2 Cfig

Wind force in a Building (F) = P × area exposed.

C_f is a force coefficient depends upon shape of element plan size & wind dir.

The values are tabulated as follows:

height	$M_{z,cat}$	$V_{site,\beta}=V_R \times M_d \times M_{z,cat} \times M_s \times M_t$ m/sec	$p=0.5[V_{des,\theta}]^2 \times \rho_{air} \times C_{fig} \times C_{dyn}$ N/m^2	P in KN/m^2
3	0.83	39.01	913.06xCfig	1.40
5	0.83	39.01	913.06xCfig	1.40
10	0.83	39.01	913.06xCfig	1.40
15	0.89	41.83	1049.84xCfig	1.61
20	0.94	44.18	1171.12xCfig	1.80
30	1.01	47	1325.40xCfig	2.04
40	1.04	48.88	1433.55xCfig	2.20

DIAMOND SHAPE:

$V_{site,\beta} = V_R \times M_d \times M_{z,cat} \times M_s \times M_t$

Where,

V_R = regional 3 s gust wind speed for Australia and New Zealand sites.

M_d = wind directional multipliers

$M_{z,cat}$ = is terrain/height multiplier.

M_s = shielding multiplier.

M_t = topographic multiplier

V_R, wind speed $= 47\ m/sec$

Md= 1

M_{zcat} = For Terrain category III Height in meter

height	M_{zcat}
3	.83
5	.83
10	.83
15	.89
20	.94
30	1.01
40	1.04

M_s=1

M_t=1

$V_{sit} = 47 \times 1 \times M_{zcat} \times 1.0 = 47\ M_{zcat}$

$p=0.5[V_{des,\theta}]^{\wedge}2 \times \rho_{air} \times C_{fig} \times C_{dyn}$

Where,

p=Design wind pressure

ρ_{air} =1.2 kg/m^3, density of air

$V_{des,\theta}$ = 47 Mzcat, building orthogonal design wind speeds

C_{dyn} =1, dynamic factor

C_{fig} =aerodynamic shape factor

C_{fig}= Kar Ki CF (x dir.),

K_{ar} =0.7 for the $\frac{l}{b}$ ratio = 8

aspect ratio correction factor for individual member forces, as given in Table E I

K_i= 1, when the wind is normal to the member

The coefficient Cf is found from Table E4 Cf=1.5

C_{fig}=1.5×0.7×1=1.05

P = 0.5×1.2×(47×M_{zcat})^2×C_{fig}×1 = 1325.4 M_{zcat}^2 C_{fig}

Wind force in a Building (F) = P×area exposed.

C_f is a force coefficient depends upon shape of element plan size & wind dir.

The values are tabulated as follows:

height	$M_{z,cat}$	$V_{site,\beta}=V_R \times M_d \times M_{z,cat} \times M_s \times M_t$ m/sec	$p=0.5[V_{des,\theta}]^2 \times \rho_{air} \times C_{fig} \times C_{dyn}$ N/m^2	P in KN/m^2
3	.83	39.01	913.06xCfig	0.96
5	.83	39.01	913.06xCfig	0.96
10	.83	39.01	913.06xCfig	0.96
15	.89	41.83	1049.84xCfig	1.10
20	.94	44.18	1171.12xCfig	1.23
30	1.01	47	1325.40xCfig	1.40
40	1.04	48.88	1433.55xCfig	1.50

OCTAGONAL SHAPE:

$V_{site,\beta} = V_R \times M_d \times M_{z,cat} \times M_s \times M_t$

Where,

V_R = regional 3 s gust wind speed for Australia and New Zealand sites.

M_d = wind directional multipliers

$M_{z,cat}$ = is terrain/height multiplier.

M_s = shielding multiplier.

M_t = topographic multiplier

V_R, wind speed =47 m/sec

M_d= 1

M_{zcat} =For Terrain category III Height in meter

height	M_{zcat}
3	0.83
5	0.83
10	0.83
15	0.89
20	0.94
30	1.01
40	1.04

M_s=1

M_t=1

V_{sit} = 47×1×Mzcat×1.0 = 47 M_{zcat}

$p=0.5[V_{des,\theta}]^2\times\rho_{air}\times C_{fig}\times C_{dyn}$

Where,

p =Design wind pressure

ρ_{air} =1.2 kg/m3, density of air

$V_{des,\theta}$ = 47 Mzcat, building orthogonal design wind speeds

C_{dyn} =1, dynamic factor

C_{fig} =aerodynamic shape factor

C_{fig}= K_{ar} K_i C_F (x dir.),

K_{ar} =0.7 for the $\frac{l}{b}$ ratio =8

aspect ratio correction factor for individual member forces, as given in Table E I

K_i= 1.0, when the wind is normal to the member

The coefficient C_f is found from Table E4 C_f=1.4

C_{fig}=1.4×0.7×1=0.98

$P = 0.5\times1.2\times(47\times M_{zcat})^2\times C_{fig}\times1 = 1325.4\ M_{zcat}^2\ \ C_{fig}$

Wind force in a Building (F) = P × area exposed.

C_f is a force coefficient depending upon shape of element plan size & wind direction

The values are tabulated as follows:

height	$M_{z,cat}$	$V_{site,\beta}=V_R\times M_d\times M_{z,cat}\times M_s\times M_t$ m/sec	$p=0.5[V_{des,\theta}]^2\times\rho_{air}\times C_{fig}\times C_{dyn}$ N/m^2	P in KN/m^2
3	.83	39.01	913.06xCfig	0.90
5	.83	39.01	913.06xCfig	0.90
10	.83	39.01	913.06xCfig	0.90
15	.89	41.83	1049.84xCfig	1.03
20	.94	44.18	1171.12xCfig	1.15
30	1.01	47	1325.40xCfig	1.30
40	1.04	48.88	1433.55xCfig	1.40

CALCULATION OF 150M HEIGHT OF BUILDING:

DEAD LOAD CALCULATION AS PER IS 875 PART 1:

Self-weight of beam and column (as per staad pro)

Floor load: Load intensity on slab = $0.150 \times 25 = 3.75\ KN/m^2$

Floor finisher = $3\ KN/m^2$

Total floor load = $6.75 KN/m^2$

Member load:

External wall = $.230 \times 1 \times 3 \times 19 = 13.12 KN/m^2$

Internal wall = $.115 \times 1 \times 3 \times 19 = 6.56\ KN/m^2$

LIVE LOAD CALCULATION AS PER IS 875 PART 2:

Live load = $3 KN/m^2$ for every floor

WIND LOAD CALCULATION AS PER IS 875 PART3 (2015): -

$V_z = V_b \times K_1 \times K_2 \times K_3 \times K_4$,

Where,

V_z = design wind speed at any height z in m/s,

K_1 = probability factor (risk coefficient) (5.3.1),

K_2 = terrain roughness and height factor (5.3.2),

K_3 = topography factor (5.3.3),

K_4 = importance factor for the cyclonic region (5.3.4)

V_b, wind speed $= 47\ m/sec$ for Delhi (zone 4)

K_1= 1

K_2= For Terrain category III

Height in meter	K2
10	0.91
15	0.97
20	1.01
30	1.06
50	1.12
100	1.2
150	1.24

K_3 =1 for plain category.

K_4=1 for a non-cyclonic region

V_z= 47×1×K2×1.0= 47 K2

P_z = .6 Vz^2

Where,

P_z = wind pressure in N/m2 at height z,

V_z = design wind speed in m/s at height z.

$P_d = K_d \times K_a \times K_c \times P_z$

Where,

P_d =design wind pressure in N/m2 at height z,

K_d = wind directionally factor

K_d = 0.9 for rectangular / square / triangular

K_a = area averaging factor

K_a = 0.967 for (tributary area in x dir & z dir are same =4×3=12)

K_c = Combination factor

K_c = 0.9 (frame with roof)

$P_d = 0.9 \times 0.967 \times 0.9 \times P_z = 0.78327 P_z$

The coefficient C_f is found from Figure 4A ($\frac{36}{36} = 1$) of IS 875-Part 3

$\frac{a}{b}$ = Width of Building/Length of Building= $\frac{36}{28}$ =1.285

$\frac{h}{a}$ = Height of Building/ Width of building= $\frac{36}{28}$ =1.285

$\frac{h}{b}$ = Height of Building/length of Building=$\frac{36}{36} = 1$

For $\frac{h}{b} = 1.285$, Cf= 1.4 in X direction in STAAD

For $\frac{h}{b} = 1$, Cf= 1.25 in Z direction in STAAD

Wind force in a Building (F) = $C_f \times P_d \times$area exposed.

C_f is a force coefficient depends upon shape of element plan size & wind dir.

The values are tabulated as follows:

height	$K2$	$V_z=V_b \times K_1 \times K_2 \times K_3 \times K_4$ m/sec	$P_z=0.6 \times Vz^2$ N/m^2	$P=K_d K_a K_c P_z$ N/m^2	$Pi=C_f \times P_d$ KN/m^2	
					X dir.	Y dir.
10	0.91	42.77	1097.56	859.68	1.203552	1.0746
15	0.97	45.59	1247.06	976.79	1.367506	1.220988

20	1.01	47.47	1352.04	1059.01	1.482614	1.323763
30	1.06	49.82	1489.21	1166.46	1.633044	1.458075
50	1.12	52.64	1662.58	1302.25	1.82315	1.627813
100	1.2	56.4	1908.57	1494.93	2.092902	1.868663
150	1.24	58.28	2037.93	1596.25	2.23475	1.995313

WIND LOAD CALCULATION AS PER AS/NZ 1170.2 (2011) –

$V_{site,\beta} = V_R \times M_d \times M_{z,cat} \times M_s \times M_t$

Where,

V_R = regional 3 s gust wind speed for Australia and New Zealand sites.

M_d = wind directional multipliers

$M_{z,cat}$ = is terrain/height multiplier.

M_s = shielding multiplier.

M_t = topographic multiplier

V_R, wind speed =47 m/sec

M_d= 1

M_{zcat} =For Terrain category III Height in meter

height	M_{zcat}
3	.83
5	.83
10	.83
15	.89
20	.94
30	1
40	1.04
50	1.07
75	1.12
100	1.16
150	1.21

M_s=1

M_t=1

V_{sit} = 47 ×1×M_{zcat}×1.0 = 47 M_{zcat}

p=0.5$[V_{des,\theta}]^2 \times \rho_{air} \times C_{fig} \times C_{dyn}$

Where,

p =Design wind pressure

ρ_{air} =1.2 kg/m3, density of air

$V_{des,\theta}$ = 47 Mzcat, building orthogonal design wind speeds

C_{dyn} =1, dynamic factor

C_{fig} =aerodynamic shape factor

C_{fig}= Kar Ki CF (x dir.),

C_{fig} = Kar Ki CF (z dir.), along member's y-axis (minor axis)

K_{ar} =0.71 for the $\frac{l}{b}$ ratio =8.33

aspect ratio correction factor for individual member forces, as given in Table E I

K_i= 1.0, when the wind is normal to the member

The coefficient C_{fig} is found from

Figure E2(A) or Figure E2(B)

$\frac{d}{b}$ = Width of Building/Length of Building= $\frac{28}{36}$ =0.778

For $\frac{d}{b} = 0.714$, Cf= 2.85 in X direction in STAAD

For $\frac{d}{b}$ = 0.714, Cf= 1.1144 in Z direction in STAAD

C_{fig}=1×0.71×2.85=1.995 in X direction in STAAD

C_{fig}=1×0.71×1.1144=0.81 in Z direction in STAAD

P = 0.5 ×1.2×$(47 \times M_{zcat})^2 \times C_{fig}$×1=1325.4 M_{zcat}^2 C_{fig}

Wind force in a Building (F) = P x area exposed.

C_f is a force coefficient depends upon shape of element plan size & wind dir.

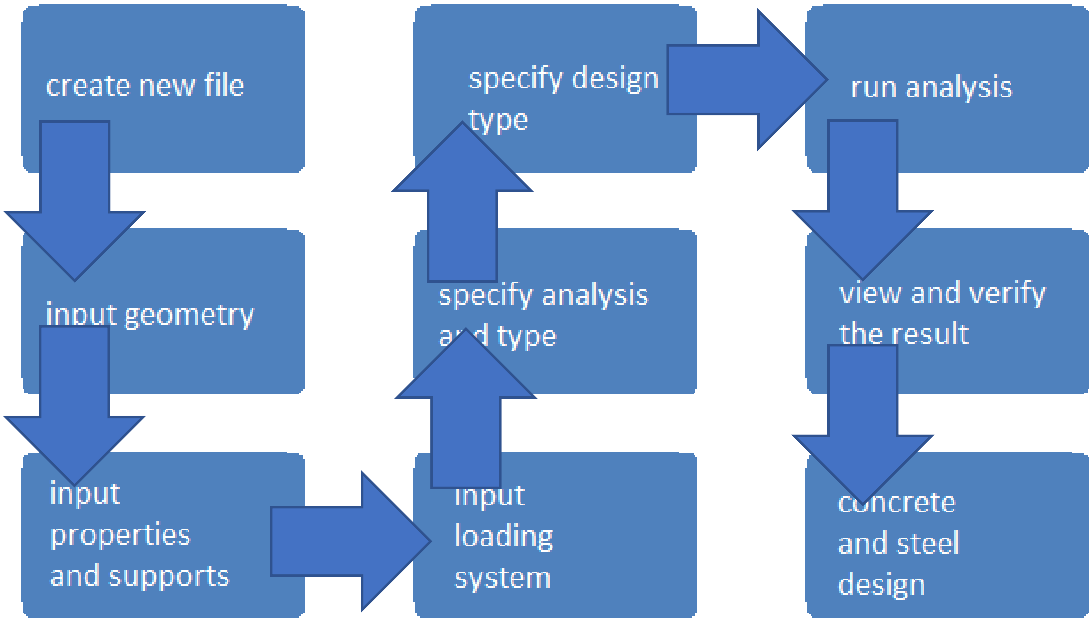
The values are tabulated as follows:

height	$M_{z,cat}$	$V_{site,\beta}=V_R\times M_d\times M_{z,cat}\times M_s\times M_t$ m/sec .	$p=0.5[V_{des,\theta}]^2\times\rho_{air}\times C_{fig}\times C_{dyn}$ N/m^2	P in KN/m^2	
				X dir.	Y dir.
3	0.83	39.01	$913.06\times Cfig$	1.82	0.73
5	0.83	39.01	$913.06\times Cfig$	1.82	0.73
10	0.83	39.01	$913.06\times Cfig$	2.09	0.73
15	0.89	41.83	$1049.84\times Cfig$	2.33	0.85
20	0.94	44.18	$1171.12\times Cfig$	2.64	0.94
30	1	47	$1325.40\times Cfig$	2.85	1.07
40	1.04	48.88	$1433.55\times Cfig$	3.02	1.16
50	1.07	50.29	$1517.45\times Cfig$	3.31	1.22
75	1.12	52.64	$1662.58\times Cfig$	3.55	1.34
100	1.16	54.52	$1783.45\times Cfig$	3.87	1.44
150	1.21	56.87	$1940.51\times Cfig$	1.82	1.57

CHAPTER -5

METHODOLOGY

Flow chart diagram:



ANALYSIS AND DESIGN OF G + 11 BUILDING USING STAAD. PRO:

Step-1: Creation of nodal points. We entered the node point according to the positioning of the plan in to the STAAD file.

Step-2: Representation of beams and columns. we had drawn the beams and columns between the various node points by using add beam command.

Step-3: 3D view of structure. Here we've used the Transitional repeat command in Y direction to urge the 3D view of structure.

Step-4: Supports and property assigning. After the creation of structure, the supports at the bottom of structure are specified as fixed. Also, the materials were specified and the cross section of beams and columns members was assigned.

Step-5: 3D rendering view. After assigning the property the 3d rendering view of the structure are often shown

Step-6: Assigning of wind loads. Wind loads are defined as per IS 875 PART 3 supported intensity calculated and exposure factor. Then loads are added in load case details in +X, -X, +Z, -Z directions.

Step-7: Assigning of dead loads. Dead loads are calculated as per IS 875 PART 1 for external walls, internal walls, including self-weight of structure.

Step-8: Assigning of live loads. Live loads are assigned for every floor as 2 KN/m2 based on IS 875 PART 2.

Step-9: Adding of load combinations. After assigning all the loads, the load combinations are given with suitable safety factor as per IS 875 PART 5.

Step-10: Analysis. After we complete all the step above then we have performed the analysis and checked for errors.

Step-11: Design. Finally, concrete design is performed as per IS 456: 2000 by defining suitable design commands for various structural components. After the assigning of commands again we performed an analysis for any errors.

CHAPTER - 6

RESULTS AND DISCUSSION

Results of 36m height of building and wind load calculated by Is 875 part3(2015)

Effect of the Shape of The Building on Lateral Displacements:

Table 6.1 - Comparison of Lateral Displacements in mm at different height in x dir.

Height (m)	Rectangular (mm)	Square (mm)	Diamond (mm)	Octagonal (mm)	Hexagonal (mm)
3	1.99	2.181	2.491	2.249	2.731
6	4.38	4.809	5.369	4.872	6.547
9	6.622	7.289	8.038	7.324	10.295
12	8.678	9.581	10.447	9.558	13.804
15	10.529	11.663	12.587	11.565	17.014
18	12.169	13.52	14.452	13.336	19.888
21	13.596	15.137	16.018	14.851	22.389
24	14.792	16.493	17.278	16.101	24.502
27	15.752	17.584	18.227	17.08	26.217
30	16.474	18.406	18.851	17.773	27.518
33	16.946	18.944	19.152	18.18	28.394
36	17.174	19.204	19.283	18.44	28.885

Table 6.2 - Comparison of Lateral Displacements in mm at different height in z dir.

Height (m)	Rectangular (mm)	Square (mm)	Diamond (mm)	Octagonal (mm)	Hexagonal (mm)
3	2.376	1.818	2.077	1.864	2.689
6	5.251	4.008	4.477	4.017	6.374
9	7.956	6.074	6.704	6.01	9.913
12	10.443	7.984	8.715	7.805	13.168
15	12.687	9.72	10.502	9.397	16.106
18	14.681	11.267	12.059	10.781	18.704
21	16.42	12.614	13.369	11.941	20.938
24	17.885	13.745	14.422	12.871	22.798
27	19.067	14.653	15.217	13.569	24.277
30	19.963	15.338	15.741	14.024	25.358
33	20.56	15.787	15.995	14.238	26.029
36	20.864	16.003	16.109	14.325	26.326

Effect of the Shape of the Building on Storey Drifts:

Table 6.3 - Comparison of Storey Drifts at Different Heights in mm in x dir.

Height (m)	Rectangular (mm)	Square (mm)	Diamond (mm)	Octagonal (mm)	Hexagonal (mm)
3	1.99	2.181	1.427	2.249	2.731
6	2.39	2.628	1.649	2.623	3.816
9	2.242	2.48	1.528	2.452	3.749
12	2.056	2.292	1.378	2.234	3.509
15	1.851	2.082	1.222	2.006	3.21
18	1.64	1.857	1.063	1.771	2.873
21	1.426	1.616	0.893	1.515	2.501
24	1.196	1.357	0.718	1.25	2.113
27	0.96	1.091	0.542	0.979	1.716
30	0.722	0.822	0.356	0.693	1.301
33	0.472	0.538	0.171	0.407	0.876
36	0.228	0.26	0.073	0.26	0.491

Table 6.4 - Comparison of Storey Drifts at Different Heights in mm in z dir.

Height (m)	Rectangular (mm)	Square (mm)	Diamond (mm)	Octagonal (mm)	Hexagonal (mm)
3	2.376	1.818	2.077	1.864	2.689
6	2.876	2.19	2.4	2.154	3.684
9	2.705	2.067	2.227	1.993	3.539
12	2.487	1.91	2.011	1.795	3.255
15	2.244	1.735	1.787	1.592	2.938
18	1.994	1.547	1.558	1.384	2.598
21	1.739	1.347	1.309	1.16	2.234
24	1.464	1.131	1.054	0.93	1.86
27	1.182	0.909	0.795	0.698	1.479
30	0.896	0.685	0.524	0.455	1.082
33	0.597	0.449	0.254	0.214	0.671
36	0.304	0.216	0.114	0.087	0.297

Effect of the Shape of The Building on Lateral Displacements:

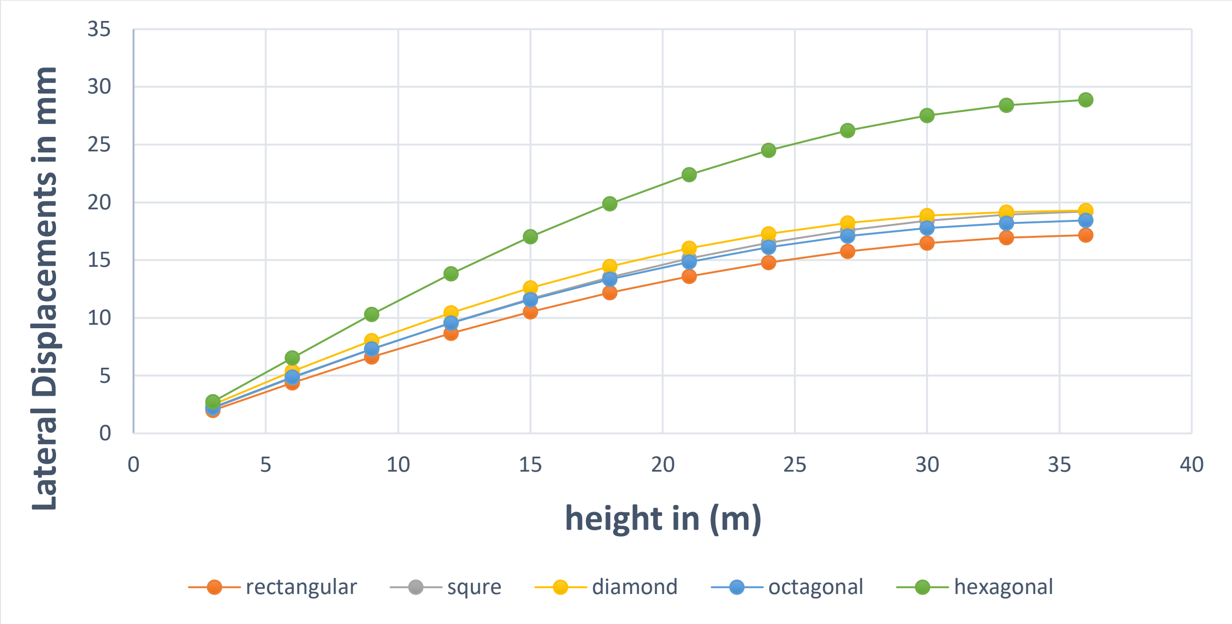


Figure 6.1: Comparison of Lateral Displacements in mm at different height in x dir.

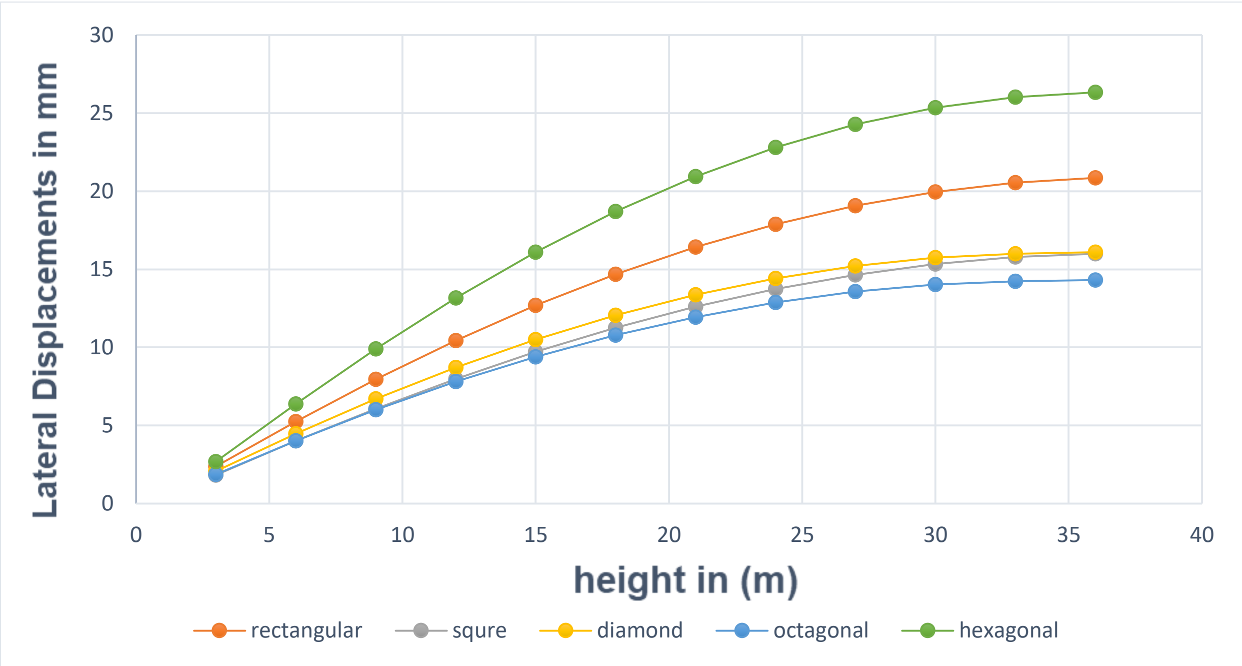


Figure 6.2: Comparison of Lateral Displacements in mm at different height in z dir.

Effect of the Shape of the Building on Storey Drifts:

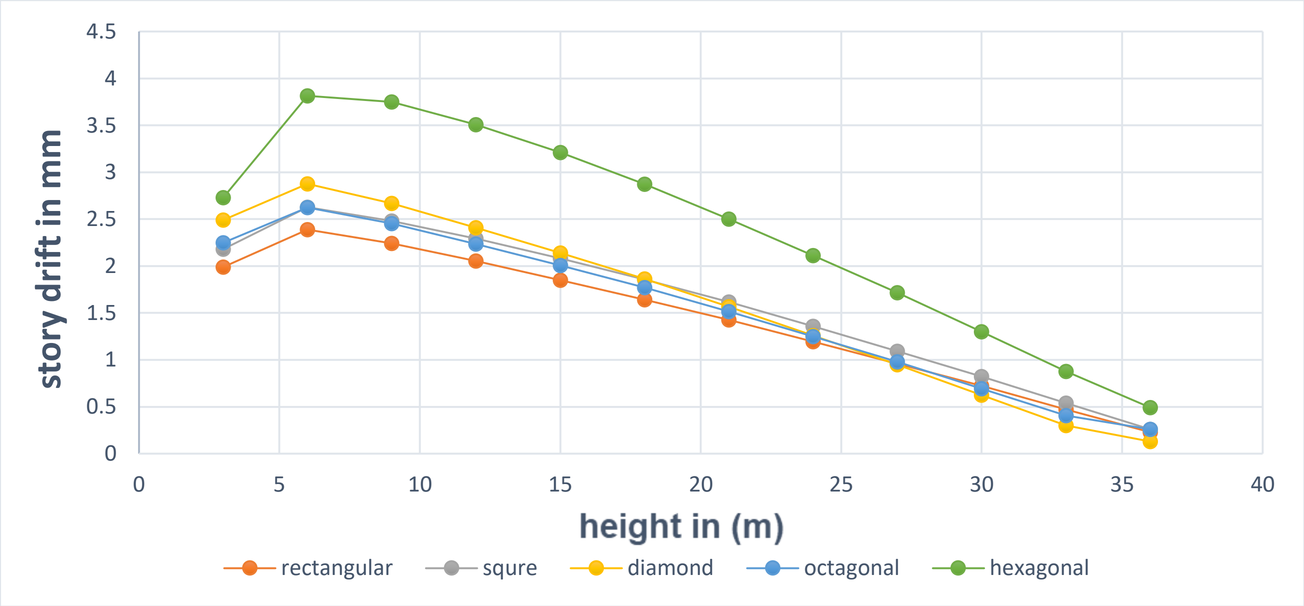


Figure 6.3: Comparison of story drift in mm at different height in x dir.

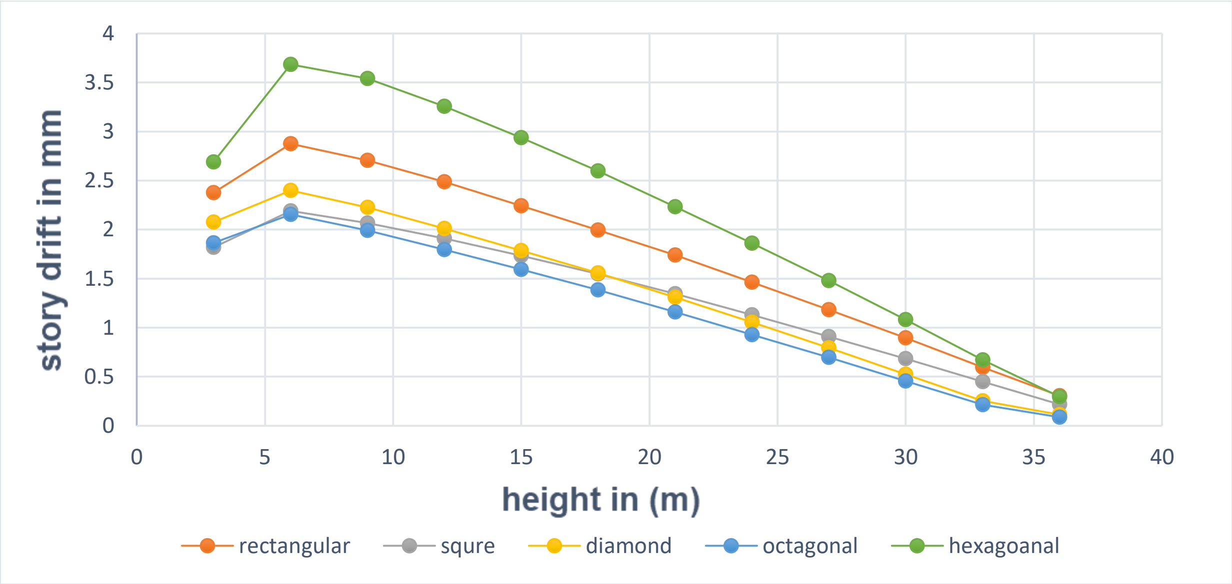


Figure 6.4: Comparison of story drift in mm at different height in z dir.

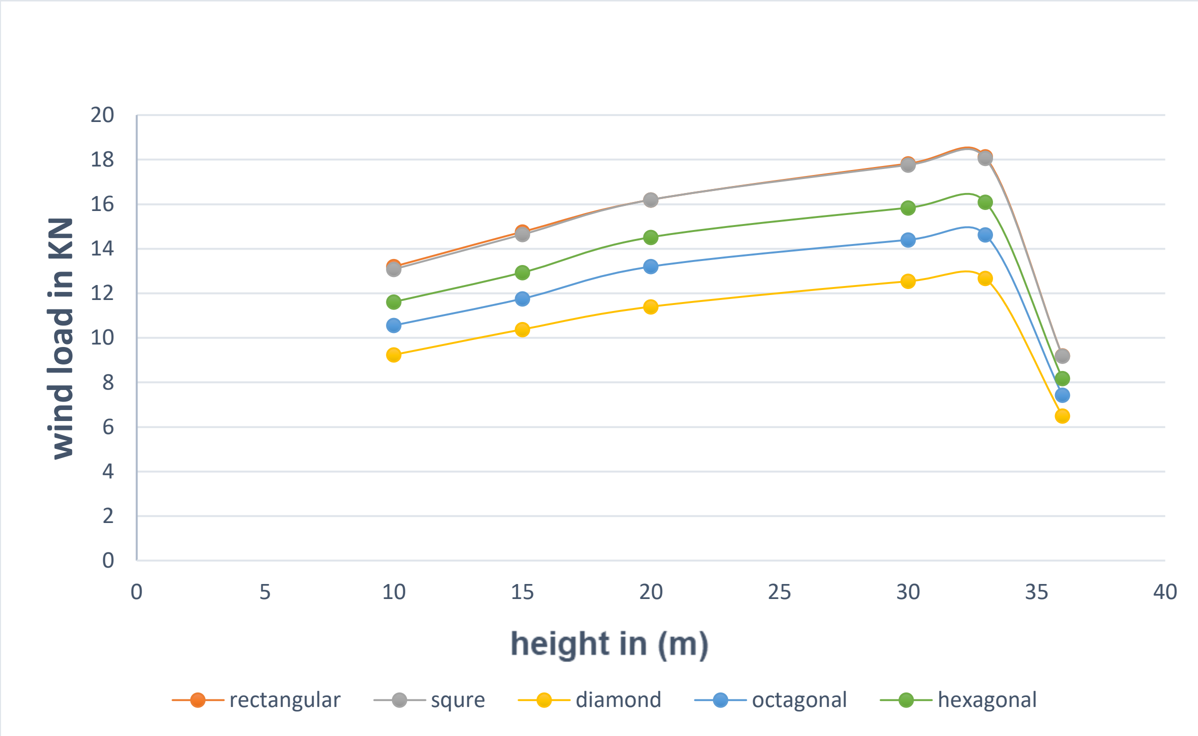


Figure 6.5: Comparison of wind forces in kn at different height in x dir.

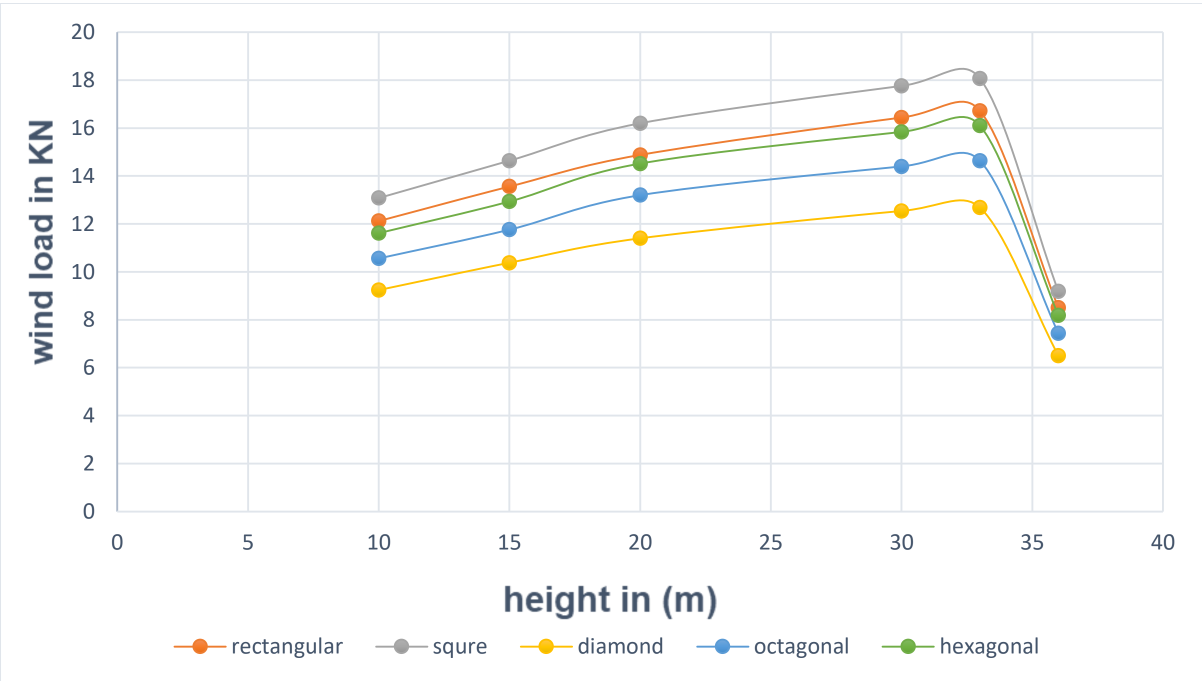


Figure 6.6: Comparison of wind forces in kn at different height in z dir.

Results of 36m height of building and wind load calculated by AS/NZ 1170.2 2011:

The Shape of The Building on Lateral Displacements:

Table 6.5 - Comparison of Lateral Displacements in mm at different height in x dir.

Height (m)	Rectangular (mm)	Square (mm)	Diamond (mm)	Octagonal (mm)
3	3.446	3.013	3.476	2.35
6	7.601	6.643	7.526	5.112
9	11.531	10.005	11.323	7.719
12	15.171	13.053	14.791	10.119
15	18.481	15.849	17.898	12.29
18	21.434	18.364	20.614	14.211
21	24.004	20.56	22.895	15.851
24	26.162	22.4	24.723	17.197
27	27.897	23.874	26.095	18.245
30	29.203	24.978	26.994	18.981
33	30.059	25.698	27.429	19.408
36	30.473	26.046	27.621	19.677

Table 6.6 - Comparison of Lateral Displacements in mm at different height in z dir.

Height (m)	Rectangular (mm)	Square (mm)	Diamond (mm)	Octagonal (mm)
3	1.788	2.511	2.897	1.948
6	3.963	5.536	6.275	4.217
9	6.027	8.338	9.441	6.339
12	7.945	10.878	12.334	8.273
15	9.696	13.207	14.927	10.002
18	11.265	15.303	17.195	11.51
21	12.639	17.133	19.099	12.774
24	13.795	18.667	20.627	13.785
27	14.725	19.895	21.774	14.54
30	15.428	20.815	22.527	15.031
33	15.895	21.415	22.893	15.261
36	16.132	21.705	23.057	15.355

Effect of the Shape of the Building on Storey Drifts:

Table 6.7 - Comparison of Storey Drifts at Different Heights in mm in x dir.

Height (m)	Rectangular (mm)	Square (mm)	Diamond (mm)	Octagonal (mm)
3	3.446	3.013	3.476	2.35
6	4.155	3.63	4.05	2.762
9	3.93	3.363	3.797	2.606
12	3.641	3.048	3.468	2.4
15	3.31	2.795	3.107	2.171
18	2.953	2.515	2.716	1.921
21	2.57	2.196	2.281	1.64
24	2.158	1.841	1.829	1.346
27	1.735	1.474	1.372	1.048
30	1.307	1.104	0.899	0.736
33	0.856	0.72	0.435	0.427
36	0.413	0.348	0.192	0.269

Table 6.8 - Comparison of Storey Drifts at Different Heights in mm in z dir.

Height (m)	Rectangular (mm)	Square (mm)	Diamond (mm)	Octagonal (mm)
3	1.788	2.511	2.897	1.948
6	2.174	3.025	3.377	2.269
9	2.064	2.802	3.167	2.122
12	1.918	2.54	2.893	1.934
15	1.751	2.33	2.593	1.729
18	1.569	2.096	2.268	1.508
21	1.374	1.83	1.904	1.264
24	1.156	1.534	1.528	1.011
27	0.931	1.228	1.147	0.755
30	0.703	0.92	0.753	0.491
33	0.466	0.6	0.366	0.23
36	0.238	0.29	0.164	0.094

Effect of the Shape of The Building on Lateral Displacements:

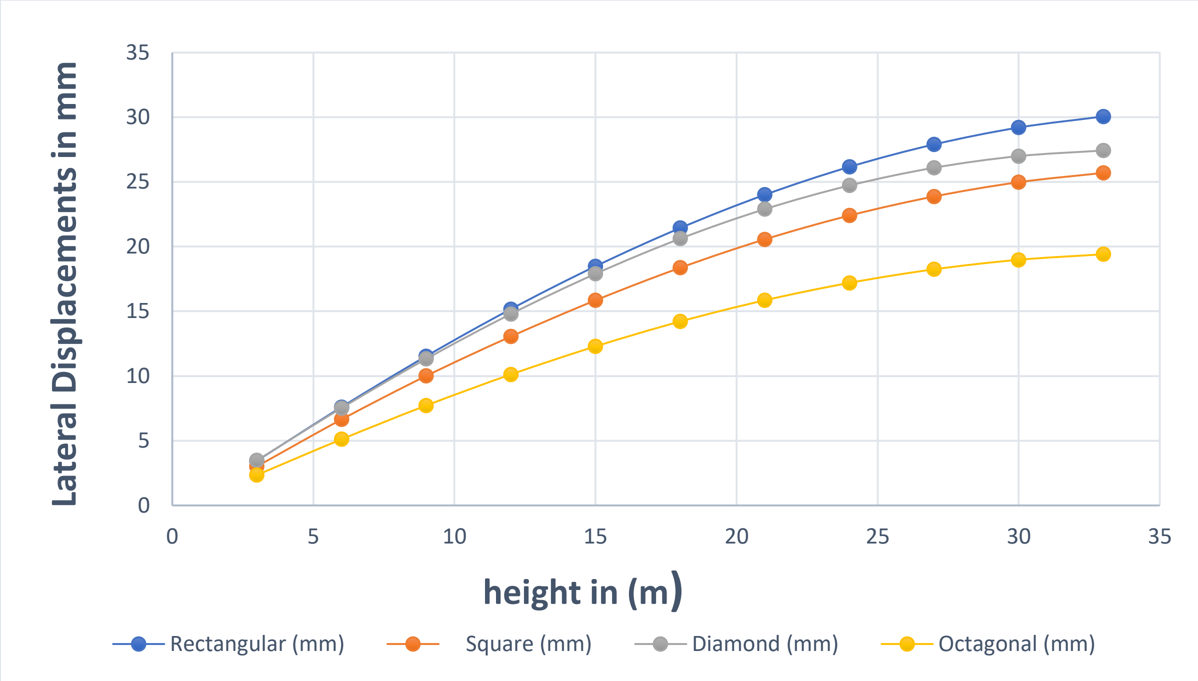


Figure 6.7: Comparison of Lateral Displacements in mm at different height in x dir.

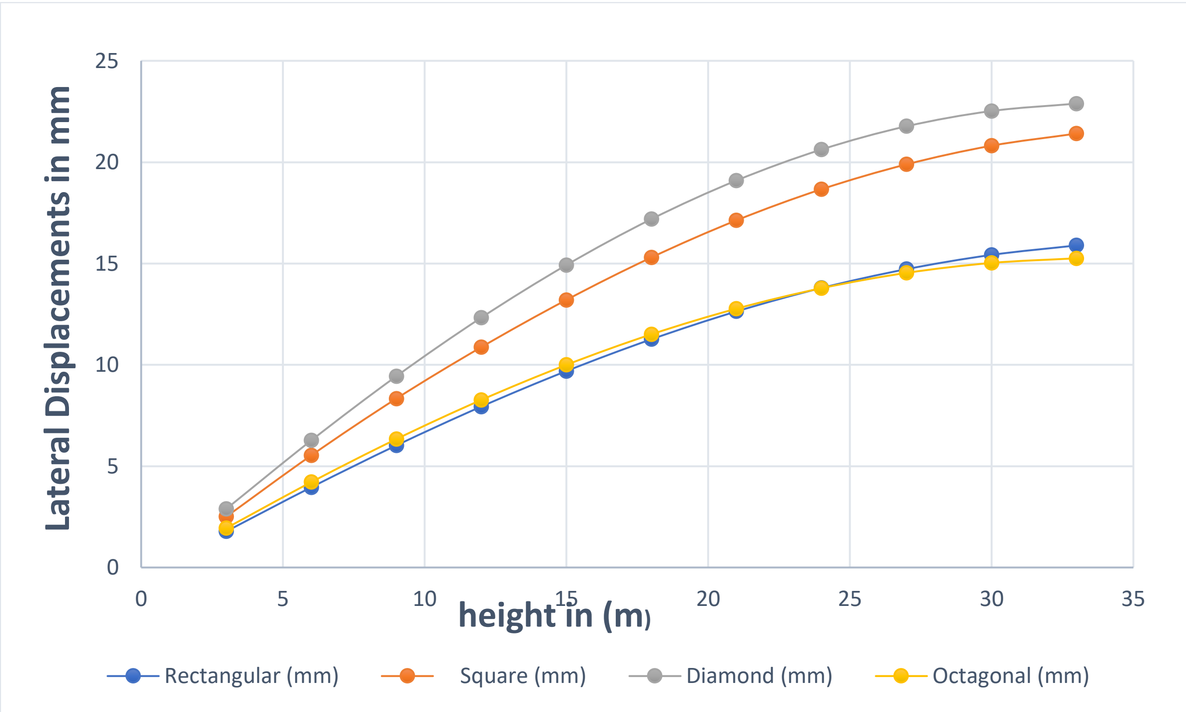


Figure 6.8: Comparison of Lateral Displacements in mm at different height in z dir.

Effect of the Shape of the Building on Storey Drifts:

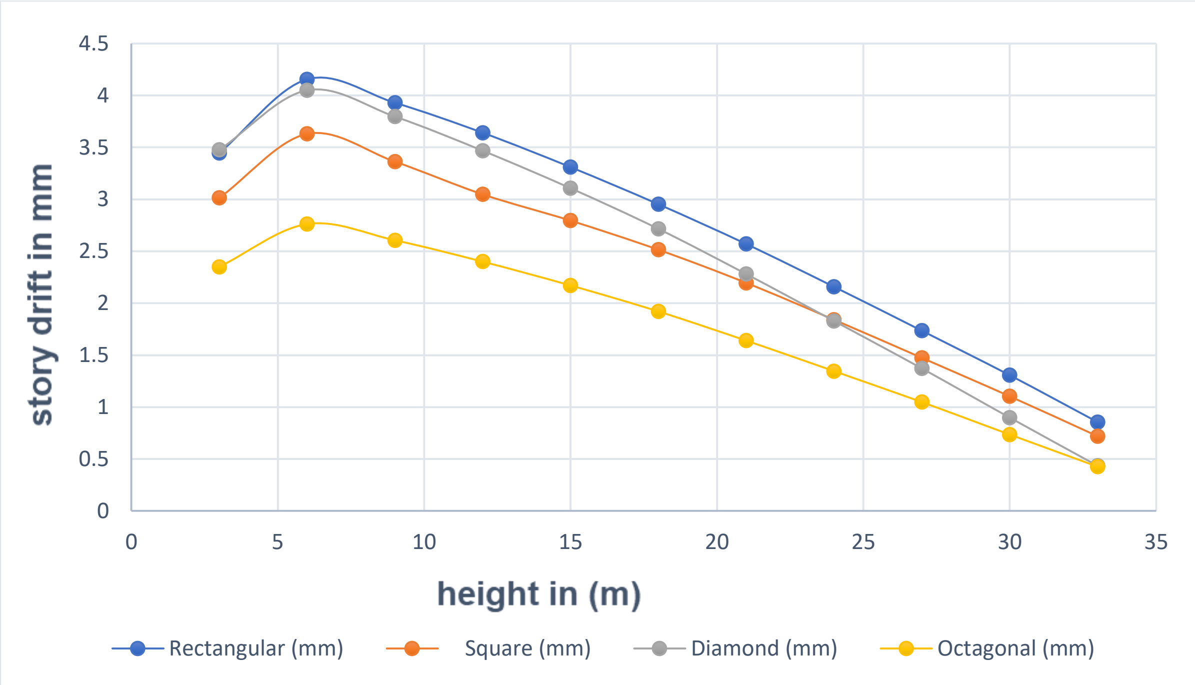


Figure 6.9: Comparison of story drift in mm at different height in x dir.

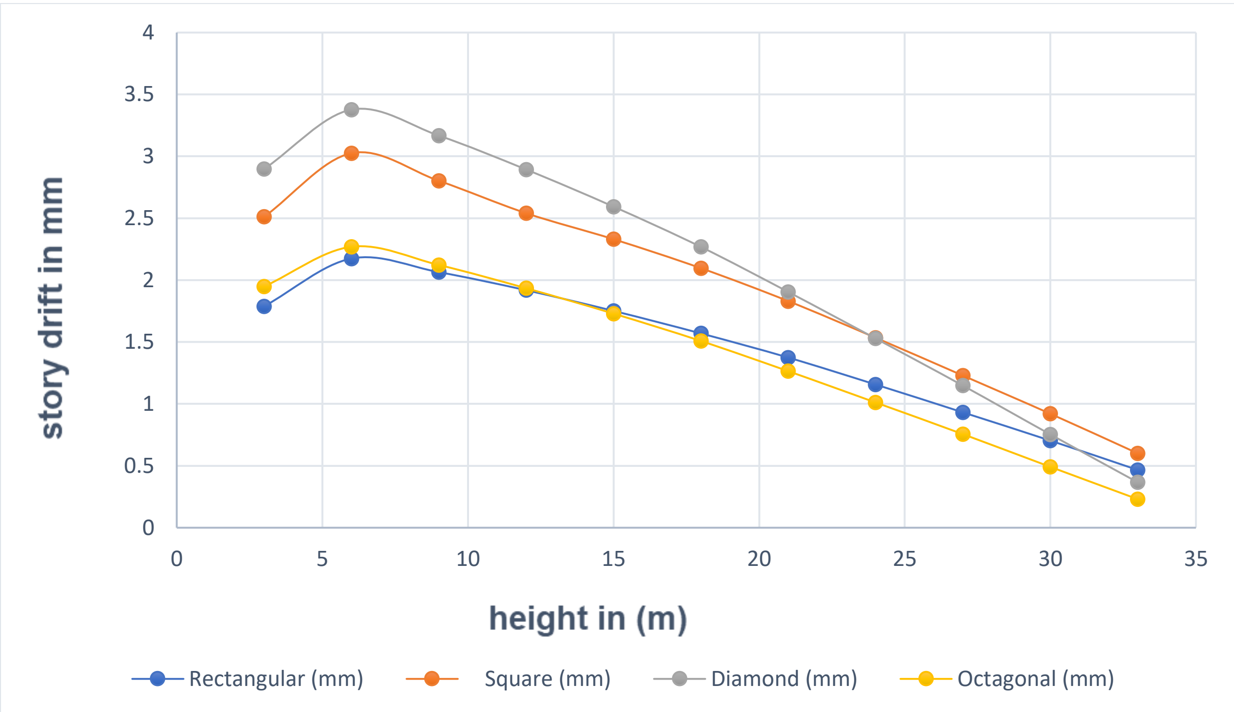


Figure 6.10: Comparison of story drift in mm at different height in z dir.

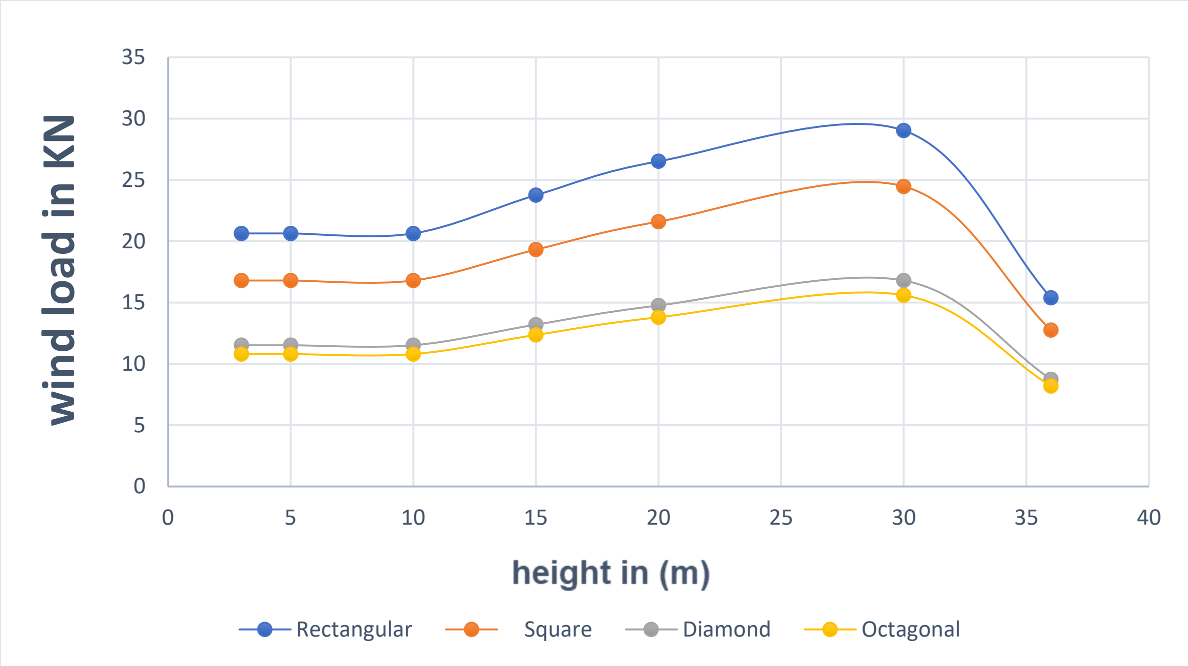


Figure 6.11: Comparison of wind forces in KN at different height in x dir.

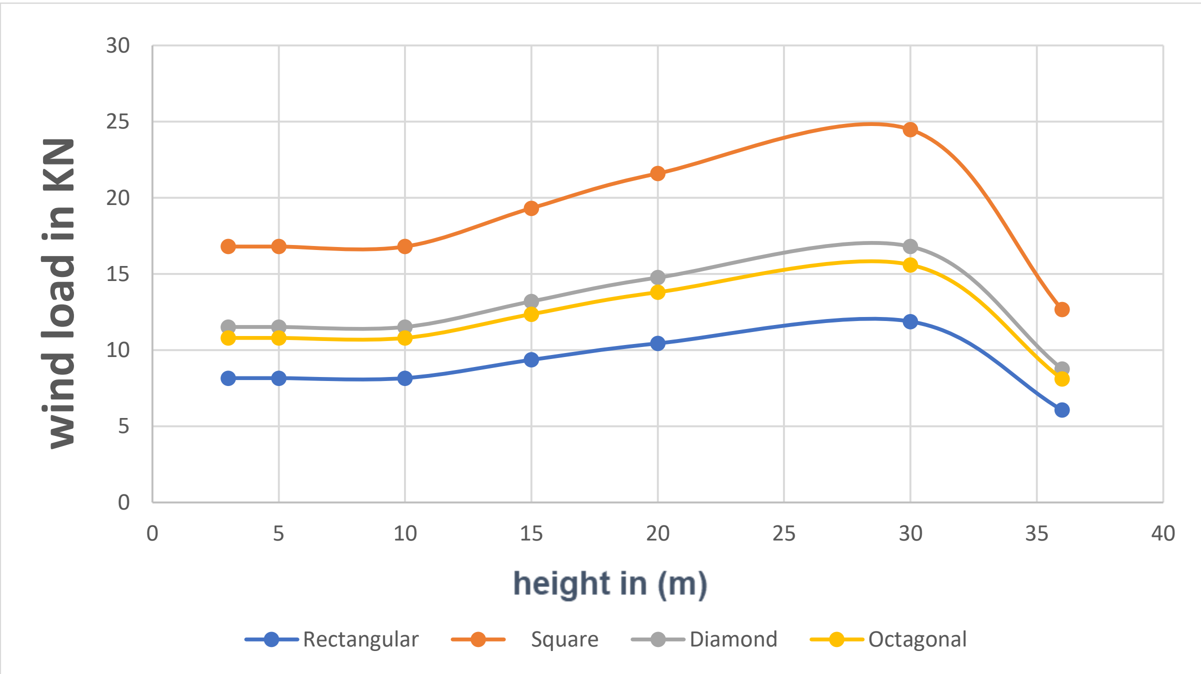


Figure 6.12: Comparison of wind forces in kn at different height in z dir.

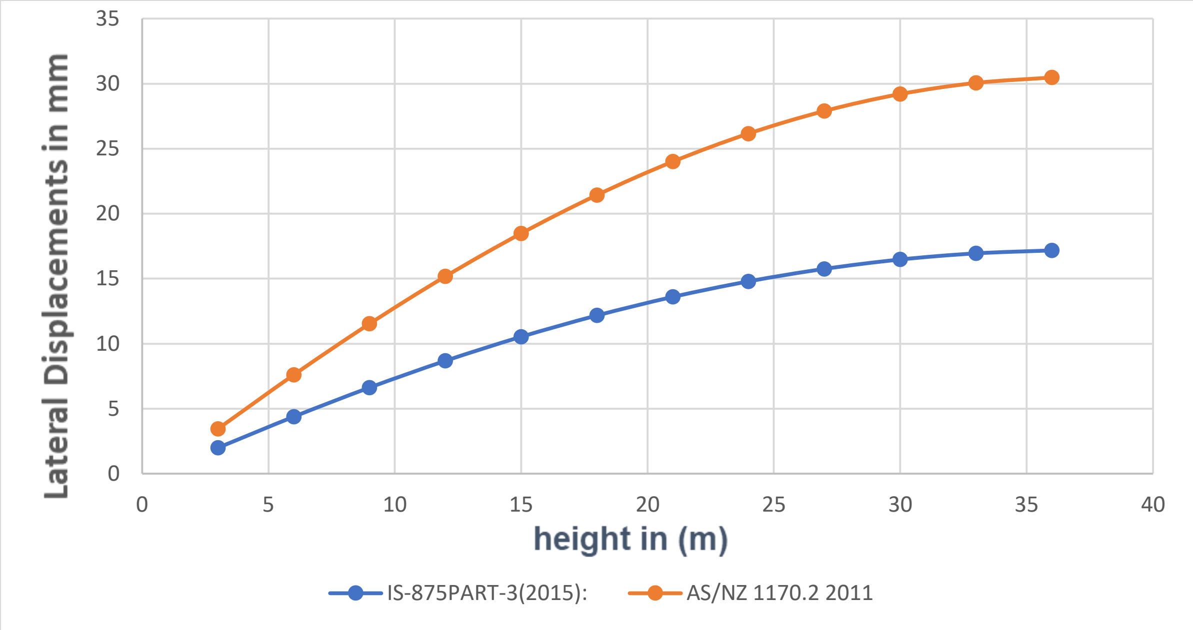


Figure 6.13: comparison of Lateral Displacements in mm in rectangular shape building at different height in x dir

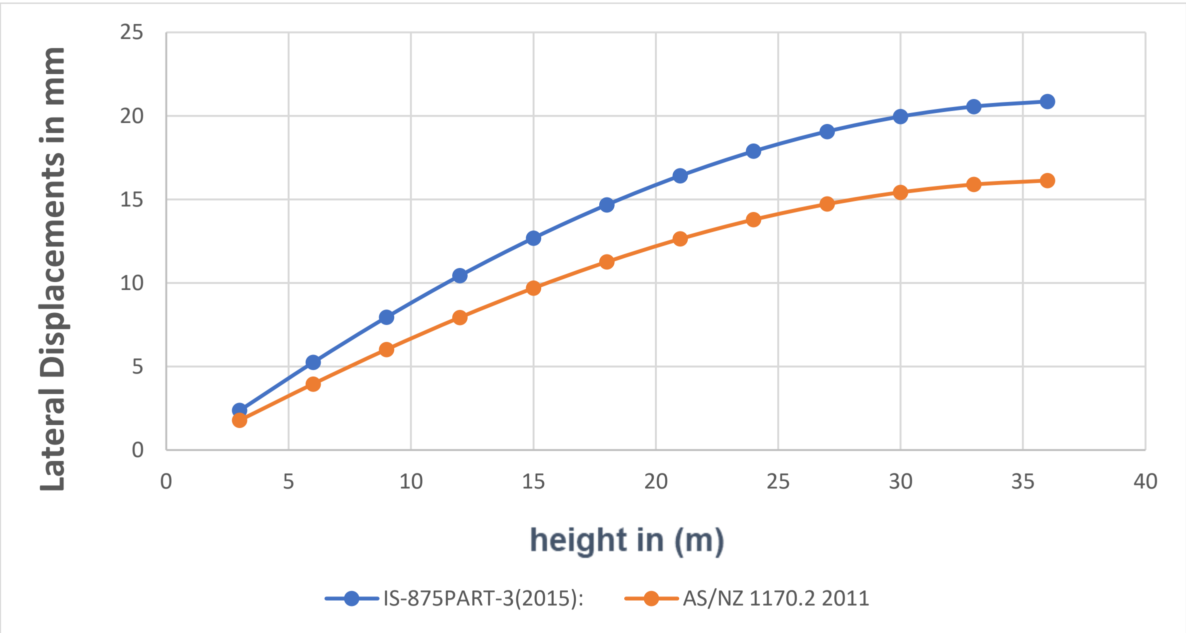


Figure 6.14: comparison of Lateral Displacements in mm in rectangular shape building at different height in z dir

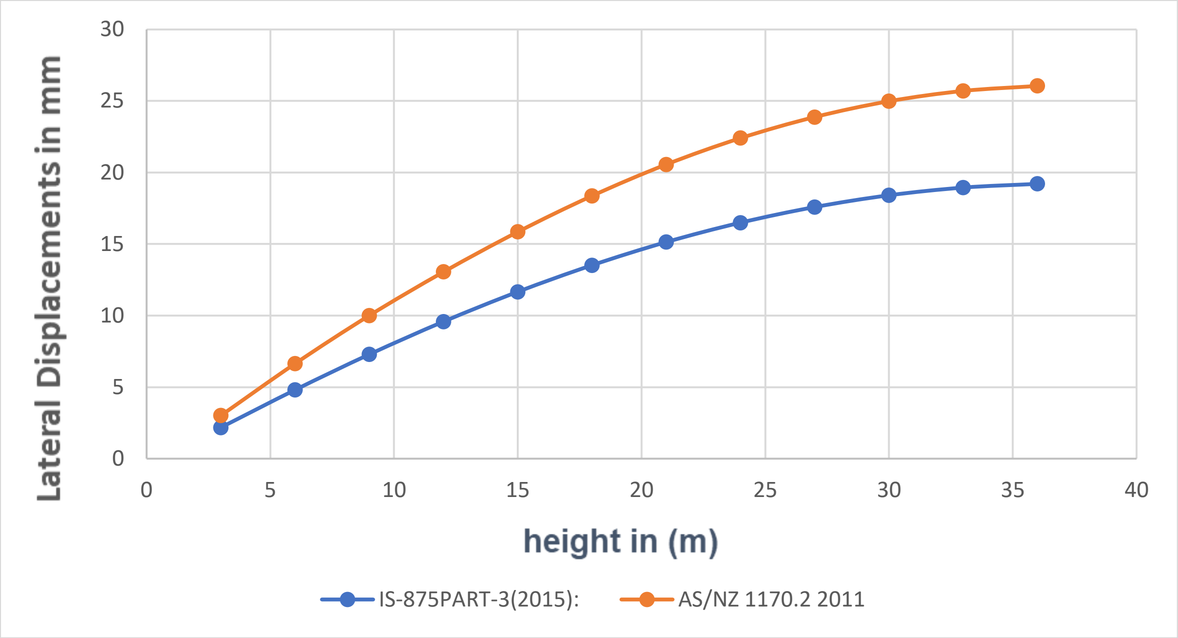


Figure 6.15: comparison of Lateral Displacements in mm in square shape building at different height in x dir

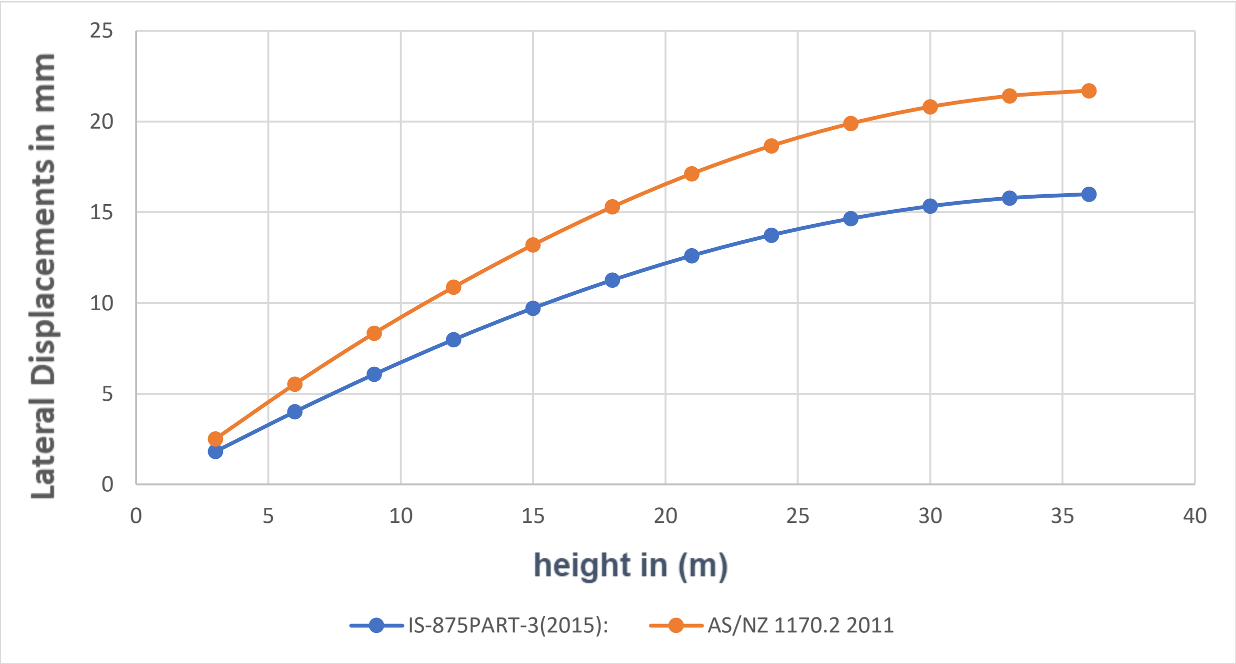


Figure 6.16: comparison of Lateral Displacements in mm in square shape building at different height in z dir

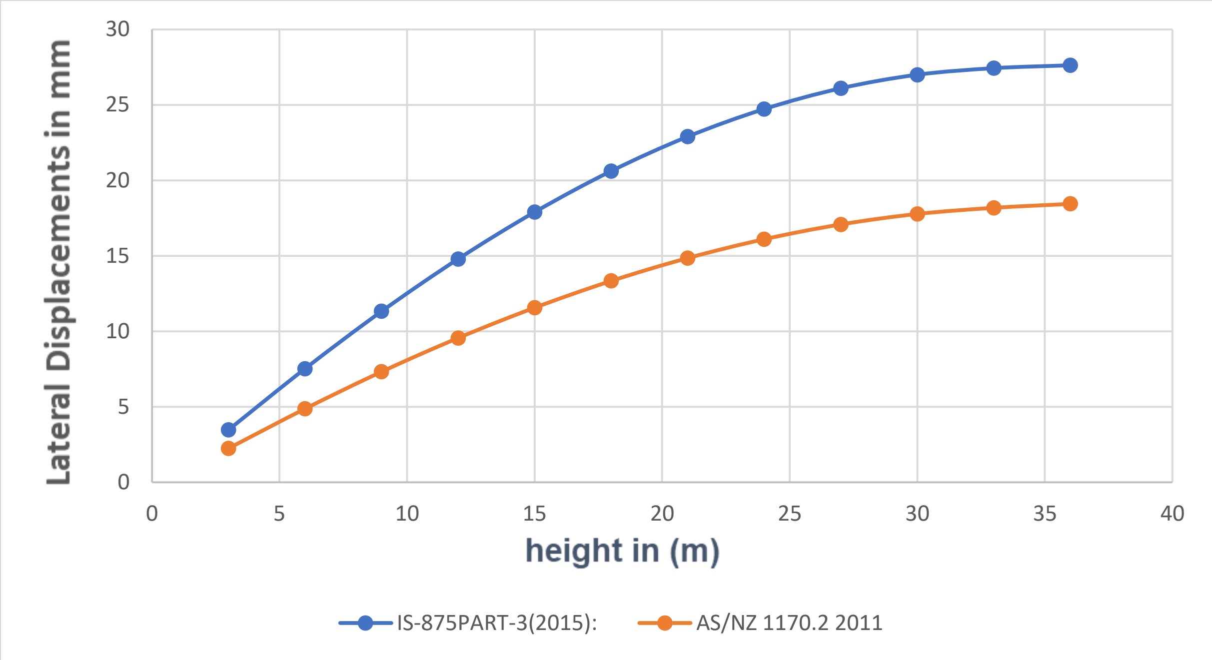


Figure 6.17: comparison of Lateral Displacements in mm in diamond shape building at different height in x dir

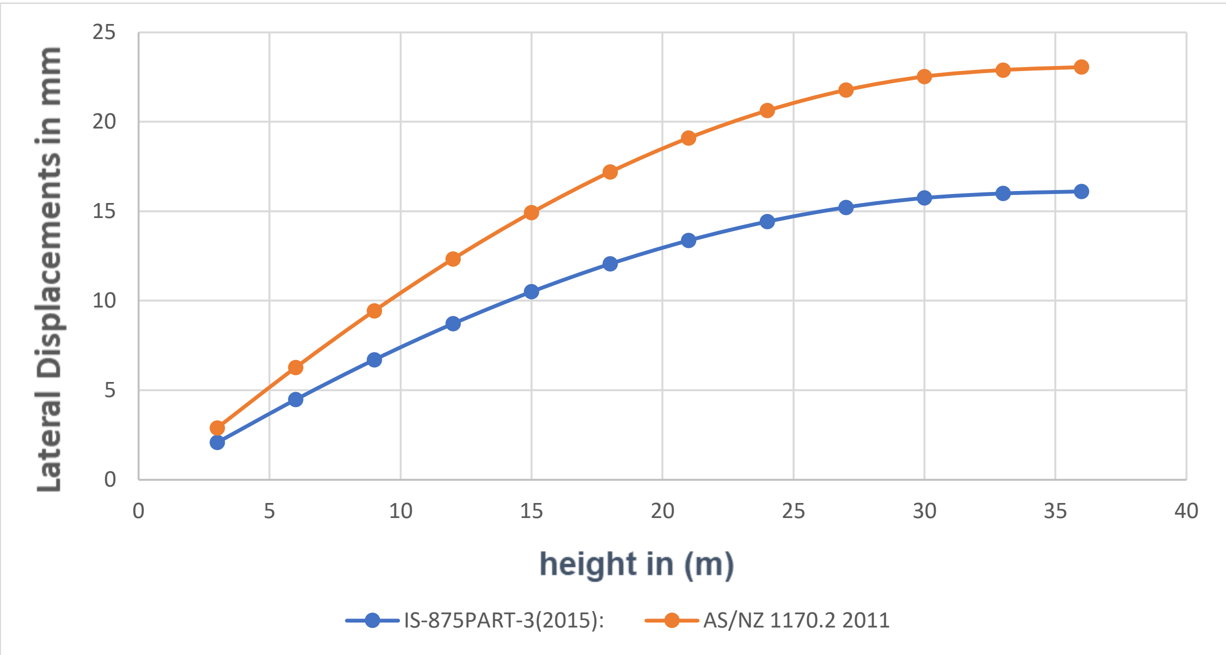


Figure 6.18: comparison of Lateral Displacements in mm in diamond shape building at different height in z dir

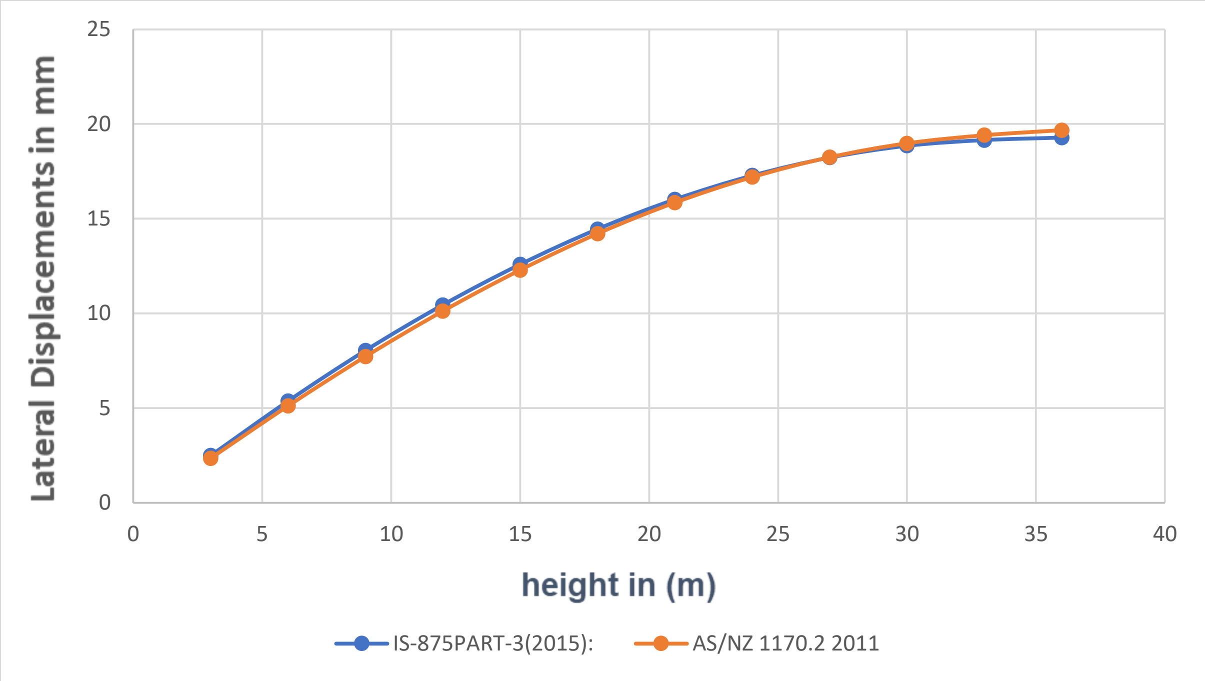


Figure 6.19: comparison of Lateral Displacements in mm in octagonal shape building at different height in x dir

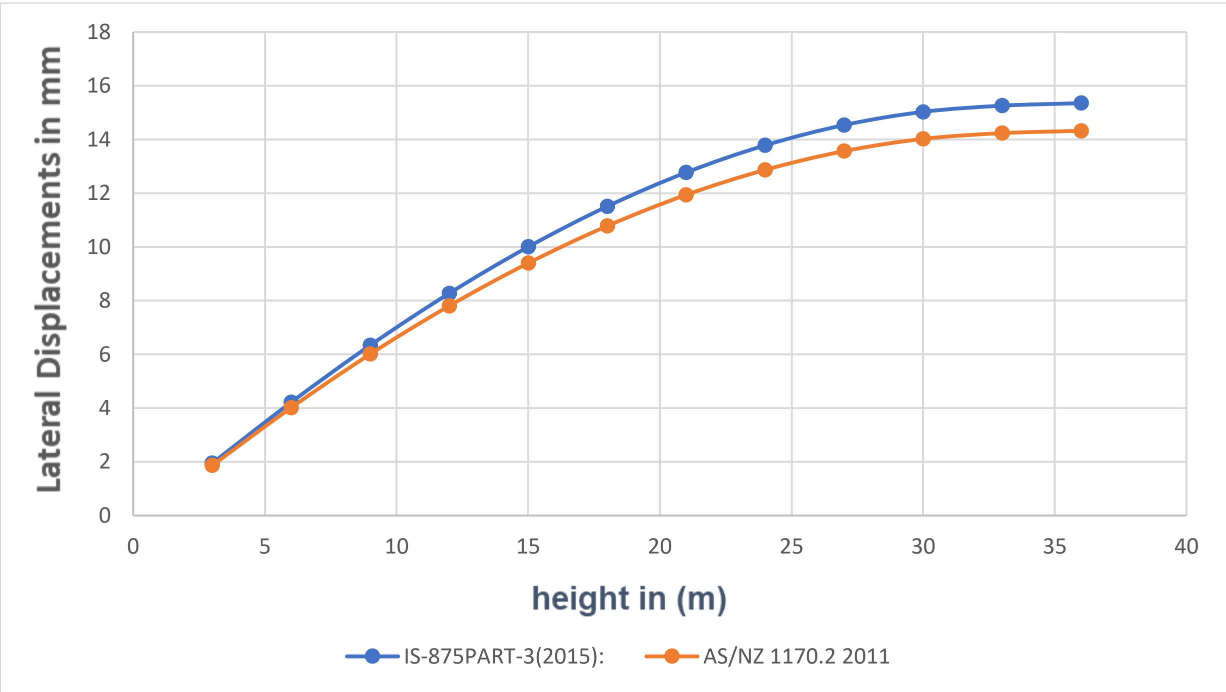


Figure 6.20: comparison of Lateral Displacements in mm in octagonal shape building at different height in z dir

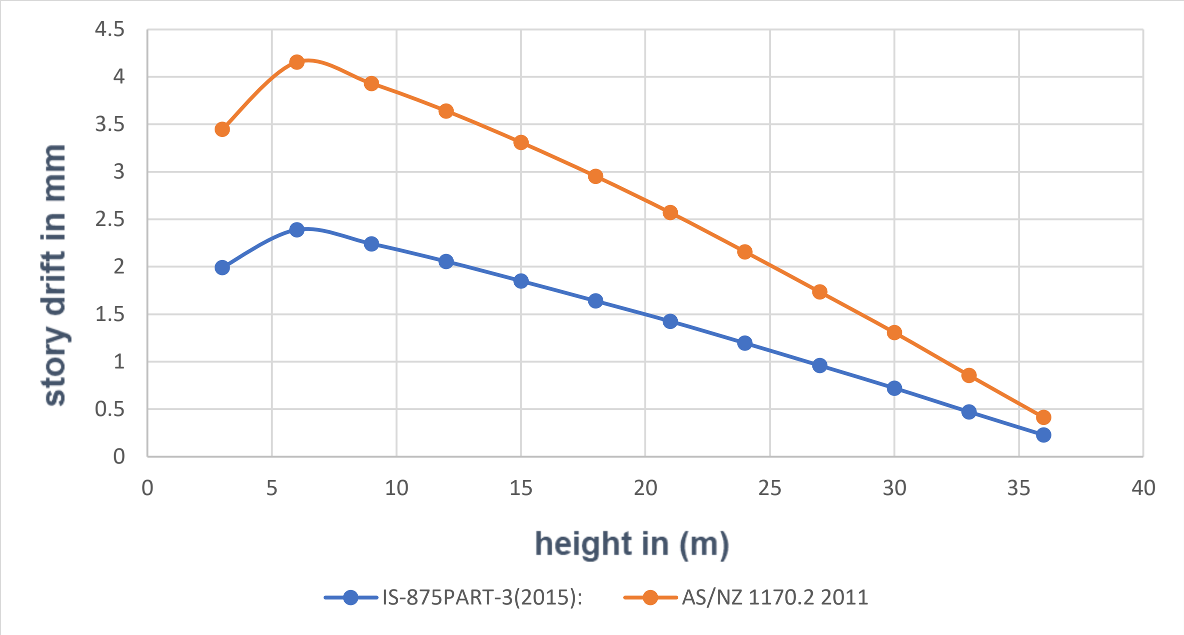


Figure 6.21: comparison of story drift in mm in rectangular shape building at different height in x dir

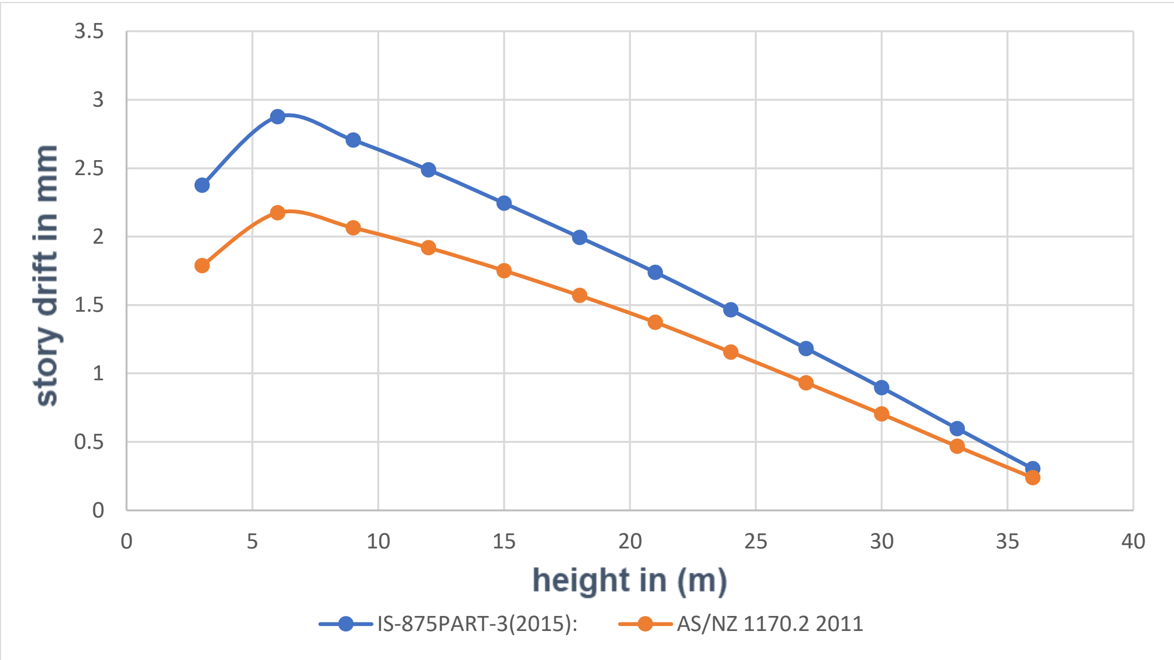


Figure 6.22: comparison of story drift in mm in rectangular shape building at different height in z dir

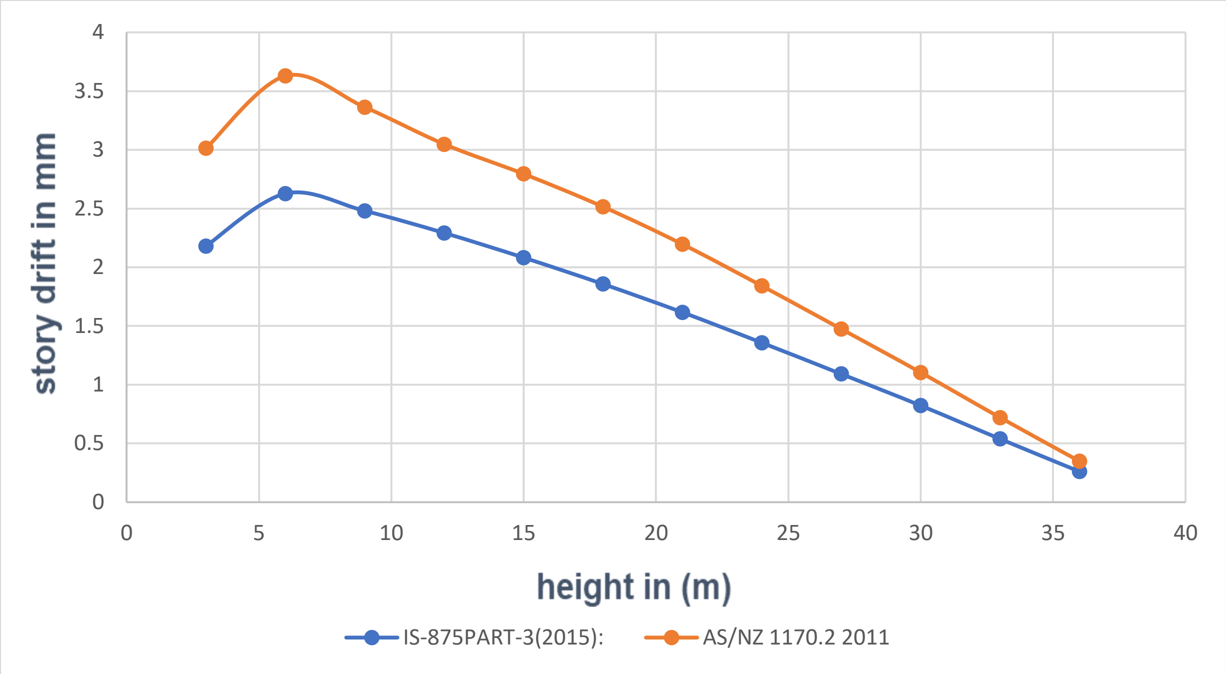


Figure 6.23: comparison of story drift in mm in square shape building at different height in x dir

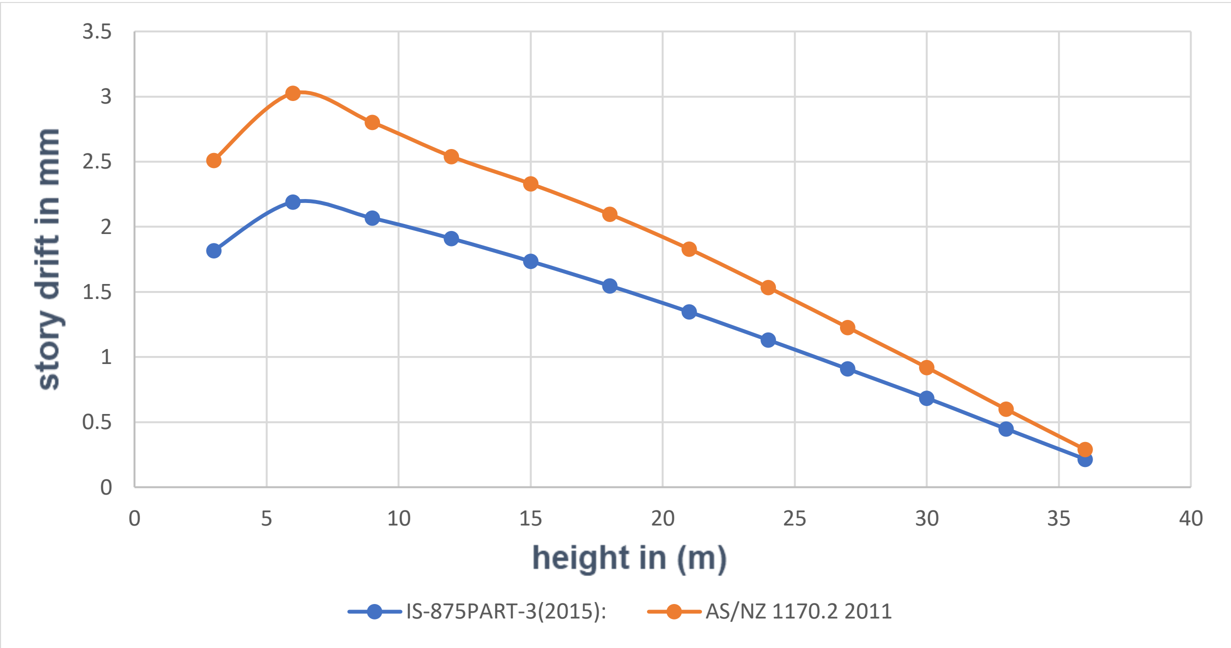


Figure 6.24: comparison of story drift in mm in square shape building at different height in z dir

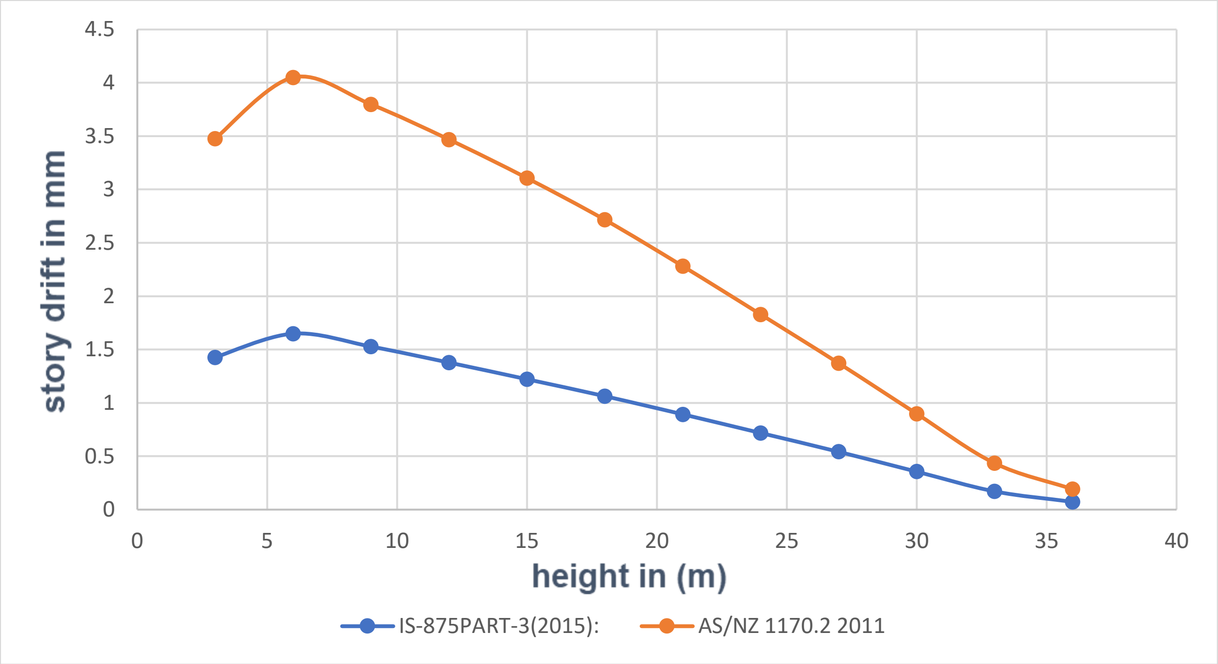


Figure 6.25: comparison of story drift in mm in diamond shape building at different height in x dir

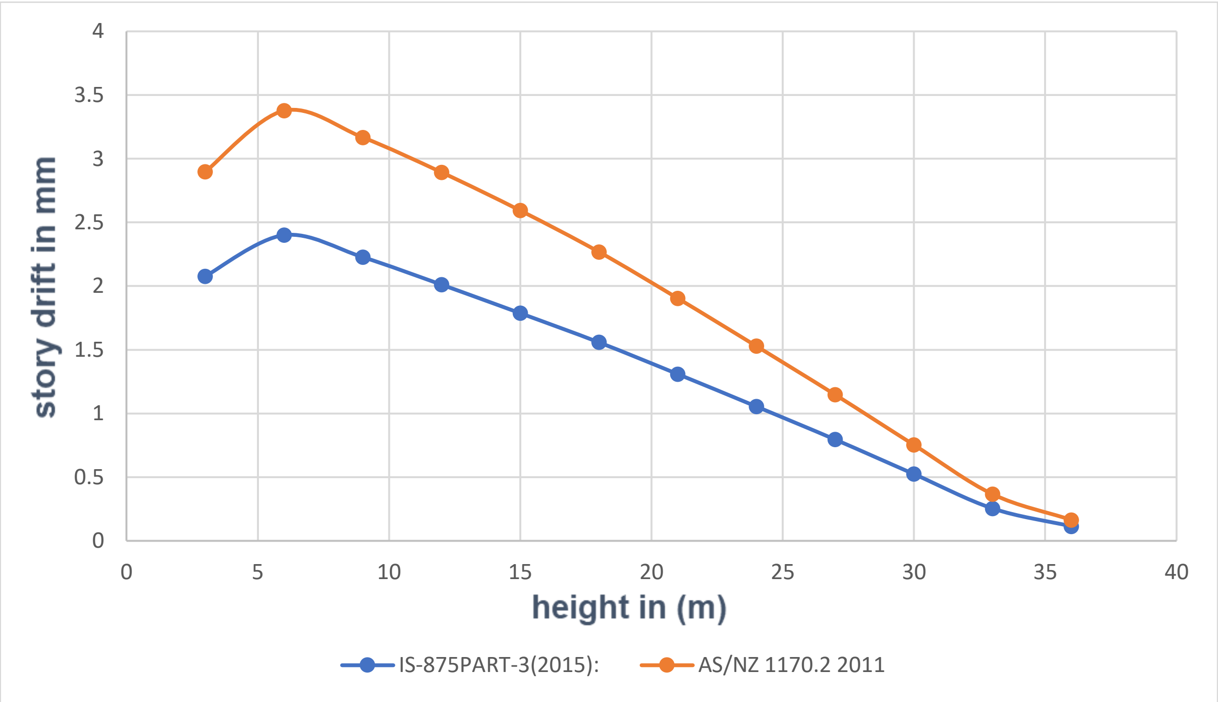


Figure 6.26: comparison of story drift in mm in diamond shape building at different height in z dir

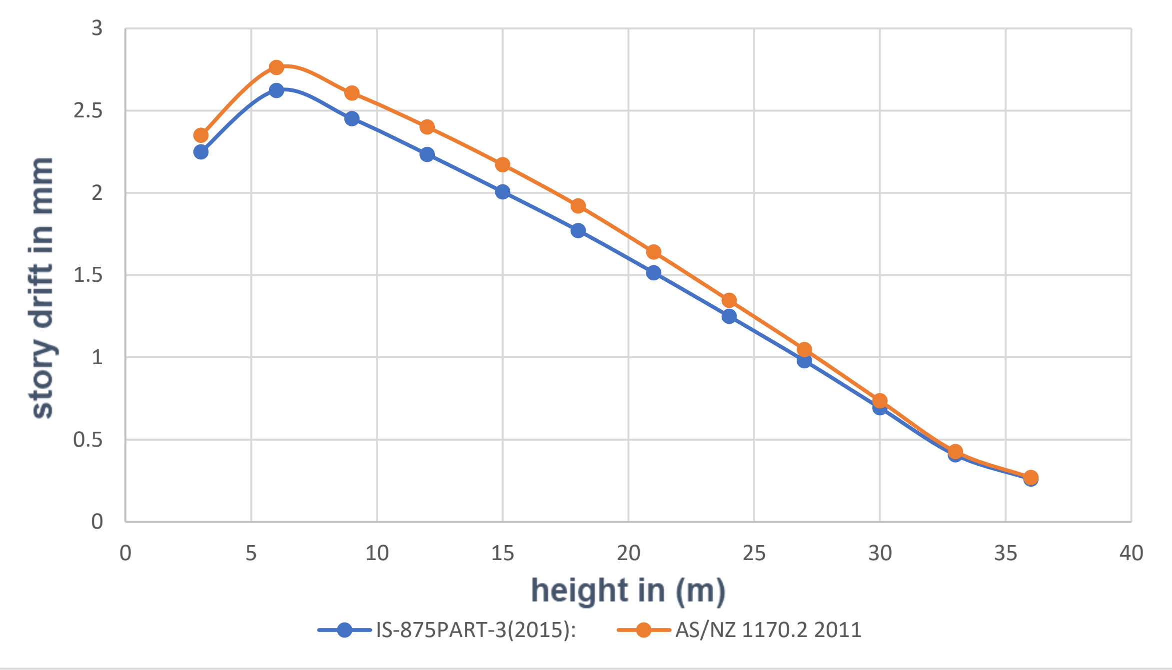


Figure 6.27: comparison of story drift in mm in octagonal shape building at different height in x dir

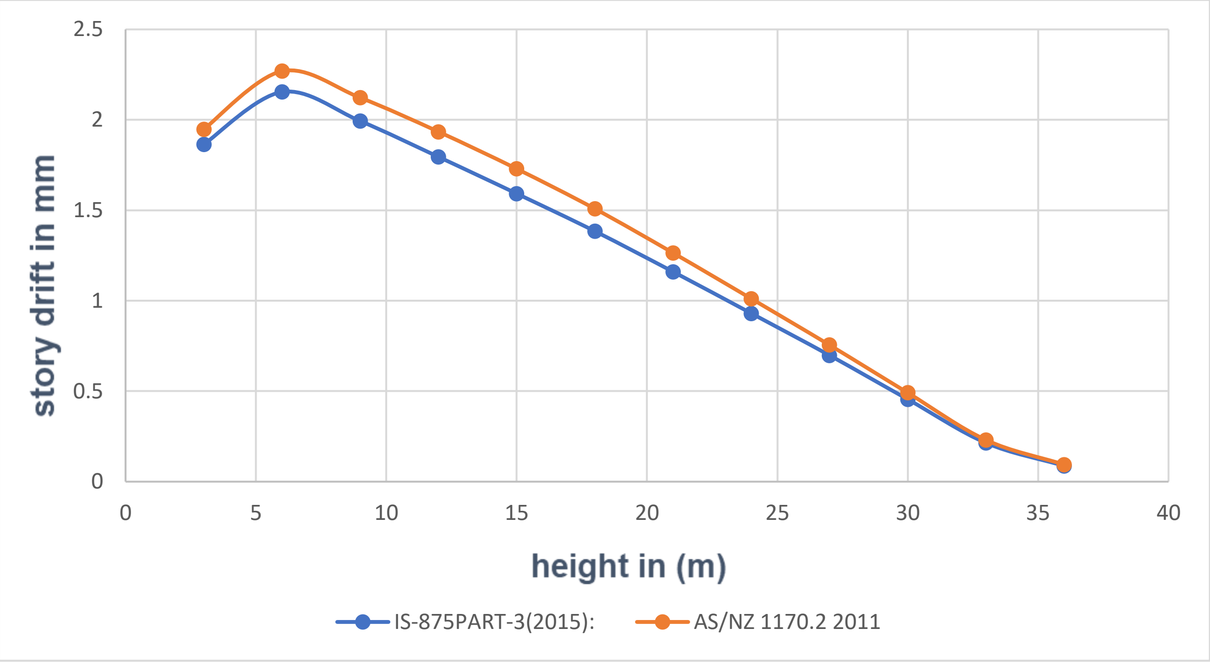


Figure 6.28: comparison of story drift in mm in octagonal shape building at different height in z dir

RESULTS OF 150M HEIGHT OF BUILDING AND WIND LOAD CALCULATED BY IS 875 PART3(2015) AND AS/NZ 1170.2 2011.

Table 6.9 - Comparison of Lateral Displacements in mm at different height in x dir

Height (m)	IS 875:2015(Part3) (mm)	AS/NZ 1170.2 2011 (mm)
3	1.502	2.504
6	4.93	8.218
9	9.364	15.616
12	14.311	23.878
15	19.505	32.56
18	24.801	41.422
21	30.12	50.331
24	35.418	59.211
27	40.668	68.019
30	45.856	76.73
33	50.971	85.328
36	56.006	93.8
39	60.956	102.14
42	65.817	110.339
45	70.588	118.392
48	75.264	126.293
51	79.843	134.037
54	84.319	141.616
57	88.688	149.027
60	92.948	156.264
63	97.097	163.327
66	101.133	170.211
69	105.056	176.916
72	108.865	183.438
75	112.558	189.775
78	116.135	195.922
81	119.596	201.875
84	122.94	207.631
87	126.165	213.188
90	129.272	218.544
93	132.26	223.697
96	135.127	228.646
99	137.873	233.386
102	140.496	237.916
105	142.992	242.228

108	145.36	246.32
111	147.6	250.19
114	149.711	253.836
117	151.692	257.257
120	153.542	260.454
123	155.263	263.425
126	156.854	266.17
129	158.315	268.691
132	159.646	270.988
135	160.85	273.063
138	161.927	274.919
141	162.882	276.564
144	163.724	278.012
147	164.465	279.287
150	165.134	280.435
141	162.882	276.564
144	163.724	278.012
147	164.465	279.287
150	165.134	280.435

Table 6.10 - Comparison of story drift in mm at different height in x dir.

Height (m)	IS 875:2015(Part3) (mm)	AS/NZ 1170.2 2011 (mm)
3	1.502	2.504
6	3.427	5.714
9	4.434	7.398
12	4.947	8.262
15	5.194	8.682
18	5.296	8.862
21	5.319	8.909
24	5.298	8.88
27	5.25	8.808
30	5.188	8.711
33	5.115	8.598
36	5.035	8.472
39	4.95	8.339
42	4.861	8.199
45	4.77	8.053
48	4.677	7.901
51	4.579	7.744
54	4.476	7.58
57	4.369	7.41
60	4.26	7.238

63	4.149	7.062
66	4.036	6.885
69	3.923	6.705
72	3.808	6.522
75	3.693	6.337
78	3.577	6.147
81	3.461	5.953
84	3.344	5.756
87	3.226	5.557
90	3.107	5.356
93	2.988	5.153
96	2.867	4.949
99	2.746	4.741
102	2.622	4.529
105	2.496	4.312
108	2.368	4.092
111	2.24	3.87
114	2.111	3.646
117	1.981	3.421
120	1.851	3.196
123	1.721	2.971
126	1.591	2.746
129	1.461	2.521
132	1.332	2.297
135	1.203	2.075
138	1.077	1.857
141	0.955	1.645
144	0.841	1.448
147	0.742	1.275
150	0.669	1.149
141	1.502	2.504
144	3.427	5.714
147	4.434	7.398
150	4.947	8.262

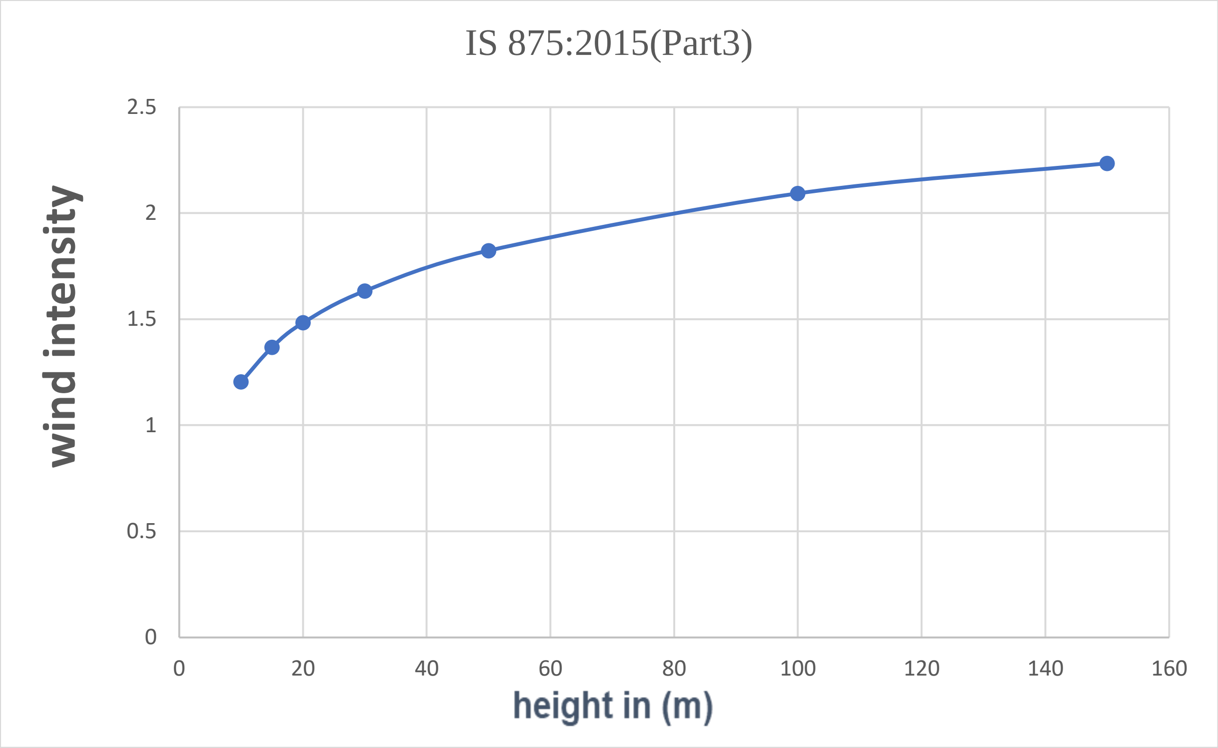


Figure 6.29: Wind intensity as per IS 875:2015(Part3) in x dir

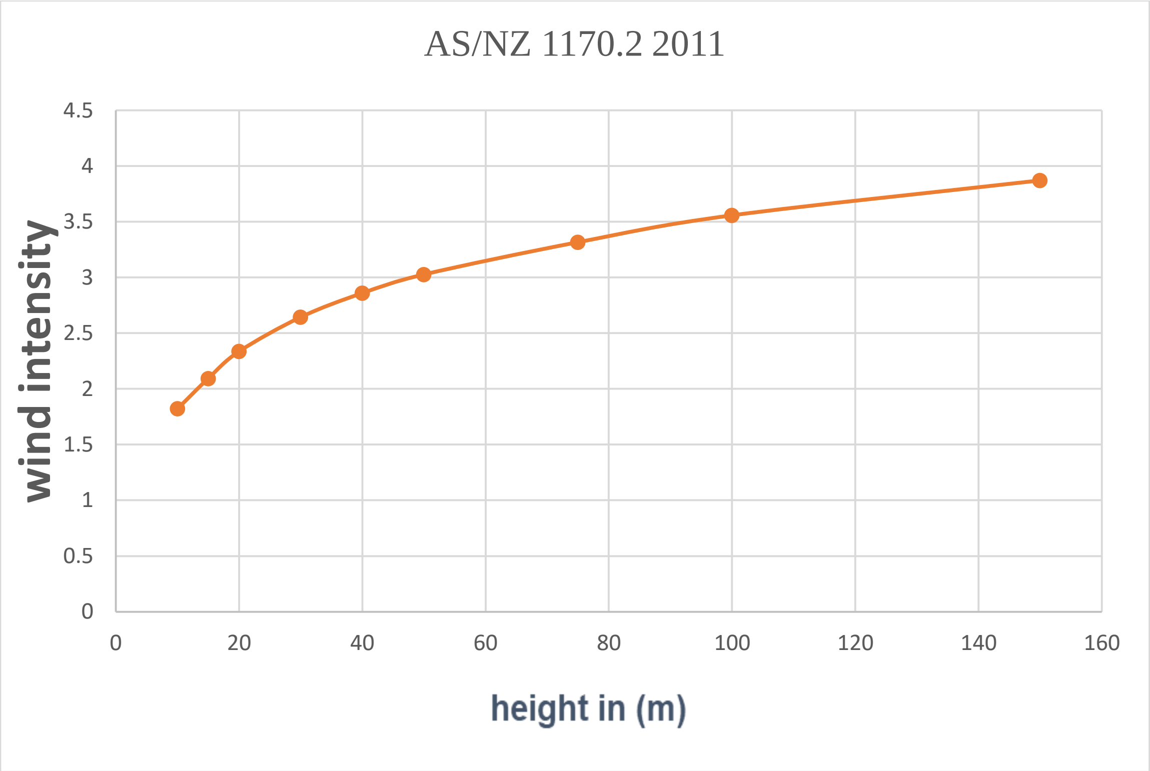


Figure 6.30: Wind intensity as per AS/NZ 1170.2 2011 in x dir

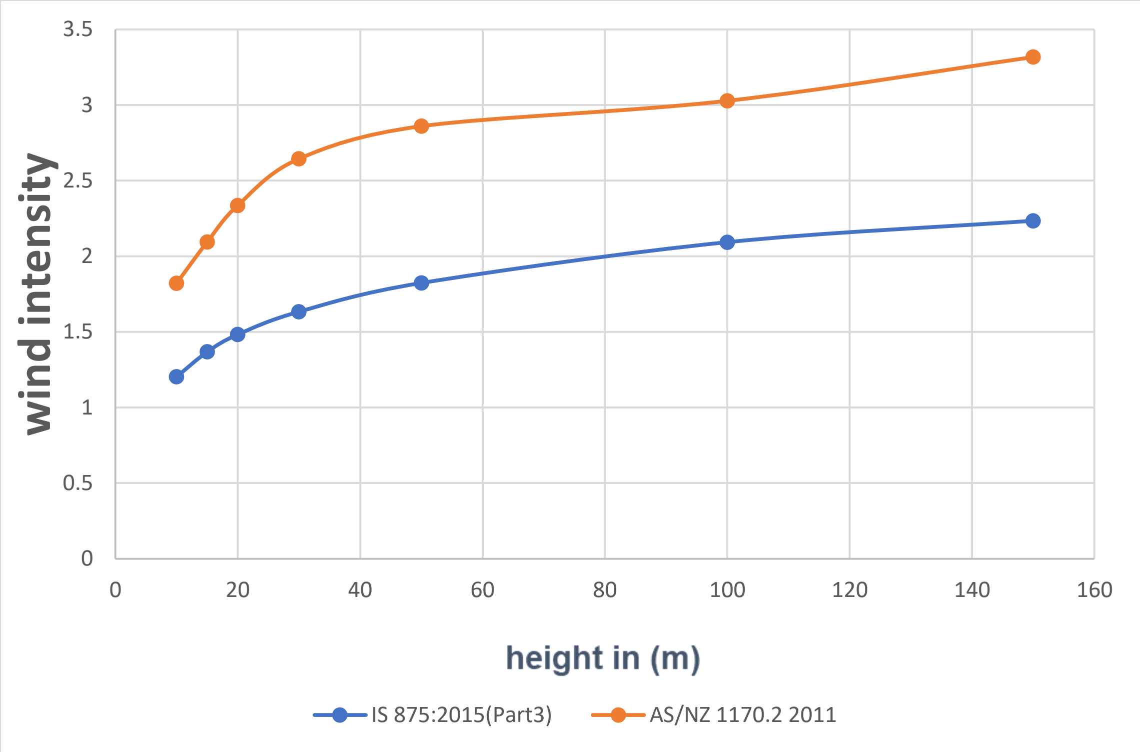


Figure 6.31: Comparison of wind intensity at different height in x dir

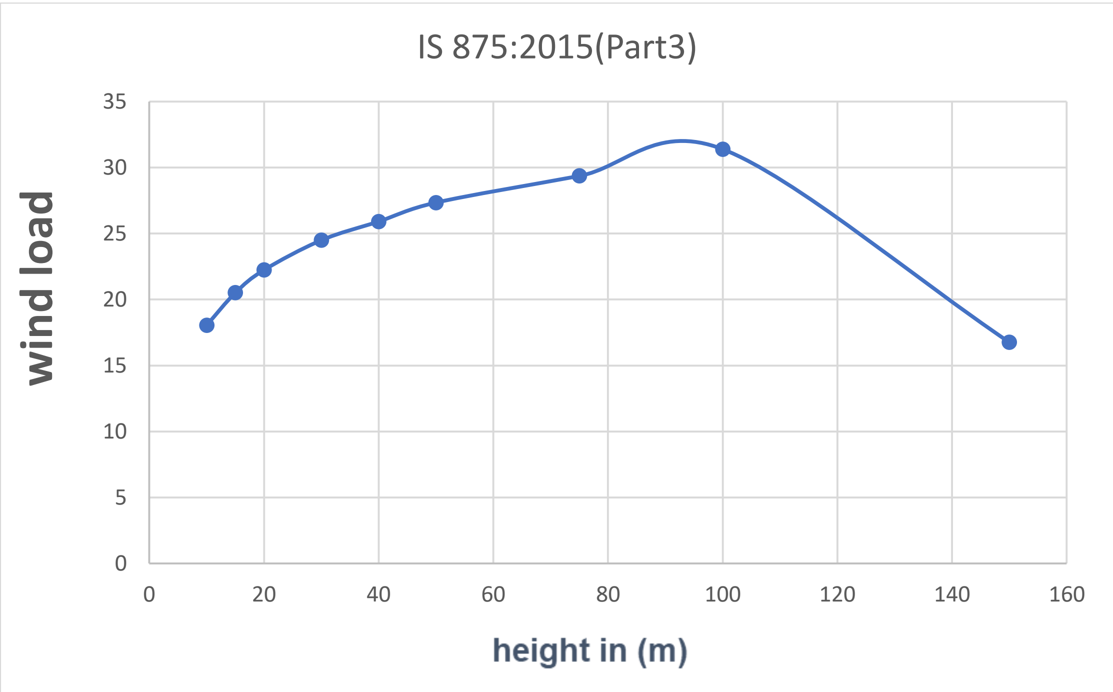


Figure 6.32: Wind load in KN as per IS 875:2015(Part3) in x dir

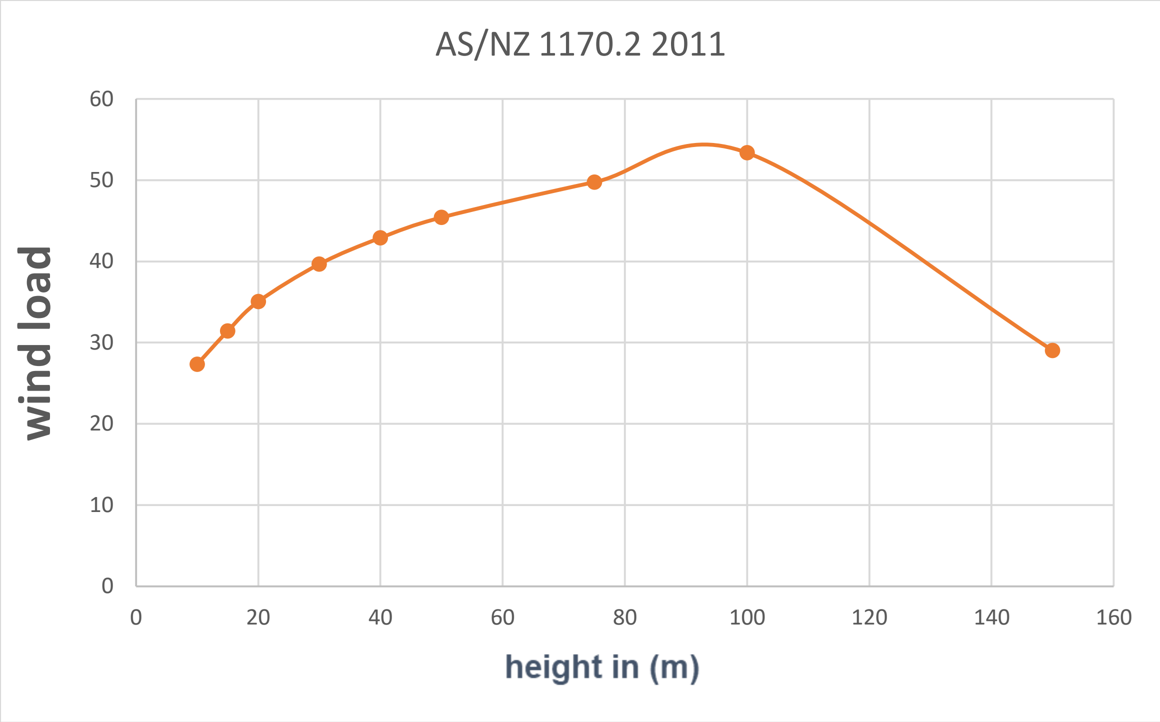


Figure 6.33: Wind load in KN as per AS/NZ 1170.2 2011 in x dir:

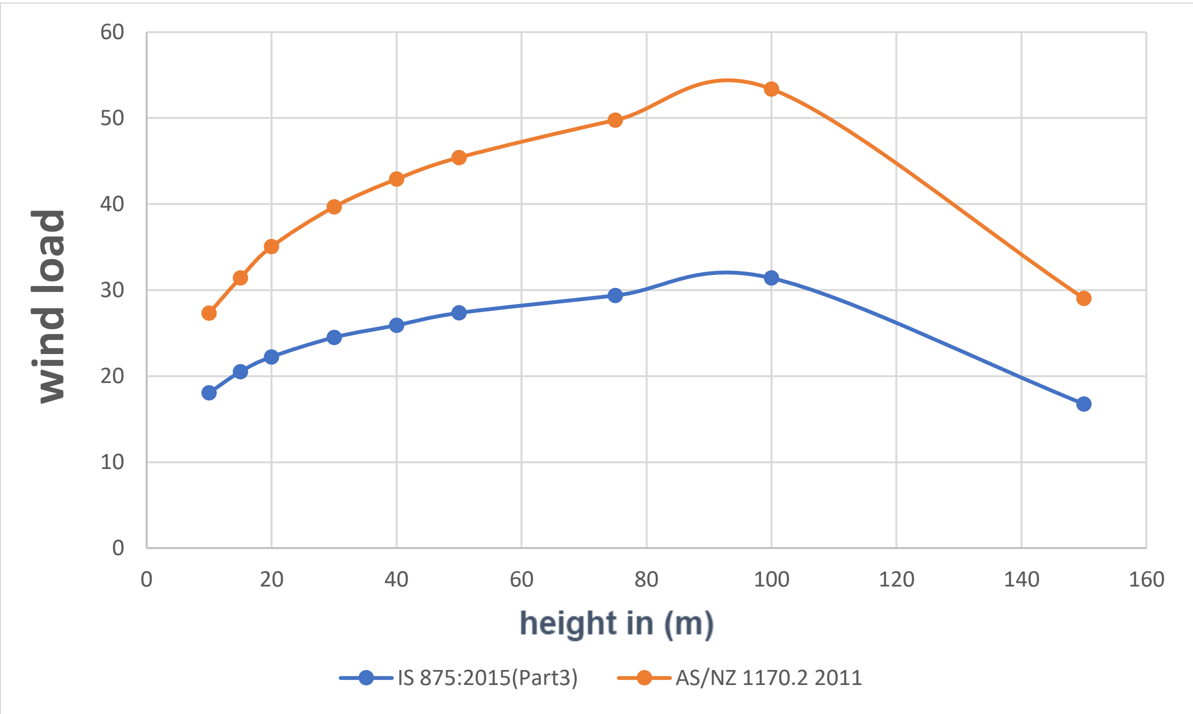


Figure 6.33: Comparison of wind intensity at different height in x dir

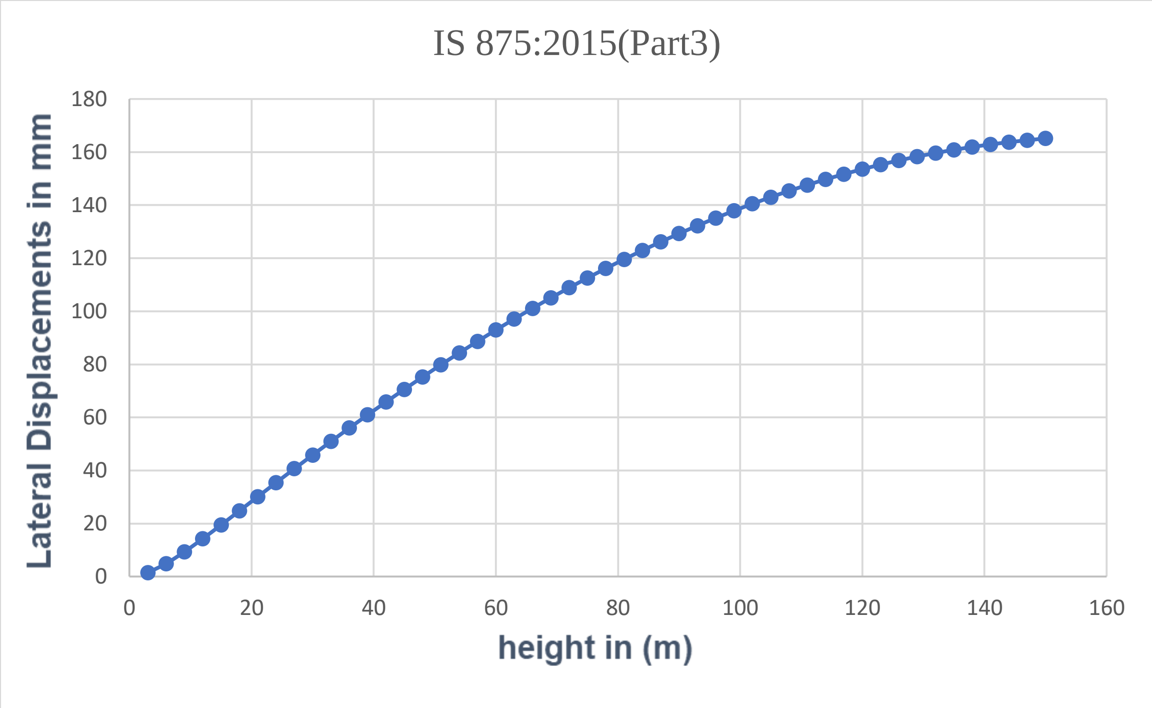


Figure 6.34: Lateral Displacements in mm at different height in x dir

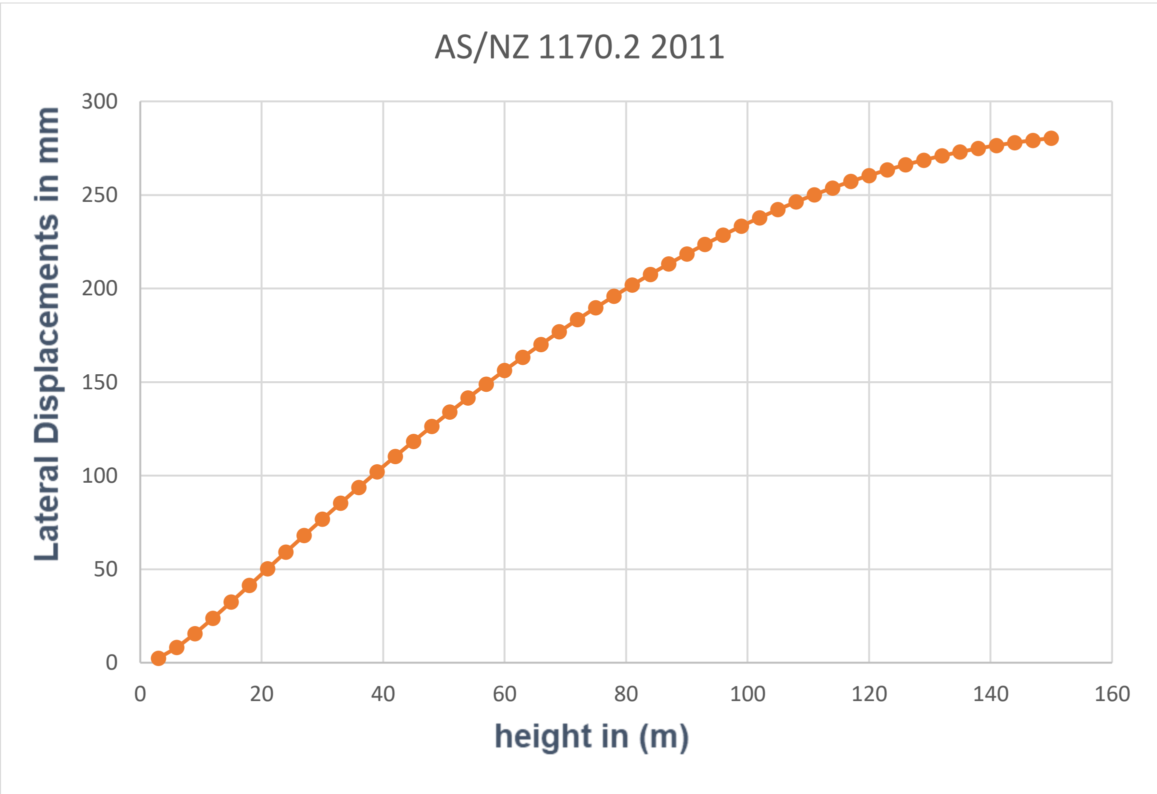


Figure 6.35: Lateral Displacements in mm at different height in x dir

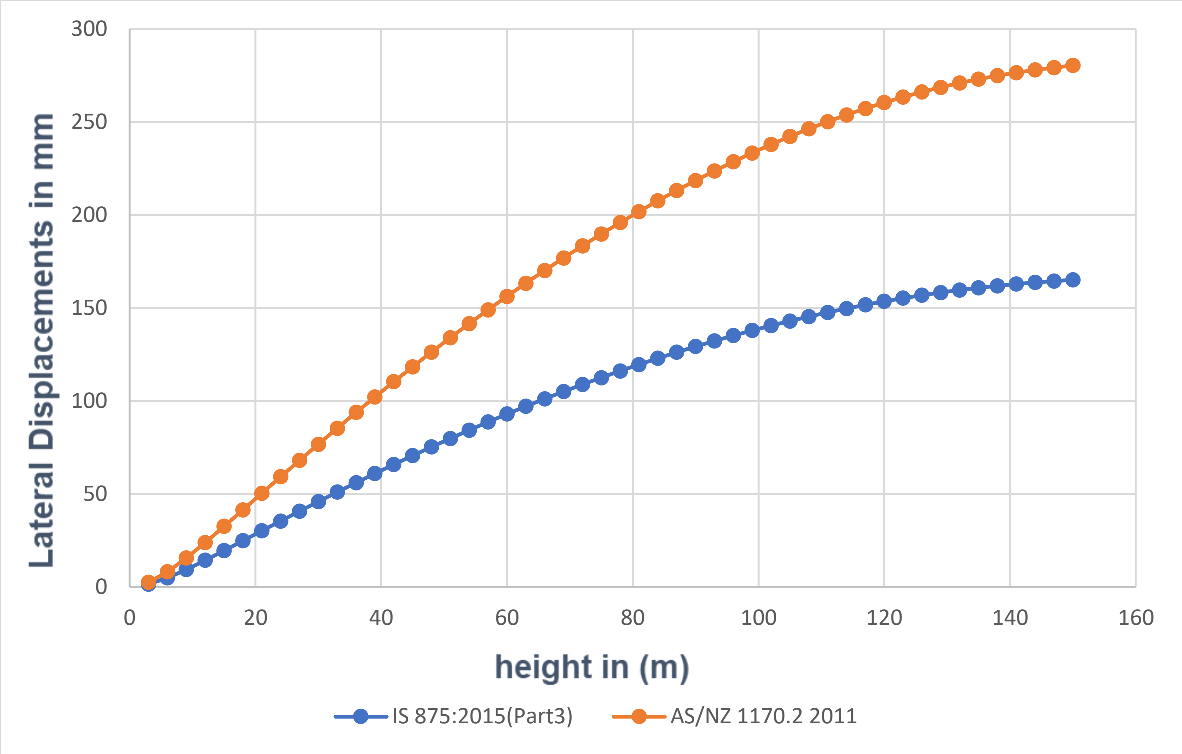


Figure 6.36: Comparison of Lateral Displacements in mm at different height in x dir

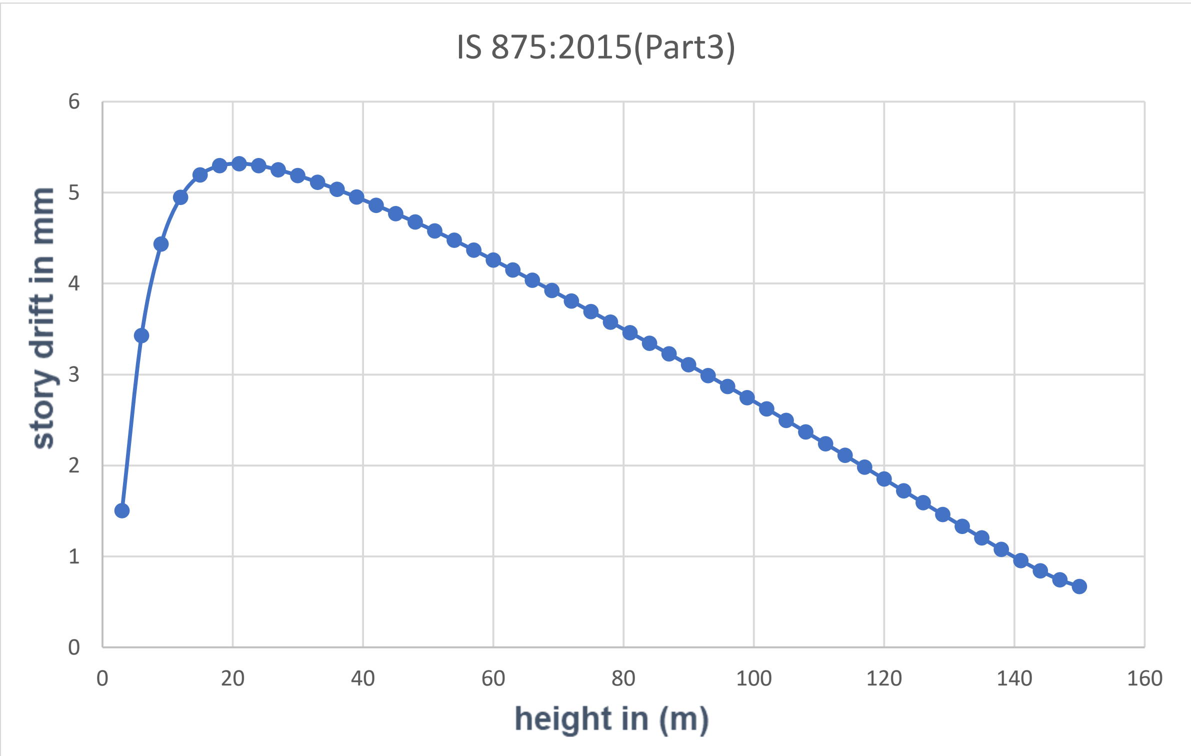


Figure 6.37: story drift in mm at different height in x dir.

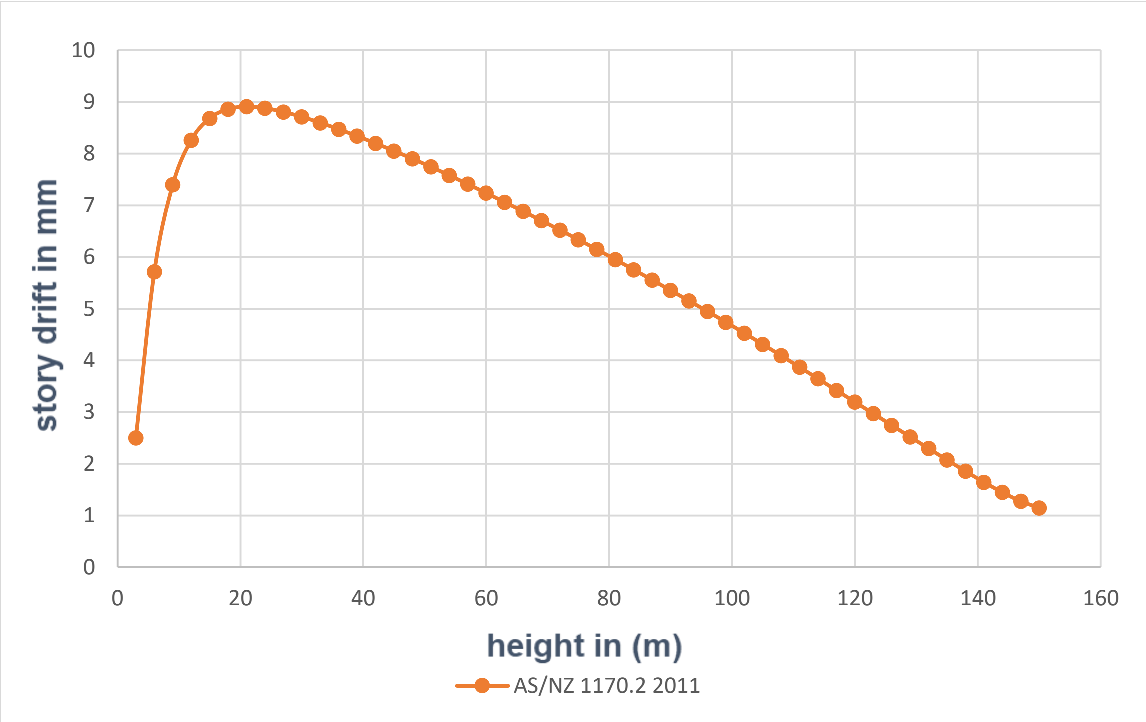


Figure 6.38: story drift in mm at different height in x dir.

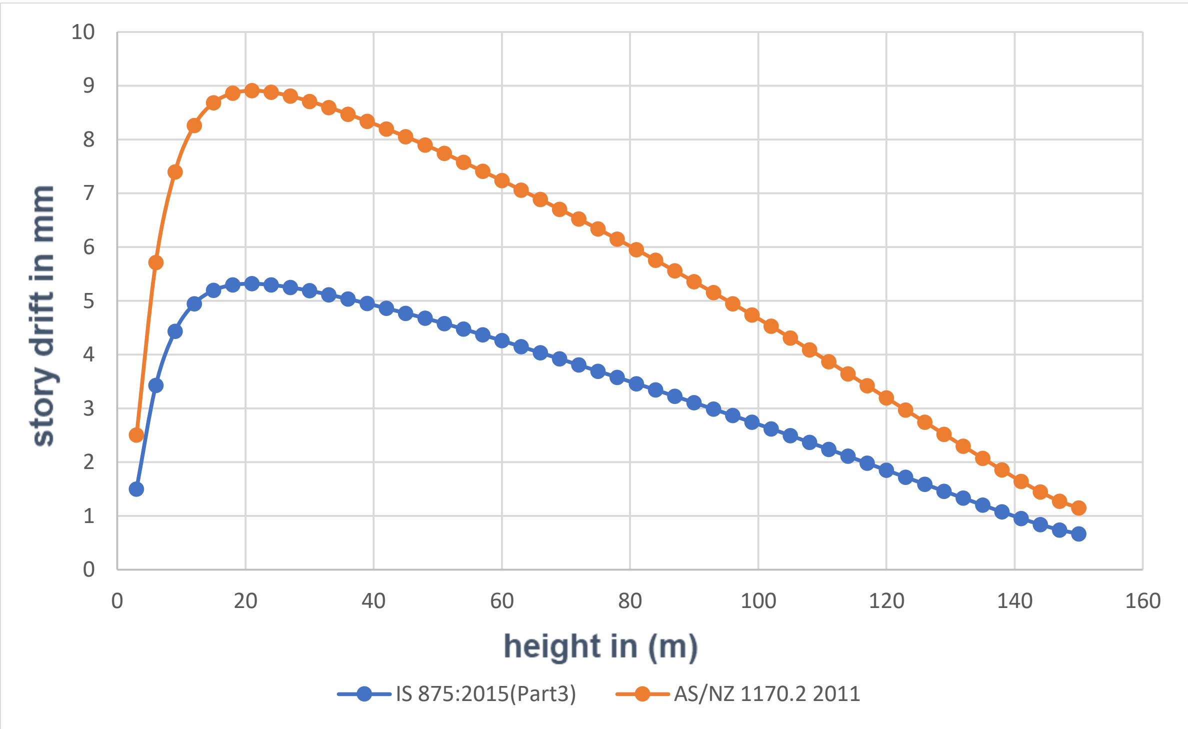


Figure 6.39: Comparison of story drift in mm at different height in x dir.

CHAPTER - 7
CONCLUSION

- as per IS: 875 (Part 3) 2015 Storey drift limitation shall not exceed 0.002 times the storey height or H/500 and all the deflection are under permissible limit.
- maximum lateral displacement in octagonal shape is 17.773 mm in x direction, which is less than all other shapes square rectangular hexagonal as per IS: 875 (Part 3) 2015.
- Based on the above result, it is concluded that shape of the structure plays an important role in resisting wind loads. Maximum lateral displacement in octagonal shape is 35% less than hexagonal shape and displacement and storey drift in octagonal shape is lesser compared to rectangular, square, diamond, hexagonal shapes as per is IS: 875 (Part 3) 2015.
- maximum lateral displacement in octagonal shape is 19.677 mm in x direction, which is less than all other shapes square rectangular hexagonal as per AS/NZ 1170.2 2011.
- Based on the above result, it is concluded that shape of the structure plays an important role in resisting wind loads. Maximum lateral displacement in octagonal shape is 35.4% less than rectangular shape and displacement and storey drift in octagonal shape is lesser compared to rectangular, square, diamond, hexagonal shapes as per AS/NZ 1170.2 2011.
- The results show that the octagonal shape structure is more effective as compared to all other shapes in case of lateral displacement according to IS: 875 (Part 3) 2015 and AS/NZ 1170.2 2011.
- The maximum deflection in the top most storey is 145.36 mm for structure which is designed as per IS: 875 (Part 3) 2015 and 246.32 mm in case of structure which is designed as per AS/NZ 1170.2 2011in x dir.

- Wind force has been decreased as per the IS: 875 (Part 3) 2015 compare to AS/NZ 1170.2 2011.Percentage decreased is 42.27% on the top most storey along “X” direction.
- Displacement for the top most storey of 50 storey building as per: 875 (Part 3) 2015 compare to AS/NZ 1170.2 2011.Percentage decreased is 40.90% along “X” direction.
- Storey drift for the top most storey of 50 storey building as per: 875 (Part 3) 2015 compare to AS/NZ 1170.2 2011.Percentage decreased is 48.56 along “X” direction.
- From the above results it can be concluded that AS/NZ 1170.2 2011 will provide high safety to the structure for static analysis as compared to IS: 875 (Part 3) 2015.

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