Comparative Study of Along-Wind Response of High Rise Building Using Major International Codes with Indian Code

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Abstract : The research paper discusses a comparative study of two major international codes and standards with the latest Indian Code for wind load i.e. IS 875 Part-III(2015) for along wind loads on high rise building. The major international codes and standards of wind loads included within the scope of this research paper are ASCE-7-02 (United States), AS/NZS1170.2-2011.Wind is an important factor in the design of buildings located in the coastal areas & in those areas where annual average wind speed is above average level. For the design of wind resistance building wind codes are available, which are widely used by the designer around the world. Different countries like India, Australia and New Zealand have their separate wind code for design of wind resistant building in their territory. All the International wind loading codes and standards provide guidelines and procedure for evaluation of wind load and effect of wind on high rise structures. This paper describes a comparison of response of building due to wind load by three countries' wind loading code. The study was conducted on 60m high rise building with different geometrical building shape such as rectangular, L-shape, C-shape for static wind characteristics i.e. static analysis. The comparative results are obtained from the different international wind loading codes and standards for terrain category 2 and category 3 for all codes using ETABS software. Different perimeter like Base Shear, Story displacement, Story Drift. The aim of this paper is comparing the results of various wind loading codes and standards with Indian wind loading code and standard.

***IndexTerms* - Wind loads, Terrain category, Static method, Tall structure, and Story Displacement. Story drift**

I. INTRODUCTION

In modern era buildings are made very tall, slender and asymmetrical, with special architectural and aesthetic requirements. Due to developments of new building materials and construction techniques, these buildings are becoming much lighter and slenderer than earlier. Buildings of modern era are very susceptible to wind load. This is due to complex interference effects induced by turbulent wind flow field. The research paper discusses a comparative study of two major international codes and standards with the latest Indian Code for wind load i.e. IS 875 Part-III(2015) for along wind loads on high rise building. The major international codes and standards of wind loads included within the scope of this research paper are ASCE-7-02 (United States), AS/NZS1170.2-2011.This paper describes a comparison of response of building due to wind load by three countries' wind loading code.

The study was conducted on 60m high rise building with different geometrical building shape such as rectangular, L-shape, C-shape for static wind characteristics i.e. static analysis. The comparative results are obtained from the different international wind loading codes and standards for terrain category 2 and category 3 using ETABS software. The aim of present study is to examine the effects of wind on tall structure under different geometric plan configuration of tall building having same parameters.

II. WIND EFFECTS ON TALL BUILDINGS

The wind is the most powerful and unpredictable force affecting tall buildings. Tall building can be defined as a mast anchored in the ground, bending and swaying in the wind. This movement, known as wind drift, should be kept within acceptable limits. Moreover, for a well-designed tall building, the wind drift should not surpass the height of the building divided by 500. Wind loads on buildings increase considerably with the increase in building heights. Furthermore, the speed of wind increases with height, and the wind pressures increase as the square of the wind speed. Thus, wind effects on a tall building are compounded as its height increases. Besides this, with innovations in Architectural treatment, increase in the strengths of materials, and advances in methods of analysis, tall building have become more efficient and lighter, and so, more vulnerable to deflection, and even to swaying under wind loading. Despite all the engineering sophistication performed with computers, wind is still a complex phenomenon, mainly owing to two major problems. Unlike dead loads and live loads, wind loads change rapidly and even abruptly, creating effects much larger than when the same loads were applied gradually, and that they limit building accelerations below human perception. Although the true complexity of the wind and the acceptable human tolerance to it have just begun to be understood, there is still a need to understand more the nature of wind and its interaction with a tall building, with particular reference to allowable defections and comfort of occupants.

III. VARIATION OF WIND SPEED WITH HEIGHT

An important characteristic of wind is the variation of its speed with height. The wind speed increase follows a curved line varying from zero at the ground surface to a maximum at some distance above the ground. The height at which the speed stops to increase is called the gradient height, and the corresponding speed, the gradient wind speed. This important characteristic of wind is a well understood phenomenon that higher design pressures are specified at higher elevations in most building codes. Additionally, at heights of approximately 366 m from the ground, surface friction has an almost negligible effect on the wind speed; as such the wind movement is only depend on the prevailing seasonal and local wind effects. The height through which the wind Speed is affected by the topography is called atmospheric boundary layer. The wind speed profile within this layer is in the domain of turbulent flow and could be mathematically calculated.

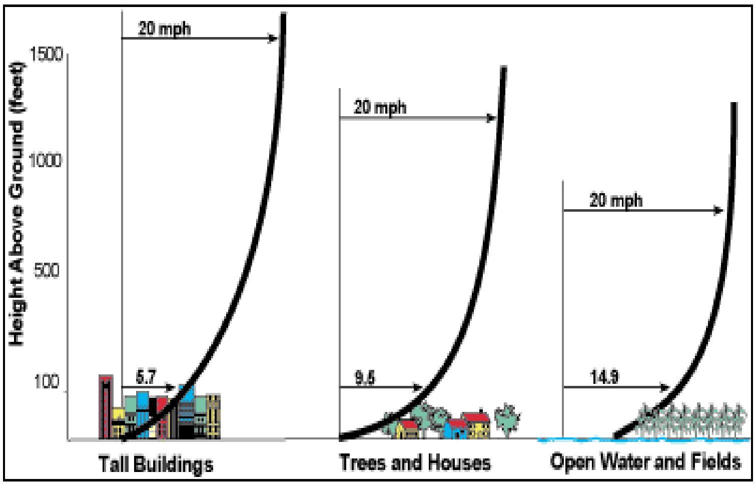


Fig.1 Variation of wind speed with height

IV. MODELLING

The numerical data for modelling of G+20 story building and the parameter consider for wind load analysis are shown in the below table.

Primary Data	Rectangular	L Shape	C Shape
Plan Area (m^2)	15m x 20 m	15m x 20 m	15m x 20 m
Story Height	3	3	3
Number of story	G+20	G+20	G+20
Beam	300 mm x 600 mm	300 mm x 600 mm	300 mm x 600 mm
Column	600 mm x 750 mm	600 mm x 750 mm	600 mm x 750 mm
Slab	150 mm	150 mm	150 mm
Concrete Grade	M25	M25	M25
Steel Grade	Fe415	Fe415	Fe415
Live Load (kn/m^2)	3	3	3
Floor finish (kn/m^2)	1	1	1
Wind Speed (m/s)	39	39	39
Category	2 and 3	2 and 3	2 and 3

A. Geometry of the building

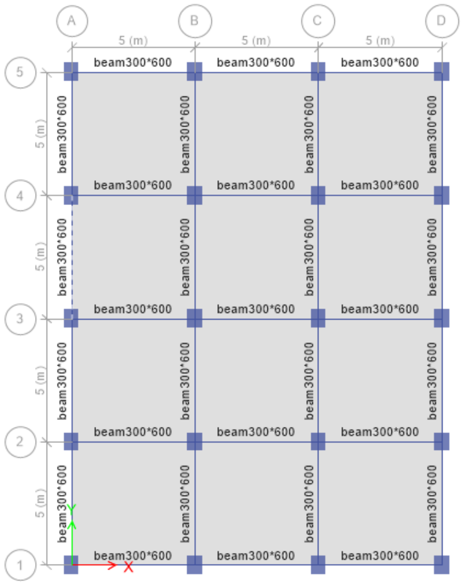


Fig.2 Regular Structure plan

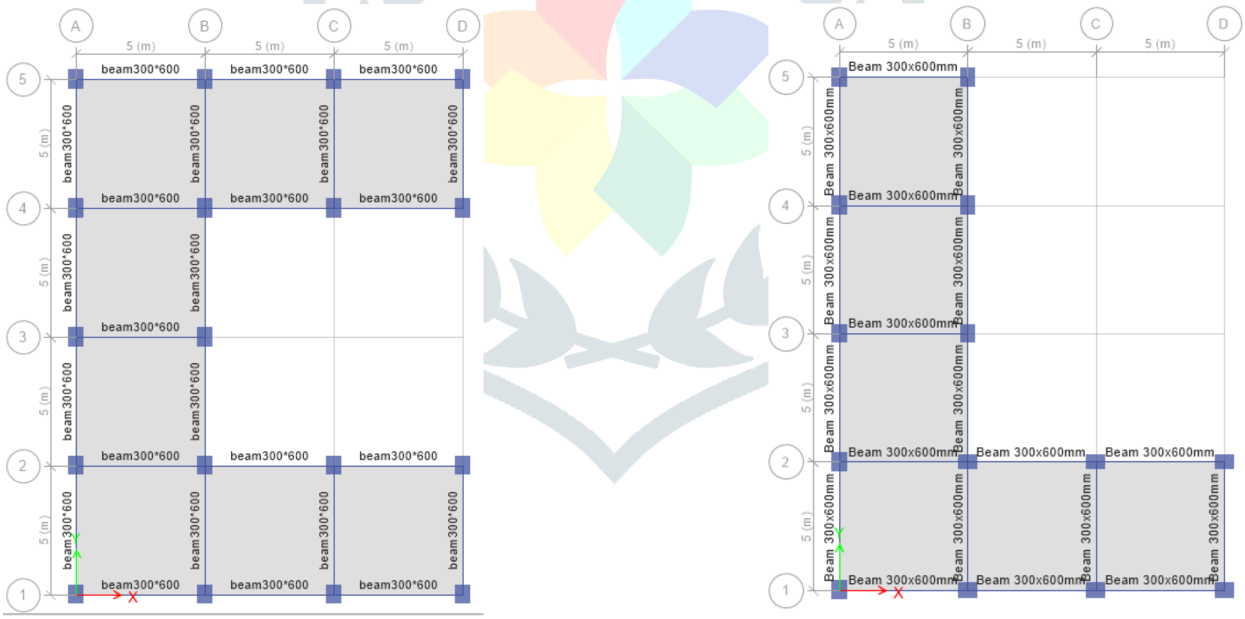
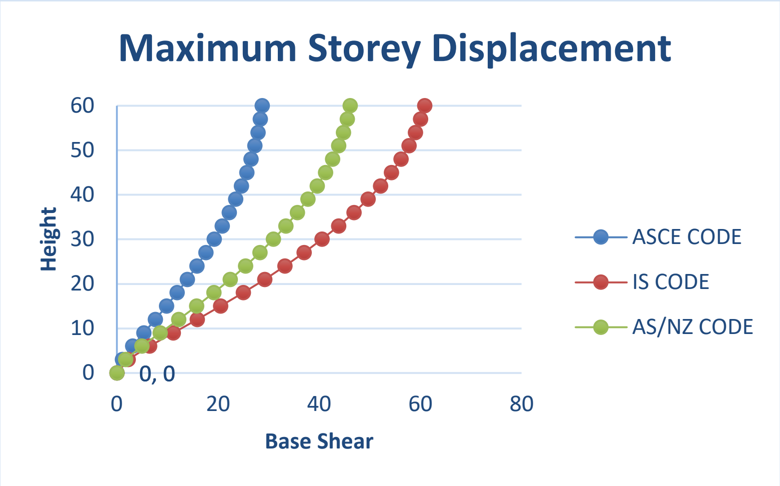


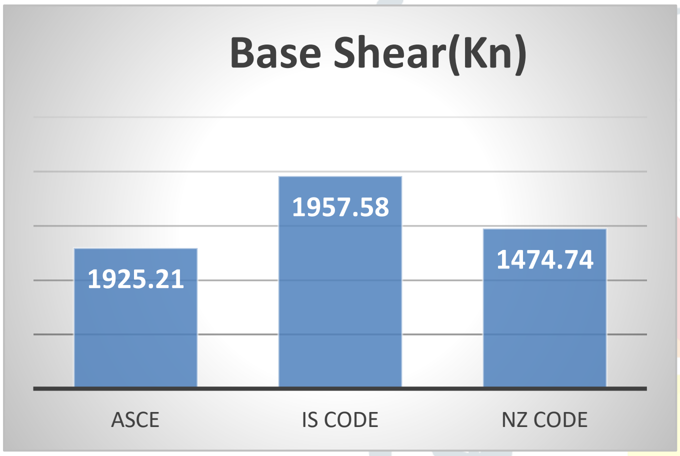
Fig.3 Irregular Structure plan

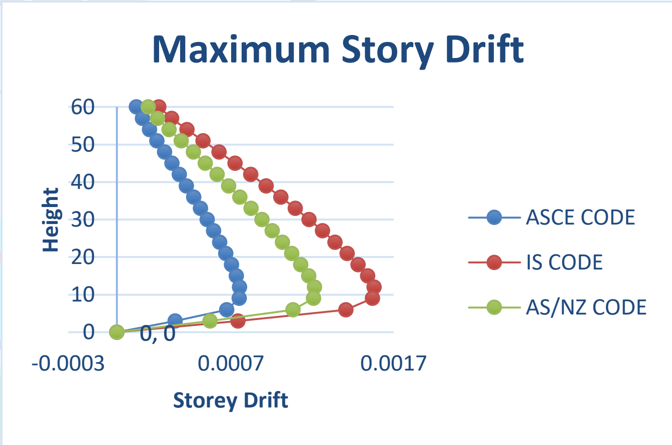
V. Result

A. Rectangular Shape (Category 2)

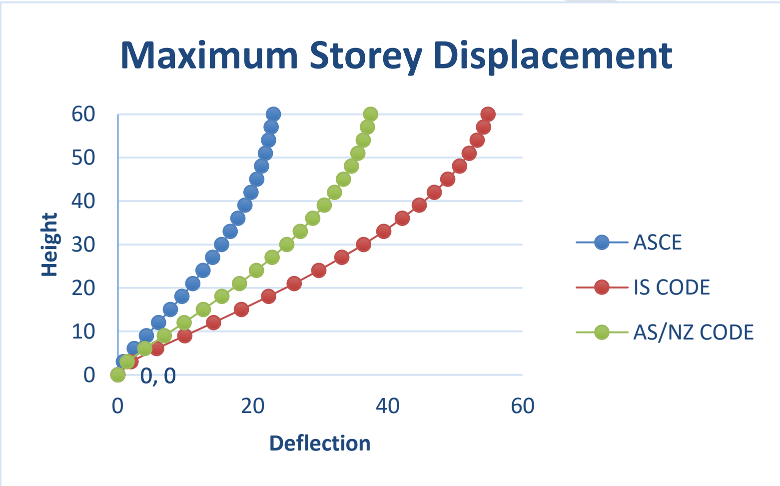


Code	Max. Displacement(mm)
ASCE Code	28.7
IS Code	60.81
AS/NZS Code	46.11

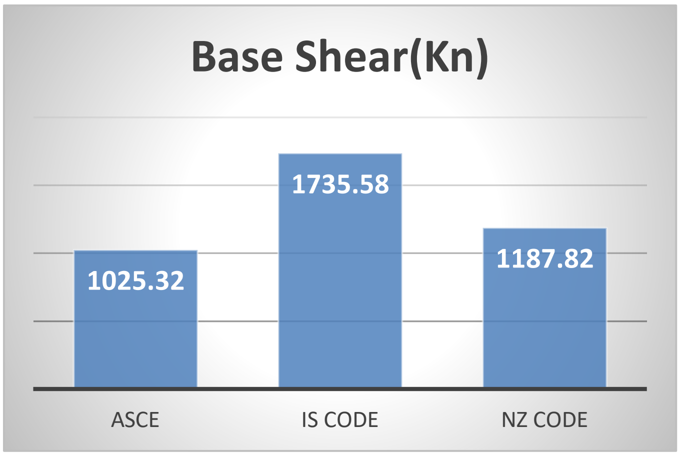


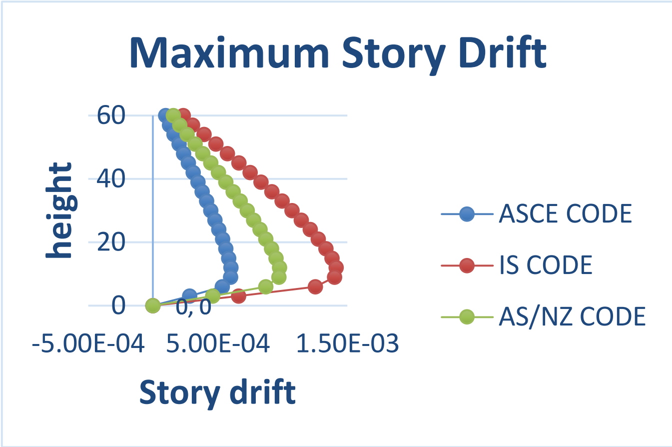


B. Rectangular Shape (Category 3)

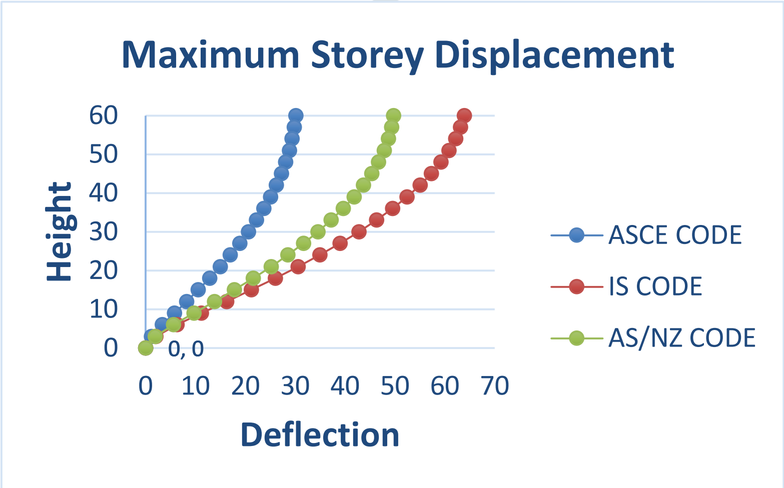


Code	Max. Displacement(mm)
ASCE Code	23.39
IS Code	54.84
AS/NZS Code	37.45

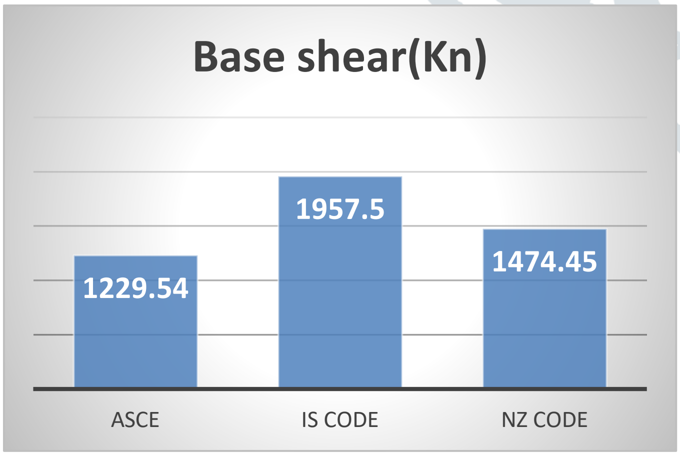


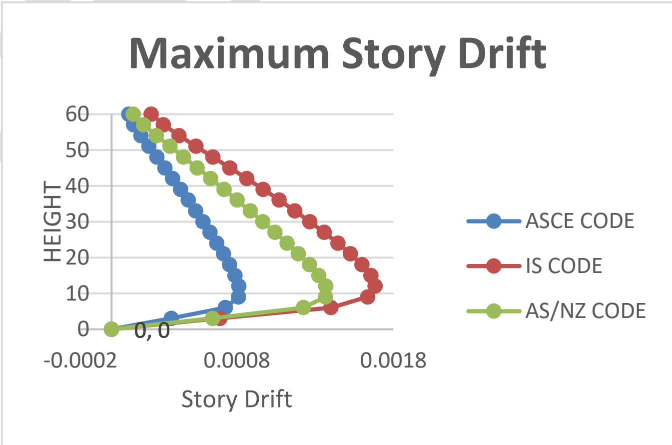


C. <u>C - Shape (Category 2)</u>

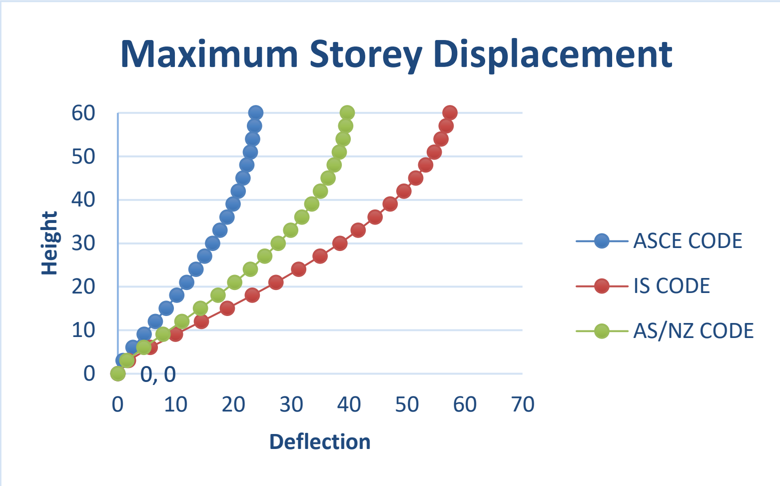


Code	Max. Displacement(mm)
ASCE	30.10
IS	63.91
AS/NZS	49.73

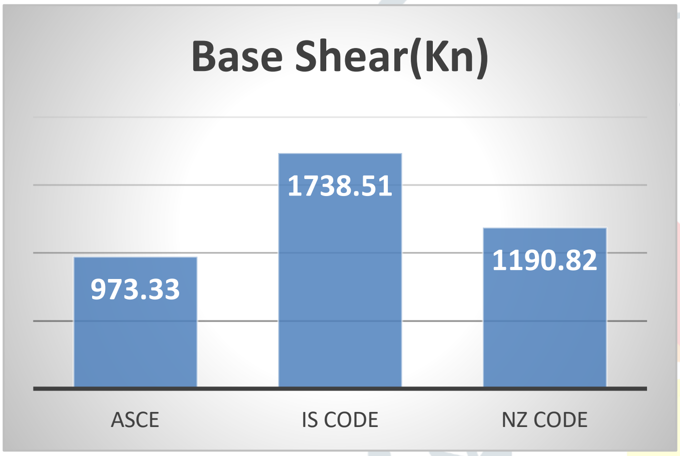


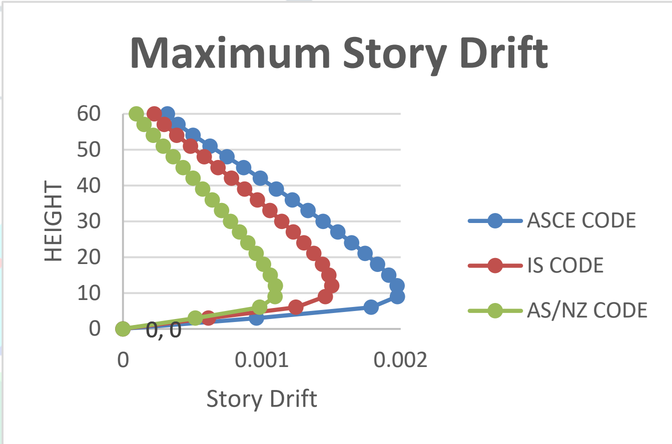


D. C - Shape (Category 3)

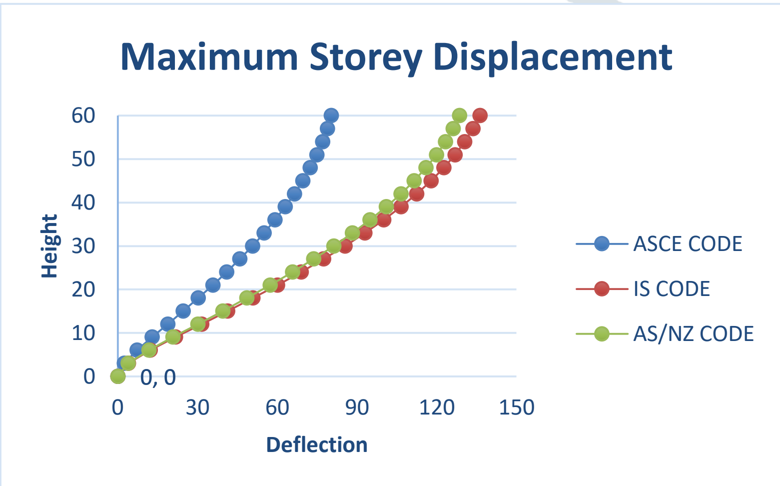


Code	Max. Displacement(mm)
ASCE Code	23.86
IS Code	57.43
AS/NZS Code	39.68

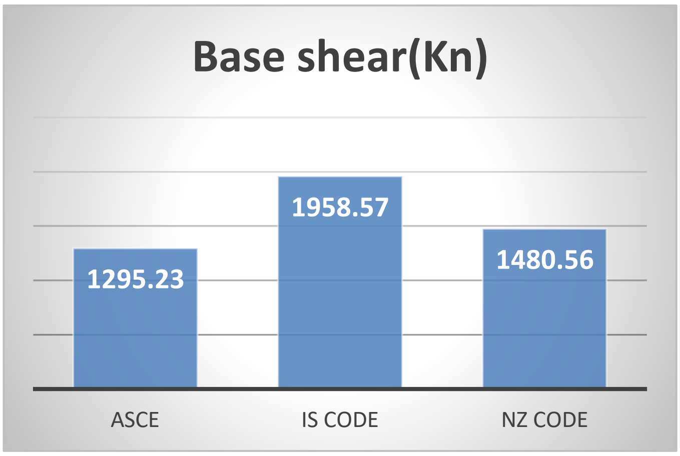


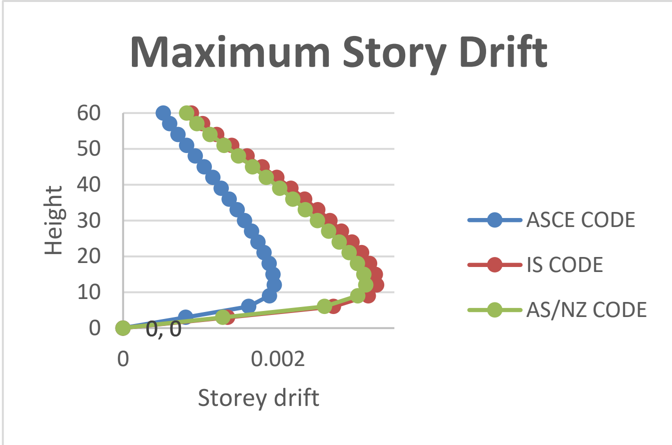


E. L - Shape (Category 2)

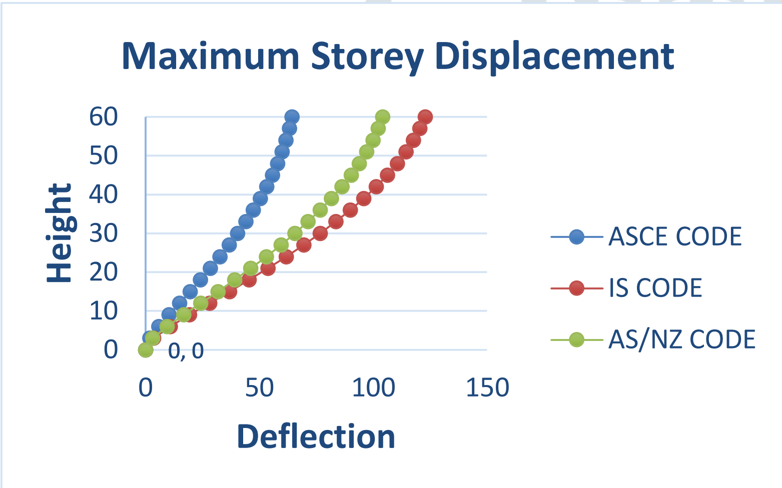


Code	Max. Displacement(mm)
ASCE Code	80.36
IS Code	136.19
AS/NZS Code	128.56

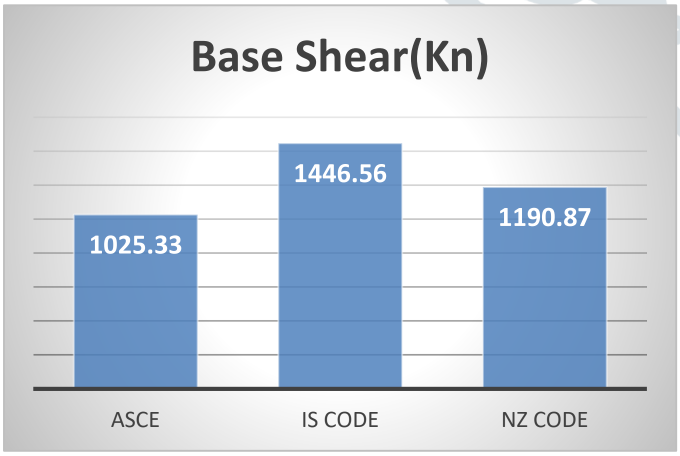


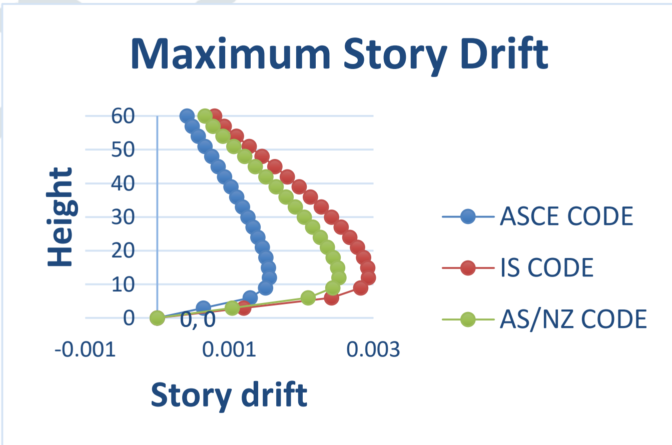


F. <u>L - Shape (Category 3)</u>



Code	Max. Displacement(mm)
ASCE Code	64.35
IS Code	122.81
AS/NZS Code	104.119





CONCLUSION

By comparing the result of G+20 story building having different geometry for IS code, ASCE code, and AS/NZS code, following conclusion can be made

1. Firstly, IS Codes gives the higher values of base shear, story displacement and story drift in comparison to NZ Code and ASCE Code and NZ Code gives the higher values than ASCE code.
2. The analysis value for IS 875(Part-3):2015 is maximum and minimum for AS/NZS code and ASCE code respectively., it means that, construction of a wind resistance building according to ASCE code is most economical and by IS 875-3 is least economical whereas by AS/NZS code is moderately economical.
3. The Story Displacement Value for L-Shape is higher compared to C-Shape and Rectangular Shape respectively, thus rectangular shape is most stable and L-Shape is least Stable under action of wind load.
4. Values of Base shear, Story Displacement and Story Drift for terrain Category 2 building are higher compared to the Terrain Category 3 building.

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