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Aerodynamic optimization of building shapes by using ETABS

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ABSTRACT
This project is concerned with the performance of G+24 story buildings like minor modifications of the structures and major modifications of the structures ,seismic zone is considered as V on medium soil. Analysis has been carried out by using ETAB's software as per IS 1893 (part 1) :2016. Different parameters like top Story displacement, Story drift , Story shear considered to check the aerodynamic optimization of building shapes at seismic zone V. High rise Structures are in demand due to scarcity of land in urban areas, economic growth, technological advancement, etc. Wind effect is very important for high rise structures and provides significant contribution to overall loading and serviceability. But as we go higher wind excitation becomes one of the most precarious force acting on the surface of the structure So modifications to the structural geometry is on of the best idea to reduce the wind impact. This project performed with considered the response spectrum analysis, and wind analysis in ETABS Software. In this paper different aerodynamic modification are applied to the G+24 square structure.
Minor modification like Sharp edge at the corners, recessed shape at the corners corner and major modification like Twisted shape of building, irregular shape of building, sharp edge at the corners with the open space of the building . Wind analysis for these models were done in ETABS software and the obtained results were compared with basic square model. Then the model having less impact for wind is concluded as the best modified structure
Key words: *response spectrum analysis, and wind analysis Story displacement, story drift ,Story shear.*

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I. INTRODUCTION

Today, it is virtually impossible to imagine a major city without tall buildings. Tall buildings are the most famous landmarks of cities, symbols of power, dominance of human ingenuity over natural world, confidence in technology and a mark of national pride; and besides these, the importance of tall buildings in the contemporary urban development is without doubt ever increasing despite their several undeniable negative effects on the quality of urban life. Nowadays the national development depicts the presence of tall high rise building all around the nation as a pride factor and a showcase to the prosperity of the country. They are primarily a reaction to the rapid growth of the urban population and the demand by business activities to be as close to each other as possible. Every architects imaginative reinterpretations of the building type, the inadequacy and high cost of land in urban areas, the need to preserve significant agricultural production, the concept of skyline, cultural significance and prestige, have all contributed to force buildings upward.

Tall, slender structures are prone to lateral loads such as wind and seismic loads to which the structures are more susceptible. Their inherent flexibility can lead to significant movement in the building during normal use when the high winds near the upper part of the building impinge on its surface. This can be a source of discomfort for occupants and may even cause damage to certain building elements. This is particularly a problem for areas that are predisposed to strong winds, both regularly and at certain times of the year such in as hurricane-prone regions. Due to climate change, it can be expected that these effects will only worsen. One of the major achievements in modern building design practice is to understand the underlying principles that may have been contained in historical wonders by coincidence and explore more creative ways to apply these principles in design. Such as Aerodynamic optimization.

Once the height of the building rises the effect of air-induced motion also increases. Day by day, the population in urban area is increasing and the space required for their residency is decreasing.

1.1 AERODYNAMIC FORCES ON BUILDINGS

A structure immersed in a given flow field is subjected to aerodynamic forces. For typical tall buildings, aerodynamic forces includes drag (along-wind) forces, lift (across-wind) forces and torsional moments. The along-wind forces act in the direction of the mean flow. The along-wind motion primarily results from pressure fluctuations on windward and leeward faces and generally follows fluctuations in the approaching flow.

1.1.1 MINOR MODIFICATIONS OF BUILDING

For most buildings projects the shape and orientation are driven by architectural considerations, functional requirements and site limitations, rather than by aerodynamic considerations, as a result these structures are bluff bodies characterized by high wind structure interaction induced loads. The aerodynamic modifications of a building's cross-sectional shape, variation of its cross section along the, can significantly reduce building response in along-wind and as well as across-wind direction around the building. Minor modifications of buildings like sharp edge at the corners of building, recessed shape at the

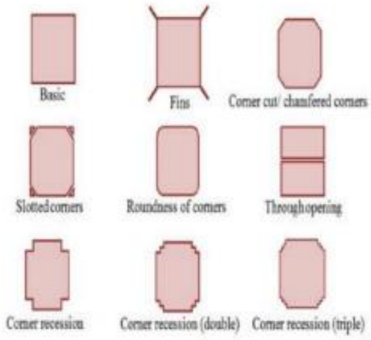


Fig.1.1: minor aerodynamic forms

1.1.2MAJOR MODIFICATIONS OF BUILDING

Major modifications of the building like twisted shape of the building, irregular shape of the building ,sharp edge at the corners with the open space of the building.

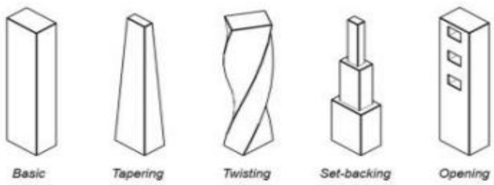


Fig.1.2: minor aerodynamic forms

II. OBJECTIVES OF THE STUDY

1. To analyse the different minor modifications and major modifications of G+24 Building structures, by using ETABS 2020 Software.
2. To Compare the different modification of structures and to determine the seismic responses and wind responses in x and y direction, as per IS 1893 (Part 1) :2016, and IS 875 (Part 3):2015 respectively, by using ETABS-2020 Software.
3. To determine the story drift, story displacement, base shear of each different modification of building structures by using response spectrum method, wind analysis method.
4. To determine the minor modifications like Sharp edge at the corners of building , and recessed shape at the corners of building and major modifications like Sharp edge with open space of building, irregular shape of building and twisting of building able to control the story displacement, story shear, story drift in x and y directions.

III. METHODOLOGY

- **ALONG-WIND RESPONSE:**

Along-wind is the term which refers to drag forces. Pressure fluctuations on windward face (building's frontal face that wind hits) and leeward face (back face of the building) as well as wind load interaction with buildings causes along-wind load.

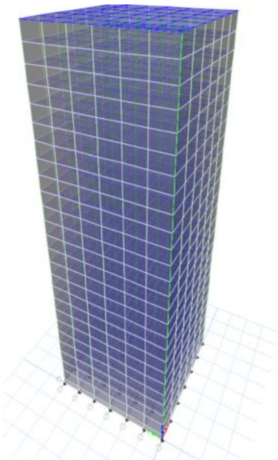
- **ACROSS-WIND RESPONSE:**

Across-wind response is a perpendicular fluctuation response of wind excitation.

MODEL DESCRIPTION

Properties of buildings adopted at present work	
Number of stories	G+24
Number of minor modification of the models	2
Number of major modification of the models	3
Plan dimension	30m x 30m , but irregular shape model plan dimension is 50m x 50m
Story height	3m
Grade of rebar	Fe550
Grade of concrete	M30, M40, M20
Column size	750mmx750mm
Beam size	300mmx300mm
Slab thickness	150mm
Floor wall load	11kN/m
Floor finish	1.5 kN/m^2
Parapet load	6.9 kN/m
Seismic zone	V
Soil type	Medium soil
Importance factor	1.5 (seismic) 1.3(wind analysis)
Location	Darbhanga (Bihar)
Wind speed	55 m/sec
Windward pressure coefficient	0.8
Leeward pressure coefficient	-0.25
Response reduction factor	5
Terrain category	4

3.1 Minor modifications of the models



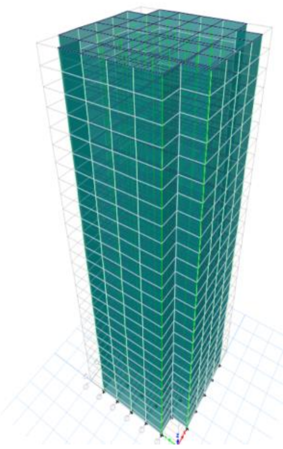


Fig.3.1: Sharp edge at the corners of the building(model 1)**and Fig.3.2:** Recessed shape at the corners of the building (model 2)

3.2 Major modifications of the models

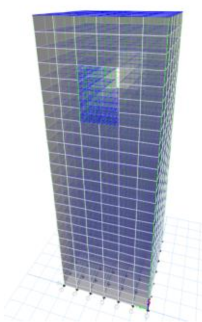
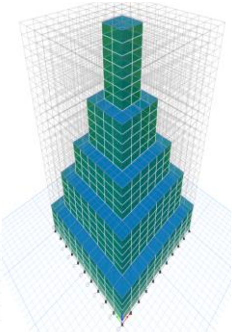



Fig.3.3:sharp edge at the corners with the open space of the building(model 3) and **Fig.3.4:** irregular shape of the building (model4)

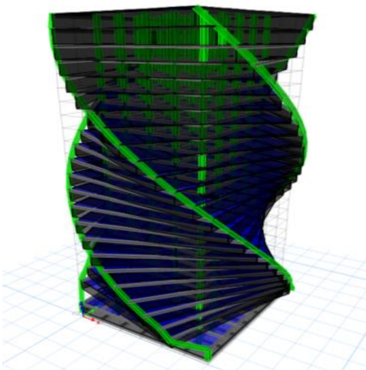


Fig 5: Twisted shape of the building (Model 5)

IV. RESULTS AND DISCUSSIONS

4.1 Minor modifications of the buildings

❖ Due to Response spectrum method

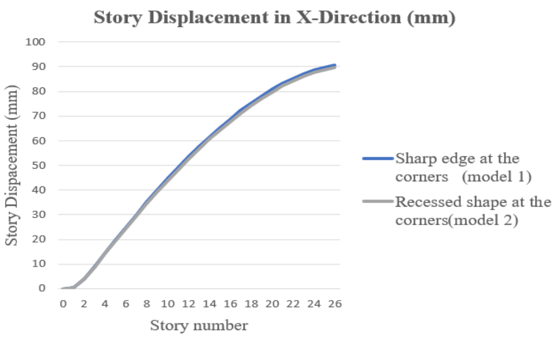


Fig.4.1: Story Displacement in X-Direction

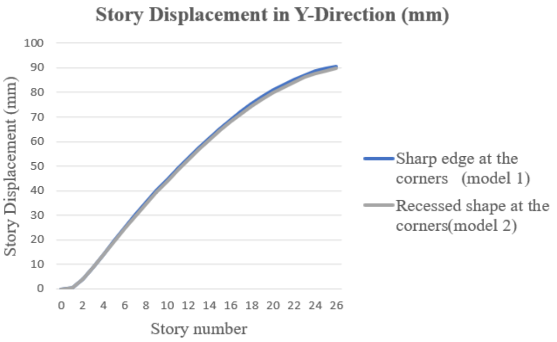


Fig.4.2: Story Displacement in Y-Direction

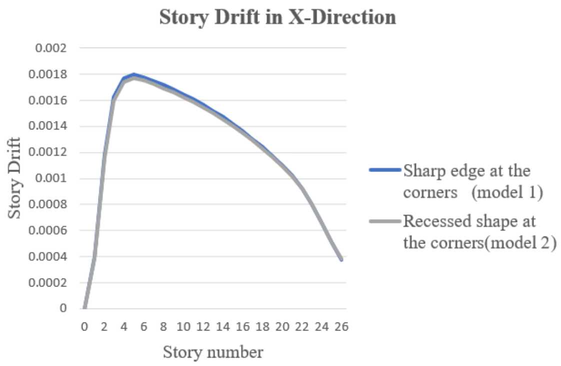


Fig.4.3: Story Drift in X-Direction

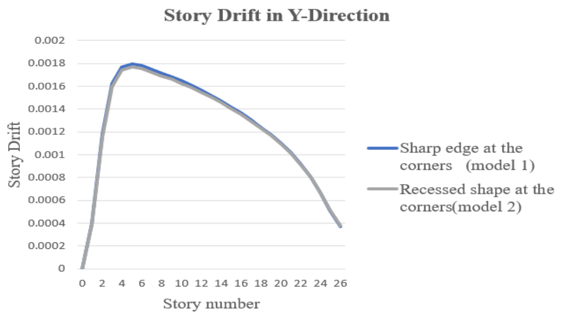


Fig.4.4: Story Drift in Y-Direction

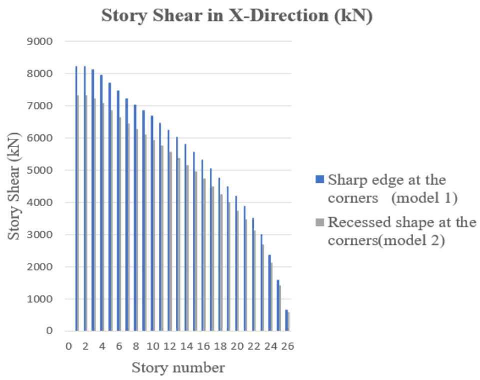


Fig.4.5: Story Shear in X-Direction

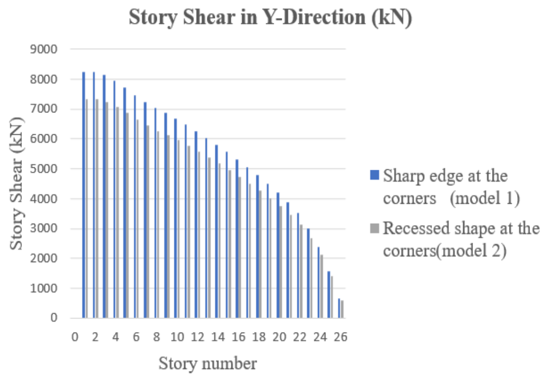


Fig.4.6: Story Shear in Y-Direction

- The percentage variation of maximum story displacement is reduced to 1.11 % in RSPAX direction and 1.11% in RSPAY direction respectively for model 2, when compared with model 1.
- The percentage variation of maximum story drift is 1.57% and 1.57% reduced in RSPAX and RSPAY direction respectively for model 2, when compared with model 1.

- The percentage variation of maximum story Shear is 11.63% and 11.63% reduced in RSPAX and RSPAYY direction respectively for model 2, when compared with model 1.

❖ Due to Wind analysis method

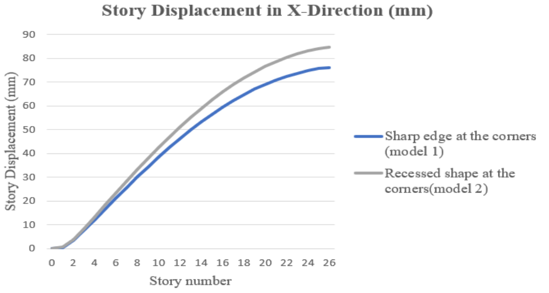


Fig.4.7: Story Displacement in X-Direction

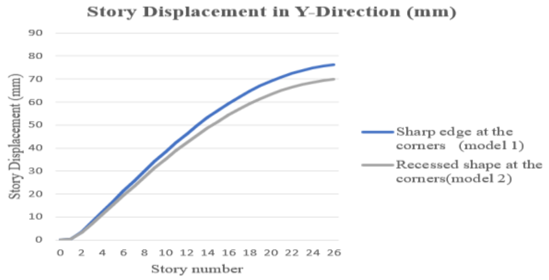


Fig.4.8: Story Displacement in Y-Direction

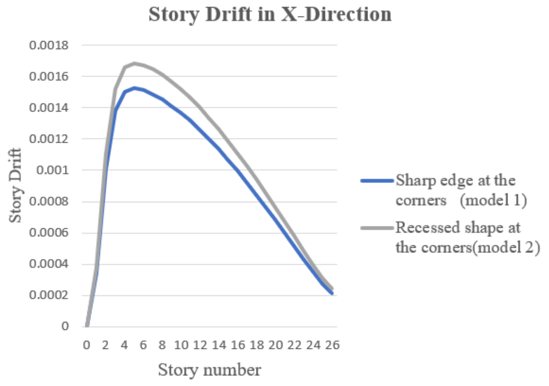


Fig.4.9: Story Drift in X-Direction

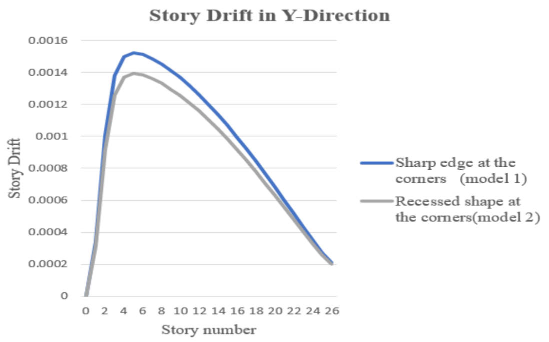


Fig.4.10: Story Drift in Y-Direction

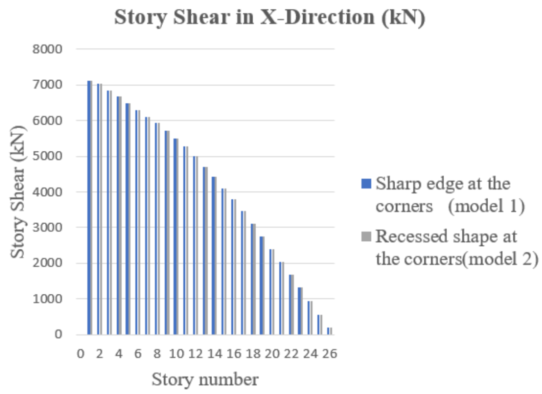


Fig.4.11: Story Shear in X-Direction

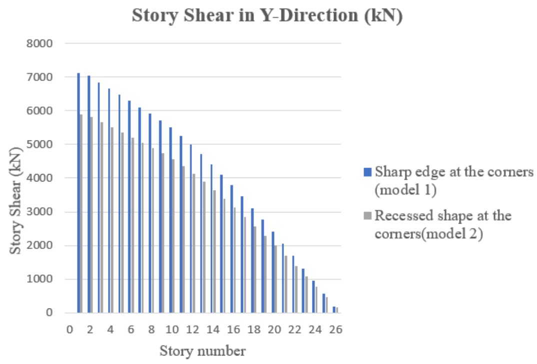


Fig.4.12: Story Shear in Y-Direction

- The percentage variation of maximum story displacement is reduced to 10.56 % in Wind X direction and 8.48% in Wind Y direction respectively for model 2, when compared with model 1.
- The percentage variation of maximum story drift is 10.09% increased and 8.92% reduced in Wind X and Wind Y direction respectively for model 2, when compared with model 1.
- The percentage variation of maximum story Shear is 0% and 19% reduced in Wind X and Wind Y direction respectively for model 2, when compared with model 1.

4.1 Major modifications of the buildings

❖ Due to Response spectrum method

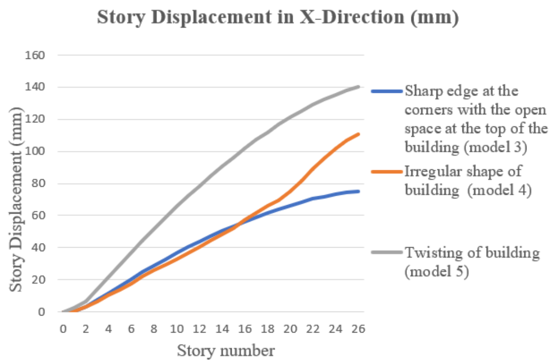


Fig.4.13: Story Displacement in X-Direction

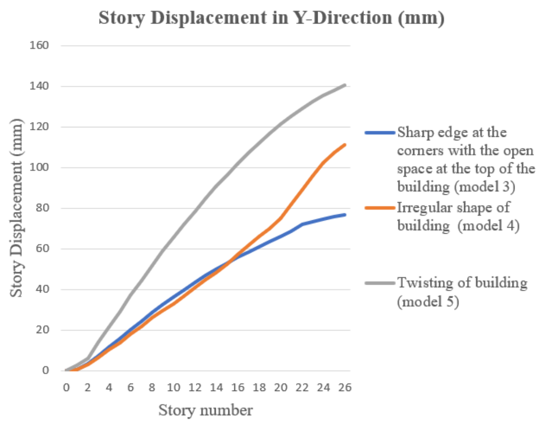


Fig.4.14: Story Displacement in Y-Direction

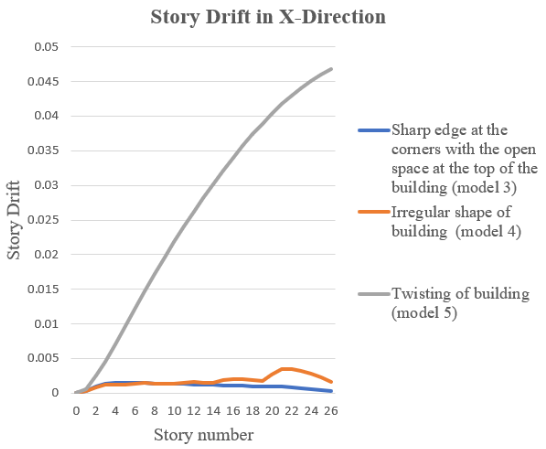


Fig.4.15: Story Drift in X-Direction

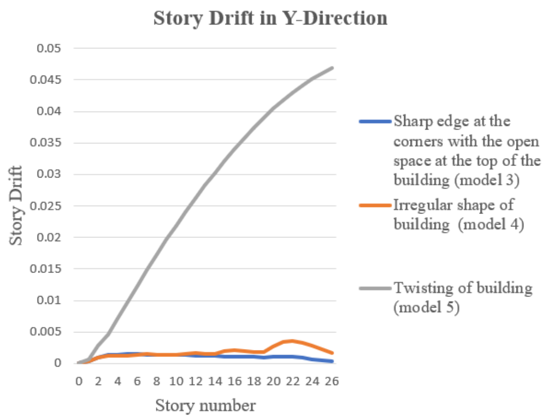


Fig.4.16: Story Drift in Y-Direction

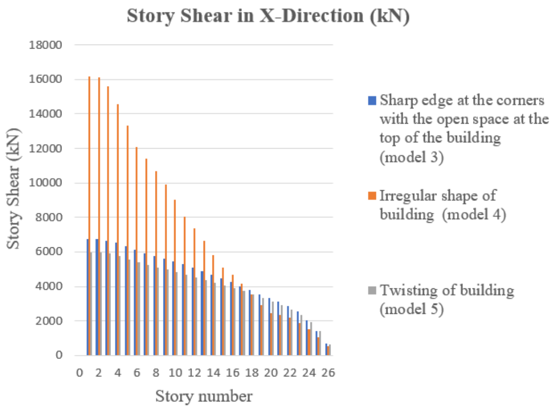


Fig.4.17: Story Shear in X-Direction

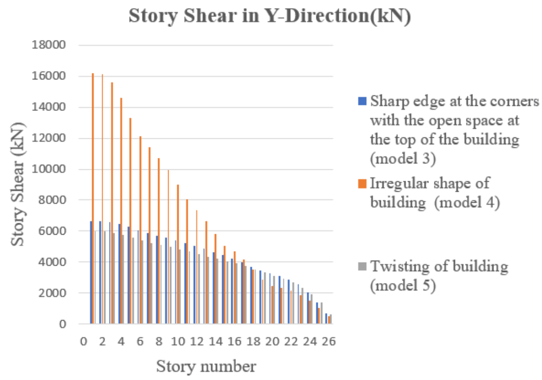


Fig.4.18: Story Shear in Y-Direction

- The percentage variation of maximum story displacement is reduced to 60.42% in RSPAX direction and 59.09% in RSPAY direction respectively for model 3, when compared with model 5. And 23.52% and 23.35% reduced in RSPAX and RSPAY direction for model 4, when compared with model 5.

- The percentage variation of maximum story drift is reduced to 188.33% in RSPAX direction and 188.75% in RSPAY direction respectively for model 3, when compared with model 5. And 173.26% and 29.21% reduced in RSPAX and RSPAY direction for model 4, when compared with model 5.
- The percentage variation of maximum story shear is increased to 11.53% in RSPAX direction and 10.64% is increased in RSPAY direction respectively for model 3, when compared with model 5. And percentage of maximum story shear is increased to 91.73% in RSPAX direction and 91.71% is increased in RSPAY direction respectively for model 4, when compared with model 5.

❖ Due to Wind analysis method

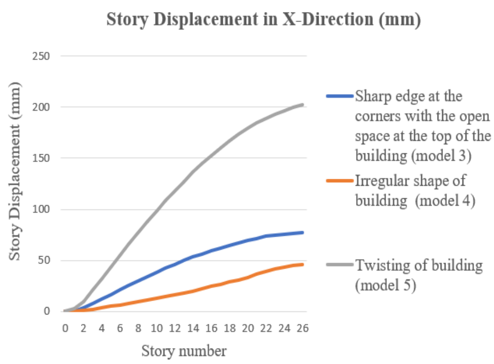


Fig.4.19: Story Displacement in X-Direction

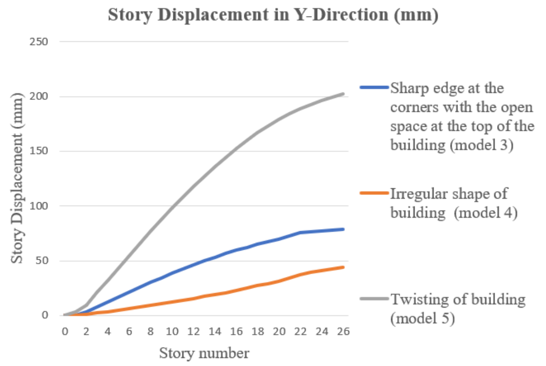


Fig.4.20: Story Displacement in Y-Direction

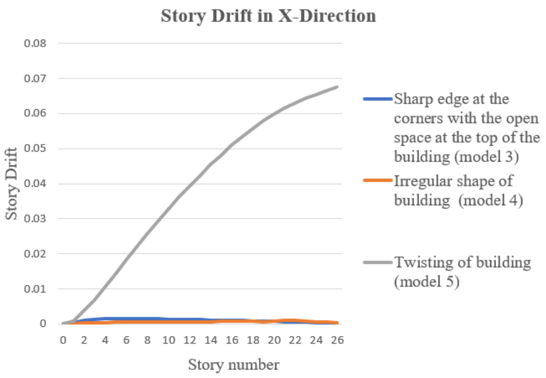


Fig.4.21: Story Drift in X-Direction

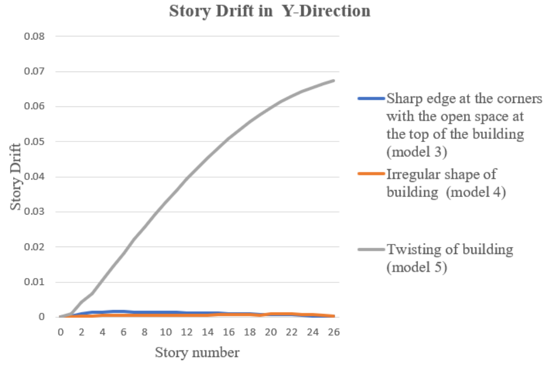


Fig.4.22: Story Drift in Y-Direction

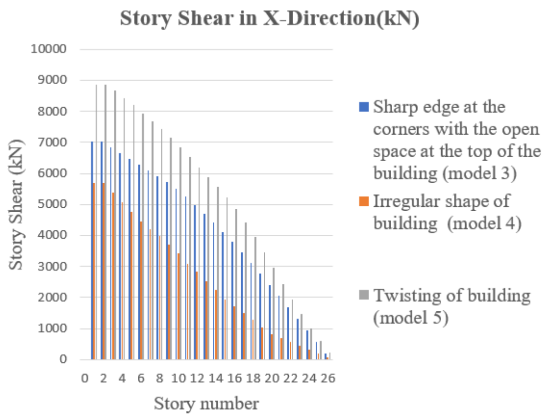


Fig.4.23: Story Shear in X-Direction

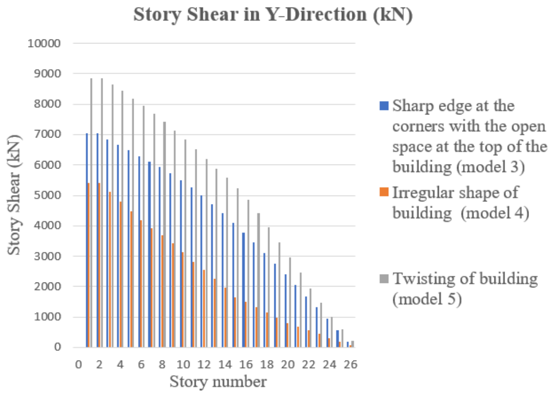


Fig.4.23: Story Shear in Y-Direction

- The percentage variation of maximum story displacement is reduced to 60% in Wind X direction and 68.21% in Wind Y direction respectively for model 3, when compared with model 5. And 3.4% and 3.2% reduced in Wind X and Wind Y direction for model 4, when compared with model 5.
- The percentage variation of maximum story drift is reduced to 193.88% in Wind X direction and 193.76% in Wind Y direction respectively for model 3, when compared with model 5. And 195.43% and 148.89% reduced in Wind X and Wind Y direction for model 4, when compared with model 5.
- The percentage variation of maximum story shear is reduced to 22.8% in Wind X direction and 22.8% is reduced in Wind Y direction respectively for model 3, when compared with model 5. And percentage of maximum story shear is reduced to 43.28% in Wind X direction and 48.10% is reduced in Wind Y direction respectively for model 4, when compared with model 5.

V. CONCLUSION

1. Incase of minor modifications of structures like sharp edge at the corners of the building and recessed shape at the corners of the building concluded that, due to action of earthquake loads and wind loads, recessed shape at the corners of building structure is capable of reducing the wind effect as well as seismic effect with observations of story displacement, story drift and base shear values by using wind method and response spectrum method.
2. Incase of minor modifications of structures like sharp edge at the corners of the building and recessed shape at the corners of the building, recessed shape at the corners of building structure is suitable only for seismic zone V.
3. The Aerodynamic minor modifications of buildings cross section shape, variation of its cross section can significantly reduces the building responses in along wind as well as across wind direction around the building.
4. Incase of major modifications of building structures like sharp edge at the corners with open space at the top of the building and irregular shape of the building and twisting of the building, due to action of earthquake loads, concluded that sharp edge at the corners with open space at the top of the building is capable of reducing the seismic effect with observations of story displacement, story drift and base shear values by using wind method and response spectrum method.
5. Incase of major modifications of building structures like sharp edge at the corners with open space at the top of the building and irregular shape of the building and twisting of the building, due to wind excitation, concluded that irregular shape of the building is capable of reducing wind excitation in critical area.

6.The aerodynamic modification of building shape like changing the cross section of building with the height through tapering, reducing their upper level plan areas by cutting of corners progressively as the height increases, which alters the flow pattern around the building could reduced the wind induced excitation of tall buildings.

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