International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 08 | Aug 2019 www.irjet.net p-ISSN: 2395-0072

EFFECT OF WIND LOAD ON TALL BUILDINGS IN DIFFERENT TERRAIN CATEGORY

Minhaj Sania[1], G K Shankar Lingegowda[2], Akshaya Kumar H S[3]

[1]PG Student, BGS Institute of Technology, B G Nagar, Karnataka
[2]Associate Professor, BGS Institute of Tech, B G Nagar, Karnataka.
[3]PG Student, BGS Institute of Technology, B G Nagar, Karnataka

---

Abstract - *Any tall building can vibrate in both the directions of "along wind" and "across wind" caused by the flow of wind. Modern tall buildings designed to satisfy lateral drift requirements, still may oscillate excessively during wind storm in different terrain category. These oscillations can cause some threats to the tall building as buildings with more and more height becomes vulnerable. Sometimes terrain conditions may cause discomfort to the building as the wind force varies because it varies relative to earth surface. The major harmful aspect which concern civil engineering structures is that, it will load any and every object that comes in its way. Wind blows less speed in rough terrain and higher speed in smooth terrain. The height of the tallest building changes year by year because skyscrapers are constructed constantly worldwide. With this development that buildings are raising, there will be larger awareness of occupants comforts due to wind induced in top floors of sloping terrain.*

***Key Words*: Wind Load, Terrain Category, Skyscarpers, Sloping Terrain.**

1. INTRODUCTION

1.1 General

In this modern era of 21st century, as urbanization Increases the availability of land is becoming less due to high population and cost of land is becoming higher. To overcome this scarcity problem the best solution is to prefer high rise structure. High rise structures are the buildings which are tall i.e "if height of the building is more than 35 meter".For design of high rise structures wind load is an important parameter especially for taller structure construction. 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. In general practise the design of tall buildings we have to consider both wind as well as earthquake loads. As per IS 875(Part 3) 1987 when wind load comes in contact with building then it experiences both type of negative and positive moments.The load coming on the building then it is unloaded or gets transferred to structural elements then passing through the foundation and then finally transferred to the ground. The pressure coming from wind basically it is a function of exposed area and shape of the building. Two load cases are considered for design of high rise structure, besides dead and live loads: earthquake loads and wind loads. Here we have made importance on wind loads. Wind load drastically changes the behaviour of high rise structures as the height and wind speed increases.

1.2 Terrain Category

By considering the obstructions that affect the ground surface roughness the selection of different terrain category is made

Category 1- The surrounding objects around the building will be less than 1.5m.

Figure 1.1: Photograph indicative of Terrain Category-1 Features

Category 2- Here surrounding objects will have spread obstructions which are having 1.5m to 10m in height.

Figure 1.2: Photograph indicative of Terrain Category-2 Features

Category 3- Here it consists of few isolated tall structures will have the obstructions closer obstructions which are having size up to 10m.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 08 | Aug 2019 www.irjet.net p-ISSN: 2395-0072

Figure 1.3: Photograph indicative of Terrain Category-3 Features

- **Category 4-** This category consists of large high closely spaced interferances. i.e more than 25m height. A developed industrial complexes falls into this category.

Figure 1.4: Photograph indicative of Terrain Category-4 Features

2. METHODOLOGY

Modelling of 12 storey structure of framed building for different category.

1. Modelling of 24 storey structure of framed building for different category
2. Wind load analysis are carried out using ETABS software
3. Comparisons of the results obtained for 12 storey and 24 storey for different category
4. Conclusions are drawn.

Modelling

Modelling of a building is a process that includes the generation and controlling of expressive both the physical and functional characteristics of a building. Modelling is the best way to check the performance of a structure which is planned at an early stage of growth without constructing for a full scaled prototype. Models are like prototype which can be altered, switched or removed to support decision-making about a building or other built structure. In this present report brief modelling steps are demonstrated below in modelling section in a simplified form.

Table 2.1: Material Properties of M30

Properties	Values
Poisson's ratio	0.2
Weight per unit volume	24.9926 kg/m³
Mass per unit volume	2548.538 kg/m³
Modulus of elasticity	27386.13 MPa
Concrete compressive strength	30 MPa

Table 2.2 : Material Properties HYSD500

Properties	Values
Weight per unit volume	76.972 kN/m³
Modulus of elasticity	200000 MPa
Mass per unit volume	7849.047 kg/m³
Minimum yield strength	500 MPa
Minimum tensile strength	545 MPa

Table 2.3: Section Properties of Structural Elements used in models for Terrain Category 1, Category 2, Category 3 and Category 4

Type of building	Structural Elements	Sectional Properties(mm)
For 12 storey	Columns	850x850
	Slab	200
	Beam	600x600
For 24 storey	Columns	1200x1200
	Slab	200
	Beam	600x600

Table 2.4: Structural Elements and their Materials

Structural Element	Material	
	Concrete	Rebar
Column	M30	HYSD500
Slab	M30	HYSD500
Beam	M30	HYSD500

Loads

The loads include in this structural part is

1. Dead load
2. Live load
3. Wind load

1 Dead Loads

These are the continuingloads thatact on the building. They depend on the material requirement used for various structural element. The data and properties of different material used for structural components are given in IS 875-1987 (Part-I). This load should be calculated from member size and estimated material densities.

2 Live Loads

This load is not depending on the structure but it depends on the usage and occupancy of the structure. Live load is taken as 3kN/m²for all the stories. This load is consider during the structural design process. This load consists of both structural and non-structural components.

3 Wind Loads

This load is produced by movement of air. Static wind results in causes of elastic bending and twisting of building. This load is main concern in several areas.

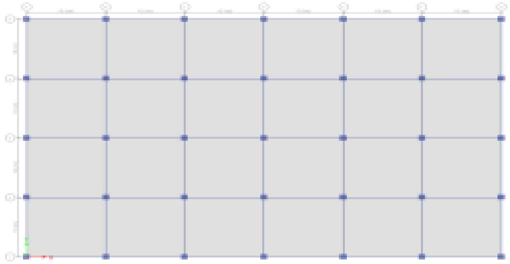

Fig4.1:PLAN

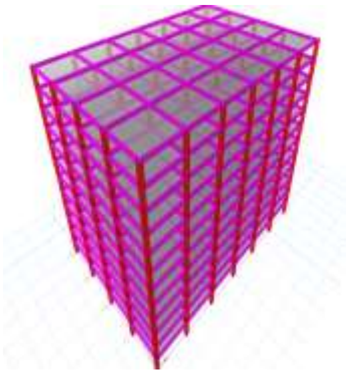

Fig 3.1: 3D View of 12 Storey Building for Terrain Category 1 Category 2, Category 3 and Category 4

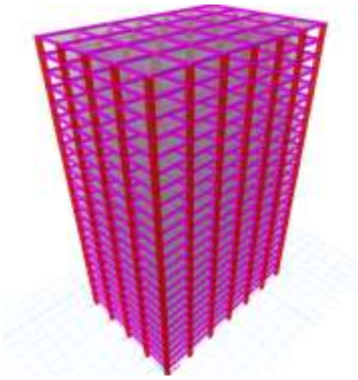

Fig 3.2: 3D View of 24 Storey Building for Terrain Category 1 Category 2, Category 3 and Category 4

3. RESULTS AND DISCUSSIONS

3.1: Storey Displacement (mm)

Table 3.1: Storey Displacement (mm) for 12 and 24 Storey Building along Wind-X

Model	Displacement, Wind-X			
	cat-1	cat-2	cat-3	cat-4
12-Storey	43.48	40.95	36.73	30.95
24-Storey	192.13	183.73	169.23	161.8988

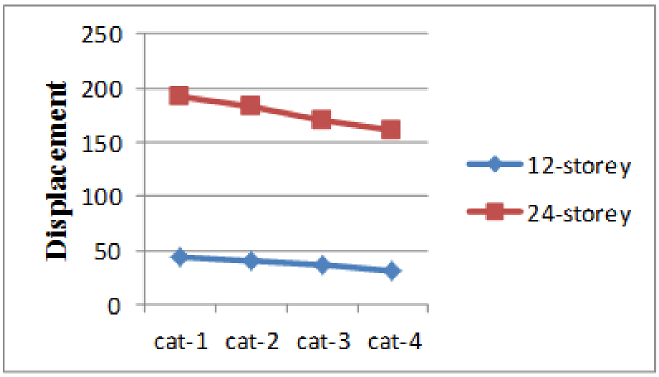

Fig 3.1: Displacement along X-direction for Equivalent Static Force

The Displacement of Category 2, Category 3, Category 4 decreased by 4.372%, 11.92%, 15.73% for 24-Storey respectively in comparison with Category 1 along X-direction.

The displacement of Category 2, Category 3, Category 4 decreased by 5.81%, 15.52%, 28.81% for 12-Storey respectively in comparison with Category 1 along X-direction.

Table 3.2: Storey Displacement (mm) for 12 and 24 storey building along Wind-Y

Model	Displacement, Wind-Y			
	cat-1	cat-2	cat-3	cat-4
12-Storey	68.56	64.57	57.93	48.82
24-Storey	307.19	293.78	270.6066	250.9436

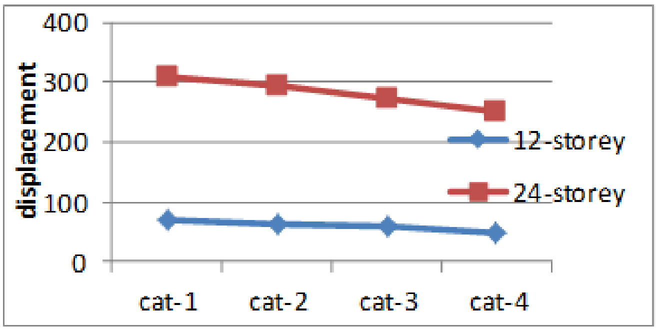

Fig 3.2: Displacement along Y-direction for Equivalent static force

The displacement of Category 2, Category 3, Category 4 decreased by 4.36%, 11.90%, 18.31% for 24-Storey respectively in comparison with Category 1 along Y-direction.

The displacement of Category 2, Category 3, Category 4 decreased by 5.81%, 15.50%, 28.79% for 12-Storey respectively in comparison with Category 1 along Y-direction.

3.3: Story Drift

Table 3.3.1: Storey Drift(Wind-X) of 12 and 24 Storey Building

Model	Storey Drift, Wind-X			
	cat-1	cat-2	cat-3	cat-4
12-storey	0.00151	0.00142	0.00126	0.00102
24-storey	0.00339	0.00323	0.00296	0.002782

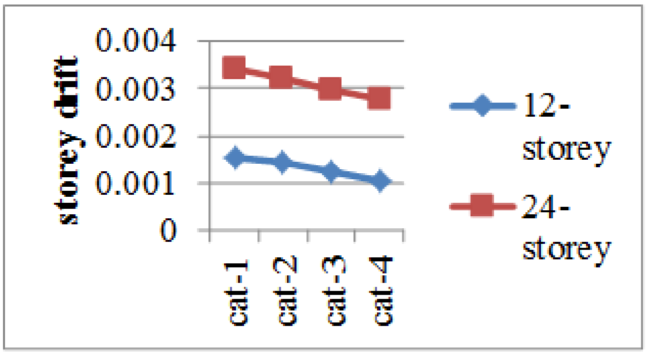

Fig 3.3.1: Storey Drift along X-direction for Equivalent Static Force

The Storey Drift of Category 2, Category 3, Category 4 decreased by 4.71%,16.55%, 18.31% for 24-Storey respectively in comparison with Category 1 along X-direction.

The displacement of Category 2, Category 3, Category 4 decreased by 5.96%,16.55%, 32.45% for 12-Storey respectively in comparison with Category 1 along X-direction.

Table 3.3.2 :Storey Drift, (Wind-Y) of 12 and 24 Storey Building

Model	Storey Drift, Wind-Y			
	cat-1	cat-2	cat-3	cat-4
12-storey	0.00236	0.00222	0.00198	0.001604
24-storey	0.0054	0.00512	0.004697	0.004415

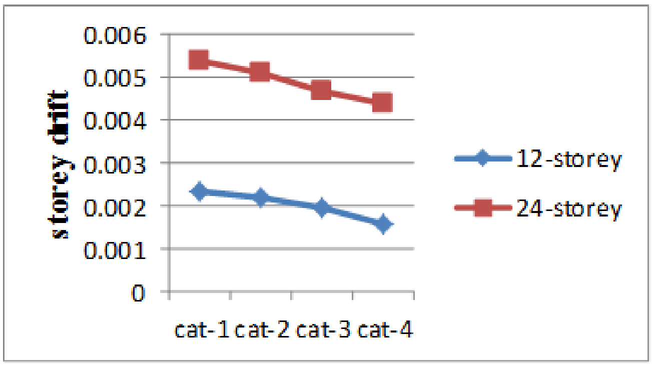

Fig 3.3.2 : Storey Drift along Y-direction for equivalent Static force

The Storey Drift of Category 2, Category 3, Category 4 decreased by 5.18%, 13.01%, 18.24% for 24-Storey respectively in comparison with Category 1 along Y-direction.

The Storey Drift of Category 2, Category 3, Category 4 decreased by 5.93%, 16.10%, 32.03% for 12-Storey respectively in comparison with Category 1 along Y-direction.

3.4: Storey Shear

Table 3.4.1:Storey Shear,(Wind-X) of 12 and 24 Storey Building

Model	Storey Shear, Wind-X			
	cat-1	cat-2	cat-3	cat-4
12-storey	5500.68	5130.8	4523.86	3627.73
24-storey	12315	11664	10571	9558

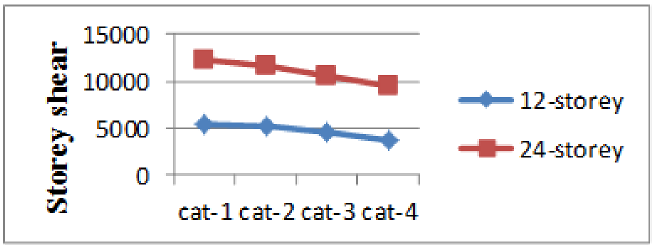

Fig 3.4.1 : Storey Shear along X-direction for Equivalent Static force

The Storey Shear of Category 2, Category 3, Category 4 decreased by 5.28%, 14.16%, 22.38% for 24-Storey respectively in comparison with Category 1 along X-direction.

Storey Shear of Category 2, Category 3, Category 4 decreased by 6.72%,17.75%, 34.04% for 12-Storey respectively in comparison with Category 1 along X-direction

Table 3.4.2: Storey Shear,(Wind-Y) of 12 and 24 Storey Building

Model	Storey Shear, Wind-Y			
	cat-1	cat-2	cat-3	cat-4
12-storey	8251.03	7696.2	6785.79	5441.59
24-storey	18473	17496	15875	14337

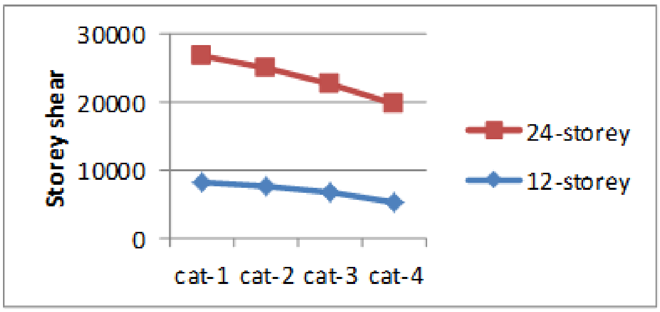

Fig 3.4.2: Storey Shear along Y-direction for Equivalent Static force

The Storey Shear of Category 2, Category 3, Category 4 decreased by 5.28%, 14.06%, 22.38% for 24-Storey respectively in comparison with Category 1 along Y-direction.

The Storey Shear of Category 2, Category 3, Category 4 decreased by 6.72%, 17.75%, 34.04% for 12-Storey respectively in comparison with Category 1 along Y-direction

Overturning Moment

Table 3.5: Overturning Moment,(Wind-X) of 12 and 24 Storey Building

Model	Overturning Moment, Wind-X			
	cat-1	cat-2	cat-3	cat-4
12-storey	153925	144799	129657	108631
24-storey	730015	697437	641387	609972

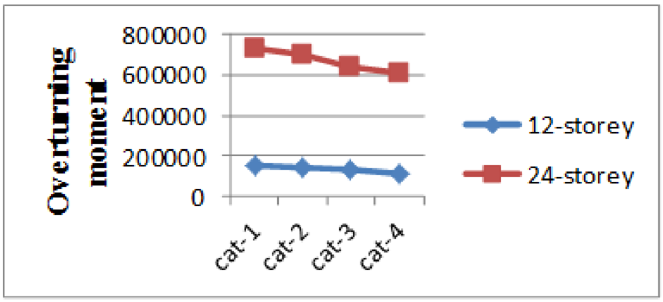

Fig 3.5: Overturning Moment along X-direction for Equivalent Static force

The Overturning Moment of Category 2, Category 3, Category 4 decreased by 4.46%,12.14%, 16.44% for 24-Storey respectively in comparison with Category 1 along X-direction.

The Overturning Moment of Category 2, Category 3, Category 4 decreased by 5.92%, 15.76%, 29.42% for 12-Storey respectively in comparison with Category 1 along X-direction

Table 3.6: Overturning Moment,(Wind-Y) of 12 and 24 Storey Building

Model	Overturning Moment, Wind-Y			
	cat-1	**cat-2**	**cat-3**	**cat-4**
12-storey	231559	217868	19586	163447
24-storey	1103308	1054075	969369	921909

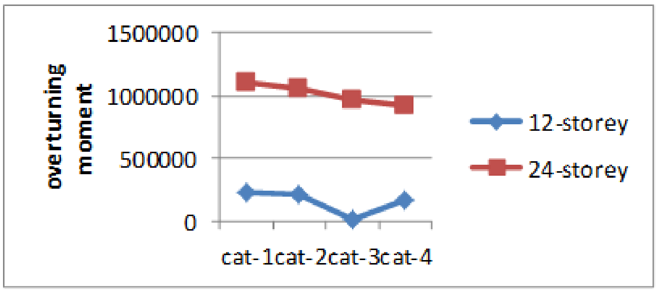

Fig3.6: Overturning Moment along Y-direction for Equivalent Static force

The Overturning Moment of Category 2, Category 3, Category 4 decreased by 4.46%, 12.14%, 16.44% for 24-Storey respectively in comparison with Category 1 along Y-direction.

The Overturning Moment of Category 2, Category 3, Category 4 decreased by 5.92%, 15.76%, 29.42% for 12-Storey respectively in comparison with Category 1 along Y-direction

3.7: Storey Stiffness

Table 3.7: Storey Stiffness,(Wind-X) of 12 and 24 Storey Building

Model	Storey Stiffness, Wind-X			
	cat-1	cat-2	cat-3	cat-4
12-Storey	1876096	1873047	1866527	1861371
24-Storey	3219877	3212377	3198287	3167289

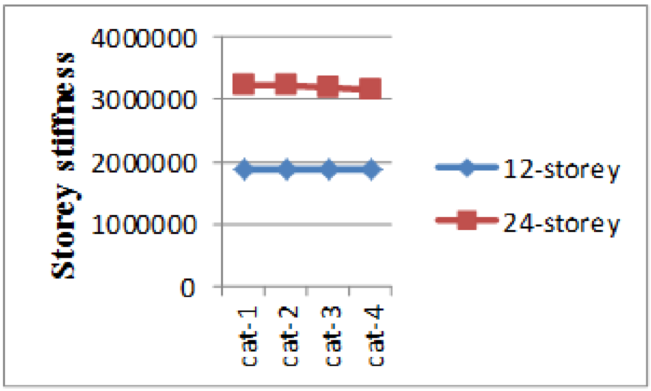

Fig 3.7: Storey Stiffness along X-direction for Equivalent Static force

The Storey Stiffnessof Category 2, Category 3, Category 4 decreased by 0.23%,0.67%, 1.63% for 24-Storey respectively in comparison with Category 1 along X-direction.

The Storey Stiffness of Category 2, Category 3, Category 4 decreased by 0.16%,0.51%, 0.78% for 12-Storey respectively in comparison with Category 1 along X-direction

Table 3.8: Storey Stiffness,(Wind-Y) of 12 and 24 Storey Building

Model	Storey Stiffness, Wind-Y			
	cat-1	cat-2	cat-3	cat-4
12-storey	1822196	1819128	1812579	1807231
24-storey	3116077	3108565	3094491	3063028

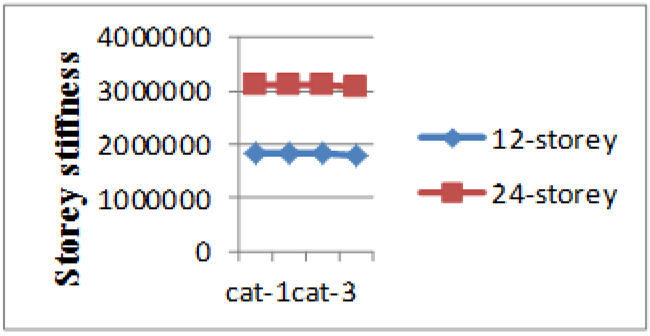

Fig 3.8: Storey Stiffness along Y-direction for Equivalent Static force

The Storey Stiffness of Category 2, Category 3, Category 4 decreased by 0.24%,0.69%, 1.70% for 24-Storey respectively in comparison with Category 1 along Y-direction.

The Storey Stiffness of Category 2, Category 3, Category 4 decreased by 0.17%,0.52%, 0.82% for 12-Storey respectively in comparison with Category 1 along Y-direction

CONCLUSIONS

1. The Displacement of category-1 is more as compared to category-2, category-3, category-4 for both 12-storey and 24-storey building along Wind-X and Wind-Y
2. The Storey drift of category-1 is more as compared to category-2, category-3, category-4 for both 12-storey and 24-storey building along Wind-X and Wind-Y
3. The Storey shear of category-1 is more as compared to category-2, category-3, category-4 for both 12-storey and 24-storey building along Wind-X and Wind-Y
4. The Overturning Moment of category-1 is more as compared to category-2, category-3, category-4 for both 12-storey and 24-storey building along Wind-X and Wind-Y
5. The Storey Stiffness of category-1 is more as compared to category-2, category-3, category-4 for both 12-storey and 24-storey building along Wind-X and Wind-Y

REFERENCES

1. Md Ahesan Md Hameed and Amit Yennawar "Comparative study on wind load analysis using different standards" IJIRSET-2018

2. B. Shobha, Dr. H. Sudarshan Rao, Dr.Vaishali G. Ghorpade " Effect of wind load on low, medium, High rise buildings in different terrain category" IJTIMES-2018

3. Aiswaria and Dr. Jisha S.V "Along and across wind loads acting on tall buildings" Second international conference on Architectural materials and construction engineering ©AMCE-2018

4. Md Asim Ahmed, Moid Amir, SavitaKomur , VaijainathHalhalli " Effect of wind load on tall buildings in different terrain category". IJRET-2015

5. Bilal Assaad "Wind effect on super-tall buildings using computational fluid dynamics and structural dynamics" Thesis -2015