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Comparative Study of Wind Dynamic Effect in Different Terrain Categories on Diagrid Structure

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ABSTRACT

In this earth surface about 75% covered with oceans, in that remaining 25% most of the land consists of mountains, deserts, forests which are not suitable for human living. Because of this land scarcity constructing of high rise buildings are the only solution to overcome this problem. But the main thing is to be considered in tall buildings design is wind effect. Main objective of this paper is to compare the wind forces with different terrain categories for dynamic loading on G+29storey high-rise diagrid structure using ETABS Software. It is execute on a building to identify the Gust factor, Lateral force, Inter story drift and Lateral displacement, Comparison of results which obtained from the software after assigning the data along both X and Y directions are showed in graph.

Key words: Diagrid, Wind dynamic effect, High-rise buildings, Terrain categories, Gust factor, Inter story drift, Lateral force, Lateral displacement, Etabs.

I.INTRODUCTION

The development of new construction techniques has created structures that are flexible, low in damping and light in weight which therefore exposes the structure to the effect of wind acting upon it. There is very much need of ensure the performance of the structure subjected to the action of wind to be within adequate limits during the life time of the structural safety and serviceability criteria. The standard wind speed over a time period of the order of ten minutes or more tends to increase with height, while the gustiness tends to decrease with height. Tall structure is designed to act as vertical cantilever beams and it is possible that High rise building will be affected by wind. It is very essential that the fluctuating loads caused by wind on a structure play a crucial role in the design and analysis of tall buildings, especially structure with large aspect ratios.

The first reason is to choose diagrid structure is the diagonal members in diagrid structural system carry gravity loads as well lateral forces due to their triangulated configuration. The structural efficiency of the diagrid system also helps in avoiding interior and corner columns. The use of diagrid decrease the quantity of steel up to 20% compared to brace frame structure. It is easy and efficient in distribution of loads. The diagrid structures resist the overturning.

Opting terrain categories shall be produce with regard to the effect of obstructions which constitute the ground surface roughness. The terrain category used in the design of a structure may differ liable to the direction of wind under consideration and the direction of any structure may be suitably planned.

Load Calculation:

Dead Load:

Dead load is the essential weight of a structure which is immovable. Dead load has been considered

Floor finish = 1 kN/m², Additional Dead load = 0.5 kN/m²from IS 875: Part-1 1987 Code

Live Load:

Live load is an engineering term that refers to the weight of people or goods in building, Live load has been considered 2kN/m² as per IS 875: Part-2 1987 Code

Wind Load:

As per IS 875 (PART-3) 2015

Design wind speed

Basic wind speed Vb =50 m/sec in Visakhapatnam

Risk Coefficient K1 = 1

Terrain, height and structure size factor $K2_1$ = 1.244

$K2_2$ = 1.221

$K2_3$ = 1.179

$K2_4$ = 1.174

Topography factor K3 = 1

Importance factor for the cyclonic region (K4)= 1

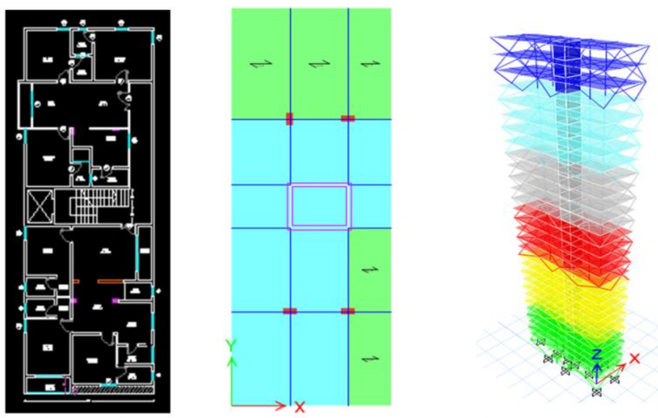
Gust Factor from IS-875 (part-3) 2015: (Along 'X and Y' direction)

$$G = 1 + r\sqrt{\left[g_v^2 B_s (1+g)^2 + \frac{H_s g_R^2 SE}{\beta}\right]}$$

	Category-1	Category-2	Category-3	Category-4
Peak factor for Upwind gv	3	3	3	3
Height factor Hs	2.44	2.44	2.44	2.44
Background Factor Bx	0.94	0.94	0.94	0.94
By	0.86	0.86	0.86	0.86
Turbine intensity factor gx	0.53	0.53	0.53	0.53
gy	0.51	0.51	0.51	0.51
Peak factor for resonant response	3.91	3.91	3.91	3.91
gRx				
gRy	3.78	3.78	3.78	3.78
Size reduction factor Sx	0.12	0.12	0.11	0.11
Sy	0.13	0.13	0.12	0.12
Spectrum of Turbulence Ex	0.05	0.05	0.05	0.05
Spectrum of Turbulence Ey	0.07	0.07	0.07	0.07
Damping Coefficient β	0.02	0.02	0.02	0.02
Gust Factor Gx	5.24	5.21	5.16	5.16
Gust Factor Gy	5.49	5.45	5.37	5.37

Methodology:

In this study comparison of wind dynamic effect in different terrain categories on G+29 diagrid structure, Section properties and Material properties are defined. Loading are given, Support conditions given and Analysis carried out. Wind forces have been calculated for the structure. Wind forces has been assigned as per IS guidelines and analysis carried out



Architectural plan – ETABS Model – Structural 3D View –

RESULTS AND DISCUSSION

Results of different parameters such as Gust factor, Lateral force, Lateral displacement, Inter storey drift and turbulence intensity are shown below with the help of graphs.

The Gust factor method is easy to study the dynamic effect on the structure and critical path of the wind loads for the tall buildings. Maximum Gust factor along X - direction and Y-direction are mentioned below.

	X-dir	Y-dir
Terrain Category-1	5.174	5.379
Terrain Category-2	5.147	5.341
Terrain Category-3	5.098	5.270
Terrain Category-4	5.091	5.260

The Gust factor has increased 1.6% in X-direction and 2.2%in Y-direction. The **FIG 4** and **FIG 5** shows the variance in Gust factor for different terrain categories.

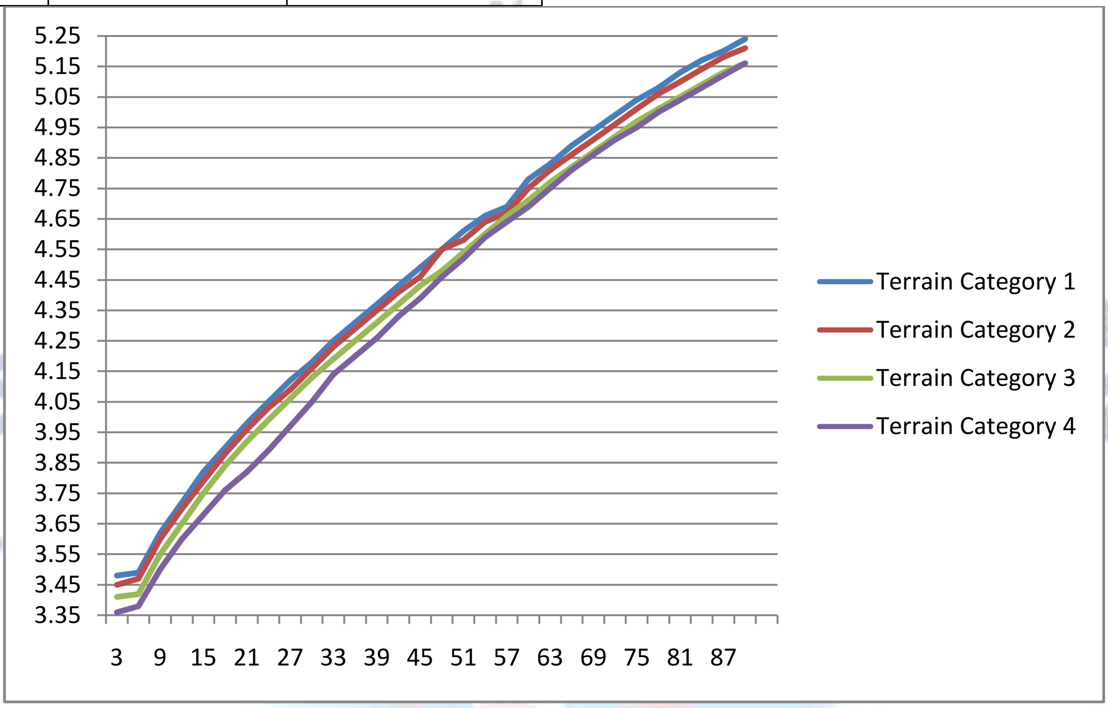


FIG 4: Variance in the Gust factor along X-direction

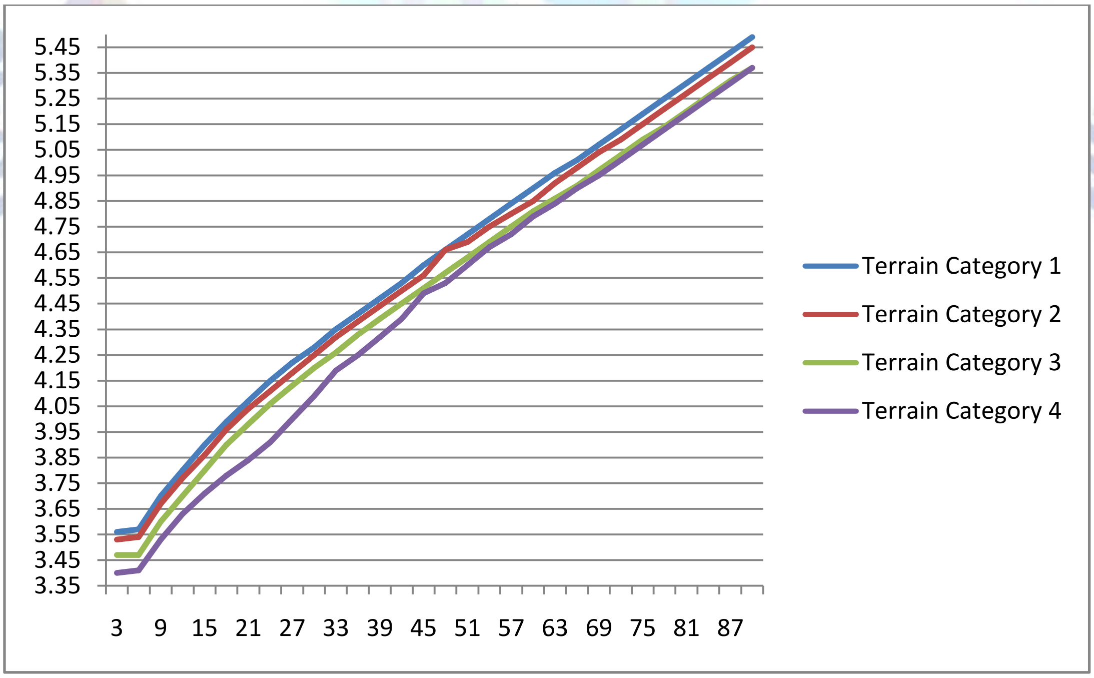


FIG 5: Variance in the Gust factor along Y-direction

Maximum Lateral forces of the Structure along X - direction and Y-direction are mentioned below.

	X-dir	Y-dir
Terrain Category-1	163.71	502.88
Terrain Category-2	156.83	480.83
Terrain Category-3	144.51	441.42
Terrain Category-4	142.73	435.77

The Lateral force has increased 12.81% in X-direction and 13.34% Y-direction. The **FIG 6** and **FIG 7** show the variance in the Lateral force for different terrain categories.

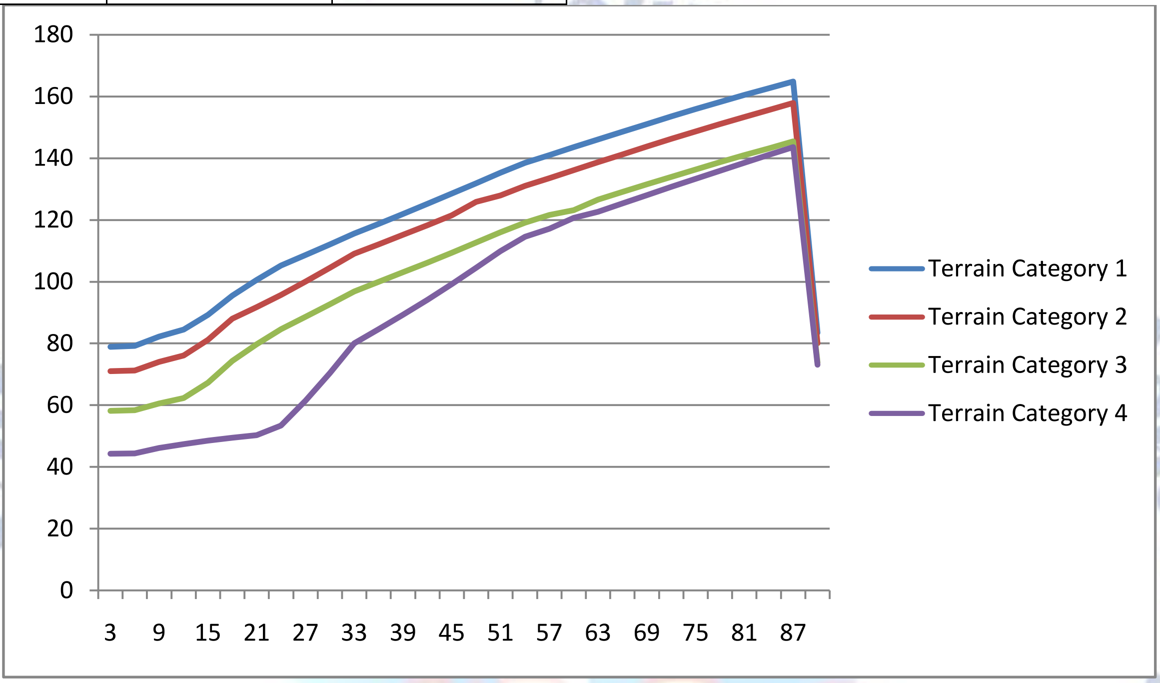


FIG 6: Lateral forces in X-direction

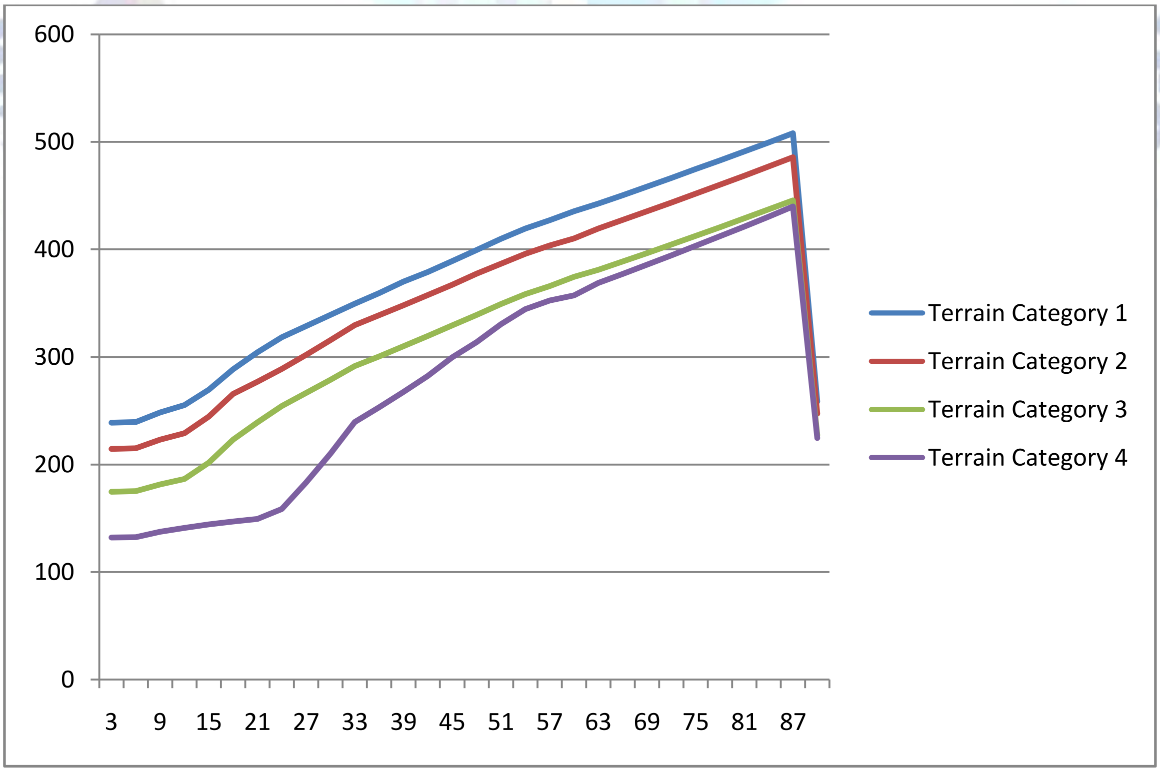


FIG 7: Lateral forces in Y-direction

Maximum Lateral Displacement of the Structure along X - direction and Y-direction are mentioned below.

	X-dir	Y-dir
Terrain Category-1	1736.90	1106.44
Terrain Category-2	1652.37	1050.30
Terrain Category-3	1502.89	951.34
Terrain Category-4	1426.82	899.08

Fig. 8 LATERAL DISPLACEMENT X-DIRECTION

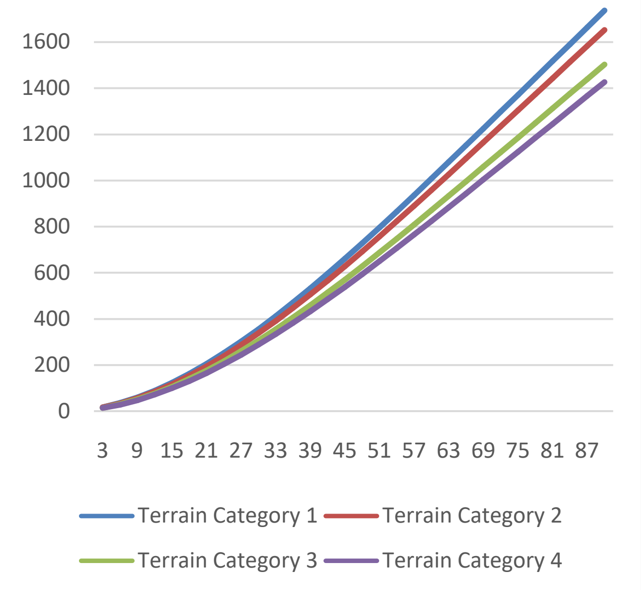
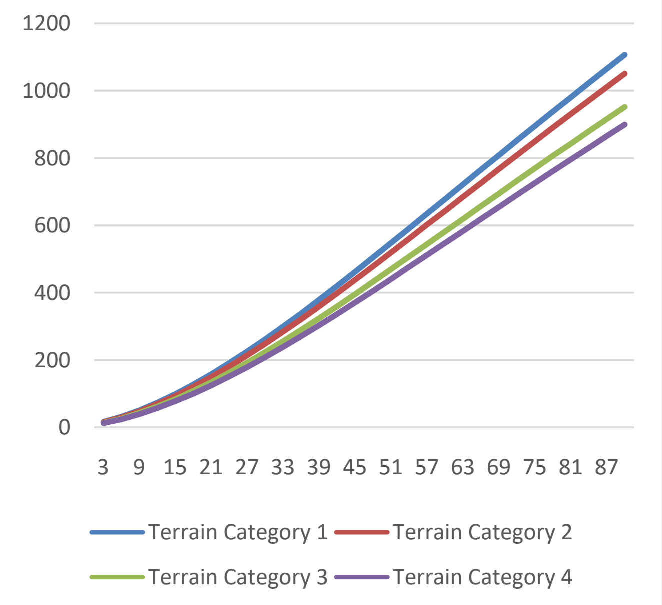


Fig.9 LATERAL DISPLACEMENT Y-DIRECTION



The Lateral force has increased 17.85% in X-direction and 18.74% in Y-direction. The **FIG 8** and **FIG 9** show the variance in the Lateral force for different terrain categories. Maximum Inter storey drift of the Structure along X - direction and Y-direction are mentioned below.

	X-dir	Y-dir
Terrain Category-1	0.024	0.014
Terrain Category-2	0.023	0.013
Terrain Category-3	0.021	0.012
Terrain Category-4	0.020	0.011

Fig. 10 INTER STOREY DRIFT X-DIRECTION

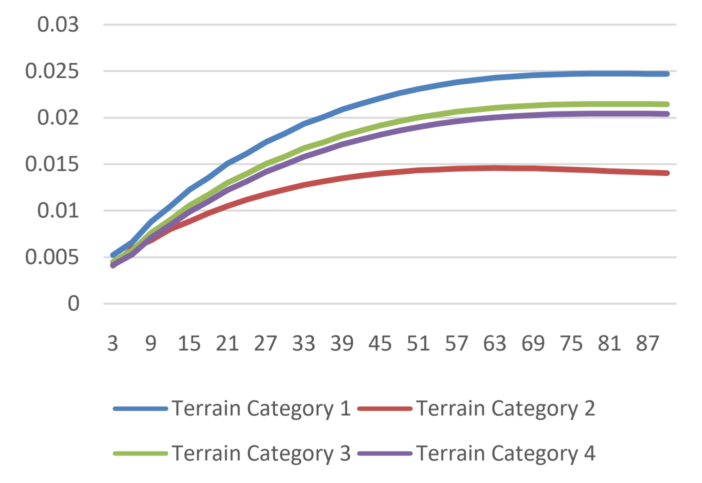
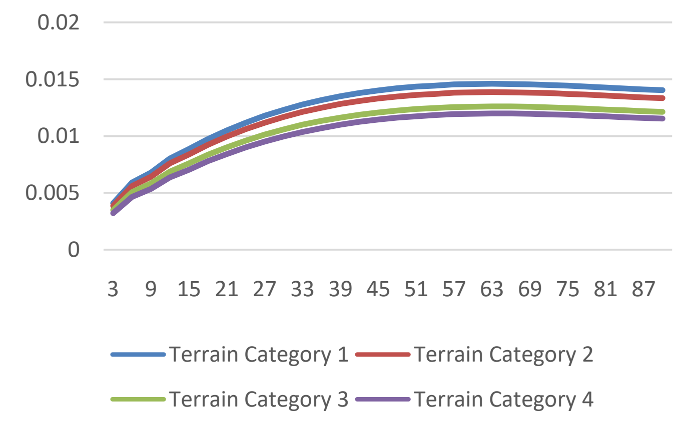


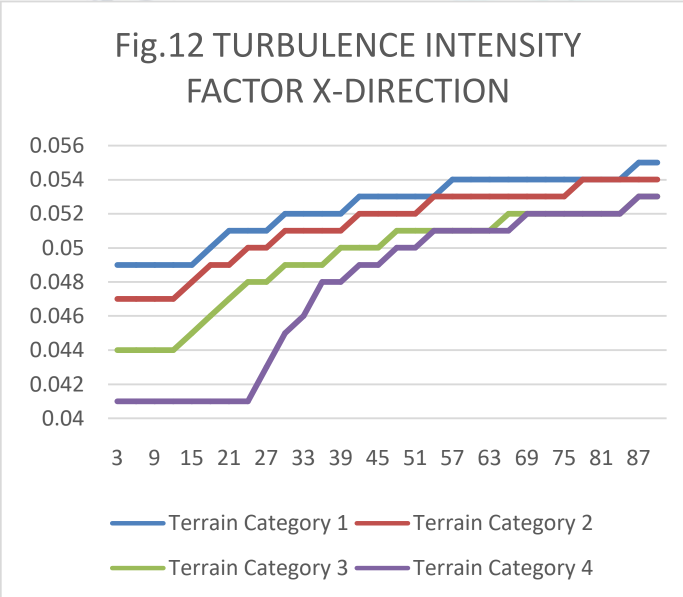
Fig. 11 INTER STOREY DRIFT Y-DIRECTION

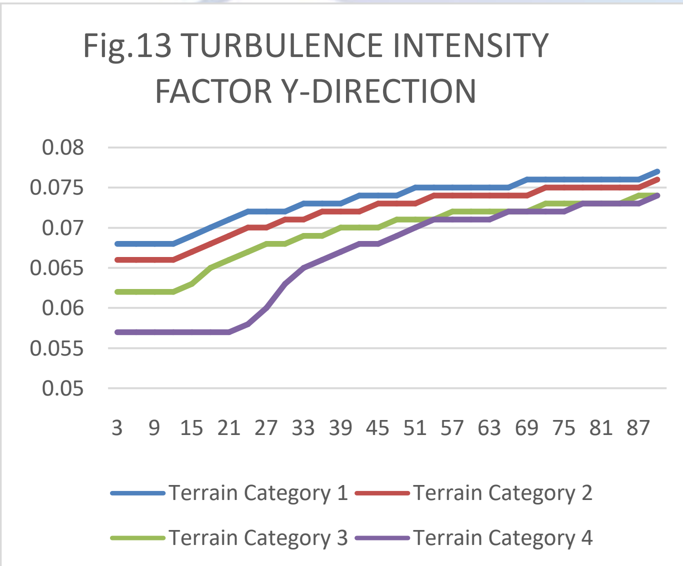


The Inter storey drift has increased 16.66% in X-direction and 21.42% in Y-direction. The **FIG 10** and **FIG 11** show the variance in the Inter storey drift for different terrain categories.

Turbulence intensity of the Structure along X - direction and Y-direction are mentioned below

	X-dir	Y-dir
Terrain Category-1	0.055	0.076
Terrain Category-2	0.054	0.075
Terrain Category-3	0.053	0.074
Terrain Category-4	0.052	0.073





The turbulence intensity has increased 5.45% in X-direction and 3.94% in Y-direction. The **FIG 12** and **FIG 13** show the variance in the turbulence intensity for different terrain categories.

CONCLUSION:

1. Percentage of Gust factor, Lateral force, Lateral displacement, Inter story drift, turbulence intensity has been increased in different terrain categories.
2. **Gust factor** has been increased 1.6% in X-direction and 2.21% in Y-direction in different terrain categories**.**
3. **Lateral Force** has been increased 12.81% in X-direction and 13.34% in Y-direction in different terrain categories.
4. **Lateral Displacement** has been increased 17.85% in X-direction and 18.74% in Y-direction in different terrain categories.
5. **Inter storey drift** has been increased 16.66% in X-direction and 21.42% in Y-direction in different terrain categories.
6. **Turbulence intensity** has been increased 5.45% in X-direction and 3.94% in Y-direction in different terrain categories.
7. The structure is economically more at terrain category-1

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