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Critical behavior of STILT columns in RC Framed Structures under the influence of wind

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Abstract: Wind is horizontal movement of air due to temperature difference. Wind has significant role to play in design of high rise building because it results in static and dynamic loads. In this paper, effect of wind load on 11 Storey RCC Building having different column heights which may be due to unevenness in the slope of the ground is analyzed. Effect of wind is studied under consideration of IS 875: Part III 1987 Models are prepared and analyzed for wind effect using ETABS 2013. Models with varying slopes are studied.

Index Terms: Displacement, Stilt Factor, Sloping Ground, Wind

I. INTRODUCTION

Wind is current of air moving from high pressure zone to low pressure zone. it is due to difference in absorption of Sun's radiation on different surfaces. Winds are classified based on velocity with which it flows. Wind acts both externally and internally on the building. As a height of structure increases its stability under wind effect decreases.

Air on surface with cool temperature won't rise will bring about sinking. In view of this there is a high air weight. This over all conduct is called convection. The vitality moving is called convection current. Wind may be stronger where the difference in the air pressure is greater. There is five basic classes:

1. Calm Air: Speed is 11km/hr.
2. Gentle Breeze: Speed Varying from 12-20km/hr.
3. Moderate winds: Speed varying from 20 – 38km/hr
4. Strong winds: Speed varying from 62-47km/hr.
5. Gale winds: Speed is 75km/hr.

The effect of lateral forces (wind load) is to be considered in design of RCC Structures in order to have good stiffness, durability, convenience, ease of construction. In present days, due to increase in population and less availability of land in horizontal direction there is great demand for construction of high rise building which are prone to wind loads The structure with height more than 5m they are to be analyzed for wind effect. Wind acts Windward or Leeward side of the building.

Structure resting on a level ground will have more stability than those resting on inclined ground. The structures on sloping ground have unequal columns at the base and hence the structure will have less stiffness as compared to the conventional structure.

A. Stilt Factor

Typically when building is laying on inclining ground zone is uncovered and development is completed yet when exhuming is disposed of then to continue building appropriate adjusted segments are developed in factor stature comparing to variable slant subsequently sections worked with variable tallness to settle building are called stilt segments. The below Fig 1 shows RCC structure having unequal columns at the base. Such RCC Structure Models are prepared considering different sloping grounds such as 0°, 5°, 8°, 10°, 12° and 15°.

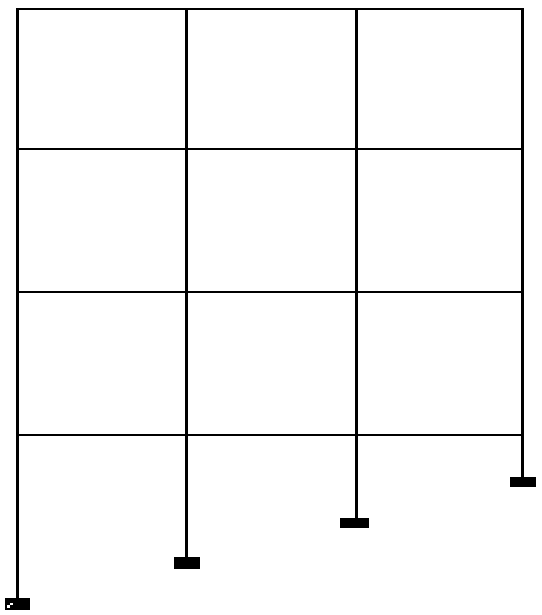

Fig1: RCC Building with Stilt Columns.

B. GUST FACTOR

A positive or negative flight of twist speed from its mean esteem, going on for not more than, says 2 minutes over a predetermined interim of time. Top blast or pinnacle blast speed is wind speed related with greatest plenty fullness.

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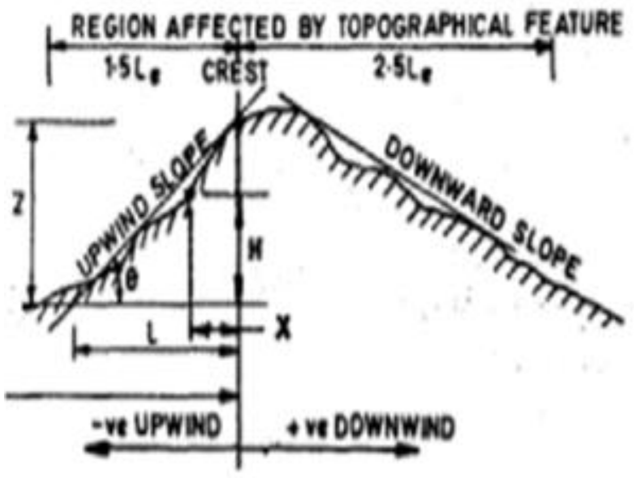

Fig 2: Movement of Wind on Sloping Ground (IS 875 Part -III 1987)

The effect of wind forces acting on structures resting on inclined ground is been analyzed. The wind effect on bare frame structure will be different from that on infill structure which is to be analyzed and comparative study should be done. The structure to be analyzed is resting on sloping ground and hence having stilt columns and also varying slopes are to be considered.

C. Literature Review:

The response of the structure for the most effective shape in prone zone under effect of wind along with the ductile nature of composite as well as RCC structure is compared[1.] Structures are critically analyzed to quantify the effects of various slope of ground with different combinations of height, wind zones and wind velocities.[2.] The response of the building under the effect of wind for varying heights and estimating the design loads of a structure which is subjected to wind loads in a particular region.[3.]

II. PROBLEM DEFINITION

A 10 Storey building having a symmetric plan of 30mx30m with each bay of 5m in both directions with bottom storey height varying with stilt columns and remaining storey height of 3m is selected.

1. Size of Bay : 5m x 5m
2. Size of Column: 300mm x 450 mm
3. Size of Beam: 300mm x 450mm
4. Slab Thickness: 125mm
5. Wall Thickness: 300mm

The study deals with comparative analysis about the effect of wind on 10 storey's RCC Structure with and without infill resting on slope ground. Following models are prepared based on the survey conducted.

1. Considering sloping angle of 0°, 5°, 8°, 10°, 12° and 15°.
2. Wind loading for Belgaum region is considered as per IS-875 (part-III):1987.
3. Bare Frame models of 10 storey RCC building and Infill Models of 10 storey RCC building are analyzed.
5. Modeling of RCC Building frames using ETABS 2013 Software.
6. Various parameters such as Maximum displacement, Max Drift, Base Reaction are studied.

TABLE 1: PHYSICAL PROPERTIES OF MATERIALS

Properties of Concrete	
Grade of concrete	M30
Modulus Elasticity	27386.13 N/mm^2
Poisson's ratio	0.2
Density of concrete	25000 N/m^3
Properties of Reinforcement	
Density of HYSD bars	7850 kg/m^3
Modulus Elasticity	200000 N/mm^2
Coefficient of thermal expansion	0.0012 1/°C

Loading conditions

1. Dead Load = 115119.48 kN
2. Live Load – 3 kN/m
3. Wind Load : Wind load is calculated as per the Indian Standard-code 875 (Part-III):1987.
4. Design Wind Speed, $V_z = V_b k_1 k_2 k_3$

The wind speed V_b is taken as 39 m/s for Belgaum Region and places have been surveyed.

5. Terrain Category : Category 3
6. Class type : B
7. K1 = 1.0
8. K2 = 1.05

TABLE 2: TOPOGRAPHY FACTOR

Topography Factor (k3)	
Model	K3 value
1	1.000
2	1.044
3	1.066
4	1.044
5	1.033
6	1.033

Calculation of k_3 value for Model 2

1. k 3 = 1+Cs
2. H/Le = 0.04
3. X/Le = 0.56
4. s = 0.2
5. C = 1.2(23.06/125)
   = 0.22
6. K3 = 1+0.22x0.2
   = 1.044

Following are the models considered for the analysis of wind effect on RCC Structure

Model 1: RCC Building Structure with columns of equal height resting on plain ground.

Model 2: RCC Building Structure with columns of unequal height at base floor resting on 5° slope ground

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Model 3: RCC Building Structure with columns of unequal height at base floor resting on with 8° slope ground.

Model 4: RCC Building Structure with columns of unequal height at base floor resting on 10° slope ground.

Model 5: RCC Building Structure with columns of unequal height at base floor resting on 12° slope ground.

Model 6: RCC Building Structure with columns of unequal height resting on 15° slope ground.

Fig 3: Plan for RCC building with columns equal height resting on plain ground

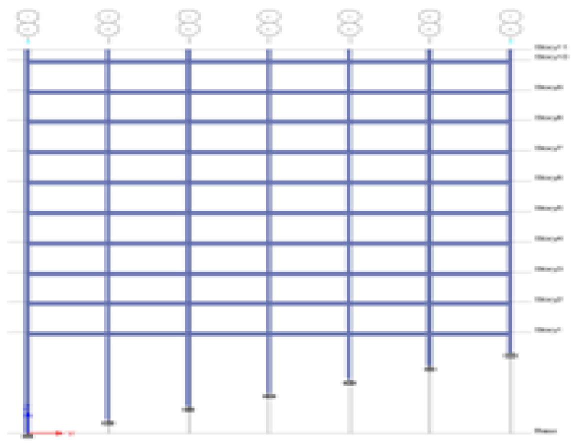

Fig 4: Elevation for RCC Building having Stilt Columns.

Table 3: Displacement Results for Infill Models

Displacement in mm for Infill Models						
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Storey 11	2.9	2.9	5.9	7	8.1	9.7
Storey 10	2.9	2.9	5.9	7	8.1	9.7
Storey 9	2.9	2.9	5.9	7	8.1	9.7
Storey 8	2.9	2.9	5.9	7	8.1	9.7
Storey 7	2.9	2.9	5.9	7	8.1	9.7
Storey 6	2.9	2.9	5.9	7	8.1	9.7
Storey 5	2.9	2.9	5.9	7	8.1	9.7
Storey 4	2.9	2.9	5.9	7	8.1	9.7
Storey 3	2.9	2.9	5.9	7	8.1	9.7
Storey 2	2.9	2.9	5.9	7	8.1	9.7
Storey 1	2.9	2.9	5.9	0	0	0
Base	0	0	0	0	0	0

Table 4: Displacement Results for Bare Frame Models

Displacement in mm for Bare Frame Models						
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Storey 11	24.9	25	26.5	34.5	35.8	38.5
Storey 10	24.7	24.8	26.3	33.7	35.5	38.2
Storey 9	24.1	23.9	25.2	32.5	34.2	36.8
Storey 8	22.9	22.4	23.6	30.9	32.5	34.9
Storey 7	21.3	20.5	21.5	28.7	30.2	32.4
Storey 6	19.3	18.1	18.9	26	27.4	29.4
Storey 5	16.8	15.1	15.9	22.8	24.1	26
Storey 4	14	11.8	12.4	19.1	20.4	22
Storey 3	10.7	8	8.4	15	16.1	17.6
Storey 2	7.2	3.9	4.1	10.6	11.5	12.8
Storey 1	3.3	0	0	5.7	6.5	7.6
Base	0	0	0	0	0	0

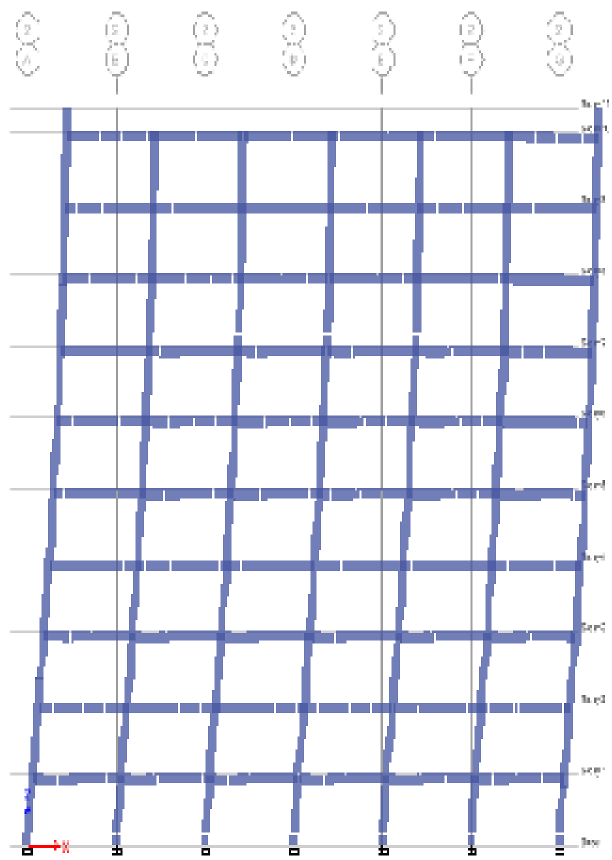

Fig 5: Deflection of RCC Building in 'x' direction with no slope.

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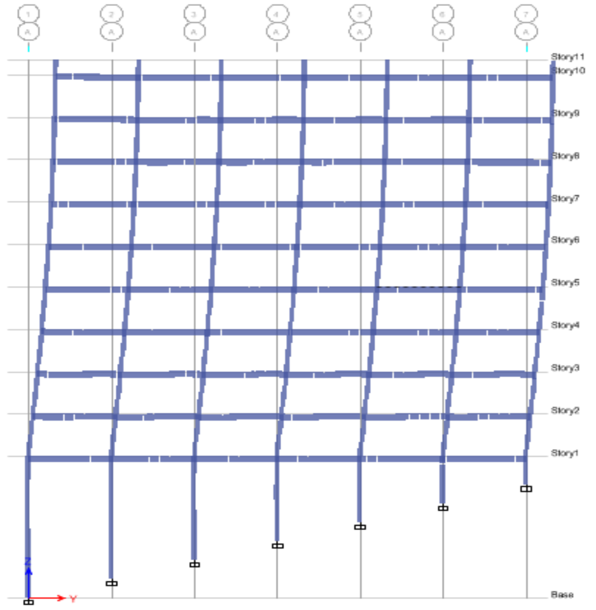
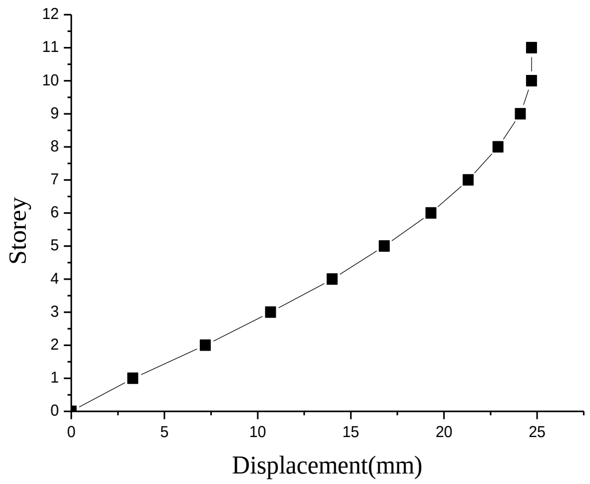
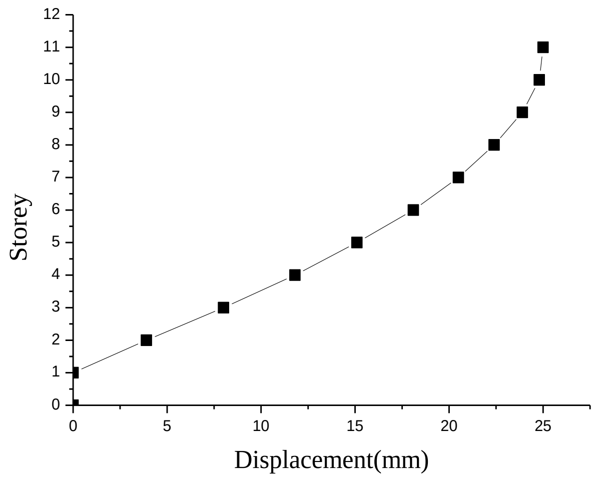


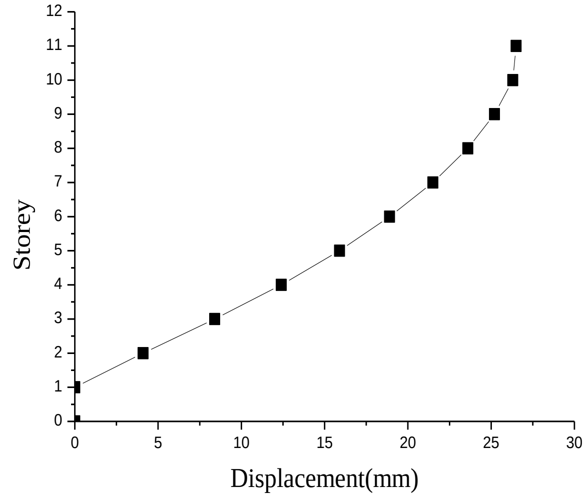
Fig 6: Deflection of RCC Building in 'y' direction with a slope angle.



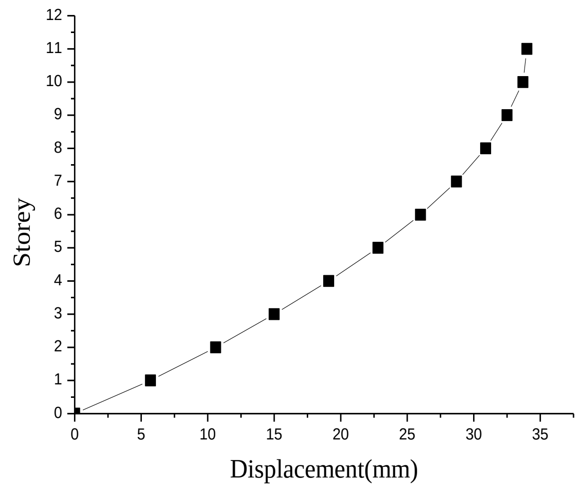
Graph 1: Graph between Displacement and Storey for Model 1.



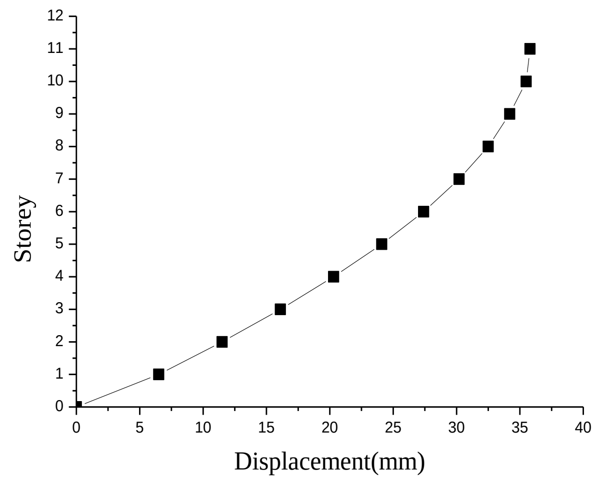
Graph 2: Graph between Displacement and Storey For Model 2



Graph 3: Graph between Displacement and Storey for Model 3



Graph 4: Graph between Displacement and Storey, for Model 4



Graph 5: Graph between Displacement and Storey, for Model 5

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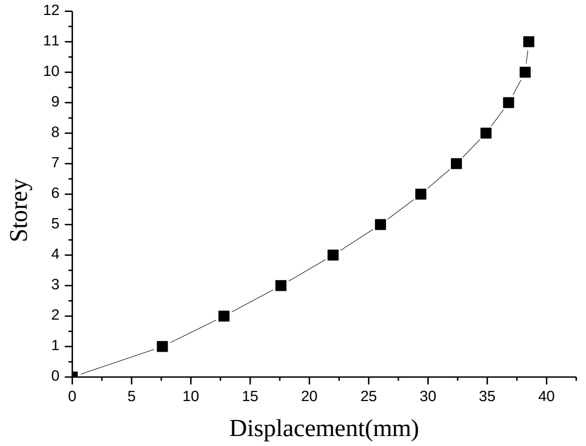
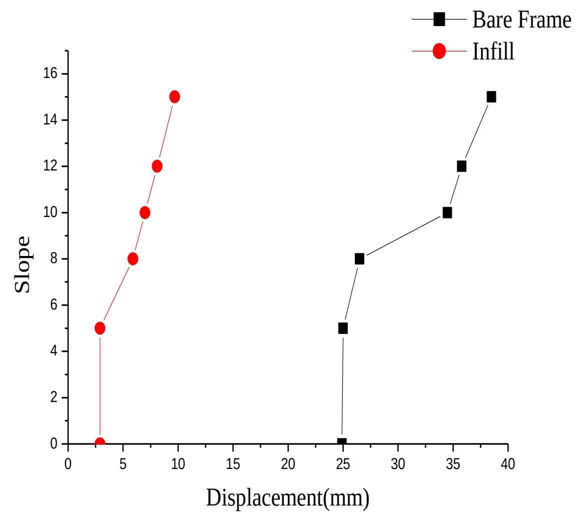
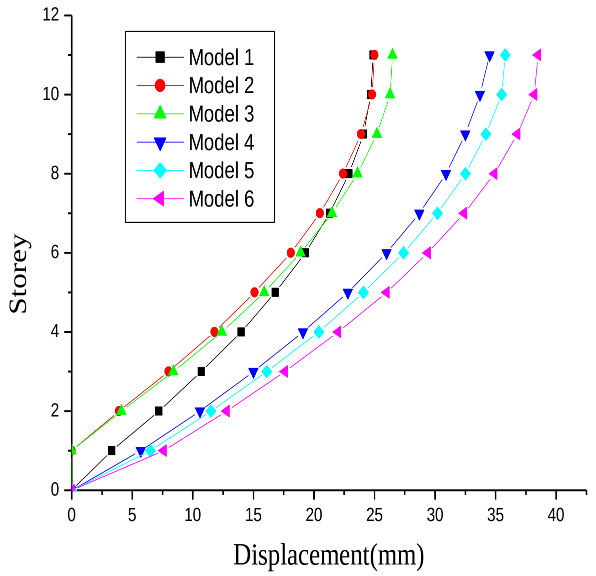


Graph 6: Graph between Displacement and Storey, for Model 6



Graph 7: Graph between Displacement and Varying Slope Bare frame and Infill



Graph 8: Graph between Displacement and varying slope angle

III. RESULTS AND DISCUSSION

The behavior of multi-storey building frames under the separate sloping ground. Considered static load and wind load for fabricating span have been analyzed. The results obtained after analysis are been represented by tables and graphs.

1. From Graph 2 and Graph 3, we can observe that there is a linear variation of displacement for 5^0 slope and 8^0 slope up to 5^{th} storey where as the displacement is more for 8^0 slope than 5^0 slope from 5^{th} storey to 9^{th} storey.
1. From Graph 3, Graph 4 and Graph 5, we can observe that the displacement for 10^0 slope has its effect from the bottom storey, where as there is no displacement for 8^0 slope and 5^0 slope on bottom storey.
2. From Graph 4 and Graph 5 , as the displacement for 10^0 slope is more when compared to 8^0 slope. Thus indicating that the stiffness is less for 10^0 as compared to 8^0.
3. From Graph 4 and Graph 5, we can observe that there is reduction in displacement by 30% from 10^0 slope to 8^0 slope.
4. From Graph 6, we can observe that as the storey number increases from 7 to 11 the displacement for 8^0 slope and 5^0 slope is more than that of 0^0 slope.
5. From Graph 6, we can observe that the displacement for 15^0 slope is increased when we compare with 5^0 slope.

IV. CONCLUSION

1. From Graph 6, we can conclude that as the ground slope decreases from 15^0 to 5^0 the deflection at the top joint also decreases by 45%.
2. From Graph 6, we can conclude that there is more displacement occurring between 5th storey and 9th storey and this is to be limit by increasing the stiffness of the columns.
3. Models with ground slope of 10^0 and higher are unstable as compared to the models with ground slope of 8^0 and lower.
4. From Graph 7, it is concluded that there is linear variation in displacement up to 5th storey for both bare frame structure and infill structure but as storey increases the displacement is more in bare frame than in infill structure. This suggest that bare frame structure has less resistance to wind loads than the infill structure.
5. The displacements reduces when a bare frame structure is provided with walls as it resist the wind loads more than that of bare frame structure.
6. Stiffness decreases with increase in slope of ground.
7. As slope of ground increases, storey forces increases in column.
8. As the slope increases stiffness decrease which in turn decreases stability of structure.
9. The successful parameters to wind strengths influencing any building are the region subjected to

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Wind and in addition the force level about wind.

10. The wind load expands for the increment in the tallness of the structure

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