Study of Wind Load of different Building Frame on Sloping Ground Surface

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Abstract- the main purpose of this paper is to study, the effect of the structural response of building frames on sloping ground and to study the effect of different wind velocities on building frames. Considering various frame geometries and slope of grounds. Combinations of static and wind loads are considered. For combination, 60 cases in different wind velocities and three various heights of building frames are studied. STAAD-Pro v8i software has been used for study purposes. Results are gathered in terms of axial force, Shear force, moment, support reaction, Storey-wise drift, and Displacement which are critically analyzed to quantify the consequences of the varied slope of the ground.

Keyword: structural frame, wind load, different wind velocity, sloping ground surface.

1. INTRODUCTION

The building rest on sloppy areas ought to be created otherwise from the flat ground, multi-storied building on sloping ground area unit occasional over level grounds were as on slopes these area units common. Wind load is one in all the necessary hundreds for engineering structures. For tall buildings, long-span bridges, and high towers or mast (tall column) structures, wind load may even be taken as a crucial loading, and complex dynamic wind load affects the management of the structural style of the structure. So data of the dynamic characteristics of a vital structure beneath wind loading becomes a demand in engineering style and tutorial study. At intervals, the continued research on tall buildings, the study of wind-induced demands is categorized as along-wind and air current responses. These demands area unit caused by totally different mechanisms. Moving on the wind-induced is attributable to the results of turbulence impact whereas the perpendicular part is claimed to the results of the storm. On the opposite hand, the impact of wind load on tall structures is not solely distributed over the broader surface however conjointly it's higher intensity. what is more, in a high-risk unstable zone the unstable performance of structures area unit thought of as a result of the primary importance that influences different hand in unstable zones, may even be the impact of impact forces ensuing from earth movement larger than the forces caused by wind hundreds and consequently, unstable loading determines the type and final style of the structure (with this assumption that with relevancy the all international codes and standards, wind and earthquake hundreds ne'er at the same time apply on the structure).

Fig 1.1 column of structure on sloping ground (Google reference)

Fig 1.2 framed structure (Google reference)

Calculation of ground slope is prime to several ancient Geographical data Systems (GIS) applications. The slope could also be a vital part of scientific, military, and civilian analyses. Numerous ways exist for scheming slope. Manual slope generation, based mostly upon contour, could also be an extended established and frequently acceptable methodology. Multi-storied building frames on the sloping ground have gotten to be arising in sizable quantity in future times. Throughout this regard realistic analysis and class of those building frames on sloping ground area unit of preponderating importance. At intervals, the trendy time, such Multi-storied building frames area unit designed victimization STAAD-Pro v8i computer code (staad professional could also be a structural analysis and magnificence computer code application). This motivation has a crystal rectifier to the current study on the impact of varied sloping angle in Multi-storied building frames (3D-Frames). Numerous configurations of those building frames of sloping ground profile layout area unit thought of in conjunction with numerous load combination of dynamic analysis on wind direction and wind forces.

1.1OBJECTIVE

There are the following objectives which are considered during the study

1. Study of the effect on sloping ground buildings due to wind load.

2. Study of the effect on sloping ground buildings due to different wind velocities.

3. Study of the effect of wind on 3 different heights of building frame on the sloping ground concerning on 5 wind velocities and 4 types of ground slopes. As per IS 875 (part-3):1983

2. METHODOLOGY AND PROBLEM FORMULATION

There are following types of problems are occurred due to wind load and ground slope

- Static wind effect
- Dynamic wind effect
- Site slope
- Ground condition
- Environment

For comparative study, three different sizes of structures at five different types of ground slopes and 5 types of wind velocity have been considered.

To achieve the objective following steps are followed:-

- Building geometry is selected as, 4 bays and 10, 15, and 18 stories of the 3D frame.
- Sloping angles of ground are taken as (00, 80, 150, and 200 types).
- Five wind zones are selected (39, 44, 47, 50 and 55 m/s) as per IS- 875 (part-III):1987.

3. BUILDING FRAMES MODELING

3.1. MODELING OF BUILDING FRAMES USING STAAD PRO SOFTWARE

STAAD-Pro may be a general-purpose program for performing the analysis and style of a good sort of sorts of structures. The basic three activities which are to be administered to realize that goal -

a. Model generation

b. The calculations to obtain the analytical results

c. Result verification is all facilitated by tools contained within the program's graphical environment.

CASE-112m×12m in the plan area and 10 stories high.

(Study of 3D-frame in critical condition)

CASE-2: 12m×12m in the plan area and 15 stories high.

(Study 3D-frame in critical condition)

CASE-3: 12m×12m in the plan area and 18 stories high.

3.2. MATERIAL AND GEOMETRICAL PROPERTIES

Following material properties have been taken in modeling: - Density of RCC: 25 kN/m3

The density of Masonry: 18.5 kN/m3

The foundation depth is taken into account at 1.50m below sloping ground level and therefore the typical story height floor to floor is 3.0m. The sections of columns are considered 350mm x 350mm, and the section of beam size is 300mm x 250mm. (Study 3D-frame in critical condition)

3.3. SELECTION OF THE BUILDING FRAMES

The following assumed three different heights of a building frame (3D-frame) have been considered for analysis.

a. Type-A: Model30 meter building height, 00 inclined footing level.

b. Type-B: Model30 meter building height, 80 inclined footing level.

c. Type-C: Model 30 meter building height, 150 inclined footing levels.

d. Type-D: Model 30 meter building height, 200 inclined footing level.

e. Type-E: Model 45 meter building height, 00 inclined footing level.

f. Type-F: Model 45 meter building height, 80 inclined footing level.

g. Type-G: Model 45 meter building height, 150 inclined footing level.

h. Type-H: Model 45 meter building height, 200 inclined footing level.

i. Type-I: Model 54 meter building height, 00 inclined footing level.

j. Type-J: Model 54 meter building height, 80 inclined footing level.

k. Type-K: Model 54 meter building height, 150 inclined footing level.

l. Type-L: Model 54 meter building height, 200 inclined footing level.

4. LOADING CONDITIONS

Following loading is adopted for analysis:-

1. Dead load: - Self weight of slab considering 125mm thick Slab = 0.125*25 = 3.125 kn/m2

Floor Finish load = 1 kn/m2

Infill Load = .10 x 3 x 18.5×2 = 11.1 kn/m(ignoring depth of beam)

2. superload s: Live Load on typical floors =2 kn/m2

3. Wind load: Calculation of wind load as per is-code 875 (part-III):1987

The speed of wind depends on several factors. All the building frames are analyzed for five wind zones The wind loads are derived for the following wind parameters as per IS: 875(1987).

Wind zones- 39 m/s, 44 m/s, 47 m/s,50m/s, and 55 m/s. Wind Induced Lateral Force on Structure. the calculation can be done at every story level and windward direction. This can be calculated by the following method:

Design wind presser

Pz = 0.6vz2

Where,

Vz = design wind speed in m/s at any height z and;

Pz = design wind presser in n/m2 at any height z.

Design wind speed is given by

VZ= Vb ×K1×K2×K3

Where

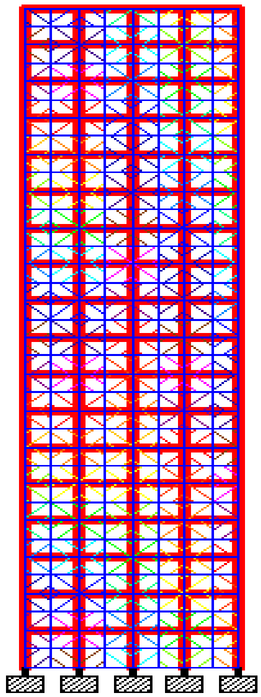
Vz = design wind speed at any height m/s (z in m/s);

Vb=basic wind speed (m/s)

K1= probability factor (risk coefficient);

K2= terrain, height, and structure size factor; and

K3= topography factor



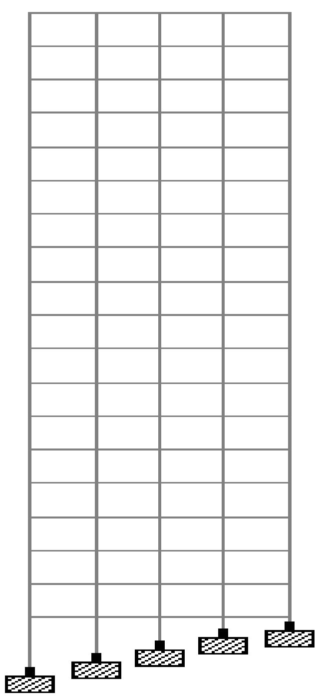


Fig4.1 wind ward face of the structure
fig 1.2 critical face of structure

5. RESULT AND CONCLUSION

5.1. MAXIMUM SHEAR FORCE

WIND VELOCITY	0◦	8◦	15◦	20◦
39M/S	11.078	13.581	16.725	16.545
44M/S	14.103	17.285	21.379	21.029
47M/S	16.092	19.724	24.378	23.996
50M/S	18.214	22.328	27.529	27.189
55M/S	22.039	27.013	33.386	32.863

Table 5.1.1: max shear force and velocity for beam of 30m

WIND VELOCITY	0◦	8◦	15◦	20◦
39M/S	16.099	23.587	28.869	27.607
44M/S	25.619	30.026	36.716	35.101
47M/S	29.232	34.243	41.93	40.054
50M/S	33.085	38.78	47.455	45.364
55M/S	40.034	46.924	57.421	54.853

Table 5.1.2: max shear force and velocity for beam of 45m

WIND VELOCITY	0◦	8◦	15◦	20◦
39M/S	22.524	26.085	31.776	30.077
44M/S	28.675	33.013	40.446	38.302
47M/S	32.658	37.894	46.128	42.522
50M/S	37.036	42.889	52.24	49.485
55M/S	51.551	51.889	63.212	59.859

Table 5.1.3: max shear force and velocity for beam of 54m

WIND VELOCITY	0◦	8◦	15◦	20◦
39M/S	9.914	14.914	84.65	82.263
44M/S	12.612	18.986	108.805	104.696
47M/S	14.402	21.663	120.904	119.468
50M/S	16.301	24.524	136.849	135.353
55M/S	19.724	29.67	165.584	163.612

Table 5.1.4: max shear force and velocity for column of 30m

WIND VELOCITY	0◦	8◦	15◦	20◦
39M/S	12.816	24.189	131.848	133.801
44M/S	20.395	30.795	167.798	173.16
47M/S	23.272	35.121	191.477	194.335
50M/S	26.339	39.774	216.855	219.949
55M/S	31.871	48.126	262.218	266.138

Table 5.1.5: max shear force and velocity for column of 45m

WIND VELOCITY	0◦	8◦	15◦	20◦
39M/S	17.334	26.221	144.394	142.055
44M/S	22.069	33.386	183.795	180.886
47M/S	24.952	38.093	209.624	201.099
50M/S	28.502	43.114	237.398	233.705
55M/S	39.684	52.172	287.25	284.252

Table 5.1.6: max shear force and velocity for column of 54m

5.2. MAXIMUM BENDING MOMENT

WIND VELOCITY	0◦	8◦	15◦	20◦
39M/S	17.208	21.071	25.946	25.77
44M/S	21.907	26.189	33.166	32.797
47M/S	24.996	30.603	37.818	37.424
50M/S	28.292	34.643	42.805	42.404
55M/S	34.234	41.912	51.793	51.254

Table 5.2.1: max bending moment and velocity for beam of 30m

WIND VELOCITY	0◦	8◦	15◦	20◦
39M/S	25.019	36.609	44.802	43.019
44M/S	39.814	46.603	57.049	54.748
47M/S	45.429	53.149	65.071	62.473
50M/S	51.417	60.192	73.646	70.756
55M/S	62.216	72.832	89.111	85.555

Table 5.2.2: max bending moment and velocity for beam of 45m

WIND VELOCITY	0◦	8◦	15◦	20◦
39M/S	35.012	40.493	49.321	46.915
44M/S	44.573	51.559	62.778	59.743
47M/S	50.765	58.825	71.598	66.326
50M/S	57.507	66.579	81.085	77.187

55M/S	80.133	80.579	98.115	93.368

Table 5.2.3: max bending moment and velocity for beam of 54

WIND VELOCITY	0°	8°	15°	20°
39M/S	22.616	31.893	45.503	47.13
44M/S	28.78	40.598	58.327	59.982
47M/S	32.84	46.324	65.637	68.445
50M/S	37.168	52.441	74.293	77.547
55M/S	44.976	63.444	89.893	93.736

Table 5.2.4: max bending moment and velocity for column of 30

WIND VELOCITY	0°	8°	15°	20°
39M/S	29.626	52.253	73.221	76.191
44M/S	47.147	66.522	94.005	96.965
47M/S	53.798	75.866	106.347	110.648
50M/S	60.887	85.918	120.364	125.314
55M/S	73.677	103.959	145.64	151.527

Table 5.2.5: max bending moment and velocity for column of 45m

WIND VELOCITY	0°	8°	15°	20°
39M/S	40.278	56.856	79.235	82.339
44M/S	51.281	72.393	100.855	104.848
47M/S	58.032	82.599	115.028	116.53
50M/S	66.23	93.487	130.269	135.464
55M/S	92.21	113.128	157.625	163.835

Table5.2.6: max bending moment and velocity for column of 54m

5.3 MAXIMUM AXIAL FORCE

WIND VELOCITY	0°	8°	15°	20°
39M/S	68.502	77.488	100.76	100.12
44M/S	87.198	98.622	129.11	127.43
47M/S	99.494	112.53	147.15	145.33
50M/S	112.61	127.38	166.55	165.95
55M/S	136.26	154.11	201.53	199.13

Table 5.3.1: max axial force and wind velocity for 30m

WIND VELOCITY	0°	8°	15°	20°
39M/S	135.047	188.753	239.052	233.672
44M/S	214.895	240.234	304.426	297.379
47M/S	245.202	273.943	347.192	339.333
50M/S	277.516	310.262	392.936	384.269
55M/S	335.807	375.439	475.46	467.701

Table 5.3.3: max axial force and wind velocity for 45m

WIND VELOCITY	0°	8°	15°	20°
39M/S	220.373	245.502	306.79	298.69
44M/S	280.536	312.555	390.479	380.204

47M/S	319.733	356.592	445.273	419.363
50M/S	362.302	403.63	504.323	491.252
55M/S	503.175	488.389	610.247	592.659

Table 5.3.5: max axial force and wind velocity for 54m

5.4 MAXIMUM DISPLACEMENT

WIND VELOCITY	0◦	8◦	15◦	20◦
39M/S	20.08	23.185	29.706	29.624
44M/S	25.552	29.508	38.079	37.702
47M/S	29.152	33.672	43.373	43.018
50M/S	33.013	38.115	49.092	48.748
55M/S	39.93	46.114	59.402	58.915

Table 5.4.1: max displacement and wind velocity for 30m

WIND VELOCITY	0◦	8◦	15◦	20◦
39M/S	42.997	60.456	75.853	74.179
44M/S	68.425	77.204	97.274	94.403
47M/S	78.076	88.037	110.167	107.721
50M/S	88.819	99.709	124.628	121.984
55M/S	107.311	120.655	150.868	147.519

Table 5.4.2: displacement and wind velocity for 45m

WIND VELOCITY	0◦	8◦	15◦	20◦
39M/S	74.14	83.029	102.497	99.711
44M/S	94.38	100.687	130.457	126.918
47M/S	107.577	107.577	148.762	139.95
50M/S	121.902	136.507	168.491	163.989
55M/S	163.246	165.171	203.88	197.659

Table 5.4.3: max displacement and wind velocity for 54m

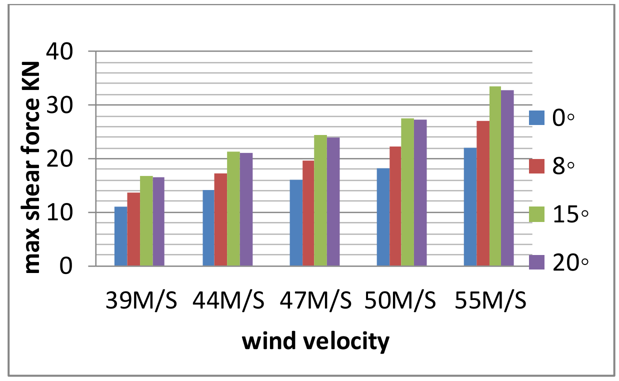


Fig5.1.1: graph of max shear force and wind velocity for beam of 30m

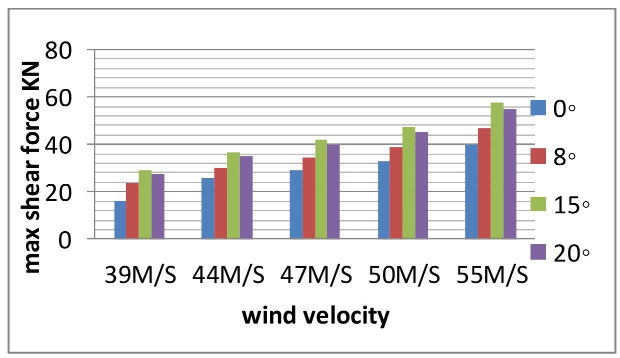


Fig 5.1.2: graph of max shear force and velocity for beam of 45m

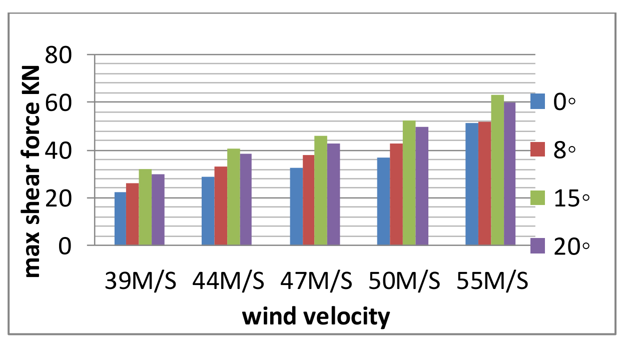


Fig 5.1.3: graph of max shear force and velocity for beam of 54m

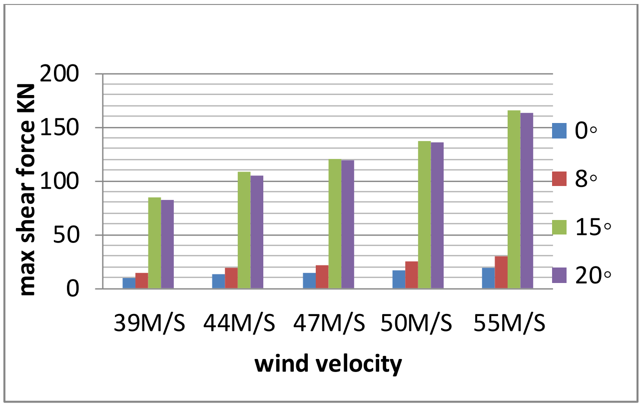


Fig 5.1.4: graph of max shear force and velocity for column of 30m

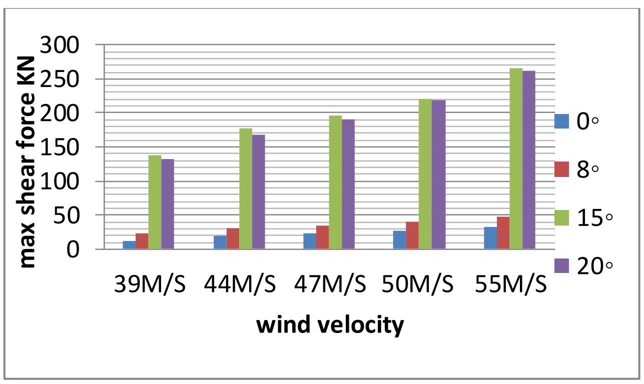


Fig 5.1.5: graph of max shear force and velocity for column of 45m

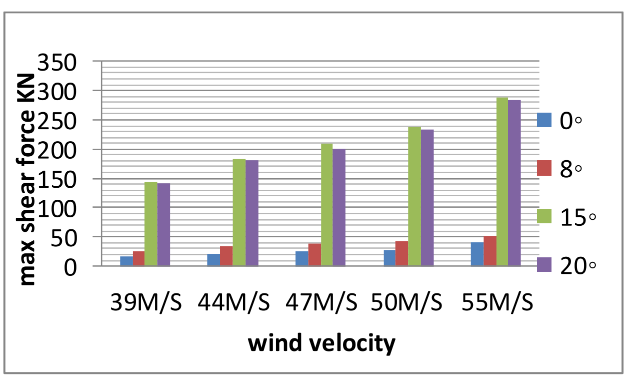


Fig 5.1.6: graph of max shear force and velocity for column of 54m

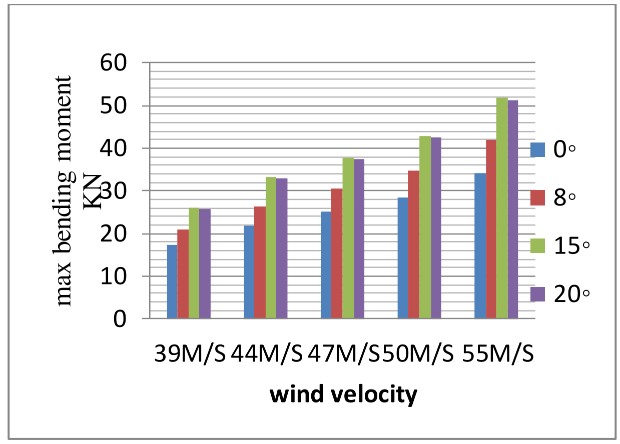


Fig 5.2.1: graph of max bending moment and velocity for beam of 30m

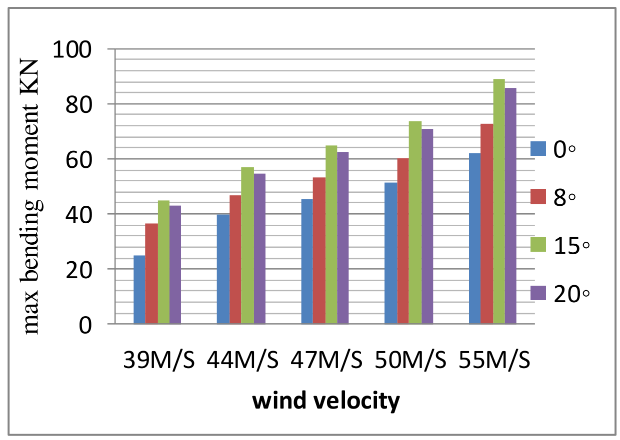


Fig 5.2.2: graph of max bending moment and velocity for beam of 45m

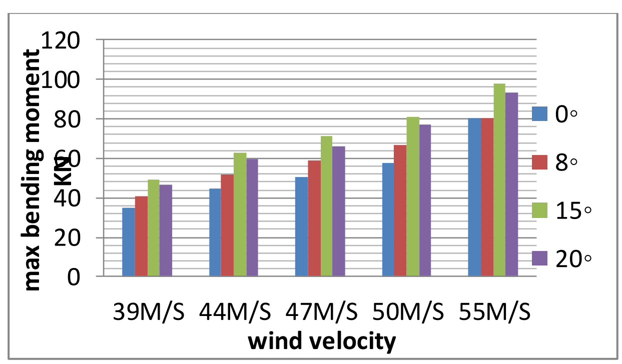


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Fig 5.2.3: graph of max bending moment and velocity for beam of 54m

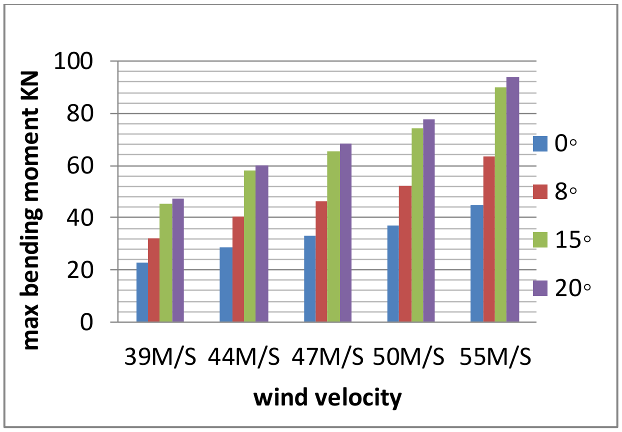

Fig 5.2.4 graph of max bending moment and velocity for column of 30m

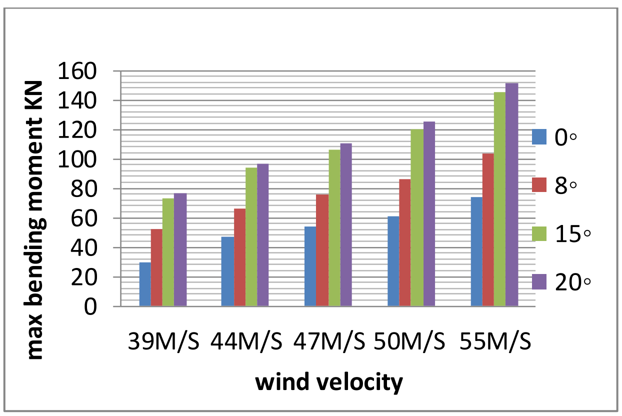

Fig 5.2.5: graph of max bending moment and velocity for column of 45m

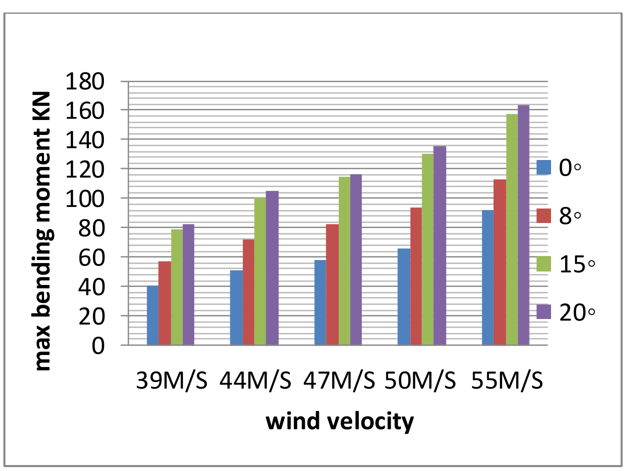

Fig 5.2.6: graph of max bending moment and velocity for column of 54ms

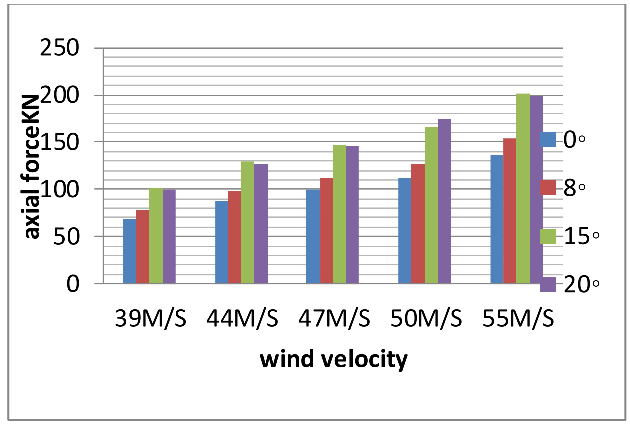

Fig 5.3.1: graph of max axial force and wind velocity for 30m

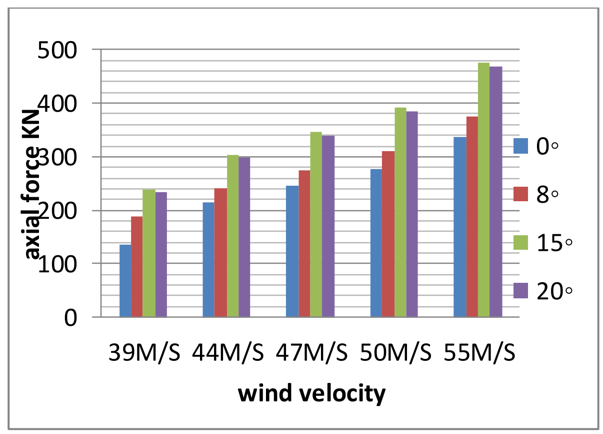

Fig 5.3.2: graph of max axial force and wind velocity for 45m

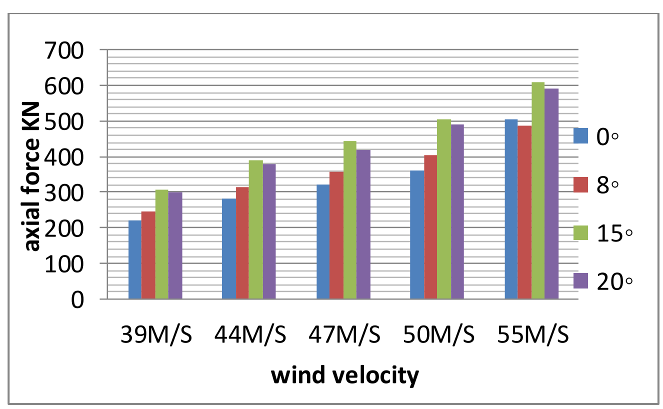

Fig 5.3.3: graph of max axial force and wind velocity for 54m

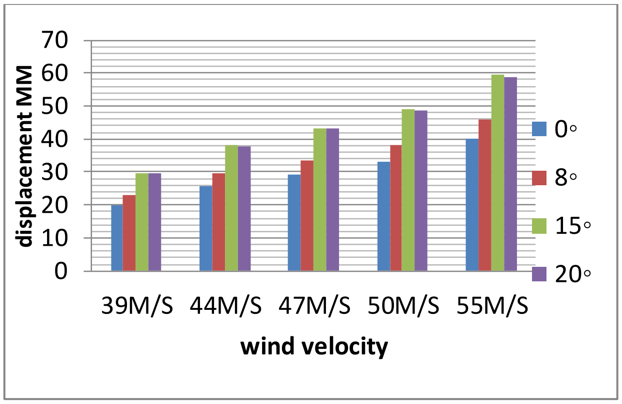

Fig 5.4.1: graph of max displacement and wind velocity for 30m

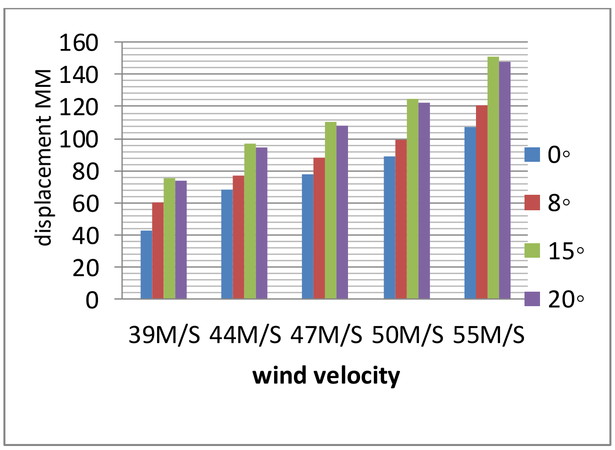

Fig 5.4.2: graph of max displacement and wind velocity for 45m

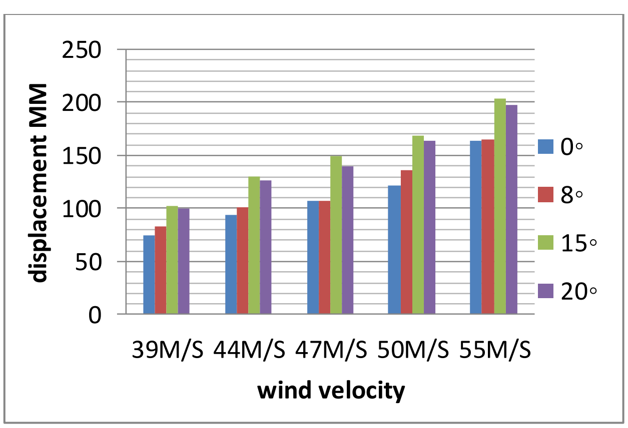

Fig 5.4.3: graph of max axial force and wind velocity for 54m

CONCLUSION

As mentioned within the objective of the study, the behavior of multi-story building frames under the various winds velocity and different ground slope. The considered static load and wind load on the different heights of building frame have been analyzed, through which we can conclude that the geometrical property, wind velocity, and height affect the results of the study.

MAXIMUM SHEAR FORCE

From the above tables and graphs, we can say that

• Max shear force in beams for all cases of building frame increased with increase in the wind velocity and it will seem to increase with the slope but in this case as the K3(topography factor) is decreases in 20◦frame the shear force is less than 15◦building frame.

• Max shear force in beams is increased with an increase in height of the structure but in this case as the K2(terrine, height, and structure size factor) and K3(topography factor) is decreases in 20◦frame the shear force is less than 15◦building frame.

• Max shear force in a column for all cases of building frame increased with increase in the wind velocity and it will seem to increase with the slop but in this case as the K3(topography factor) is decreases in 20◦frame the shear force is less than 15◦building frame.

• Max shear force in a column is increased with an increase in height of the structure but in this case as the K2(terrine, height, and structure size factor) and K3(topography factor) is decreases in

20◦frame the shear force is less than 15◦building frame

MAXIMUM BENDING MOMENT

From the above tables and graphs, we can say that

• Max bending moment in beams are increased with an increase in wind velocity and slope till 15 degree after that due to K3(topography factor) is decreases in 20◦frame the shear forces are decreased.

• Max bending moment in beams is increased with increase in height till 15 degree after that due to K3 (topography factor) is decreases in 20◦frame the shear forces are decreased.

• Max bending moment in columns increase with the increase in slope.

• Max bending moment in columns increase with an increase in height of the building frame.

• Maximum bending moments in columns are increased with an increase in wind velocity in all cases.

MAXIMUM AXIAL FORCE

With the increase in height, wind velocity and slope axial force is increased all factors affect axial force but with 20-degree slope and 54-meter building frame height K2 (terrine, height, and structure size factor) and K3 (topography factor) is decreases as compared to 15degree structure

MAXIMUM DISPLACEMENT

From the above tables and graphs, it is clear that the nodal displacement is also affected by the change in K2 (terrine, height, and structure size factor) and K3 (topography factor) which means nodal displacement is more in a 15-degree structure frame than the other structural frame. The nodal displacement of any structural frame can be affected by Wind velocity and height of the structural frame

FUTURE SCOPE

• The present study was done only for wind analysis, In the future, it can be done for the seismic load as well.

• This study is done for the frame structure; in the future, it can be done for the RCC structure.

• The study is done according to BIS code 875 (part 3): 1987, it can also be done for wind load as per code ASCE.

• In this study only static load is considered, the study can be done for dynamic load.

REFERENCES

1. Umakant Arya, Aslam Hussain, WaseemKhan(2014), “wind Analysis of Building Frames on Sloping Ground”, International journal of scientific research and publications, volume 4, issue 5.

2. Mohit Sharma, Dr. Savita Maru, volume(2014), “Dynamic Analysis of

Multistoried Regular Building Analysis and design of buildings for static

force”, International journal of civil engineering and technology, volume

2, issue 1.

3. Anagha Sai Pramod, Dr. V R A Saathappan (2017) “Comparative study of

wind analysis of 3-D framed structure on the sloping ground using etabs” International

Research Journal of Engineering and Technology (IRJET)

Volume: 04 Issue: 05

4. Chandwani Vinay, Agrawal Vinay, Gupta and Naveen Kumar (2012), "

Role of Conceptual Design in High Rise Buildings.", Vol. 2, Issue 4, July-

August 2012, pp.556-560

5. Hajra B and Godbole P.N. (2006). "Along Wind Load on Tall Buildings

Indian Codal Provisions." 3NCWE06 Kolkata, pp 285-292.