Wind Analysis of a Multi Storied Building with Basic Wind Speeds

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Abstract

The present study describes the effect of wind on a multi storied building. It deals with the analysis of G+10 multi storied framed structure for different wind speeds such as 33m/sec, 39m/sec, 44m/sec, 47m/sec, 50m/sec, 55m/sec using Staad-pro. Four different frames are considered, two in longitudinal direction and two in transverse direction. They are analysed for gravity and wind loading with different load combinations as per IS:875 part-1and part-2 and IS875 part-3.These frames are compared with different wind speeds, and members in one storey are compared with another storey for a particular wind speed and corresponding results are drawn for critical load combination. All the above results will be studied thoroughly to draw conclusions. Sample design calculations were done for randomly chosen set of columns and beams in those frames.
Keywords: basic wind speeds, wind load, multi-storey r/c building, staad-pro

I. INTRODUCTION

Buildings are defined as structures utilized by the people as shelter for living, working or storage. In 21ST century due to huge population the number of areas in units is decreasing day by day. Few years back the population was not so vast so they used to stay in horizontal system (due to large area available per person). But nowadays, people prefer vertical system (high rise building due to shortage of area). In high rise buildings we should be concerned about all the forces that act on the building the beam, column reinforcements and joint detailing should be good enough to counteract these forces successfully. As nowadays there is shortage of land for building more buildings at a faster growth in both residential and industrial area the vertical construction is given due importance because of which tall buildings are being built on a large scale.

Wind in general has two main effects on the tall buildings.

1) It exerts forces and moments on the structure and its cladding.
2) It distributes the air in and around the building mainly termed as wind pressure. Sometimes because of unpredictable nature of wind it takes so devastating form during some wind storms that it can upset the internal ventilation system when it passes into the building. For these reasons the study of air-flow is becoming integral with the planning a building and its environment.

This analysis mainly deals with the study of a regular building with six different basic wind speeds i.e. 33m/sec, 39m/sec, 44m/sec, 47m/sec, 50m/sec, 55m/sec using Staad pro. A 20.96mm × 19.43mm G+10 storey structure is modeled using staad pro. The height of each storey is taken as 3.45m; making to height of structure is 37m. Loads considered are taken in accordance with IS-875(part1, part2) IS-1893(2002) code. Post analysis of the structure, maximum shear forces, bending moment and storey maximum displacement are computed and then compared for all the analyze cases.

II. METHOD OF ANALYSIS

Code based procedure for wind analysis:

The basic wind speed for any site shall be obtained from Fig 3.1 and shall be modified to include the following effects to get design wind speed, V_z at any height, Z for the chosen structure: (a) Risk level, (b) Terrain roughness and height of structure, (c) Local topography, and (d) Importance factor for the cyclonic region. It can be mathematically expressed as follows:

$$V_z = V_b k_1 k_2 k_3 k_4.$$

Where,

V_z = design wind speed at any height z in m/s

k_1 = probability factor (risk coefficient) (see 5.3.1),

k_2 = terrain roughness and height factor (see 5.3.2),

k_3 = topography factor (see 5.3.3), and

k_4 = importance factor for the cyclonic region (see 5.3.4).

NOTE: The wind speed may be taken as constant up to a height of 10 m. However, pressures for buildings less than 10m high may be reduced by 20% for stability and design of the framing.

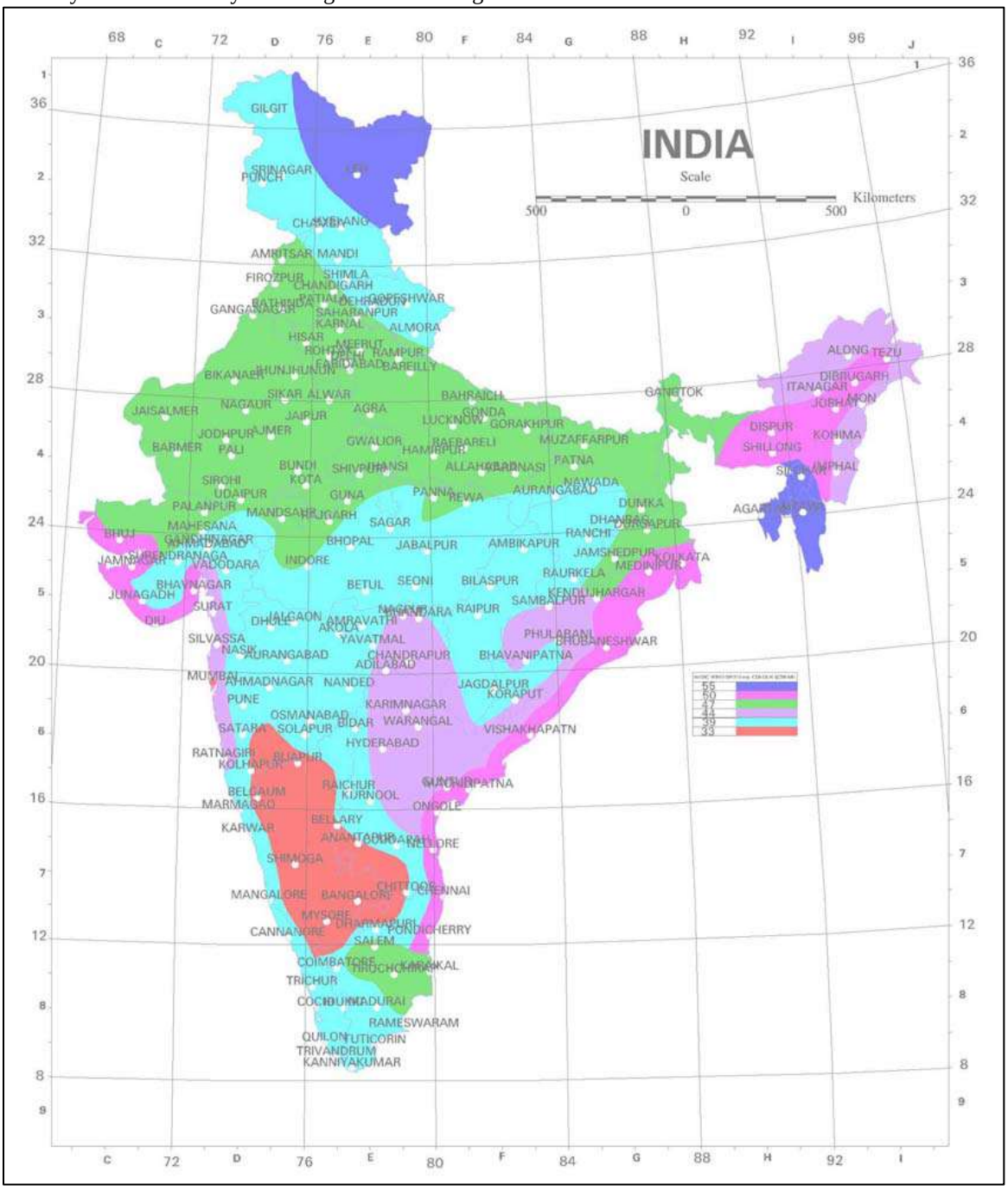

Fig. 1: Risk coefficients for different classes of structures in different wind speeds zones

III. MODELLING AND ANALYSIS

An RCC framed structure is basically an assembly of slabs, beams, columns and foundation inter-connected to each other as a unit. The load transfer mechanism in these structures is from slabs to beams, from beams to columns, and then ultimately from columns to the foundation, which in turn passes the load to the soil. In this structural analysis study, we have adopted the cases by assuming different speeds for the same structure, as explained below

- 33m/s

- 39m/s
- 44m/s
- 47m/s
- 50m/s
- 55m/s

Design characteristic: The following design characteristic are considered for multi-storey structure

Table – 1
Design Data of RCC Frame Structures

S.NO	*PARTICULARS*	*DIMENSION/SIZE/VALUE*
1	*MODEL*	*G+10*
2	*Wind Speed*	*33m/s*
3	*FLOOR HEIGHT*	*3.45 m*
4	*PLAN SIZE*	*20.96 x 19.43 m*
5	*SIZE OF COLUMNS*	*0.60 x 0.60 m*
6	*SIZE OF BEAMS*	*0.45 x 0.30 m*
7	*WALLS*	*1) EXTERNAL WALL =0.23 m* *2) INTERNAL WALL =0.115 m*
8	*THICKNESS OF SLAB*	*120 mm*
9	*TYPE OF SOIL*	*TYPE-II,MEDIUM SOIL AS PER IS-1893*
10	*MATERIAL USED*	*CONCRETE M-25 AND REINFORCEMENT FE-415*
11	*STATIC ANALYSIS*	*EQUIVALENT LATERAL FORCE METHOD*
12	*SOFTWARE USED*	*Staad.pro FOR STATIC ANALYSIS*

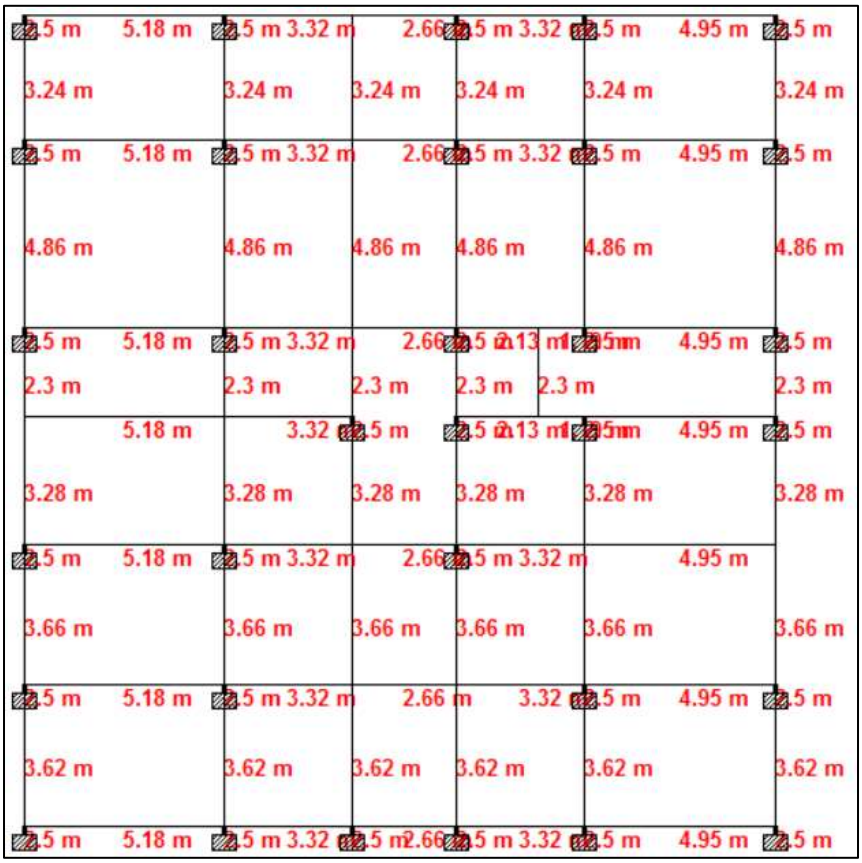

Fig. 2: Plan of Regular Building

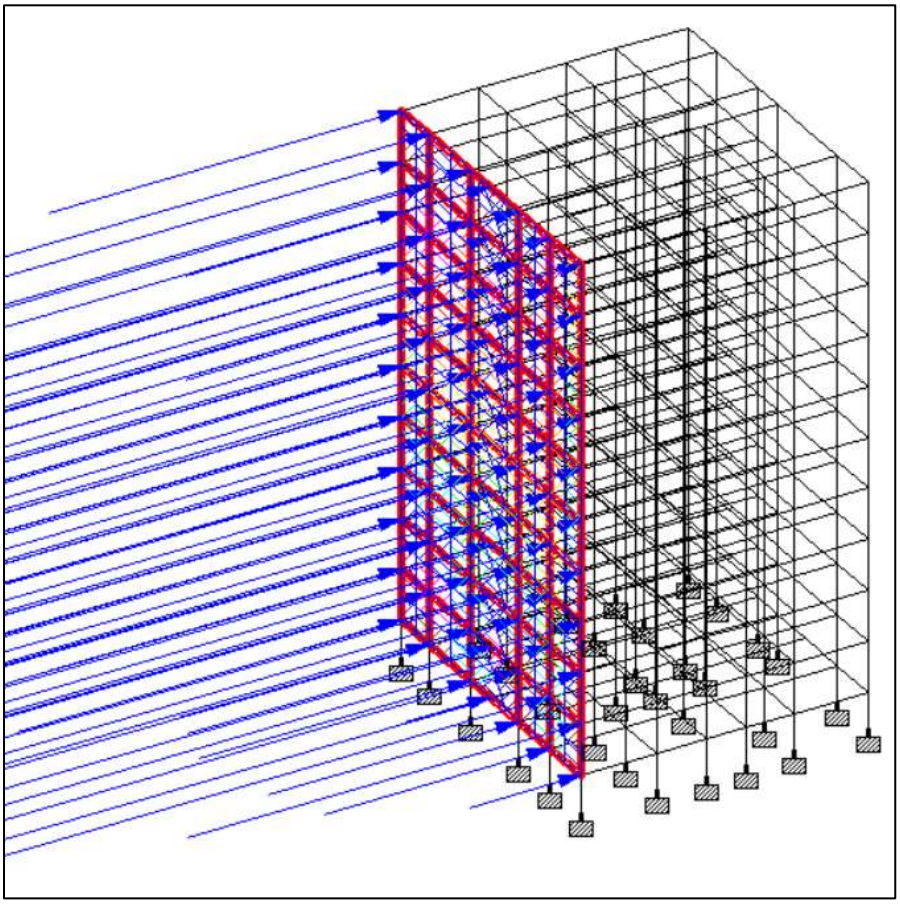

Fig. 3: Wind Loading In (+) X-Direction for Regular Building

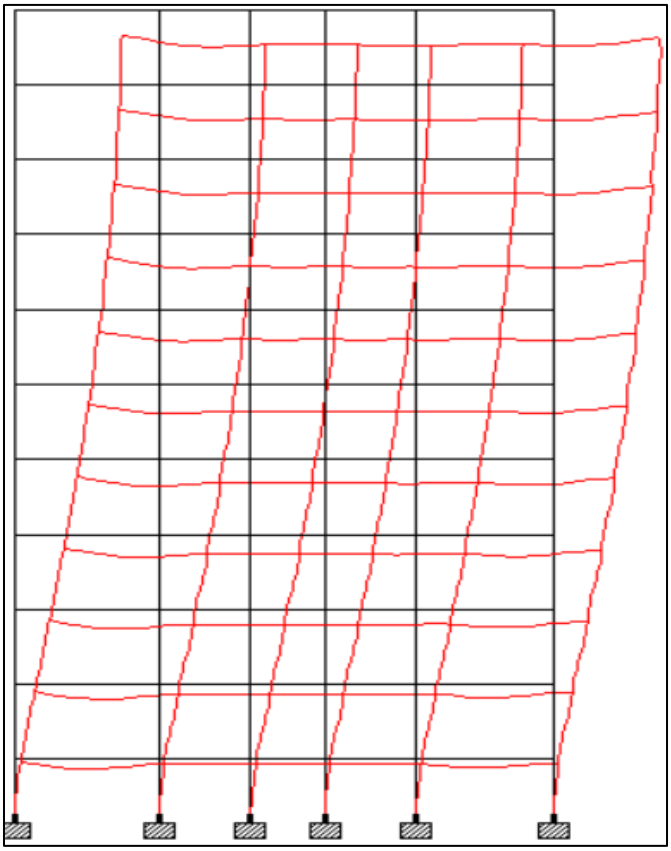

Fig. 4: Deflection of Regular Building

IV. RESULTS AND GRAPHS

Table – 2
Maximum Bending Moment in Beams of Frame -A-1-2-3-4-5-6-

STOREY NO	*B987 (KN-m)*	*B984 (KN-m)*	*B1018 (KN-m)*	*B1027 (KN-m)*
STOREY-5	*141.61*	*89.26*	*199.52*	*134.78*
STOREY-8	*121.25*	*79.78*	*193.24*	*117.00*

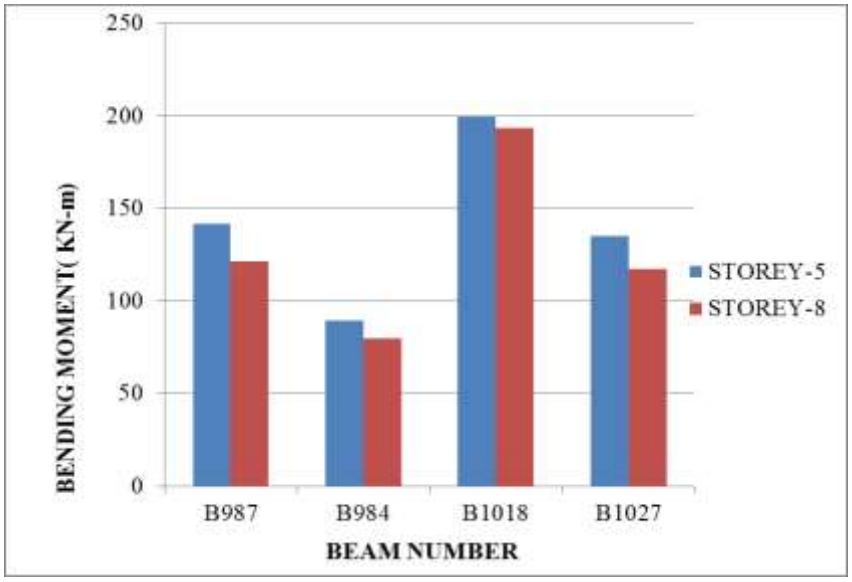

Fig. 5: Maximum Bending Moment in Beams of Frame A-1-2-3-4-5-6-7

Table – 3
Maximum Shear Force In Beams For Frame -A-1-2-3-4-5-6-7

STOREY NO	*B987 (KN)*	*B984 (KN)*	*B1018 (KN)*	*B1027 (KN)*
STOREY-5	*125.32*	*79.42*	*139.99*	*107.79*
STOREY-8	*123.96*	*77.20*	*138.994*	*106.474*

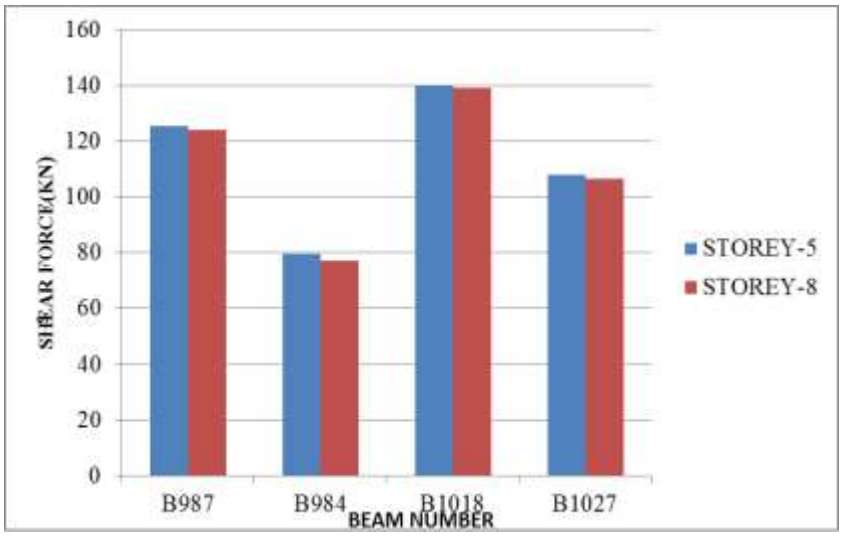

Fig. 6: Maximum Shear Force In Beams For Frame -A-1-2-3-4-5-6-7

Table – 4
Maximum Bending Moment in Continous Beams for Different Wind Speeds of Frame A-1-2-3-4-5-6-7

Wind speed	*Beam No.s*	*Storey-10 (KN-m)*	*Storey-8 (KN-m)*	*Storey-6 (KN-m)*	*Storey-4 (KN-m)*	*Storey-2 (KN-m)*	*Storey-G (KN-m)*
33m/s	*1400-1404*	*108.96*	*128.73*	*137.30*	*145.84*	*153.14*	*148.27*
39m/s	*1234-1238*	*111.42*	*133.76*	*145.10*	*156.14*	*165.15*	*156.60*
44m/s	*1068-1072*	*113.76*	*138.62*	*152.60*	*166.03*	*176.66*	*164.60*

47m/s	*902-906*	*115.30*	*141.80*	*157.53*	*172.54*	*184.23*	*169.87*
50m/s	*736-740*	*116.95*	*145.20*	*162.79*	*179.47*	*192.31*	*175.48*
55m/s	*570-574*	*119.91*	*151.33*	*172.27*	*191.99*	*206.86*	*185.60*

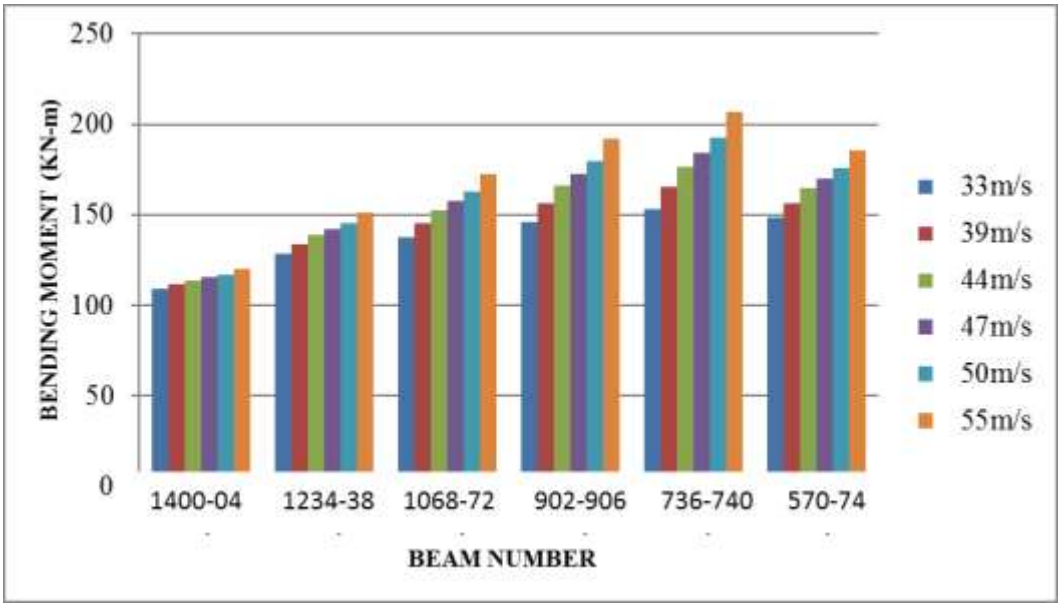

Fig. 7: Maximum Bending Moment in Continous Beam for Different Wind Speeds of Frame A-1-2-3-4-5-6-7

Table – 5
Maximum Shear Force in Continous Beams for Different Wind Speeds of Frame A-1-2-3-4-5-6-7

Wind speed	*Beam No. s*	*Storey-10 (KN)*	*Storey-8 (KN)*	*Storey-6 (KN)*	*Storey-4 (KN)*	*Storey-2 (KN)*	*Storey-G (KN)*
33m/s	*1400-1404*	*101.42*	*121.25*	*123.96*	*126.65*	*128.92*	*127.33*
39m/s	*1234-1238*	*102.20*	*122.90*	*126.50*	*129.98*	*132.79*	*130.03*
44m/s	*1068-1072*	*102.96*	*124.49*	*128.94*	*133.19*	*136.49*	*132.63*
47m/s	*902-906*	*103.45*	*125.54*	*130.54*	*135.30*	*138.95*	*134.33*
50m/s	*736-740*	*103.98*	*126.65*	*132.25*	*137.55*	*141.56*	*136.10*
55m/s	*570-574*	*104.93*	*128.66*	*135.34*	*141.60*	*146.26*	*139.44*

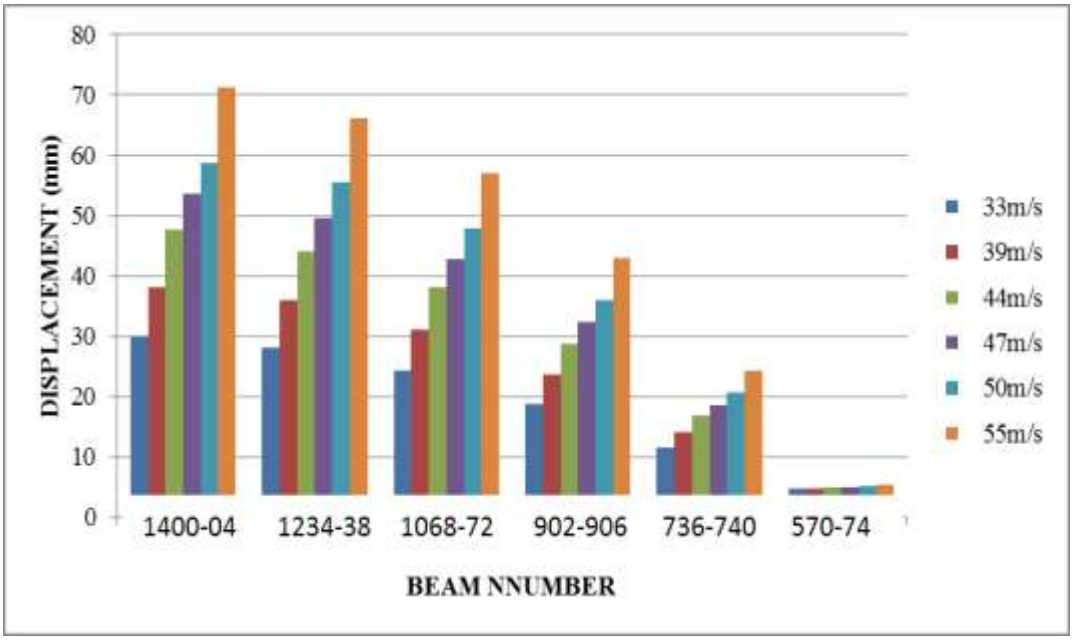

Fig. 8: Maximum Shear Force in Continous Beams for Different Wind Speeds of Frame A-1-2-3-4-5-6-7

Table – 6
Maximum Displacement in Continous Beams for Different Wind Speeds of Frame A-1-2-3-4-5-6-7

Wind speed	*Beam No. s*	*Storey-10 (mm)*	*Storey-8 (mm)*	*Storey-6 (mm)*	*Storey-4 (mm)*	*Storey-2 (mm)*	*Storey-G (mm)*
33m/s	*1400-1404*	*30.02*	*28.05*	*24.31*	*18.78*	*11.69*	*4.72*
39m/s	*1234-1238*	*38.13*	*36.07*	*31.15*	*23.76*	*14.17*	*4.82*
44m/s	*1068-1072*	*47.72*	*44.18*	*38.10*	*28.88*	*16.81*	*4.96*
47m/s	*902-906*	*53.58*	*49.64*	*42.78*	*32.34*	*18.63*	*5.07*
50m/s	*736-740*	*58.73*	*55.52*	*47.84*	*36.10*	*20.63*	*5.20*
55m/s	*570-574*	*71.37*	*66.25*	*57.08*	*42.98*	*24.33*	*5.46*

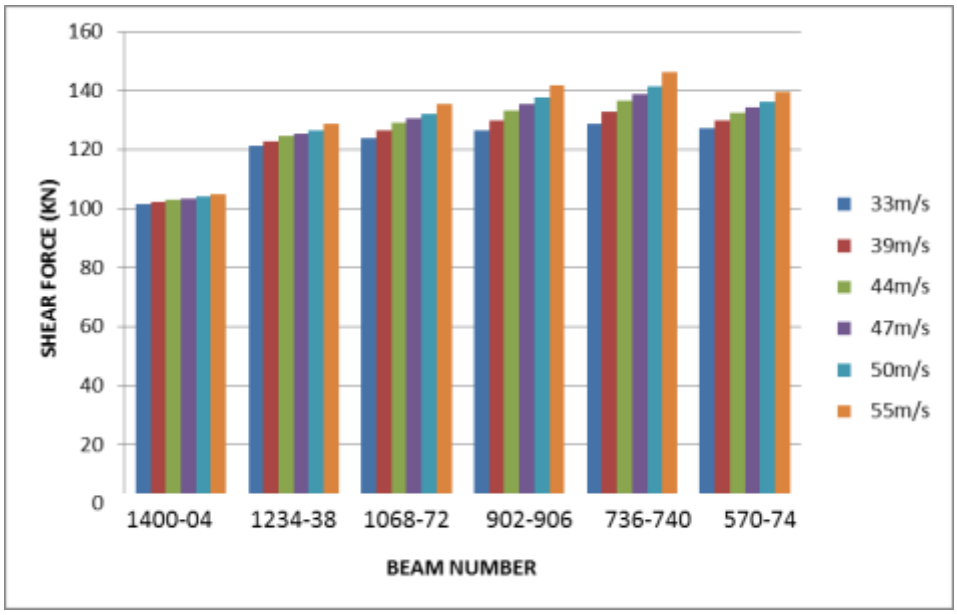

Fig. 9: Maximum Displacement in Continous Beams for Different Wind Speeds of Frame A-1-2-3-4-5-6-7

Table – 7
Maximum Bending Moment in Columns for Different Wind Speeds of Frame A-1-2-3-4-5-6-7

Wind speed	*Column No. s*	*Storey10 (KN-m)*	*Storey-8 (KN-m)*	*Storey-6 (KN-m)*	*Storey-4 (KN-m)*	*Storey2 (KN-m)*	*Storey-G (KN-m)*
33m/s	*376*	*47.93*	*39.38*	*49.30*	*45.56*	*44.59*	*32.75*
39m/s	*374*	*48.12*	*42.76*	*39.29*	*53.36*	*53.66*	*49.57*
44m/s	*372*	*48.31*	*33.86*	*42.66*	*60.86*	*62.38*	*65.74*
47m/s	*370*	*48.43*	*48.15*	*58.07*	*65.79*	*68.12*	*76.38*
50m/s	*368*	*48.55*	*50.43*	*61.91*	*71.05*	*74.23*	*87.72*
55m/s	*366*	*48.79*	*54.54*	*68.83*	*80.54*	*85.26*	*96.24*

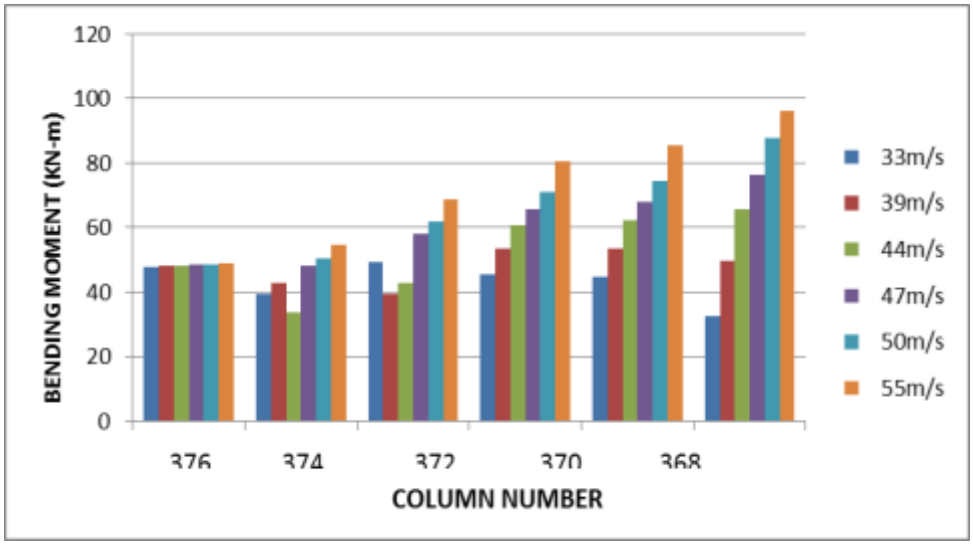

Fig. 10: Maximum Bending Moment in Column for Different Wind Speeds of Frame A-1-2-3-4-5-6-7

Table – 8
Maximum Shear Force In Columns For Different Wind Speeds Of Frame-A-1-2-3-4-5-6-7

Wind speed	*Column No. s*	*Storey-10 (KN)*	*Storey-8 (KN)*	*Storey-6 (KN)*	*Storey-4 (KN)*	*Storey-2 (KN)*	*Storey-G (KN)*
33m/s	*12*	*21.92*	*20.26*	*22.49*	*23.86*	*24.25*	*23.97*
39m/s	*10*	*22.58*	*21.39*	*25.09*	*27.93*	*29.76*	*30.78*
44m/s	*8*	*23.22*	*22.48*	*27.58*	*31.83*	*35.07*	*37.33*
47m/s	*6*	*23.63*	*23.19*	*29.22*	*34.40*	*38.56*	*41.63*
50m/s	*4*	*24.08*	*23.95*	*30.97*	*37.15*	*42.29*	*46.22*
55m/s	*2*	*24.88*	*25.33*	*34.13*	*42.09*	*49.00*	*54.50*

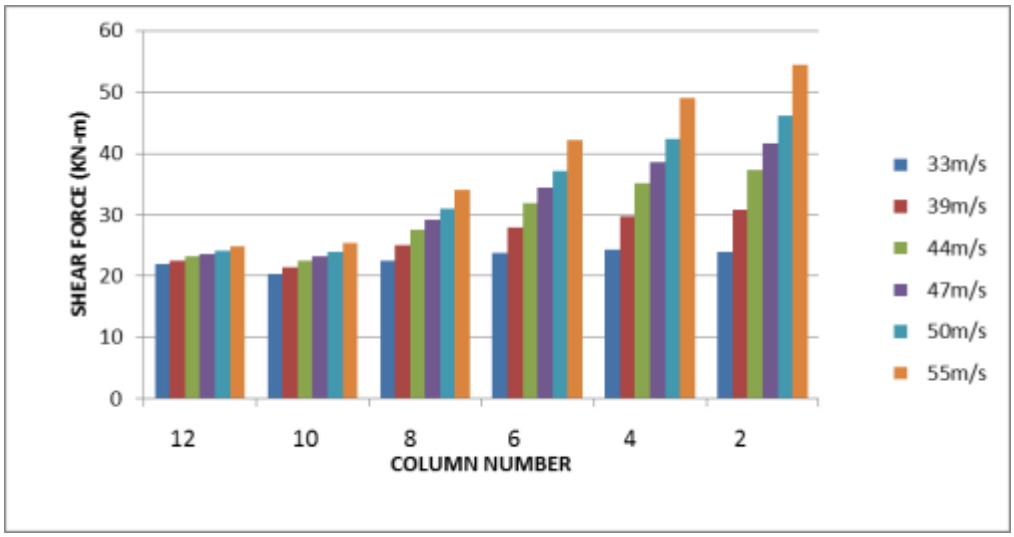

Fig. 11: Maximum Shear Force in Column for Different Wind Speeds of Frame A-1-2-3-4-5-6-7

Table – 9
Maximum Displacement in Column for Different Wind Speeds of Frame A-1-2-3-4-5-6-7

Wind speed	*Column No. s*	*Storey-10 (mm)*	*Storey-8 (mm)*	*Storey-6 (mm)*	*Storey-4 (mm)*	*Storey-2 (mm)*	*Storey-G (mm)*
33m/s	*376*	*28.50*	*25.74*	*22.26*	*16.51*	*9.33*	*1.64*
39m/s	*374*	*37.38*	*34.71*	*29.46*	*21.88*	*12.31*	*2.02*
44m/s	*372*	*46.06*	*42.90*	*36.51*	*27.15*	*15.24*	*2.41*
47m/s	*370*	*51.81*	*48.33*	*41.18*	*30.65*	*17.19*	*2.68*
50m/s	*368*	*57.97*	*54.14*	*46.19*	*34.40*	*19.29*	*2.92*
55m/s	*366*	*69.11*	*54.54*	*55.25*	*41.18*	*23.09*	*3.51*

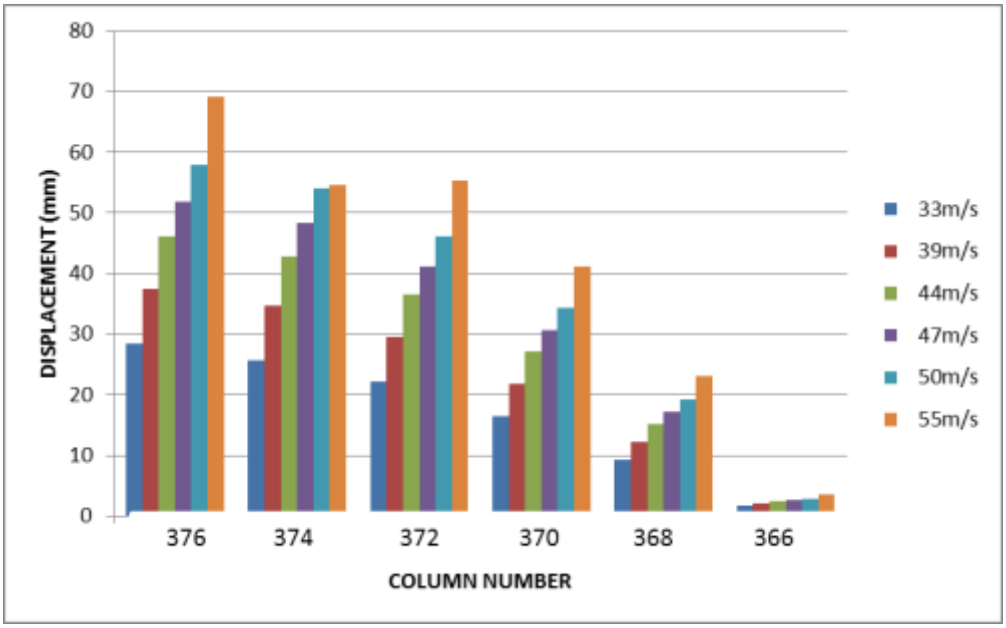

Fig. 12: Maximum Displacement in Columns for Different Wind Speeds of Frame A-1-2-3-4-5-6-7

Table – 10
Maximum Axial Load in Columns for Different Wind Speeds of Frame A-1-2-3-4-5-6-7

Wind speed	*Column no*	*Storey-10 (KN)*	*Storey-8 (KN)*	*Storey-6 (KN)*	*Storey-4 (KN)*	*Storey-2 (KN)*	*Storey-G (KN)*
33m/s	*376*	*124.19*	*455.89*	*774.60*	*1080*	*1370*	*1640*
39m/s	*374*	*123.84*	*453.20*	*767.08*	*1060*	*1340*	*1610*
44m/s	*372*	*123.49*	*450.60*	*759.85*	*1050*	*1320*	*1580*
47m/s	*370*	*123.27*	*448.90*	*755.11*	*1040*	*1310*	*1560*
50m/s	*368*	*123.03*	*447.08*	*750.04*	*1030*	*1290*	*1530*
55m/s	*366*	*122.60*	*443.81*	*740.90*	*1010*	*1260*	*1490*

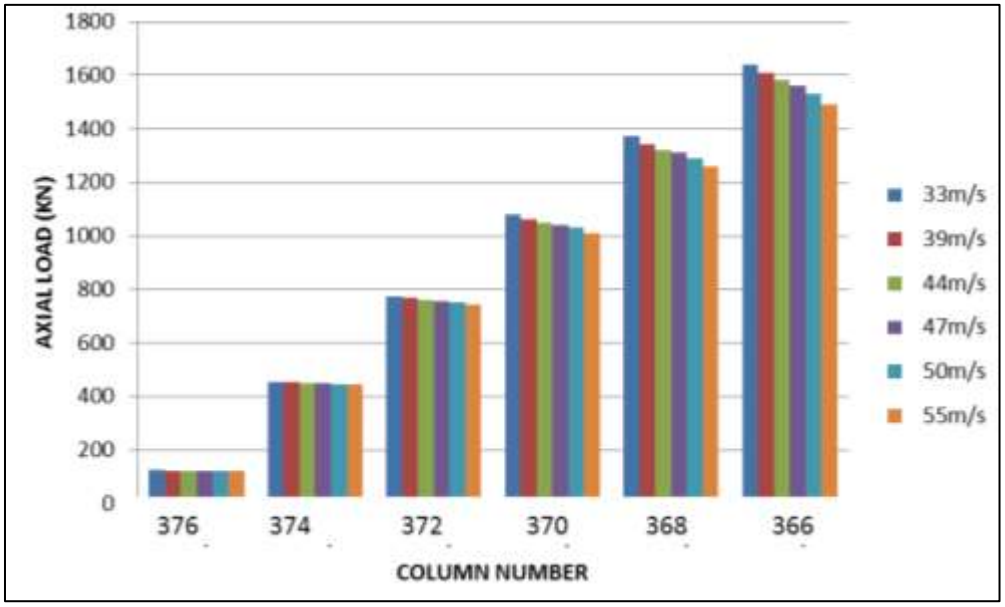

Fig. 13: Maximum Axial Load in Columns for Different Wind Speed of Frame A-1-2-3-4-5-6-7

V. CONCLUSION

- The bending moment for a continuous beam in a frame for a storey-5 is more than bending moment for the same frame in storey-8
- The Shear force for a continuous beam in a frame for a storey-5 is more than shear force for the same frame in storey-8
- The moment in beams for the basic wind speed of 55 m/sec is more when compared to basic wind speeds 33m/sec, 39m/sec , 44m/sec , 47m/sec , 50m/sec.
- The Shear force in beams for the basic wind speed of 55 m/sec is more when compared to basic wind speeds 33m/sec, 39m/sec, 44m/sec, 47m/sec, 50m/sec.
- The displacement in beams for the basic wind speed of 55 m/sec is more when compared to basic wind speeds 33m/sec, 39m/sec, 44m/sec, 47m/sec, 50m/sec.
- The bending moment in columns for the basic wind speed of 55 m/sec is more when compared to basic wind speeds 33m/sec, 39m/sec, 44m/sec , 47m/sec , 50m/sec.
- The shear force in columns for the basic wind speed of 55 m/sec is more when compared to basic wind speeds 33m/sec, 39m/sec, 44m/sec , 47m/sec , 50m/sec.
- The displacement in beams for the basic wind speed of 55 m/sec is more when compared to basic wind speeds 33m/sec, 39m/sec , 44m/sec , 47m/sec , 50m/sec.
- The axial force in columns decreases with decreases in wind speed.

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