iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 Issue: V Month of publication: May 2019

DOI: https://doi.org/10.22214/ijraset.2019.5370

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

Comparison of Seismic and Wind Loading Effects on G+11 Building

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Abstract: Reinforced concrete (RC) framed buildings with ground parking are commonly seen in major cities. These RC framed structures are constructed in densely populated cities of developing countries all around India. Earthquakes in the past have major effects on the life and economy as to the buildings and infrastructure was poorly built. Earthquake and wind are both juggernaut as they cannot be stopped in any way, though the solutions are provided only to safeguard the buildings. It is therefore necessary to analyze and modify the building elements satisfactorily to withstand earthquake and wind effects. The Indian code for wind load resisting structure is prepared for analysis of the building and to design the structure for resisting wind loading effects. The wind loading is predominant in effect for three seconds. When the wind loading is taken account the internal pressure of wind and external pressure of the wind loading is taken into account. Wind acts on the surface that is been exposed to it. Mostly windward wind is considered to act on the building. The parameter from analysis of the wind loading on the structure is compared to seismic loading in different zones. Practically seismic effect on building is unpredictable though there is specification suggested in IS code for designing of earthquake resistant structure. The structure is accordingly designed and analyzed with proper method with respect to the building height and plan aspect. The response of the building to lateral forces of seismic loading is considered to be in horizontal direction whereas the force acting in the vertical direction is negligible. The response of the building is considered to the same movement that of the shaking to earth motion. The response of building in wind loading effect is compared with response of the elements in seismic loading effects. Up to a certain height wind effect is considered to be same. Seismic loading affects from the foundation itself and the lateral force shake the building in the direction of earthquake motion. The design criteria can be changed when building can be efficiently analyzed for both wind and seismic effect. With the help of comparison of the building structure in seismic and wind loading effect, the building can be designed safely if in the analysis the structure is shown failure. Precautions can be adopted in designing of the building material or the building elements. The consulting structural engineer needs to design, and build to safeguard the building from the seismic and wind effect.

Keywords: Earthquake, Bending moment, Seismic zones, Wind, Direction, Effects.

I. INTRODUCTION

India is a country with a vast variation of geographical conditions. These varying conditions are observed in India which makes prone to many calamities. India has major calamities like earthquake and cyclones majorly. There is a population of India which already lives in major cities, now for opportunities there is migration of Indian village population to cities like Mumbai, Delhi, Kolkata, Chennai etc. This makes cities overcrowded, resulting in reduction of land area to live. Land available is less to construct any building thus building size is increased in vertical direction only. Thus tall structures are constructed for residential, commercial, official purposes. So according to IS code 16700-2017, super tall-structures whose height are above 250 m; and for tall structures whose height is above 50 m but less than 250 m are to be considered when RCC building is taken into account. Usually building height is taken according to IS code and all criteria are satisfied. Buildings are increasing with height they are more susceptible to failures which are due to wind and earthquake. Both earthquake and wind forces are unpredictable and uncontrollable. Accordingly the building structure is built to resist wind and earthquake lateral forces. Building criteria are developed in IS codes according to the zones in which cities are considered to be built. In general, for design of tall buildings both wind as well as earthquake loads need to be considered. Governing criteria for carrying out dynamic analyses for earthquake loads are different from wind loads. According to the provisions of Bureau of Indian Standards for earthquake load, IS 1893(Part 1):2016 Criteria for Earthquake Resistant Design of Structures, height of the structure, seismic zone, vertical and horizontal irregularities, soft and weak storey necessitates dynamic analysis for earthquake load. The contribution of the higher mode effects are included in arriving at the distribution of lateral forces along the height of the building. As per IS 875(Part 3):2015Design Loads Other than Earthquake for Buildings and structures, when wind interacts with a building, both positive and negative pressures occur simultaneously, the building must have sufficient strength to resist the applied loads from these pressures to prevent wind induced building failure. Load exerted on the building envelope are transmitted to the structural system and they in turn must be transferred through the foundation into the ground, the magnitude of the wind pressure is a function of exposed basic wind speed, topography, building height, internal pressure, and building shape.

In order to design a structure to resist wind and earthquake loads, the forces on the structure must be specified. The exact forces that will occur during the life of the structure cannot be anticipated. Most National Building Codes identify some factors according to the boundary conditions of each building considered in the analysis to provide for life safety. A realistic estimate for these factors is important; however the cost of construction and therefore the economic viability of the project is essential. The code introduces simplified methods for the design which depend on different factors for wind and earthquake that govern the design and influence the results.

A. Earthquake

India has varied land condition; there are tectonic plates which are moving along the fault lines which makes the land surface shake. This shaking of land is Earthquake. Earthquakes are themselves not fatal but the building in which people are living or working and building is weak structurally. This can prove to be fatal. Earthquakes are unpredictable thus making the aftermath dangerous. Earthquakes are juggernauts as they cannot be stopped. IS codes have already clarified in ANNEXE E of IS code 1893(part1):2016, all the cities with population of over three lakh and the zones in which the cities lie.

Based on the occurrence of earthquakes in the past around India, the country is divided into four seismic zones, namely zones II, III, IV, V, where II is the least severe and V is the most severe. Based on this zoning, about 60% of India’s land area is under moderate seismic threat or more, i.e., under seismic zone III or above in fact, the Gujrat, Latur earthquake which were fatal. Even now amongst our four mega-cities, Delhi is in seismic zone IV, which Mumbai, Calcutta and Chennai are in seismic zone III. Despite this level of seismic hazard, little is being done, particularly in these cities, to make the development akin to earthquake shaking. The quality of both design engineering and construction is way behind the expected seismic standards. The experience of severe earthquake has shown that when structures were built in accordance with seismic codes, the consequences of earthquakes were least severe.

The characteristic of seismic ground vibrations expected at any site depend on magnitude of earthquake, its focal depth, epicentre distance, characteristics of path through which seismic waves travel, and soil strata on which seismic waves travel, soil strata on which structure is founded. The random earthquake ground motions, which cause structure to oscillate, can be resolved in any three mutually perpendicular directions. The predominant direction of ground vibration is usually horizontal.

B. Wind

Wind is air in motion relative to the surface often earth. The primary cause of wind is traced to earth's rotation and differences in terrestrial radiation. The radiation effects are primarily responsible for convection either upwards or downwards. The wind generally blows horizontal to the ground at high wind speeds. Since vertical components of atmospheric motion are relatively small, the term 'wind' denotes almost exclusively the horizontal wind. Winds are proven to be fatal because there are juggernauts, they cannot be controlled. Building in which people are residing or working should resist the wind effects. Wind affects the surface of the exposed area of the building.

Wind forces static and dynamic should be taken into account when designing the building, Wind speeds vary randomly both in space and time and hence assessment of wind loads and response prediction are very important in design of several buildings and structures.

Buildings shall also be designed with due attention to the effects of wind on the comfort of people inside and outside the buildings. The liability of a building to high wind pressures

depend not only upon the geographical location and proximity of other obstructions to air flow but also upon the characteristics of the structure itself.

The effect of wind on the structure as a whole is determined by the combined action of external and internal pressures acting upon it. In all cases, the calculated wind loads act normal to the surface to which they apply. According to IS code 875 (part 3):2015 Wind speed may be taken as constant up to a height of 10 m. Accordingly basic wind speed is categorized in zones, cities are classified in those zones. Basic wind speed is based on gust velocity averaged over a short time interval of about 3 seconds. Basic wind speed for some important cities/towns is given in ANNEXE A of IS code 875(part3):2015.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
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II. SUMMARY OF LITERATURE REVIEW

Sr. No.	Author/ source	Research work	Application of the research into the project work.
1.	Adityan Verma	Author performed study on 200m high rise building for static wind analysis with help of four countries code for wind analysis.	Indian code IS875 (part3):2015 is applied to the building effectively. Calculations are done concerning the code.
2.	Anupam Rajmani	Author suggested that for G+15 building circular shape and triangular shape is preferable and building of G+45 circular shape and rectangular shape are preferable.	Rectangular building and the size of building plan with building aspect ratio is used which is applied.
3.	K.R.C Reddy	Author compared study of lateral loads i.e. wind & earthquake loads to design loads of multi-storey building for a particular region.	The wind and earthquake loads were compared and results used shown that the wind loads were more critical than earthquake loads in most of the cases. The author concludes that building should be designed for critical wind and seismic loading separately.
4.	Mohammed A. Ahmed	Author compared G+16 and G+30 building using ETABS for wind and seismic loadings.	Comparison of inter-storey drift produced by wind is more than seismic loading. The use of shear walls should be done to resist the lateral forces by wind and earthquake.
5.	Rabi Akhtar	Author performed analysis of G+50 building in STAAD PRO for wind load and seismic loading .	Seismic loading are predominant on structure than wind loading effect. No. of shear walls can be increased to withstand seismic effect.
6.	Sanhik Mujumdar	Author studied building model of G+7 using STAAD PRO with loading of wind and seismic on different types of building structure.	The period coefficient depends on dimension and weight of the building and soil coefficient. Building model is studied with response spectrum and static coefficient method.
7.	Reeti Sarkar	Author studied a single modification in high rise building and carried out model analysis in STAAD PRO software.	The effect of the wind loadings can be resisted by implementation of bracings. The seismic effects can be resisted by the use of shear walls or dampers.
8.	Susheel S.	Author evaluated the building model of G+30 and effect of wind forces using E-TABS software.	It can be concluded that storey shear is less at higher storey level than lower storey level. They observed that displacement due to wind loading is maximum at roof.
9.	K. Rama Raju	Author carried out analysis of G+34 Building model with Wind And Earthquake analysis using Staad Pro, Building is assumed to be located in Mumbai.	Response of building to wind and seismic loading effect can be reduced by application of shear walls. Heavier dimensions of elements can be preferred for foundation height to certain height.

III. METHODOLOGY AND ANALYSIS

1) Review of literature available.
2) Study of various codes that are used.
3) Design and analysis of building by Wind analysis method.
4) Design and analysis of building by Response Spectrum Method.
5) Modal Analysis of buildings u*sing software.
6) Comparison between buildings in various aspects.
7) Conclusion and Future Scope.

A. Codal Analysis For Structural Analysis

During the analysis of various models, following IS Codes were used:

1) IS: 875 (Part I):1987 - Indian Standard Code of Practice for design loads (other than earthquake) for buildings and structures (Dead Load).
2) IS: 875 (Part II): 1987 - Indian Standard Code of Practice for design loads (other than earthquake) for buildings and structures (Live Load).
3) IS 875 (Part 3): 2015 - Indian Standard Criteria for Design Loads (other than Earthquake) for buildings and structures (Third Revision).
4) IS 1893 (Part 1): 2016 - Indian Standard Criteria for Earthquake Design of Structures (Sixth Revision).
5) IS 1893 (Part I) : 2016 - Indian Standard Criteria For Earthquake Design of Structures Sixth Revision).

a) Load Combinations: When earthquake forces are considered on a structure, these shall be combined as per 6.3.1.1 and 6.3.1.2 where the terms DL, IL and EL stand for the response quantities due to dead load, imposed load and designated earthquake load respectively. When responses from three earthquake components are considered the response due to each component may be combined using assumption that when maximum response from one component occurs, the responses from other two components are 30 percent each of their maximum
b) Partial safety factors for limit state design of reinforced concrete and pre stressed concrete structures. In the limit state design of reinforced and pre stressed concrete structures, the following load combinations shall be accounted for:

i) 1.5 (DL+IL)
ii) 1.2 (DL + IL ± EL)
iii) 1.5 (DL ± EL)
iv) 0.9 DL ± 1.5 EL

B. Design Acceleration Spectrum

The design horizontal seismic coefficient A_h for a structure shall be determined by following expression:

$$A_{h} = Z*I*S_{a/}2*R*g$$

Provided that for any structure with T < 0.1s, the value of A_h will not be taken less than Z/2 whatever be the value of I/R.

Where,

Z=Zone Factor given in table 3, is for the Maximum Considered Earthquake (MCE) and service life of structure in a zone. The factor 2 in the denominator of Z is used so as to reduce the Maximum Considered Earthquake (MCE) zone factor to the factor for Design Basis Earthquake (DBE).

R=Response Reduction Factor, depending on the perceived seismic damage performance of the structure, characterized by ductile or brittle deformations. However, the ratio (I/R) shall not be greater than 1.0(Table 9). The values of R for buildings are given in Table 9.

I=Importance Factor, depending upon the functional use of the structures, characterized by hazardous consequences of its failure, post earthquake functional needs, historical value, or economic importance.(Table 8).

S_a/g=Average Response Acceleration Coefficient, for medium or stiff soil as given 6.4.2 b) for Response spectrum method based on appropriate natural periods and damping of the structure.

C. Design Seismic Base Shear

The total design lateral force or design seismic base shear (V_b) along any principal direction shall be determined by following expression:

$$\mathbf{V_b = A_h * W}$$

where,
A_h= Design horizontal acceleration spectrum value as per 6.4.2 using fundamental natural time period T_a as per 7.6.2a)
W = Seismic weight of building.
Finally, the calculated lateral force is applied to the building and analyzed by structural analysis and design (STAAD) or (STAAD.PRO) software.
7.6.2 The approximate fundamental translational natural period of vibration(T_a) of oscillation, in seconds, shall be estimated by following expression:
For Bare MRF buildings (without any masonry infill)

1) $T_a = 0.075\ h^{0.75}$.(for RC MRF building)
2) $T_a = 0.080\ h^{0.75}$.(for RC-Steel Composite MRF building)
3) $T_a = 0.085h^{0.75}$.(for Steel MRF building)

where, h= height of building from the ground.
4.4 IS 875 (Part 3): 2015 - Indian Standard Criteria for Design Loads (other than Earthquake) for buildings and structures (Third Revision)
The basic wind speed V_b for any site at chosen height shall be obtained from ANNEXE A.
Design wind speed is obtained from 6.3

$$V_z = V_b\, k_1\, k_2\, k_3\, k_4$$

From 6.3.1 $k_{1=}$ probability factor (risk factor) gives basic wind speeds for terrain category 2 as applicable for 50 years return period.
From 6.3.2 $k_{2=}$ terrain roughness factor gives terrain category used in design of structure depending on direction of wind under consideration.
From 6.3.3 $k_{3=}$ topography factor the effect of topography is to accelerate wind near summit of hills or crest of cliffs, ridges, valleys or near foot of cliffs.
From 6.3.4 $k_{4=}$ importance factor area under the influence of cyclones i.e. coastal regions values are applicable according to importance of structure.

D. Design Wind Pressure

The wind pressure at any given height above mean ground level shall be obtained by following relation between wind pressure and wind speed. Wind load on a building is calculated for

1) Building as a whole,
2) Individual structural elements as roofs and walls
3) Individual cladding units including glazing and their fixings

$$P_z = 0.6\ V_z^2$$

Where,
Pz = wind pressure at height z, in N/m^2; and
Vz = design wind speed at height z, in mfs.
The design wind pressure P_d can be obtained as,

$$Pd = K_d\, K_a\, K_c\, P_z$$

where
K_d = wind directionality factor,
K_a = area averaging factor, and
$K_{c\,=}$ combination factor
The value of P_d however shall not be taken as less than 0.70 P_z.

a) Wind directionality factor K_d, for rectangular building and sign boards, trussed towers factor of 0.9 used for design wind pressure.
b) Averaging Area factor K_a, as area becomes larger the correlation of measured values decrease, decreased values are taken into account in table no.4

E. Pressure Coefficients

The wind load acting normal to a surface is obtained by multiplying the area of that surface or its appropriate portion by the pressure coefficient (Cp) and the design wind pressure at the height of the surface from the ground.

F. Wind Load On Individual Members

When calculating the wind load on individual structural elements such as roofs and walls, and individual cladding units and their fittings, it is essential to take account of the pressure difference between opposite faces of such elements or units.

$$F= (C_{pe} – C_{pi})* A* P_d$$

Where,
Cpe = external pressure coefficient,
Cpi = internal pressure coefficient,
A =surface area of structural element or cladding unit, and
P_d = design wind pressure.

G. Internal Pressure Coefficients

Internal air pressure in a building depends upon the degree of permeability of cladding to the flow of air. The internal air pressure may be positive or negative depending on the direction of flow of air in relation to openings in the buildings.
Buildings with medium openings between about 5 and 20 percent of wall area shall be examined for an internal pressure coefficient of +0.5 and later with an internal pressure Coefficient of -0.5, when percentage is less than 5 ,internal coefficient is taken as +0.2 or -0.2. When percentage opening is more than 20 percentage, then internal pressure is taken as +0.7 or -0.7.

H. External Pressure Coefficient

The building height ratio is found out, and then building plan ratio is calculated. The average external pressure coefficient for the walls of clad buildings of rectangular plan shall be as given in Table 5.
These values are used in the finding wind load F, acting in a direction normal to individual structural element or cladding unit.
The analysis is performed with help of STAAD PRO v8i; STAAD.PRO provides us a fast, efficient, easy to use and accurate platform for analysis and designing structures. Design and construction of the structure are intimately related and the achievement of good workmanship depends, to a large degree, on the simplicity of detailing of members and their connections and supports.

I. Earthquake (Seismic) Loads

Seismic loads on the structure are basically due to inertial property of the structure itself. During earthquakes, as the ground shakes, lower part of the structures is enforced to move with ground, whereas its upper part by virtue of inertia tries to maintain its original state of rest. Seismic loads can be calculated taking a view of acceleration response of ground to the super structure. When seismic loading occurs they predominant in horizontal direction only. When three component of seismic effect are considered responses due to each component may be combined using assumption that maximum response from one component occurs then response from other two are 30 percent of their maximum. In STAAD PRO v8i the effect due to seismic response in local Y direction is not considered. Also the individual effect due in Y direction or vertical direction is considered negligible.

1) EQ(+X) (seismic load in +X direction)
2) EQ(-X) (seismic load in -X direction)
3) EQ(+Z) (seismic load in +Z direction)
4) EQ(-Z) (seismic load in -Z direction)
5) EQ(+Y) (seismic load in +Y direction)
6) EQ(-Y) (seismic load in -Y direction)

J. Calculation Of Loads

1) Dead Load

Wall Load = Unit weight of brick x wall thickness x height
= 20 x 0.23 x 3
= 13.8 kN/m^3
Internal wall load = Unit weight of brick x wall thickness x height
= 20 x 0.115 x 3
= 6.9 kN/m^3

2) Live Load

Live Load is defined as the load on the structure due to moving weight.
Live load is assumed 2 kN/m^3 on floors and 1.5 kN/m^3 on roofs.

K. Load Combination Details For Earthquake

1) DL
2) LL
3) EQ(+X)
4) EQ(-X)
5) EQ(+Z)
6) EQ(-Z)
7) 1.5 (DL+LL)
8) 1.5 DL+EQ(+X)
9) 1.5 DL+EQ(-X)
10) 1.5 DL+EQ(+Z)
11) 1.5 DL+EQ(-Z)
12) 0.9DL+1.5EQ(+X)
13) 0.9DL+1.5EQ(-X)
14) 0.9DL+1.5EQ(+Z)
15) 0.9DL+1.5EQ(-Z)
16) 1.2DL+1.2LL+1.2EQ(+X)
17) 1.2DL+1.2LL+1.2EQ(-X)
18) 1.2DL+1.2LL+1.2(EQ+Z)
19) 1.2DL+1.2LL+1.2(EQ-Z)

L. Load Combination Details For Wind Loading

1) DL
2) LL
3) WL(+X) WINDWARD
4) EQ(-X) LEEWARD
5) EQ(+Z) WINDWARD
6) EQ(-Z) LEEWARD
7) 1.5 (DL+LL)
8) 1.5 DL+WL(+X)
9) 1.5 DL+WL(-X)
10) 1.5 DL+WL(+Z)
11) 1.5 DL+WL(-Z)
12) 0.9DL+1.5WL(+X)
13) 0.9DL+1.5WL(-X)
14) 0.9DL+1.5WL(+Z)
15) 0.9DL+1.5WL(-Z)
16) 1.2DL+1.2LL+1.2WL(+X)
17) 1.2DL+1.2LL+1.2WL(-X)
18) 1.2DL+1.2LL+1.2(WL+Z)
19) 1.2DL+1.2LL+1.2(WL-Z)

M. Dead Load And Live Load Acting On The Building

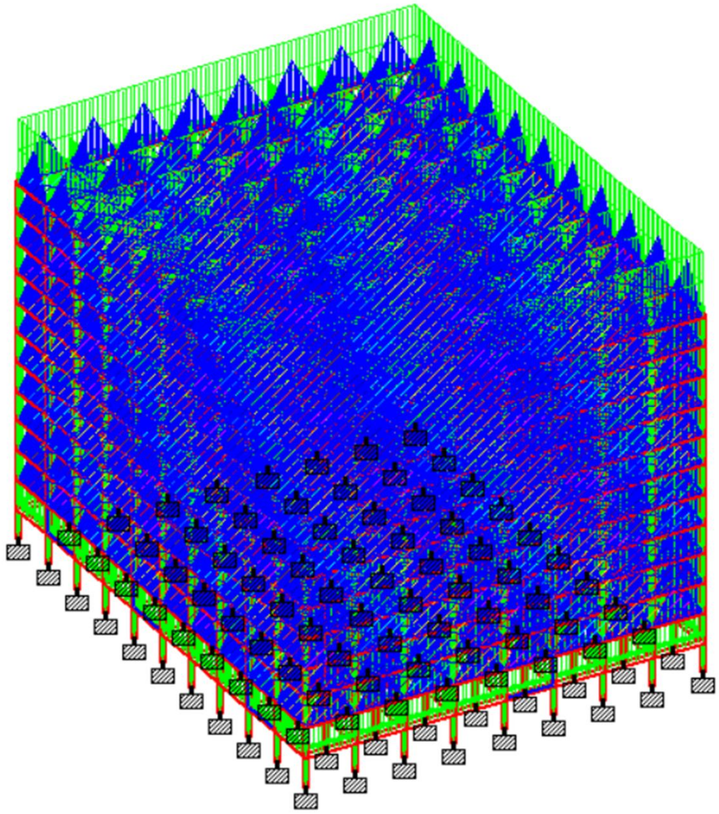

Fig.1 Dead load acting on the structure

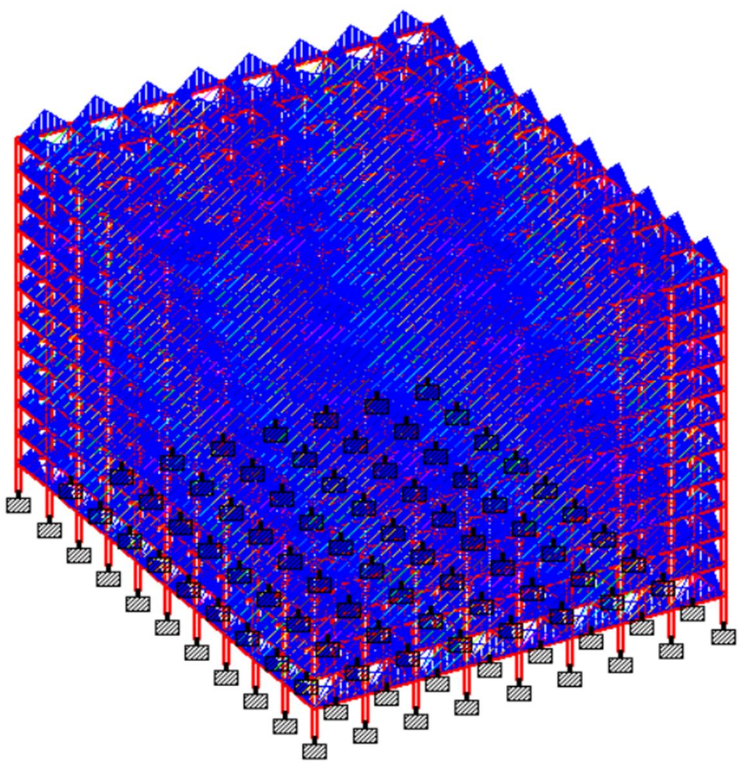

Fig.2 Live load acting on the structure

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N. Structural Plan of G+11 Building Model

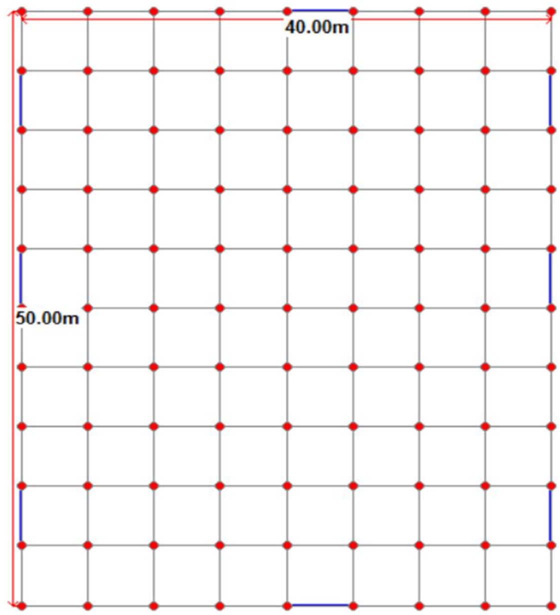

Fig.3 top view plan with plan dimension

O. RCC Detail of Building

RCC BUILDING DETAILS	
Model	G+11
Floor to Floor Height	3 m
Depth of Foundation	2.5 m
Total Building Height	36 m
Plan Size	50 m x 40 m
Plan Area	2000 m2
Soil Type	Medium
Slab thickness	115 mm
Inner Wall Thickness	115 mm
Outer wall Thickness	230 mm
Density of Brick	20 kN/m3
Grade of Concrete	M25
Grade of Steel	Fe 415
Density of Concrete	25 kN/m^3
Seismic Zone	Zone II,III,IV,V
Importance Factor	1.0
Zone Factor corresponding to seismic zone	0.10,0.16,0.24,0.36
Size of Beam - First Floor to fourth floor	0.5 x 0.3 m
Size of Beam - Fourth Floor to eighth floor	0.45 x 0.3 m
Size of Beam - Eighth floor to twelfth floor	0.3 x 0.3m
Size of Column -First Floor to fourth floor	0.6 x 0.6 m
Size of Column - Fourth Floor to eighth floor	0.6 x 0.45 m
Size of Column - Eighth floor to twelfth floor	0.6 x 0.3m
Size of thickness of shear wall	0.2 m

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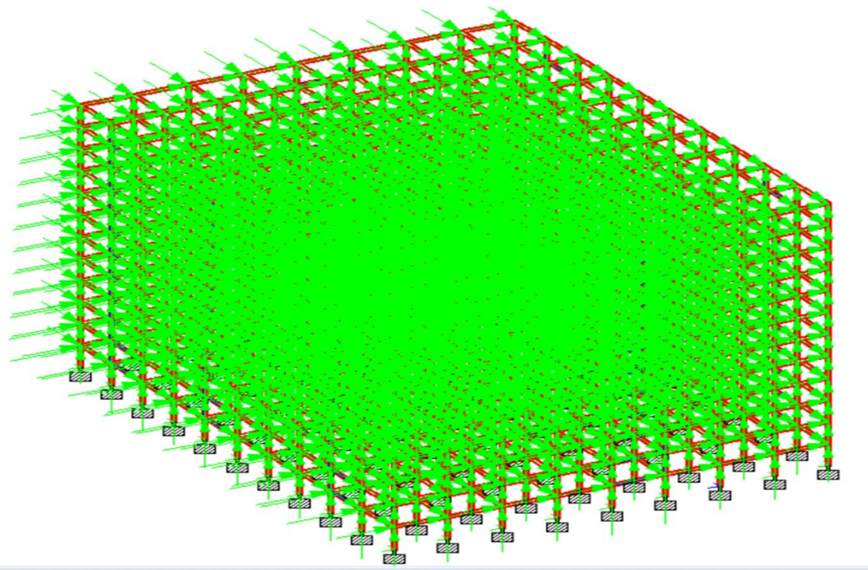

Fig.4 Support reaction acting on each node in Response spectrum methd

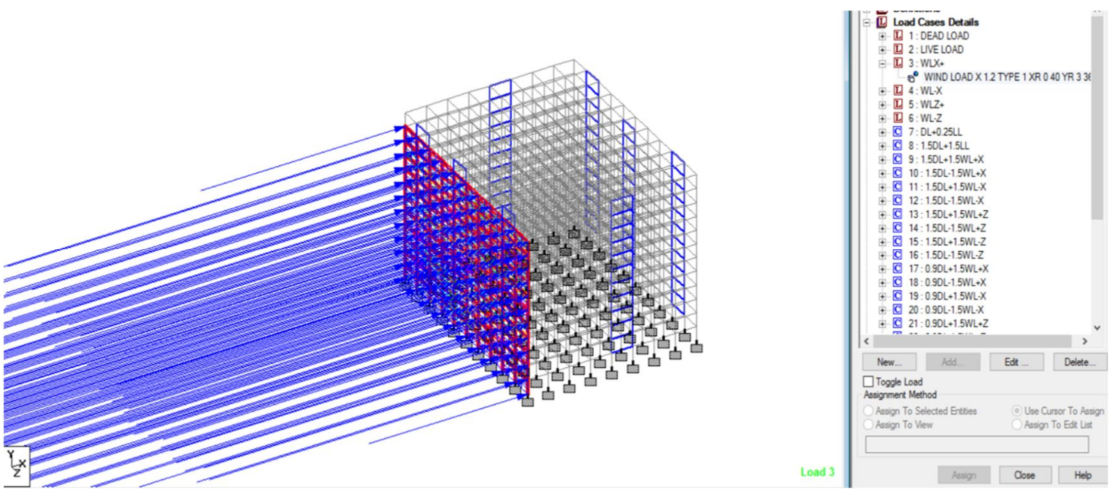

Fig.5 Wind in windward x direction

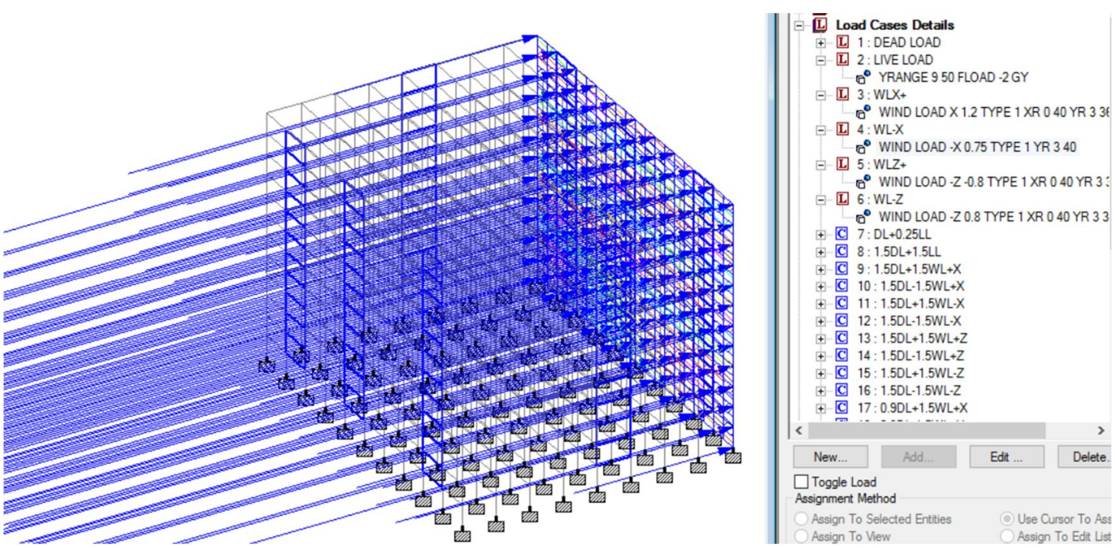

Fig.6 Wind in leeward x direction

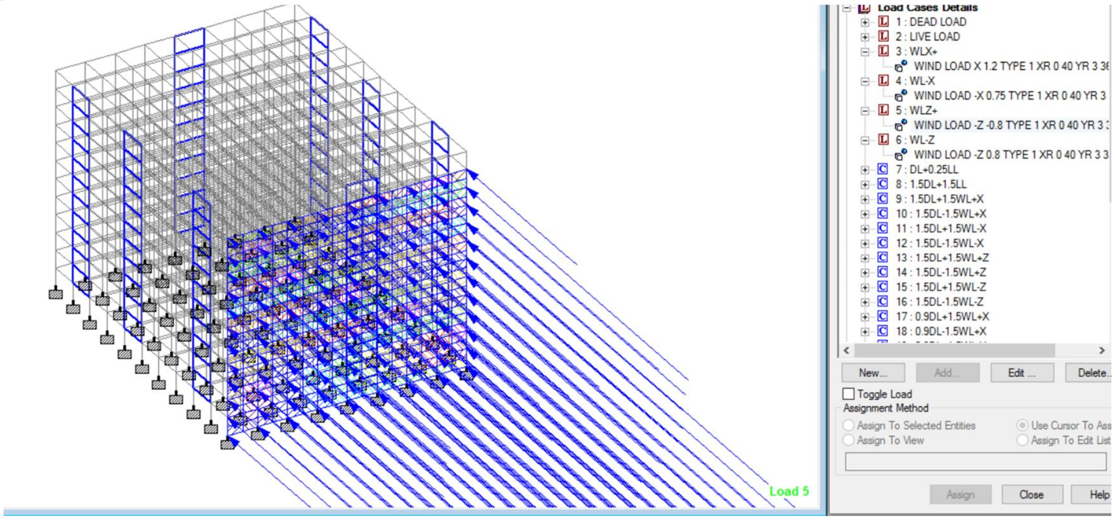

Fig.7 Wind in windward z direction

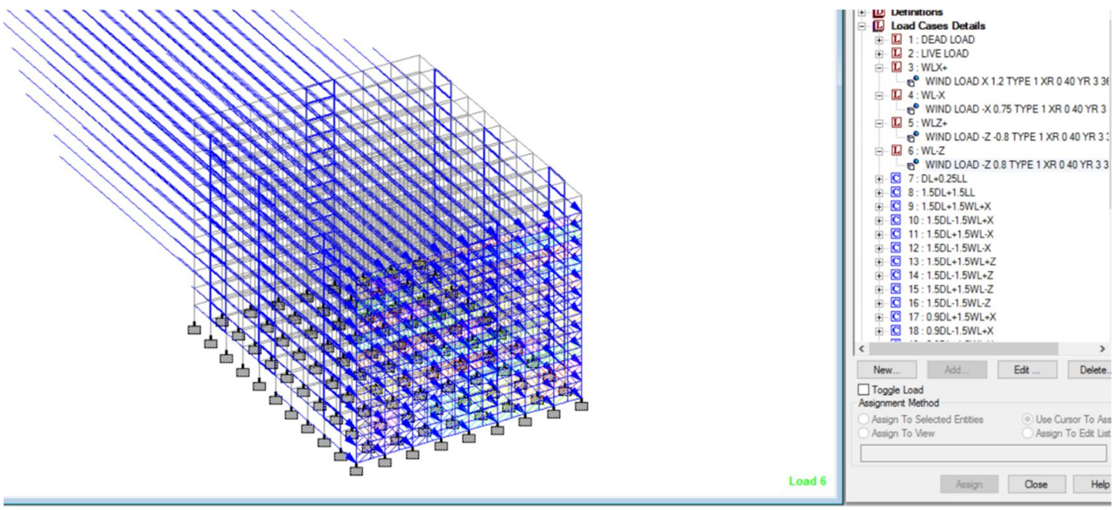

Fig.8 Wind in leeward z direction

Seismic Analysis is a subset of structural analysis and its calculation of the response of building structure to earthquake. It is a part of process of structural design. Various types structural analysis methods are :

1) Equivalent Static Analysis
2) Response Spectrum Analysis

Linear dynamic analysis shall be performed to obtain the design lateral force (design seismic base shear, and its distribution to different levels along height of building, and to various lateral loads resisting elements) for all buildings, other than regular buildings lower than 15 m in seismic zone II. Thus Response spectrum method is used for analysis. The response from each node is calculated by the STAAD PRO by response spectrum method.

The wind and earthquake are not considered simultaneously. There effects are analysed separately. Therefore, same model is considered for both wind and seismic analysis.

Analysis of building is done for Design wind speed with mathematical formula given on 6.3. The corresponding risk coefficient, terrain factor, topography factor, importance factor are used in the calculation of design wind speed. Basic Wind speed is given in IS code ANNEXE-A for a particular city or town. Wind load on individual members are calculated from 7.3.1. Internal pressure coefficient and external pressure coefficient are assumed according to dimension of the building. Wind analysis is done in STAAD PRO software.

Parameters of maximum shear force, axial forces, moments; for beams and columns are calculated from the wind analysis .The values for this analysis are compared with maximum values in different seismic zones.

IV. RESULTS AND COMPARISON GRAPHS

A. *Base Shear*

Base Shear is estimate of maximum expected lateral force that will occur due to seismic ground motion at the base of structure. Base shear depends on soil condition & sources of seismic activity due to geological faults. As the base shear is the horizontal reaction to the earthquake forces and horizontal forces results from storey weight. Storey weight includes self weight of the structure and hence in R.C.C structure, the self weight is more and hence maximizing the earthquake forces results in maximum base shear. As we have the static formula, base shear is directly proportional to seismic weight of building.

Comparison of Base Shear for different seismic zones

MODEL	SEISMIC ZONE II	SEISMIC ZONEIII	SEISMIC ZONEIV	SEISMIC ZONEV
BASE SHEAR (in KN)	3393.65 KN	5435.37 KN	8166.85 KN	12250.27KN

Percentage Reduction in Base Shear

MODEL	Seismic zone III	Seismic zone IV	Seismic zone V
BASE SHEAR (in KN)	5435.37 KN	8166.85 KN	12250.27KN
% REDUCTION IN COMPARISION WITH SEISMIC ZONE II	60.16%	140.65%	260.97%

1) From the result, the value of base shear is maximum in seismic zone IV, V.
2) The base shear in seismic zone II is the least. The base shear for seismic zone III is 60% more than seismic zoneII.
3) The base shear of seismic zone IV is 140% more than base shear of seismic zone II.
4) The base shear of seismic zone V is 260% more than base shear of seismic zone II.

B. *Axial Force (F_X)*

Axial force is the force with its resultant passing through the centroid of the particular section and is perpendicular to the plane of section. Axial force is the compression or tension acting on the member. If axial force is acts through the centriod of the member then it is called concentric loading and if it is acting through the centriod of member then it is called eccentric loading. Axial force in columns is in compression because column is a vertical member and is subjected to tensile forces when lateral forces are acting on them.

Maximum value for axial force is found out in the whole structure in wind analysis and then the member corresponding is compared with maximum value for axial force in seismic zone II, III, IV in accordance to same member.

BEAM NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE II	PERCENTAGE VARIATION
1105	AXIAL FORCE	425.68	656.28	54.17%

BEAM NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE III	PERCENTAGE VARIATION
1105	AXIAL FORCE	425.68	656.28	54.17%

BEAM NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE IV	PERCENTAGE VARIATION
1105	AXIAL FORCE	425.68	656.28	54.17%

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BEAM NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE V	PERCENTAGE VARIATION
1105	AXIAL FORCE	425.68	656.276	54.17%

COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE II	PERCENTAGE VARIATION
13066	AXIAL FORCE	5115.39	7678.07	50.09%

COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE III	PERCENTAGE VARIATION
13066	AXIAL FORCE	5115.39	7678.07	50.09%
COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE IV	PERCENTAGE VARIATION
13066	AXIAL FORCE	5115.39	8181.96	59.94%

COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE V	PERCENTAGE VARIATION
13066	AXIAL FORCE	5115.39	10015.42	95.78%

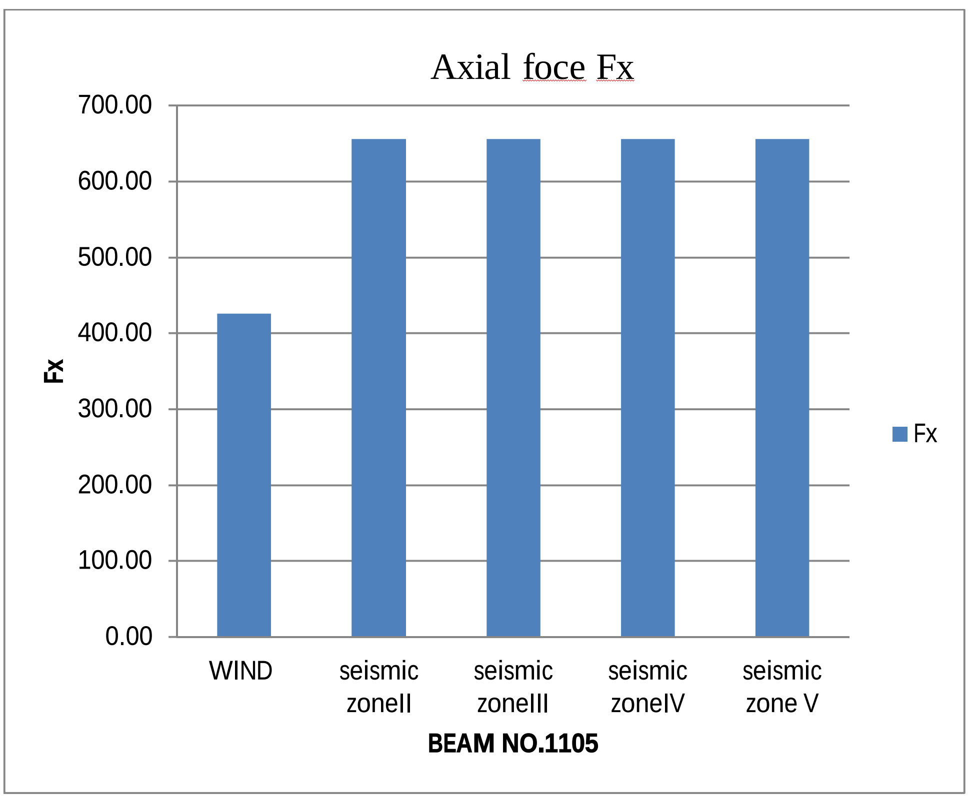
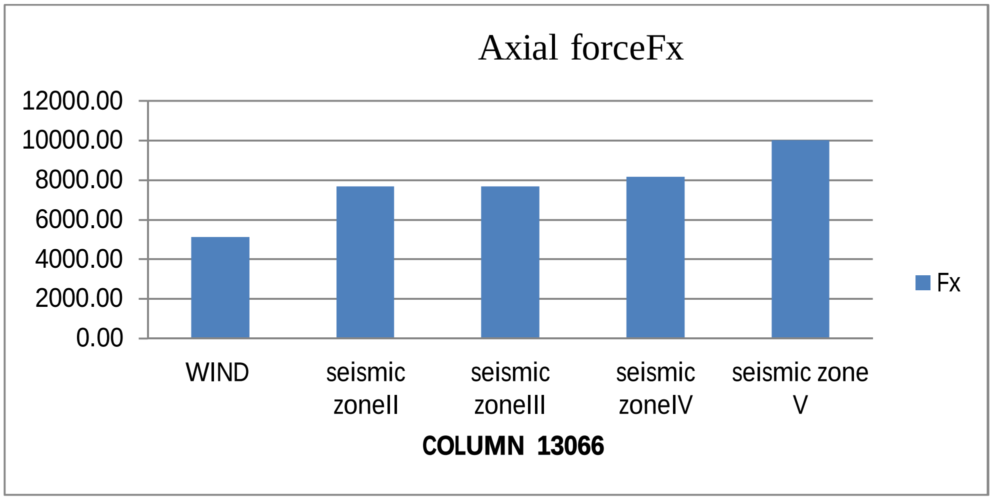


Fig.9 Comparison of axial forces for beam no.1105



Fig, 10 Comparison of axial forces for column no.13066

1) The percentage variation in Axial force and shear force for beams in local Y direction in wind an all seismic zone is 54.17% and 46.02% respectively.
2) There is percentage increase in axial force for column for seismic zone IV when compared to seismic zone II, III, IV to wind loading.

C. *Shear Force*

Shear force at a section in a beam is the force that is obtained as the algebraic sum of all the forces including the reactions acting normal to the axis of the beam either to the left or to the right of the section. Shear force is the force in the beam acting perpendicular to its longitudinal (X) axis. Shear force is more important in beam to resist axial forces.

1) *Fy:* It is the shear force in building's local Y direction.
2) *Fz:* It is the shear force in building's local Z direction.
3) *Fy:* It is the shear force in building's local Y direction.

BEAM NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE II	PERCENTAGE VARIATION
8162	Shear Force +Y	111.01	162.10	46.02%
8022	Shear Force +Z	3.17	7.86	147.94%

BEAM NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE III	PERCENTAGE VARIATION
8162	Shear Force +Y	111.01	162.10	46.02%
8022	Shear Force +Z	3.17	12.57	296.52%

BEAM NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE IV	PERCENTAGE VARIATION
8162	Shear Force +Y	111.01	162.10	46.02%
8022	Shear Force +Z	3.17	18.79	492.74%

COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE II	PERCENTAGE VARIATION
13066	Shear Force +Y	82.43	134.26	62.87%
13010	Shear Force +Z	61.91	143.34	131.52%

COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE III	PERCENTAGE VARIATION
13066	Shear Force +Y	82.43	194.56	136.03%
13010	Shear Force +Z	61.91	202.03	226.32%

COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE IV	PERCENTAGE VARIATION
13066	Shear Force+Y	82.43	274.97	233.58%
13010	Shear Force+Z	61.91	280.29	352.73%

COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE V	PERCENTAGE VARIATION
13066	Shear Force+Y	82.43	395.575	379.89%
13010	Shear Force+Z	61.91	397.67	542.33%

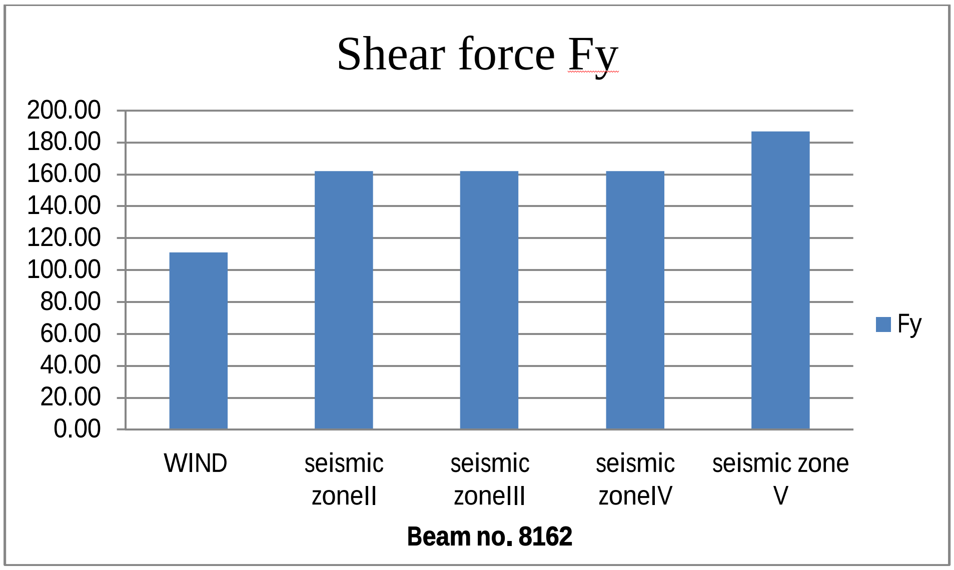


Fig. 11 Comparison of shear forces for beam no.8162

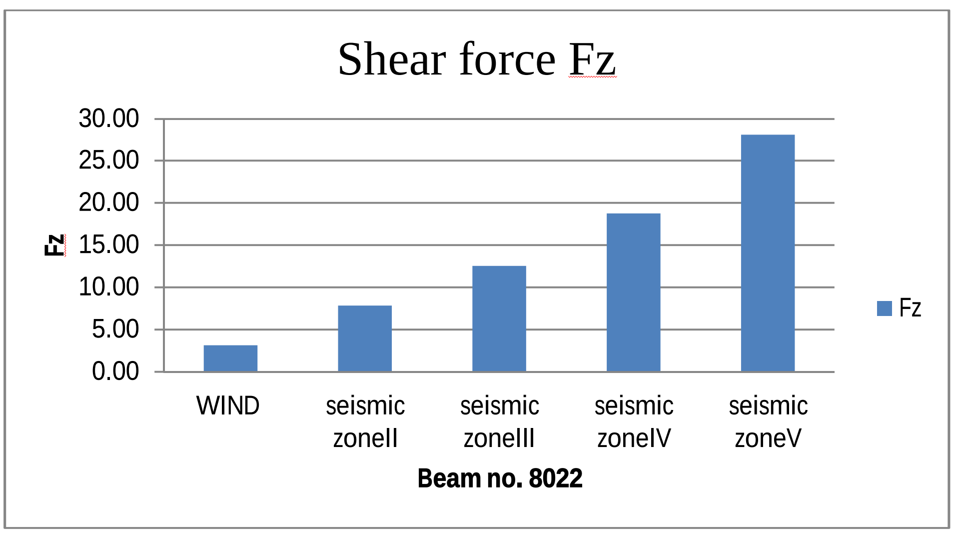


Fig. 12 Comparison of shear forces for beam no.8022

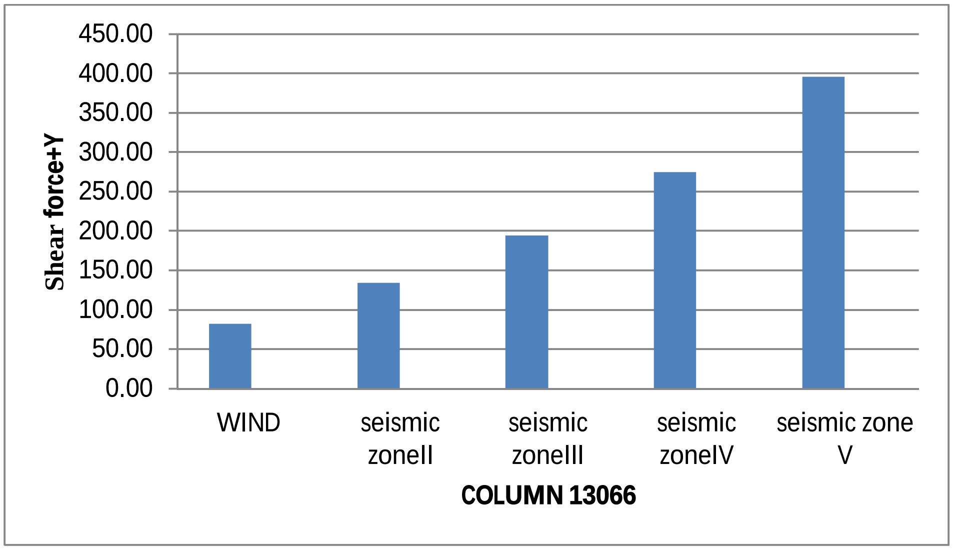


Fig.13 Comparison of axial forces for column no.13066

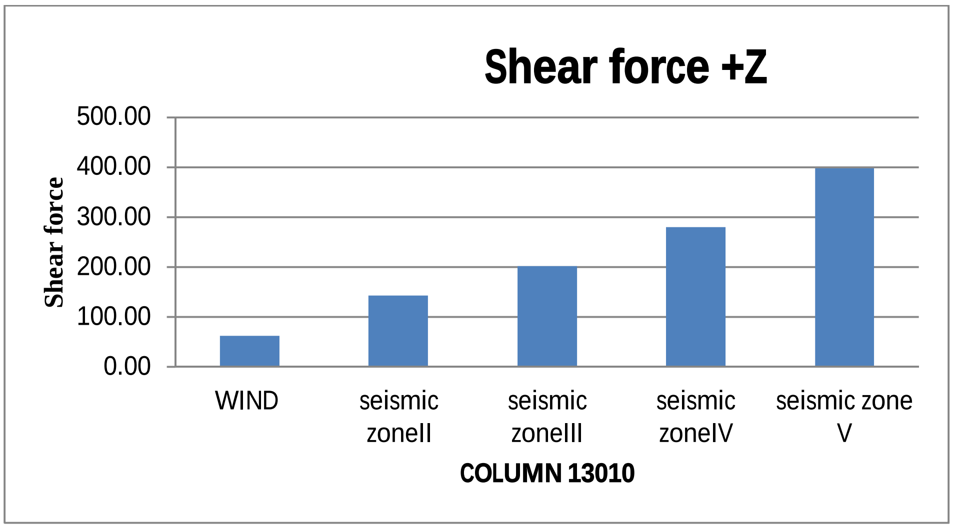


Fig. 14 Comparison of shear forces for column no.13010

a) When comparing wind effect with seismic zone II effects for beams Shear force is less than 147.94%.
b) When comparing wind effect with seismic zone III effects for beams Shear force is less than 296.52%.
c) When comparing wind effect with seismic zone IV effects for beams Shear force is less than 492.74%.
d) When comparing wind effect with seismic zone II effects for columns Shear force in local Y and local Z direction is less than 62.87% and 131.52%.
e) When comparing wind effect with seismic zone III effects for columns Shear force in local Y and local Z direction is less than 136.03% and 226.32 %.
f) When comparing wind effect with seismic zone IV effects for columns Shear force in local Y and local Z direction is less than 233.58% and 352.73 %.

This proves that there is an increase in shear force in columns and beams when seismic zone is changed from seismic zone II, III, IV simultaneously.

D. Bending Moment

Bending moment at a section in a beam is the moment that tries to bend it and is obtained as the algebraic sum of all the moments about a section of all the forces including the reactions acting on the beam either to the left or to the right of the section. A bending moment is the measure of bending effect that can occur when external forces is applied to an structural element.

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1) *My:* It is the bending moment in building's local Y direction.
2) *Mz:* It is the bending moment in building's local Z direction.
3) *My:* It is the bending moment in building's local Y direction.

BEAM NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE II	PERCENTAGE VARIATION
8031	Moment +y	8.19	20.86	154.70%
8013	Moment +Z	133.72	194.24	45.25

BEAM NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE III	PERCENTAGE VARIATION
8031	Moment +y	8.19	33.18	305.12%
8013	Moment +Z	133.72	195.39	46.11%

BEAM NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE IV	PERCENTAGE VARIATION
8031	Moment +y	8.19	49.60	505.61%
8013	Moment +Z	133.72	242.65	81.46%

COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE II	PERCENTAGE VARIATION
13066	Moment +y	98.20	252.47	157.09%
13010	Moment +Z	141.24	243.05	72.08%

COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE III	PERCENTAGE VARIATION
13066	Moment +y	98.20	363.40	270.06%
13010	Moment +Z	141.24	360.15	154.99%

COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE IV	PERCENTAGE VARIATION
13066	Moment +y	98.20	511.31	420.68%
13010	Moment +Z	141.24	516.28	265.53%

COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE V	PERCENTAGE VARIATION
13066	Moment +y	98.20	733.172	646.61%
13010	Moment +Z	141.24	750.468	431.34%

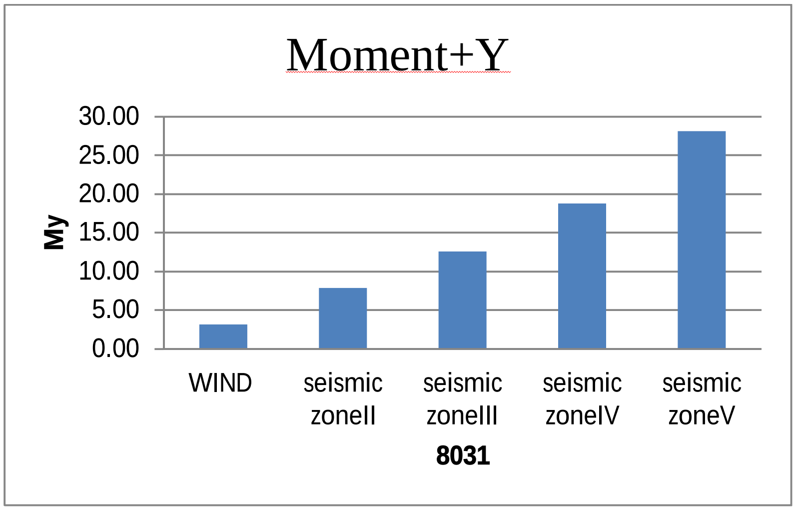

Fig. 15 Comparison of bending moment for beam no.8031

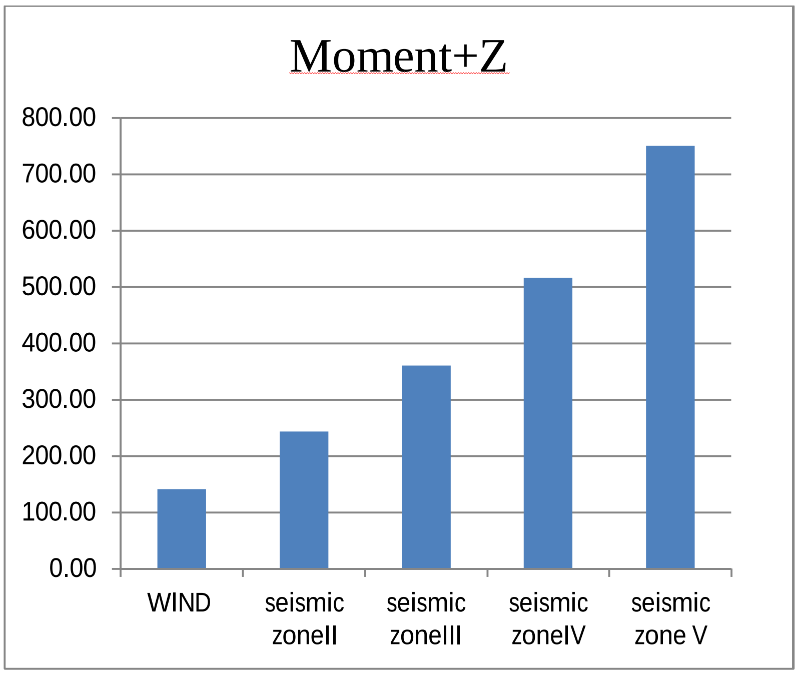

Fig. 16 Comparison of axial forces for beam no.8013

a) When comparing wind effect with seismic zone II effects for beams Moment in local Y direction and local Z direction is less than 154.70%, 45.25% respectively.
b) When comparing wind effect with seismic zone III effects for beams Moment in local Y direction and local Z direction is less than 305.12%, 46.11% respectively.
c) When comparing wind effect with seismic zone IV effects for beams Moment in local Y direction and local Z direction is less than 505.61%, 81.46% respectively.
d) When comparing wind effect with seismic zone II effects for columns Moment in local Y direction and local Z direction is less than 157.09%, 72.08% respectively.
e) When comparing wind effect with seismic zone III effects for columns Moment in local Y direction and local Z direction is less than 270.06%, 155% respectively.
f) When comparing wind effect with seismic zone IV effects for columns Moment in local Y direction and local Z direction is less than 420.68%, 265.53 % respectively.
g) Thus with increase in seismic zone there is increase in seismic zone II and seismic zone IV in terms of moment.

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E. Torsion

Torsion is the twisting moment in created when there is a turning force in member due to wind or seismic loading. Basically it's a turning force making it deflect at an angle. A moment that a cause twisting is called a twisting or torsion moment. Torsion produces shear stresses inside the element.

Percentage Variation Of Torsion In Beams And Columns

BEAM NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE II	PERCENTAGE VARIATION
2115	Torsion	1.39	1.97	41.72%

BEAM NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE III	PERCENTAGE VARIATION
2115	Torsion	1.39	1.97	41.72%
BEAM NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE IV	PERCENTAGE VARIATION
2115	Torsion	1.39	1.97	41.72%

COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE II	PERCENTAGE VARIATION
15098	Torsion	2.78	5.18	86.33%

COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE III	PERCENTAGE VARIATION
15098	Torsion	2.78	8.29	198.20%

COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE IV	PERCENTAGE VARIATION
15098	Torsion(KNm)	2.78	12.43	347.12%

COLUMN NO.	PARAMETERS	WIND EFFECT	SEISMIC ZONE V	PERCENTAGE VARIATION
15098	Torsion(KNm)	2.78	18.637	570.39%

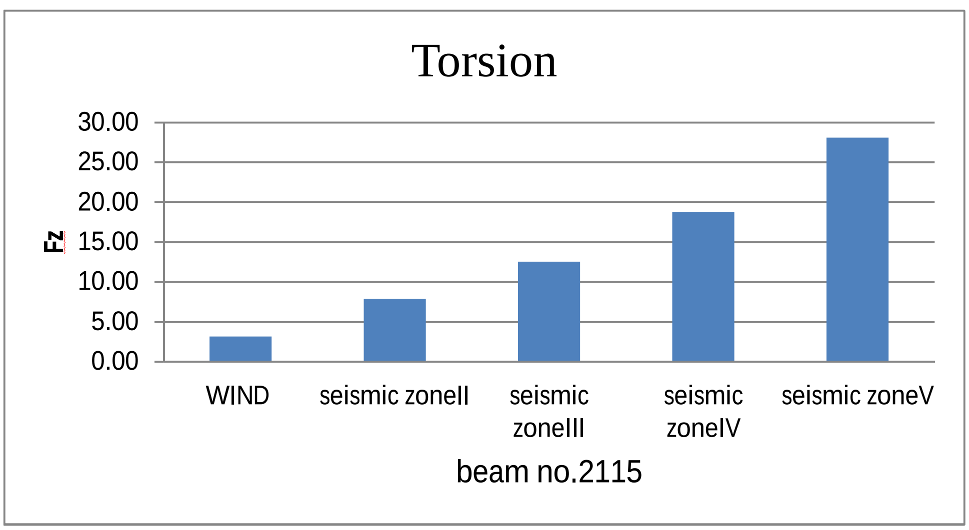

Fig. 19 Comparison of axial forces for beam no.2115

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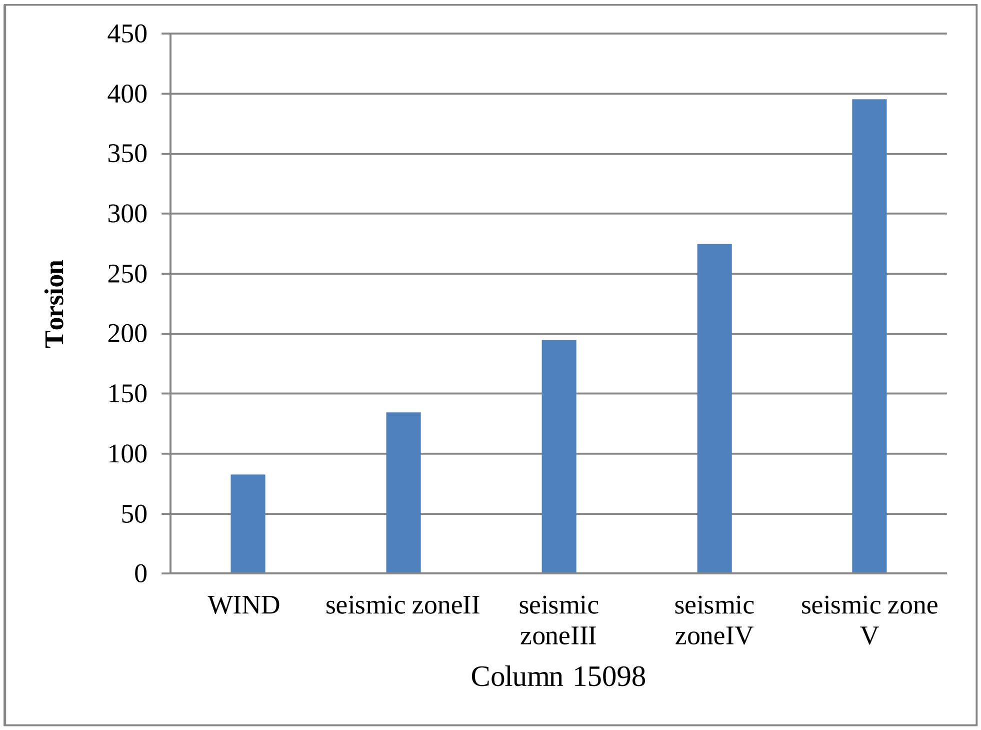

Fig. 20 Comparison of axial forces for beam no.15098

1) When comparing wind effect with seismic zone II effects for beams, Torsion is less than 41.72%.
2) When comparing wind effect with seismic zone III effects for beams, Torsion is less than 108.63%.
3) When comparing wind effect with seismic zone IV effects for beams, Torsion is less than 198.56%.
4) Thus when torsion values increases about 150% when compared wind effect to seismic zone II to seismic zone IV.
5) There is increase of 570% in torsion when comparison of wind loading effect is done with respect to seismic zone V.

V. CONCLUSION

A. Comparison of wind loading effect on building structure is done with seismic effect on building effect on building in seismic zone II, III, IV simultaneously.

B. It shows that when the seismic zone is increased there is change in shear force, moment, torsion, and axial force.

C. Axial force is in same proportion as in seismic zone III, IV for beams.

D. Moment increases about 1.8 times in local Z direction when compared wind to seismic zone III and seismic zone IV for beams.

E. When torsion is assumed as parameter then there is an increase of 1.5 times in torsion in beams when comparison is done with wind to seismic zone III and seismic zone IV.

F. When moment parameter is compared there is increase of 3.5 times in local Y direction when a comparison is done of wind loading to seismic zone III, seismic zone IV simultaneously.

G. Since effects of wind loading on elements is less than seismic loading effects in zone II. There is a factor that building would be safer in seismic zone two without any seismic dampers, or without any special earthquake resistant system.

H. When seismic zone are considered there is factor that building would collapse if structural strength is not provided to the building with help of elements like seismic dampers, bracings, etc.

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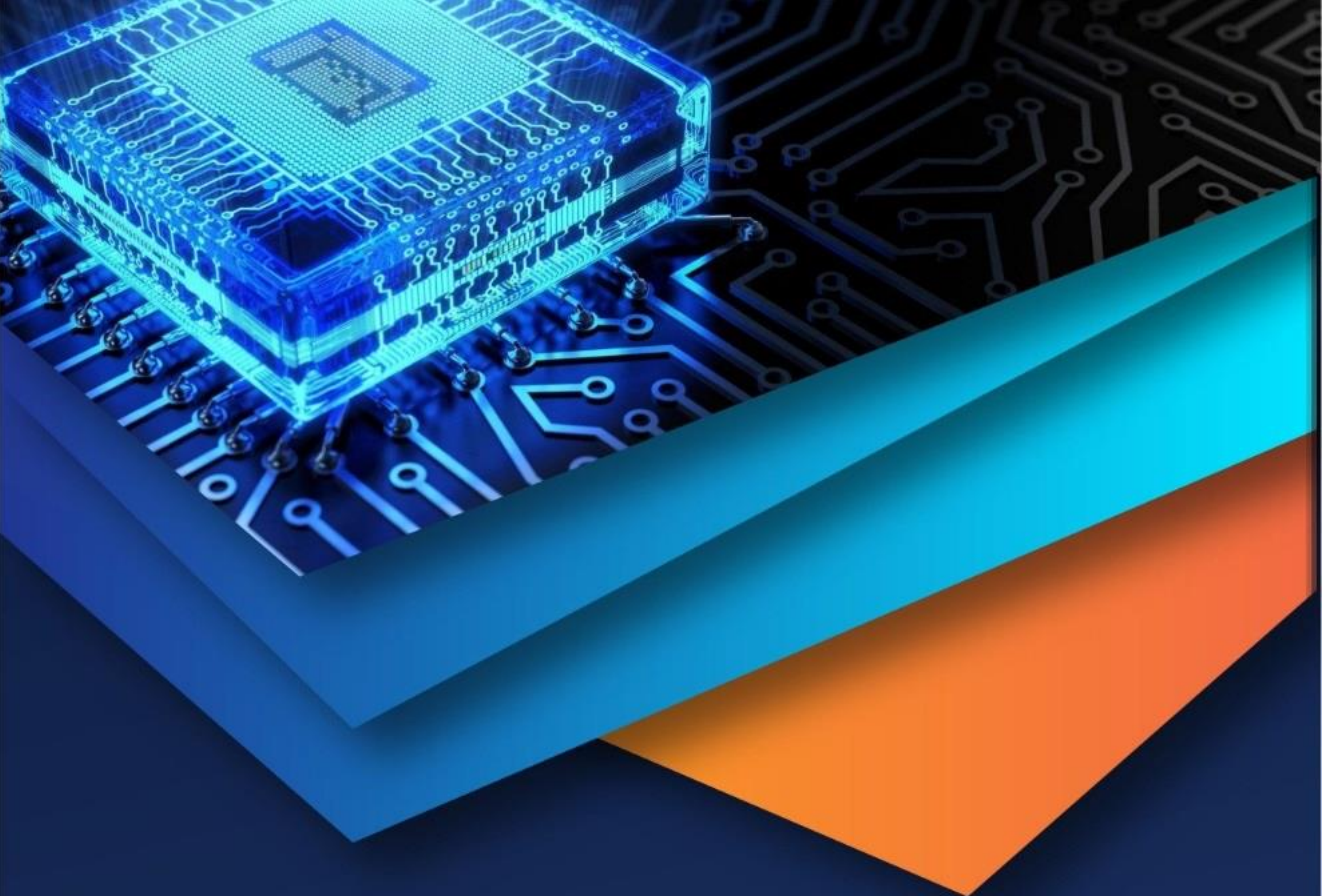

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