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Analysis and Design of Tall Building Subjected to Wind and Earthquake Loads by using STAAD.PRO

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ABSTRACT

Designing a structure in such a way that reducing damage during an earthquake makes the structure quite uneconomical, as the earthquake might or might not occur in its life time and is a rare phenomenon. In this project a multi existing RCC framed structure & Wind plays a critical position in design of tall structures because of its dynamic nature. The effect of wind is predominant on tall structures depending on location of the structure, height of the structure. In this project equivalent static method is used for evaluation of wind loads on buildings in different wind categories has been analysed and designed using STAAD.Pro V8i. The building is designed as per IS 1893(Part 1):2002 for earthquake forces in different seismic zones. The main objectives of the project are to compare the variation of steel percentage, maximum shear force, maximum bending moment, and maximum deflection in different wind categories and seismic zone.

1. INTRODUCTION

A building can be defined as a structure board by consisting of walls, floors and roofs, erected to provide covered for different uses such as for residence, education, business, manufacturing, storage, hospitalization, entertainment, worship, etc.Nowadays, Construction of high-rise building is a basic need because of scarcity of land. Conventional method of manual design of high-rise building is time consuming as well as possibility of human errors. So, it is necessary to use some computer-based software which gives more accurate results and reduce the time. STAAD PRO is the structural software is nowadays accepted by structural engineers which can solve typical problem like static analysis, wind analysis, seismic analysis using various load combination to confirms various codes such as IS 456:2000, 1893:2002, IS 875:1987 etc.

Urban and High Raised Construction

Urbanization is the physical growth of urban areas because of global change. Urbanization is also defined by united nations as movement of people from rural to urban areas with population growth equating to urban migration.

Urbanization is closely linked to modernization industrial-ization and sociological process of rationalization.

Low rise buildings are the forerunners of the Indian residential property sector and continue to represent its bulk. However, the concept is also highly location specific and as lot to do with available FSI in any given location. In the centralized location of metropolitan cities such as Delhi, Bangalore, Mumbai, Hyderabad. A builder first instinct is to consume all available FSI by building a high-rise project, and this make sense, when one considers that available space is used more efficiently.

Basically, high raised buildings provide developers with a means of savings on land cost. They open up wider arenas to operate on. This means project will be cheaper on a unit-to-unit basis, and also more plentiful in profitable areas.

Growth of High-Rise Buildings in Hyderabad

In Recent Times Construction of high-rise buildings in Hyderabad has been a recent phenomenon. Khan Lateef Khan estates, Basheer Bagh, and roof of Hyderabad, Banjara Hills were the earliest high rises in Hyderabad. There were only about 10 high rises in Hyderabad during the 1990 but they have increased tremendously in the recent post. High-rise buildings are not allowed in the city core and other congested areas as per the Hyderabad multi-storied building regulations, 1981. With the trends of development gravitating on the outskirts, government brought out the common building plans in 2006.

In the new rules floor area ratio and plot coverage parameters are not specified, and other parameters like height, abutting road widths, plot size and all-round setbacks determine the built form and bulk. This gives immense scope and freedom in design especially in the design of high-rise buildings. All these parameters have increased the construction of high rises in Hyderabad many folds.

2. LITERATURE SURVEY

M. R. Patel (2017): The effect of wind velocity and structural response of building frame on sloping ground has been studied. Considering various frame geometries. Combination of static and wind loads are considered. For combination, 10cases in different wind zones are analyzed. STAAD-Pro v8i software has been used for analysis purpose. Results are collected in terms of axial force, Shear force, moment, Storey-wise drift and Displacement which are critically analyzed to quantify the effects of various heights of structure.

Inchara, K.P., Ashwini, G., (2016):The main objectives of this study were to study the performance and variation in steel percentage and quantities concrete in R.C framed irregular building in gravity load and different seismic zones. And to know the comparison of steel reinforcement percentage and quantities of concrete when the building is designed as per IS 456:2000 for gravity loads and when the building is designed as per IS 1893(Part 1):2002 for earthquake forces in different seismic zones. In this study five (G+4) models were considered. All the four models were modelled and analysed for gravity loads and earthquake forces in different seismic zones. ETABS software was used for the analysis of the models. According to their research, it can be inferred that support reactions tended to increase as the zone varied from II to V, which in turn increased volume of concrete and weight of steel reinforcement in footings and in case of beams, percentage of steel reinforcement increased through zones II to V.

Perla Karunakar (2014): The author put his efforts to find out the performance and variation in steel percentage and concrete quantities in various seismic zones and impact on overall cost of construction. According to his research, the concrete quantities are increased in exterior and edge columns due to increase in support reactions however; variation is very small in interior column footings. Reinforcement variation for whole structure between gravity and seismic loads are 12.96, 18.35, 41.39, 89.05%.the cost variation for ductile vs. non-ductile detailing are 4.06%.

Papa Rao and Kiran Kumar (2013): The author's researches on the changes in the percentage of steel and volume of concrete for the RCC framed structure for various seismic zones of India. They have designed the structure for gravity load and seismic forces, which might be effect on building. According to their research, they concluded that the variation in support reactions for exterior columns increased from 11.59% to 41.71% and in case of edge columns, it is 17.72% to 63.7% from Zone II to Zone V and as in the case of interior columns, it is very less.

3. MODELLING AND ANALYSIS

Modelling of the structure in STAAD PRO

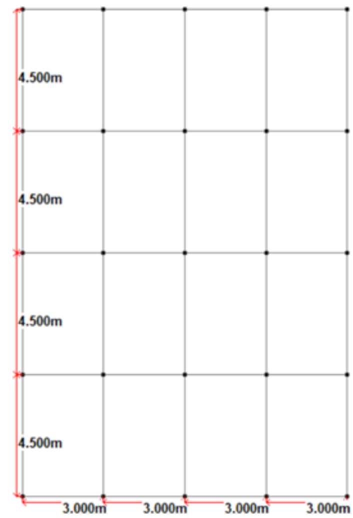

Figure 1. Typical floor plan model of structure considered.

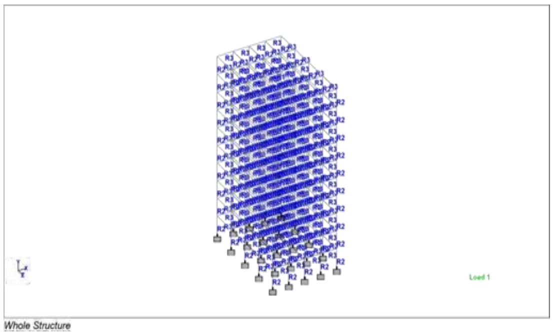

Figure 2. Whole Structure view

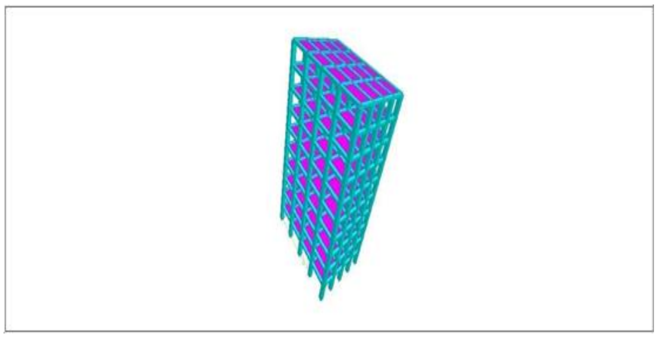

Figure 3. 3D Rendering view

4. RESULTS AND DISCUSSION

4.1. Wind Analysis

Wind load is primarily horizontal load caused by the movement of air relative to earth. Wind load is required to be considered in structural design especially when the height of the building exceeds two times the dimensions transverse to the exposed wind surface. For low rise building say up to four to five stories, the wind load is not critical because the moment of resistance provided by the continuity of floor system to column connection and walls provided between columns are sufficient to accommodate the effect of these forces.

The horizontal forces exerted by the components of winds is to be kept in mind while designing is the building. The calculation of wind loads depends on the two factors, namely velocity of wind and size of the building. Complete details of calculating wind load on structures are given below (by the IS-875 (Part 3) -2015).

Wind velocity:

Using colour code, basic wind pressure 'Vb' is shown in a map of India. Designer can pick up the value of Vb depending upon

the locality of the building.

To get the design wind velocity Vz the following expression shall be used:

Vz = K1 K2 K3 K4Vb

Where,

K1= Probability factor(Risk coefficient)

K2=Terrain roughness and height factor (Coefficient based on terrain, height and structure size.) K3 = Topography factor

K4=Importance factor

The design wind pressure is given by,

Pz = 0.6(Vz)2

where Pz is in N/m2 at height Z and Vz is in m/sec. Up to a height of 30 m, the wind pressure is considered to act uniformly. Above 30 m height, the wind pressure increases.

Wind loads are considered in accordance with IS-875 (Part3)-2015. Basic wind Speed of 44m/s is considered for the analysis as stipulated in the IS code for wind loads.

The structure analysis of frame model that includes different wind categories has been done by using software STAAD.Pro and the results are shown below. The parameters which are to be studied are maximum bending moment, maximum shear force, maximum beam and node displacement and maximum support reactions.

MAXIMUM SHEAR FORCE (kN):

Wind category	Fy (kN)
Category -I	1.160
Category -II	1.812
Category -III	2.610
Category-IV	3.552.

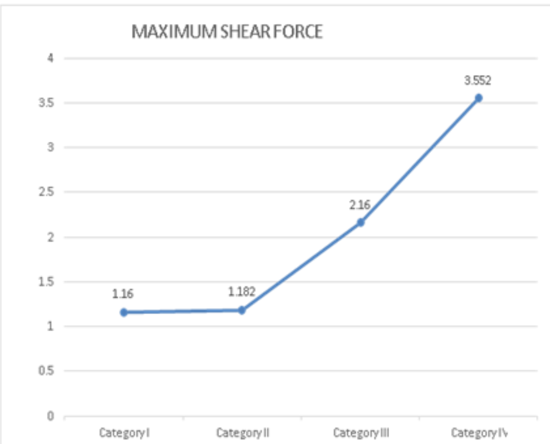

Figure 4. Maximum Shear Force in Beams

MAXIMUM BENDING MOMENT (kNm):

Wind category	Mz (kNm)
Category -I	0.019
Category -II	0.028
Category -III	0.042
Category-IV	0.057

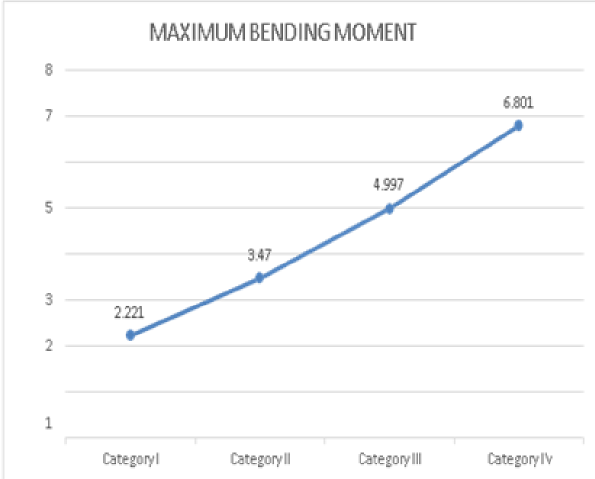

Figure 5. Maximum Bending Moment in Beams

MAXIMUM BEAM DISPLACEMENT (mm):

Wind category	Displacement(mm)
Category –I	2.221
Category -II	3.470
Category –III	4.997
Category-IV	6.801

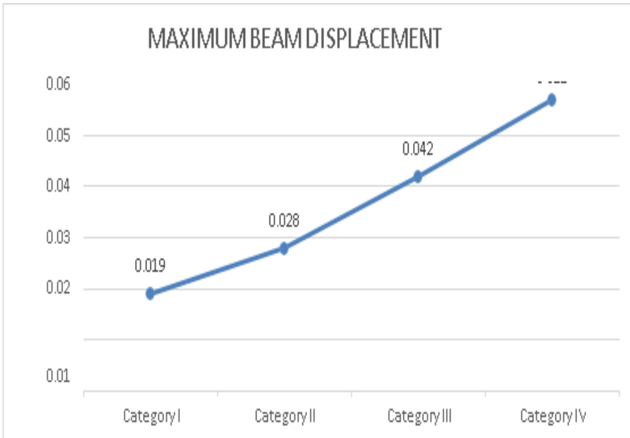

Figure 6. Maximum Displacement in Beam

MAXIMUM SUPPORT REACTION (kN):

Wind category	Fy (kN)
Category -I	0.086
Category -II	0.134
Category -III	0.193
Category-IV	0.263

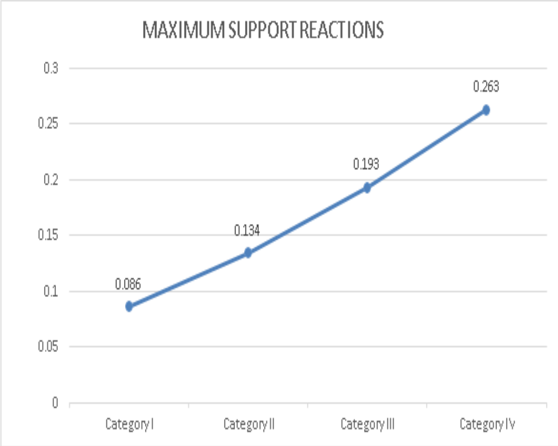

Figure 7. Maximum Support Reactions

Seismic Zone	Weight(N)
Zone -II	391821
Zone -III	392599
Zone -IV	418873
Zone -V	464364

4.2. Seismic Analysis

Seismic analysis is a subset of structural analysis and is the evaluation of the response of a structure to earthquakes. It is part of the process of structural analysis.

Methods of analysis are:

- Equivalent static analysis
- Response spectrum analysis
- Nonlinear static analysis (pushover analysis)
- Nonlinear dynamic analysis (time history analysis)

EQUIVALENT STATIC ANALYSIS

This approach defines a series of forces acting on a building to represent the effect of earthquake ground motion, typically defined by a seismic design response spectrum. It assumes that the building responds in its fundamental mode. For this to be true, the building must be low- rise and must not twist significantly when the ground moves. The response is read from a design response spectrum, given the natural frequency of the building (either calculated or defined by the building code). The applicability of this method is extended in many building codes by applying factors to account for higher buildings with some higher modes, and for low levels of twisting. To account for effects due to "yielding" of the structure, many codes apply modification factors that reduce the design forces (e.g., force reduction factors).

Methodology:

As per IS 1893 (PART-1): 2002
Zone factor value for different zones are considered as, Zone II - 0.1
Zone III - 0.16 Zone IV - 0.24 Zone V - 0.36
Response reduction factor for SMRF type building RF = 5.0
Importance factor for all other buildings I = 1.0
Damping ratio for the RCC structure DM = 5%= 0.05

Period of vibration

$$T_a = \frac{0.09\,h}{\sqrt{d}}$$

The structure analysis of frame model that includes different seismic zones has been done by using software STAAD.Pro and the results are shown below. The parameters which are to be studied are maximum bending moment, maximum shear force, maximum beam and node displacement, maximum support reaction and steel percentage.

STEEL WEIGHT (N)

MAXIMUM SHEAR FORCE (kN):

Seismic Zone	Fy (kN)
Zone –II	21.375
Zone –III	33.879
Zone –IV	51.699
Zone –V	70.472

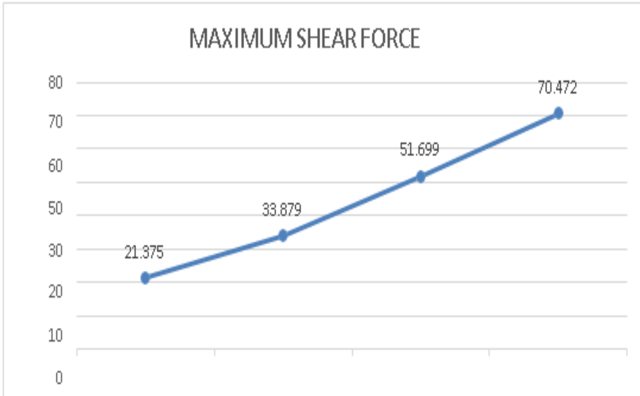

Figure 8. Maximum Shear Force in beams

MAXIMUM BENDING MOMENT (kNm):

Seismic Zone	Mz (kNm)
Zone –II	52.838
Zone -III	84.541
Zone -IV	126.812
Zone –V	190.218

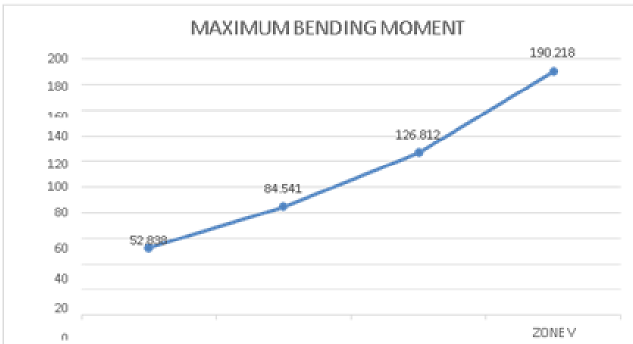

Figure 9. Maximum Bending Moment in beams

MAXIMUM BEAM DISPLACEMENT (mm):

Seismic Zone	Displacement (mm)
Zone –II	7.791
Zone -III	12.466
Zone -IV	18.698
Zone –V	28.047

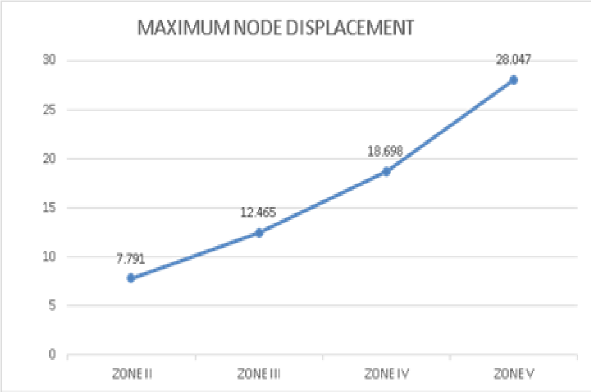

Figure10. Maximum Displacement in beams

MAXIMUM NODE DISPLACEMENT (mm):

Seismic Zone	Displacement(mm)
Zone –II	7.791
Zone -III	12.465
Zone -IV	18.698
Zone –V	28.047

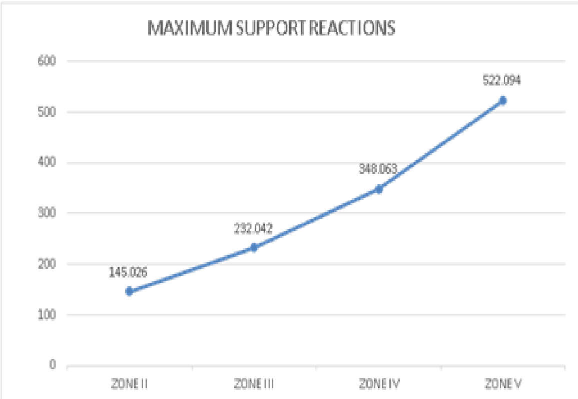

Figure 11. Maximum Node Displacement

MAXIMUM SUPPORT REACTION (kN):

Seismic Zone	Fy (kN)
Zone –II	145.026
Zone -III	232.042
Zone -IV	348.063
Zone –V	522.094

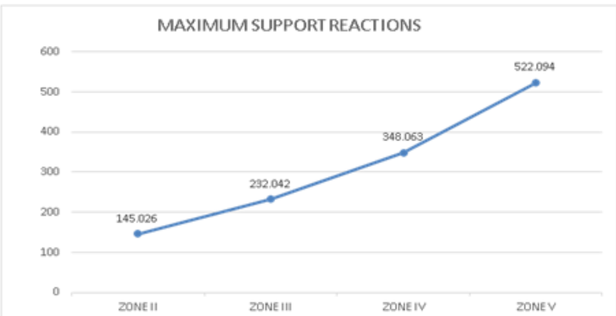

Figure 12. Maximum Support Reactions

BASE SHEAR VALUES IN DIFFERENT SEISMIC ZONES:

SEISMIC ZONE	BASE SHEAR(kN)
ZONE II	439.14
ZONE III	702.63
ZONE IV	1053.94
ZONE V	1580.92

5. CONCLUSION

Wind analysis was accomplished out on the g+9 story rcc structural building with different wind categories and with the help of analysis it can be concluded that,

- When wind load is applied along length of the building the displacement value was increased from category-i to category-iv.
- The value of maximum bending moment in wind category-4 is more as compared to wind category-1 when wind load was applied.
- Maximum beam displacement and maximum node displacement of structure is approximately equal in all wind categories individually.

In this project seismic response of a residential g+9 rc frame building is analyzed by the linear analysis approaches of equivalent static lateral force and method using staad pro software as per the is- 1893-2002-part-1. these analysis are carried out by considering different seismic zones, medium soil type for l zones 2, 3, 4 &5 . seismic analysis of zone- 2 to zone-5 are performed by equivalent static method and result of seismic analysis in all the zones are compared on the basis of maximum bending moment, maximum shear force, support reactions, beam displacement, base shear, nodal displacement, and steel percentage.

- Variations are drastically higher from zone ii to zone v.
- Steel percentage in zone v is more as compared to zone ii.
- Maximum beam displacement and maximum node displacement of structure is approximately equal in all zones individually.
- Maximum bending moment varies from 52.838,84 .541,126.812, 190.218 knm from zone ii to zone
- Maximum shear force varies from 21.375,33.879,51.699,70.472 kn from zone ii to zone

References

1. IS-456-2000:"Indian Standard of code and practise for plain and Reinforced concrete "Bureau of Indian Standards ,New Delhi-2002.
2. IS 875(Part1&2) – 1987: “Code of practice for design loads (other than earthquake) for buildings and structures”, Part 2 Imposed Loads, Second. revision, Sixth reprint June 1998.
3. IS 875(Part-3) – 2015:“Code of practice for wind loads for buildings and structures”, Part 3 Wind Loads.
4. IS: 1893 (part-I) 2002: criteria for earthquake resistant design of structures, part-i general provisions and buildings, fifth revision, bureau of Indian standards, new Delhi.
5. Inchara K P, Ashwini G (2016): A study on comparison of percentage steel and concrete quantities of a RC irregular building in different seismic zones”.
6. Karunakar Perla (2014): “Earthquake Resistant Design-Impact on Cost of Reinforced Concrete Buildings”

International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 3.

7. Mr. Kiran Kumar and Mr. Papa rao g (2013): "Comparison of percentage steel and concrete quantities of a r.c building in different seismic zones", volume: 02.