Analysis of Multi-Storied Building in Different Seismic Zones using STAAD Pro

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Abstract: The aim of this paper is to analysis of a multi-stored building [G+5] using STAAD Pro by considering different seismic zones. The analysis of a multi-stored building [G+5] initially for all type of loads (Seismic load, Dead load, Live load and Wind load) and possible load combinations are performed as per Indian codes. The seismic analysis is done under different zones which are Zone-II, Zone-III, Zone-IV, Zone-V and also zone factor values are considered as per IS 1893-2002 (Part-1). By considering each zone factor value and loads including self-weight, member weight, floor weight in seismic load, dead load, live load and wind loads the structure may affect. Also observing the Shear force, bending moment and deflection values for the whole building in different Seismic zones by using STAAD Pro. In analysing the whole structure considering all parameters like all loads (live load, dead load, seismic loads wind load) and type of structure, damping ratio, importance factor, response reduction factor, zone factor/different cities under different zones plays major role in building how it reacts to it and by shear force, bending moment, deflection values states that it is safe in particular zones or all the factors must be taken in consideration to imply the building is safe or not.

Key words: Damping ratio, Floor weight, Importance Factor, Live load, Response Reduction factor, Seismic Zones.

1. Introduction: Seismic activities are occurred in India due to several geographical reasons and by analysing and observing a building’s seismic activity, India divides into four seismic zones in latest version (Zone 2, 3, 4 and 5) and its previous version consisted of five or six zones [1]. Seismic analysis is necessary for a structure to attain or withstand to earthquake for some extent, so while performing seismic analysis we must follow some procedures to resist from earthquake and also structure may not fail while some factors need to be considerate in seismic analysis. In some specific areas like high-risk areas the earthquake occurring zones the seismic analysis is performed and designed according to seismic waves. In this project multi-storeyed building of G+5 framed structure is drawn using Auto-CAD Software showing columns and beams according structure dimensions created and analysed a multi-storeyed building (G+5) using STAAD Pro. V8i, by considering all possible load combinations for each zone in India. Here STAAD Pro is chosen because of its advantages such as easy to user interface, confirmation with the Indian standard codes, versatile nature of solving any type of problem, accuracy of solution [2]. The main aim is to complete Analysis of multi-storeyed building by using STAAD Pro against all possible load combinations and full fill the function for which they have built. Safety requirements must be met so that the structure is able to serve its purpose with the maintain cost. Here the analysis is done for a multi-storeyed building in each zone in India, such as from zone-II-Visakhapatnam city is chosen, from zone-III- Vijayawada city is chosen, from zone-III- New Delhi city is chosen and from zone-IV- Guwahati city is considered.

2. Objectives
   1. To prepare plan and beam-column layout by using Auto CAD.
   2. To prepare G+5 building frame in STAAD Pro.
   3. To perform the analysis of residential building (G+5) under dead load, live load, wind load, and seismic load by using STAAD Pro.
4. To compare the values of shear, bending moment and deflection for different zones.

3. Modelling analysis
Seismic zones: II, III, IV & V
Number of stories: G+5
Floor height: 3m
Size of column: 350mm * 350mm
Size of beam: 300mm * 350mm
Thickness of slab: 125mm
Type of soil: medium
Response reduction factor: 3.2
Importance factor: 1.2
Damping ratio: 5%
Seismic load: 20 kN
Floor weight: 2 kN/m²
Dead load: 10 kN
Live load: 1.5 kN/m²
Wind load: intensity of 0.8 kN/m²

4. Methodology:
The methodology of project is initially by assuming a G+5 framed structure of 15m X 15m length & height of a building respectively. And with chosen dimensions a framed structure’s elevation, beam-column layout and building plan have been drawn using Auto-CAD software. Then the same building is drawn in STAAD Pro software as given below: [3]

- Nodes are created as per considered dimensions (i.e., of spacing 3m node-node)
- All the nodes are connected to form a base of the structure
- All the base nodes are arrayed using transitional repeat tool, all the 5 floors are been formed.
- Nodes are connected in both horizontal and vertical directions as per requirements, to form proper beams and columns.
- Member properties were assigned to whole structure.
- Load cases are generated and applied to the structure and then analysis is performed.

5. Planning of building:
The Figure 1 and Figure 2 depicts the framed structure and layout of beams and columns drawn using AUTO-CAD model
6. Seismic zones:

Table 1. Zone factor table from IS Code book

| Seismic zone | II  | III | IV  | V   |
|--------------|-----|-----|-----|-----|
| Seismic intensity | Low | Moderate | Severe | Very severe |
| Z            | 0.10 | 0.16 | 0.24 | 0.36 |

In India there are few zones according to the seismic intensity which will affect the area or city when earthquake exists at particular zones as listed in Table 1[4]. According to IS1893-2002(Part-1) the cities are categorized zone wise with zone factor values, Considering Vishakhapatnam under zone II with zone factor value of 0.10, Vijayawada under zone III with zone factor value of 0.16, New Delhi under zone III with zone factor value of 0.24 and Guwahati under zone IV with zone factor value of 0.36 from IS code 1893-2002 (Part-1)[1] and also considered Response Reduction factor is 3(OMRF), Importance factor 1 and Damping ratio of 5%.

Figure 3. Skeletal diagram of the structure

Figure 4. Rendered view after assigning properties

The nodes are created and connected beams along X&Z axis, columns along Y-axis the structure is formed. Figure 3 shows the model of the building with assigned fixed supports with beams and columns. The whole structure of the building was shown as a skeletal view. The length and width of the structure is 15m x 15m. Figure 4 shows the render view of the structure after assigning properties which is column size 0.3X0.3m, beam size 0.35X0.3m and with slab thickness 0.125m.

7. Analysis of building

7.1 Load definitions

In load definitions considering the wind intensity of 0.8KN/m² with exposure of 0.75 which is assigned to the nodes. In seismic definitions the zone factor value and generated by considering the different seismic parameters such as zone factor value, damping ratio 5%, Response Reduction factor 3 (OMRF) and importance factor of 1 for all general buildings as per IS 1893-2002(Part-1) and also including self-weight member weight of 20KN in downward direction, floor weight is 2KN/m² along height 15m acting on the structure, considering for all zone factor values. Seismic loads and Wind loads acting on +X, -X, +Z&-Z Directions.[5]
7.2 Load case details

7.2.1 Seismic loads
In load cases details seismic load acting on all directions of the structure, which is +X, -X, +Z & -Z. The seismic load acting along X direction is depicted in Figure 5. Similarly, the seismic load acting along Z direction is depicted in Figure 6.

![Figure 5. Seismic Load acting along X direction](image1)

![Figure 6. Seismic Load acting along Z direction](image2)

7.2.2 Dead load:
For dead load considering the self-weight is taken as 1 which is acting in Y-direction and uniform force of 10kN/m. Uniform force of 10kN/m² is assigned to the beams in X- direction and beams in Z-direction. The dead loads are taken by using IS: 875 PART1 [1]. The Figure 7 depicts the Self-weight of the structure taken in STAAD Pro.

![Figure 7. Self-weight of the structure](image3)

7.2.3 Live load:
Live load of 1.5kN/m² which is acting in Y-direction and having range of minimum 0 and maximum 15m, which is the height of the whole structure. Live loads are taken from IS: 875 PART-2 and Figure depicts the structure after the application of live load.
7.2.4 Wind load:
In load cases details wind load acting on all directions of the structure which is +X, -X, +Z & -Z are illustrated in Figure 9 and Figure 10.

7.3 Load combinations:
The load combinations are considered by using IS:1893-2002. The steps considered for load combinations are first go to edit load combinations then select Indian code and select category and tick on dead load, live load, wind load, seismic load and enter load values then click on update table. After generating the load combinations, the analysis is done, the shear force, Bending Moment and Deflection values are taken in zone wise for different beams which is edge beam, outer beam and inner beam [6] [7] [8]. Also the results are compared zone wise

8. Zonal analysis results:

8.1 Shear Force values for all 4 Zones:
The comparisons of the results as per zones were listed in Table 2. Also the variations of shear force in zones are depicted in Figure 11. From the Table 2 and Figure 11 it is noticed that the Zone-V lists higher shear force values as compared to the other zones.

| Shear Force (kN) | Zone-II | Zone-III | Zone-IV | Zone-V |
|------------------|---------|----------|---------|--------|
| Outer beam       | 16.13   | 25.80    | 32.13   | 48.19  |
| Edge beam        | 16.49   | 26.39    | 32.86   | 49.29  |
| Inner beam       | 14.70   | 22.67    | 28.22   | 42.34  |

Table 2. Shear force values for different zones
Shear force varying in different seismic Zones

8.2 Bending moment in all zones:

The bending moment results with respect to different zones are listed in Table 3 and depicted in Figure 12. From the Table 3 and Figure 12 it is noticed that the Zone –V possess higher bending moment values as compared to other zones.

Table 3: Bending moment values for different zones

| Bending moment (kN.m) | Zone-II  | Zone-III | Zone-IV | Zone-V  |
|-----------------------|----------|----------|---------|---------|
| Outer beam            | 24.29    | 38.87    | 48.40   | 72.60   |
| Edge beam             | 22.67    | 36.27    | 45.16   | 67.74   |
| Inner beam            | 21.38    | 34.21    | 42.60   | 63.90   |
8.3 Deflection in all zones:

The deflections in all stories in different zones are illustrated in Table 4 and Figure 13. From the Figure 13 it is noticed that the Zone –V members shows larger deflections as compared to the other zones.

Table 4. Deflection values for different zones

| Deflection(m) | Zone-II | Zone-III | Zone-IV | Zone-V |
|---------------|---------|----------|---------|--------|
| Ground floor  | 0.00200 | 0.00320  | 0.00398 | 0.00598|
| Storey1       | 0.00329 | 0.00526  | 0.00656 | 0.00984|
| Storey2       | 0.00766 | 0.01225  | 0.01526 | 0.02289|
| Storey3       | 0.01191 | 0.01906  | 0.02374 | 0.03561|
| Storey4       | 0.01573 | 0.02517  | 0.03133 | 0.04700|
| Storey5       | 0.01872 | 0.02996  | 0.03730 | 0.05595|
Figure 13. Deflection values for storey in different zones

9. Conclusions

1. After analysis the G+5 building, shear force, bending moment and deflection values are observed in different seismic zones.

2. Shear force, bending moment and deflection values for Zone III increased by 60% when compared to Zone II.

3. Shear force, bending moment and deflection values for Zone IV increased by 24% when compared to Zone III.

4. Shear force, bending moment and deflection values for Zone V increased by 50% when compared to Zone IV.

5. For the same loading condition Zone V having more shear force, bending moment and deflection values.

6. As comparing the results zone II having lower shear force, bending moment and deflection values.

10. References

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