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Analysis of a Multistorey Building Resting on Sloping Ground in Different Seismic Zone and Comparison of Results

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Abstract: ***The structures are generally constructed on level ground; however, due to scarcity of level grounds the construction activities have been started on sloping grounds. There are two types of configuration of building on sloping ground, the one is step back and the other is step back setback. Structural analysis is mainly concerned with finding out the behavior of the structure when subjected to some action. In this project a R.C.C structure of (G+10) multi-storey building is studied for earthquake loads using ETABS software. Assuming that the material property, the linear static analysis is performed. These linear static analyses are carried out by considering severe seismic zones (zone-II, zone-III, zone-IV, and zone-V) and the behavior is assessed by taking types II soil condition. Different responses like bending moment, axial forces of various load combination and zones are studied. The seismic load has significant impact on bending moment and axial force.***

Keywords: Axial force, Bending moment, Load combination, Linear Static analysis, ETABS Software, IS 1893(part 1):2002

1. Introduction

When an earthquake is take place, a building undergoes dynamic motion. This is because of building is subjected to inertia forces that acting in opposite direction to the acceleration of earthquake excitations. These inertia forces are called seismic loads, are usually dealt with by assuming forces external to the building. So apart from gravity loads, the structure will experience dominant lateral forces of considerable magnitude during earthquake shaking. In India, based on past history of earthquake records the Bureau of Indian Standards have grouped the country into four seismic zones, as Zone-II, -III, -IV and –V. Out of these, Zone V is the most seismically active region, while zone II is the least. This project is mainly concerned with the study of seismic analysis of multi-storey building. The structural analysis of G+10storey building is done with the help of ETABS software. The Linear static analysis is done for all four zones and response like axial force, bending moment is compared..The work of a civil engineer especially in a seismic region is to provide maximum safety in the structures designed and constructed by him against the earthquake shocks at the acceptable economical costs. Apparently a simple statement but in actual practice it remains as yet most difficult and complicated task. During last five decades a lot of research and practical works has been done in this direction. Plainly speaking with the present state of knowledge, earthquake can never be predicted accurately. Hence to develop a system for forewarning & eliminating the risks of loss of life is yet a distant dream. Identifying potential hazards ahead of time and advance planning to save lives and significantly reduces injuries and property damage. Hence it is mandatory to do the seismic analysis & design structures against collapse. It is tempting to think that the risk of earthquake is concentrated only in areas of high seismicity but this reasoning does not hold. In region of low to moderate seismicity can be predominate risk as well. To analyze and design a RC structure by considering the combination of gravity load and seismic load is common. But for a tall structure there is always a risk due to wind load along with seismic and gravity load .In this project we consider wind load along with the combination of gravity loading and earthquake loading. According to IS-875 the earthquake load exceed the wind load but in various foreign codes E.g. structural loads-2012 IBC and ASCE/SEI 7-10 etc. we can consider both earthquake and wind load and such combinations is adopted practically in various tall structure analysis and design. E.g. Burj Al-Khalifa. According to IS-875 Part-III clause 0.3.1 page no. 3 earthquake load should be considered along with following dead load, imposed load, snow load, special load and load combination.This paper makes an attempt to bring forth and analysis the most important points of comparison between the old and the revised codes to highlight the changes required to be incorporated in the planning, analysis and design of general and industrial buildings to make them earthquake resistant as mandated by the latest codes. Provisions pertaining to most generally encountered buildings are covered to understand the basic changes which need attention of almost all structural designers. The study also includes some inescapable revised provisions of IS 13920 i.e. code of practice for “Ductile Design and detailing of Reinforced Concrete Structures Subjected to Seismic forces” which was last published in 1993 prior to revisionin 2016.

2. Modeling Description

In the present study, one building configurations are considered, which include buildings situated on plain ground. Number of storey considered for each type of configurations is 10 storeys. Plan layout is kept same for all configurations of building frame. The columns are taken to be square to avoid the issues like orientation.

Geometric Properties:-
Floor height: 3.1 m
Spacing in X direction: 7.0 m
Spacing in Y direction: 5.0 m
Beam Sizes: 300 X 500 mm
Column sizes: 600 X 600 mm
Slab Thickness: 150 mm
Number of bays in x-direction: 7 bays
Number of bays in y- direction: 4 bays
Number of stories: G+10

Material Properties:-
Concrete Grade: M30
Compressive strength of Concrete: 30000 KN/m3
Steel: Fe500
Characteristics strength of reinforcing steel fy = 50000 KN/m3 Density of concrete = 25000 KN/m3

Gravity Loads:-
(i) Dead load: Self-Weight: Self weight is calculated by the software based on material constants and section properties provided Super imposed dead load (water Proofing's or Floor finishes)=1 KN/m2
(ii) Live Load:
Live load on Slab = 3 KN/m3

Lateral loads Response Spectrum Method: - The response spectrum analysis is carried out using the spectra for medium soil as per IS 1893 (Part 1) 2002 for seismic zone V, medium soil and 5% damping. The spectral acceleration coefficient (Sa/g) values are calculated as follows. For medium soil sites, Sa/g = 1 + 15T, $(0.00 \leq T \leq 0.10)$, (T= time period in seconds) = 2.50, $(0.10 \leq T \leq 0.55)$ = 1.36/T, $(0.55 \leq T \leq 4.00)$

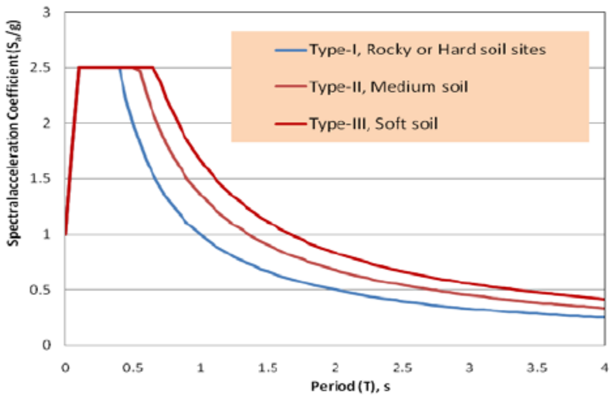

Figure 1: Response Spectra for Rock and Soil Sites for 5% Damping as per IS1893 (Part1):2002 (Fig.2 of code)

3. Methodology

Seismic analysis of the structures is carried out on the basis of lateral force assumed to act along with the gravity loads. The base shear which is the total horizontal force on the structure is calculated on the basis of structure mass and fundamental period of vibration and corresponding mode of shape. The base shear is distributed along the height of the structure in terms of lateral forces according to codal provisions (Kazuhiro, 1987). In this study, a (G+10) storied RC building has been analyzed using the equivalent static method in ETABS. The plan and elevation of the building taken for analysis is shown in Fig.1 and Fig.2. The nomenclature of columns is shown in Fig.3. Three Dimensional view of the whole structure is shown in Fig.4. Fig.5 is showing the structure subjecting to the vertical loading and Fig.6 & Fig.7 are showing the structure subjected to loading of earthquake in "+X" and "+Z" directions. In the earthquake analysis along with earthquake loads, vertical loads are also applied. For the earthquake analysis, IS 1893-2002 code was used .The total design seismic base shear (Vb) along any principal direction shall be determined by multiplying the design horizontal acceleration in the considered direction of vibration (Ah)and the seismic weight of the building.

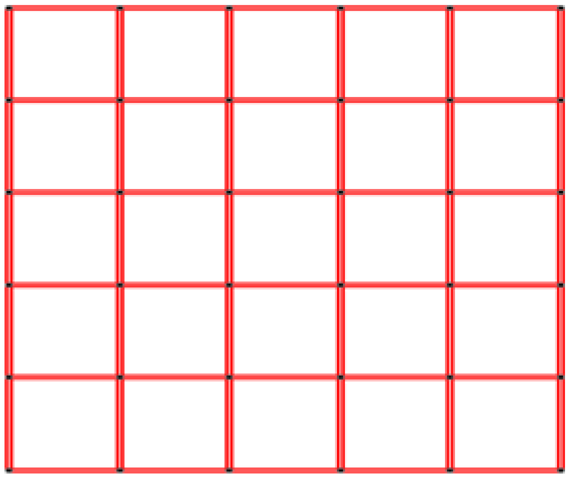

Figure 2: Plan of the Building

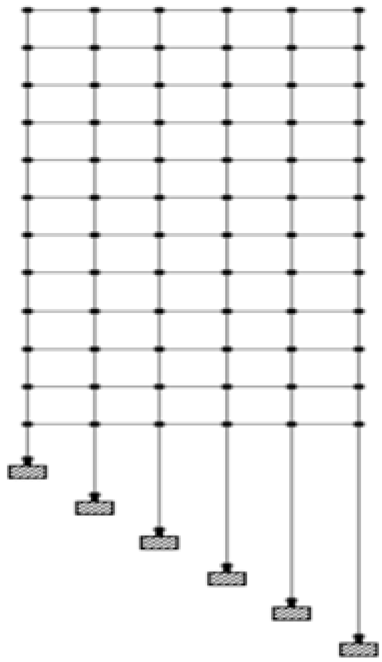

Figure 3: Elevation of the Building

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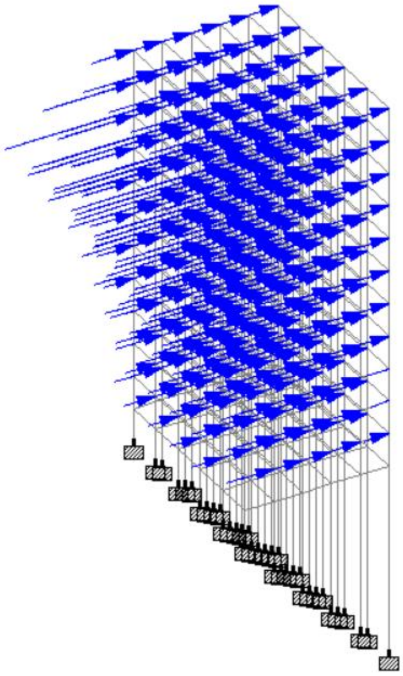

Figure 4: Structure subjected to Earthquake loading in +X-direction

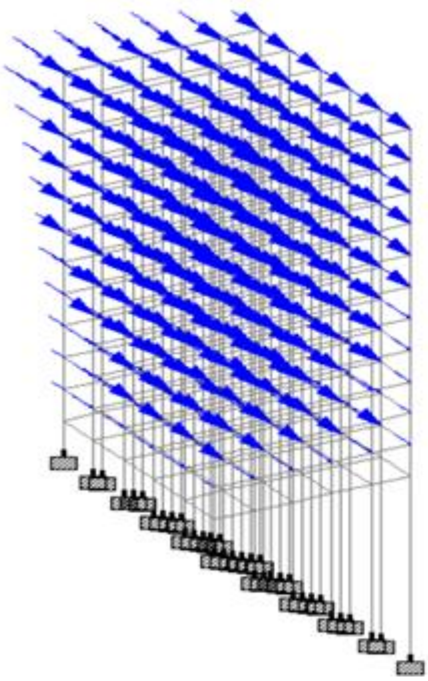

Figure 5: Structure subjected to Earthquake loading in +Z-direction

Load Combinations: The following load combinations are used in the seismic analysis, as mentioned in the code IS 1893(Part-1): 2002, Clause no. 6.3.1.2.

1. 1.5(DL+LL)
2. 1.2(DL+LL+EQX)
3. 1.2(DL+LL- EQX)
4. 1.2(DL+LL+ EQZ)
5. 1.2(DL+LL- EQZ)
6. 1.5(DL+ EQX)
7. 1.5(DL- EQX)
8. 1.5(DL+ EQZ)
9. 1.5(DL-EQZ)
10. 0.9DL+ 1.5EQX
11. 0.9DL- 1.5EQX
12. 0.9DL+ 1.5EQZ
13. 0.9DL-1.5EQZ

Earthquake load was considered in +X,-X, +Z and –Z directions. Thus a total of 13 load combinations are taken for analysis. Since large amount of data is difficult to handle manually (M.H. Arslan, 2007), all the load combinations are analyzed using software STAAD Pro. All the load combinations are mentioned above

4. Results & Discussions

The variation of support reactions at each location of the columns and the percentage difference in different seismic zones with respect to gravity loads is represented in the in Fig.6. It is observed that in edge columns, variations are 17.72, 28.35, 42.53, and 63.7% between gravity load to seismic zones II, III, IV and V respectively. In exterior columns, the variations are 11.59, 18.54, 27.81, and 41.71% between gravity load to seismic zones II, III, IV and V respectively. The variation is very small in interior columns.

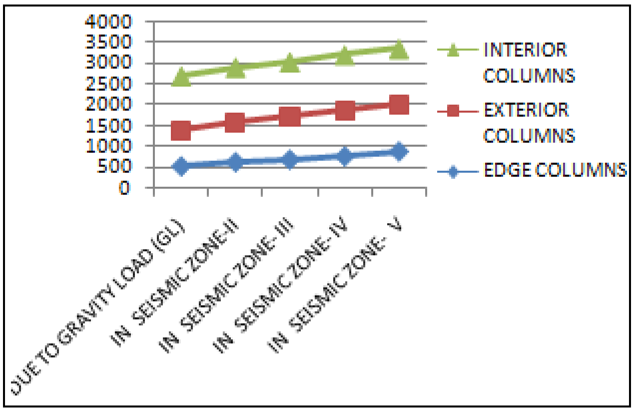

Figure 6: Variation of support reactions in different seismic zones

The variation of volume of concrete at each location of the column footing and the increase in percentage difference in different seismic zones with respect to gravity loads is represented in the Fig.7. It is observed that in edge column footings, variations are 17.75, 17.75, 27.17 and 42.0% between gravity load to seismic zones II, III, IV and V respectively. In exterior column footings, the variations are21.51, 21.51, 45.15 and 57.77% between gravity load to seismic zones II, III, IV and V respectively. Therefore, the volume of concrete in footings is increasing in seismic zones III, IV and V due to increase of support reactions due to lateral forces. However the variation is very small in interior column footings.

5. Conclusions

The following conclusions can be based on the Analysis of multistory building resting on slopping ground in different seismic zone and comparison of results.

The variation of support reactions in exterior columns increasing from 11.59% to 41.71% and in edge columns increasing from 17.72% to 63.7% in seismic Zones II to V. However the variation of support reactions are very small in interior columns.

The volume of concrete in exterior and edge column footings is increasing in seismic zones III, IV and V due to increase of support reactions with the effect of lateral forces. However the variation is very small in interior column footings

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