Comparative Seismic Analysis of Multi Storey Building with Flat Slab and Conventional Grid Slab

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Abstract: ***This analysis is to assess the comparative seismic behavior of multi storey building with flat slab and conventional grid slab. In this seismic analysis of a 15 storey building is performed with response spectrum method for medium soil in the all four seismic zones of India according to the Indian code of earthquake resistant structures. In this analysis storey drift, base shear and column force is assessed with the help of STAAD Pro software.***

Keywords: Flat slab, Grid slab, Base shear, Story draft, Storey displacement

1. Introduction

The rapid increase in population results in limited availability in space. This dearth of space forcing us to raise the height of building. With increase in height there is need for resisting lateral loads like earthquake load and wind load comes in picture. So, it is necessary to study the seismic performance of multi storey building. Earthquake of different intensities can damage the building differently. So, it is necessary to analyze the various seismic behavior of multi storey building with different responses such as lateral displacement, storey drift and base shear. Thus a careful modeling is done for analyze the seismic behavior.

The arrangement of slabs, beams and columns can be done in two ways as conventional grid system and flat slab system. In conventional grid system, slab rested over beam to resist moment and loads. In flat slab system, slab directly rested over the column in four corners. This can be done with or without drop and also with or without column head. This arrangement gives the advantage of reduced floor to floor height.

2. Methods of Analysis

Analysis of conventional grid slab and flat slab can be done according to the Indian standard code.

The dynamic analysis can be performed on the basis of the type of external action and the behavior of the structure. This analysis is classified as linear static analysis, linear dynamic analysis, non-linear static analysis and non-linear dynamic analysis.

Linear static analysis or equivalent static analysis can be used for regular structures with limited height. Linear dynamic analysis can be performed by two ways, either by response spectrum method or by the elastic time history method. The significant difference between linear static and linear dynamic analysis is the level of the forces and their distribution along the height of the structure.

Non-linear static analysis of simple to implement and provide information on the strength, deformation, and ductility of the structure, as well as the distribution of demands. This permits the identification of the critical members that are likely to reach limit states during the earthquake, to which attention should be paid during the design and detailing process. But the non-linear static method is based on many assumptions, which neglect the variation of loading patterns, the influence of higher modes of vibration, and the effect of resonance. In spite of deficiencies, this method, known as push-over analysis, provides a reasonable estimation of the global deformation capacity, especially for structures that primarily respond according to the first mode.

Non-linear dynamic analysis or inelastic time history analysis is the only method to describe the actual behavior of a structure during an earthquake. This method is based on the direct numerical integration of the differential equations of motion by considering the elasto-plastic deformation of the element.

3. Analysis

3.1 Preliminary Data

A 15 storey building is modeled using conventional grid slab and flat slab respectively. Then the building is analyzed using response spectrum method for all four seismic zones of India. The prilimenary data for analysis is given as

1	Plan dimensions	35mx28m
2	Length in X-direction	35m
3	Length in Y-direction	28m
4	Floor to floor height	3.6m
5	No. of stories	15
6	Total height of building	54 m
7	Thickness for grid slab	150mm
8	Size of grid beam	230mm x 650mm
9	Thickness of flat slab	270mm
10	Panel dimensions	7m x 7m
11	Grade of concrete	M25
12	Grade of steel	Fe415
13	Soil type	Type II medium soil
14	Size of column	
	1 to 3 story	900mm x 900mm
	4 to 6 story	800mm x 800mm
	7 to 9 story	700mm x 700mm
	10 to 12 story	600mm x 600mm
	13 to 15 story	500mm x 500mm

3.2 Loading Considered

- Live load = 4KN/m^2
- Floor finish = 1 KN/m^2
- Roof live load = 1.5 KN/m^2
- Wall load = 12 KN/m

3.3 Loading Combinations

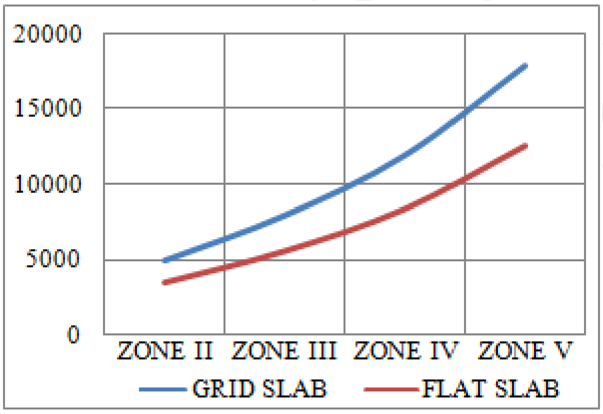
- 1.5 DL + 1.5 LL
- 1.5 DL+1.5 EQX
- 1.5 DL-1.5 EQX
- 1.5 DL+1.5 EQY
- 1.5 DL-1.5 EQY
- 1.2 DL + 1.2 LL+1.2EQX
- 1.2 DL + 1.2 LL-1.2EQX
- 1.2 DL + 1.2 LL+1.2EQY
- 1.2 DL + 1.2 LL-1.2EQY
- 1.5 DL + 1.5 RSPX
- 1.5 DL-1.5 RSPX
- 1.5 DL-1.5 RSPY
- 1.5 DL+1.5 RSPY
- 1.2 DL + 1.2 LL+1.2RSPX
- 1.2 DL + 1.2 LL-1.2RSPX
- 1.2 DL + 1.2 LL+1.2RSPY
- 1.2 DL + 1.2 LL-1.2RSPY

4. Results

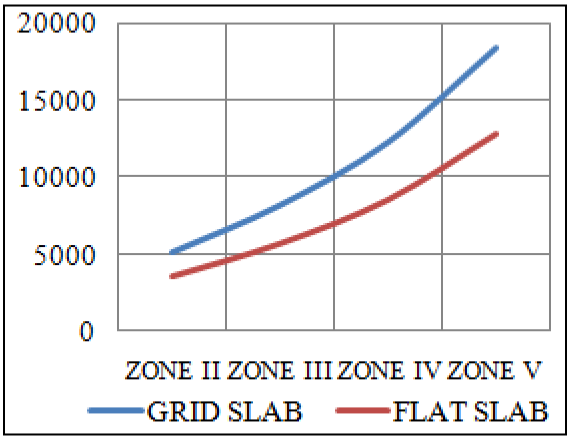
4.1 Base shear

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

$V_B = A_h \times W$
A_h= design horizontal acceleration spectrum
W= seismic weight of the building



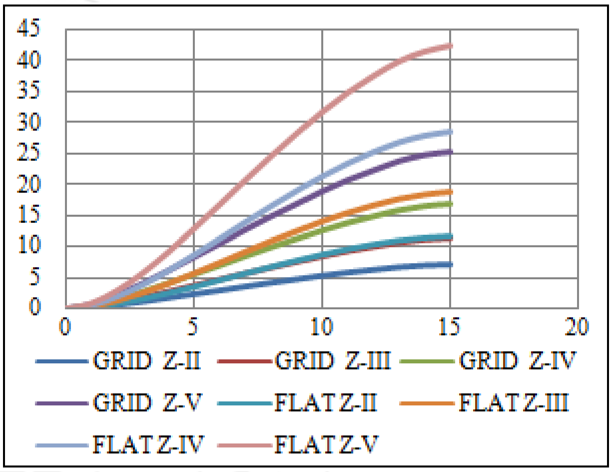
Graph 1: Base Shear along X-Direction



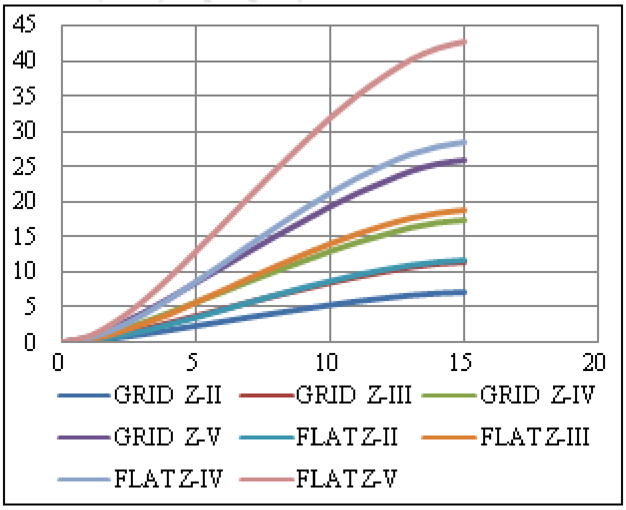
Graph 2: Base Shear along Y-Direction

A. Storey Displacement

The results f story displacement have been shown in graphs (Displacement in cm vs. Story height) below.



Graph 3: Storey Displacement (in cm) along X-Direction



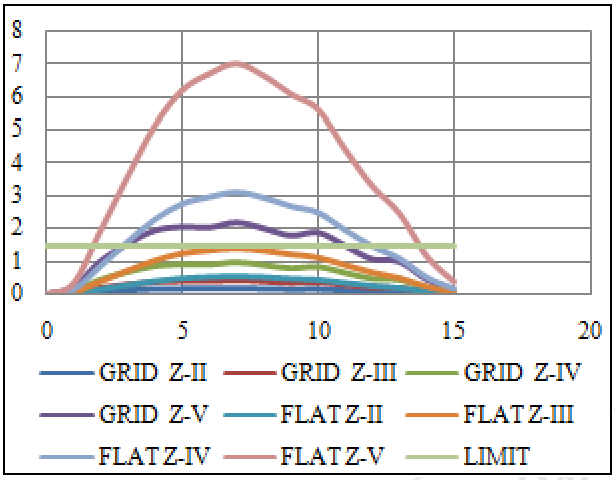
Graph 4: Storey Displacement (in cm) along Y-Direction

4.2 Storey Drift

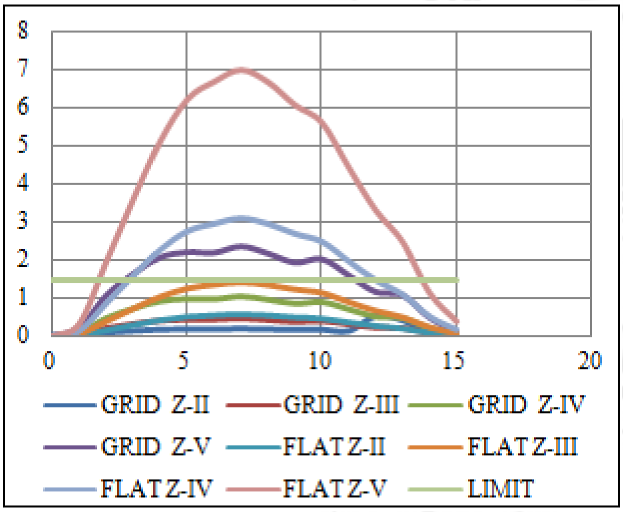
Storey drift defined as lateral displacement of one floor relative to the other floor. The total drift in any storey is the absolute displacement of any point relative to base. Due to the minimum specified design lateral force, the storey drift in any storey with a partial load factor of 1.0 should not exceed

0.004 times the storey height. For a building that has been designed to accommodate storey drift, this limit of 0.004 is not placed.

In this case height is 3.6m, so limit storey drift=1.44cm



Graph 5: Storey Drift (in cm) along X-Direction



Graph 6: Storey Drift (in cm) along Y-Direction

5. Conclusions

a) Base Shear of Grid slab is higher than the Flat slab.
b) Displacement in Flat slab is higher than the grid slab.
c) Displacement is increase with height of building and is maximum at the terrace.
d) Storey drift is higher in Flat slab than grid slab in all Zones and in both X and Y direction.
e) Storey drift is maximum at middle storey and decrease towards base and terrace.

References

[1] IS 1893(part-1) 2002 criteria for earthquake resistant
[2] Design of structures. Part-1 general provision & buildings.
[3] Criteria for Earthquake Resistant Design of Structures Part 1 General Provisions and Buildings (Fifth Revision) IS 1893(part 1)2002.
[4] Indian standard "Plain & Reinforced Concrete Code of Practice" Fourth Revision IS: 456:2000.
[5] M.Anitha, B.Q.Rahman, JJ.Vijay, "Analysis and Design of Flat Slabs Using Various Codes" International Institute of Information Technology, Hyderabad (Deemed University) April 2007.
[6] S. K. Duggal, "Earthquake Resistance Design of Structure", Second Edition, Oxford University Press, New Delhi
[7] B. A. Izzuddin, X. Y. Tao; and A. Y. Elghazouli, "Realistic Modeling of Composite and Reinforced Concrete Floor Slabs under Extreme Loading." I: Analytical Method Journal of Structural Engineering, Vol. 130, No. 12, December 1, 2004.
[8] Dr. Ram Chandra, Virendra Gahlot, "Elements of Limit State Design of Concrete Structures" Scientific Publishers (India), 2004.
[9] Durrani A. J.; Mau S. T., AbouHashish A. A., and Yi Li, "Earthquake Response of Flat-Slab Buildings," Journal of Structural Engineering, Vol. 120, No. 3, March, 1994.
[10] Static and dynamic analysis of grid beams by " Baishali Das".
[11] S.S.Bhavikatti "Advanced R.C.C. Design (R.C.C. Volume-II).
[12] Ramamrutham s. "Book of Reinforced cement concrete design".
[13] Agrawal & Shrikhande" Earthquake Resistant Design book".
[14] Shah &Kurve "limit state design book".
[15] P.C.Varghese,"book of advanced reinforced concrete design".
[16] Software: - STAAD Pro V8i.

Author Profile

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