Comparison Between Seismic and Nonseismic Analysis of Multistorey Building

P. HariharaVenkata Nagasai, V. Bhargav Reddy, Rama Krishna Kolli, Lingeshwaran Nagarathinam

Abstract:--- Earthquakes are very common in all part of the world, geographical statistics of India show that almost 54% of the land is vulnerable to earthquakes. It is estimates that around 200 million city dwellers in India will be exposed to earthquakes by 2050.In recent scenario most of the structure are high raised multi-storey buildings which are designed to withstand the seismic forces . SAP2000 stands for Structural Analysis Programming and its commonly used to analyse concrete structures, steel structures, parking garages, skyscrapers, low and high raise buildings In this paper analysing and design of G+7 (Hostel building) & comparing the support reaction of a seismic and non-seismic analysis of the multi-storey building by using SAP2000 & the loads are assigned as per the IS codal provisions and by using the support reaction further proceed to the different type of footings, various soil parameters. The site conditions we are considering are AMARAVTI the new capital city of A.P, it is located over zone III and soil type is mostly black cotton soil.

Index Terms: Multistorey building, SAP2000, Seismic analysis, Support Reactions

I. INTRODUCTION

An earthquake is a result of sudden release of energy in the earth crust that creates seismic waves. Seismic load is very powerful and it will collapse the structure in fraction of seconds this leads to loss of life and property. The seismicity or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time. The most common loads resulting from the effect of gravity are dead load, live load and snow load. Besides these vertical loads, buildings are also subjected to lateral loads caused by wind, earthquake. Lateral loads can develop high stresses, produce sway movement or cause vibration. The earthquakes are measured by using seismometers. In addition to IS: 456-2000, IS: 1893-2002 also referred while designing this type of structures. Figure 1 shows the seismic zonation map of India.

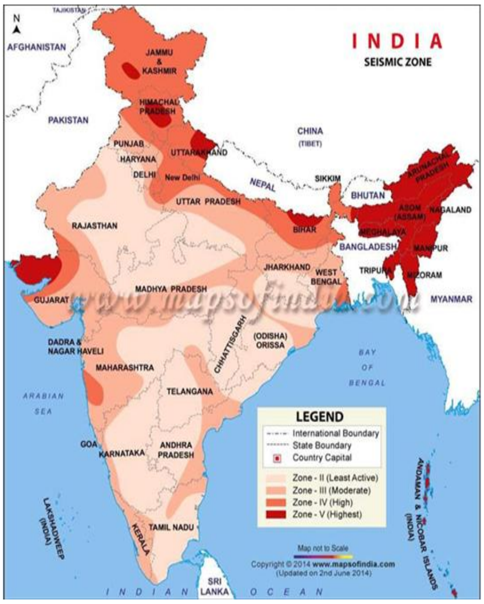

Fig.1: Seismic zonation map of India

II. EARTHQUAKE ZONES

The latest version of seismic zoning map of India given in the earthquake resistant design code of India [IS 1893 (Part 1) 2002] assigns four levels of seismicity for India in terms of zone factors. In other words, the earthquake zoning map of India divides India into 4 seismic zones (Zone 2, 3, 4 and 5) unlike its previous version which consisted of five zones for the country. According to the present zoning map, Zone 5 expects the highest level of seismicity whereas Zone 2 is associated with the lowest level of seismicity. Table I shows the Zone factors.

Table I: Zone factors

ZONE TYPE	ZONE FACTORS
V	0.36
IV	0.24
III	0.16
II.	0.1

III. RESEARCH SIGNIFICANCE

The following significances are proposed for the present study.

1. Analyzing the building for seismic loads.
2. Analyzing the building for non-seismic loads.
3. Comparison between the seismic and non-seismic analysis.
4. Proposing the building design for the earthquake zone areas.

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IV. SEISMIC DESIGN FACTORS

These are the following factors affect the design of the building.

A.Torsion

Objects and buildings have a center of mass, a point by which the object (building) can be balanced without rotation occurring. If the mass is uniformly distributed then the geometric center of the floor and the center of mass may coincide. Uneven mass distribution will position the center of mass outside of the geometric center causing "torsion" generating stress concentrations. A certain amount of torsion is unavoidable in every building design. Symmetrical arrangement of masses.

B. Damping

Buildings in general are poor resonators to dynamic shock and dissipate vibration by absorbing it. Damping is a rate at which natural vibration is absorbed.

C. Ductility

Ductility is the characteristic of a material (such as steel) to bend, flex, or move, but fails only after considerable deformation has occurred. Non-ductile materials (such as weak reinforced concrete) fail by crumbling. Good ductility can be achieved with carefully detailed joints.

D. Strength and Stiffness

Strength is a property of a material to resist applied forces within a safe limit. Stiffness of a material is a degree of resistance to deflection or drift.

E. Building Configuration

This term defines a building size and shape, and structural and nonstructural elements. Building configuration determines the way seismic forces are distributed within the structure, their relative magnitude, and problematic design concerns.

V. DIFFERENCE BETWEEN LINEAR AND NON LINEAR ANALYSIS

A. Linear Analysis

The design of structural components or the whole structure such that even when maximum design forces are applied to the structure, the displacement of the structure does not exceed its elastic limit. So, the structure would always come back to its initial position without any damage (since it is linear behaviour). When the forces become large in the case of earthquake, dimensions of the structural components or whole building would become huge which is not an economic solution. So, considering non-linear analysis is necessary.

B. Non-Linear Analysis

Allowing the structure or structural components sway more than the elastic limit and utilize its non-linearity is called non-linear analysis. In this case we design the structure for reduced forces and thus allow more deflection. Therefore, a component with smaller dimension an resist the same forces but sway a little more. Therefore, by non-linear analysis we can design more economical structure with controlled damage.

VI. DIFFERENCE BETWEEN STSTIC AND DYNAMIC ANALYSIS

Structural analysis is mainly carried out to find the structural response and behaviour when it is subjected to the external forces. External forces can be in the form of live load, wind load, blast, snow etc. And may be in the form of earthquake that is shaking of the earth surface.

A. Static Analysis

If load is applied gradually and slowly, the inertia force can be neglected and the analysis is carried as static analysis. A static load is one which varies slowly.

B. Dynamic Analysis

If a structure is subjected to dynamic loads (actions having high acceleration) then the analysis is carried as dynamic analysis. Loads such as wind load, earthquake load, wave load, blast load are dynamic in nature. Dynamic load changes quickly with time in comparison to natural frequency of the structure.

VII. BULDING DATA

The analysis of G+7 and terrace is carried out using SAP2000 software for ordinary moment resisting frame situated in zone III. Table 2 consists of the plan area, beam size, column size, slab thickness, the height of the building. Seismic parameters such as Seismic Zone, Zone factor, Importance factor, Response Reduction factor, Soil type are considered as criteria for earthquake resistant design of structures as per IS 1893-2002 The properties of the building and its components are as follows. The model was generated in commercial software SAP2000. Different load cases are taken such as dead load, live load, and earthquake load are applied to the building. Table II gives the information about detailed plan details.

Fig. 2 shows the Typical plan of building that is designed for the project.

Fig. 3 shows the Side view of building with fixed base in Green color and the building beams and columns are in red color.

Fig. 4 shows the 3D view of building with entire beams and columns that are under gone the design loads.

Table II: Plan details

Plan Area (building)	112.576*58.170m
Beam size	230*450mm
Column size	230*600mm
Slab thickness	130mm
Utility of building	Commercial building
Height of building	24m
Type of construction	RCC framed structure
Grades	M25, Fe500
Seismic Zone	III

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Zone Factor	0.1
Importance factor	1
Response reduction factor	3 (OMRF)
Soil Type	Medium
Structure	OMRF
Damping Ratio	5%

Description of Structure

The Fig. 2 shows G+7 and terrace of structural plan, which was used to investigate the seismic response of the building. The plan which is symmetrical in nature was used for observing the varying storey drift and displacement. The number of bays in X and Y direction is different in the building. All column sizes and beam sizes are assumed are same through all stories of the building. The building is designed for wind and earthquake loads of the structure by using Indian standard code. The model was generated in commercial software SAP2000. Different load cases are taken such as dead load, live load, wind load and earthquake load are applied to the building.

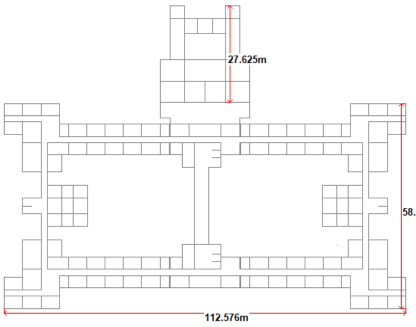

Fig.2: Typical plan of building

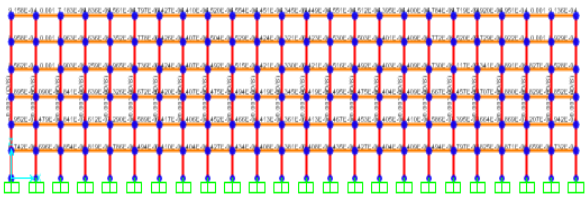

Fig.3: Side view of building

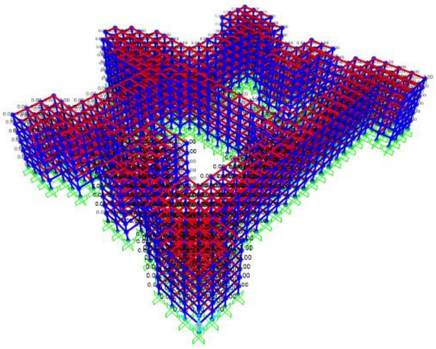

Fig.4: 3D view of building

VIII. METHODOLOGY

1. Initially a building plan is selected and modelled in SAP2000 setting preliminary units, dimensions, and codes according to Indian standards.
2. Assigning the properties for columns, beams and slabs.
3. Assign the fixed supports as required for the building.
4. Calculating loads such as dead, live, wind and earthquake loads as per IS 875-part1, 2, 3 and IS 1893 respectively.
5. Creating load combinations as per IS: 1893-2002, IS: 456-2000.
6. Assigning dead load, live load, earthquake load on the building.
7. Modelling the RC framed structure with various configurations.

Procedure for building analysis

- Choosing the model from template.
- Defining the grids
- Editing the grid data and storey data.
- Defining materials.
- Defining frame sections (Beam/Column).
- Defining slab sections.
- Assigning joint restraints.
- Assigning frame properties.
- Assigning slab sections.
- Defining load cases.
- Load combinations

The combinations are taken from the code book IS1893:2016

COMB1**:**1.5(D.L+L.L)
COMB2**:**1.2(D.L+LL+EQ_x)
COMB3**:**1.2(D.L+L.L-EQ_x)
COMB4**:**1.2(D.L+L.L+EQ_y)
COMB5**:** 1.2(D.L+L.L-EQ_y)
COMB6**:**1.5(D.L+EQ_x)
COMB7**:** 1.5(D.L-EQ_x)
COMB8**:** 1.5(D.L+EQ_y)
COMB9**:** 1.5(D.L-EQ_y)
COMB10**:** Envelop of all combinations

- Assigning dead, live, wall loads to the sections
- Define load combinations
- Define load cases
- Running the analysis
- Displaying the results

IX. RESULTS

After doing the analysis part of both non-seismic and seismic analysis, there has been different shear force, bending moment, axial force and the displacement values

The following charts show the Maximum values of shear force, bending moment, axial force and displacement comparisons between non-seismic analysis and seismic analysis.

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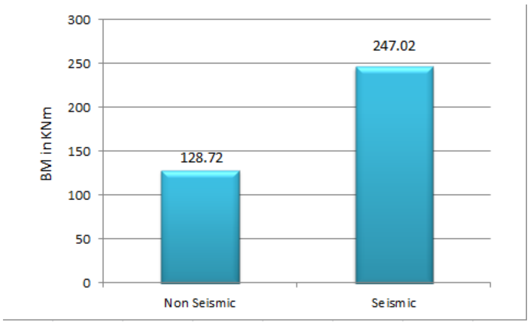

Fig.5: Comparison of Maximum Bending Moment

From figure it is clear that the maximum bending moment of seismic analysis is increased more than the non-seismic analysis. This is due to that equivalent lateral forces on the structure are applied to have the effect of ground shaking during earthquake. Thus, 45.5 % of additional maximum bending moment is obtained on the members with the seismic load considered

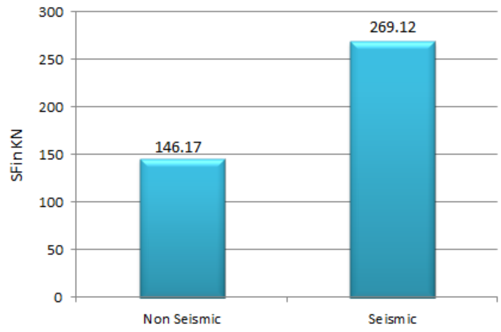

Fig.6: Comparison of Maximum Shear Force

In the same way the shear force obtained on the members with seismic load has 42.05% additional than with the non-seismic loads

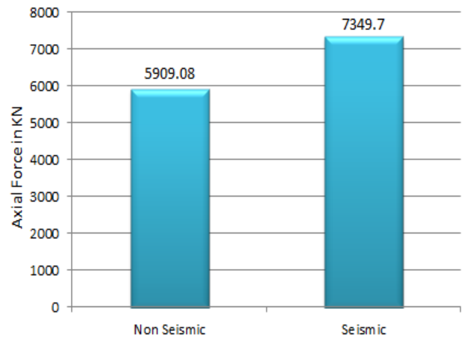

Fig.7: Comparison of Maximum Axial Force

The above figure shows the maximum axial force columns for both seismic and non-seismic analysis. The seismic analysis axial force is high than the non-seismic because of vibration in vertical direction due to earthquake loads.

The following table shows the maximum displacement values of top floor, where the seismic analysis displacement is more than the non-seismic analysis. This shows about the ductility of the structure. These displacements of seismic analysis may cause the cracks during the earthquake, which are repaired after the earthquake. Table III shows the comparison of maximum displacement.

Table III: Comparison of maximum displacement

Displacement	X-axis	Y-axis	Z-axis
Non-seismic	0.42 mm	0.65 mm	22.5 mm
Seismic	16.7 mm	90.9 mm	76.2 mm

X. CONCLUSION

The objective of the paper is to study and evaluate the behaviour of buildings under seismic conditions with practical application of conditions. Thus the analysis results were compared and it was concluded that the bending moment, shear force, axial force and displacement values were drastically higher in the seismic analysis. To restrain the additional seismic loads of the structure, relevant design method is to be adapted like using seismic design strategies and devices in the construction.

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