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COMPARISON BETWEEN SEISMIC ANALYSIS AND NON-SEISMIC ANALYSIS OF G+17 BUILDING USING SAP2000

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ABSTRACT

Engineers mostly adopt complex non-linear methodsto analyze multistorey residential building to sustain earthquake forces. This paper uses much simpler Equivalent Static method to analyse G+17 storey building to resist earthquake forces using SAP2000 software. The seismic analysis is further compared with non-seismic analysis using DL+LL combination. It was observed that the seismic results obtained consisted of drastically increased maximum moments and shear forces than the non-seismic analysis.

KEYWORDS: Equivalent Static Method, Seismic Analysis, SAP2000, Earthquake, Maximum Moments, Shear Forces

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Original Article

INTRODUCTION

Earthquake is considered as a catastrophic natural disaster. Many people die every year due to collapse of buildings due to earthquakes. The most recent example is the Ecuador earthquake of 7.8 magnitude on Richter scale which struck on 16th April 2016. It killed more than 650 people with buildings collapsing hundreds of kilometers from the epicenter of earthquake. The damage to structures can be reduced by adopting principles of earthquake resistant designs.

This paper shows a comparative analysis of G+17 storey residential building between non-seismic analysis (with dead loads and live loads) and seismic analysis (with dead, live and earthquake loads). Seismic response of a structure can be obtained by using linear, non-linear, static, dynamic analysis. Various methods of seismic analysis include (i) Equivalent Static Analysis, (ii) Response Spectrum Analysis, (iii) Linear Dynamic Analysis, (iv) Non-linear Static Analysis and (v) Non-linear Dynamic Analysis also known as Pushover Analysis. This paper employs Equivalent Static Analysis to obtain seismic response of G+17 storey residential building. This method defines a series of lateral forces acting on the building to represent the effect of ground shaking during earthquake. The analysis is done using the software SAP2000. First the building is modelled and various load combinations are assigned. The load combination which gives the critical value is considered for comparison.

LITERATURE REVIEW

Evaluating seismic demands of tall structures, engineers mostly adopt non-linear static or pushover analyses for more accuracy and better predictions. There have been few researches on this topic. Most of them were done using Response spectrum analysis.

(Suresh and Nanduri, 2012) compare the results of normal and seismic design of building. They state that to design a structure to be earthquake resistant does not require additional costwhen proper method of design is utilized. Making the structural joints more ductile to sustain the earthquake forces, using more reinforcement bars of smaller diameter and distributing them on all sides can reduce the damage to the structure from lateral forces. (Kumar and Naresh, 2014) using response spectrum analysis analyzed G+15 storey building in STAAD Pro. They compared static and dynamic analysis results of structural frame and concluded that the performance of dynamic analysis of frame is good in resisting earthquake forces as compared to that of static analysis of frame.

This paper adopts much simpler method for analysis using Static Equivalent method. The equivalent lateral forces due to seismic forces because of ground shaking are applied to the frame. Additional moments and displacements are developed in the beams and columns due to these equivalent lateral forces. Similarly, analysis of the frame is done using dead and live loads which gives the values of moments in beam and columns which are then compared with the seismic results.

Model Generation and Analysis

The model of the building was prepared with G+17 floors on the Y-axis. The ground floor and 17 floors had clear height of 3m each. Considering combined raft footing, the supports at the base were all fixed. The values of live load, dead load and self-weight were assigned to the structure according to specifications of IS 875 part I and part II. For the general analysis of the building, live load and floor finish values were used as per specifications of IS 456-2000.

Live Load (*LL*)= 2kN/m

Floor Finish(*FF*)= 1.5kN/m

Dead Load(*DD*)= Wt. of main wall+ partition wall+ parapet wall

The seismic load calculations were done abiding by the specifications of IS 1893-2002-part I. Some of these calculations are shown below.

- **Undamped Fundamental Natural Period**

For X-direction

$T_a = \frac{0.09h}{\sqrt{d}} = \frac{0.09X61.5}{\sqrt{0.87}} = 0.879$ sec

For Y-direction

$T_a = \frac{0.09h}{\sqrt{d}} = \frac{0.09X61.5}{\sqrt{13.5}} = 1.50$ sec

- **Zone Factor for Zone IV**

Z = 0.24

- **Importance Factor**

I = 1.0

- **Average Response Acceleration Coefficient**

$\frac{S_a}{g} = \frac{1.67}{1.5} = 1.113$

- **Response Reduction Factor for Special Moment Resisting Frame (SMRF)**

  R= 5.0

- **Horizontal Seismic Coefficient**

  $A_h = \frac{Z\ I\ S_a}{2\ R\ g} = \frac{0.24X1X1.113}{2X5} = 0.027$

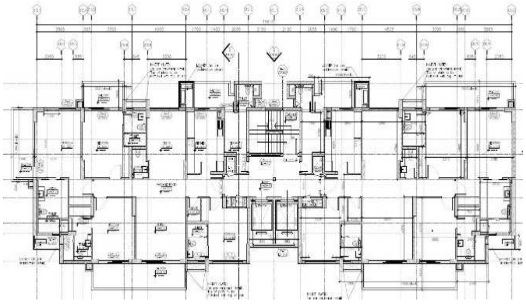

Figure 1: Plan of G+17 Building

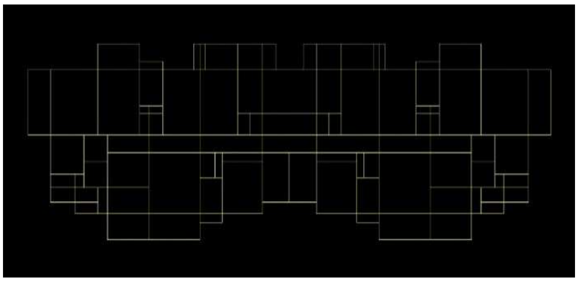

Figure 2: Top View in SAP

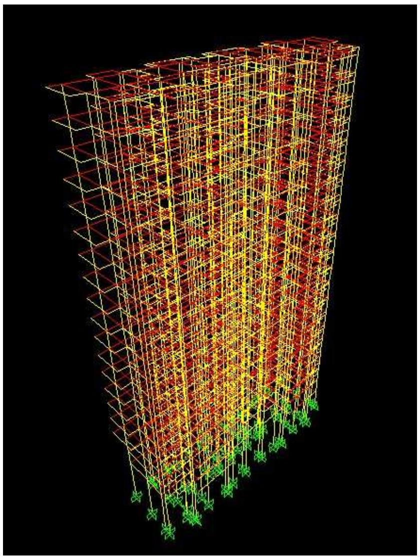

Figure 3: 3D Grid in SAP

A grid was created based on the plan of building. Nominal sizes of columns and beams were added and model was created. Upon analysis the dimensions of beams and columns were changed to obtain safe structure.

A non-seismic analysis was performed for DL+LL combination. The results were noted. Another analysis was done for seismic loads using various load combinations as per IS1893-2002 part I.

RESULTS

For the seismic analysis 1.5(DL+EQx) value was found to be critical.

Following graphs shows the comparision between the maximum values of results of non-seismic analysis and seismic analysis.

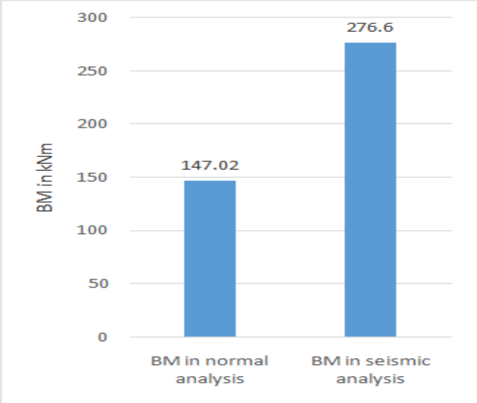

Figure 4: Comparison of Maximum Bending Moment in Members

From Figure 4 it is evident that the maximum bending moment in the members of building increased drastically when seismic forces were considered. This is due to the fact that equivalent lateral forces on the structure were applied to have the effect of ground shaking during earthquake. These forces are applied throughout the structure up to 17 floors. As the distance from the ground to point of application of lateral force increases, there is escalation in bending moment and shear at the bottom of the structure. Thus 46.84% of additional maximumBending Moment obtained in the members with earthquake load considered.

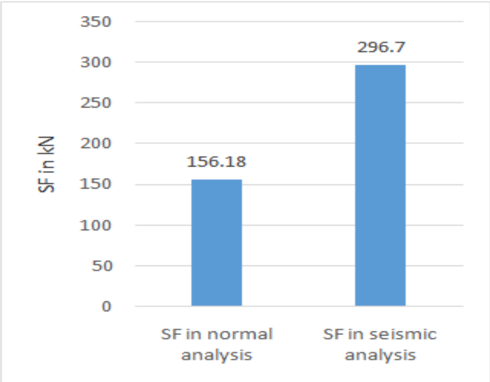

Figure 5: Comparison of Maximum Shear Force in Members

Similarly, in Figure 5 the shear force value in seismic analysis is higher by the same percentage as that of bending moment.

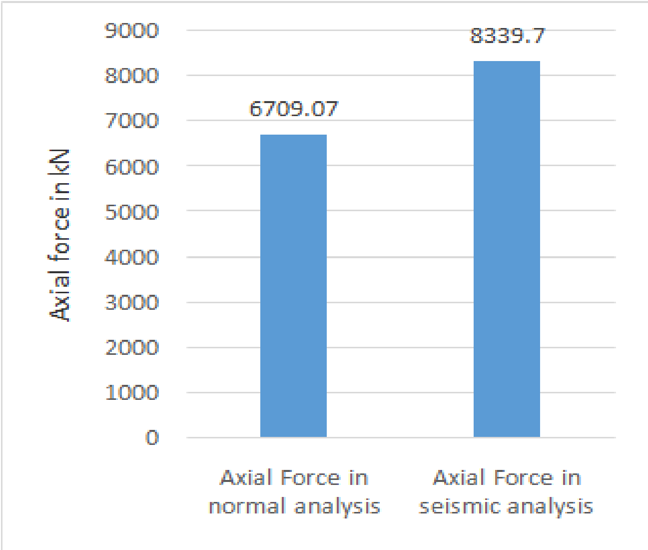

Figure 6: Comparison of Maximum Axial Force in Column

Figure 6 shows maximum axial forces in the columns. The axial force of seismic analysis is higher because of vibration in vertical direction caused during earthquake.

Table 1: Comparison of Maximum Displacement of Top Floor

Analysis	X-axis	Y-axis	Z-axis
Simple Analysis	0.85mm	1.2mm	44.5mm
Seismic Analysis	33.6mm	178.3mm	133.4mm

In Table 1, the maximum displacement of top floor of seismic analysis is very high as compared to non-seismic analysis. This signifies the importance of ductility of structure during earthquake. If the beam column joints are designed to be ductile, they have more capacity to absorb the forces generated during earthquake and vibration of the structure. So when earthquake strikes, these joints undergo significant displacements and absorb the forces. These displacements may cause some damage like cracks to the structure which can be repaired aftermath of an earthquake. In columns longitudinal reinforcement bars resist axial force and bending during earthquake. These bars should be uniformly distributed in all sides of the columns. It is much safe to use large number of small diameter bars instead of few bars of large diameters. If these principles are practiced during execution of work, building will sustain less damage.

CONCLUSIONS

Thus the analysis results were compared and it was concluded that themaximum moment and force values were drastically higher in the seismic analysis. Relevant design method should be adopted to satisfy additional seismic requirements of the structure. With early collaboration between architect and civil engineer during conceptualization phase and by choosing appropriate approach during construction, buildings can be designed to reduce damage to the structure during earthquake without much increase in cost of project.

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