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Seismic Analysis of Multistoried RCC Building frames in Zone V

Bhakti R. Kharwade(1), Rhishikesh D. Ingole(2),Krunal M. Nandagawali(3), Shital C. Patle(4)

Civil Engineering Department, ITM College of Engineering, Kamptee, Maharashtra, India

Abstract- *Earthquake resistant structures are structures designed to protect the buildings from earthquakes. While no structure can be entirely immune to damage from earthquakes, the goal of earthquake resistant construction is to erect a structure that fare better during seismic activity than their conventional counterparts. The analysis of a structure to determine the forces and deformations induced in RCC frames due to applied static loads such as dead load and live load and dynamic loads due to earthquake is a necessity in the design of an earthquake resistance structure. In this paper, the modeling and analysis of three structures are carried out with the help of SAP-2000 (v.16.0.0) software. For validation of SAP-2000 the comparison of manual analysis of Equivalent Static Method is made with SAP-2000 for base shear. The seismic loads are calculated as per the provisions in IS 1893: 2002. The main objective of this paper is to study the seismic behavior of RCC building with different heights.*

Keywords:-*Equivalent static method, SAP 2000, base shear.*

I. Introduction

An earthquake is the result of a sudden energy release in the earth's crust that creates seismic waves. The seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Earthquake has always been a threat to human civilization from the day of its existence, devastating human lives, property and man-made structures. It is such an unpredictable calamity that it is very necessary for survival to ensure the strength of the structures against seismic forces. Therefore there is continuous research work going on around the globe, revolving around development of new and better techniques that can be incorporated in structures for better seismic performance.

According to building codes, earthquake resistant structures are intended to withstand the largest earthquake of a certain probability that is likely to occur at their location. Earthquake causes random ground motions, in all possible directions emanating from the epicenter. Vertical ground motions are rare, but an earthquake is always accompanied with horizontal ground shaking. The ground vibration causes the structures resting on the ground to vibrate, developing inertial forces in the structure. Earthquake can cause generation of high stresses, which can lead to yielding of structures and large deformations, rendering the structure non-functional and unserviceable. There can be large storey drift in the building, making the building unsafe for the occupants to continue living there. Thus the seismic analysis of the building is a necessity to examine the deformations and lateral forces on the members of the building to study the effects of earthquake on the structure.

Methods of Analysis

a) Equivalent Static Method
b) Response Spectrum Method
c) Time History Analysis
d) Seismic coefficient method

II. Literature Review

Suchi Nag Choudhary, June 2017, analyzed a G+10 multistoried building in Zone V by using seismic coefficient method and response spectrum method. Seismic coefficient method analysis is done using manual calculation and Response spectrum method analysis is done using STAAD-PRO-V8i. It was concluded that SCM is a surmised approach as it take seismic load as static and RSM is more exact as it consider dynamic nature of seismic load. However SCM is simple to apply as contrast with RSM. The base shear for lower storey obtained from RSM was greater than that from SCM.

SakshiManchalwar, April 2016, carried out analysis on a 3 storey building with storey height 3m and having 4 bays of 5m each in X- direction and 3 bays of 5m each in Y- direction situated in Zone V. The analysis is done using response spectrum method in SAP-2000 software while for the manual calculations Equivalent static method was preferred. The results obtained from static analysis method showed lesser storey displacement values as compared to response spectrum analysis. It was observed that the displacement obtained by static analysis & was nearly equal to the results of dynamic analysis. It was conclude that static analysis is not sufficient for high-rise building and it is necessary to provide dynamic analysis.

Raghavendra Rao K., Aug 2016, considered a G+10 residential building with irregular mass in Zone II for the seismic analysis using response spectrum method. The results are compared with equivalent static method. The software ETABS 2015.0.0 was used. The total height of the building is 36m having 42 residential flats. Drift and displacement results obtained by ESA are greater than the results obtained by RSA. Also in ESA the storey drift is maximum at fourth storey where as in RSA it is maximum at third storey. The displacement was more in top storey. Storey shear is maximum at base.

AlhamdFarqaleet, Aug 2016, analyzed a 10 storey RCC building in SAP-2000 software considering the el centro earthquake 1940. After modelling, nonlinear time history analysis is performed using el centro time history. Maximum storey drift is found to be within permissible storey drift range as per IS 1893:2002. Time history analysis should be performed as it predicts the structural response more accurately than the response spectrum analysis.

R.Hymavathi, Feb-March 2017, comparatively studied the static and dynamic analysis of a G+10 RCC building due to earthquake. The software used for the analysis was ETABS. The load consideration was done using Indian building code (IS 875: part 1, 2, 3, 5). Firstly the building is analysed statically using equivalent static method and then dynamic analysis is done using response spectrum method. It was concluded that irregular shaped buildings undergo more deformation and hence regular shape building must be preferred. Also the static analysis is not sufficient for high rise buildings and it is necessary to provide dynamic analysis.

Objectives Of The Study

- To study the behavior of RCC frames of a building in Zone V
- To find the base shear for RCC building in different seismic zones

III. Methodology

Three models are prepared using SAP-2000 software and the manual calculations are done using Equivalent Static Method.

Equivalent Static Method :

a) Horizontal seismic coefficient

$A_h = \frac{Z\ I\ Sa}{2\ R\ g}$

where,

Z= zone factor given in table 2 (IS: 1893 Part 1- 2002) is for the Maximum Considered Earthquake and service life of structure.

I= importance factor depending upon the service life of the structure.

R= response reduction factor

S_a/g= average response acceleration coefficient

b) Seismic Base Shear (V_b):

$V_b = A_h W$

where,

A_h= design seismic coefficient at horizontal direction.

W= seismic weight of the building

c) Natural time period (T_a):

For reinforced concrete framed building

$T_a = 0.075\ h^{0.75}$

For steel framed building

$T_a = 0.085\ h^{0.75}$

where,

h = height of building

Analysis by SAP 2000 :
Three models have been prepared in SAP 2000. The description of the building is as follows,

Sr. No.	Particulars	Building 1	Building 2	Building 3
1	Plan Dimensions	12m × 3m	15m × 15m	18m × 15m
2	Height of building	18m	33m	48m
3	Grade of concrete	M20	M25	M25
4	Grade of steel	Fe415	Fe415	Fe415
5	Beam Size	0.30m × 0.45m	0.35m × 0.45m	0.35m × 0.45m
6	Column Size	0.35m × 0.5m	0.35m × 0.5m	0.35m × 0.5m
7	Soil Type	I	I	I
8	Seismic Zone	V	V	V

Table1. Building Description

The plans of the buildings as follows,
Building 1:

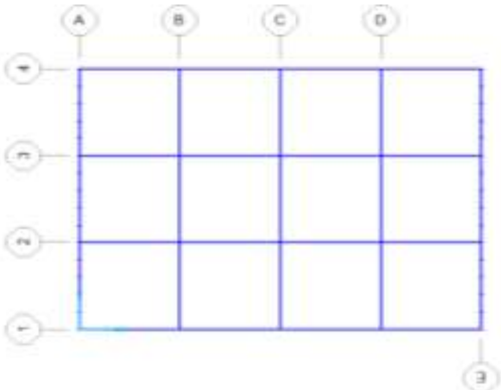

Figure1. Plan of G+5 building

Building 2:

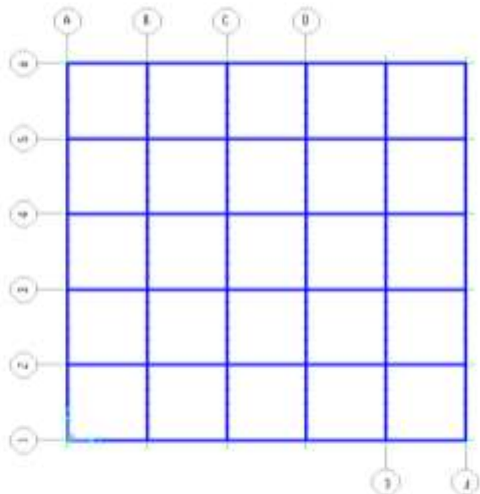

Figure2. Plan of G+10 building

Building 3:

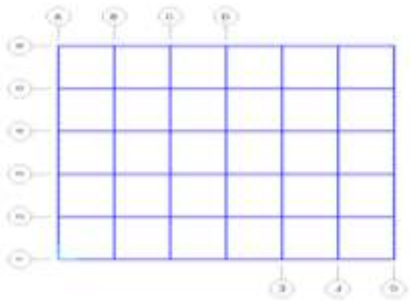

Figure3. Plan of G+15 building

IV. Results

The results obtained by analysis in SAP 2000 are tabulated as below:

Building 1:

Storey No.	Displacement (mm)	Storey Drift (mm)
0	0	0
1	0.542	0.542
2	1.372	0.83
3	2.207	0.835
4	2.958	0.751
5	3.545	0.587
6	3.903	0.358

Table2. Displacement and storey drift

Storey No.	Column Shear (KN)	Moments (KNm)
1	7.98	17.4757
2	6.426	10.2056
3	6.02	8.7577
4	5.239	7.0237
5	3.995	4.5341
6	0	0

Table3. Column Shear and Moments

Comparison of manual Base shear with Base shear obtained in SAP 2000:

Sr. No.	Manual Base Shear (KN)	Base Shear in SAP 2000 (KN)
1.	190.20	189.461

Table4. Comparison of Base Shear

Building 2:

Storey No.	Displacement (mm)	Storey Drift (mm)
0	0	0
1	0.6	0.6
2	1.509	0.909
3	2.464	0.955
4	3.425	0.961
5	4.371	0.946
6	5.283	0.912
7	6.134	0.851
8	6.899	0.765
9	7.546	0.647
10	8.043	0.497
11	8.375	0.332

Table 5. Displacement and Storey Drift

Storey No.	Column Shear (KN)	Moments (KNm)
1	10.351	22.0957
2	8.159	13.0884
3	7.838	12.0291
4	7.474	11.2607
5	7.066	10.4768
6	6.542	9.4984
7	5.859	8.2623
8	4.977	6.7045
9	3.84	4.7588
10	2.48	2.425
11	0.165	0

Table 6. Column Shear and Moments

Comparison of manual Base shear with Base shear obtained in SAP 2000:

Sr. No.	Manual Base Shear (KN)	Base Shear in SAP 2000 (KN)
1.	453.71	454.016

Table 7. Comparison of Base Shear

Building 3:

Storey No.	Displacement (mm)	Storey Drift(mm)
0	0	0
1	0.657	0.657
2	1.652	0.995
3	2.708	1.056
4	3.789	1.081
5	4.884	1.095
6	5.983	1.099
7	7.075	1.092
8	8.148	1.073
9	9.189	1.041
10	10.183	0.994
11	11.116	0.933
12	11.97	0.854
13	12.73	0.76
14	13.376	0.646
15	13.889	0.513
16	14.269	0.38

Table 8. Displacement and Storey Drift

Storey No.	Column Shear (KN)	Moments (KNm)
1	11.278	24.1397
2	8.717	14.0734
3	8.338	12.947
4	7.982	12.2448
5	7.672	11.6826
6	7.356	11.107
7	7.014	10.4891
8	6.629	9.7992
9	6.183	9.0104
10	5.658	8.0963
11	5.035	7.0303
12	4.296	5.7851
13	3.423	4.3336
14	2.386	2.6432
15	1.242	0.7407
16	0	0

Table 9. Column Shear and Moments

Comparison of manual Base shear with Base shear obtained in SAP 2000:

Sr. No.	Manual Base Shear (KN)	Base Shear in SAP 2000 (KN)
1.	585.093	585.192

Table 10. Comparison of Base Shear

V. Conclusion

From the results obtained the following conclusions can be made:

1. Manual and SAP result of base reaction of Equivalent Static method are approximately same as obtained in SAP 2000.
2. The maximum displacement is obtained at the top storey.
3. Maximum storey drift is obtained at third storey in G+5 building, at fourth storey in G+10 building and at sixth storey in G+15 building.
4. Story drift is increased as height of building increased.
5. Storey shear is maximum at base.
6. The calculations done manually and by software are nearly same hence we conclude that SAP software is beneficial for analysis of frames of building.

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