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Comparison of Earthquake Resistant Structure Using E-TABS Software and Manual Calculation

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ABSTRACT: - In the present day E-tabs software used for analysis and design of building especially reinforced cement concrete building. The project explain both the calculation and comparison between manual calculation and E-tabs software. Analysis is done with the help of equivalent static analysis methods per IS 13920:2016 and IS 1893(Part1):2016 guidelines. Total load of building and base shear calculated manual as well as E-tabs software.

Keywords: Analysis, E-tabs software, Load, Displacement.

I. INTRODUCTION

Earthquake causes shaking of the ground so because of this any structure on ground will experience certain movement at base. Slab connected to beam and beams connected to column so they also get affected by shaking which is cause due to earthquake. Seismic analysis is a part of structural analysis and it is the calculation of how a structure will respond during shaking ground. This create lateral load on building at its bottom and structure starts shaking and therefore it is required to consider various forces for analysis. Equivalent static analysis method is used for analysis and design for both the calculation. Therefore, it is necessary to evaluate these forces in order to design the structure capable of resisting these loads.

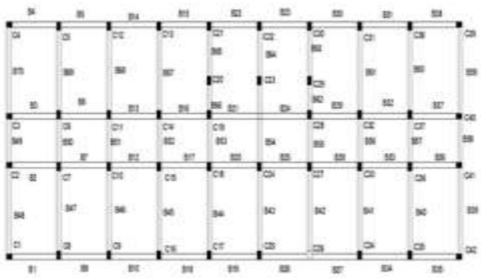
- Methods for analysis

1) Equivalent static analysis
2) Response spectrum analysis
3) Non-linear dynamic analysis
4) Non-linear static analysis
5) Time history method
6) Seismic coefficient method
7) Pushover analysis method

II. PROBLEM STATEMENT

Example: Seismic Analysis & Design of a G+9 Multi-Story Building.

Problem Statement: A G+9 multi-story RC building for an institutional building has plan dimensions the building is located in seismic zone III on a site with hard rock. Design the building for seismic loads as per IS: 1893 (Part 1): 2016.



Column Beam Plan of Building

Assumed preliminary data required for analysis frame

Types of structure	Multi-storey rigid jointed frame (special RC moment resisting frame)
Seismic zone	ZONE III (table 3, IS 1893 (part 1) 2016)
Number of storey	Ten (G + 9)
Floor height	3.5 m
Infill wall	250 mm thick
Imposed load	2 KN/M
Materials	Concrete M25 Reinforcement Fe 415
Size of column	First to third floor :450 x 600 mm Fourth to sixth floor : 350 x 500 mm Seventh to tenth floor : 250 x 400 mm
Size of beam	First to third floor :400x 600 mm Fourth to sixth floor : 300 x 450 mm Seventh to tenth floor : 230 x 350 mm
Depth of slab	100 mm thick
Specific weight of RCC	25 KN/M3
Specific weight of infill	20 KN/M3
Type of soil	Rocky soil

Step 1: calculation of lumped masses to various floor level of the earthquake forces shall be calculated for the full dead load plus the percentage of imposed load as given in given in table 8 of IS 1893 Part: 2016

The imposed load on roof is assumed to be zero

The lumped masses of each floor are worked as follows

• First to third floor

1) Mass of infill
= (((0.25x180x3.5) + (0.25x150x3.5)) 25)
= 5775 KN

2) Self-weight of slab
= 180x150x25x0.10
= 67500 KN

3) Self weight of column
= 42 (0.45 x0.6) x3.5 x25
= 992.25 KN

4) Self weight of beam
Horizontal = 38 (0.4 x 0.6) x 5 x25 = 1140
Vertical = 20 (0.4 x0.6) x 6x 25 = 720
10 (0.4 x 0.6) x3 x 25 = 180

5) Imposed load of floor
= (180 x 150 x2 x 0.5)
= 13500 KN

Total load of floor = 5775 + 67500 + 992.5 + 2040 + 13500
Total load = 89807.25 KN

• Fourth floor to sixth floor

1) Mass of infill
= (((0.25x180x3.5) + (0.25x150x3.5)) 25)
= 5775 KN

2) Self-weight of slab
= 180x150x25x0.10
= 67500 KN

3) Self weight of column
= 42 (0.35x0.5) x3.5 x25
= 643.125 KN

4) Self weight of beam
Horizontal = 38 (0.3 x 0.45) x 5 x25 =641.25
Vertical = 20 (0.3 x 0.45) x 6x 25 = 405
10 (0.3 x 0.45) x3 x 25 = 101.25

5) Imposed load of floor
= (180 x 150 x2 x 0.5)
= 13500 KN

Total load of floor = 5775 + 67500 + 367.5+684.24 + 13500
Total load = 87826.74 KN

• Seventh to tenth floor

1) Mass of infill
= (((0.25x180x3.5) + (0.25x150x3.5)) 25)
= 5775 KN

2) Self-weight of slab
= 180x150x25x0.10
= 67500 KN

3) Self weight of column
= 42 (0.25 x 0.4) x3.5 x25
=367.5 KN

4) Self weight of beam
Horizontal = 38 (0.23 x 0.35) x 5 x25 =382.37
Vertical = 20 (0.23 x 0.35) x 6x 25 = 241.5
10 (0.23 x 0.35) x3 x 25 = 60.37

5) Imposed load of floor
= (180 x 150 x2 x 0.5)
= 13500 KN

Total load of floor = 5775 + 67500 + 367.5+684.24 + 13500
Total load = 87826.74 KN

• Calculation of Roof

1) Mass of infill
= (((0.25x180x3.5/2) + (0.25x150x3.5/2))25)
=2887.5 KN

2) Self-weight of slab
= 180x150x25x0.10
= 67500 KN

3) Self weight of column
= 42 (0.25 x 0.4) x3.5/2 x25
=183.75 KN

4) Self weight of beam
Horizontal = 38 (0.23 x 0.35) x 5 x25 =382.37
Vertical = 20 (0.23 x 0.35) x 6x 25 = 241.5
10 (0.23 x 0.35) x3 x 25 = 60.37

5) Imposed load of floor
= Zero Total load of floor = 2887.5 + 67500 + 183.75+684.24
Total load = 71255.49 KN

• Seismic weight of building

Seismic weight of all floors
= 89810 X 3 + 88566 X 3 + 87827 X 3 + 71256
= Final load = 869865 KN

NOTE: the seismic weight of each floor is its full dead load plus appropriate amount of imposed load.

As specified in clause 7.3.1 and 7.3.2 IS 1893 (Part) 2016

Any weight supposed in between stories shall be distributed to the floor above and below in inverse proportion to its distance from the floors

Step 2: Determination of fundamental natural period

The approximate fundamental natural period of a vibration (Ta) in seconds of a moment resisting frame building without brick infill panels may be estimated by empirical expression.

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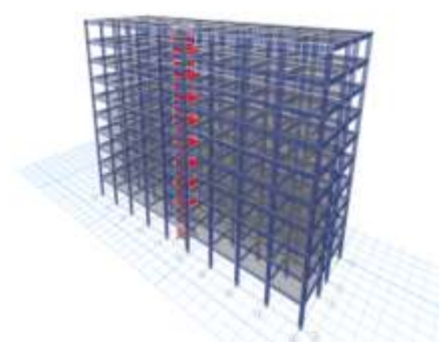
Ta= 0.075 X h^0.75……………….. ..(Cl 7.6.2)
= 0.075 X 35 ^ 0.75
Ta = 1.079 sec

Step 3: Determination of design of base floor
Design of seismic base shear
Vb = Ah x W
Z = zone factor = 0.16 ………… . (Table no 3)
R = Response reduction factor = 5….. (Table no 9)
I = Importance factor = 1.5…….…… (Table no 8)
Sa/g= for rocky hard soil = 0.926. (From fig no 2A)
Ah = Z/2 X I/R X Sa/g..…. (Formula from cl 6.4.2)
Ah = 0.022
Design of seismic base shear
Vb = Ah x W
= 0.022 X 869865
Vb = 19137.03 KN
Total load = 88565.62 KN

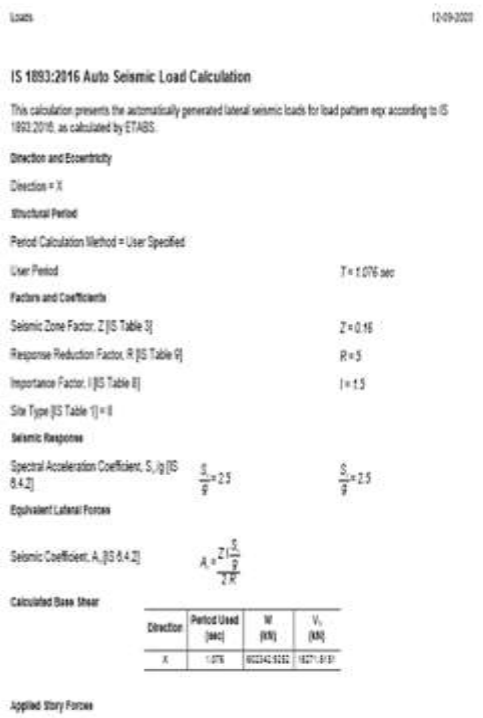
Step 4: Lateral distribution of various floors

Storey level	Wi (KN)	hi (KN)	(Wihi)^2	(Wihi)^2/Σ(Wihi)^2	Qi=Vb X (Wihi)^2/Σ(Wihi)^2
10	71256	35	872880.6 X 10^3	0.000998	187.35
9	87827	31.5	87146.34 X 10^3	0.000996	186.98
8	87827	28	68856.36 X 10^3	0.00078	146.43
7	87827	24.5	52718.15 X 10^3	0.00062	112.64
6	88566	21	39057.60 X 10^3	0.00044	82.66
5	88566	17.5	27123.33 X 10^3	0.00031	58.19
4	88566	14	13358.93 X 10^3	0.00015	28.16
3	89810	10.5	9901.55 X 10^3	0.00011	20.65
2	89810	7	4400.69 X 10^3	0.00005	9.38
1	89810	3.5	1100.17 X 10^3	0.000012	2.25
			Σ87448.76 X 10^6		

III.E-TABS ANALYSIS RESULTS



3-D View of the Model in E-Tabs



Loads 12-09-2020

IS 1893:2016 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern eqx according to IS 1893:2016, as calculated by ETABS.

Direction and Eccentricity

Direction = X

Structural Period

Period Calculation Method = User Specified

User Period T = 1.076 sec

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 3] Z = 0.16

Response Reduction Factor, R [IS Table 9] R = 5

Importance Factor, I [IS Table 8] I = 1.5

Site Type [IS Table 1] = II

Seismic Response

Spectral Acceleration Coefficient, S_a/g [IS 6.4.2] $\frac{S_a}{g} = 2.5$ $\frac{S_a}{g} = 2.5$

Equivalent Lateral Forces

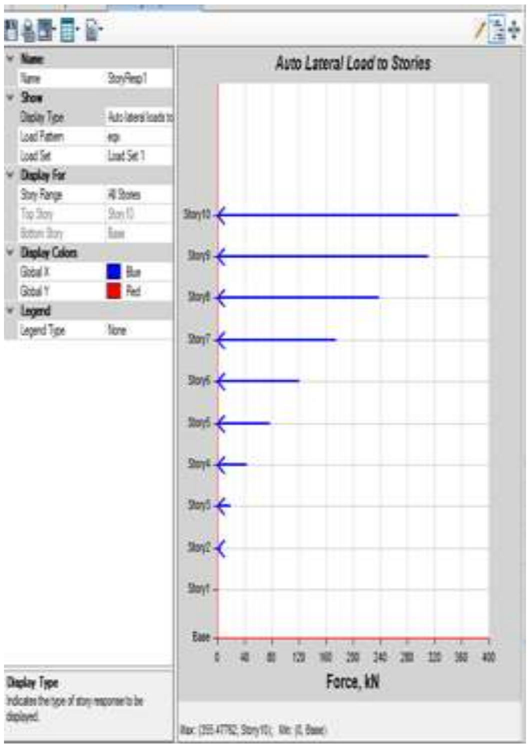
Seismic Coefficient, A_h [IS 6.4.2] $A_h = \frac{Z I \frac{S_a}{g}}{2R}$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
X	1.076	[illegible]	[illegible]

Applied Story Forces

Seismic Load Calculation



Lateral Load at Stories

IV. CONCLUSION

1) Value of design base shear by manual calculation is 19271.03 KN and in E-tabs software

is 18271.89 KN. Hence value obtained using E-tabs software is less than value obtained by manual calculations.

2) Analysis was done by using ETABS Software and manually as per IS 1893(part1):2016. The lateral load to stories obtained in both the cases are approximately same.

3) There is a gradual increase in the value of lateral forces from bottom floor to top floor in software analysis

4) Seismic weight of structure is approximately same in both cases.

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