# SEISMIC ASSESSMENT OF A BUILDING BY IS 1893-1984 (Criteria for Earthquake Resistant Design of Structure)

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**Abstract -** *Earthquake engineering is a branch of structural engineering in which the Design and Analysis of structures such as buildings, bridges, dams etc. is carried out by considering earthquake forces which are possibly going to act on structure. The main moto behind that design and analysis is, to make the structure more earthquake resistant. The structural engineer wants to design structure such that, it should not be damage by minor earthquake and should not be collapse by the highly intensive earthquake. In this paper IS 1893-1984 is preferred for analysis & Design by Etabs software*

***Key Words***: **Earthquake Engineering, Earthquake resistant, Minor & Intensive Earthquake, Etabs, IS-1893:1984.**

## 1.INTRODUCTION

Earthquake engineering is now widely preferring and developing since few decades because of the urbanization. There are also drastic changes going to made in Indian Standards due to change in the method of construction and climatic conditions. A large numbers of existing buildings are constructed from last few decades by referring IS codes which is latest while designing that building. But due to changes in the criteria and guidelines in current seismic code it is required to check whether that building is fulfilling all the possible guidelines as per current code or not. By comparing considered building with both old and current codal provisions, we can take the appropriate decision against the safety of that structure.

There Ground vibration due earthquake may cause forces & deformations in the structure. So it is required to design those structures by a standard procedure to withstand against earthquake effect without significant loss of life as well as property. These standard procedure is nothing but the Indian Standard Codes which will helps to the engineers for planning, designing, detailing and constructing the structure. The major aspects of IS codes are as follows-

1. Good structural configuration
2. Lateral strength
3. Adequate stiffness
4. Good ductility

Seismic codes are unique for every country as per there local seismology, method of construction and accepted level of seismic risk. The first Indian seismic code namely 1893 was published in 1962 then further it had been revised in years of 1966, 1970, 1975 and 1984.The said code is again revised in 2002 as a fifth revision after earthquake which was happened at Bhuj in 2001. Then after the latest revision of code is carried out in 2016 by BIS namely *"Criteria for Earthquake Resistant Design of structures (sixth revision)"*. IS 1893-2002 is further divided into five different parts as per the different types of structures but IS 1893-1984 contains provisions for all these structures in single document.

## 2. OBJECTIVE

For the project, the following objectives have been set.

a. To carry out modelling of Considered G+4 Public building by using ETABS software.
b. To Calculate earthquake forces using Equivalent Static Load Method & analysis.
c. To design the considered building using IS 1893-1984.

## 3. METHODOLOGY

Considered building properties are discussed below -

**Table -1:** Building Description

| | |
|---|---|
| Particulars | Reinforced concrete Building |
| Occupancy | Public building |
| Number of stories | (G+4) |
| Total height of building | 21.3 M |
| Ground floor height | 3.66 M |
| Intermediate floor height | 3.66 M |
| Nature of soil | Medium soil |
| Seismic zone | III |

**Table -2:** Member Dimensions

| | |
|---|---|
| Column Size | 230 x 450 MM<br>230 x 600 MM<br>230 x 750 MM |
| Beam size | 230 x 380 MM<br>230 x 450 MM<br>230 x 600 MM |
| Slab Thickness | 125 MM |
| External wall thickness | 230 MM |
| Internal wall thickness | 150 MM |

**Table -3:** Loading Considered

| | |
|---|---|
| Live load bank hall | 3KN/m² (IS 875 part2:1987) |
| Store Room | 5 KN/m² |
| Sunk load | 5 KN/m² |
| Pantry | 3 KN/m² |
| Floor finish Load | 1 KN/m² (IS875 part2:1987) |
| Staircase Load | 4 KN/m² |
| Lift Machine Room Load | 10 KN/m² |
| External Wall load | 13.28 KN/m |
| Internal wall Load | 8.66 KN/m |
| Papapet wall Load | 4.96 KN/m |

**Table -4:** Material Used

| | |
|---|---|
| Grade of concrete | M20 |
| Grade of steel | Fe-415 |
| Density of concrete | 25KN/m³(IS-875 part1:1987) |
| Density of Brick masonry | 18 KN/m³ |

## 4. SEISMIC LOAD CALCULATION (AS PER IS 1893-1984

**Total Column loads by analyzing ETABS model**

= 407.27 + 1019.65 + 824.68 + 662.697 + 673.01 + 777.78 + 876.44 + 2192.31 + 949.92 + 722.50 + 1029.91 + 1121.12 + 892.56 + 1136.19 + 996.83 + 1970.13 + 1715.96 + 1258.62

= 19955.46 KN

Design Seismic Base Shear (Vb):

Vb = K x C x αh x W……………….(Clause 4.2.1.1,page no. 21)

K=Performance Factor =1.6…………..(Table 5,page no. 24)

C = Coefficient defining the flexibility of structure with the increase in number of storeys depending upon fundamental time period T……..………..(Table 5,page no. 22)

αh = Design Seismic Coefficient…..(Clause3.4.2.3,page no. 16))

W = Total Dead load + Appropriate amount of Live load

**Along X direction-**

'C' depends on 'T'

$$T_x = \frac{0.09\,H}{\sqrt{d}}$$

$$T_x = \frac{0.09 \times 21.3}{\sqrt{15.25}}$$

$$T_x = 0.49\ sec$$

From Graph,

C = 0.8

$$\alpha h = \beta \times I \times F_o \times \frac{Sa}{g}$$

β = Coefficient depends on soil foundation system =1 ….(Table 3,page no. 19)

I = Importance Factor = 1.5.. (Table 4,page no. 19)

$F_o$ = Zone factor = 0.……. (Table2,page no. 16)

$\frac{Sa}{g}$ = Average acceleration Coefficien…..(Fig. 2 ,page no. 18)

From Graph, for 5% damping

$$\frac{Sa}{g} = 0.16$$

$$\alpha h = \beta \times I \times F_o \times \frac{Sa}{g}$$

$$\alpha h = 1 \times 1.5 \times 0.2 \times 0.16$$

$$\alpha h = 0.048$$

$Vb_x$ = K x C x αh x W

$Vb_x$ = 1.6 x 0.8 x 0.048 x 19455.46

**$Vb_x$ = 1195.34 KN**

**Along Y direction-**

'C' depends on 'T'

$$T_x = \frac{0.09\,H}{\sqrt{d}}$$

$$T_x = \frac{0.09 \times 21.3}{\sqrt{8.83}}$$

$$T_x = 0.645\ sec$$

From Graph,

C = 0.69

$$\alpha h = \beta \times I \times F_o \times \frac{Sa}{g}$$

β = Coefficient depends on soil foundation system =1 ....(Table 3,page no. 19)

I = Importance Factor = 1.5 ............ (Table 4,page no. 19)

$F_o$ = Zone factor = 0.2 ........................ (Table2,page no. 16)

$\frac{Sa}{g}$ = Average acceleration Coefficient.....(Fig. 2 ,page no. 18)

From Graph, for 5% damping

$$\frac{Sa}{g} = 0.14$$

$$\alpha h = \beta \times I \times F_o \times \frac{Sa}{g}$$

$$\alpha h = 1 \times 1.5 \times 0.2 \times 0.14$$

$$\alpha h = 0.042$$

$Vb_y$ = K x C x αh x W

$Vb_y$ = 1.6 x 0.69 x 0.042 x 19455.46

**$Vb_y$ = 902.110 KN**

## 5. Lateral Load Distribution with Height by the Static Method

| Storey Level | Wi | hi | $\frac{Wihi2}{\Sigma Wihi2}$ | Lateral Force in Direction X: Qi= $Vbx\frac{Wihi2}{\Sigma Wihi2}$ | Lateral Force in Direction Y: Qi=Vby $\frac{Wihi2}{\Sigma Wihi2}$ |
|---|---|---|---|---|---|
| 6 | 808.4 | 21.3 | 0.110 | 131.48 | 99.23 |
| 5 | 3654.22 | 18.3 | 0.368 | 439.88 | 331.97 |
| 4 | 4660.38 | 14.64 | 0.300 | 358.60 | 270.63 |
| 3 | 3795.47 | 10.98 | 0.137 | 163.76 | 123.58 |
| 2 | 4625.85 | 7.32 | 0.074 | 88.45 | 66.75 |
| 1 | 1910.78 | 3.66 | 0.0077 | 9.21 | 6.95 |

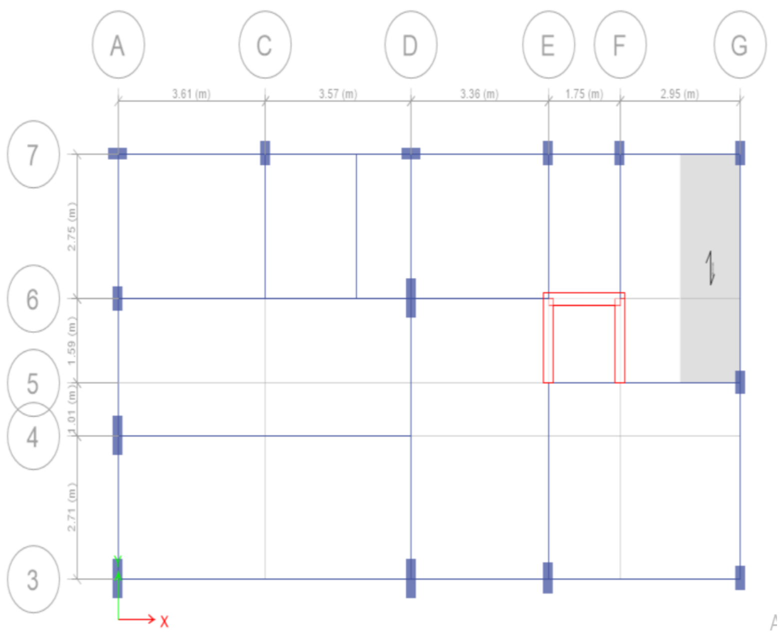


**Fig -1:** Plan of model using ETABS

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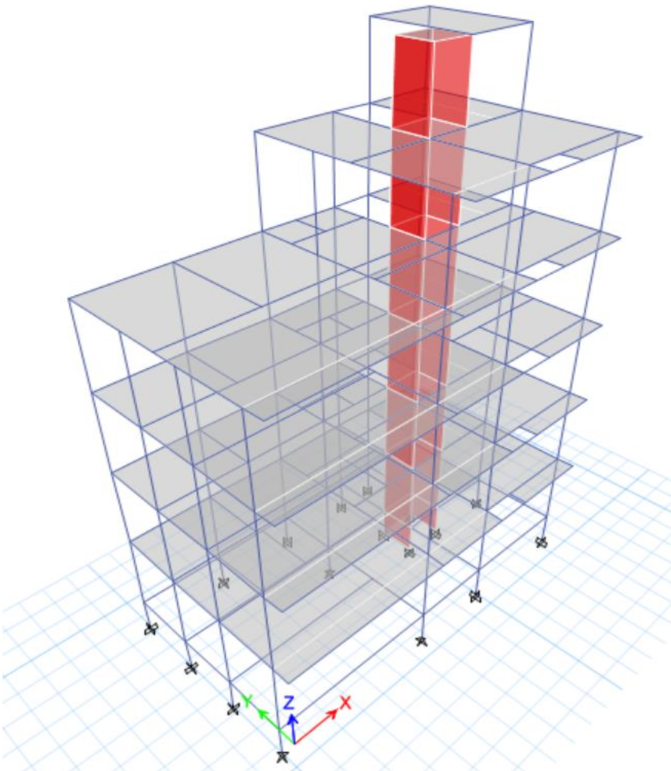
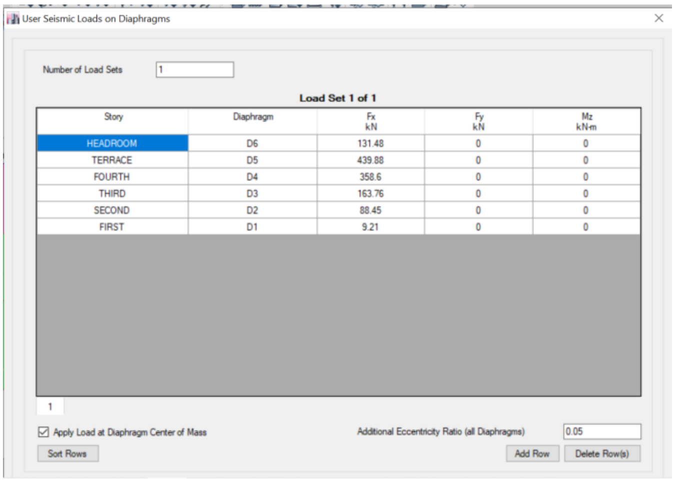



**Fig -2:** 3D view of model using ETABS



User Seismic Loads on Diaphragms

Number of Load Sets 1

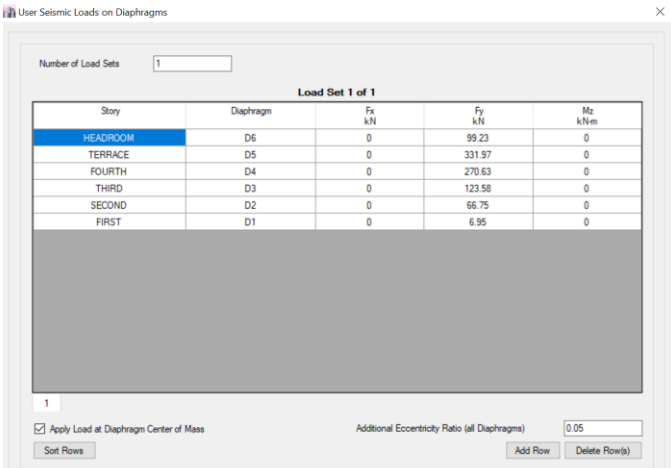
Load Set 1 of 1

| Story | Diaphragm | Fx kN | Fy kN | Mz kN-m |
|---|---|---|---|---|
| HEADROOM | D6 | 131.48 | 0 | 0 |
| TERRACE | D5 | 439.88 | 0 | 0 |
| FOURTH | D4 | 358.6 | 0 | 0 |
| THIRD | D3 | 163.76 | 0 | 0 |
| SECOND | D2 | 88.45 | 0 | 0 |
| FIRST | D1 | 9.21 | 0 | 0 |

Apply Load at Diaphragm Center of Mass — Additional Eccentricity Ratio (all Diaphragms) 0.05

Sort Rows — Add Row — Delete Row(s)

**Fig -3:** Application of lateral load in X direction



User Seismic Loads on Diaphragms

Number of Load Sets 1

Load Set 1 of 1

| Story | Diaphragm | Fx kN | Fy kN | Mz kN-m |
|---|---|---|---|---|
| HEADROOM | D6 | 0 | 99.23 | 0 |
| TERRACE | D5 | 0 | 331.97 | 0 |
| FOURTH | D4 | 0 | 270.63 | 0 |
| THIRD | D3 | 0 | 123.58 | 0 |
| SECOND | D2 | 0 | 66.75 | 0 |
| FIRST | D1 | 0 | 6.95 | 0 |

Apply Load at Diaphragm Center of Mass — Additional Eccentricity Ratio (all Diaphragms) 0.05

Sort Rows — Add Row — Delete Row(s)

**Fig -4:** Application of lateral load in Y direction

## 5. RESULTS

From above analysis procedure we got the design results is as follows-

1. Schedule of Footing

FOOTING SCHEDULE (M20:Fe415)

| FOOTING NUMBERS | COLUMN NUMBERS | FOOTING TYPE | FOOTING DIMENSION | | | FOOTING REINFORCEMENT | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | BOTTOM | | TOP | |
| | | | L | B | D1 | ALONG B | ALONG L | ALONG B | ALONG L |
| FC2 | C2 | Pad | 1250 | 1050 | 350 | T10@160 C/C | T10@175 C/C | T10@300 C/C | T10@300 C/C |
| FC17 | C17 | Pad | 1750 | 1550 | 500 | T12@125 C/C | T10@100 C/C | T10@295 C/C | T10@300 C/C |
| FC18 | C18 | Pad | 1650 | 1450 | 475 | T10@100 C/C | T10@105 C/C | T10@300 C/C | T10@290 C/C |
| FC6 | C6 | Pad | 1300 | 1100 | 350 | T10@130 C/C | T10@160 C/C | T10@300 C/C | T10@300 C/C |
| FC5 | C5 | Pad | 1400 | 1200 | 400 | T10@130 C/C | T10@150 C/C | T10@300 C/C | T10@300 C/C |
| FC7 | C7 | Pad | 1650 | 1450 | 475 | T10@100 C/C | T10@105 C/C | T10@300 C/C | T10@290 C/C |
| FC4 | C4 | Pad | 1750 | 1550 | 500 | T12@125 C/C | T10@100 C/C | T10@295 C/C | T10@300 C/C |
| FC16 | C16 | Pad | 2800 | 2300 | 800 | T16@160 C/C | T16@165 C/C | T10@170 C/C | T10@165 C/C |
| FC12 | C12 | Pad | 1950 | 1750 | 575 | T12@120 C/C | T12@120 C/C | T10@245 C/C | T10@250 C/C |
| FC3 | C3 | Pad | 2150 | 1650 | 550 | T12@120 C/C | T12@140 C/C | T10@240 C/C | T10@275 C/C |
| FC1 | C1 | Pad | 2000 | 1500 | 500 | T12@145 C/C | T10@100 C/C | T10@290 C/C | T10@300 C/C |
| FC15 | C15 | Pad | 2750 | 2250 | 775 | T16@165 C/C | T16@175 C/C | T10@175 C/C | T10@175 C/C |
| FC14 | C14 | Pad | 2350 | 2000 | 650 | T16@170 C/C | T12@100 C/C | T10@215 C/C | T10@225 C/C |
| FC13 | C13 | Pad | 2000 | 1800 | 600 | T12@115 C/C | T12@120 C/C | T10@225 C/C | T10@225 C/C |

2. Schedule of Column

| COLUMN NO. | | C1 | C2 | C3 |
|---|---|---|---|---|
| M20 | SIZE | 230 X 750 | 230 X 450 | 230 X 600 |
| | STEEL | 16-#20 | 8-#20 | 8-#20 + 4-#16 |
| Fe415 | LINKS | #8@225 C/C | #8@225 C/C | #8@225 C/C |

3. Schedule of Beam

BEAM SCHEDULE (M20:Fe415)

| SIZE | | BOTTOM REINFORCEMENT | | | TOP REINFORCEMENT | | | SHEAR STIRRUPS | | |
|---|---|---|---|---|---|---|---|---|---|---|
| B | D | LEFT | MID SPAN | RIGHT | LEFT | MID SPAN | RIGHT | LEFT | MID SPAN | RIGHT |
| 230 | 380 | 2-#16 | 3-#16 | 2-#16 | 2-#12 | 2-#12 | 2-#12 | 2L-#8@285 C/C | 2L-#8@285 C/C | 2L-#8@285 C/C |
| 230 | 600 | 3-#16 | 3-#16 + 3-#16 | 3-#16 | 3-#16 | 3-#12 | 3-#16 + 3-#16 | 2L-#8@185 C/C | 2L-#8@300 C/C | 2L-#8@180 C/C |
| 230 | 450 | 2-#16 | 2-#16 | 2-#16 | 3-#12 | 3-#16 + 2-#12 | 3-#16 | 2L-#8@300 C/C | 2L-#8@150 C/C | 2L-#8@150 C/C |
| 150 | 230 | 2-#12 | 2-#12 | 2-#12 | 2-#12 | 2-#12 | 2-#12 | 2L-#8@170 C/C | 2L-#8@170 C/C | 2L-#8@170 C/C |

4. Schedule of slab

SLAB SCHEDULE (M20 : FE415)

| SLAB THICKNESS | BOTTOM REINFORCEMENT | | TOP REINFORCEMENT | | | | |
|---|---|---|---|---|---|---|---|
| | ALONG SHORT SPAN | ALONG LONG SPAN | OVER LONG SUPPORT | | OVER SHORT SUPPORT | | DISTRIBUTION |
| | FULL LENGTH | FULL LENGTH | CONTINUOUS SUPPORT | END SUPPORT | CONTINUOUS SUPPORT | END SUPPORT | |
| 125 | T8 @ 300 C/C | T8 @ 300 C/C | T8 @ 300 C/C | T8 @ 300 C/C | --- | T8 @ 300 C/C | T8 @ 300 C/C |
| 125 | T8 @ 300 C/C | T8 @ 300 C/C | T8 @ 300 C/C | T8 @ 300 C/C | T8 @ 300 C/C | T8 @ 300 C/C | T8 @ 300 C/C |
| 125 | T8 @ 225 C/C | T8 @ 225 C/C | T8 @ 225 C/C | T8 @ 225 C/C | T8 @ 225 C/C | T8 @ 225 C/C | T8 @ 225 C/C |
| 125 | T8 @ 300 C/C | T8 @ 300 C/C | T8 @ 300 C/C | --- | T8 @ 300 C/C | --- | T8 @ 300 C/C |
| 125 | T8 @ 300 C/C | T8 @ 300 C/C | T8 @ 300 C/C | --- | T8 @ 300 C/C | T8 @ 300 C/C | T8 @ 300 C/C |
| 125 | T8 @ 300 C/C | T8 @ 300 C/C | T8 @ 245 C/C | --- | --- | T8 @ 300 C/C | T8 @ 300 C/C |
| 125 | T8 @ 200 C/C | T8 @ 270 C/C | T8 @ 150 C/C | T8 @ 300 C/C | T8 @ 200 C/C | T8 @ 300 C/C | T8 @ 300 C/C |
| 125 | T8 @ 300 C/C | T8 @ 300 C/C | T8 @ 265 C/C | --- | --- | T8 @ 300 C/C | T8 @ 300 C/C |
| 125 | T8 @ 155 C/C | T8 @ 300 C/C | T8 @ 130 C/C | T8 @ 300 C/C | --- | T8 @ 300 C/C | T8 @ 300 C/C |

## 6. CONCLUSIONS

1. In ETABS 17 IS 1893-1984 is not available so the earthquake forces are calculated manually and applied in software as a user defined forces.
2. The lateral forces calculated by equivalent static load method in X & Y direction shows lesser value at upper most story i.e. at headroom compare to below stories but from first story to fifth story it increases gradually.
3. ETABS software is easy for model making also for assign various loads and easy to apply earthquake user defined forces.

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