



## Design and analysis ten storied building using ETABS software-2016

Ali Kadhim Sallal

Department of Hydraulic Structures, College of Water Resource Engineering, Iraq

### Abstract

ETABS software stands for extended three dimensional analysis of building systems. The main purpose of this software is to design and analysis multi-Storeyed building in a systematic process. This paper present a building where designed and analyzed under effect of earthquake and wind pressure by using ETABS software. In this case, (18m x 18m) and eight stories structure are modeled using ETABS software. Ten story is taken as (3m) height and making the total height of the structure (31m).

**Keywords:** ETABS software, building systems, designed and analyzed

### 1. Introduction

The effective design and construction of earthquake resistant structures have much greater importance in all over the world therefore engineers are trying to use different materials to their best advantage keeping in view the unique properties of each material structurally robust and aesthetically pleasing building are being constructed by combining the best properties at individual material and at the same time meeting the specific requirements of large span, building load, soil condition, time, flexibility and economy high rise buildings are best suited solution.

### 2. Literature Survey

**Structural Analysis of a Multi-Storeyed Building using ETABS for different Plan Configurations [1].** {Abhay Guleria}

In this paper, the case study mainly emphasizes on structural behavior of multi- story building for different plan configurations like rectangular, C, L and I-shape. Modeling of 15- story R.C.C. framed building is done on the ETABS software for analysis. Post analysis of the structure, maximum shear forces, bending moments and maximum story displacement are computed and then compared for all the analyzed cases.

### Conclusions

1. The analysis of the multi-Storeyed building reflected that the story overturning moment varies inversely with story height. Moreover, L-shape, I-shape type buildings give almost similar response against the overturning moment.
2. Story drift displacement increased with story height up to 6th story reaching to maximum value and then started decreasing.
3. From dynamic analysis, mode shapes are generated and it can be concluded that asymmetrical plans undergo more deformation than symmetrical plans.

### Design and Analysis of Multi-Storeyed Building Under Static and Dynamic Loading Conditions Using ETABS.

{Balaji.U. A, Mr. Selvarasan M.E. B}

In this work a residential of G+13 multi-story building is studied for earthquake loads using ETABS software. Assuming that material property is linear static and dynamic analysis are performed. These non-linear analysis are carried out by considering severe seismic zones and the behavior is assessed by taking types II soil condition. Different response like, displacements, base shear are plotted.

### Conclusions

1. From this work, it's observed that, in first five stories, the difference between the results obtained with different methods is insignificant.
2. It's observed that, the maximum displacement is increasing from first storey to last one.
3. The maximum displacement of center of mass, obtained by time history analysis for both earthquakes.

### Seismic Analysis of Multistoried Building, {Mahesh N.

Patil, Yogesh N. Sonawane}: In this paper, the earthquake response of symmetric multistoried building is studied by manual calculation and with the help of ETABS 9.7.1 software. The method includes seismic coefficient method as recommended by IS 1893:2002. The responses obtained by manual analysis as well as by soft computing are compared. This paper provides complete guide line for manual as well as software analysis of seismic coefficient method.

### Conclusions

1. Seismic analysis was done by using ETABS software and successfully verified manually as per IS 1893-2002.
2. There is a gradual increase in the value of lateral forces from bottom floor to top floor in both manual as well as software analysis

3. There is slight variation in the values of base shear in manual analysis as well as software analysis
4. Base shear values obtained by manual analysis are slightly higher than software analysis.

**Procedure for Analysis and Design Building by Etabs**

**Step 1: Step by Step procedure for ETABS Analysis:**

The procedure carried out for Modeling and analyzing the structure involves the following flow chart.

**Step 2: Create the Grid points and Generation of structure**

After getting opened the program, select a new model and a window appears where we had entered the details of grid dimensions and story dimensions of our building. Here the program had generated 2D and 3D structure by specifying the building details in the following two windows.

**Step 3: Define property**

After created the grids, start to define the material property by selecting define menu → material properties (define concrete and steel reinforcements). After that define section properties (beams, columns, slabs, and wall) by giving the specified details in defining. After that we define section size by selecting frame sections as shown below and added the required section for beams, columns etc.

**Step 4: Assigning of Property**

After defining the property for materials and section properties, now draw the structural components using command menu → Draw line for beam and create columns in region for columns by which property assigning is completed for beams and columns sections.

**Step 5: Assigning of Supports**

After drawing the details of building (beams, columns, slabs, wall), now assigned the supports by going to assign menu → joint/frame → Restraints (supports) → fixed.

**Step 6: Defining of loads**

The loads in ETABS program are defined as using static load cases command in define menu

**Step 7: Assigning of Dead loads**

After defining all the loads, dead loads are assigned for external walls and internal walls

**Step 8: Assigning of Live loads**

Live loads are assigned for the entire structure including floor finishing.

**Step 9: Assigning of wind loads**

Wind loads are defined and assigned as per IS 875 1987 PART 3 (Indian code) by giving the value of wind speed and wind angle in X,X1,Z & Z1 directions as 0, 180, 90, 270 respectively

**Step 10: Assigning of Seismic loads**

Seismic loads are defined and assigned as per IS 1893: 2002

(Indian code) by giving the details of zone, soil type, and response reduction factor in X and Y directions

**Step 11: Assigning of load combinations**

Load combinations are given based on IS 875 1987 PART 5 (Indian code) using load combinations command in define menu

**Step 12: Analysis**

After the completed all the above steps, now performed the analysis and check all the errors.

**Step 13: Design**

This step consider the last step of procedure. After completed the analysis, now performed concrete design on the structure as per IS 456: 2000 (Indian code). For this go to Design menu → concrete design → select design combinations. After this again go to design menu → concrete frame design → start design \ check of structure then ETABS performs the design for every structural element.

**3. Problem Definition**

**A. Preliminary Data**

**Table 1:** Preliminary Data

Length x Width	18m * 18m
Number of Storeys	10
Number of Beams	12
Size of Beam	30cm * 60cm
Number of columns in (8-9-10) storey	16
Number of columns in (7-6-5-4-3-2-1) storey	15
Size of Column	50cm * 50cm
Slab Thickness	15cm
Support Condition	Fixed
Thickness External Wall	20 cm
Grade of Concrete and Steel	M-27.59 Fe-380
Length of each bay	6 m

**Table 2:** Details of Codes

Steel Frame Preferences	IS 800 - 2007
Concrete Frame Preferences	IS 456 - 2000
Shear Wall Preferences	IS 456 - 2000
Composite Beam Preferences	AISC 360 - 10
Composite Column Preferences	AISC 360 - 10

**4. Story Data**

**Table 3:** Story Data

Name	Height m	Elevation m	Master Story	Similar To
Story10	3	31	Yes	None
Story 9	3	28	No	Story10
Story 8	3	25	No	Story10
Story 7	3	22	Yes	None
Story 6	3	19	No	Story7
Story 5	3	16	No	Story7
Story 4	3	13	No	Story7
Story 3	3	10	No	Story7
Story 2	3	7	No	Story7
Story 1	4	4	No	Story7
Base	0	0	No	None

**Table 4:** Frame Sections – Summary

Name	Material	Shape
Beam 30*60	concrete	concrete rectangular
column 50*50	concrete	concrete rectangular

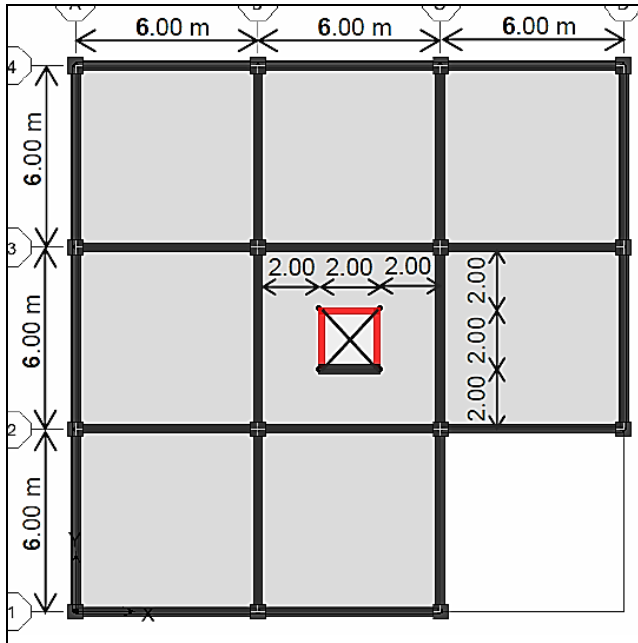
**Table 5:** Grid Lines

Grid System	Grid Direction	Grid ID	Visible	Ordinatem
G1	X	A	Yes	0
G1	X	B	Yes	6
G1	X	C	Yes	12
G1	X	D	Yes	18
G1	Y	1	Yes	0
G1	Y	2	Yes	6
G1	Y	3	Yes	12
G1	Y	4	Yes	18

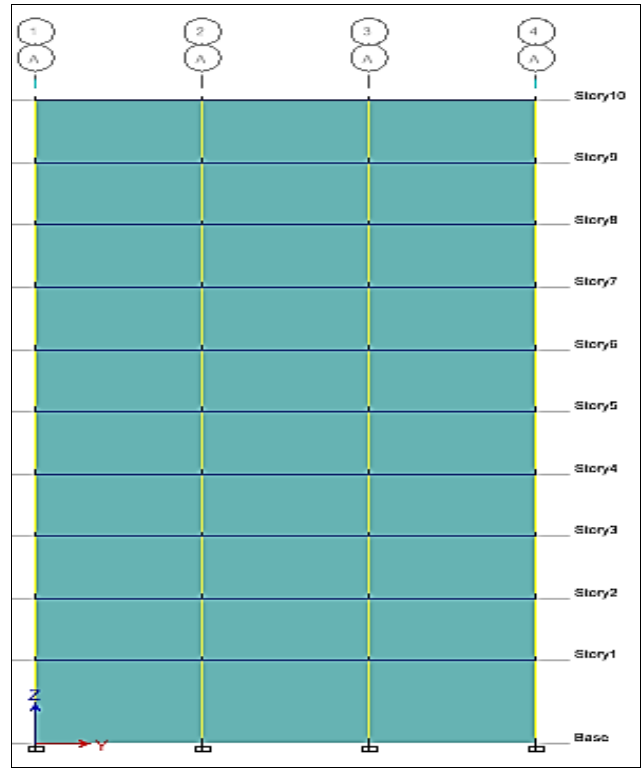
**Table 6:** Reinforcing Bar Sizes

Name	Diameter mm	Area mm <sup>2</sup>
10	10	79
18	18	255
20	20	314

**5. Actual Analysis**



**Fig 1:** plan of the structure



**Fig 2:** Elevation of structure

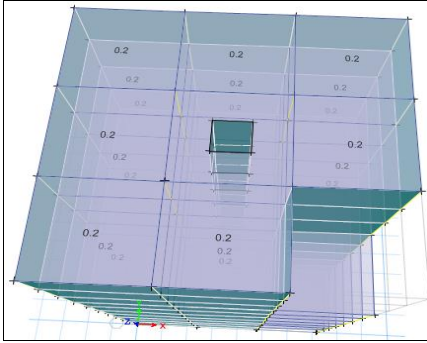
**A. Loading Consideration**

Loads acting on the structure are dead load (DL), Live Load (LL), Earthquake Load (EL) and wind load (WL)

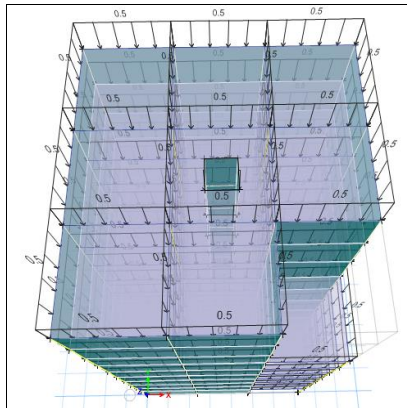
**Table 7:** Loading Consideration

Details of dead load (D.L)	
D.L on Floors	0.2 ton/m <sup>2</sup>
D.L on Beams	0.5 ton/m <sup>2</sup>
Details of live load (L.L)	
L.L Reduction Factor	UBC97
L.L on Floors	0.25 ton/m <sup>2</sup>
Details of wind load (W.L)	
Wind Speed	90 mph
Exposure Type	B (Suburban area)
Importance Factor	1 (Building normal importance)
Details of Earthquake load (E.L)	
Seismic Group	I
Seismic Coefficient	Per code
Site Class	E
Response Acceleration Ss	0.45
Response Acceleration S1	0.18
Response Modification R	5.5
Time Period	1.47 sec

**B -Details of Load**



**Fig 3:** Details OF D.L on Shells



**Fig 4:** details OF L.L on beams

**Table 8:** load patterns

Name	Type	Self-Weight Multiplier	Auto Load
Dead	Dead	1	
Live	Reducible Live	0	
WIND-X	Wind	0	UBC 97
WIND-Y	Wind	0	UBC 97
EQ-XA	Seismic	0	NEHRP 97
EQ-XB	Seismic	0	NEHRP 97
EQ-YA	Seismic	0	NEHRP 97
EQ-YB	Seismic	0	NEHRP 97

**Table 9:** axial force and biaxial moment design ( $p_u, m_{u2}, m_{u3}$ ) for columns in storey 10

Design $P_u$ tonf	Design $M_{u2}$ ton f-m	Design $M_{u3}$ tonf-m	Minimum M2 tonf-m	Minimum M3 tonf-m	Rebar Area $m^2$	Rebar %
14.6495	3.3764	5.4551	0.443	0.443	0.0025	1

**Table 10:** Design moment and flexural reinforcement for moment, ( $m_{u3}$ ) for beam in storey 10

	Design-Moment tonf-m	Design + Moment tonf-m	- Moment Rebar $m^2$	+ Moment Rebar $m^2$	Minimum Rebar $m^2$	Required Rebar $m^2$
Top (+2 Axis)	-9.0228		0.000451	0	0.00054	0.00054
Bottom (-2 Axis)		4.5114	0	0.000223	0.000297	0.000297

**A1- Auto Wind Loading**

**UBC-97/ Auto Wind Load Calculation**

**For WIND – X**

This calculation presents the automatically generated lateral wind loads for load pattern WIND-X according to UBC 97, as calculated by ETABS.

**Exposure Parameters**

Exposure From = Shell Objects

Exposure Type = Exposure B

Top Story = Story10, Bottom Story = Base

Include Parapet = No

**Factors and Coefficients**

Importance Factor,  $I_w = 1$

**Lateral Loading**

**Wind Stagnation Pressure,**

$$q_s = 0.00256 V^2 \geq 10\text{psf}$$

$$q_s = 20.736$$

Design Wind Pressure, P

$$P = C_e C_q q_s I_w$$

**4.3 Auto Seismic Loading**

**NEHRP 97 Auto Seismic Load Calculation**

This calculation presents the automatically generated lateral seismic loads for load Pattern EQ-XA according to NEHRP 97, as Calculated by ETABS.

**Direction and Eccentricity**

Direction = X + Eccentricity Y

Eccentricity Ratio = 5% for all diaphragms

**Structural Period**

Period Calculation Method = User Specified

User Period  $T = 1.47 \text{ sec}$

**Factors and Coefficients**

Response Modification Factor,  $R = 5.5$

Seismic Group = I, Site Class = E

Response Acceleration,  $S_s = 0.45$

Response Acceleration,  $S_1 = 0.18$

Site Coefficient,  $F_a = 1.86$

Site Coefficient,  $F_v = 3.26$

**Seismic Response**

MCE Spectral Response Acceleration,  $S_{MS} S_{MS} = F_a S_s$ ,  $S_{MS} = 0.837g$

MCE Spectral Response Acceleration,  $S_{M1} S_{M1} = F_v S_1$ ,  $S_{M1} = 0.5868g$

Design Spectral Response Acceleration,  $S_{DS} S_{DS} = \frac{2}{3} S_{MS}$ ,  $S_{DS} = 0.558g$

Design Spectral Response Acceleration,  $S_{D1} S_{D1} = \frac{2}{3} S_{M1}$ ,  $S_{D1} = 0.3912g$

**Table 11:** Shell Loads - Uniform

Story	Label	Unique Name	Load Pattern	Load tonf/m <sup>2</sup>
S 10	F2	51	D.L	0.2
S 10	F3	52	D.L	0.2
S 10	F4	53	D.L	0.2
S 10	F5	54	D.L	0.2
S 10	F6	55	D.L	0.2
S 10	F7	56	D.L	0.2
S 10	F9	58	D.L	0.2
S 10	F10	59	D.L	0.2
S 9	F2	60	D.L	0.2
S 9	F3	61	D.L	0.2
S 9	F4	62	D.L	0.2
S 9	F5	63	D.L	0.2
S 9	F6	64	D.L	0.2
S 9	F7	65	D.L	0.2
S 9	F9	67	D.L	0.2
S 9	F10	68	D.L	0.2
S 8	F2	69	D.L	0.2
S 8	F3	70	D.L	0.2
S 8	F4	71	D.L	0.2
S 8	F5	72	D.L	0.2
S 8	F6	73	D.L	0.2
S 8	F7	74	D.L	0.2
S 8	F9	76	D.L	0.2
S 8	F10	77	D.L	0.2
S 7	F1	4	D.L	0.2
S 6	F1	5	D.L	0.2
S 5	F1	6	D.L	0.2
S 4	F1	7	D.L	0.2
S 3	F1	8	D.L	0.2
S 2	F1	9	D.L	0.2
S 1	F1	10	D.L	0.2
S 10	F2	51	L.L	0.25
S 10	F3	52	L.L	0.25
S 10	F4	53	L.L	0.25
S 10	F5	54	L.L	0.25
S 10	F6	55	L.L	0.25
S 10	F7	56	L.L	0.25
S 10	F9	58	L.L	0.25
S 10	F10	59	L.L	0.25
S 9	F2	60	L.L	0.25
S 9	F3	61	L.L	0.25
S 9	F4	62	L.L	0.25
S 9	F5	63	L.L	0.25
S 9	F6	64	L.L	0.25
S 9	F7	65	L.L	0.25
S 9	F9	67	L.L	0.25
S 9	F10	68	L.L	0.25
S 8	F2	69	L.L	0.25
S 8	F3	70	L.L	0.25
S 8	F4	71	L.L	0.25
S 8	F5	72	L.L	0.25

S 8	F6	73	L.L	0.25
S 8	F7	74	L.L	0.25
S 8	F9	76	L.L	0.25
S 8	F10	77	L.L	0.25
S 7	F1	4	L.L	0.25
S 6	F1	5	L.L	0.25
S 5	F1	6	L.L	0.25
S 4	F1	7	L.L	0.25
S 3	F1	8	L.L	0.25
S 2	F1	9	L.L	0.25
S 1	F1	10	L.L	0.25

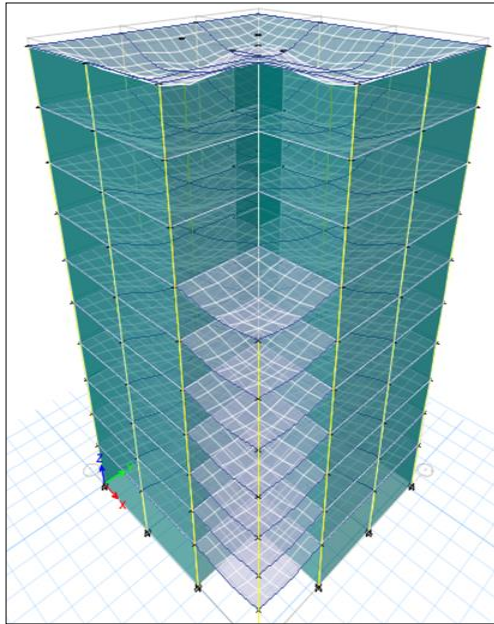


Fig 5: Shape of B.M Failure Due To D.L

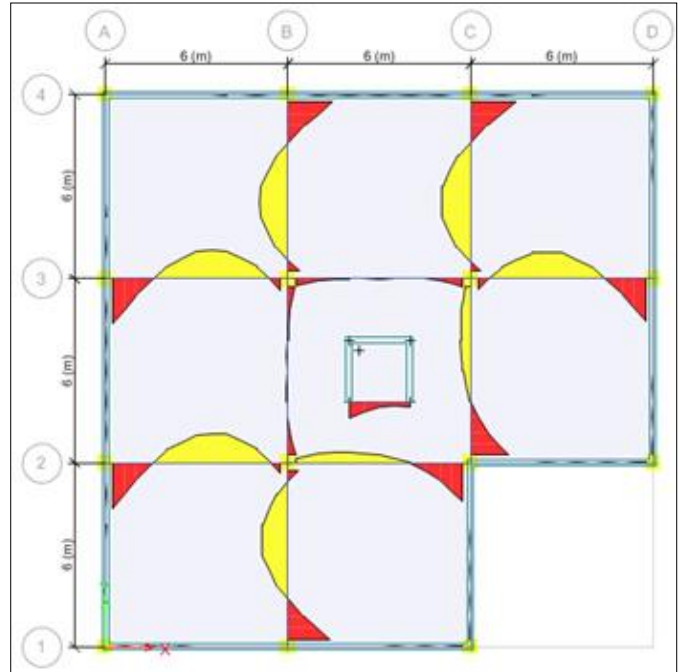


Fig 7: Showed B.M Due To D.L

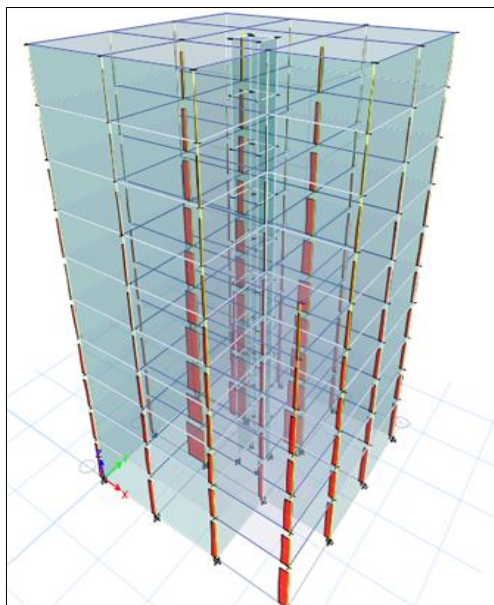


Fig 6: Showed axial load due to d.l

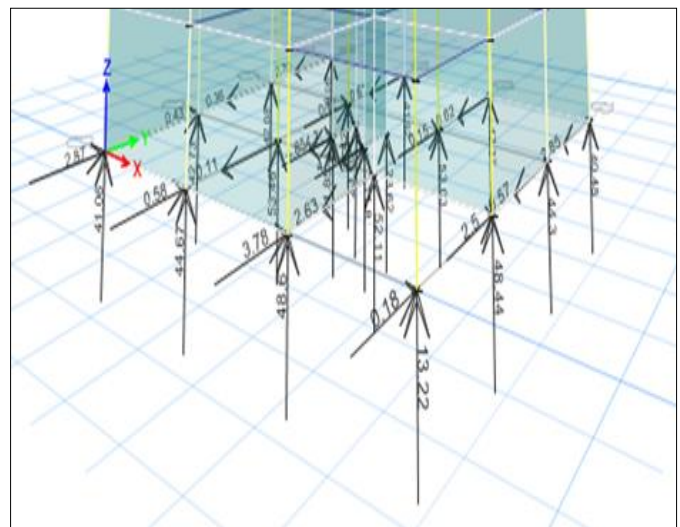


Fig 8: Showed Reactions Due TO L.L (FY-FZ)

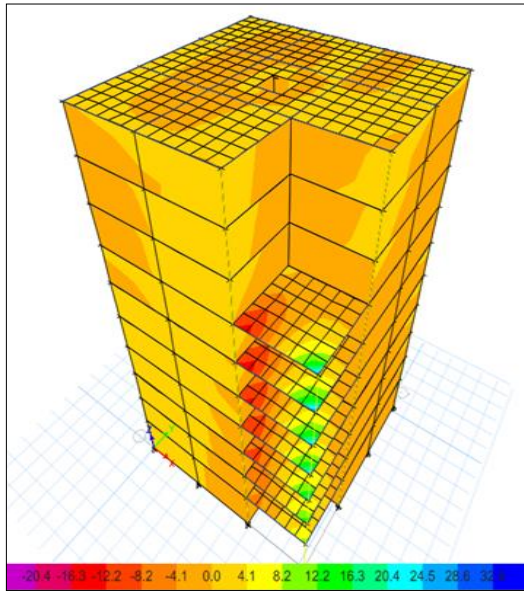


Fig 9: Showed shear stress due to wind-x load at top face

**6. ETABS Shear Wall Modeling**

In ETABS shear wall design is available for objects that are defined as piers and spandrels by the user. One must assign a pier or spandrel element a label before he can get output forces for the element or before one can design the element.

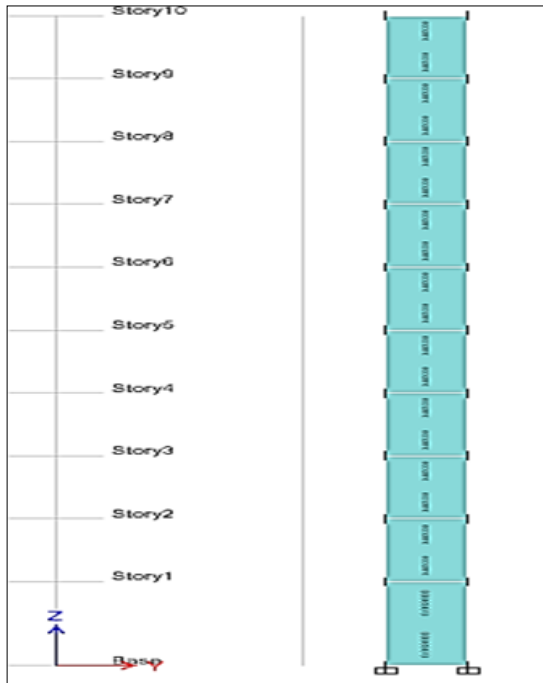


Fig 10: Shear wall design

Table 12: Shear Design for Shear Wall

Station Location	ID	Rebar m2/m	Pu tonf	Mu Tonf.m	Vu Tonf	Ø Vu Tonf	Ø Vn Tonf
Top	Leg 1	0.0005	9.69	-10.66	12.02	36.67	61.98
Top	Leg 2	0.0005	10.85	-7.27	9.80	36.84	62.15
Top	Leg 3	0.0005	15.65	-20.99	18.46	37.56	62.87
Bottom	Leg 1	0.0005	13.43	25.42	12.02	33.26	58.57
Bottom	Leg 2	0.0005	14.60	22.13	9.80	30.40	55.71
Bottom	Leg 3	0.0005	19.4	34.41	18.46	38.12	63.43

Table 13: flexural design for (pu, mu2, mu3) for shear wall

Station Location	Required Rebar Area (m2)	Required Rein Area (m2)	Current Rein Area (m2)	Pu Tonf	Mu2 Ton f.m	Mu3 Ton f.m	Pier Ag m2
Top	0.003	0.0025	0.0085	28.59	3.68	-0.24	1.2
Bottom	0.003	0.0025	0.0085	35.51	59.30	3.50	1.2

**7. Conclusions**

1. The value of dead, live and floor finish loads obtained by the ETABS program are similar to the manually calculated values
2. The analysis results of the structural integrity of building in withstanding the design earthquake loadings was conducted and was judged to be safe.
3. Various important results like bending moments, shear force and deflection results are similar to the manually calculated values.

**8. Scope for Further Study**

This experimental work was carried out on a building of 10 Storeys with frame and shear walls only to get an optimized design. The future work can be studied on four different models precast elements with (frame + shear walls), (frame +shear core), (frame + shear walls + shear core) to get an optimized design

**9. References**

1. Abhay Guleria. (Structural Analysis of a Multi-Storeyed Building using ETABS for different Plan Configurations), International Journal of Engineering Research & Technology (IJERT). 2014; 3(5):2278-0181. ISSN: IJERTV3IS051552 www.ijert.org
2. Balaji UA. Mr. Selvarasan ME. B (Design and analysis of multistoreyed building under static and dynamic conditions using etabs), International Journal of Technical Research and Applications.
3. Mahesh N, Patil Yogesh N. Sonawane, [Seismic Analysis of Multistoried Building], International Journal of Engineering and Innovative Technology (IJEIT). 2015; 4(9).
4. UBC 97 (uniform building code, 1997.
5. IS: Indian Standards Criteria For Earthquake Design of Structures, 1893-2002.
6. Nehrp Guidelines for the Seismic Rehabilitation of Buildings.
7. IS. 456. Indian Standards (plain and reinforced concrete code of practice), (Fourth Revision), 2000.