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Design and Analysis of Residential Building using E-TABS

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Abstract - *ETABS stands for Extended Three Dimensional Analysis of Building Systems. The main purpose of this software is to design multi-storeyed building in a systematic process. The effective design and construction of an earthquake resistant structures have great importance all over the world. This project presents multi-storeyed residential building analysed and designed with lateral loading effect of earthquake using ETABS. This project is designed as per INDIAN CODES- IS 1893-part2:2002, IS 456:2000..*

Every structural engineer should design a building with most efficient planning and also be economical. They should ensure that it is serviceable, habitable in healthy environment for its occupants and have longer design period. Structurally robust and aesthetically pleasing building are being constructed by combining the best properties of any construction material and at the same time meeting specific requirements like type of building and its loads, soil condition, time, flexibility and economy. In the view of above, the high rise buildings are best suited solution. This paper discusses the analysis of a commercial building (G+1) located at Hyderabad under effect of Seismic forces. Shear forces and bending moments of beams and columns are observed and concluded that larger span have more shear forces and bending moment.

Key Words: **Structural design, ETABS, Shear forces, Bending moments.**

1. INTRODUCTION

ETABS is a sophisticated, yet easy to use, special purpose analysis and design program developed specifically for building system. ETABS version 9.0 features an intuitive and powerful graphical interface coupled with unmatched modeling, analytical, and design procedures, all inte-grated using a common database. Although quick and easy for simple structures, ETABS can also handle the largest and most complex building models, including a wide range of nonlinear behaviors, making it tool of choice for structural engineers in the building industry.

Dating back more than 30 years to the original development of ETABS, the predecessor of ETABS, it was clearly recognized that buildings constituted very special class structures. Early releases of ETABS provide input, output and numerical solution techniques that took into consideration and characteristics unique to building type structure, providing a tool that offered significant savings in time and increased accuracy, over general purpose programs.

As computers and computer interfaces evolved, ETABS added computationally complex analytical options such as dynamic nonlinear behavior, and powerful CAD-like drawing tools in a graphical and object based interface.

Most building is of straightforward geometry with horizontal and vertical beams and vertical columns. Although any building configuration is possible with ETABS, in most cases, simple grid system defined by horizontal floors and vertical column lines can establish building geometry with minimal effort.

1.1 DESIGN PHILOSOPHIES

There are three philosophies for the design of reinforced concrete namely:

1) Working stress method
2) Ultimate load method
3) Limit state method

1.2 STAGES IN STRUCTURAL DESIGN

1) Drawing Study
2) Load Combinations
3) Analysis Of Structures
4) Structural design

2 OBJECTIVE

Following are the objectives

1. Modeling the building using the software ETABS V.9
2. Applying gravity loads and different load combinations as per Indian codal provision.
3. Analysing and designing of Residential building(G+1) for worst case of load combination

3. Plan of Residential Building

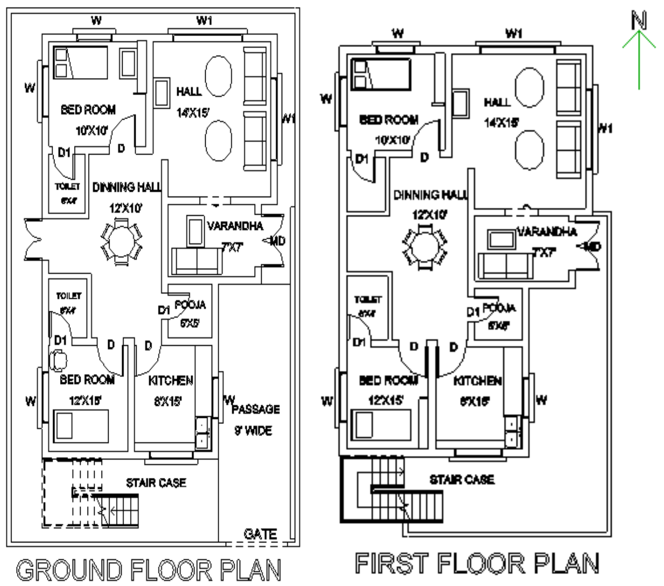

Table -1: SILENT FEATURE OF PROPSED BUILDING:

Sl.No	Description	Features
1	LOCATION	BANGLORE
2	TYPE OF BUILDING	G+1
3	STRUCTURE.	R.C.C FRAME
4	BUILT UP AREA	140 m^2
5	HEIGHT B/W THE FLOOR	3.1 m
6	DEPTH OF FOUNDATION BELOW G.L	1.5 m
7	PRIMARY AND SECONDARY WALL THICKNESS	230, 115 mm

4. Analysis Methods

Etab is the premier FEM analysis and design tool for any type of project including towers, culverts, plants, bridges, stadiums, and marine structures. With an array of advanced analysis capabilities including linear static, response spectra, time history, cable, and pushover and non-linear analyses, Etab provides good compatibility with a scalable solution that will meet the demands of project every time.

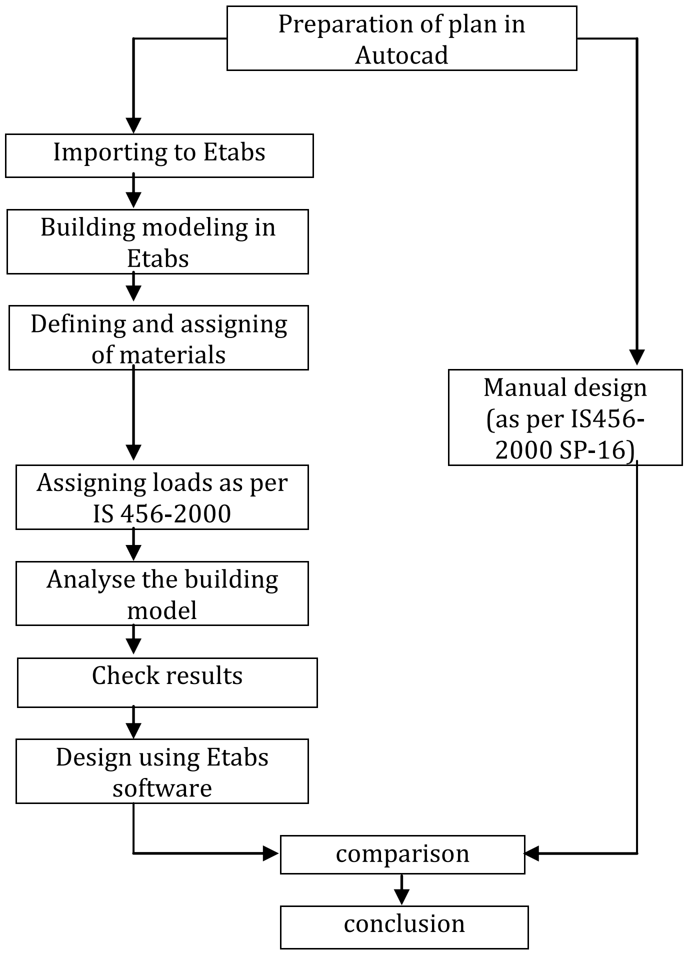

Fig -1: **METHODOLYGY**

5. ANALYSIS RESULT

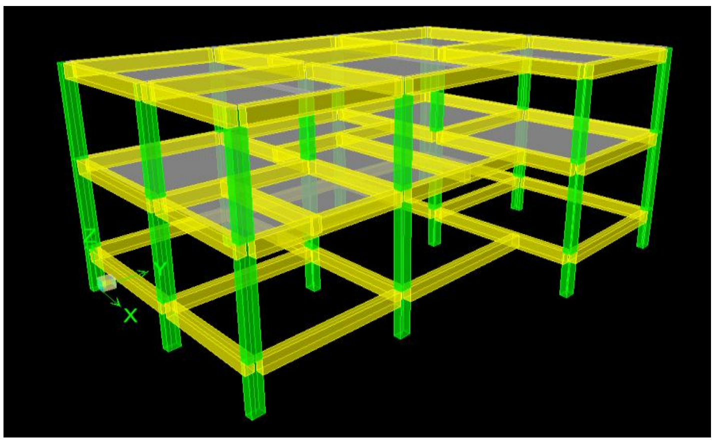

Fig-2:3D MODEL

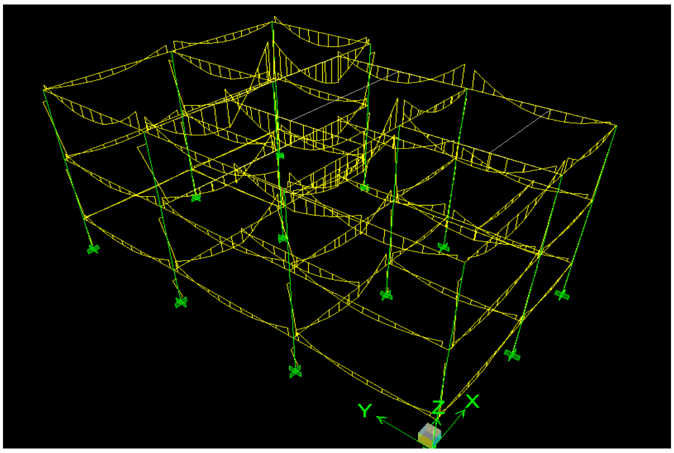

Fig-3:_BENDING MOMENT DIAGRAM

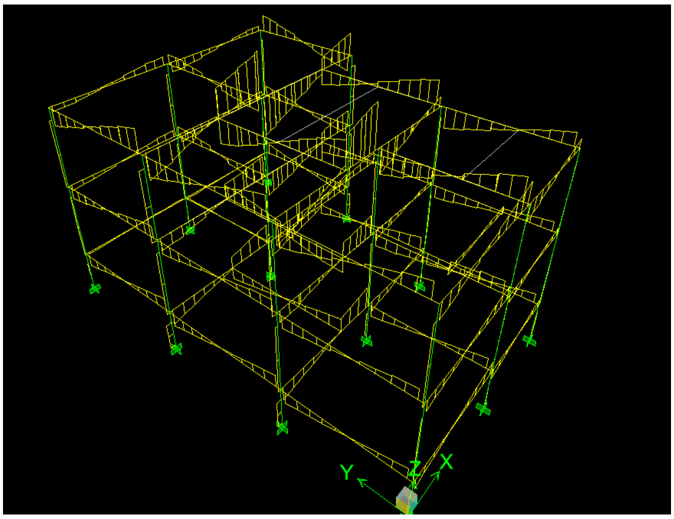

Fig-4: Shear force diagram from Etab

6. DESIGN DETAILS

Design of slab 1

L_x=2.40 m
L_y=4.37 m
L_Y/Lx =1.80 < 2 (Hence slab designed as two way)
Total load on slab = 9.35 kN/m^2
Factored moment =10 Kn-m
Assuming depth of slab = 150 mm
Design of the as under reinforced
Slab cover =25 mm
Bend the alternative bars@ a distance of L/7 from the face of the wall = 2.40 / 7= 0.342 m
Assuming dia 8mm 150 c/c (main reinforcement)

Distribution reinforcement
$A_{st\ min}$ as distribution reinforcement = 0.12 % *b*D
=0.12 %*1000*150
=180 mm^2

Sapcing of 10 mm dia = (π *10^2 *100)/180 = 200 mm

Provide 8 mm dia @ 150 mm c/c
Check for deflection:
Assuming span to depth ratio = L/d < 20
= 2.4/125 <20
= 19.2 < 20, Hence safe.

Design of Slab 2:

L_Y = 4.7 m ,
L_X = 4.0 m,
Aspect ratio (ly/ lx) =4.7/4 =1.17 < 2 (hence two way slab
two edges discontinuous , two edge continuous

	x	y	M_X =x * w*L_X^2	M_y=Y * w*L_X^2	Dia spacing x	Dia spacing y
-ve reinforcement	0.084	-	12.56 kN .m	-	8 dia @200 mm c/c	8 dia @150 mm c/c
+ve reinforcement	0.064	0.043	9.57 kN.m.	8.88 kN.m	8 dia @150 mm c/c	8 dia @150 mm c/c

Design of slab 3:

L_Y = 3.9 m ,
L_X = 3.5 m,
Aspect ratio (l_y/ l_x) =3.9/3.5=1.11 < 2 (hence two way slab)
One short edge discontinuous.

	x	y	M_X =x * w*L_X^2	M_y =Y * w*L_X^2	Dia spacing x	Dia spacing y
-ve reinforcement	0.048	0.037	5.5 KN.m	4.5KN.m	10 dia 200 mm c/c	8 dia 180 mm c/c
+ve reinforcement	0.036	0.028	4.2 KN.m	3.5 KN.m	8 dia 180 mm c/c	8 dia 180 mm c/c

Slab 6: L_x=2.4, L_y =5.0, aspect ratio (L_y/L_X)= 2.1 > 2 , one way slab)
Total load on slab = 9.35 kN/m^2
M_X= w *L_x^2 / 8 = (9.35 *2.4 ^{2})/8
= 6.73 kN.m
Factored moment = 1.5 *6.73 = 10 kN.m
Assuming 8 dia @ 270 mm c/c (main reinforcement)
Distribution reinforcement
A_{st} as distribution reinforcement = 0.12 %*1000*150
=180 mm^2
Spacing of 6 mm dia =3.142 *6^2*1000/(4*180)
= 150 mm
So, provide 8 mm dia @ 150 c/c.

Check for deflection:

Assuming span to depth ratio = L/d < 20
= 2.4/125 <20
= 19.2 < 20, Hence safe

7. DESIGN OF BEAM

Data Grid beam no 1-A

Characteristic compressive strength of concrete = f_{ck} = 20 N/mm^2

Characteristic strength of steel = f_y = 500 N/mm^2
Adopt d = 400 mm
D = 450 mm
b = 230 mm
Length = L =7.6 m

From Etab results,
Negative moment at interior support, M_u = 55 kN-m
Positive moment at center of span, M_u = 43 kN-m
Maximum shear force at support section, V_u = 50 KN

Main reinforcement

For -ve B.M,
$M_u = 0.87\, f_y A_{st} d[1- A_{st} f_y/bdf_{ck}]$
$55x10^6 = 0.87x500xA_{st}x450x[1- A_{st}x500/230x450x20]$
A_{st} = 350.63 mm^2
Provide 2 bars of 12 mm dia and 2 bars of 10mm dia (A_{st}=380mm^2) @ top tension face near supports

For +ve B.M,
$M_u = 0.87\, f_y A_{st} d[1- A_{st} f_y/bdf_{ck}]$
$43x10^6 = 0.87x500xA_{st}x450x[1- A_{st}x500/230x450x20]$
A_{st} = 300 mm^2
Provide 3 bars of 12 mm dia (350 mm^2) at bottom tension face at centre of span section.

Shear reinforcement,

$\tau_v = v_u/ b\, d = 50x10^3/230x450$
= 0.48 N/mm^2
$P_t = 100x\, A_{st} / b\, d$ = 100x350 / 230x450
= 0.33 %
Refer table 19 (IS 456) read out,

τ_c = 0.42 N/mm^2
Hence shear reinforcement is required.

$V_{us} = v_u - \tau_c\, b\, d$
=50 – (0.42x230x450)10^3
= 10.16 kN
Use 8 mm dia two legged stirrups, the spacing is,
$S_v = (0.87 f_y A_{sv}\, d) / V_{us}$
= (0.87x 500 x 50 x 450) / 10.16x1000
S_v = 250 mm
Adopt 8 mm dia two legged stirrups @ 220 mm c/c
Check for deflection,
At centre of span:
$P_t = 100\, A_{st} / b\, d$ = 100x350 / 230x450
= 0.33 %

From fig,4 of IS 456 , K_t = 1.2 , K_c =1 ,K_f =1
$(L/d)_{max} = (L/d)_{basic} \times K_t \times K_f$
=26 x 1.2 x 1
= 31.2
$(L/d)_{actual}$ = 7600/450 = 16.88
$(L/d)_{actual} < (L/d)_{max}$
Hence deflection control is satisfied

8. DESIGN OF COLUMNS

Data,
Characteristic compressive strength of concrete = f_{ck} = 20 N/mm^2
Characteristic strength of steel = f_y = 500 N/mm^2
P_u = 250 KN (taken from Etab)
b = 230 mm
D= 350 mm
Length = L = 3100 mm
Longitudinal reinforcement = $P_u = 0.4 * f_{ck} * A_C + 0.67 * f_y * A_{sc}$
$=0.4* f_{ck} * A_g + (0.67 *415 – 0.4 *20)*A_{sc}$
$250*10^3=0.4 *20*230*350 + (0.67*500-0.4*20)*A_{st}$
A_{st} = 1200 mm^2
So , $P_{t\,min}$ = 0.8%

A_{st} = 699.2 mm^2

Provide # 4 bars of 16 mm diameter

Design of lateral ties

Tie diameter

So , provide lateral reinforcement 8mm ties

Tie spacing S_t

So , provide tie spacing at 8mm @ 230 mm c/c

Design of uniaxial column

P_U = 164 kN
M_{uz}= 10 kN.m
Width =b =230 mm
Depth = d= 350 mm
d'/D =0.15
$P_U/(f_{ck} *b*D) = 164*10^3/(20*230*350) = 0.101$
$M_U/(f_{ck} *b*D^2)= 10*10^6/(20*230*350^2)=0.017$
$A_{ST\,min}$ =0.8 (from SP 16 code)
P/f_{ck} = 0.06 (minimum)
P= 0.06*20=1.2
Area of steel = (1.2*230*350)/100
=966 mm^2
=9.66 cm^2

So, provide 4 bars of 20 mm diameter

Design for lateral ties
Tie diameter =

So, provide 8 mm lateral ties

Design tie spacing ≯
So, provide tie spacing 230 mm

18 DESIGN OF FOOTING

Isolated Footing

Unfactored Load = 266 KN
Factored Load
= 398 KN
Moment about X-X axis, Mux =9 KN-m
Moment about Y-Y axis, Muy = 3 KN-m
S.B.C. of Soil = 180 KN/ m^2
Grade of Concrete = M 20
Grade of Steel = Fe-500

- **Proportioning of footing size:**

A_{g} =1.1P/SBC
=1.1*266/180=1.63m^2
Assume, L=B= 1.3m
Let provide footing size 1.3m*1.3m
Provide A=1.7m^2
e= M/P=9/266=0.033 < L/6=1.5/6=0.5,
C=1.3/2=0.65m, Zx=Zy=1.3*1.3^3/12=0.238m^4,
Pmax = (P/A) + (Mux*C/Zx) + (Muy*C/Zy) ≤ SBC
=266/1.7+11*0.65/0.238 +3*0.65/0.238
=149+23.6+5.4
=178 kn/m^2 < 180 (safe)

Depth of footing calculation,

- Bending consideration.

Factored upward pressure =P '= 1.5*178 = 261.79 kN/m^2
Maximum bending moment = (261.79 * 0.575^2) / 2 =44.04 kN-m
For known material property M20 & Fe-500
So, Depth = √ ((M_u)/(0.138*fck*b*))
=√(44*10^6)/(0.138*20*1000)
Depth = 130.26 mm
As per Indian standard depth = 150 (minimum)

Based on one way shear
Permissible shear stress (τv) = k * τc
Here, K = (0.5 + βc) = 1
βc = SHORT SPAN / LONG SPAN) = 1
so, K=(0.5+1)=1.5
τ_c = 0.25 = 0.25 *√20 = 1.18 N/mm^2
$\tau_v = k_s * \tau_c$ = 1*1.118 = 1.118 N/mm^2
Therefore, Resisting force = (1220 + 4d) * d*1.18

= 4.472* d^2 + 1363.9 d ....(1)

Punching shear force = (1.5 * P –(1.5 * P' *Area))

= (1.5*210 *10^3 - (1.5*90*10 ^{3} *87400+380d + 230d +d^2))...(2)

Taking, punching shear force = Resisting shear force

540*10^3 – 11799 – 82.35d – 0.135 d^2 = 4.472 *d ^{2} +1363.96 d

This implies effective depth 'd_3'= 216.24 mm

Let overall depth of footing D =300 mm

Assuming diameter of bar in footing = 16 mm

Minimum cover required for footing = 50mm

Therefore, effective depth =d =300-58=242 mm

CONCLUSION

Finally concluded that I have my satisfaction with my internship in that particular company, further procedure of Dynamic analysis of the multi-story buildings I will keep my internship with the company and I hope am learned what they gives design works with period of internship. The Internship gave ample exposure to the field practice in the modeling, analysis and design of the multi storied buildings and various construction techniques used in the industry. The analysis was done using the software package ETAB and drawing details in AutoCAD and REVIT. The structural components were designed manually in addition to the software design. This training helped to understand and analyze the structural problem faced by the construction industry. Site visits also gave an exposure to the industry. It provide help us to apply theoretical knowledge in industrial application, acquire knowledge of various stages of construction, project management and team-work, practice ethical and professional work culture, provide opportunity for students to work with industrial practitioners.

In next eight weeks I am going to learn SAFE software to design foundation and study the dynamic analysis of some more multistory buildings in ETAB.

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