Analysis, Design, and Estimation of Multi-Storied Institutional Building by using ETABS

Ananda G[1], Dr.M.S. Shobha[2]

[1]PG Student, Department of Civil Engineering RYM Engineering College Ballari, Karnataka, India
[2]Professor, Department of Civil Engineering RYM Engineering College, Ballari, Karnataka, India

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Abstract - *The majority of the structure has a simple geometry with horizontal beams and vertical columns. ETABS V.16.0.0 allows for any building layout, however, in most circumstances, a simple grid system characterized by horizontal floors and vertical column lines may generate building geometry with minimal effort. The building has a lot of comparable floor levels. This resemblance may be utilized to speed up modeling and design.*

The design for beams, columns, and footing is derived from ETABS, which with its additional feature, outperformed its predecessors in teams of data exchange.

Our major goal is to finish a multi-story building and verify that it's safe and cost-effective under gravity loading circumstances while still performing the purpose for which it was designed. The dead and live are taken into account while designing the structure. The structure was analyzed and designed using the ETABS software tool. We used the limit state approach of analysis in this assignment. The design meets the requirement IS 456-2000

The finding of the analysis has been used to confirm the structure's suitability for usage. For a complicated structural system, computer software is also utilized to calculate forces, bending moment, stress, strain, and deformation or deflection. The main goal of this project is to compared ETABS design and analysis of a multi-story structure

Key Words: dead load, live load, ETABS, multi-storeyed building,

1. INTRODUCTION

Our project's major goal is to learn about many design components such as modelling, analysis, and design. We intend to construct a multi-story building with a G+3 floor. ETABS software is the most popular design program in the market today. This program is used by a lot of design firms for project design. As a result, the major focus of this article is on a comparison of the findings produced from manual and ETABS software analyses of a multi-story building structure.

2. OBJECTIVES

•Generating structural frame of the ground plan, floor plan, and column position drawing of the PG building by using AutoCAD

•Creating structural frame-like column, slab, staircase, model by using ETABS 2018.

•Design and Analysis of structure by using ETABS 2018 software.

•Design of structure manually as per IS codes provision.

•Calculate the Estimation and Cost of the structure.

3. METHODOLOGY

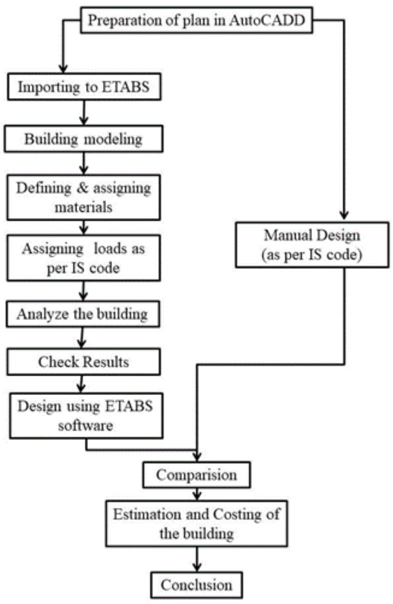


Fig -1: Methodology of the project

4. PLAN OF THE BUILDING

Fig -2: Ground floor plan; typical floor plan

5. ANALYSIS RESULTS

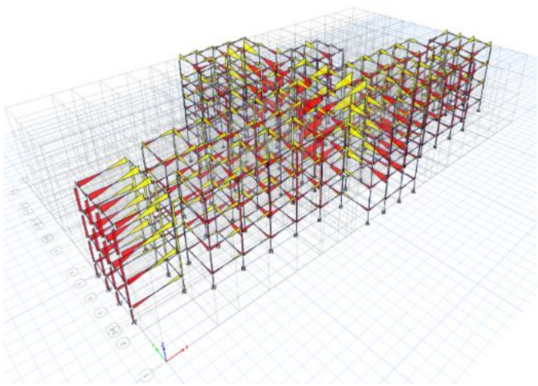


Fig -3: 3-D shear force diagram

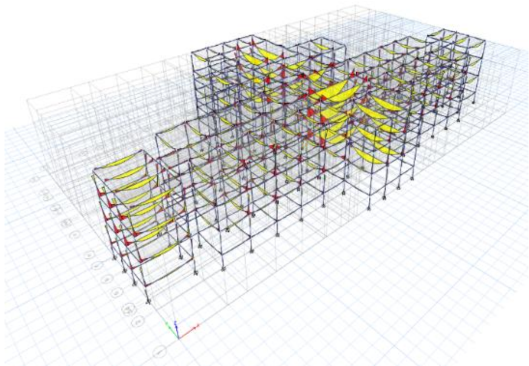


Fig -4: 3-D Bending moment diagram

6. DESIGN DETAILS

6.1. Slab design

L_x = 4.23m
L_y = 5.23 m

L_y/L_x = 1.24 < 2

Because the long to short span ratio is less than 2, should be designed as a two-way slab.

Assume slab thickness = 150 mm
Cover = 25 mm

LOAD CALCULATION:

Dead load = 0.151 X 251
= 3.751 KN/m²
service load = 3KN/m²
Floor finish = 1KN/m²
Partition wall = 1KN/m²
Total load = 8.75KN/m²
Factored load Wu = 1.5 x 8.75
=13.125 KN/m²

ULTIMATE DESIGN MOMENT:

support condition: - Two adjacent edges discontinuous. From table 26 of IS 456:2000 bending moment coefficients for long to short span ratio is

Coefficients	Continuous edge	Midspan
αx	0.062	0.0466
αy	0.047	0.035

SHORT SPAN MOMENT:

At continuous edge:
M_{ux} = αx Wu lx²
= 0.062X 13.125X4.232
= 14.56 KN-m
At mid span:
M_{ux} = αx Wulx²
= 0.0466X13.125X 4.232
= 10.93 KN-m

LONG SPAN MOMENT:

At continuous edge:
M_{uy} = αy Wulx²
=0.062X 13.125 X 5.232
= 22.25 KN-m
At mid span:
M_{uy} = αy Wu lx2
= 0.0466 X 13.125 X 3.352
= 17.50 KN - m

CHECK FOR DEPTH:

For balanced (M_{ulim})section,
M_{ulim} = 0.138 f_{ck}*b*d²
B =1000mm

22.25X 106 = 0.138 X 20 X b X d^2
D = 80.78 mm < 150mm
Hence slab is safe in depth.

STEEL REINFORCEMENT:

LONG SPAN:

At continuous edge:
M_{ux} = 22.25KN-m
M_u = 0.87 $f_y A_{st}$ *d [1-(Ast Xf_y)/(bd f_ck)
14.46 X106 ¬= 0.87X415XA_{st}X150[1-(A_{st}X415)/(1000 x150x 25)]
A_{st} = 431.43mm^2
$A_{st\ min}$ = 0.12% of the cross-sectional area
= 0.0012 X 1000 X 150 = 180 mm^2
Use 8 mm ϕ bar
Spacing = a_st/A_st x 1000
= 50.26/431.43 x 1000
= 115.25mm
Hence 8 mm ϕ bar @ 110 mm c/c

At mid span:
M_{ux} =17.50 KN-m
M_u = 0.87 f_y A_std [1-(A_{st} X f_y)/(bd f_{ck})]
A_{st} = 335.59 mm^2
Using 8 mm ϕ bar
Spacing = 50.265/335.59 x 1000 = 149.76mm
Hence 8 mm ϕ bar @ 140 mm c/c

SHORTER SPAN:

Continues edges:
M_u = 14.56KN-m
M_u = 0.87 f_y A_std [1-(A_{st} X f_y)/(bd f_{ck})]
Ast = 227.35mm^2
Using 8mm ϕ bar
Spacing = 50.26/227.35 x 1000 = 221.06mm
Provide 8 mm ϕ bar @ 220 mm c/c

Mid span:
M_{uy} =10.93 KN-m
M_u = 0.87 fy A_std [1-(Ast X f_y)/(bd f_{ck})]
A_{st} = 198.80 mm^2
Use 8 mm ϕ bar
Spacing = 50.26/198.80x 1000= 252.81 mm
Provided 8 mm ϕ bar @ 250 mm c/c

CHECK SHEAR STRESS:

Considering the short span and unit width of slab
V_u = 0.5 W_u L_x = 0.5 X 13.125 X 4.23 = 27.76 KN
τ_v = V_u/(b d) = (27.76 x 10^3)/(1000 x 125)
= 0.222 N/mm2
P_t = (100 A_{st})/(b d) = (100 X 180)/(1000 X 125) = 0.144

From table 19 of IS 456:2000, for M20 concrete and Pt = 0.144
τ_c = 0.28N/mm2 > τ_v
slab is safe in shear stress.

CHECK FOR DEFLECTION:
Considering the unit width of the slab in the short span direction L_x
$(L/d)_{basic}$ = 20
From fig. 4 of IS 456:2000, for Pt = 0.144; kt =1.7
$(L/d)_{max}$ = 20 X 1.7 = 34mm
$(L/d)_{actual}$ =423/125 = 33.84 mm
For P_t = 0.144

$(L/d)_{actual} < (L/d)_{max}$
Therefor slab is safe in deflection

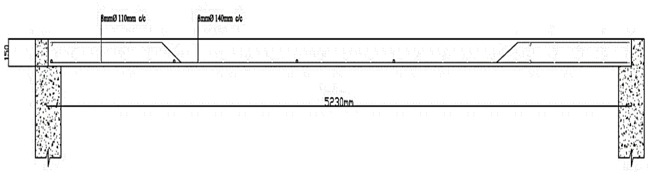


Fig -4: Reinforcement details along a long span

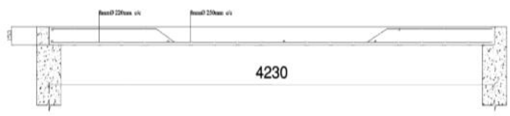


Fig -5: Reinforcement details along the shorter span

6.2. Beam

Dimension of beam = 230 × 450 mm
Max support moment =95 kN – m
Middel span moment =45kN – m
Mulim = 0.138f_{ck}bd^2
= 0.138×200×230×425^2
= 114.660 kN – m

AT SUPPORT SECTION:

Mu = 95kN-m <Mulim
Hence design singly reinforced beam
M_u/bD^2 = ($95X10^6$/ $30x450^6$)= 2.03

From table2 of SP 16 code book
P_t = 0.655
Tensile steel; A_{st} = P_t (b d)/100 = (0.655x 230 x 425)/100
Ast = 640.26 mm^2
provide 16 mm ϕ bar
No. of bars = A_{st}/a_{st} = 640.26/314.16 ≈ 2 bars
Provide 2 bars 16mm ϕ

AT MID SECTION:

M_u =45kN-m < M_{ulim}
Hence design singly reinforced beam
$M_u/b\ D^2$ = (45 × 10)^6/(230×450^2) = 0.966
From table 2 of SP 16
P_t = 0.28
Area of tensile steel
A_{st} = P_t (b d)/100
= (0.28 x 230 x 425)/100
A_{st} = 273.7 mm²
Provide 12 mm ϕ bar
No. of bars = A_{st}/a_{st}
= 273.7/201.06 ≈ 2 bars
Provide 2 bars of 16 ϕ.

SHEAR REINFORCEMET:

V_u = 90 KN
b =230mm d = 425mm
Nominal shear stress
T_v = V_u/bd
= (90 × 1000)/(230× 425)
= 0.869N/mm²
P_t = (100 A_{st})/(bd) = 0.600
From table 19 of IS 456:2000
τc = 0.512 N/mm²< τ_v
therefore, provide share reinforcement
provide 2leged 8 mm ϕ vertical stirrups
Asv = 20 × π/40 × 802 = 100.530 mm²
Vus = $V_u - \tau_c$ b d = (0.87 $f_y A_{sv}$d)/S_v
90× 103 – 0.512 × 230 ×425 = (0.87 × 415 × 100.53 × 425)/S_v
Spacing S_v = 195 mm
Provide 2 Legged 8 mm ϕ vertical stirrups @ 190 c/c.

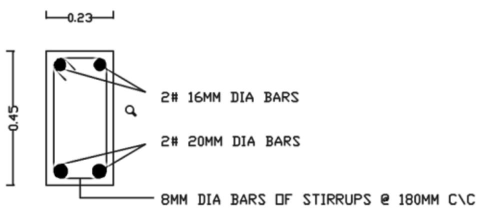


Fig -6: Reinforcement details of Beam

6.3. Column

P_u = 600 kN
M_u = 12.15kN - m
Unsupported length = 3m
Clear cover = 40mm
f_{ck} = 20kN/m²
Column are the held in position and restrained against rotation.
L_{eff} = 0.65L = 0.650 x 3 = 1.950 m
Column dimension = 230 x 450mm
L_{eff}/D = 1.95/0.45 = 4.3 < 12
L_{eff}/b = 1.95/0.23 = 8.5 < 12
therefore, column are design short column

CHECK FOR ECCENTRICITY:

e_{min} = l/500 + D/30
= 3000/500 + 450/30
= 21
e_{min}/D = 21/450 = 0.044 < 0.05
Design short column.
Design of longitudinal reinforcement:
$M_u/f_{ck}bD^2$ = (12.15x 10^6)/(20 x 230 x 450^2) = 0.013
P_u/(fckbD) = 600 x 10^3/(20 x 230 x 450) = 0.298
d^'/D = 40/450
= 0.088 ≈ 0.013,
SP: 16 (chart book) code book
$P_t/(f_{ck}$) = 0.04
p = 0.04 x 20 = 0.8 %
∴ A_{sc} = 0.8/100 b D
= 0.8/100 x 230 x 450
A_{sc} =828mm²
Provide 4 no - 20 mm ϕ steel.

LATERAL REINFORCEMENT:

diameter of the lateral ties is must not be less than
Ø/4 = 8mm (b) 5 mm
Provide 8 mm ϕ bars
Minimum spacing provided to be
smaller lateral dimension = 230 mm
16x Ø = 400mm
300mm
Hence 8 mm diameter of lateral ties at 230 m c/c

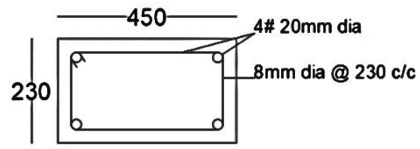


Fig -7: Reinforcement details of Column

66.4. Footing

Ultimate load P_u = 1150 KN
Live load P = 767KN
dead weight of footing = 10% of live load
= 76.7 KN
overall load = 843.7 KN
Assume SBC = 195 KN/m²
Area of footing required = 8371/1951 = 4.29 m²
Provide footing of dimension = 2 X 2.2 m
SOIL PRESSURE FOR DESIGN:
q_u = 1150/(2 X 2.2)
= 261.36 KN/m²
= 0.261 N/mm²

ONE WAY SHEAR:

Lets Assume p_t = 0.15, τ_c for M_{20} concrete = 0.32 N/mm2
$V_u = \tau_c$ b d
0.261 *1500 (1275 – d) = 0.320 * 1500 * d
d = 572.76mm
Take d = 600 mm D = 650 mm

CHECK FOR DEPTH:

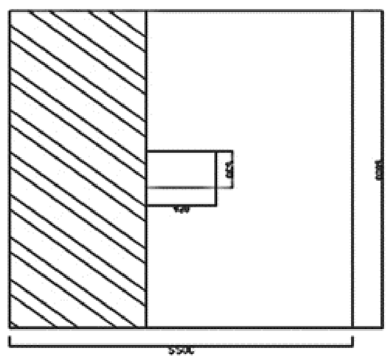


Fig -8: Cross-section for one way shear

M_u = q_u X 2000 X (775^2)/8
M_u = 0.255 X 2000 X 775^2/8
M_u = 38.28 KN-m
M_{ulim} = 0.138 f_{ck} bd^2
= 0.138 X 20 X 2000 X 600^2
= 1987.2 KN-m less than M_u
safe in depth

Check for two-way share :

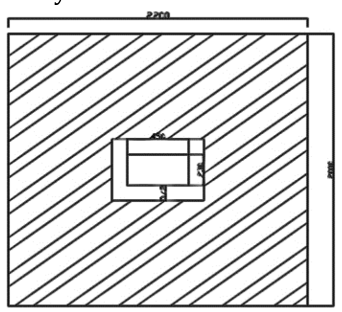


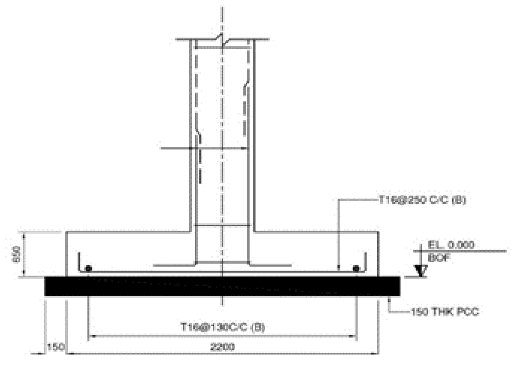
Fig -9: Cross-section for two-way shear

Perimeter of resisting section
b_1 = 20* (680 + 460)
= 2280 mm
Resisting area = perimeter x d
= 2280 x 600
= 1.368x 106 mm²
Punching shear force = 38.28 [3.00 * 1.5 – 0.68 *0.46
= 160 KN
Nominal shear (τv) = Vu/(resisting area) = (160x 10^3)/(1.368 x 10^6) = 00.117 N/mm²
But permissible shear stress = ks * τc
ks = (0.50 + β) <0 1
β_1 = b/d = 230/600 = 0.4
k_s = 0.960 Take k_s = 1

τc = 0.250√(f_{ck}) = 0.25 x √200= 1.110 N/mm²
Permissible shear stress = 1.11 N/mm² > τ_v
footing are safe in two way shear.

DESIGN OF REINFORCEMENT:

In long direction:
M_u = 155.45 x 106
M_u = 0.87 X f_y X A_{st} X d X [1-(A_{st} X f_y)/(f_{ck} X$_b$X d)]38.28X106
=0.87X415xA_{st}X600X[1(A_{st}x415)/(20X2200X 600)]
A_st = 117.200 mm²
Ast $_{min}$ = 0.12% cross sectional area
= 0.0012 * 3000 * 6500 = 2340 mm²
A_st< Ast $_{min}$
hence provide Ast$_{min}$
Use 16 bar
Spacing = (π/4 x 16^2)/2340 X 1500 ≈130 mm
Provide 16 bars @ 130 0mm c/c
In short direction:
M_u =155.45 x 106
M_u = 0.87 x f_y x A_{st} x d x [1-(A_st x f_y)/(fck x b x d)]
M_u = 0.87 x 415 x Ast x 600 x [1-(Ast x 415)/(20 x 2000 x 600)]
A_{st} = 117.25 mm²
$A_{st\ min}$ = 0.12% * cross sectional area
= 0.0012 X 1500 X 650 = 1170 mm²
A_{st}< $A_{st\ min}$
hence provide $A_{st\ min}$
Use 16 diameter bar
Spacing = (π/4 x 16^2)/1170 X 1500 ≈250 mm
Provide 16 diameter bar @ 250 mm c/c



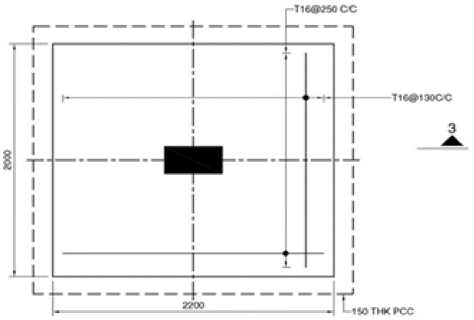


Fig -10: Reinforcement details of rectangle Footing

7. Conclusion

•This project study attended to provide information of the component of a multi-story structural drawing are reviewed, a concept of structural parts may be obtained.
•For all loading combinations, ETABS used employed for the analysis since it minimizes time and provides the needed accuracy.
•These structural components are tested to ensure that they meet the serviceability standards, and the dimensions of all structural components are sufficient.
•We may estimate the cost of the entire structure based on the "analysis and design " before the construction begins. As a result, the whole expenditure of the structure will be known ahead of time.

ACKNOWLEDGEMENT

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BIOGRAPHIES

Ananda G
P.G. Scholar
Department of Civil Engineering.,
RYM ENGINEERING COLLEGE
BALLARI, Karnataka, India.

Dr. M.S. Shobha
Professor.
Department of Civil Engineering.,
RYM ENGINEERING COLLEGE
BALLARI, Karnataka, India.