Analysis, Design and Estimation of Multi Storied Residential Building using ETABS Software

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Abstract - *Most buildings are of straight forward geometry with horizontal beams and vertical columns. Although any building configuration is possible with ETABS version 2016, in most cases, a simple grid system defined by horizontal floors and vertical column lines can establish building geometry with minimum effort. Many of the floor level in buildings are similar. This similarity can be used to reduce modelling and design time.*

The present work deals with the analysis and design of a multi storied building of (G+3) by using most economical beam to column method. The dead load &live loads are applied and the design for beams, columns, footing is obtained from etabs with its new features surpassed its predecessors with its data sharing.

Our main aim is to complete a multi-storey building and to ensure that the structure is safe and economical against gravity loading conditions and to fulfil the function for which the structures have been built for. For the design of the structure, the dead load and live load are considered. The analysis and design of the structure done by using a software package ETABS. In this project, we have adopted limit state method of analysis. The design is in confirmation with IS 456-2000.

The results of analysis are used to verify the fitness of structure for use. Computer software's are also being used for the calculation of forces, bending moment, stress, strain & deformation or deflection for a complex structural system. The principle objective of this project is to compare the design and analysis of multi-storied building (G+3) by ETABS 2016 with manual calculations.

Key Words: **Gravity load, multi storied building, Etabs, Design**

1. INTRODUCTION

The main objective of our project is to know the various design aspects like planning, analysis and design etc. We have planned to design a multi-storey Building structure consisting of G+3 Floors. The planning is done as per the requirements and regulations given by the National Building Code (NBC).

ETABS is the present day leading design software in the market. Many design company's use this software for their project design purpose. So, this paper mainly deals with the comparative analysis of the results obtained from the analysis of a multi storied building structure when analyzed manually and using ETABS software.

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

The process of structural design involves the following stages

1. Structural planning.
2. Estimation of loads.
3. Analysis of structure.
4. Member design.
5. Drawing, detailing and preparation of structures.
6. Estimation.

2. OBJECTIVE

Following are the objectives

1. Modeling has done using ETABS V.16.0.0
2. Applying different load combination as per India codal provision.
3. Analyzing and designing of multistory building for Worst case of load combination.
4. We should estimate the whole structures in advance.

3. PLAN OF MULTISTORY BUILDING:

4. ANALYSIS RESULT

Sl. No.	Column	No. of Column	Pu (KN)	Mux (KN-m)
1	C1	2	515.8	10.15
2	C2	2	745.4	16.74
3	C3	2	710.8	16.06
4	C4	2	710.5	14.76
5	C5	2	476.4	22.67
6	C6	2	855.88	19.85
7	C7	2	1140.7	14.22
8	C8	2	1132.4	22.63
9	C9	2	1075.7	18.98
10	C10	2	760.56	14.25
11	C11	2	933.04	21.67
12	C12	2	1088.34	14.35
13	C13	2	957.8	9.68
14	C14	2	588.55	15.81
15	C15	2	591.04	22.69
16	C16	2	966	10.12

5. DESIGN DETAILS

5.1. DESIGN OF SLAB:

Centre to centre dimension = 1.46 X 3.08
l= Ly/Lx = 2.11 > 2
Therefore design as one way slab
Assume, D = 150 mm
Cover =25 mm

LOAD CALCULATION:

Self weight = 0.15 X 25 = 3.75 kN/m2
Live load = 3 kN/ m2
Floor finish = 1 kN/ m2
Partial wall = 1 kN/ m2
Total = 8.75 kN/m2
Ultimate load Wu=1.5x8.75=13.125kN/m2

ULTIMATE MOMENT AND SHEAR FORCE:

Mu = 0.125
Wu l2 = 0.125 X 13.125 x 2.109 = 7.297 kN-m
Vu = 0.5 Wu l = 0.5 X 13.125X 2.109 =13.84 kN

CHECK FOR DEPTH:

For balanced section,
Mulim = 0.138 fck b d2
7.297 X 106 = 0.138 X 25 X 1000 X d2
d= 45.98 mm < 125
Hence slab is safe in depth.

REINFORCEMENT:

Mu/bd2 = (7.297x106)/(1000x1252) = 0.467
From table 2 of sp 16
Pt = 0.16
Pt bd/100 =(0.16x1000x125)/100
Ast = 200 mm2
Ast min = 0.12% of cross sectional area
Ast min = 0.0012 X 1000 X 150 = 180 mm2
Using 8 mm dia bar
Spacing = 50.26/200 x 1000 = 251.3 mm
Provide 8 mm dia bar @ 250 mm c/c

5.2 DESIGN OF BEAM

Beam section provided = 230 × 450 mm
Maximum support moment = 88.337kN – m
Mid span moment =43.733kN – m
Mu lim = 0.138 fck b d2
= 0.138 × 20 × 230 × 4252
= 2.699kN – m

AT SUPPORT SECTION:

Mu = 88.337kN – m< Mu lim
Hence design as singly reinforced beam
Mu/bD2 = (88.337x106)/(230x4502) = 1.90
From table 2 of SP 16
Pt = 0.602
Tension steel; Ast =
Pt bd/100 = (0.602x230x425)/100
Ast = 606.05 mm2
Using 16 mm dia bar
No. of bars =Ast/ast = 606.05/314.16 ≈ 2 bars

AT MID SECTION:

Mu =43.733 kN-m < Mu lim
Hence design as singly reinforced beam
Mu/bD2 =(43.733x106)/(230x4502) = 0.94
From table 2 of SP 16
Pt = 0.28
Area of tension steel
Ast = Pt bd/100 = (0.28x230x425)/100
Ast = 273.7 mm2
Using 12 mm dia bar
No. of bars = Ast/ast =273.7/201.06 ≈ 2 bars
Provide 2 bars of 16 dia.

SHEAR REINFORCEMET:

Vu = 88.34
b = 230 mm d = 425 mm
Nominal shear stress
τ_v = Vu/bd = (88.34x1000)/(230.x425) = 0.90N/mm2
Pt = (100Ast)/bd = 0.60
From table 19 of IS 456:2000
τ_c = 0.512 N/mm2< τ_v
Hence shear reinforcement is required
Using 2L – 8 mm dia vertical stirrups
Asv = 2 × π/4 × 82 = 100.53 mm2
Vus = Vu – τ_c b d = 0.87xfyxAsvxd/Sv 88.34 × 103 - 0.512×230×425=(0.87x415x100.53x425)/sv
Spacing Sv = 185 mm
Provide 2L – 8 mm dia vertical stirrups @ 180 c/c.

5.3. DESIGN OF RECTANGLE FOOTING

Ultimate load Pu = 1141 kN
Service load P = 761kN
Self weight of footing = 10% of service load
= 76 kN
Total load = 837 kN
Assume SBC = 185 KN/m2
Area of footing required =837/185 =4.4m2
Provide footing of size 3 X 1.5 m

SOIL PRESSURE FOR DESIGN:

qu =1141/3x1.5 = 253.55 kN
= 0.253N/mm2

ONE WAY SHEAR:

Assuming pt = 0.15, τ_c for M20 concrete = 0.32N/mm2
Vu = τ_c b d
0.247 X 1500 (1275 – d) = 0.32 X1500 X d
d = 555.42 mm
Take d = 600 mm D = 650 mm

CHECK FOR DEPTH:

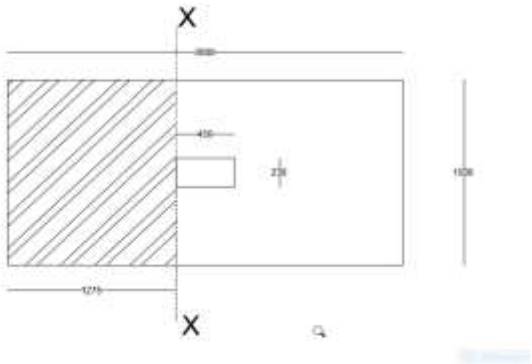

Fig.6.8 (a) Critical section for one way shear

Mu = qux3000x12752/8
Mu =0.247x3000x12752/8
Mu = 150.57 KN-m
Mu lim = 0.138xfckxbxd2
= 0.138x20x3000x6002
= 2980.8 KN-m > Mu
Hence safe in depth

CHECK FOR TWO WAY SHEAR:

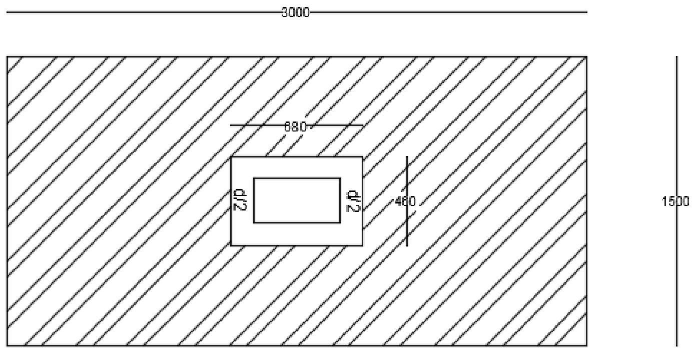

Fig.6.8 (b) Critical section for two way shear

Perimeter of resisting section
b1 = 2(680 + 460) = 2280 mm
Resisting area = perimeter x d
= 2280 x 600
= 1.368x 106 mm2
Punching shear force
= 150.573 [3.0 x 1.5 – 0.68 x 0.46] = 630.47 kN
Nominal shear (τ_v)= vu/resisting area
=(630.47x103)/(1.368x106) = 0.47 N/mm2
But permissible shear stress = ks τ_c
ks = (0.5 + β) < 1
β =b/d =230/600 = 0.4
ks = 0.96
Take ks = 1
τ_c =0.25√fck =0.25x√20 = 1.11 N/mm2
Permissible shear stress = 1.11 N/mm2 > τ_v
Hence footing is safe in two way shear.

DESIGN OF REINFORCEMENT:

In long direction:
Mr = 0.87 x *f*y x *Ast*x d (1 - Ats fy/(bdfck))
Mu = 150.573 x 106
Mu = 0.87 x fy x Ast x d x [1-Astxty/fckxbxd]
Mu = 0.87 x 415 x Ast x 600 x [1-Astx415/20x3000x600]
Ast = 700.73 mm2
Ast min = 0.12% of cross sectional area
= 0.0012 X 3000 X 650 = 2340 mm2
Ast < Ast min
Hence provide Ast min
Use 16 Φ bar
Spacing = (π/4x162)/2340x1500≈130mm
Provide 16 Φ bars @ 130 mm c/c
In short direction:
Mu =150.573 x 106
Mu = 0.87 x fy x Ast x d x[1-Astxty/fckxbxd]
Mu = 0.87 x 415 x Ast x 600 x [1-Astx415/20x1500x600]
Ast = 706.580 mm2
Ast min = 0.12% of cross sectional area
= 0.0012 X 1500 X 650 = 1170 mm2
Ast < Ast min
Hence provide Ast min
Use 16 Φ bar
Spacing = π/4x162/1170x1500≈250 mm
Provide 16 Φ bars @ 250 mm c/c

5.4. DESIGN OF COLUMN

COLUMN 1:

Pu = 515.8 kN
Mu = 10.15 kN-m
Unsupported length = 3m
Effective cover = 40 mm
fck = 20 kN/m2
Column are held in position and restrained against rotation.
02Leff = 0.65L =0.65 x 3 = 1.95 m
Column size = 230 x 450 mm
Leff/D =1.95/0.45 = 4.3 < 12
Leff/b =1.95/0.23 = 8.5 < 12
Hence column is designed as short column.

CHECK FOR ECCENTRICITY:

emin = l/500+D/30=3000/500+450/30= 21
e_{min}/D =21/450 = 0.044 < 0.05
Hence column is design as short column.

LONGITUDINAL REINFORCEMENT:

Mu/fck b D2 = 10.15x106/20x230x4502 = 0.011
Pu/fck b D=515.8x103/20x230x450 = 0.245
d/D = 40/450= 0.088 ~ 0.01
From chart 44 of SP: 16 – 1980
Pt/fck= 0.04
p = 0.04 x 20 = 0.8 %
Asc = 0.8/100 b D = 0.8/100x230x450
Asc =828 mm2
Provide 4 # 20 mm dia bars

LATERAL REINFORCEMENT:

Diameter of the lateral ties should not be less than
(a) Φ/4 = 8mm
(b) 5 mm
Use 8 mm dia bars
Spacing is provided minimum of
Least lateral dimension = 230 mm
16 x Φ = 400mm
300 mm
Provide 8 mm ties @ 230 mm c/c

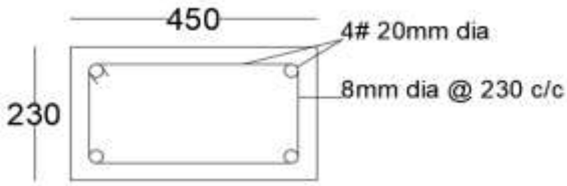

Fig.5.4 (a) Reinforcement details of Column

6. CONCLUSIONS

1. This project report has sought to give details of the components of a multi-storey building and an idea of structural components can be achieved when structural drawings are read.

2. ETABS was used for the analysis for all loading combinations since it reduces the time consumption and gives required accurate results,

3. The Detailing of Reinforcement is made as per IS-code provision which provides Ductility to the Structure and hence better performance.

4. All the structural components are checked to satisfy the serviceability criteria and hence provided dimension of all structural components are adequate.

5. From the "Analysis and design", we can estimate the cost of whole structure before the work is to be executed. Hence the appropriate cost of whole building will be known in advance.

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8. IS-SP-16 Design aids for Reinforcement designs

BIOGRAPHIES

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