Planning , Analyzing and Designing of College Building by Using STAAD Pro

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ABSTRACT
Planning analysis and designing of College Building is our project which is to propose at Salem. The College building consists of a 1st ground floor Civil dept., laboratories, Mechanical dept., laboratories, Staff rooms for civil & mechanical staffs, Auditorium, Canteen for girls & boys. In first floor, Class rooms for civil & mechanical departments, Dining hall, In second floor, CS dept., laboratories, IT dept., laboratories, ECE dept., laboratories, EEE dept., laboratories, Library. In third floor, Class rooms for CS&IT departments, Staff rooms for CS & IT departments. In fourth floor, Class rooms for ECE&EEE departments, Staff rooms for ECE & EEE departments. In fifth floor, Conference hall, Seminar hall. Medical room for girls & boys. Drafting method for design the plan is by Auto cad. The framed type of construction is used for the construction and the designing of structure is carried out by limit state method with the IS 456: 2000 code book. The analysis is carried out by using limit state method. The plan and structural elements are designed using limit state method STAAD Pro and the reinforced detail has been obtained slabs and foundation has been designed using STAA Pro. This project helps us in exploring knowledge about planning analyzing and designing a College building.

Keywords: Planning, Analysis, Designing and Departments.

1. INTRODUCTION
Colleges touch all aspects of civilization. Great works of humankind, from the construction of the pyramids to the creation of the internet, are marvels of college. College is an evolving discipline that reinvents itself to explore and create solutions to new problems. Thus, while strategic planning is important for any organization, it is critical for an college where its role is two-fold: leadership in creating revolutionary technological advances through scientific discovery; and education of students who will have a significant positive impact on society.

2. STRUCTURAL DESIGN

2.1 Design Of Slab
\[ f_{ck} = 25 \text{ N/mm}^2 \]
\[ f_y = 415 \text{ N/mm}^2 \]
Room size = 6.0 x 5.8m
Support = 300 mm
Thickness of slab = 200mm

2.1.1 Type of Slab
\[ l_y/2 = 6/5.8 = 1.03 < 2 \]
Hence designed as two way slab

2.1.2 Load Calculation
Consider 1m width of slab
Live load = 2 KN/m²
Self weight of slab \( = 1 \times b \times D \times \text{unit weight} \)
\( = 1 \times 1 \times 0.20 \times 25 \)
\( = 5 \text{ KN/m}^2 \)

Weight of floor finish \( = 1 \times 1 \times 0.05 \times 20 = 1.0 \text{ KN/m}^2 \)

Total load \( = 8 \text{ KN/m} \)

Design load \( = 8 \times 1.5 = 12 \text{ KN/m} \)

2.1.3 For Shorter Span, (Max Mom In Shorter Span)

\[
M_m = 0.87 f_y A_{st} \left( 1 - \frac{f_y A_{st}}{f_{ck}} \right)
\]
\[
20.60 \times 10^6 = 0.87 \times 415 \times A_{st} \times 180 \left( 1 - \frac{415 \times A_{st}}{25 \times 1000 \times 180} \right)
\]
\[
5.99A_{st}^2 - 64.98 \times 10^3 A_{st} + 20.60 \times 10^6 = 0
\]
\[
A_{st} \text{ min} = 326.87 \text{ mm}^2
\]

2.1.4 Spacing

Assume 10 mm dia bars

- \( S = A_{st}/A_{st} \times b = 78.54/326.87 \times 1000 = 240 \text{ mm} \)
- \( 3d = 3 \times 180 = 540 \text{ mm} \)
- 300 mm c/c

Provide 10 mm dia bars @ spacing 240 mm c/c distance.

Figure 1 shows the Cross section of two way slab

2.2 Design of Beams

\( f_{ck} = 25 \text{ N/mm}^2 \)

\( f_y = 415 \text{ N/mm}^2 \)

Clear Room size \( = 14.3 \times 6 \text{m} \)

Support \( = 300 \text{ mm} \)

Thickness of slab \( D = 200 \text{mm} \)

2.2.1 Type Of Slab

\( l_y/l_x = 14.3/6 \)

= 2.38 > 2

Hence designed as one way slab

2.2.2 Load Calculation

Consider 1m width of slab

Live load \( = 2 \text{ KN/m}^2 \)

Self weight of slab \( = 1 \times b \times D \times \text{unit weight} \)
\( = 1 \times 1 \times 0.20 \times 25 \)
\( = 5 \text{ KN/m}^2 \)

Weight of floor finish \( = 1 \times 1 \times 0.05 \times 20 \)
\( = 1.0 \text{ KN/m}^2 \)

Total load \( = 8 \text{ KN/m} \)

Design load \( = 8.0 \times 1.5 = 12 \text{ KN/m} \)
2.2.3 Main Reinforcement

\[
M_x = 0.87 \text{fy}_{A_{st}} (1 - \frac{\text{fy}_{A_{st}}}{f_{ck bd}})
\]
\[
= 0.87 \times 415 \times A_{st} x 180 \times (1 - 415 \times A_{st} / 25 \times 1000 \times 180)
\]
\[
5.99A_{st}^2 - 64.98 \times 10^3A_{st} + 57.28 \times 10^6 = 0
\]
\[
A_{st \min} = 967.85 \text{mm}^2
\]

2.2.4 Spacing

Assume 10 mm dia bars

- \( S = \frac{A_{st}}{bd} \times b = \frac{78.54/967.85 \times 1000}{90} = 90 \text{ mm} \)
- \( 3d = 3 \times 180 = 540 \text{ mm} \)
- \( 300 \text{ mm c/c} \)

Provide 10 mm dia bars @ spacing 90 mm c/c distance.

2.2.5 Check For Deflection

Assume 10mm dia

\[
A_{st_{pro}} = (\text{ast/s}) \times b = (78.54/90) \times 1000
\]
\[
= 872.67 \text{mm}^2
\]

% of steel = \( 100\% \times A_{min} / bd \)
\[
= 100 \times 872.67 /1000 \times 180
\]
\[
= 0.48 \%
\]

\( F_s = 0.58 \times \text{fy}_{A_{st_{req}}} / A_{st_{pro}} \)
\[
= 0.58 \times 415 \times 967.85 / 872.67
\]
\[
= 290
\]

\( M.F = 1.15 \) (by using 290 curve in graph)
\[
d_{v } = \frac{\text{span/B}_{v} \times M.F}{6180/32 \times 1.15} = 160 \text{mm}
\]
\[
d_{req} < d_{pro}
\]

Hence design is safe

Figure 3 shows the cross section of one way slab.

2.3 Simply Supported Roof Beam

2.3.1 Available Data

Center to center distance \( l_{eff} = 6.30 \text{m} \)

\( B = 300 \text{mm} \)
\( D = 600 \text{mm} \)
\( D = 560 \text{mm} \) (assumption)

\( F_y = 415 \text{N/mm}^2 \)
\( F_{ck} = 25 \text{N/mm}^2 \)
\( Q = 3.45 \)
\( \%A_{st} = 1.197\% \)
2.3.2 Load Calculation

Self weight of beam = b x D x unit Weight
= 0.30 x 0.34 x 25 = 2.55 KN/m

Slab floor finish 1 = perpendicular distance x thickness x unit weight
= 2.9 x 0.20 x 25 = 14.5 KN/m

Wall load = 0.30 x 4.5 x 19 = 25.65 KN/m

Total load = 46 KN/M

Factored load = 46 x 1.5
F_d = 69 KN/m

2.3.3 Size of Beam

Equating Mu = Mulim
D = (3 x Mu/2 x Qu)^(1/3)
D = (3 x 342.32 x 10^6/(2 x 3.45))^(1/3)
D = 530 mm

D = 530 mm < 560 mm
Hence safe
D = 600 mm

Adopt greater value for further design

2.3.4 Area Of Reinforcement

Mu = 0.87 fyAst (d-fyAst/fck\times b)
342.32\times10^6 = 0.87\times415\times Ast\times560(1-415Ast/25 \times 300\times560)
19.97Ast^2 - 202.18\times10^3Ast + 342.32\times10^6 = 0
Ast = 2149.52 mm^2

2.3.5 Check For Stiffness

%Ast @ mid span = 2280.84\times100 / 300\times560
= 1.35%

Stress in tension reinforcement,
F_s = 0.58 Fy(Astreq/Astpro)
MF = 0.95 (From pg no 1.52)
D = 6300/32x0.95

= 280 mm < 560 mm

Hence it is safe

Figure 4 shows the Simply supported roof beam.

Figure 4 Simply supported Roof Beam

2.4 Design of Square Column

2.4.1 Available Data
2.4.2 Load Calculation

2.4.2.1 Slab

Weight of slab1 = L x B x D x unit Weight
= 3.0 x 2.9 x 0.20 x 25 = 43.5 KN

Weight of slab ff1 = L x B x D x unit Weight
= 3.0 x 2.9 x 0.05 x 20 = 8.7 KN

Live load 1 = 3.0 x 2.9 x 2.0 = 17.4 KN

2.4.2.2 Beam

Beam (1) = L x B x D x unit Weight
= 2.9 x 0.3 x 0.6 x 25 = 13.05 KN

Beam (2) = 3.0 x 0.3 x 0.6 x 25 = 13.5 KN

2.4.2.3 Wall

Wall load (1) = L x B x H x unit Weight
= 2.9 x 0.3 x 4.5 x 19 = 74.38 KN

Wall load (2) = 3.0 x 0.3 x 4.5 x 1 = 76.95 KN

2.4.2.4 Column

Self weight of column = L x B x H x unit Weight
= 0.45 x 0.45 x 4.5 x 25 = 22.78 KN

Sum of all above loads = 263.72 KN

No of floor consideration = 270 x 5 = 1350 KN

Say W = 1350 KN

2.4.2.5 Transverse Reinforcement

2.4.2.6 Minimum Diameter

1/4 x dia = 1/4 x 22 = 5.5mm

Not less than 6mm

2.4.2.7 Pitch

LLD = 450 mm

16 x 22 = 352 mm

300mm

Provide 6mm dia laterals at 300mm c/c

2.4.2.8 Result

Size of column = 450 x 450 mm

Longitudinal reinforcement = 6nos of 22mm dia bars

Transverse reinforcement = 6mm dia at 300 mm c/c

Figure 5 shows the Reinforcement of R.C.C square column
2.5 Design Of Simply Supported Plinth Beam

2.5.1 Available Data

Center to center distance $l_{c}=6.30$m

$B=300$mm, 

$D=400$mm 

$D=360$mm (assumption)

$F_{y}=415$N/mm$^2$

$F_{c}=25$N/mm$^2$

$Q=3.45$

$\%Ast=1.197$

2.5.2 Load Calculation

Self weight of beam $=b \times D \times$ unit Weight  

=0.3 x 0.4 x 25=3.0 KN/m

Wall load $=0.3 \times 4.5 \times 19=25.65$ KN/m

Total load $=28.65$ KN/M

Factored load $=28.65 \times 1.5$

$F_d=43$KN/m

2.5.3 Reinforcement

$Ast_{1}=M_{u}/(0.87 \times f_y \times (d-0.42 \times \mu_{max}))$

=134.13 x $10^6$/(0.87 x 415 x (360-0.42 x 0.48 x 360)

$Ast_{1}=1292.51$mm$^2$

$Ast_{1}=M_{u}/(0.87 \times f_y \times (d-d'))$

=79.2 x $10^6/(0.87 \times 415 \times (360-40))$

$Ast_{2}=685.50$mm$^2$

TOTAL Ast $=Ast_{1}+Ast_{2}$

=1978mm$^2$

Provide 22mm dia bars

Ast $=380.14$mm$^2$

NOS $=Ast/ast=1978/380.14=6$nos

Ast $=6 \times \pi \times 22^2/4=2280.78$mm$^2$

Provide 6nos of 22mm dia bars as tension reinforcement.

2.5.4 Check for Stiffness

$\%Ast = 100Ast/bd = 100 \times 2280.78/(300 \times 360)$

$\%Ast = 2.11$

$F_s = 0.58f_y (Ast_{col}/Ast_{pro})$

= 0.58x415x (1978/2280.78) = 240 Curve MF = 0.8

$d_{as} = \text{span}/(B_V \times MF^2)$
\[ d = \frac{6300}{32 \times 0.8} = 250 \text{ mm} < 360 \text{ mm.} \]

Hence design is safe.

Figure 6 shows the simply supported Plinth beam.

### 2.6 Design of Isolated Square Footing

#### 2.6.1 Available Data

- Size of column = 450 x 450 mm
- Safe bearing capacity = 200 KN/m²
- \( f_{ck} = 30 \text{ N/mm}^2 \)
- \( f_y = 415 \text{ N/mm}^2 \)

#### 2.6.2 Size of Footing

Axial load of footing = 1350 KN

Assume the self Weight of footing as 10% of the column load

- \( W_1 = 10/100 \times 1350 = 135 \text{ KN} \)
- Total load on soil = 1350 + 135 = 1485 KN
- Area of footing required = total load / SBC
  \[ = \frac{1485}{200} = 7.425 \text{ m}^2 \]

Since it is a square column

\[ B \times L = 7.425 \text{ m}^2 \]

\[ B \times (B) = 7.425 \text{ m}^2 \]

\[ B^2 = 7.425 \]

\[ B = 1.8 \text{ & } L = 2.8 \text{ m} \]

Area of footing = 2.8 x 2.8 = 7.84 m²

#### 2.6.3 Tension Reinforcement

\[ M_{d} = 0.87 \times f_y A_{st} d \left( 1 - \frac{f_y A_{st}}{f_{ckb}d} \right) \]

\[ 2397.76 \times 10^6 = 0.87 \times 415 \times 920 \times (1 - 415 \times 920 / 30 \times 2800 \times 920) \]

\[ 1.78A_{st}^2 - 332.16 \times 10^3 A_{st} + 2397.76 \times 10^6 = 0 \]

\[ A_{st} = 7521.88 \text{ mm}^2 \]

\[ A_{st_{min}} = 0.12/100 \times (b \times D) = (0.12/100) \times 2800 \times 970 \]

\[ A_{st_{min}} = 3259.20 \text{ mm}^2 \]

\[ A_{st} = \pi \times 22^2/4 = 380.14 \text{ mm}^2 \]

\[ \text{NOS} = \frac{A_{st}}{A_{st} / \text{ast}} = \frac{3529.20}{380.14} = 10 \text{ nos} \]

Provide 10 nos of 22 mm dia bars in long direction at uniform spacing

- \( A_{st} = 10 \times \pi \times 22^2/4 = 3801.32 \text{ mm}^2 \)
2.6.4 Check for SBC of Soil

- Column load = 1350 KN
- Weight of footing = 2.8 x 2.8 x 0.97 x 25 = 190.12 KN
- Total load on soil = 1550 KN
- Pressure on soil = 1550 / (2.8 x 2.8) = 197.70 KN/m²

197.70 KN/m² < 200 KN/m²

Hence safe.

Figure 7 shows the Reinforcement of the Square footing.

2.6.5 Staad Report

Figure 8 shows the 3D structure of the building.

Figure 9 shows the Beam 35 bending moment.

Figure 10 shows the slab stress normal fill.
Figure 10 Slab Stress Normal Fill

Figure 11 shows the Slab stress normal line.

Figure 11 Slab Stress Normal Line

Figure 12 shows the column reinforcement design.

Figure 12 Column Reinforcement Design

Figure 13 shows the shear bending.
2.6.6 Concrete Take off (For Beams And Columns Designed Above)

Total volume of concrete = 368.15 cu.meter

<table>
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<tr>
<th>BAR DIA (in mm)</th>
<th>WEIGHT (in New)</th>
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<tr>
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<td>83762.62</td>
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<tr>
<td>16</td>
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<tr>
<td>20</td>
<td>25889.59</td>
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<tr>
<td>25</td>
<td>15814.41</td>
</tr>
</tbody>
</table>

TOTAL = 355318.50

Figure 14 shows the Blue Print of the building.

3. CONCLUSION

Through our study concluded that application of software in civil industry plays important role in our study. In our study college building designed by adopting limit state method for analysis and design of our structure. Time taken for doing this project is very less due to the application of the software. It bring extra accuracy in dimension and analysis part through study. Hence, concluded that application of software in Civil Engineering filed is quite good and comprehensive for further study of structural parameter.

References


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Prof. Dr. T. Subramani Working as Professor and Dean of Civil Engineering in Vinayaka Missions Kirupananda Variyar Engineering College, Vinayaka Missions Research Foundation (Deemed to be University), Salem, Tamilnadu, India. Having more than 28 years of Teaching experience in Various Engineering Colleges. He is serving as reviewer for many International Journals and also published 250 papers in International Journals. He has presented more than 100 papers in conferences, especially 70 in International and 30 National Level. He has authored 07 books. Guided more than 259 students in PG projects. Currently he is guiding 03 Ph.D., Research Scholars. He is serving as examiner and Valuer for B.E & M.E Degree Theory and Practical Examinations for Madras University, Periyar University, Anna University, Annamalai University and Vinayaka Missions Research Foundation [Deemed to be University]. He is Question paper setter and Valuer for UG and PG Courses of Civil Engineering in number of Universities. He is serving as Chairman of Board Of Studies (Civil Engineering), Vinayaka Missions Research Foundation [Deemed to be University], also a member of Board of studies in Periyar University. He is Life Fellow in Institution of Engineers (India) and Institution of Valuers. Life member in number of Technical Societies and Educational bodies like MISTE, MIGS, MRC,ISRMTT, UWA, Salem District Small and Tiny Association (SADISSTIA), SPC – Salem Productivity Council. He has delivered much technical talk in various field. He is a Chartered Civil Engineer and Approved Valuer for many banks. He
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