Planning, Analyzing and Designing of Staff Quarters Building By Using STAAD Pro

T.Subramani¹, A.Fizoor Rahman², D.Kumar³, K.Dasarah⁴, N.Danikachalam⁵

¹Professor & Dean, Department of Civil Engineering, VMKV Engineering College, Vinayaka Missions Research Foundation (Deemed to be University), Salem, India

²Assistant Professor, Department of Civil Engineering, VMKV Engineering College, Vinayaka Missions Research Foundation (Deemed to be University), Salem, India

³,⁴,⁵UG Student, , Department of Civil Engineering, VMKV Engineering College, Vinayaka Missions Research Foundation (Deemed to be University), Salem, India

Abstract
Planning analysis and designing of staff quarters Building is our project which is proposed at Salem. The staff quarters building consists of Bed room, Kitchen, Hall, Garden, Car parking, Rest room. Drafting method for design the plan is by AutoCAD. 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 plan and structural elements are designed using STAAD Pro and the reinforced details have been obtained slabs and foundation has been designed using STAAD Pro etc. This project helps us in exploring knowledge about planning analyzing and designing of a staff quarters building.

Keywords: Planning, Designing, Building and Staff quarters.

1. INTRODUCTION
Staff quarters are those parts of a building, traditionally in a private house, which contain the domestic offices and staff accommodation. From the late 17th century until the late 19th/early 20th century they were a common feature in many large houses. Sometimes they are an integral part of a smaller house - in the basements and attics, especially in a town house, while in larger houses they are often a purpose-built adjacent wing or block. In architectural descriptions and guide books of stately homes the servants’ quarters are frequently overlooked, yet they form an important piece of social history, often as interesting as the principal part of the house itself. Before the late 17th century, servants dined, slept and worked in the main part of the house with their employers, sleeping wherever space was available. The principal reception room of a house often known as the great hall would have been completely communal regardless of hierarchy within the household.

2. SPECIFICATIONS

2.1 Foundation
Earth work excavation for foundation for all column footings will be excavated and will be in cement concrete 1:1:2 mixes, 1828mm wide and 7314mm thick laid at 2743mm below ground level. The masonry footings will be in brickwork in cement mortar 1:6. The footing size is 9662x6431mm.

2.2 Basement
The basement will be in 1st class brick work in cement mortar 1:5, and 450mm thick above ground level for all walls. The basement will be filled with clean sand to a depth of 300mm. A damp proof course in cement mortar 1:3, 20 thick will be provided for all walls at basement level. The basement will be constructed by using Random Rubble masonry with cement mortar 1:5.

2.3 Sand Filling in Basement
The basement filled up with clean sand to a depth of 710mm and it should be compacted with water as per standard specifications.
2.4 Damp Proof Course
A Damp proof course using cement mortar 1:3 of 150mm thick will be provided for all main walls at basement level.

2.5 Flooring Concrete
The flooring concrete of 1:1:2 mix with suitable thickness will be provided should be finished above the sand filling and it is by mosaic tiles.

2.6 Super Structure
All the walls will be in I class brick work in cement mortar 1:5, using first class bricks, and 300mm thick. The partition walls will be 100mm thick in brick work in cement mortar 1:5, using first class brick. The height of all walls will be 3000mm above floor level. All the walls including basement will be plastered smooth with cement mortar 1:4 externally and 1:6 internally for 12.5 thick. Parapet walls 230mm thick and 1m high will be provided all around.

2.7 Roofing
The roofing will be of R.C.C 1:1:2 mix, 150mm thick flat slabs over all the rooms. A weathering course in brick jelly lime concrete plastered with combination mortar 1:1:2 mix, 75mm thick will be provided over the slab.

2.8 Plastering For Super Structure
All walls will be plastered smooth surface with cement Mortar 1:5, 12 mm thick.

2.9 Sound Proofing For Ceiling & Wall
In ceiling of all rooms and walls are soundproofed with latest type soundproofing material.

2.10 Weathering Course
A Weathering course using brick jelly concrete will be provided average 75 mm thick over the slab and finished with two course of hydraulic pressed Mangalore flat tiles using cement mortar 1:5 mixed with 10% of crude Oil.

2.11 Size Of All Doors, Windows And Ventilators
- MD - MAIN DOOR =1800 x 2400 mm
- D1 - DOOR =1600 x 2100 mm
- D2 - DOOR =1500 x 1800 mm
- W1 - WINDOW = 900 X 1350 mm
- V - VENTILATOR =700x700mm

2.12 White Washing
One primer coat and two coats of colour wash to be done for all plastered wall surface.

2.13 Steps
The step will be in brick work in cement mortar 1:5,
- Rise =150mm
- Tread = 200mm

3. STRUCTURAL DESIGN

3.1 Design of Slab
- fck = 25 N/mm²
- fy = 415 N/mm²
- Room size = 5 x 5 m
- Support = 230 mm
- Thickness of slab =150 mm

3.1.1 Type of Slab
- ly/lx = 5/5 = 1>2
Hence designed as two way slab

3.1.2 Load Calculation
Consider 1m width of slab
Live load = 2 KN/m²
Self-weight of slab = 1 x b x D x unit weight
   = 1 x 1 x 0.15 x 25
   = 3.75 KN/m²
Weight of floor finish = 1 x 1 x 0.05 x 20 = 1.0 KN/m²
Total load = 6.75 KN/m
Design load = 6.75 x 1.5 = 10.125 KN/m

3.1.3 Main Reinforcement

\[ M_x = 0.87 \times f_y A_{st} (1 - f_y A_{st} / fckbd) \]
\[ 12.52 \times 10^6 = 0.87 \times 415 \times A_{st} \times 130 (1 - 415 \times A_{st} / 25 \times 1000 \times 130) \]
\[ 5.99A_{st} - 46.93 \times 10^3 A_{st} + 48 \times 10^6 = 0 \]
\[ A_{st} \text{ min} = 276.54 \text{ mm}^2 \]

3.1.4 Spacing
Assume 10 mm dia bars
\[ S = A_{st}/A_{st} \times b = 78.54/1209.52 \times 1000 = 290 \text{ mm} \]
3d = 3 x 180 = 390 mm
300 mm c/c
Provide 10 mm dia bars @ spacing 290 mm c/c distance.

3.1.5 Distributor Reinforcement
\[ A_{d} \text{ min} = 0.12 / 100 \times B \times D \]
\[ = 0.12 / 100 \times 1000 \times 150 \]
\[ = 180 \text{ mm}^2 \]

3.1.6 Spacing
Assume 8 mm dia of distribution steel
\[ S = A_{d} \text{ min} \times b = (50.26/180) \times 1000 \]
\[ = 280 \text{ mm} \]
5d = 5 x 150 = 650 mm
450 mm
Provide 8 mm dia bars @ spacing 280 mm c/c
Figure 1 shows the Reinforcement detail of one way slab.

Figure 1 Rehabilitation Detail of one way slab

3.2 Design of Beams
Center to center distance \( l_{eff} \) = 5.23 m
B = 230 mm
D = 340 mm
3.2.1 Load Calculation

- Self-weight of beam: \( b \times D \times \text{unit Weight} = 0.23 \times 0.34 \times 25 = 1.955 \text{ KN/m} \)
- Slab floor finish 1: \( \text{perpendicular distance} \times \text{tk} \times \text{unit Weight} = 2.5 \times 0.05 \times 20 = 2.5 \text{ KN/m} \)
- Slab self Weight1: \( 2.5 \times 0.15 \times 25 = 9.375 \text{ KN/m} \)
- Wall load: \( 0.23 \times 3 \times 19 = 13.11 \text{ KN/m} \)
- Total load: \( = 27 \text{ KN/M} \)
- Factored load: \( = 27 \times 1.5 F_d = 40.5 \text{ KN/m} \)

3.2.2 Type of Section

\[ M_{\text{lim}} = 3.45 \times 230 \times 440^2 = 153.62 \times 10^6 \text{ N.mm} \]

\[ M_{\text{lim}} < M_u \]

Hence the section shall be designed as singly reinforced section.

3.2.3 Area of Reinforcement

\[ M_u = 0.87 f_y A_{st} \times (d - f_y A_{st}/f_{ck} \times b) \]
\[ 138.47 \times 10^6 = 0.87 \times 415 \times A_{st} \times 400 \]
\[ 26.05 A_{st}^2 - 144.42 \times 10^3 A_{st} + 138.47 \times 10^6 = 0 \]
\[ A_{st} = 1233.04 \text{ mm}^2 \]

Provide 2 legged 8 mm dia stirrups @ 250mm c/c.

Figure 2 shows the Reinforcement detail of beam.

3.3 Design of Square Column

Size of column: \( 230 \times 230 \text{ mm} \)

\[ f_{ck} = 25 \text{ N/mm}^2 \]
\[ f_y = 415 \text{ N/mm}^2 \]

3.3.1 Load Calculation

3.3.1.1 Slab

\[ \text{Weight of slab (1)} = L \times B \times D \times \text{unit Weight} \]
\[ = 2.5 \times 2.5 \times 0.15 \times 25 = 23.43 \text{ KN} \]
Weight of slab ff (1) = L x B x D x unit Weight
= 2.5 x 2.5 x 0.05 x 20 = 6.25 KN
Live load (1) = 2.5 x 2.5 x 2.0 = 12.5 KN
Weight of slab (2) = L x B x D x unit Weight
= 1.5 x 2.5 x 0.15 x 25 = 14.06 KN
Weight of slab ff (2) = L x B x D x unit Weight
= 1.5 x 2.5 x 0.05 x 20 = 3.75 KN
Live load (2) = 1.5 x 2.5 x 2.0 = 7.5 KN

3.3.1.2 Beam
Beam (1) = L x B x D x unit Weight
= 2.5 x 0.23 x 0.44 x 25 = 6.33 KN
Beam (2) = 2.5 x 0.23 x 0.44 x 25 = 6.33 KN

3.3.1.3 Wall
Wall load (1) = L x B x H x unit Weight
= 3.75 x 0.23 x 3 x 19 = 49 KN
Wall load (2) = 3 x 0.23 x 3 x 19 = 39.33 KN
Wall load (2) = 2.15 x 0.23 x 3 x 19 = 28.18 KN

3.3.1.4 Column
Self weight of column = L x B x H x unit Weight
= 0.23 x 0.23 x 3 x 25 = 3.96 KN
Sum of all above loads = 210KN
No of floor consideration = 210 x 2.0 = 420 KN

3.3.1.5 Result
Size of column = 230 x 230 mm
Longitudinal reinforcement = 6nos of 12mm dia bars
Transverse reinforcement = 6mm dia at 195 mm c/c

Figure 3 shows the Reinforcement detail of R.C.C. Column.

3.4 Design of Footing
Size of column = 230 x 230 mm
Safe bearing capacity = 50 KN/m²
fck = 30 N/mm²
fy = 415 N/mm²
Axial load of footing = 420 KN
Assume the self Weight of footing as 10% of the column load
W1 = 10/100 x 420 = 42 KN
Total load on soil = 420 + 42 = 470 KN
Area of footing required = total load / sbc
= 470 / 150
= 3.13 m²
Since it is a Square column

3.4.1 Tension Reinforcement

\[ M_{UL} = 0.87 \, f_y \, A_{st} \, d \times (1 - \frac{f_y A_{st}}{f_{ckbd}}) \]
\[ 496.75 \times 10^6 = 0.87 \times 415 \times A_{st} \times 520 \times (1 - 415 \times A_{st} / 30 \times 1800 \times 520) \]
\[ 2.17A_{st}^2 - 187.74 \times 10^3 A_{st} + 496.75 \times 10^6 = 0 \]
\[ = 2758.20 \, mm^2 \]

Provide 16 nos of 10 mm dia bars in long direction at uniform spacing
Figure 4 shows the reinforcement details of footing.

4. STAAD REPORT

Figure 5 shows the whole structure of the building.

Figure 6 shows the 3D Rendering view.
Figure 6 3D Rendered view

Figure 7 shows the Bending moment diagram.

Figure 7 Bending Moment diagram

Figure 8 shows the shear force diagram.

Figure 8 Shear Force Diagram

Figure 9 shows the Maximum bending moment at Critical Beam.

Figure 9 Maximum Bending moment at Critical Beam

4.1 BEAM NO. 297 DESIGN

<table>
<thead>
<tr>
<th>Beam Design</th>
<th>Fe415 (Main)</th>
<th>Fe415 (Sec.)</th>
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</thead>
<tbody>
<tr>
<td>LENGTH:</td>
<td>5000.0 mm</td>
<td></td>
</tr>
<tr>
<td>SIZE:</td>
<td>230.0 mm X</td>
<td>230.0 mm</td>
</tr>
<tr>
<td>COVER:</td>
<td>25.0 mm</td>
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SUMMARY OF REINF. AREA (Sq.mm)

<table>
<thead>
<tr>
<th>SECTION</th>
<th>0.0 mm</th>
<th>1250.0 mm</th>
<th>2500.0 mm</th>
<th>3750.0 mm</th>
<th>5000.0 mm</th>
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<tbody>
<tr>
<td>TOP</td>
<td>253.20</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>303.70</td>
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<tr>
<td>REINF.</td>
<td>(Sq. mm)</td>
<td>(Sq. mm)</td>
<td>(Sq. mm)</td>
<td>(Sq. mm)</td>
<td>(Sq. mm)</td>
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</tbody>
</table>
### SUMMARY OF PROVIDED REINF. AREA

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<th>SECTION</th>
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<th>REINF.</th>
<th>(Sq. mm)</th>
<th>TOP</th>
<th>REINF.</th>
<th>(Sq. mm)</th>
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</thead>
<tbody>
<tr>
<td>0.0 mm</td>
<td>0.00</td>
<td>1 layer(s)</td>
<td>1250.0 mm</td>
<td>2-16í</td>
<td>1 layer(s)</td>
<td>2500.0 mm</td>
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<tr>
<td>92.80</td>
<td>151.21</td>
<td>1 layer(s)</td>
<td>3750.0 mm</td>
<td>2-16í2-16í2-16í</td>
<td>1 layer(s)</td>
<td>5000.0 mm</td>
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<tr>
<td>92.80</td>
<td>0.00</td>
<td>1 layer(s)</td>
<td></td>
<td></td>
<td>1 layer(s)</td>
<td></td>
</tr>
</tbody>
</table>

### SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM 310.0 mm AWAY FROM START SUPPORT

- VY = 18.85
- MX = 0.08
- LD = 1

Figure 10 shows the Reinforcement details for beam.

![Figure 10 Reinforcement Details for Beam](image)

Figure 11 shows the Maximum Bending moment at critical column.

![Figure 11 Maximum Bending moment at Critical Column](image)
4.2 COLUMN No. 398 DESIGN RESULTS

M25 Fe415 (Main) Fe415 (Sec.)
LENGTH: 5000.0 mm CROSS SECTION: 230.0 mm X 300.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 1 BRACED LONG COLUMN
REQU. STEEL AREA : 248.42 Sq.mm.
REQU. CONCRETE AREA: 68751.59 Sq.mm.
MAIN REINFORCEMENT : Provide 4 - 16 dia. (1.17%, 804.25 Sq.mm.)
(Equally distributed)
TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 230 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)

---------------------------------------------
Puz : 850.78 Muz1 : 28.01 Muy1 : 20.83

INTERACTION RATIO: 1.00 (as per Cl. 39.6, IS456:2000)

Figure 12 shows the Reinforcement details for column.

4.2 Concrete Take off
(FOR BEAMS AND COLUMNS DESIGNED ABOVE)

TOTAL VOLUME OF CONCRETE = 41.40 CU.METER

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<th>BAR DIA</th>
<th>WEIGHT</th>
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<tr>
<td>(in mm)</td>
<td>(in New)</td>
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<tr>
<td>8</td>
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<tr>
<td>16</td>
<td>38398.60</td>
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<tr>
<td>20</td>
<td>2902.56</td>
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<tr>
<td>25</td>
<td>1511.89</td>
</tr>
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TOTAL = 57516.18

5. DRAWING

Figure 13 shows the blue print of the building.
6. CONCLUSION

Our study concluded that application of software in Civil industry plays important role in our study. Staff quarters are essential and very important for the staffs working nearby industry. The structure is designed as a framed structure for the purpose of extending floors time taken for doing this project is very less due to the application of the software and this software is quite good and comprehensive for further study of structural parameter.

References


AUTHOR

Prof. Dr. T. Subramani Working as Professor and Dean of Civil Engineering in Vinayaka Missions Kirupananda Varipayar 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 250 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, MIRC,ISKMTT, 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 is a Licensed Building Surveyor in Salem City Municipal Corporation-Salem, and Licensed Civil Engineer in Salem Local Planning Authority- Salem. He is the recipient of many prestigious awards.

A.Fizoor Rahman working as an Assistant Professor in VMKV Engg. College, Vinayaka Missions Research Foundation (Deemed to be University), Salem, Tamilnadu, India. He has completed his Master of Engineering Degree in the branch of Structural Engineering in Anna University, Chennai. He’s having more than 2 years of teaching experience in Various Engineering Colleges and he had guided many UG projects. He has attended more than 3 international conferences and submitted 2 international journals.

D.Kumar completed his branch of Civil Engineering in Government Polytechnic College Krishnagiri, Tamilnadu, India and now he is perusing his B.E Degree in the branch of Civil Engineering at V.M.K.V. Engineering College, Vinayaka Missions Research Foundation (Deemed to be University), Salem, Tamilnadu, India. He has well knowledge in AUTOCAD drawing. His hobbies are playing Basketball, Shuttlecock and Cricket.

K.Dasarah is perusing his B.E Degree in the branch of Civil Engineering at V.M.K.V. Engineering College, Vinayaka Missions Research Foundation (Deemed to be University), Salem, Tamilnadu, India. He has well knowledge in AUTOCAD and STADD PRO Skills. His hobbies are playing Basketball, Shuttlecock and Cricket.

N.Danikachalam has completed his B.E Degree in the branch of Civil Engineering at V.M.K.V. Engineering College, Vinayaka Missions Research Foundation (Deemed to be University), Salem, Tamilnadu, India. He has well knowledge in Structural design and AUTOCAD drawing skills. His hobbies are Listening music and playing Basketball, Shuttlecock and Cricket.