G+1 RESIDENTIAL BUILDING – ANALYSIS, DESIGN, AND ESTIMATION
Pranav Sai Gajapathi Raju Danthuluri*1
*1Student, Department Of Civil Engineering, Amrita Vishwa Vidyapeetham, Coimbatore, Tamil Nadu, India.

ABSTRACT
This report has been prepared as part of project work to fulfill the requirement of the course syllabus prescribed to the Civil Engineering final year course. We have chosen the project entitled "G+1 Residential Building - Analysis, Design, and Estimation" under the guidance of our dedicated supervisor and the Department of Civil Engineering. The housing site area consists of a plot area of 12.2m x 18.3m and a carpet area of 91.1m². The proposed building area was 9.15m x 13.72m i.e., It is a 2-bedroom house, with a study area, kitchen, living room on the ground floor and 3-bedroom house on the 1st floor and gardening facilities on the terrace with some open area for balcony. The walls provided are of brick masonry 300 mm thick, for the external walls and 230 mm thick in case of partition walls, where an over-head tank is also provided. Sump and a septic tank are also provided underground. Solar energy is a truly renewable energy source. Hence use of solar panels for generating electricity to power the house will be one big step to sustainability. It can help in reducing or eliminating the electricity bills while reducing the environmental impact of the house.

Keywords: Analysis, Design, Estimation, Structural, Autocad, Staad Pro.

I. INTRODUCTION
This report has been prepared as part of project work to fulfill the requirement of the course syllabus prescribed to the Civil Engineering final year course. We have chosen the project entitled "G+1 Residential Building - Analysis, Design, and Estimation" under the guidance of our dedicated supervisor and the Department of Civil Engineering. The housing site area consists of a plot area of 12.2m x 18.3m and a carpet area of 91.1m². The proposed building area was 9.15m x 13.72m i.e., It is a 2-bedroom house, with a study area, kitchen, living room on the ground floor and 3-bedroom house on the 1st floor and gardening facilities on the terrace with some open area for balcony. The walls provided are of brick masonry 300 mm thick, for the external walls and 230 mm thick in case of partition walls, where an over-head tank is also provided. Sump and a septic tank are also provided underground. Solar energy is a truly renewable energy source. Hence use of solar panels for generating electricity to power the house will be one big step to sustainability. It can help in reducing or eliminating the electricity bills while reducing the environmental impact of the house.

II. METHODOLOGY
2.1 Development of Housing plan and Analysis model
- The 2-D Modeling of the house was developed using AutoCAD comprising of the plan, section, and elevation view.
- A Staad pro model was also developed with the help of the AutoCAD model and analysis of frames was done.

Design of G+1 Housing The design parameters conformed to IS 456, and the Dead Load (DL) and Live Load (LL) were taken from IS 875 PART 1 and 2 respectively. The design was aided by the use of SP – 16 which is aid of design for Structural RCC members.

2.2 Analysis and Design Approach
- Loads acting on the structure
- Analysis of forces acting on the structure
- Designing of structural components based on the forces found out from the analysis
- Transfer of load from Slab – Beam, Beam-Column, Column to Footing analysis was also done and design was provided for the same.
- Based on the Design values, the required amount of steel was provided, and detailing was done.
III. ANALYSIS OF STRUCTURE

M Analysis of the structure is done manually using the substitute frame method and is compared with the analysis obtained from the STAAD pro software which was found to be almost the same. The moments obtained using STAAD pro software for the critical frame are as shown in the figure. Design of the slabs, beams, columns, footings of the building is done for the moments obtained for the critical frame using staad pro software: https://drive.google.com/file/d/1uGtApPG2yDr1kiU_B0SEvUGngE902ECX/view?usp=sharing

**Design of slabs:**
- Slabs are to be designed under the limit state method by reference of IS 456:2000.
- When the slabs are supported in a two-way direction it acts as a two-way supported slab.
- If $L_y/L_x < 2$ it is a two-way slab and if $L_y/L_x > 2$ it is a one-way slab.
- The building consists of 6 slabs at the first-floor level and 6 slabs at the second-floor level which are all two-way slabs.
- The design of the two-way slab is as follows.

**Design of Two-way slab**

Slab dimension = 4.6 * 3.74 m $L_y/L_x = 1.22 < 2$

Therefore, it is a 2-way slab. Load on slabs:
1. Self-Weight = 3 kN/m²
2. Floor finish = 2 kN/m²
3. Wall finish = 1 kN/m²
4. Plastering = 1 kN/m²

Live load = 2 kN/m² Total load = 9 kN/m²

Factored load = 1.5 * 9 = 13.5 kN/m² $D = 150$ mm Therefore, $d = 120$ mm

Slab supported by beams on 4 sides all edges are discontinuous, short span coefficients $\alpha_x = 0.072$

Long span coefficients $\alpha_y = 0.056$

$M_{ux} = 0.072 \times 13.5 \times (3.835)^2 = 14.29$ kNm

Ast required in shorter span = 286 mm² Providing 10mm diameter bars Spacing = 150 mm c/c

Bend half of the bars @ 0.15 $L_x = 0.15 \times 3890 = 600$ mm (approx.) Ast required in longer span = 114 mm²

Providing 10mm diameter bars Spacing = 150 mm c/c

Ast provided = 198.38 mm²

Bend half of the bars @ 0.15 $L_x = 0.15 \times 4600 = 690$ mm (approx.)

**Design of Beams:**
- The beam is a member which transfers the loads from slab to columns
- The beam is a tension member.
- The span of slabs, which decide the spacing of beams.
- Following are the loads which are acting on the beams.
  - Dead load
  - Live load
- The total number of horizontal beams are 36
- The design of the beam is as follows

**Design of Beam:**
DESIGN SECTION OF BEAM:
Unit weight of Concrete =25KN/m3
Concrete grade (fck) =25N/mm²
Steel grade (fy) =415N/mm²
Clear Cover =30mm
Dia of rod used =16 mm
"Beam Size(b x d)" = 300mm x 400mm
deff = (d - clear cover -dia of bar/2 -dia of stirrups) =350mm
Moment M (from staad) =64.11KN-m
Factored Moment Mu = 1.5 x M =96.165KN-m
k = (Mu / (bx deff²)) x106 =2.616 N/mm²
d'/d =0.09
Ast required sqmm=(Ptx( bx deff))/100 =884.67mm²
No of bars required =4.87
No of bars provided =6
Ast provided sqmm =1205.76 mm²
Maximum Ast = 4 x bx d / 100
(Refer clause 26.5.1.of IS 456) =4800 mm²
Minimum Ast = 0.2 % bd
( For fy 415 grade ) =240mm²
Shear V (from staad) =79.2 KN
Factored shear stress tv=(1.5xV/bxdeff)x1000 =1.13N/mm²
pt provided=( Ast /bx deff ) x100=1.15%
Permissible shear stress tc (from SP16) for pt =0.44 N/mm²
Vus /d =( (tv - tc) x b / 100) =2.07Kn/cm Stirrups
spacing should not exceed
0.75 d (or) 300mm whichever is less. =200.000mm
(Refer clause 25.6.1 of IS 456) Minimum shear reinforcement
Asv > 0.4 x b sv / 0.87 x fy =55.72mm²
sv = spacing of shear reinforcement
Provide 6 no's of 16mm dia stirrups at a spacing of 200 mm c/c

Section of Beam
Therefore, the beams of size 300mmx 400mm are provided with 6 no of 16 mm dia bars throughout the length with shear reinforcement of 8 mm dia stirrup at 200mm spacing c/c and all the other beams are found to have the same specifications.

DESIGN OF CRITICAL COLUMN
• Columns are compression members.
• Larger spacing columns cause stocking columns in lower stores of multi-storied buildings.
• Columns transmit loads that are coming from slabs to foundations. Larger spans of beams shall also be avoided from the consideration of controlling the deflection & cracking.
• There are 13 columns on each floor.
• The design procedure for column of critical frame is as follows:/ Factored axial load= 405.94 kN
Mx in the column= 21.57 kNm My in the column= 3.23 kNm
Length of column = 3000 mm Dimension of column:
Dimension in the x direction = 300 mm Dimension in the y direction = 300 mm
\[ e_x = 16 \text{ mm} < 20 \text{ mm} \]
\[ e_y = 16 \text{ mm} < 20 \text{ mm} \]

Hence \( e_x \) min = \( e_y \) min = 20 mm

The moment due to eccentricities in both the direction was considered \( f_y = 415 \text{ N/mm}^2 \)

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

Percentage of steel = 1.5; \( d'/D = 0.186 \) (Table 45, SP – 16)

\[ p/f_{ck} = 0.06; \; d'/B = 0.187 \]

\[ p_u/f_{ck}b*d = 0.12 \]

\[ M_x = 21.57 \text{ kNm} \]

\[ M_y = 3.23 \text{ kNm} \]

\[ M_x/(f_{ck}bd^2) = 0.075 \]

\[ M_y/(f_{ck}b^2d) = 0.075 \]

\[ M_x = 50.625 \text{ kNm} \]

\[ M_y = 50.625 \text{ kNm} \]

Area of steel = 1350 mm\(^2\)

no. of bars 6.71  Provide 8 bars of 16 mm dia \( P_{uz} = 1417.2 \text{kN} \)

\[ P_u/P_{uz} = 0.19 \]

Interaction equation:

\[ [Mux/Mux1]\alpha_n + [Muy/Muy1]\alpha_n \textless 1 \]

\( \alpha_n = 1 \) for 0.2 and less than 0.2

\( \alpha_n = 2 \) for 0.8 Here, \( \alpha_n = 1 \)

\[ 21.57/50.6251 + [6.6/50.625]1 = 0.556, \text{ which is less than 1 Hence okay.} \]

Interaction equation = 0.556 \( <1 \)

#8 – 16mm dia bar

8 mm stirrups with 200mm spacing

Therefore, the column 300mm X 300mm is reinforced with 8 no. of 16 mm dia bars and 8mm stirrups @200mm c/c spacing.

And all the columns are provided with the same specifications

**Design of Footing:**

- Footings distribute the weight of the superstructure over the ground to provide stability to the superstructure.
- Footings receive the load from the columns and transfer to the hard strata.
- Footings are designed to resist:
  1. Punching shear
  2. Bending moment
- There is a total of 13 footings to be designed.
The design of the footing is as follows

**Design of Footing:**
1. Design Forces From STAAD
   1. Axial Load on column = 270.63 kN
   2. Bending moment along x-x, \( M_x = 21.57 \text{ kNm} \)
   3. Bending moment along y-y, \( M_y = 3.23 \text{ kNm} \)
2. Design Data
   1. Compressive strength of Concrete, \( F_{ck} = 25 \text{ N/mm}^2 \)
   2. Yield Strength of steel, \( F_y = 415 \text{ N/mm}^2 \)
   3. Diameter of Reinforcement, (x-direction) = 16 mm
   4. Diameter of Reinforcement, (y-direction) = 16 mm
   5. Clear cover to the reinforcement, \( C = 40 \text{ mm} \)
   6. Safe bearing capacity of the soil, \( S_{BC} = 150 \text{ kN/m}^2 \)
   7. Type of Footing = Square
   8. Size of pedestal/Column = \( b \times d \)
   \[ = 0.6 \times 0.2 \text{ m} \]
   3. Assume trial size of footing
      Area of footing = Total Load / SBC Self Wt. of footing
      (Assume 10% of column load) = 0.3 kN
      Total Load = 270.93 kN
      Area of footing required = 270.93 / 150
      \[ = 1.81 \text{ m}^2 \]
      Size Required B = 0.58 m
      L = 0.87 m
      Size Provided B = 2 m
      L = 2.5 m
      Area of Footing Provided = 5 m^2
      \( S > 1.81 \)

Check
1. Section geometry
   Assume Overall depth of footing, \( D = 400 \text{ mm} \)
   Depth at free end, \( C = 200 \text{ mm} \)
   \( d_{ef} \text{ at critical moment section} = 352 \text{ mm} \)
   \( d_{ef} \text{ at critical one-way shear section} = 290.78 \text{ mm} \)
   \( d_{ef} \text{ at critical two-way shear section} = 321.39 \text{ mm} \)
2. Check for soil pressure
   **A) Along X direction**
   Eccentricity, \( e_{xx} = \frac{M_{xx}}{P} \)
   \[ = 21.57 / 270.93 \]
   \[ = 0.08 \]
   \[ L_x / 6 = 0.417 > 0.08 \]
   \( e_{xx} < L_x / 6 \)
   Maximum Pressure, \( P_{max} \)
   \[ = \frac{P}{A(1+6e/B)} \]
   \[ = \frac{270.93}{5(1 + 6 \times 0.08/2.5)} = 64.6 \text{ kN/m}^2 \]
   \[ = 64.6 < 150 \]

Check
Minimum Pressure, \( P_{\text{min}} \)
\[
= \frac{P}{A} (1 - \frac{6e}{B})
= \frac{270.93}{5} (1 - \frac{6 \times 0.08}{2.5})
= 43.8 \text{kN/m}^2
= 43.8 < 150
\]
Check

**B) Along Y direction**

Eccentricity, \( e_{yy} = \frac{M_{yy}}{P} \)
\[
= \frac{3.23}{270.93}
= 0.012 \text{m}
\]
\[
0.333 > 0.012
\]
Check

Maximum Pressure, \( P_{\text{max}} \)
\[
= \frac{P}{A} (1 + \frac{6e}{B})
= \frac{270.93}{5} (1 + \frac{6 \times 0.012}{2})
= 56.1 \text{KN/m}^2
= 56.1 < 150
\]
Check Minimum Pressure, \( P_{\text{min}} \)
\[
= \frac{P}{A} (1 - \frac{6e}{B})
= \frac{270.93}{5} (1 - \frac{6 \times 0.001}{2})
= 52.2 \text{KN/m}^2
= 52.2 < 150
\]
Check

3. **Bending moment calculations**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Direction</th>
<th>( P_{\text{max}, \text{net}} )</th>
<th>( P_{\text{min}, \text{net}} )</th>
<th>( P ) at the face of the column</th>
<th>Moment, KN/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>x</td>
<td>64.54</td>
<td>43.74</td>
<td>53.31</td>
<td>39.47</td>
</tr>
<tr>
<td>2</td>
<td>y</td>
<td>56.04</td>
<td>52.14</td>
<td>53.31</td>
<td>13.33</td>
</tr>
</tbody>
</table>

4. **Check for depth (Moment consideration)**

\[
M_{\text{ulim}} = (0.36 \times F_{ck} \times (x_{\text{u,max}}/d)) \times (1 - 0.42(x_{\text{u,max}}/d)) \times bd\]
\[
d_{\text{reqd}} = (M_{\text{ulim}}/Q_b)^{1/2}
= (39470000/(3.34 \times 1000))/2
= 108.71 \text{mm}
= 108.71 < 352
O.K

5. **Calculation of Reinforcement**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Direction</th>
<th>( M_{u}/bd^2 )</th>
<th>Pt from SP16</th>
<th>Pt, min</th>
<th>Pt, provided</th>
<th>Ast, mm$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>x</td>
<td>0.3</td>
<td>0.090</td>
<td>0.12</td>
<td>0.120</td>
<td>422.4</td>
</tr>
<tr>
<td>2</td>
<td>y</td>
<td>0.1</td>
<td>0.031</td>
<td>0.12</td>
<td>0.120</td>
<td>422.4</td>
</tr>
</tbody>
</table>

\[
pt = 100Ast/bd\]
\[
Ast = (pt/100) \times bd\]
6. Spacing of reinforcement

<table>
<thead>
<tr>
<th>Spacing, mm</th>
<th>Spacing provided, mm</th>
<th>Ast provided, mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>Minimum</td>
<td></td>
</tr>
<tr>
<td>460</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>460</td>
<td>300</td>
<td>300</td>
</tr>
</tbody>
</table>

Spacing = (ast x 1000)/Ast where, ast= C/s area of bar and Ast=Area of reinforcement provided

10. Check for one-way shear

<table>
<thead>
<tr>
<th>S.No</th>
<th>Direction</th>
<th>max(net)</th>
<th>Pmin(net)</th>
<th>P at critical 1way shear Xₙ</th>
<th>Shear. KN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>x</td>
<td>64.54</td>
<td>43.74</td>
<td>50.38</td>
<td>37.55</td>
</tr>
<tr>
<td>2</td>
<td>y</td>
<td>56.04</td>
<td>52.14</td>
<td>52.82</td>
<td>18.55</td>
</tr>
</tbody>
</table>

Nominal Shear stress, tv

=Vu/bd

=37550/1000 x 290.78

=0.13N/mm²

pt,max, Provided=0.1903% Allowable shear stress, tc (for pt, max)

=0.32346N/mm²

tv<tc O.K

11. Check for two-way shear

Punching shear, Vu = Net upward pressure x (AF - Ac)

=264.13KN

Punching Shear stress,

=Vu/perimeter at critical section*deff

=0.46898N/mm²

Allowable Stress=0.25(fck)1/2

=1.25N/mm² O.K

4) DESIGN OF STAIRCASE:

1. DATA:

number of steps in the flight= 10 tread T =300mm

Rise R=150mm

Width of landing beams=900mm fck=25N/mm²

fy=415N/mm²

width of staircase b=900mm

1. EFFECTIVE SPAN:

Effective span = (no of steps *thread) + width of landing beam Effective span =4000mm=4m

thickness of waist slab =span /20=200mm adopt overall depth = D=200mm

effective depth=d=160mm

2. LOADS:

Dead load on slab on slope =wₘ= D*1*25=5KN/m Dead load of slab on horizontal span is

wₘ=wₙ(R²+T²)/2 wₙ=5.590169944KN/m

dead load on one step =0.5*R²*T² =0.5625KN/m loads of steps per meter length = (d.l*b/T) = 1.875KN/m finishes =0.53KN/m

www.irjmets.com  @International Research Journal of Modernization in Engineering, Technology and Science
total dead load =8.3701699KN/m service live load=3KN/m
factored load = wu= 1.5*t. l=17.05525492KN/m

3. BENDING MOMENTS:
the maximum bending moment at the Centre of the span is Mu =0.125 WuL^2

Mu =34.11050983 kN.m

4. CHECK OF DEPTH OF WAIST SLAB:

Mu = 0.138f_c,bd^2
by solving d =104.81255mm < 160mm hence safe

5. MAIN REINFORCEMENTS:

Mu=0.87fy Ast d
by solving Ast =529.2407726m^2 dia of bar=12mm
no of bar =4.6818894nos so Ast =529.24077mm^2
provide 12mm diameter bar at 200mm C-C distance as main reinforcement

1. DISTRIBUTION REINFORCEMENT
distribution reinforcement = 0.12 percent of cross-section
=216mm^2
dia of bar=8mm
no of bars=4.2993631
provide 8mm diameter bar at 200mm C-C distance as distribution reinforcement Ast=216mm^2

DESIGN OF OVERHEAD WATER TANK

Dimensions
Average per capita water required =135lpcd Total no of people =15 Total water required per day =135*15 =2025L
Storage =4days
Total water for 4 days =8100 L
Assume depth =2 m
Area =8.1/2 =4.05m^2
\[ \frac{\pi}{2} = 3.3 \times b^2 = 4.05 \]

\[ b = 1.16 \, \text{m} \]

\[ l = 3.48 \]

Dimension of overhead tank: \( 3.48 \times 1.16 \times 2 \, \text{m} \)

**Design of Overhead Tank**

Given Capacity of the tank = 8100 litres = 84 \( \text{m}^3 \) Free board = 0.2 m

Depth of tank = 2 m

Length of tank = 3.48 m

Breadth of tank = 1.16 m Grade of concrete = M25 grade

Permissible Stress \( c_{bc} = 8.5 \, \text{N/mm}^2 \)

Modular ratio, \( M = \frac{280}{(3 \times c_{bc})} = 10.98 \approx 11 \)

\[ st = 275 \, \text{N/mm}^2 \text{ for Fe 500} \]

K = (\( mx \, cb \))/(\( mx \, cbc \times st \)) = 0.25373 \approx 0.254

\[ k = 0.5 \times 0.314 \times n \times j = 0.988 \, \text{N/mm}^2 \]

Dimensions of Tank Height = 2 + 0.2 = 2.2 m \( (L \backslash B) = 3 \, \text{m} \)

Maximum Bending Moment at the base of,

**Long walls** = \( H/6 = (9.81 \times 2.2^3)/6 = 17.40 \, \text{kN} \, \text{m} \)

\[ d = \frac{M^0.5}{(Qb)^0.5} = (17.40 \times 10^6)^{0.5}/(0.988 \times 1000)^{0.5} = 132.7 \, \text{mm} = 133 \, \text{mm} \]

Let us use 12 mm diameter bars and 30 mm nominal cover, Overall depth (\( D \)) = 169 mm

Effective depth (\( d \)) = 133 mm

Therefore, \( A_{st} = 17.40 \times 10^6 / (93.5 \times 0.915 \times 133) = 1529.2 \, \text{mm}^2 \)

Spacing of 12 mm bars = \( (1000 \times 0.25 \times 3.14 \times 12^2)/1529.2 = 73.92 = 75 \, \text{mm} \)

Let us provide 75 mm c/c spacing. The spacing is increased towards the top for 1 m. Intensity of pressure 1 m above base is, \( p = 9.81 \times (2-1) = 9.81 \, \text{kN/m}^2 \)

Direct tension in long walls, \( T = (9.81 \times B)/2 = (9.81 \times 1.16)/2 = 5.68 \, \text{kN} \)

\[ A_{st} = (5.68 \times 1000)/275 = 56.8 \, \text{mm}^2 \]

\[ A_{st} \text{min} = 0.12 \times b \times D/10 = 235.248 \, \text{mm}^2 \]

Provide 8 mm diameter bars, spacing = \( (1000 \times 0.25 \times 3.14 \times 8 \times 8)/235.248 = 213.5 \, \text{mm} \)

Let us provide 250 mm c/c.

**Design of Short wall:**

\[ p = 9.81 \, \text{kN/m}^2 \]

Effective span of horizontal slab = \( (1.16 + 0.3) = 1.46 \, \text{m} \)

Bending Moment (Corner Section) = \( pl^2/12 = (9.81 \times 1.46^2)/12 = 1.74 \, \text{kN} \, \text{m} \)

Tension transferred per meter height of short wall = 9.81 \times 1 = 9.81 \, \text{kN} \)

\[ A_{st} = (M-Tx)/st \, jd + (T)/st = (1.74 \times 10^6) - (9.81 \times 1000)(133-75)/275 \times 0.915 \times 133 + (9.81 \times 1000)/275 = 105.83 \, \text{mm}^2 \]

Spacing of 8 mm bars = \( 1000 \times 50.265/105.83 = 474.95 \, \text{mm} \)

Adopt 8 mm bars at 300 mm c/c.

**DESIGN OF UNDERGROUND SUMP**

**Dimensions**

Total water required per day = 2025

Storage = 2025 \times 10 = 20250 \, \text{L}

Assume depth = 1.5 m

Area = 13.5 \, \text{m}^2

\[ l/d = 3 \]

3b^2 = 13.5

\[ b = 2.12 \, \text{m} \]

\[ l = 3 \times 2.12 = 6.3 \, \text{m} \]

Dimensions of underground sump: 6.3 \times 2.12 \times 1.5
Design of Sump

Given
Capacity of the tank = 20250 liters
= 20.25 m³
Free board = 0.2 m
Breadth of tank = 2.12 m
Length of tank = 6.3 m
Height of tank = 1.5 m

Two Conditions:
1. Tank Full:
   H = 1.3 m
   Y = 10 m
   \( M = \frac{(10 \times 1.33)}{6} = 3.66 \text{ kNm} \)
   \( T = \frac{(10 \times 1.3) \times 2.12}{2} = 13.78 \text{ kN} \)

   For \( M 20 \) and Fe 415
   \( Q = 1.16, j = 0.87 \)
   \( M = Qbd \)
   \( 3.66 \times 10^6 = 1.16 \times 1000 \times d^2 \)
   \( d = 57 \text{ mm} \)
   \( D = d + \text{cover (30 mm)} + (\text{diameter of bar}) / 2 = 93 \text{ mm} \)
   \( \text{Ast} = 3.66 \times 10^6 / 0.87 \times 57 \times 150 = 492.034 \text{ mm}^2 \)

   Using 12 mm bars
   Spacings: 1000 / Ast x 113.09
   = 230 mm c/c
   \( \text{Ast (min)} = 0.12 \times b \times D / 100 \)
   = 223 mm²

   Proving 8 mm bars for distribution Spacings: 1000 / (223 / 71.74) = 320 mm c/c

   Check for Tension (T):
   Consider 1 m height of the well, Tensile stress induced = \( T / \text{area} \)
   \( = 13.78 \times 10^3 / 1000 \times 93 = 0.148 \text{ N/mm}^2 < 1.2 \text{ N/mm}^2 \)

   Therefore, safe

2. Tank Empty:
   \( M = K_a \times V_{soil} \times H^3 / 6 = \)
   \( K_a = \frac{1 - \sin \phi}{1 + \sin \phi} (\phi = \text{angle of repose}) \)
   \( = 1 + \sin 30 = 0.3 \times 15 \times 1.3^3 / 6 = 1.647 \)
   \( \text{Ast} = 492 \text{ mm}^2 \) Using 12 mm bars
   Spacing = 1000 x 71.74 / 492 = 145.8 mm

   Provide distribution reinforcement horizontally in both faces @ 140 mm.
   Spacing = 2 x 140
   = 280 mm

   Provide 8 mm bars @ 250 mm

**Design of Septic Tank**

Total no of person = 15
Average wastewater generated per head = 108 L per day (80%)
Sludge deposited = 40 L per person per year
Cleaning period = 1 year
The total volume of wastewater = 20 * 108 = 2160 L per day
The capacity of tank required = 15 * 40 = 600 L per year
Sludge accommodation:
Detection = 2 days
The total volume of tank = 2 * 2160 + 600 = 4920 L = 4.9 cusecs
Assume, l/d = 3
Depth = 1.5 m
Freeboard = 0.3 m
Area = 3.26 m²
Breath = 1.05 m
Length = 3.15 m
Dimension of septic tank: 3.15 m x 1.05 m x 1.5 m

**Bar bending schedules COLUMN:**

Length of longitudinal bar:
\[ [(3000 + 600 + 1000) - (40 + 16 + 16) + (Ld + 300)] \]
\[ = 4600 - 72 + [(40 \times 25) + 300] = 5828 \text{ mm} \]

Number of lateral ties:
\[ \text{Length of longitudinal bar} \times (Ld + 300) / \text{Spacing} \times 1 \]
\[ = [5828 - (40 \times 25) + 300 / 300] + 1 \]
\[ = 16 \text{ (approximately)} \]

Cutting length of one lateral tie:
\[ 2(a + b) + \text{Hook length - bends} \]
Where \( a = 300 - (2 \times 40) - (2 \times 8) = 204 \text{ mm} \)
\( b = 300 - (2 \times 40) - (2 \times 8) = 204 \text{ mm} \)
\[ 2(204 + 204) + (2 \times 10 \times 8) - (3 \times 2 \times 8) = 928 \text{ mm} \] (135 deg bend = 10d; 90 deg bend = 2d)

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Type of bar</th>
<th>Dia (mm)</th>
<th>No.</th>
<th>Length (m)</th>
<th>Total length (m)</th>
<th>Weight (kg/m)</th>
<th>Total weight (kg)</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Longitudinal bar</td>
<td>25</td>
<td>8</td>
<td>5.828</td>
<td>46.624</td>
<td>3.85</td>
<td>179.5</td>
<td>d*d / 162.2</td>
</tr>
<tr>
<td>2</td>
<td>Lateral tie</td>
<td>8</td>
<td>16</td>
<td>0.928</td>
<td>14.828</td>
<td>0.39</td>
<td>5.78</td>
<td>d*d / 162.2</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>185.28</td>
<td></td>
</tr>
<tr>
<td>5% wastage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9.264</td>
<td></td>
</tr>
<tr>
<td>GROSS WEIGHT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>195.544</strong></td>
<td></td>
</tr>
</tbody>
</table>
FOOTING:
Number of bars along x-axis (Bottom Bar):
\[ B = (2 \times \text{Clear cover}) + 1 = 2000 - (2 \times 40) + 1 = 8 \text{ bars} \]
spacing 300
Number of bars along y-axis (Top bar):
\[ B = (2 \times \text{Clear cover}) + 1 = 2500 - (2 \times 40) + 1 = 10 \text{ bars} \]
spacing 300
Cutting length of bottom bar:
\[ L = (2 \times \text{clear cover}) + (2 \times H) - (4 \times \text{clear cover}) - \text{Bend deduction} = 2500 - (2 \times 40) + (2 \times 200) - (4 \times 40) - (2 \times 2 \times 12) = 2612 \text{mm} \]
Cutting length top bar:
\[ B = (2 \times \text{clear cover}) + (2 \times H) - (4 \times \text{clear cover}) - \text{Bend deduction} = 2000 - (2 \times 40) + (2 \times 200) - (4 \times 40) - (2 \times 2 \times 12) = 2122 \text{mm} \]

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Type of bar</th>
<th>Dia(mm)</th>
<th>No.</th>
<th>Length(m)</th>
<th>Total length(m)</th>
<th>Weight(kg)</th>
<th>Total weight(kg)</th>
<th>notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Longitudinal bar</td>
<td>16mm</td>
<td>8</td>
<td>2.612</td>
<td>20.896</td>
<td>1.58</td>
<td>33.015</td>
<td>256</td>
</tr>
<tr>
<td>2</td>
<td>Lateral tie</td>
<td>16mm</td>
<td>10</td>
<td>2.122</td>
<td>21.22</td>
<td>1.58</td>
<td>33.52</td>
<td>256</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td>66.54</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Wastage</td>
<td></td>
<td>1.996</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gross</td>
<td></td>
<td>68.53</td>
<td></td>
</tr>
</tbody>
</table>

SLABS ESTIMATION
\[ S1 = 3.68 \times 3.4 \]
\[ \frac{L_y}{L_x} < 2 \text{ therefore it's a 2-way slab.} \]
- Slab size = 3680*3400*150 mm
- Main bar = 10mm dia @150 mm c-c spacing
- Distribution bar = 10mm dia @150mm c-c spacing
- Development length = 40d
No. of bars in longer span (3680/150) +1 =26 (aprx.)
No. of bars in shorter span (3400/150) +1=24 (aprx.)
Cutting length of main bars in x and y direction
- C.L = clear span +2ld+(1*0.42D) -(bent length *2)
  =3400 + (2*40*10) + (1*0.42*150) - (10*2)= 4243mm
• \[C.L. = 3680 + (2 \times 40 \times 10) + (1 \times 0.42 \times 150) - (10 \times 2) = 4523 \text{mm}\]
  No. of distribution bars

• \[(3400/5)/150 + 1 = 5.53 = 6 \text{(appx)}\) therefore \(6 \times 2 = 12\) bars

• \[(3680/5)/150 + 1 = 4.90 = 5 \text{(appx)}\) therefore \(5 \times 2 = 10\) bars

Cutting Length calculations

• \[C.L. = 3680 + (2 \times 40 \times 10) = 4480\]

• \[C.L. = 3400 + (2 \times 40 \times 10) = 4200\]

<table>
<thead>
<tr>
<th>Description</th>
<th>Dia of bar</th>
<th>Numbers</th>
<th>L(m)</th>
<th>Wt (kg/m)</th>
<th>Quantity(kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main bars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longer span</td>
<td>10 mm</td>
<td>26</td>
<td>4.24</td>
<td>0.62</td>
<td>68.34</td>
</tr>
<tr>
<td>Shorter span</td>
<td>10 mm</td>
<td>24</td>
<td>4.52</td>
<td>0.62</td>
<td>67.25</td>
</tr>
<tr>
<td>Dist bars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longer span</td>
<td>10 mm</td>
<td>12</td>
<td>4.2</td>
<td>0.62</td>
<td>31.28</td>
</tr>
<tr>
<td>Shorter span</td>
<td>10 mm</td>
<td>10</td>
<td>4.48</td>
<td>0.62</td>
<td>27.776</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td>389.26</td>
</tr>
</tbody>
</table>

1. \[S2 = 4.61 \times 3.4\]

\[\text{Ly/Lx} < 2\) therefore it’s a 2-way slab.

• Slab size = \(4610 \times 3400 \times 150\) mm

• Main bar = 10mm dia @150 mm c-c spacing

• Distribution bar = 10mm dia @150mm c-c spacing

• Development length = 40d

No. of bars in longer span \((4610/150) + 1 = 32\) (appx.)

No. of bars in shorter span \((3400/150) + 1 = 24\) (appx.)

Cutting length of main bars in x and y direction

• \[C.L. = \text{clear span} + 2ld + (1 \times 0.42D) - (\text{bent length} \times 2) = 3400 + (2 \times 40 \times 10) + (1 \times 0.42 \times 100) - (10 \times 2) = 4222 \text{mm}\]

• \[C.L. = 4610 + (2 \times 40 \times 10) + (1 \times 0.42 \times 100) - (10 \times 2) = 5432 \text{mm}\]

No. of distribution bars

• \[(3400/5)/150 + 1 = 5.53 = 6 \text{(appx)}\) therefore \(6 \times 2 = 12\) bars

• \[(4610/5)/150 + 1 = 7.14 = 8 \text{(appx)}\) therefore \(8 \times 2 = 16\) bars

Cutting Length calculations

• \[C.L. = 4610 + (2 \times 40 \times 10) = 5410\]

• \[C.L. = 3400 + (2 \times 40 \times 10) = 4200\]

<table>
<thead>
<tr>
<th>Description</th>
<th>Dia of bar</th>
<th>Numbers</th>
<th>L(m)</th>
<th>Wt (kg/m)</th>
<th>Quantity(kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main bars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longer span</td>
<td>10 mm</td>
<td>32</td>
<td>4.22</td>
<td>0.62</td>
<td>83.72</td>
</tr>
<tr>
<td>Shorter span</td>
<td>10 mm</td>
<td>24</td>
<td>5.43</td>
<td>0.62</td>
<td>80.79</td>
</tr>
<tr>
<td>Dist bars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longer span</td>
<td>10 mm</td>
<td>12</td>
<td>4.20</td>
<td>0.62</td>
<td>31.24</td>
</tr>
<tr>
<td>Shorter span</td>
<td>10 mm</td>
<td>16</td>
<td>5.41</td>
<td>0.62</td>
<td>53.66</td>
</tr>
</tbody>
</table>
2. $S_3 = 4.61 \times 3.74$

$\frac{L_y}{L_x} < 2$ therefore it's a 2-way slab.

- Slab size = 4610*3740*150 mm
- Main bar = 10 mm dia @ 150 mm c-c spacing
- Distribution bar = 10 mm dia @ 150 mm c-c spacing
- $(4610/5)/150 + 1 = 4.39 = 5$ (apprx) therefore $5 \times 2 = 10$ bars
- $(2870/5)/150 + 1 = 4.28 = 5$ (apprx) therefore $5 \times 2 = 10$ bars

Cutting Length calculations

- $C.L = 2870 + (2 \times 40 \times 10) = 4080$
- $C.L = 4610 + (2 \times 40 \times 10) = 4190$

<table>
<thead>
<tr>
<th>Description</th>
<th>Dia of bar</th>
<th>Numbers</th>
<th>L(m)</th>
<th>Wt (kg/m)</th>
<th>Quantity(kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main bars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longer span</td>
<td>10 mm</td>
<td>24</td>
<td>4.10</td>
<td>0.62</td>
<td>61.01</td>
</tr>
<tr>
<td>Shorter span</td>
<td>10 mm</td>
<td>23</td>
<td>4.21</td>
<td>0.62</td>
<td>60.03</td>
</tr>
<tr>
<td>Dist bars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longer span</td>
<td>10 mm</td>
<td>10</td>
<td>4.08</td>
<td>0.62</td>
<td>25.30</td>
</tr>
<tr>
<td>Shorter span</td>
<td>10 mm</td>
<td>10</td>
<td>4.19</td>
<td>0.62</td>
<td>25.98</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td>344.64</td>
</tr>
</tbody>
</table>

4. $S_5 = 3.68 \times 3.24$

$\frac{L_y}{L_x} < 2$ therefore it's a 2-way slab.

- Slab size = 3680*3240*150 mm
- Main bar = 10 mm dia @ 150 mm c-c spacing
- Distribution bar = 10 mm dia @ 150 mm c-c spacing
- Development length = 40d

No. of bars in shorter span $(3240/150) + 1 = 23$
No. of bars in longer span $(3680/150) + 1 = 26$

Cutting length of main bars in x and y direction

- $C.L = \text{clear span + } 2l_{bd} + (1 \times 0.42D) - (\text{bent length *2}) = 3680 + (2 \times 40 \times 10) + (1 \times 0.42 \times 100) - (10 \times 2) = 4502 \text{ mm}$
- $C.L = 3240 + (2 \times 40 \times 10) + (1 \times 0.42 \times 100) - (10 \times 2) = 4062 \text{ mm}$

No. of distribution bars

- $(3680/5)/150 + 1 = 5.90 = 6$ (apprx) therefore $6 \times 2 = 12$ bars
- $(3240/5)/150 + 1 = 5.32 = 6$ (apprx) therefore $6 \times 2 = 12$ bars

Cutting Length calculations

- $C.L = 3680 + (2 \times 40 \times 10) = 4480$
- $C.L = 3240 + (2 \times 40 \times 10) = 4040$

<table>
<thead>
<tr>
<th>Description</th>
<th>Dia of bar</th>
<th>Numbers</th>
<th>L(m)</th>
<th>Wt (kg/m)</th>
<th>Quantity(kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main bars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Longer span | 10 mm | 26 | 4.062 | 0.62 | 65.47
Shorter span | 10 mm | 23 | 4.502 | 0.62 | 64.19
Dist bars
Longer span | 10 mm | 12 | 4.04 | 0.62 | 30.05
Shorter span | 10 mm | 12 | 4.48 | 0.62 | 33.33
Total | 2 | | | | 386.08 kg

5. $S_6 = 3.68 \times 3.43$

Ly/Lx < 2 therefore it's a 2-way slab.

- Slab size = 3680*3430*150 mm
- Main bar = 10 mm dia @150 mm c-c spacing
- Distribution bar = 10 mm dia @150 mm c-c spacing
- Development length = 40d

No. of bars in shorter span (3430/150) + 1 = 24 (apprx.)
No. of bars in longer span (3680/150) + 1 = 26 (apprx.)

Cutting length of main bars in x and y direction

- $C_L = \text{clear span} + 2ld + (1 \times 0.42D) - (\text{bent length} \times 2) = 3430 + (2 \times 40 \times 10) + (1 \times 0.42 \times 100) - (10 \times 2) = 4252 \text{mm}$
- $C_L = 3680 + (2 \times 40 \times 10) + (1 \times 0.42 \times 100) - (10 \times 2) = 4502 \text{mm}$

No. of distribution bars

- $3430/5/150 + 1 = 5.57 = 6 \text{ (apprx.) therefore 6} \times 2 = 12 \text{ bars}$
- $3680/5/150 + 1 = 5.90 = 6 \text{ (apprx.) therefore 6} \times 2 = 12 \text{ bars}$

Cutting Length calculations

- $C_L = 3430 + (2 \times 40 \times 10) = 4230; 4480$

<table>
<thead>
<tr>
<th>Description</th>
<th>Dia of bar</th>
<th>Numbers</th>
<th>L(m)</th>
<th>Wt (kg/m)</th>
<th>Quantity(kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main bars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longer span</td>
<td>10 mm</td>
<td>26</td>
<td>4.252</td>
<td>0.62</td>
<td>68.54</td>
</tr>
<tr>
<td>Shorter span</td>
<td>10 mm</td>
<td>24</td>
<td>4.502</td>
<td>0.62</td>
<td>66.98</td>
</tr>
<tr>
<td>Dist bars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longer span</td>
<td>10 mm</td>
<td>12</td>
<td>4.23</td>
<td>0.62</td>
<td>31.47</td>
</tr>
<tr>
<td>Shorter span</td>
<td>10 mm</td>
<td>12</td>
<td>4.48</td>
<td>0.62</td>
<td>33.33</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td>400.64 kg</td>
</tr>
</tbody>
</table>

Total weight:

$S1 + S2 + S3 + S4 + S5 + S6 = 389.26 + 498.82 + 526.7 + 344.64 + 386.08 + 400.64$

$= 2546.14 \text{ kg} = 2.546 \text{ tonnes}$

BEAMS:

- Development length = 40d

No. of bars in shorter span (4610/150) + 1 = 32 (apprx.)
No. of bars in longer span (3740/150) + 1 = 26 (apprx.)

Cutting length of main bars in x and y-direction

- $C_L = \text{clear span} + 2ld + (1 \times 0.42D) - (\text{bent length} \times 2) = 4610 + (2 \times 40 \times 10) + (1 \times 0.42 \times 100) - (10 \times 2) = 5432 \text{mm}$
- $C_L = 3740 + (2 \times 40 \times 10) + (1 \times 0.42 \times 100) - (10 \times 2) = 4562 \text{mm}$
No. of distribution bars

- \((4610/5)/150 + 1 = 7.14 = 8\) (aprx) therefore \(8 \times 2 = 16\) bars
- \((3740/5)/150 + 1 = 5.98 = 6\) (aprx) therefore \(6 \times 2 = 12\) bars

Cutting Length calculations

- \(C.L = 3740 + (2 \times 40 \times 10) = 4540\)
- \(C.L = 4610 + (2 \times 40 \times 10) = 5410\)

<table>
<thead>
<tr>
<th>Description</th>
<th>Dia of bar</th>
<th>Numbers</th>
<th>L(m)</th>
<th>Wt (kg/m)</th>
<th>Quantity (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main bars</td>
<td>10 mm</td>
<td>32</td>
<td>4.562</td>
<td>0.62</td>
<td>90.51</td>
</tr>
<tr>
<td>Longer span</td>
<td>10 mm</td>
<td>26</td>
<td>5.432</td>
<td>0.62</td>
<td>87.56</td>
</tr>
<tr>
<td>Shorter span</td>
<td>10 mm</td>
<td>16</td>
<td>4.540</td>
<td>0.62</td>
<td>45.03</td>
</tr>
<tr>
<td>Dist bars</td>
<td>10 mm</td>
<td>12</td>
<td>5.410</td>
<td>0.62</td>
<td>40.25</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td>526.7kg</td>
</tr>
</tbody>
</table>

3. \(S4 = 4.61 \times 2.87\)

\(L_y/L_x < 2\) therefore it's a 2-way slab.

- Slab size = 4610*2870*100 mm
- Main bar = 10 mm dia @150 mm c-c spacing
- Distribution bar = 10 mm dia @150 mm c-c spacing
- Development length = 40d

No. of bars in shorter span (2870/150) + 1 = 23 (aprx.)
No. of bars in longer span (4610/150) + 1 = 24 (aprx.)

Cutting length of main bars in x and y direction; \(C.L = 4212 mm, = 4102 mm\)
No. of distribution bars
DIA OVERALL WEIGHT (kg)
8 mm 382.63808
10 mm 2546.14
12 mm 451.29392
16 mm 397.326
Total = 4.83 tonnes

STAIRCASE:
Let the riser be 0.15  Tread 0.3
Height of each floor 3m  height of each flight 1.5m No of risers = 10 (for each flight)
No of treads = 10 (for each flight) Total no of flights 2
Riser 0.15m
Tread 0.3m Length of step 0.9m
Height Distance Length of flight
3m 3.25m 3.28m

IV. RESULTS AND DISCUSSION

Rate analysis

<table>
<thead>
<tr>
<th>S. No</th>
<th>Item of work</th>
<th>Quantity</th>
<th>Rate</th>
<th>Unit</th>
<th>Total cost (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excavation</td>
<td>126</td>
<td>Rs. 140.0</td>
<td>% Cu. m</td>
<td>17640</td>
</tr>
<tr>
<td>2</td>
<td>PCC Bedding</td>
<td>9</td>
<td>Rs. 5,850.0</td>
<td>% Cu. m</td>
<td>52650</td>
</tr>
<tr>
<td>3</td>
<td>Footing Concrete</td>
<td>23.7</td>
<td>Rs. 7,600.0</td>
<td>% Cu. m</td>
<td>180120</td>
</tr>
<tr>
<td>4</td>
<td>Sand filling</td>
<td>64.34</td>
<td>Rs. 4,500.0</td>
<td>% Cu. m</td>
<td>289530</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Quantity</td>
<td>Rate</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------</td>
<td>----------</td>
<td>------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>RCC works</td>
<td>54.25685358</td>
<td>Rs. 8,800.0</td>
<td>% Cu. m 477460.3115</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Reinforcing steel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8 mm</td>
<td>2.02402458</td>
<td>Rs. 50,000.0</td>
<td>% Tonne 101201.229</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 mm</td>
<td>3.898251</td>
<td>Rs. 50,000.0</td>
<td>% Tonne 194912.55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12 mm</td>
<td>0.042326508</td>
<td>Rs.50,000.0</td>
<td>% Tonne 2116.3254</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16 mm</td>
<td>5.08581008</td>
<td>Rs.50,000.0</td>
<td>% Tonne 254290.504</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20 mm</td>
<td>5.44077</td>
<td>Rs.48,000.0</td>
<td>% Tonne 261156.96</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Brickwork</td>
<td>115616.2697</td>
<td>Rs. 8.0</td>
<td>Piece 924930.1572</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Labor for Brick-laying</td>
<td>220.221466</td>
<td>Rs. 920.0</td>
<td>% Cu. m 202603.7487</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Damp Proof Course (50 mm thick)</td>
<td>123.4686</td>
<td>Rs. 325.0</td>
<td>% Sq. m 40127.295</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Flooring Concrete</td>
<td>18.52029</td>
<td>Rs. 5,850.0</td>
<td>% Sq. m 108343.6965</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Tile flooring</td>
<td>268.9078</td>
<td>Rs. 1,700.0</td>
<td>% Sq. m 457143.26</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Rooftop area</td>
<td>101.498</td>
<td>Rs. 600.0</td>
<td>% Sq. m 60898.8</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Wall plastering</td>
<td>1116.928</td>
<td>Rs.190.0</td>
<td>% Sq. m 212216.32</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Ceiling plastering</td>
<td>268.9078</td>
<td>Rs. 190.0</td>
<td>% Sq. m 51092.482</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Ceiling Whitewash</td>
<td>806.7234</td>
<td>Rs. 8.0</td>
<td>% Sq. m 6453.7872</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Whitewash</td>
<td>3350.784</td>
<td>Rs. 8.0</td>
<td>% Sq. m 26806.272</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Colour wash</td>
<td>2233.856</td>
<td>Rs. 10.0</td>
<td>% Sq. m 22338.56</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Doors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wooden doors</td>
<td>6.174</td>
<td>Rs. 6,800.0</td>
<td>% Sq. m 41983.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PVC Doors</td>
<td>5</td>
<td>Rs.2,000.0</td>
<td>Numbers 10000</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Windows</td>
<td>21</td>
<td>Rs. 2,800.0</td>
<td>Numbers 58800</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Ventilators</td>
<td>2.7755</td>
<td>Rs. 700.0</td>
<td>% Sq. m 1942.85</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total cost</td>
<td></td>
<td></td>
<td>2486837.389</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sanitary fixtures (10%)</td>
<td></td>
<td></td>
<td>2486837.389</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electrical fixtures (8%)</td>
<td></td>
<td></td>
<td>198946.9911</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contingency (3%)</td>
<td></td>
<td></td>
<td>74605.12166</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supervision (8%)</td>
<td></td>
<td></td>
<td>198946.9911</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Net total</td>
<td></td>
<td></td>
<td>Rs. 32,08,020.23</td>
<td></td>
</tr>
</tbody>
</table>

### V. CONCLUSION

- The number of beams were 36 in number
- The number of slabs were 12 in number
- The number of columns were 26 in number
- The number of footings is 13 in number
- Cost estimation analysis of the project was worked out and the final cost projected was Rs. 32,08,020.23
- Total reinforcement steel was estimated to be 16.491182 tons
- Total concrete quantity was estimated to be 54.25685358 m³
VI. REFERENCES