Analysis, Design and Estimation of RC Shear Walls G Plus 13 Multi-Storied Residential Building

L Ravi Kumar[1] K. V. Ganesh[2] T Bhanu Prakash[3] P Geetha[4] Afjal Basha[5]
[1]Associate Professor [2,3,4,5]BE Student
[1,2,3,4,5]Department of Civil Engineering
[1,2,3,4,5]Kuppam Engineering, Ananatapur, A.P, India

Abstract— Computer Aided "Analysis, design and estimation of RC Shear Walls G PLUS 13 Multi-Storied Residential Building" involves analysis of building frames by using STAAD Pro. Conventional method of analysis involves lot of complications and tedious calculations such analysis is a time consuming task. Analysis can be made quickly by using software's. STAAD Pro is the leading design software in the market. Many design companies use this software for their project design purposes. Hence this project mainly deals with the analysis of the building by using STAAD Pro , drafting by AutoCAD, Architecture design by REVIT architecture and Estimation done by the MS excel.

Keywords: STAAD Pro, REVIT Architecture, RC Wall Load

I. Introduction

Day to day increase in the industrial growth and population established the problem of constructing number of buildings either for the residence or for office or for industry. On account of the high cost involved in acquiring land especially in densely populated areas, there is invariably a need for the construction of multi-storied buildings. So, the advanced knowledge in technology especially knowledge in reinforced cement concrete has come to the rescue of the engineer for planning and designing multi-storied buildings. The stage has come in which multi-storied construction is essential and inevitable.

In this project, the concept of monolithic construction technology is adapted. That means the whole structure along with the slab is casted at a single pour [at a time]. In order to construct a monolithic structure obviously we require formwork of greater strength, which means the conventional formwork, is not suitable for the construction. Hence we require an aluminum formwork which is called mivan shuttering.

The proposed building is G+13 stories R.C.C framed structure. The building consists of four flats in each floor and the total flats in the building are 56 numbers. This project which is going on in Bangalore comprises of development of residential Building along with other necessary utilities. This document pertains to the structural designs carried out for a part of above said residential township project for various structures. The development is in the seismic Zone – II. The basic wind speed at location of the development is 33 m/s. SBC of soil according to soil investigations is 250 KN/m^2. The design parameters considered are as per Indian Standard Code of practice.

	Block 3	Block 2	Block 1
Living room	5.1x3.20	6.5x4.7	5.5x3.3
Bed room 1	4.1x3.2	4.5x3.7	3.9x3.3
Bed room 2	4.4x3.2	3.7x3.2	4.0x3.2
Bed room 3		4.5x4.2	
Dining/kitchen	4.1x3.2	4.2x2.7	5.6x3.2
Bathroom 1	1.8x1.4	2.4x1.2	2.1x1.5
Bathroom 2	2.3x1.2	2.5x1.2	2.3x1.5
Shaft 1	1.2x0.7	3.1x1.5	1.5x0.7
Shaft 2	3.2x0.9		
Utility	3.2x1.0	2.0x1.2	3.2x1.2
Balcony		2.0x1.2	3.3x1.2

Table 1: Dimensions of the rooms

Fig. 1: Building layout

II. LITERATURE REVIEW

A. IS: 875 (Part 1) for Dead Loads:

Indian Standard Code of Practice For Design Loads (Other Than Earthquake) For Buildings and Structures. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead loads may be calculated from the dimensions of various members and their unit weights. The unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 KN/m^3 and 25 KN/m^3 respectively.

B. IS: 875 (Part 2) for Imposed Loads:

Indian Standard Code Of Practice For Design Loads (Other Than Earthquake), For Buildings And Structures, Imposed load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. Imposed loads do not include loads due to wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo.

C. IS: 875 (Part 3) for Wind Loads:

Indian Standard Code Of Practice For Design Loads (Other Than Earthquake) For Buildings And Structures, This standard gives wind forces and their effects (static and dynamic) that should that taken into account when designing buildings, structures and components thereof. Wind is air in motion relative to the surface of the earth.

The primary cause of wind is traced to earth's rotation and differences in terrestrial radiation. The effects are primarily responsible for convection either upwards or downwards. The wind generally blows horizontal to the ground at high wind speeds. Since vertical components of atmospheric motion are relatively small the term 'Wind' denotes almost exclusively the horizontal wind, vertical winds are always identified as such. The wind speeds are assessed with the aid of anemometers or anemographs which are installed at meteorological observatories at heights generally varying from 10 to 30 meters above ground.

D. IS: 1893 (Part 1) for Earthquake Resistant Design of Structures:

Indian Standard Criteria for Earthquake Resistant Design of Structures, (Part 1-General Provisions and Buildings), It deals with assessment of seismic loads on various structures and earthquake resistant design of buildings. Its basic provisions are applicable to buildings; elevated structures; industrial and stack like structures; bridges; concrete masonry and earth dams; embankments and retaining walls and other structures. Temporary elements such as scaffolding, temporary excavations need not be designed for earthquake forces.

E. A Study on Construction of RC Shear Walls for Multi-Storied Residential Building-by A. Shiva Shankar, S. Sunil Prathap Reddy

A study has been carried out to determine the strength of RC shear wall of a multistoried building by changing shear wall location. Three different cases of shear wall position for a multi-story building have been analyzed. Incorporation of shear wall has become inevitable in multi-store building to resist lateral forces

III. ANALYSIS AND DESIGN

A G+13 floor residential building is considered whose architectural plan and structural framing plans were prepared as shown in figure below, before it is modeled in STAAD Pro. The entire analysis of building has been done in one stage keeping the IS code provision in view wherever necessary. The whole building has been split into its structural components viz., slab, beams, columns and footings.

A. Statement of the Project

The design data shall be as follows:
Live load : 3.0 kN/m^2
Floor finish : 1.0 kN/m^2
Location : Bangalore (Zone -II)
Depth of foundation below ground: 3.25 m
Safe bearing capacity (SBC) of the soil: 250 kN/m^2
Ground floor and first floor height : 3.8 m
First floor to fourteenth Floor Height: 2.825m
Floors : G + 13 floors.
Inner and exterior Wall: 150 mm thick reinforced concrete walls

1) Material Properties Concrete:

All components unless specified in design: M25 grade all

2) Material Properties Steel:

HYSD reinforcement of grade Fe 415 confirming to IS: 1786 is used throughout.

B. Load Combinations:

Dead load + Live load
Dead load + live load + seismic load
Dead load + live load + wind load
Dead load + wind load
Dead load + seismic load
Live load + wind load
Partial safety factor for loads: 1.5
Partial safety factor for steel: 1.15
Partial safety Factor for Concrete: 1.5

1) Dead Load

Dead load consists of the permanent construction material load compressing the roof, floor, wall, and foundation systems, including claddings, finishes and fixed equipment. Dead load is the total load of all the components of the building (or) structure.
Weight = volume x density
Slab weight = 0.15x25 = 3.75 kN/m^2
Self-weight of Floor finishing = 0.01x25 = 0.25 kN/m^2

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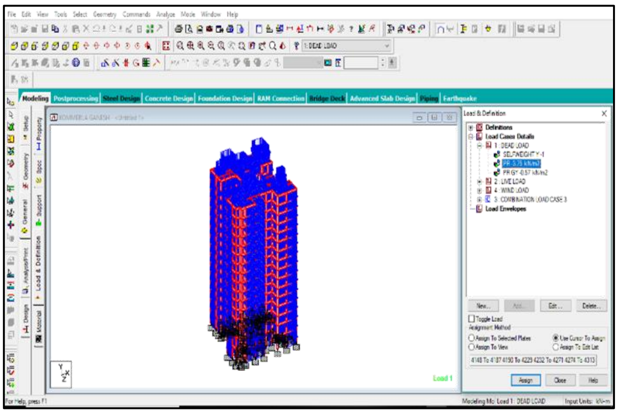

Fig. 2: Dead load

2) *Live load*

Live loads are produced by the use and occupancy of a building. Load includes those from human occupants, furnishings, no fixed equipment, storage, and construction and maintenance activities. In STAAD we assign live load in terms of UDL. We have to create a load case at live load and select all the beams to carry such load. After the assignment of the live load the structure appears as shown below.

Live load is taken as 3 kN/m^2

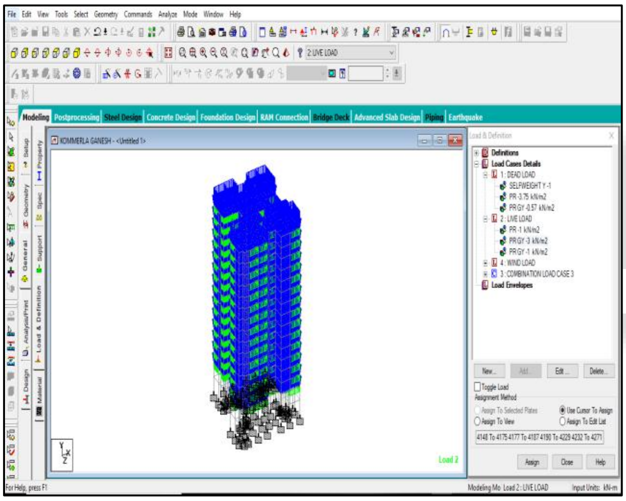

Fig. 3: live load

3) *Wind Load*

In the list of loads we can see wind load is present both in vertical and horizontals loads. This is because wind causes uplift of the roof by creating a negative pressure on the top of the roof. Wind produces non static loads on a structure at highly variable magnitudes. The variation in pressure at different locations on a building is complex to the point that pressure may become too analytically intensive for precise consideration in design.

a) Design Wind Pressure:

It can be mathematically expressed as follows

Vz = Vb x k1x k2 x k3 x k4 {Pg.no 5 clause no 6.3 of IS 875-2015}

$p_z = 0.6Vz^2$ {Pg.no 9 clause no 7.2 of IS 875-2015}

p_d = Kd x Ka x Kc x pz {Pg.no 9 clause no 7.2 of IS 875-2015}

0.7 p_z {Pg.no 9 clause no 7.2 of IS 875-2015}

Design Wind Pressure is Maximum of (p_d , 0.7p_z)

Where Vb = design wind speed at height Z in m/s {Pg.no 51 Annexure A of IS 875 Part3-2015}

k1 = risk coefficient

k2 = terrain roughness and height factor

k3 = topography factor

k4 = Importance factor for cyclonic region.

Basic wind speed in Bangalore 33 m/s

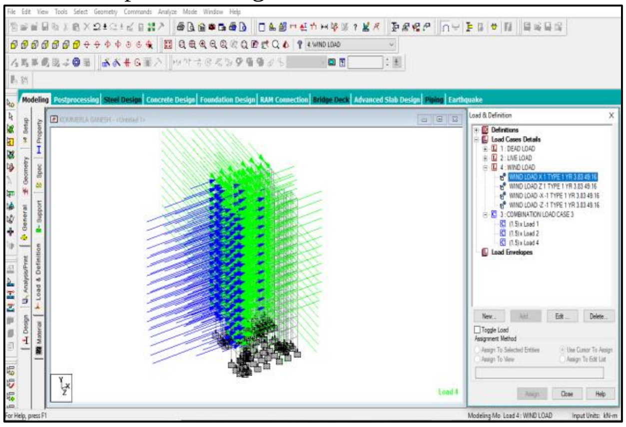

Fig. 4: wind load

4) *RC Wall Load*

Floor load is calculated based on the load on the RC WALL. Assignment of floor load is done by creating load case for RC WALL load. After the assignment of RC WALL load of a structure look as shown in below.

The intensity of RC WALL load is taken as 3 .75 kN/m^2

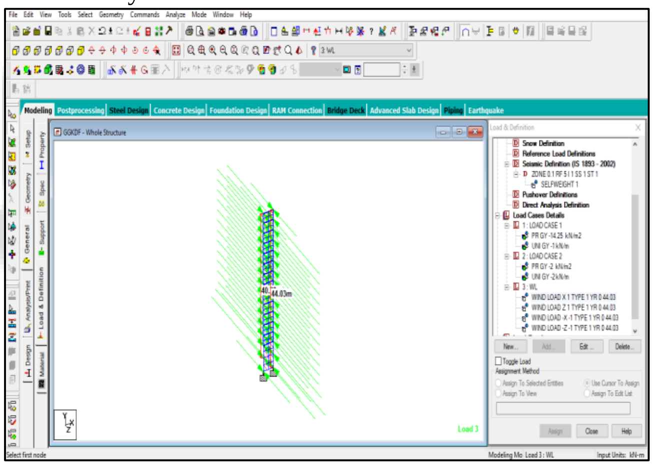

Fig. 5: shear wall load

IV. Manual Design of Reinforced Structures

A. *Design of Beam:*

Beam is the horizontal member of a structure, carrying transverse loads. Beams are rectangular in cross-section. Beam carries the floor slab or the roof slab. Beam transfer all the loads including its self –weight to the columns or walls. Beam is subjected to bending moments and shear forces.

It is typically used for resisting vertical loads, shear forces and bending moments.

Types of Beams

1) Simply supported beam
2) Fixed beam
3) Cantilever beam
4) Continuous beam
5) Overhanging beam
6) We are considering the fixed beam.

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1) Details of Beam Materials:
For M25 Concrete, Fck = 25 N/mm^2
For Fe 415 Steel, f_y = 415 N/mm^2
Clear span l = 7.4 m
Effective length leff = 7.26+0.23 = 7.49m
D = 600 mm
Mu = 361.73 KN-m
Moment of Resistance

$$M_{u,lim} = 0.36\frac{X_u max}{d}\times\left(1-0.42\frac{X_u max}{d}\right)\times bd^2 f_{ck}$$

$$361.73\times10^6 = 0.360\times0.48(1-0.42\times0.48)\times200\times d^2\times25$$

d = 520mm
D = 600mm
Assuming ϕ 20 for main reinforcement and ϕ8for shear reinforcement

$$d = 600 - \left(20+\frac{20}{2}\right) = 570mm$$

Breath of the beam between $\frac{D}{3}$ and $\frac{2D}{3}$

B = 450 mm
Hence provide b = 450 mm
Tensile reinforcement (Ast)

$$M_u = 0.87\times f_y\times A_{st}\times d\times\left(1-\frac{A_{st}\times f_y}{b\times d\times f_{ck}}\right)$$

$$361.73\times10^6 = 0.87\times415\times A_{st}\times570\times\left(1-\frac{A_{st}\times415}{600\times450\times25}\right)$$

Ast = 2004.79 mm^2
Curtailment and detailing of reinforcement
16 ϕ of 8 bars

$$M_u = 0.87\times f_y\times A_{st}\times d\left(1-\frac{A_{st}\times f_y}{b\times d\times f_{ck}}\right)$$

$$M_u = 0.87\times415\times Ast\ pro\times450\times\left(1-\frac{Ast\ pro\times415}{450\times600\times25}\right)$$

Mu = 308.98 $\times10^6$ N-mm
Let theoretical cut off section from support=x

$$Mu = \frac{17.4\times7.49}{2}\times\left(x-\frac{17.4\times x^2}{2}\right)$$

X = 1.00

$$= \left(\frac{7.49}{2}-1.00\right)$$

from center of the beam
Actually upper bars will be curtailed at 2.745+ (12 ϕ or d (or) whichever greater) from Centre of the beam
= 2.745+0.412
= 3.157
The curtailment of upper bars will be done at 3.157 m from Centre of the beam

$$LD = \left(\frac{\varphi\times\sigma_{st}}{4\tau_{bd}}\right)$$

$$= \left(\frac{20\times0.87\times415}{4\times1.6\times1.2}\right)$$

= 0.940 < 2.02m

Length available beyond the actual cutoff point from center of supports

$$\left(\frac{l_{eff}}{2}\right)-1.85 = \left(\frac{4}{2}\right)-1.85 = 0.15\,m$$

Provision of shear reinforcement

$$Vu = \left(\frac{w_u\times l_{eff}}{2}\right) = \left(\frac{73.2\times4}{2}\right)$$

= 146.4KN
Design shear force at distance d = 412 face to support at a distance of

$$= \left(\frac{l_{eff}}{2}-\frac{support\ width}{2}-d\right) \text{Centre of beam}$$

$$= \left(\frac{4}{2}-\frac{0.23}{2}-0.412\right)$$

= 1.47m
From similarity of triangle

$$Vu = \left(\frac{146.4\times2}{4}\right)\times1.873 = 137.10\ KN$$

$$\tau_c = \frac{V_u}{b\times d} = \frac{137.10\times10^3}{230\times412}$$

= 0.426N/mm^2

$$\%\ Ps = \frac{100\times2\times314.1}{230\times412} = 0.66\%$$

τ_c = 0.42
D = 412mm = (412+20+8) = 440mm
At the upper lever of bars does not continue up to the critical section for shear force.

$$V_S = \frac{0.87\times f_y\times A_{sv}\times d}{S_v} = \frac{0.87\times415\times100\times412}{1.78\times10^3}$$

=8356.269mm
Sv, min = 0.75×d = 0.75×412 = 309mm
(or)
Sv, min = 300mm
Sv, min given by the following formula

$$\left(\frac{A_{sv}}{b\times S_{vmin}}\right)\geq\frac{0.4}{0.87\times f_y}$$

$$\left(\frac{100}{230\times S_{vmin}}\right)\geq\frac{0.4}{0.87\times415}$$

$$Sv\ min \leq \frac{100\times0.87\times415}{230\times0.4}$$

Sv min =300mm
Provide 2-Legged stirrups ϕ8 @ 300mm c/c
Check shear strength at cut off point as per Cl 26.2.3.2(a)
Shear at cut off point =

$$= \frac{W_u\times l_{ef}}{2} - w_u\left(\frac{l_{ef}}{2}-1.85\right)$$

$$= \frac{73.2\times4}{2} - 73.2\left(\frac{4}{2}-1.85\right)$$

= 135.4KN
Shear strength of the section with ϕ8 @300mmc/c stirrups

$$= \frac{2}{3}\times(\tau_c bd + V_{us})$$

$$= \frac{2}{3} \times \left[(0.42 \times 230 \times 412 \times 416) + \frac{0.87 \times f_y \times A_{sv} \times d}{S_v} \right]$$

= 102.4KN

As 2-Legged stirrups ϕ8 @ 330mm c/c is the minimum shear reinforcement, hence the same shall be continued for full span of the beam

2) Detailing Near Support

As per L_d requirement the continuing bars shall continue into the support =940-630=310mm from center of support

$$\frac{L_d}{3} = \frac{940}{3} = 313 \qquad \text{i.e, } 313 - \frac{230}{2} = 198$$

$$Ld > \frac{1.3M_1}{V} + L_0$$

$$L_0 < Ld - \frac{1.3M_1}{V} = 940 - \frac{1.3 \times 51.43 \times 10^3}{73.42} = 30mm$$

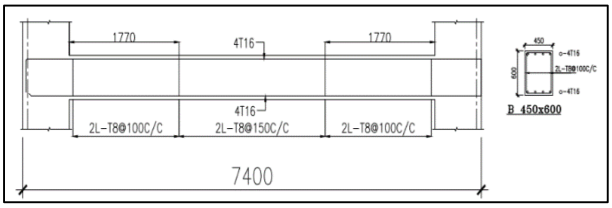

Fig. 4: Beam results

FLOOR	BEAM NO	BEAM SIZE	REINFORCEMENT	
G.F	1	450x600	16 mm dia @ 4 no's (main)	8mm dia @100mm c\c (shear)
	71		16 mm dia @ 4 no's (main)	8mm dia @100mm c\c (shear)
1st FLOOR	72	450x600	16mm dia @ 4 no's (main)	8mm dia @100mm c\c (shear)
	145		16 mm dia @ 4 no's (main)	8mm dia @100mm c\c (shear)

Table 1: Beam reinforcement details

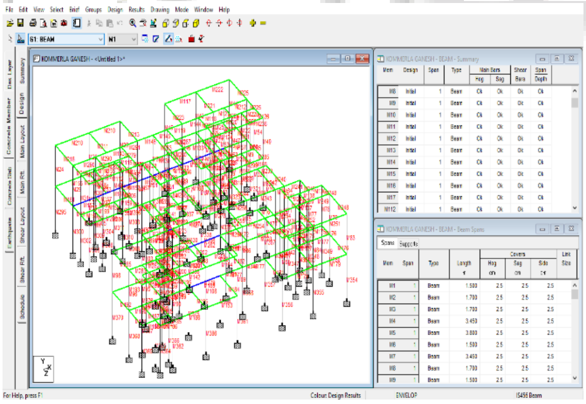

Fig. 6: beam details in STAAD details

B. Design of Column

1) Column

A column is a vertical structural member used primarily in supporting axial compression loads, and commonly having an at least three times its width or thickness. Column might transfer loads from a ceiling, floor or roof slab or from a beam, to the foundation.

- Shapes of column
- Circular
- Rectangular
- Square
- Hexagonal
- Octagonal

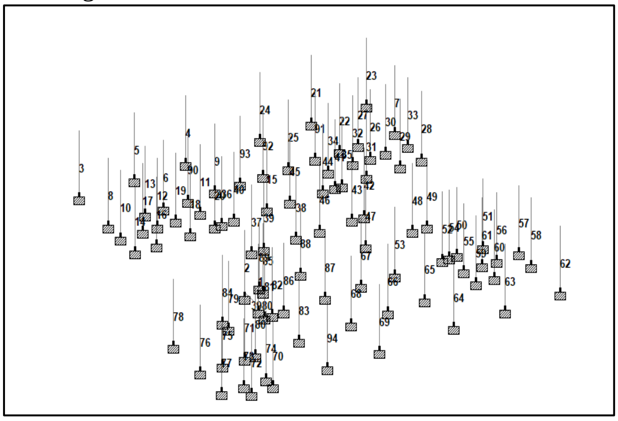

Fig. 7: Column numbers in STAAD

2) Design of Column: C1

a) Material Constants:

Concrete, fck = 25 N/mm²

Steel, fy = 415 N/mm²

Column size = 450 mm× 750 mm

Depth of column, D = 750 mm

Breadth of column B = 450 mm

Effective length of column, L = 382.5 cm

Factored axial Load, Pu = 2206.423 KN

Factored Moment in Y-dir, M_{uy} = 0.758 kNm

Factored Moment in Z-dir, M_{ux} = 2.345 kNm

As a first trial assume the reinforcement percentage P = 2 %

Assume 40 mm clear cover and 16 mm Ø bars,

d′ = 40 + (16/2) = 48 mm

b) Minimum Eccentricity:

e_x = l/500 + d/300 = 382.5/500 + 150/300 = 1.265cm

e_x = 1.265cm

e_y = l/500 + b/300 = 382.5/500 + 450/30 = 2.265 cm

ey = 2cm

c) Moments due to minimum eccentricity:

Mux = Pu x e_x /100 = (2206.423 X 1.265)/100 =27.91125 KN-m

Muy = Pu x e_y /100 = (2206.423 X 2.265)/100 =49.9754 KN-m

d) Moment capacity of the section about x-x axis

$$\frac{d'}{D} = \frac{48}{450} = 0.10$$

$$\frac{P_u}{bD \times f_{ck}} = \frac{2206.423 \times 10^3}{25 \times 450 \times 750}$$

= 0.261

$$\frac{m_u}{f_{ck} bD^2} = 0.235$$

(From chart 44 of SP 16)

$$m_{ux1} = 0.235 \times 25 \times 750^2 \times 450$$

m_{ux1} = 148.71 KN-m

e) Moment capacity of the section about y-y axis

d′/D = 48/450

= 0.11

Pu/bDfck = (2206.423 ×10³)/(25×450×750)

= 0.261

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$M/f_{ck}bD^2$ = 0.235 (From chart 45 of SP 16)
Muy1 = 0.235×25×750×450^2
Muy1 = 892.22656 kN-m
Puz/Ag = 15.03 N/mm² (From chart 63 of SP16)
Puz = 15.03×Ag
Puz = 15.03×450×750
Puz = 5072.625 KN
Pu / Puz = 2206.423 /5072.625
= 0.43
Muy/Muy 1 = 49.9754 / 892.22656
= 0.056
Mux/Mux 1 = 27.91125 / 148.71
= 0.18
= (p × b × D)/100
= (2 × 450 × 750)/100 = 6750 mm²
So provide 16 numbers of 16mm ∅ bars.
Lateral ties
The diameter of lateral ties shall not be less than one fourth of the largest longitudinal bar
=1/4× 16 = 4 mm.
Provide 8 mm Ø lateral ties
f) Pitch of Lateral Ties
Least lateral dimension of compression member = 230 mm
16 times the smallest diameter of the longitudinal Reinforcement bar to be tied=16×16 = 255 mm
300 mm

16T16@255 c/c and T8 @255

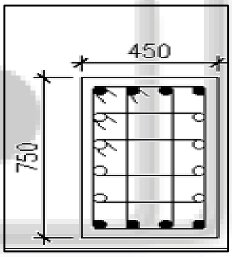


Figure 7: column numbers in STAAD
Provide 8 mm diameter lateral ties at 255 mm c/c

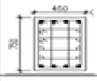
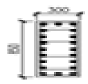
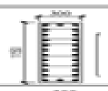
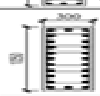
S NO	COLUMN SIZE	NAME OF COLUMN	REINFORCEMENT DETAILS	COLUMN LAYOUT
1	450X750	C1	16T16@255 cc and T8 @255cc	
2	300X850	C2	12T16@255 cc and T8@255cc	
3	300X1150	C3	20T16@255 cc and T8@255cc	
4	300X1050	C4	24T16@255cc and T8@255cc	

Table 2: Beam reinforcement details

C. Design of Slab:

1) Slab

Slab is flat horizontal surfaces. It is supported by beam and column. The main function of slab is to transfer load from beams to column and from column to footing
Types of slabs:
One-way slab
Two-way slab
Flat slabs
We are using two-way slab

2) Design of two way slab

a) Material Constants:
Use M25 grade concrete and HYSD steel bars of grade Fe415.
For M25 Concrete, fck = 25 N/mm^2
For Fe415Steel, fy = 415 N/mm^2
b) Type of Slab
Longer span, Ly = 3.8 m
Shorter span, Lx = 3.44 m

$$\frac{L_y}{L_x}$$

$$\frac{3.8}{3.44}$$

= 1.10< 2
∴ Two-way slab with two adjacent edges discontinuous.
Assuming D = 150mm
c) Load Calculation
Dead load of slab = 0.15 × 25 ×1
= 3.75 kN/m^2
Live load = 2.00 kN/m^2
Floor finish load = 1.00 kN/m^2
Total load = 6.75 kN/m^2
Factor load = 1.5 ×6.75
w = 10.125 kN/m^2

3) Ultimate Design Moment

Refer table 26 of IS 456:2000 and read out the moment Coefficients for

$$\frac{L_Y}{L_X} = 1.10$$

Short span moment coefficients:
–ve moment coefficient, αx = 0.053
+ve moment coefficient, αx = 0.040
Long span moment coefficients:
–ve moment coefficient, αy =0.047
+ve moment coefficient, αy =0.0350
Mux (+ve) = $\alpha x \times w \times L_X^2$
= 0.040× 10.125 × 3.44 ^{2}
= 4.792 kN-m
Muy (+ve) = $\alpha y \times w \times L_x^2$
=0.0350 × 10.125 × 3.44 ^{2}
= 4.1935kNm
a) Check for Depth
$Mu = 0.138 \times f_{ck} \times b \times d^2$
4.792 ×10 ^{6} = 0.138×25×1000×d^2
dreq = 37.68 mm
d required < d provided
d = 150mm
Hence the effective depth selected is sufficient to resist the Design ultimate moment.
Reinforcements along short and long span directions.
The area of reinforcement is calculated using the relation:

$$M_u = 0.87 \times f_y \times A_{st} \times d \left(\frac{1 - A_{st} \times f_y}{b \times d \times f_{ck}} \right)$$

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$$4.26\times10^{6} = 0.87\times415\times A_{st}\times150\left(\frac{1-A_{st}\times415}{1000\times150\times25}\right)$$

Ast = 80mm^2
Spacing (S) = Area of one bar/ (total area) ×1000
S = 0.785 x 10^2/ (80) x 1000
b) Check for spacing
As per IS 456:2000 clause 26.3.3(b)
Maximum spacing = 3d (or) 300 mm
= 3 × 150 = 450 mm
Or
300 mm
Whichever is less?
Provide 8 mm@ 200mmc/c
Negative reinforcement in long span

$$M_u = 0.87\times f_y\times A_{st}\times d\left(\frac{1-A_{st}\times f_y}{b\times d\times f_{ck}}\right)$$

$$3.54\times10^{6} = 0.87\times415\times A_{st}\times150\left(\frac{1-A_{st}\times415}{1000\times150\times25}\right)$$

Ast = 70mm^2
Spacing (S) = Area of one bar/ (total area) ×1000
S = 0.785 x 10^2 / (70) x 1000
c) Check for spacing
As per IS 456:2000 clause 26.3.3(b)
Maximum spacing = 3d (or) 300 mm
= 3 × 150 = 450 mm
Or
300 mm
Whichever is less?
Provide 8 mm ϕ @ 200mm c/c

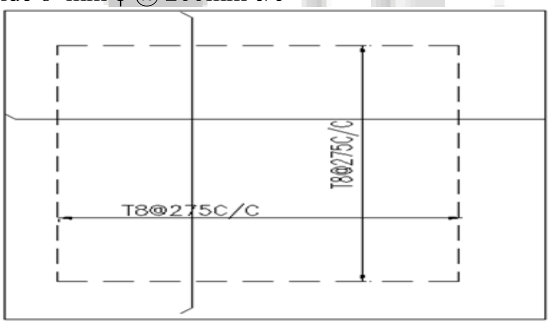

Fig. 7: Slab details

D. Footing

A footing is a part of the foundation that helps support the foundation so that the structure does not settle. It is typically made of concrete with rebar reinforcement. The depth and width of the footing depends on the type of soil and the size and type of the foundation. The main function of the footing is to transfer the dead load and live load of the building to the soil.

1) Types of Footing

1) Strip footing
2) Isolated or single footing
3) Combined footing
4) Cantilever or strap footing
5) Continuous footing
6) Rafted or mat footing

2) Footing design

Load P = 944 KN
Ultimate load, Pu = 1.5× 944
= 1416 KN
Soil bearing capacity, (SBC) = 250 KN/m^2
M25, fck = 25 N/mm^2
A = 450mm
B = 750mm
Self-weight of footing = 10%P
$= \frac{10}{100}\times1416$
= 141.6 KN
Total load = load + self-weight
= 1416 + 141.6
= 1557.6 kN
Plan area of footing = 1557.6 /200
= 7.78 m^2
$\frac{a}{b}$ Ratio of the column = $\frac{750}{450}$
= 1.66
1.66 B×B = 7.78 m^2
1.66B^2 = 7.78
$B^2 = \frac{7.78}{1.66}$
B = 4.68 m
L = 1.66×4.68
L = 7.78 m
L = 7.78m
B = 4.68m
Ultimate soil pressure, $P = \frac{2367}{4.110\times2.108}$
P = 273.2 KN/m^2
Depth of one-way shear y-y direction

$$\frac{L-a}{2-d}\times B\times\left(\frac{P}{L\times B}\right) = B\times d\times\tau_c$$

For 0.25% Steel & M25concrete
τ_c from table -19 Is 456
τ_c = 0.36 N/mm^2
p = 2367 kN

$$\left(\frac{4110-450}{2}-d\right)\times\left(\frac{2367\times10^{3}}{4110}\right) = 2108\times d\times0.36$$

(1830-d) ×575.9 = 758.8d
1053897 = 575.9 d + 758.8d
1334.7d= 1053897
$= \left(\frac{1053897}{1334.7}\right)$
d = 790mm
One-way shear x-x Direction

$$\left(\frac{B-b}{2}-d\right)\times L\times\left(\frac{P}{L\times B}\right) = L\times d\times\tau_c$$

$$\left(\frac{2108-230}{2}-d\right)\times4110\times\left(\frac{2367\times10^{3}}{2108}\right) = 4110\times d\times0.36$$

(939-d) × 1122.8 = 1479.6 d
1054309.2 – 1122.8d = 1479.6d
2872.4d = 1054309.2
$d = \left(\frac{1054309.2}{2872.4}\right)$

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d = 370 mm
Adopt higher value y-y direction
L = 4110mm
B = 2108mm
Check for Two-way shear
(τ_p) allowable = 0.25 x $\sqrt{f_{ck}}$

$= 0.25 \times \sqrt{25}$
= 1.25 N/mm^2

$$(4110\times2108) - 1220 \times 1057 \times \left(\frac{273.2\times10^3}{10^6}\right) = \tau_p \times 2(1220+1057)$$

(8663880-1289540) ×0.2732 = τ_p×3354620

$$\tau_p = \left(\frac{2014669.6}{3354620}\right)$$

τ_p = 0.6N/mm^2
τ_p< (τ_p) permissible 1.25N/mm^2
Check for depth from bending
Longer direction

$$M_{long} = \left(\frac{P}{L\times B}\right)\times B\left(\frac{L-a}{2}\right)\times\left(\frac{L-a}{2\times2}\right)$$

$$M_{long} = \left(\frac{273.200}{1000\times2108}\right)\times2108\left(\frac{4110-450}{2}\right)\times\left(\frac{4110-450}{2\times2}\right)$$

= 1245 KN-M
Shorter direction

$$S_{shoter} = \left(\frac{P}{L\times B}\right)\times L\left(\frac{B-b}{2}\right)\times\left(\frac{B-b}{2\times2}\right)$$

$$= \left(\frac{273.200}{1000\times4110}\right)\times4110\left(\frac{2108-230}{2}\right)\times\left(\frac{2108-230}{2\times2}\right)$$

= 1204 KN-M
(Depth) required

$$d = \sqrt{\frac{m}{0.138 f_{ck} B}}$$

$$d = \sqrt{\frac{1245\times10^6}{0.138\times25\times2108}}$$

d = 550mm
Depth for one-way shear=790mm
Depth for two-way shear=<790mm
Depth for bending<790mm
Calculation of Ast

$$A_{st} = \frac{M_{long}}{0.87\times f_y \times Z}$$

$$Z = d\times(1-0.416\times\frac{x}{d}$$

$$\frac{X}{d} = 1.2 - \sqrt{\frac{1.44-6.6m_u}{f_{ck}bd^2}}$$

$$\frac{X}{d} = 1.2 - \sqrt{\frac{1.44-6.6\times1245\times10^6}{25\times2108\times790^2}}$$

$$\frac{X}{d} = 0.71$$

Z = 790× (1-0.416×0.71)
Z = 556mm

$$A_{st} = \frac{1245\times10^6}{0.87\times415\times556}$$

Ast = 6194.5mm^2
Assuming 16ϕ bars
Number of bars = $\frac{6194.5}{\left(\frac{\pi}{4}\right)\times16^2}$

= 25 Nos
Along L-direction Provide 16ϕ-25Nos
Ast required in shorter direction

$$A_{st} = \frac{M_{short}}{0.87\times f_y\times Z}$$

Over all depth (D) = $d + \left(\frac{\varphi}{2}\right) + cover$

$$D = 790 + \left(\frac{16}{2}\right) + 50$$

D = 1120mm

$$d = 1120 - \left(\frac{16}{2}\right) - 50$$

d = 1100mm

$$Z = d\times\left(1-0.416\times\frac{x}{d}\right)$$

$$\frac{X}{d} = 1.2 - \sqrt{\frac{1.44-6.6m_u}{f_{ck}bd^2}}$$

$$\frac{X}{d} = 1.2 - \sqrt{\frac{1.44-6.6\times1204\times10^6}{25\times2108\times1100^2}}$$

$$\frac{X}{d} = 0.85$$

Z = 1100× (1-0.416×0.85)
Z = 720mm

$$A_{st} = \left(\frac{(1204\times10^6)}{0.87\times415\times720}\right)$$

Ast = 4632mm2
Assuming 16ϕ bars
Number of bars = $\frac{4632}{\frac{\pi}{4}\times16^2}$

= 20Nos
Along L-direction Provide 16ϕ-20Nos
Development length

$$L_d = \left(\frac{(\varphi\times0.87\times f_y)}{4\times\tau_{bd}}\right)$$

$$L_d = \left(\frac{(16\times0.87\times415)}{4\times(1.92\times1.25)}\right)$$

L_d = 601mm

$$L_d < \left(\frac{(B-b)}{2}\right)$$

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$$L_d < \left(\frac{(2108-450)}{2}\right)$$

601< 829mm Hence ok

Detailing

Ld. = 601 mm

Depth, D = 790 mm

B = 2108 mm

b = 230mm

a = 450mm

L = 2100mm

Provide 12 ϕ-25Nos for longer direction

Provide 12 ϕ-20Nos for shorter direction

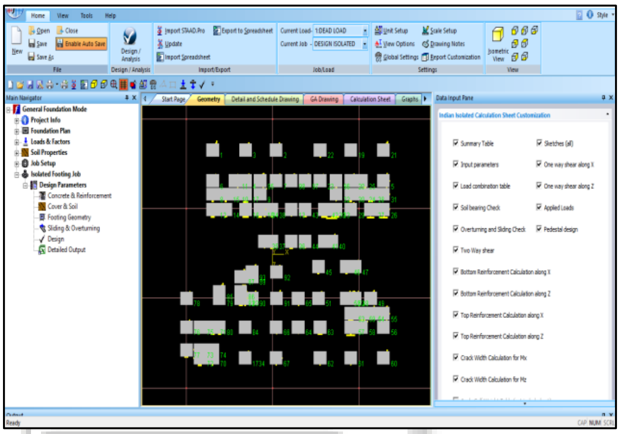

Fig. 8: Footing plan in STAAD pro

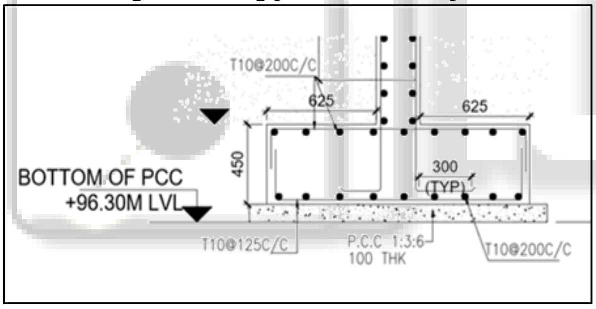

Fig. 9: Footing layout

FOOTING SCHEDULE					
FOOTING NUMBER	FOOTING SIZE			REINFORCEMENT	
	LENGHT	BREADTH	DEPTH	SHORT BARS	LONG BARS
F1	2750	1900	500	T12@125 C/C	T12@125 C/C
F2	2450	1900	500	T10@100 C/C	T10@100 C/C
F3	1900	1750	500	T10@100 C/C	T10@100 C/C
F4	1750	1600	450	T10@100 C/C	T10@100 C/C
F5	1650	1500	450	T10@100 C/C	T10@100 C/C
F6	2350	1800	500	T10@100 C/C	T10@100 C/C
F7	2550	1900	500	T10@100 C/C	T10@100 C/C

Table 3: Footing reinforcement details

E. Design of Stair Case:

1) Stair Case

Stairs is a construction designed to bridge a large vertical distance by dividing it into smaller vertical distances, called steps. Stairs may be straight, round, or may consist of two or more straight pieces connected at angles. Stairway is the one which is constructed for access between the floors of a building

Types of stair cases

Straight stairs

Quarter turn stairs

Dog-legged or half turn stairs

Three quarter turn stairs

Open newel stairs

We are using the Dog-legged stair case

2) Design of Staircase

Effective span = 5.5m

Live load = 3 KN/m2

Tread, T = 300mm

Rise, R = 175mm

Going, G = 200mm

Thickness of waist

$$d = \frac{Span}{30} = 183.3mm$$

Total thickness = 183.3+15+6

= 191mm

Dead load from staircase

$$B = \sqrt{\left(R^2 + G^2\right)}$$

$$= \sqrt{\left(175^2 + 200^2\right)}$$

= 265mm

$$\text{Dead load} = \frac{1}{G}\left(WB + \frac{R \times T}{2}\right) \times 25 + \frac{F \times T}{G} \times 23.5$$

$$\text{Dead load} = \frac{1}{0.20}\left(0.195 \times 0.265 + \frac{0.175 \times 0.20}{2}\right) \times 25 + \frac{0.015 \times 0.27}{0.20} \times 23.5$$

= 8.69 KN/m^2

Live load

live load = 3 kn/m^2

factored load = 1.5(8.69+3)

= 18 kn/m^2

Design / factored moment

$$M_u = \frac{W \times l^2}{10} = M_u = \frac{18 \times 5.5^2}{10} = 54.5 \text{ KN-m}$$

Check for depth required

$$d = \sqrt{\left(\frac{M_u}{0.138 \times f_{ck} \times b}\right)}$$

$$d = \sqrt{\left(\frac{54.5 \times 10^6}{0.138 \times 25 \times 1000}\right)}$$

= 125 < 183 mm

Calculation OF Ast (Main reinforcement)

$$A_{st} = \frac{M_u}{0.87 \times f_y \times Z}$$

$$Z = d\ x\left(1 - 0.46\frac{x}{d}\right)$$

$$\frac{x}{d} = 0.248$$

Z = 110 mm

$$A_{st} = \frac{54.5 \times 10^6}{0.87 \times 415 \times 110}$$

= 1372 mm^2

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Total Ast required = 1372×1.5= 2058 mm^2

Number of bars $= \dfrac{2058}{\left(\frac{\pi}{4}\times 16^2\right)} = 10$

% Ast provided = $\dfrac{2058}{(1500\times 170)} = 0.51$

Ast provided = $10\times\dfrac{\pi}{4}\times 16^2$ = 2246 mm^2

Calculation of ast (distribution reinforcement)

0.12% of cross sectional area

$0.12\times\dfrac{1000\times 190}{100}$ = 234 mm^2

Provide 8mm Ø bars

Spacing = $\dfrac{50.26\times 1000}{234}$ = 214 mm

Provide 8mm Ø bars at 210 c/c

3) Check For Shear

$V = \dfrac{W\times l}{2} = \dfrac{18\times 5.5}{2}$

= 49.5 KN

$\tau_v = \dfrac{v}{bd} = \dfrac{49.5\times 10^3}{1000\times 178}$

=0.278N/mm^2

τ_c From table-14 fck = 2.0 N/mm^2

0.15% of steel = 0.29 N/mm^2

$\tau_c > \tau_v$ safe against shear stress

CHECK FOR DDEFLECTION:

$$f_s = 0.58\times f_y \times \left(\frac{A_{st}\text{required}}{A_{st}\text{provided}}\right)$$

$$f_s = 0.58\times 415\times\left(\frac{2058}{2246}\right)$$

= 220 N/mm^2

From IS 456

$\dfrac{L}{d}$ (Permissible) = 1.2×25 =30

$\dfrac{L}{d}$ (Assumed) = 30

Safe against deflection control.

4) Check for Maximum Spacing

Sv = 12Ø = 192

3d = 3×125 = 375

300mm

Provide spacing of 16mmØ bars at 190 mm c/c

Secondary reinforcement

Sv = 8Ø = 128

5d = 5×125 =625

450mm

Provide reinforcement spacing of 8mmØ bars at 100mm c/c

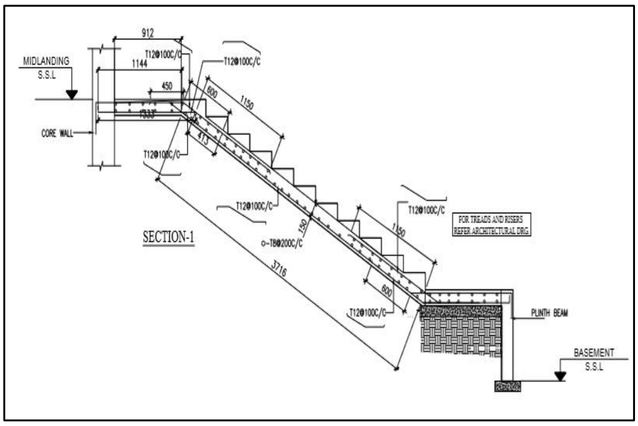

Fig. 10: Staircase Layout

F. Design of Water Tank:

1) Water Tank

Water tank is a container for storing water. The need for a water tank is as old as civilization, to provide storage of water for use in many application like drinking water, irrigation, fire suppression etc..,

2) Types of water tank

1) Ground water tank
2) Elevated water tank
3) Circular tank - flexible and rigid
4) Rectangular tank

3) Water Tank Design

Assume M25 grade of concrete

Fe415 grade of steel

σ_{cbc} = 8.5 N/mm^2

σ_{cbt} = 1.2 N/mm^2

σ_{st} = 100 N/mm^2

Modular ratio m = 280/3 σ_{cbc}

= 11

Dimensions of the tank

Capacity of tank = 20000 liters

= 20X10^3

= 20 m^3

Assuming height of the tank as 3 m with free board of 0.3m

d = H – free board

= 3 – 0.3

= 2.7 m

Area of the tank required

A req = (capacity of the tank) / (depth of water in tank)

= 20 / 2.7

= 7.4 m^2

Π/4 x D2 = 7.4 m^2

D = $\sqrt{\dfrac{4X7.4}{\pi}}$

D = 3.06 m

Provide 3m dia & 3m height of tank with the free board of 0.3m

Capacity of the tank provided = (π/4) X 32 X 2.7

= 20m^3

Design of vertical wall

Considering 3m from top

Pressure intensity at 1.5m depth from top

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P = wh
= 10 X 3
= 30 kN/m^2
Hoop tension, T = 0.5 x P x D
= 0.5 x 30 x 3
= 45 KN
Area of steel reinforcement required
Ast = T / σst
= 45000/150
= 300mm^2
Provide 10mm dia bars

Spacing S = $\frac{1000 X \frac{\pi}{4} X 10^2}{300}$
= 250mm
Provide 10mm dia rings @ 250mm c/c

Ast (provided) = $\frac{1000 X \frac{\pi}{4} X 10^2}{250}$
= 314mm^2
Thickness of the wall, t = (30xd) + 50
= (30x2.7) + 50
= 150mm
Let us provide thickness of the wall = 150mm

Check for tensile stress

Tensile stress in the wall σt = $\frac{T}{bt + (m-1)A_{st}}$

$\frac{45X10^3}{(1000X150)+(13-1)X314}$
= 0.29 N/mm2 < 1.7 N/mm2
Hoop stress at 2m from top
Pressure intensity at 1m depth from top
P = WH
= 10 X 2
= 20 kN/m^2
Hoop tension T = 0.5 X P X D
= 0.5 X 20 X 3
= 30 KN
Area of the steel reinforcement required
Ast (required) = T / σst
= (300 x103)/150
= 200 mm^2

Spacing of 8mm dia bars S = $\frac{1000 X \frac{\pi}{4} X 8^2}{200}$
= 250mm
Provide 8mm dia @ 250mm c/c
Pressure intensity at 1m depth from top
P = wh
= 10 X 1
= 10 kN/m2
Hoop tension T = 0.5 X P X D
= 0.5 X 10 X 3
= 15 KN
Ast = T/ σst
= (15 X 103)/150
= 100mm^2

Spacing of 8 mm dia bars, S = $\frac{1000 X \frac{\pi}{4} X 8^2}{100}$
= 500 mm
Provide 8mm dia @ 500mm c/c
Distribution reinforcement
For 150 mm thick wall

Ast = (0.3) – $\frac{0.3-0.2}{450-100}$ (150-100)
= 0.285 % of cross sectional area
= (0.285/100) X 150 X1000
= 352 mm^2
Provide 8mm dia bars

Spacing S = $\frac{1000 X 78.5}{352}$
S = 200 mm
Provide 12mm dia bars @ 100mm c\c

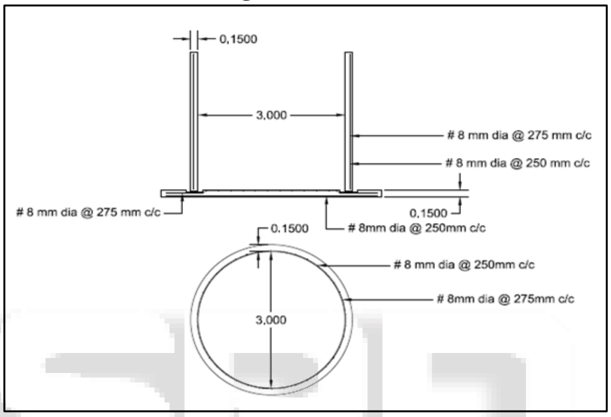

Fig. 11: Water Tank Layout

G. *Design of RC Shear Wall*

Reinforced concrete wall is designed as a compression member. Reinforced concrete wall is used in case where beam is not provided and load from the slab is heavy or when the masonry wall thickness is restricted.

Reinforced concrete wall is classified as:

1) Plain concrete wall, when reinforcement < 0.4%
2) Reinforced concrete wall, when reinforcement > 0.4%
3) Load from slab is transferred as axial load to wall. When depth is large, it is called RC wall. Design is similar to a RC column, breadth equal to thickness of wall and depth equal to 1m. RCC Wall is designed as:
4) Axially loaded wall
5) Axially loaded with uniaxial bending

1) *Classification of Concrete Walls:*

– Plain concrete wall
– Reinforced concrete wall

In plain concrete wall, the reinforcement provided is less than 0.4% of c/s. In reinforced concrete wall, the percentage of steel provided is greater than 0.4% and is designed similar to reinforced concrete columns.

Slenderness ratio is equal to least of (l/t or h/t), where, l is effective length of wall, h is effective height of wall, t is thickness of wall If λ < 12, the wall is short and if λ > 12, the wall is slender.

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2) Braced and Unbraced Concrete Walls

Braced: When cross walls are provided for the walls such that they can take lateral load and 2.5% of vertical load, then the wall is braced. Otherwise, the wall is known as unbraced wall.

Note: Other walls under special cases are,

1) Cantilever wall
2) Shear walls – to take lateral loads [Take care of flexure developed due to lateral loading on the structure, depth is provided along the transverse direction]

3) Guidelines for Design of Reinforced Concrete Wall

1) The limiting slenderness (λ_{lim}) if any for unbraced wall is 30 and for braced wall is 45.
2) For short braced RC wall (λ < 12), $P_u = 0.4 \times f_{ck} \times A_c + 0.67 \times f_y \times A_{st}$
3) For short unbraced RC wall, along with the above axial load P_u, the moment due to minimum eccentricity is checked for e_{min}= t/20 or 20mm, where, M = P x e.

For the above axial load and moment, the RC wall is designed similar to RC column subjected to axial load and uniaxial moment.

4) Slender braced wall (λ < 45):

The additional moment due to additional eccentricity as per Table 1 of SP16 is considered. Where the additional eccentricity,

$$e_a = \frac{L_e^2}{2000t}, \quad M_a = P \times e_a$$

The additional moment due to eccentricity is added with the moment on the column and moment on the wall. The wall is designed for axial load with uniaxial moment.

5) For slender unbraced wall [λ limited to 30]: Similar procedure as in case 4 is adopted.

4) Detailing of Reinforcement [IS 456 Guidelines]:

1) For plain concrete wall, minimum vertical steel is 0.12% for HYSD bars and 0.15% for mild steel bar.
2) For RC wall, minimum vertical reinforcement is 0.4% of c/s
3) In plain concrete wall, transverse steel is not required
4) In RC wall, transverse steel is not required (not less than 0.4%)
5) Maximum spacing of bars is 450mm or 3t, whichever lesser
6) The thickness of wall in no case should be less than 100mm
7) If thickness is greater than 200mm, double grid reinforcement is provided along both the faces.

5) Detailing of Reinforcement (BS 8110 guidelines):

1) Horizontal reinforcement same as IS456
2) Vertical reinforcement not to be greater than 4%
3) When compression steel is greater than 2% of vertical reinforcement, horizontal reinforcement of 0.25% for HYSD bars or 0.3% of MS bars are provided. [As per IS456, it is 0.2% for HYSD bars and 0.3% for mild steel bars].
4) The diameter of transverse bars (horizontal) should not be less than 6mm or $\phi_L/4$.
5) Links are provided when the compression steel is greater than 2%. Horizontal links are provided for thickness less than 220mm. Diagonal links are provided when thickness is greater than 220mm. The spacing of links should be less than 2t and diameter of links not less than 6mm or $\phi_L/4$.

6) The support conditions for Effective Length Of Wall:

1) Both ends fixed (Restrained against rotation and displacement) → $l_{eff} = 0.65l_o - 0.75l_o$
2) Both ends hinged → $l_{eff} = l_o$
3) One end fixed and other end → $l_{eff} = 2l_o$
4) One end fixed and other end hinged → $l_{eff} = l_o/\sqrt{2}$

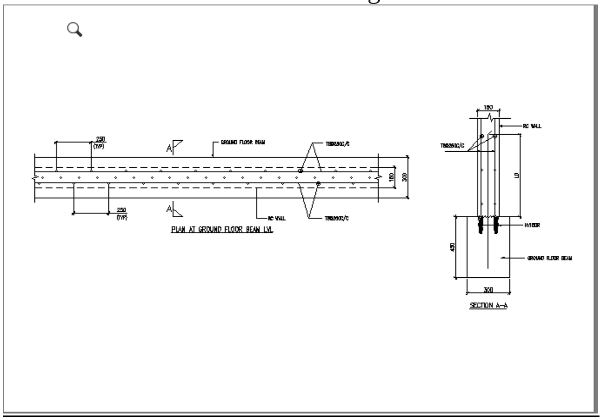

Fig. 12: Shear wall layout

```
PANEL  NO.   1 OF SHEARWALL      1  DESIGN PER IS 456-2000


WIDTH :       3.80 M                FC :            25.00 MPA
HEIGHT :      2.83 M                FY :           415.00 MPA
THICKNESS : 150.00 MM               CONC. COVER :  25.000 MM

REINFORCING SUMMARY (REBAR SPACING/AREA UNITS: MM/MM^2)
=============================================================================
LEVEL    GOV.LOAD  LEFT EDGE     HORIZONTAL      VERTICAL        RIGHT EDGE
(M)      NO. FOR   AREA                                          AREA
         L. E. R.
         HOR.      RATIO         RATIO           RATIO           RATIO
         VER.
         R. E. R.  (MIN. RATIO)  (MIN. RATIO)    (MIN. RATIO)    (MIN. RATIO)
         LINK                    HOR. LINK       VER. LINK
----------------------------------------------------------------------------
-2.54        1     6 - DIA  8   DIA  8@ 167.00  DIA  8@ 285.00    0 - DIA  0
             1      301.710                                         0.000
             1     0.00066       0.00201          0.00132         0.00000
             0   ( 0.00000)     ( 0.00200)       ( 0.00120)      ( 0.00000)
                                 NOT REQUIRED    NOT REQUIRED
----------------------------------------------------------------------------
-2.26        1     6 - DIA  8   DIA  8@ 167.00  DIA  8@ 285.00    0 - DIA  0
             1      301.710                                         0.000
             1     0.00066       0.00201          0.00132         0.00000
             0   ( 0.00000)     ( 0.00200)       ( 0.00120)      ( 0.00000)
                                 NOT REQUIRED    NOT REQUIRED
----------------------------------------------------------------------------
```

Fig. 13: shear wall details in STAAD pro

V. ARCHITECTURE DESIGN

The Revit platform for building information modeling is a design and documentation system that supports the design, drawings, and schedules required for a building project. Building information modeling (BIM) delivers information about project

Design, scope, quantities, and phases when you need it. In the Revit model, every drawing sheet, 2D and 3D view, and schedule is a presentation of information from the same underlying building model database. As you work in drawing and schedule views

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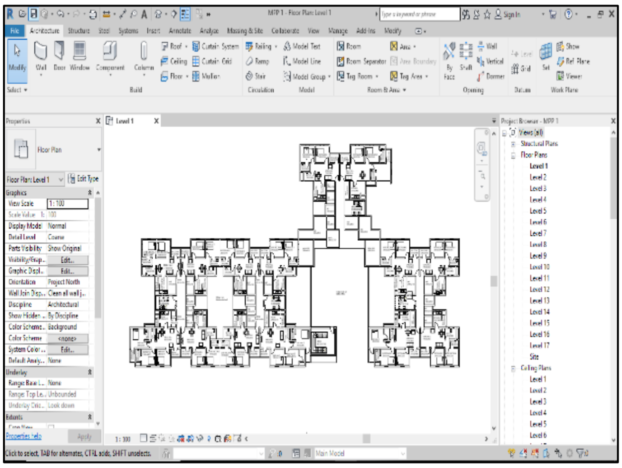

Fig. 14: Plan in Revit architecture

Fig. 15: Render view in Revit architecture

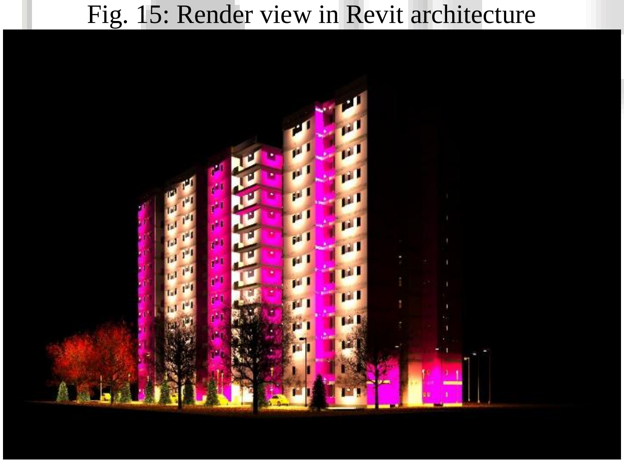

Fig. 16: Render view 2 in Revit architecture

VI. ESTIMATION

Preparation of an estimate is for arriving the cost of the structure to verify the available funds or to procure the required funds for completion of the proposed structure.

The total Abstract estimation of the project taken PRs 21,08,44,76

VII. CONCLUSION

This project is mainly concentrated with the analysis and design of RC wall framed residential building with all possible cases of the loadings using STAAD. Pro Meeting the design challenges are described in conceptual way. We may also check the deflection of various members under the given loading combinations. Further in case of rectification it is simple to change the values at the place where error occurred and the obtained results are generated in the output. Very less space is required for the storage of the data.

STAAD Pro V8i advanced software which provides us a fast, efficient, easy to use and accurate platform for analyzing and designing structures. REVIT gives a clear design and modeling of a residential building with the efficient structural and architectural plans. It provides the overall knowledge of material take off and schedule/quantities in the model of the building defined in the project. 3 D realistic view enables us to indicate the family and the components placed within the building model.

REFERENCES

– Theory of structures by B.C Punmia for literature on moment distribution method.
– Limit state design of Reinforced concrete by P.C.Verghese.
– Fundamentals of reinforced concrete structures by N.C Sinha.

IS Codes:

[1] IS: 875 (Part 1) – 1987 for Dead Loads, Indian Standard Code Of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures, Bureau of Indian Standards, ManakBhavan, 9 Bahadur Shah ZafarMarg, New Delhi 1100 02.
[2] IS: 875 (Part 2) – 1987 for Imposed Loads, Indian Standard Code Of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures, Bureau of Indian Standards, ManakBhavan, 9 Bahadur Shah ZafarMarg, New Delhi 110002.
[3] IS: 875 (Part 3) – 1987 for Wind Loads, Indian Standard Code Of Practice for Design Loads (Other Than Earthquake) For Buildings And Structures, Bureau of Indian Standards, ManakBhavan, 9 Bahadur Shah ZafarMarg, New Delhi 110002.
[4] IS 1893 (Part 1)-2002, Indian Standard Criteria for Earthquake Resistant Design of Structures, (Part 1-General Provisions and Buildings), Bureau of Indian Standards, ManakBhavan, 9 Bahadur Shah ZafarMarg, New Delhi 110002.
[5] IS 456-2000, Indian standard code of practice for plain and reinforced concrete standards, New Delhi, 1980.
[6] IS 456-2000, Indian standard code of practice for plain and reinforced concrete standards, New Delhi, 1980.
[7] SP: 34-1987, Hand Book of Concrete Reinforcement and Detailing, Bureau of Indian standards, New Delhi, 1987

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