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ANALYSIS AND DESIGN OF RESIDENTIAL BUILDING (G+5)

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ABSTRACT

Residential building detail estimation and costing or Quantity surveying The primary objective of this project is to gain sufficient knowledge in planning, analysis, and design of building and Quantity surveying

Our project deals with the plan and design of a Bank building. It is a reinforced concrete framed structure consisting of G +2 with adequate facilities.

IS 456:2000 codes is the basic code for general construction in concrete structures, hence all the structural members are designed using limit state method in accordance with the IS 456:2000 code and design aids.

The planning of any building in India will be recognized by National Building Code (NBC) , hence the building is planned in accordance with the National Building Code of India.

The building includes the following:

1. *Hall*
2. *Bedroom*
3. *Kitchen*
4. *Drawing room*
5. *Guest room*
6. *Toilet*

The residential building has proper ventilation, it is provided with sufficient doors, windows. Water supply and electrification are also provided.

The ceiling height is provided as 3.2m, for assembly buildings as mentioned Building Code (NBC)

I. INTRODUCTION

1.1 General

The main objective of our project is to know the various design aspects like planning, analysis and design etc. We have planned to design a bank building consisting of three floors (G+2).The planning is done as per the requirements and regulations given by the National Building Code (NBC).

1.2 Practical considerations

Besides all the fundamentals of planning discussed, following practical points should be additionally considered:

1) The elements of the building should be strong and capable to withstand the likely adverse effects of natural agencies.

2) Strength, stability, convenience and comfort of the occupants should be the first consideration in planning.

3) Elevation should be simple but attractive. The number of doors and windows provided should be less for a bank building.

4) The provisions of built in furniture at proper places are useful from the point of view of utility.

5) Since the plan is for a bank building, the locker rooms must be secured with thicker walls than usual.

1.3 Planning considerations

The plan and detailing was drawn using Auto CAD. The proposed area of the bank is 324sq.m. The shape of the building is rectangular in plan. The building consists of ground floor, first floor and second floor.The parking space is provided around the building. The floor height of the building is 3.2m.The height of the parapet wall is 1m.The staircase is provided with enough safe.

Area of each floor is given below

Ground floor = 108 sq.m

First floor = 108 sq.m

Second floor = 108 sq.m

Total area = 324 sq.m

1.4 Specifications

1.4.1Footing

Earth work excavation for foundation is proposed to a depth of 1.50m.below the ground level. For design, the safe bearing capacity of soil is assumed as 200KN/m^2.Isolated footings are provided with a concrete grade of M20. The maximum axial load 2210KN as arrived from analysis result is taken for the design of the footing.

1.4.2Damp proof coarse

The damp proof coarse is to be provided around the plinth level using C.M 1:3 with a thickness of 20mm. The column below the ground level are also provided with damp proof coarse of C.M 1:3

1.4.3 Plinth

The plinth beam will be at a level of 0.5m above the ground level. M20 grade of concrete is used and Fe415 steel was used for plinth design.

1.4.4Frames

All the R.C.C. structural components are designed using M20 grade steel. Each member is designed separately for its loading condition

And its location as per the IS 456:2000 and SP 16 codes. The dimension of slab, beam, column and footing are designed according to the IS 456:2000 code. The column is designed as per the design principles given in SP-16 and the axial load was taken from the analysis results.

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1.4.5. Super Structure

The super structure is proposed in CM.1:6 using second class brick work. Brick partition walls of 110mm thick are also proposed using the C.M 1:4 with a width of 300mm as a safety measure.

1.4.6. Roof

R.C.C Roof in M20 concrete is to be laid. A layer of weathering coarse using brick jelly lime mortar is to be used. Considering the future expansion of the structure, the roof slab is also designed as same as that of the floor slabs.

1.4.7. Flooring

In each floor, all the rooms are to be provided with P.C.C. 1:5:10 as flooring base. The floors of entrance, toilet floors, staircase and entire flat are to be finished with granite tiles over the P.C.C. 1:2:4 flooring.

1.4.8 . Plastering

All walls and structural members including the basement will be plastered smooth with C.M. 1:5 externally and internally, using 12mm thick plastering mortar.

1.4.9. Doors and windows

The main door will be of steel having a sliding shutter. The other doors inside the bank are to be provided with aluminium panel. The windows are to be provided with steel and glazing is provided to supply a good light from outside.

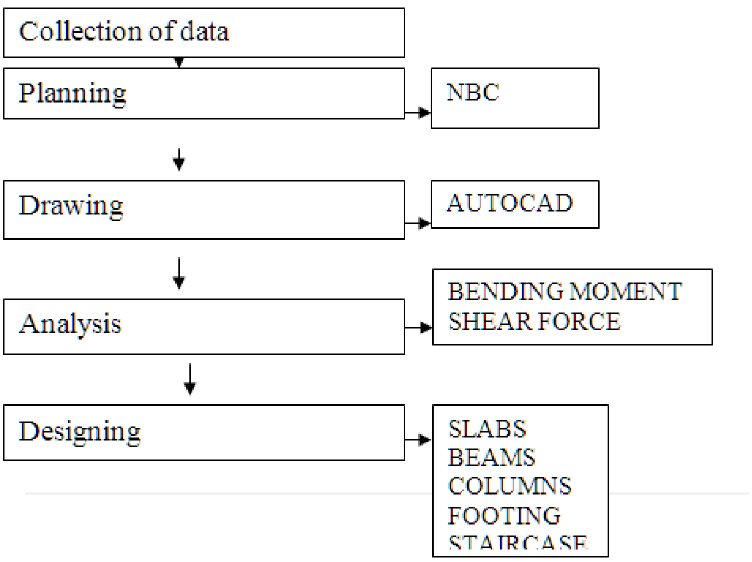
1.4.10 Staircase

The stair will be of M20 grade concrete and Fe415 steel with a rise of 150mm and tread of 300mm. The staircase is designed as spanning parallel to landing slab referring to IS 456-2000.

1.4.11.White washing, Colour washing, Painting

All the inner walls are to be finished with a first coat of white cement wash and then colouring as required. All the joiners and iron works are to be finished with two coats of synthetic enamel paint. The toilet walls are to be provided with mat finishing.

II. METHODOLOGY



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III. ANALYSIS

3.1 Introduction

Structural analysis is the application of solid mechanics to predict the response (in terms of force and displacements) of a given structure (existing or proposed) subjected to specified loads. Based on degree of indeterminacy the structure will be classified as

i. Determinate structure

ii. Indeterminate structure

The determinate structure can be completely analyzed by using equilibrium equation. i.e.

M =0; V=0; & H=0.

Example: simply supported beam, cantilever beam, overhanging beam.

In the indeterminate structure, can't be complete analyzed by equilibrium equations.

Example: Fixed beam, continuous beam, and propped cantilever beam

Moment Area method:

This method is used for analyzing cantilever and fixed beam.

Theorem of three moment equation:

It is more suitable for continuous beam.

Moment distribution method:

It is the iterative technique.

Slope- deflection method:

When the beam has more than four spans then the calculation is difficult.

Stiffness method:

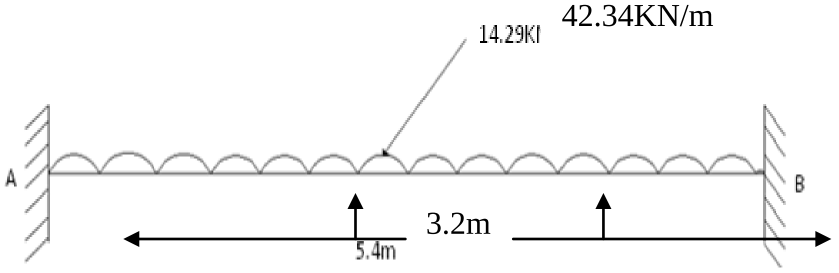
Force and displacements play on important role in the structuralanalysis. In this method the force is measured to produce a unit displacement.

Flexibility method:

It is the inverse of stiffness. It is defined as the measure of displacement caused by the unit load. The moment distribution method for the analysis of beam is adopted in this project.

3.2. Analysis

FIXED END MOMENTS



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Span AB

$$MF_{AB} = \frac{-Wl^2}{12} = \frac{-42.34 \times (3.2)^2}{12} = -36.12 \ KNm$$

$$MF_{BA} = \frac{Wl^2}{12} = \frac{42.34 \times (3.2)^2}{12} = 36.12 \ KNm$$

$$MF_{BC} = MF_{CB}$$

Distribution factor (DF)

@Joint B

$$DF_{AB} = \frac{K_{BA}}{K_{BA} + K_{BC}} = \frac{0.3125}{0.3125 + 0.3125} = 0.5$$

$$DF_{BC} = \frac{K_{BC}}{K_{BC} + K_{BA}} = \frac{0.3125}{0.3125 + 0.3125} = 0.5$$

Distribution factor (DF) is same as each member

Table 3.1 Moment distribution method

Joint	A	B		C
Member	AB	BA	BC	CB
D.F		0.5	0.5	
I.M	-36.12	36.12	-36.12	36.12
B	0	0	0	0
Net B.M	-36.12	36.12	-36.12	36.12

$$\text{Span AB} = \frac{Wl^2}{8} = \frac{26.95 \times 5.4^2}{8} = 98.23 \ KNm$$

$$\text{Span CE} = \frac{Wl^2}{8} = \frac{25.7 \times 3^2}{8} = 28.92 \ KNm$$

IV. DESIGN

Introduction

The slab is designed by assuming it as simply supported with four edges discontinuous, for easier design calculation. The beam is designed by knowing its span and its location (inner and outer). The beam has to carry the self-weight of slab and live load of 4KN on its self-weight also. The column alone is designed by following the SP – 16 codes.

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4.1 Design of Slab

4.1.1 Slab 1: Two adjacent edges discontinuous

Data

Dimension of slab = 3 m × 3 m f_{ck} = 20 N/m^2

Support width = 230 mm f_y = 415 N/m^2

Live load = 4 KN/m^2

Floor finish = 1 KN/m^2

Depth of slab

Minimum depth = Span / B.V × M.F

B.V = 26 (For continuous slab)

M.F = 1.4

Minimum depth d = 3000/(26 × 1.2)

= 96.15 mm ≈ 100 mm

Assume effective cover = 25 mm, Using 10 mm diameter bars

Effective depth = d = 100 mm

Overall depth = D = 100 + 25 + (10/2)

= 130 mm

- d = 100 mm
- D = 130 mm

Effective span

The least value of:

(1) (Clear span + effective depth) = (3 + 0.1) = 3.1 m

(2) (Centre to centre of supports = (3 + 0.23) = 3.23 m

(3) Hence L = 3.1 m

Loads

Self weight of slab = (0.12 × 25) = 3 KN/m^2

Floor finish = 1 KN/m^2

Live load = 4 KN/m^2

Total service load = w =8 KN/m^2

Ultimate load = w_u = 1.5 × 8 = 12 KN/m^2

Ultimate moments and shear forces

L_y / L_x = 3 / 3 = 1< 2

So it is a two way continuous slab

The coefficients for the positive and negative moments are taken from IS 456 – 2000

$+\alpha_x$ = 0.035

$-\alpha_x$ = 0.047

$+\alpha_y$ = 0.035

$-\alpha_y$ = 0.047

$M_{ux} = \alpha_x w_u x_x^2$

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$M_{uy} = \alpha_y w_u L_y^2$

$V_{ux} = 0.5\ W\ l_x$

(1) B.M along span (+ve) $= 0.035 \times 12 \times 3.1^2$

$M_{ux} = 4.036$ KN.m

(2) B.M along span (-ve) $= 0.047 \times 12 \times 3.1^2$

$M_{uy} = 5.420$ KN

(3) Shear force V_{ux} $= 0.5 \times 12 \times 3.1$

= 18.6KN

Check for depth

$M_{max} = 0.138 f_{ck} b d^2$

$d^2 = 5.420 \times 10^6 / (.138 \times 20 \times 10^3)$

$d = 44.31\text{mm} < 100\text{mm}$

Reinforcements (Short and long span)

$\mathbf{M_u} = .87 f_y A_{st} d [1 -(f_y A_{st} / b d f_{ck})]$

$A_{st} = 155.10\text{mm}^2$

Adopt 10mm diameter bars at 400 mm centers (A_{st}=185.71mm^2)

Edge strip

Minimum area of steel = 156mm^2

Provide 10mm diameter bars

a_{st} =78.5mm^2

Spacing $= a_{st}/ A_{st} \times 1000$

$78.5/156 \times 1000$ = 509 mm

So adopt 10 mm bar @ 500mm c/c

Middle strip [+ve moment]

$M_u = .87 f_y A_{st} d [1 -(f_y A_{st} / b d f_{ck})]$

$A_{st} = 201.44\text{mm}^2$

Provide 10mm diameter bars

$a_{st} = \pi/4 \times d^2$

$a_{st} = 78.5\text{mm}^2$

Spacing $= a_{st}/ A_{st} \times 1000$

S = 300mm

Provide 10 mm diameter bars @ 300mm c/c

Torsional reinforcement

Single torsional reinforcement $= l_x/5 \times l_y/5$

Area of torsional steel = 151.08mm^2

Provide 8mm bars

Spacing = 332 mm c/c or 300 mm c/c.

Check for deflection

(Shorter span/depth)$_{provided}$ = 3000/130 = 23.07

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(Shorter span/depth)$_{permissible}$ = B.V × M.F

F_s = 0.58 × 415 × (156/102)

F_s = 368.12

% A_{st} = 1.2%

M.F = 1.2

(Shorter span/depth) = 31.2

Hence safe in deflection

4.2. Design of Beam

Dimension

Shear force = 135 KN

Moment M_u = 67 KN.m

Beam size = 0.3 × 0.4m

Limiting moment of resistance

$M_{u\ limit}$ = $0.138\ f_{ck}\ bd^2$

$M_{u\ limit}$ = $[0.138 \times 20 \times 300 \times 400^2] \times 10^{-6}$

= 132.48 KN.m

Since $M_u < M_{u\ lim}$, section in under reinforced

Main Reinforcement:

M_u = $0.87 fy A_{st} d[1-(fy A_{st} d/(bd f_{ck}))]$

A_{st} = 920 mm^2

Provide 4 bars of 16 mm diameter @ the top tension face near support

Provide 2 bars of 18 mm diameter @ the bottom tension face @ centre of span section.

Actual A_{st} = 1017mm^2

Shear Reinforcement:

Ast $_{min}$ = 0.84 N/mm^2

Hence shear reinforcement are required

Balance shear = 34.2 KN

Using 8 mm diameter 2 legged stirrups spacing

S_v = 221 mm

S_v > 0.75 d = 337.5mm

Adopt spacing of 200mm near support, gradually increasing to 300mm towards center of span.

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Check For Deflection:

p_t = 0.76

Neglecting bar in compression side

$[L/d]_{max}$ = 34.44

$[L/d]_{actual}$ = 9 < 34.4

Hence deflection cont

4.3 DESIGN OF COLUMN

4.3.1 COLUMN TYPE - 1

Data

Size of column = 450mm × 450mm

Concrete mix = M20

Characteristic strength of reinforcement = 415 N/mm^2

Factored load = 1660 KN

Factored moment = 60.12 KN.m

Assuming 25mm bars with 40mm cover, = 5.25cm

d'/D = 0.12

By using SP16,

Chart for d'/D = 0.15 will be used.

$P_u / (f_{ck} bD)$ = 0.409

$M_u / (f_{ck} Bd^2)$ = 0.033

a) Reinforcement on two sides.

Refer Chart 33 of SP16,

P/f_{ck} = .02

Percentage of reinforcement,

P = 0.4

A_s = 8.1cm^2

b) Reinforcement on four sides.

Refer Chart 45 of SP16,

P/f_{ck} = 0.02

P = 8.1cm^2

Provide 6 bars of 20mm diameter

Lateral Ties

Diameter of lateral ties

- 1 /4 of main bars = 1/4 x 20 = 5mm.

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- Min diameter of bar = 6mm

Follow 6# bars.

Pitch of lateral ties

- 16n times main bars = 16 x 20 = 320 mm.
- Lateral dimension = 450mm
- 300mm

Provide 25mm diameter bars at 300mm c/c.

4.4 DESIGN OF FOOTING

Data

Factored axial load P_u = 1660KN

Size of Column = 450 × 450 mm

Safe Bearing Capacity = 200 KN/m^2

Assume self weight of footing 10% of load

Self weight of footing = 166 KN

Area of footing required =6.08m^2

Side of square footing = 2.46m

Assume breadth of square footing = 3m

Provide a square footing of 3m×3m = 9m^2

Net upward design pressure W =1660/3×3

= 184.4<200×1.5

Bending moment

Projection of footing from column face

(B-b)

M_x = 449.74 KNm

Depth required

d = 233.06mm = 240mm

Consider the effect of shear providing 2 times the depth required.

Provide depth = 480mm

Assume 20mm diameter and cover 40mm

Over all depth = 550mm

Tension Reinforcement

M_{max} $= 449.74 \times 10^6$

M_u $= 0.87 f_y A_{st} d[1-(A_{st} \times f_y / bd f_y)]$

A_{st} = 2700mm^2

Minimum A_{st} to be provided = (0.15/100) × 3000 × 550

= 2475 < 2700mm^2

Provide 20 mm diameter bars,

Number of bars = 8.59 ≈ 10nos

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Provide 10 numbers of 20mm bars (Actual A_{st} = 3141mm^2)

Check for one way shear

The critical section for traverse shear (section yy) is at distance of 480mm (effective depth).

Length of critical section = 0.795m or 795mm

V_u = 439.79 KN

Nominal shear stress

τ_v = 0.26 N/mm^2

From the table -19 of IS456-2000

$100A_{st}/bd$ = 0.24 for $M_{20.}$

τ_v = 0.34

$\tau_c > \tau_v$, Hence safe.

Checking for punching shear

The critical section for shear is at distance of ½ (d_{eff})

ie , 240mm around the face of the column.

Side of the section =930mm

Punching shear across section zz

V_z = 1496.99 KN

Nominal shear stress across section zz

τ_v = $(1496.66\times10^3)/(4\times940\times480)$

τ_v = 0.82N/mm^2

As per clause 31.6.31 of IS456:2000

Permissible shear stress in concrete = $k\tau_c$

For square column,

k = 1.0, τ_c = 0.33

$k\tau_c$ = 0.33

Check for Safe bearing capacity

Column of load = 1660 KN

Total = 1783.75 KN

Pressure =198.3< 300 (200 × 1.5) Hence safe.

4.5. Design of Staircase

DATA

Spanning parallel to landing slab (stair-1)

Type: dog-legged

Number of steps in the flight = 11 per flight

Thread T = 300 mm

Rise R = 150 mm

Width of landing beam = 300 mm

Width of landing slab = 1850 mm

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M-20 grade concrete (f_{ck} = 20 N/mm^2)

Fe-415 hysd bars (f_y = 415 N/mm^2)

V. SOLUTION

5.1 Design of first flight

Effective span = 4375 mm = 4.375 m

Thickness of waist slab = (span/20) =4375 /20)

overall depth (D) = 218.75 mm

Assume using 25mm cover and 10mm diameter bars

Effective depth (d) = 188.75 mm

5.2.Loads

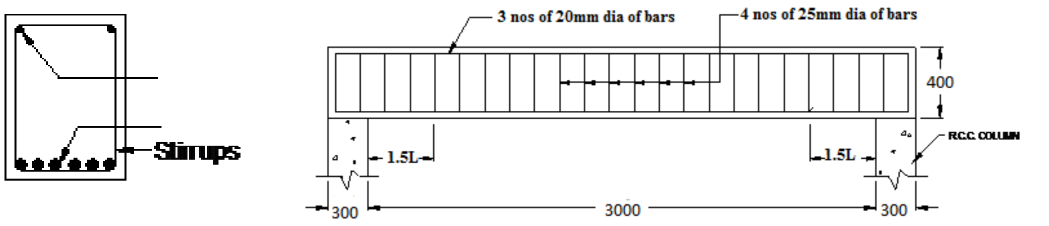
Dead loads of slab on slope (w_s) = 4.717KN/m

Dead load of slab on horizontal span (w)

Dead load of one step = 0.56 KN/m

of span ((M_u) = 42.235 KNm

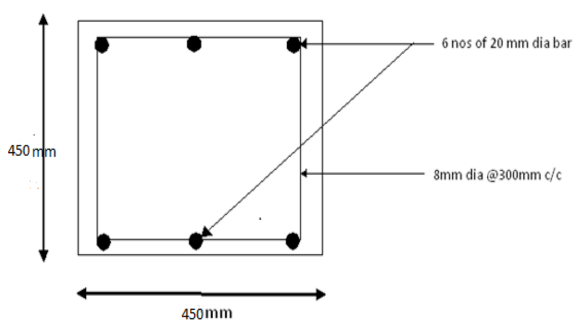
5.3 Beam- Reinforcement Details

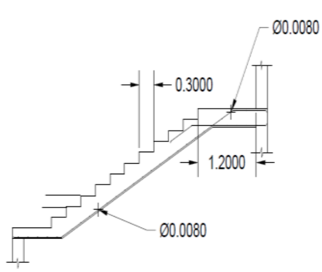


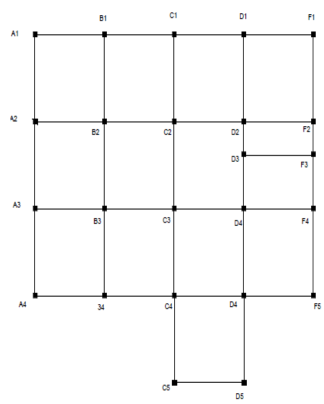
5.4 Column – Reinforcement Details

CENTRE LINE PLOT

5.6 REINFORCEMENT DETAILS OF STAIRCASE







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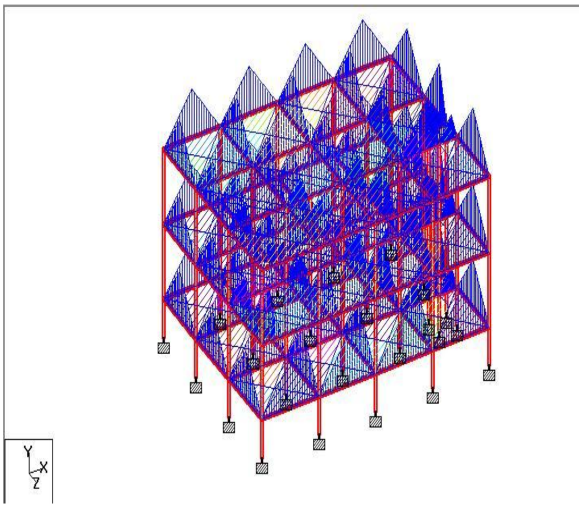
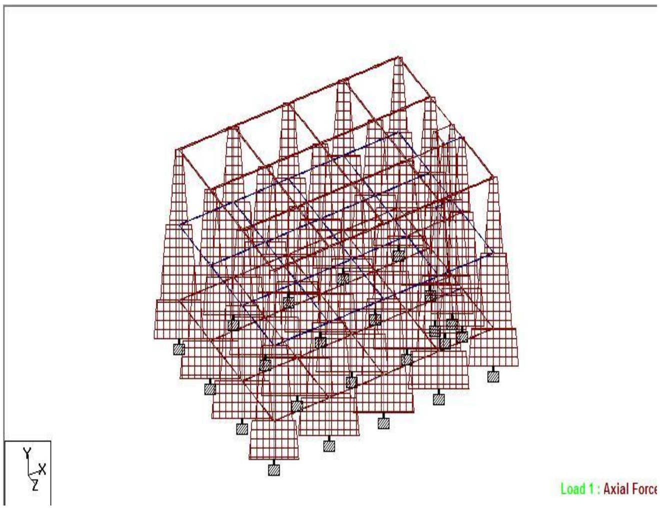
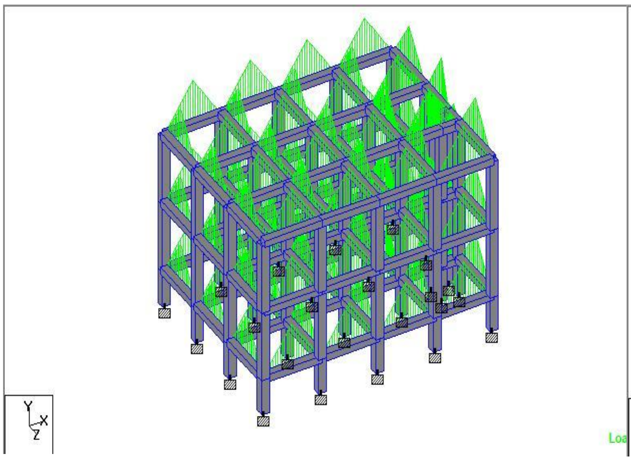
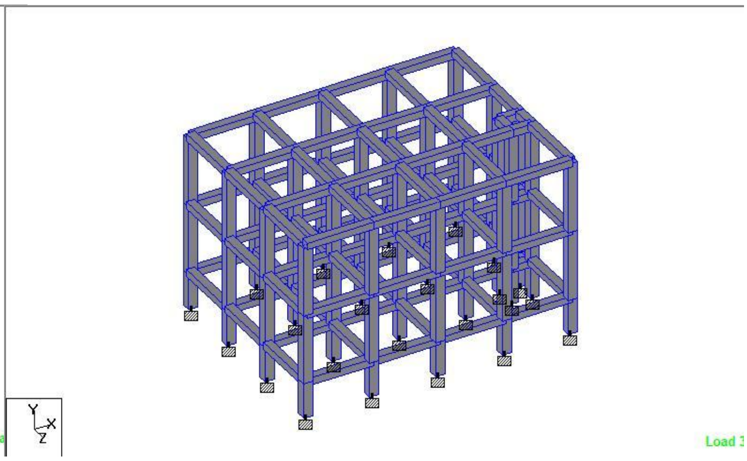


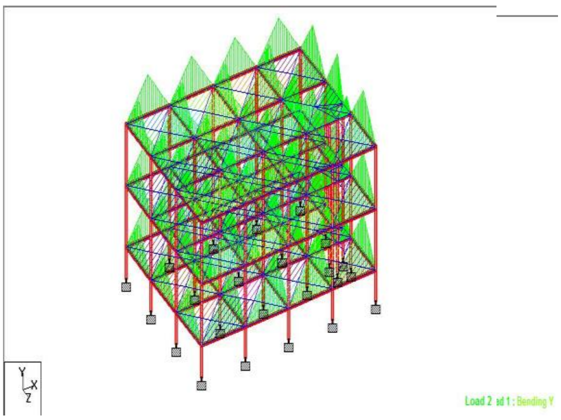






CONCLUSION

1. In this project, planning designing and analyzing of residential building**.** We all the members of our team has learned to plan a building with referring to National Building Code of India -2005.



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2. This bank building project has made us to learn Drawing and drafting the building plans using Auto cad software.
3. In this bank building project we learnt to create the models by giving nodes and property to the structural elements using analysis and also we learnt to the same structure with corresponding loads as given **IS 875 part 1&2** using analysis.
4. This project is very useful in making us learn the design by referring to the IS 456:2000 for each slab and beam. SP: 16 codes alone are used for easier design of columns yet we learned to design the columns.
5. The important thing that we done was referring to a lot of books for designing and we are very much satisfied with exposing to field of design.

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