Residential Building – Structural Design Report

Feb 2026

STRUCTUAL CONSULTANT

S.ARUN KUMAR, M.E., (Structural)

9, 9-1, Lakshmi Garden,

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TABLE OF CONTENT

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1. PREAMBLE

TABLE 1. GENERAL INFORMATION ABOUT THE STRUCTURE

1.	NAME OF BUILDING	
2.	NATURE OF BUILDING	
3.	TYPE OF STRUCTURE	Framed
4.	PLINTH LEVEL	At 0.45m
5.	TOTAL HEIGHT OF THE BUILDING (Above Plinth)	10.0m

2. MODEL AND ANALYSIS

The Model of the structure is created using STAAD.Pro V8i and the Structural analysis is carried out under the following considerations.

2.1 Material Used

Concrete = M20 (For All Concrete Structural Members)
Rebar = HYSD550D (For Structural Members)

2.2 Member Properties

a) Column Sizes (in mm)

C1 = 200x300
C2 = 200x380
C3 = 200x450

3. LIST OF CODES USED

1. IS 456 – 2000 - Plain and reinforced concrete- code of practice
2. IS 875 – (Part –I) -1987 Code of practice for design loads (other than earthquake) for buildings and structures - Dead loads
3. IS 875 – (Part- II) -1987 - Code of practice for design loads (other than earthquake) for buildings and structures. - Imposed loads.

4. LOADING PARAMETERS

i. Self-Weight is default in Staad.pro and it is considered as dead load.
ii. Apart from self-weight, all other dead loads are considered as super dead loads.

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TABLE 2. GRAVITY LOADS

S.No	Floor	Load Type		Load	Reference
1.	**Plinth Beam Level**	**Dead Load**	Brick Wall Load (8”)	11.48 kN/m	=(3.25-0.38)*0.2*20 = 11.48 kN/m Ht. of the wall = 3.25m Width of the wall = 0.2m Unit Weight of Brick = 20kN/m^3 Reduction Factor = Average Beam Depth is 0.38m
			Brick Wall Load (4”)	5.74 kN/m	=(3.25-0.38)*0.1*20 = 5.74 kN/m Ht. of the wall = 3.8m Width of the wall = 0.1m Unit Weight of Brick = 20kN/m^3 Reduction Factor = Average Beam Depth is 0.38m
		Live Load	Staircase	3 kN/m	
2.	**Ground Floor Roof Level**	**Dead Load**	Brick Wall Load (8”)	11.48 kN/m	=(3.25-0.38)*0.2*20 = 11.48 kN/m Ht. of the wall = 3.25m Width of the wall = 0.2m Unit Weight of Brick = 20kN/m^3 Reduction Factor = Average Beam Depth is 0.38m
			Brick Wall Load (4”)	5.74 kN/m	=(3.25-0.38)*0.1*20 = 5.94 kN/m Ht. of the wall = 3.35m Width of the wall = 0.1m Unit Weight of Brick = 20kN/m^3 Reduction Factor = Average Beam Depth is 0.38m
			Rail Load	2 kN/m	Assumed.
			Slab Load (5”)	4.625 kN/m²	Self Wt. of slab = 0.125*25 =3.125kN/m² Slab Thickness = 0.125m Floor Finish of Slab = 1.5kN/m² Self Wt. of Slab = 4.625 kN/m²

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			Slab Load (6”)	5.25 kN/m²	Self Wt. of slab = 0.15*25 =3.75kN/m² Slab Thickness = 0.150m Floor Finish of Slab = 1.5kN/m² Self Wt. of Slab = 5.25 kN/m²
			Sunken Load (300mm)	4.5 kN/m²	=0.3*15 = 4.5 kN/m²
			Sunken Load (450mm)	6.75 kN/m²	=0.45*15 = 6.75 kN/m²
			Sunken Material	15 kN/m²	Hemalite
		Live Load	Floor Load	2 kN/m²	IS 875 – (PART -2) - 1987
			Staircase	3 kN/m	
			Balcony Load	3 kN/m	IS 875 – (PART -2) - 1987
2.	**Terrace Floor Level**	**Dead Load**	Parapet Load	4.8 kN/m	=1.20*0.2*20 = 4.8 kN/m Ht. of the wall = 1.20m Width of the wall = 0.2m Unit Weight of Brick = 20kN/m^3
			Staircase	3 kN/m	
			Slab Load (5”)	4.625 kN/m²	Self Wt. of slab = 0.125*25 =3.125kN/m² Slab Thickness = 0.125m Floor Finish of Slab = 1.5kN/m² Self Wt. of Slab = 4.625 kN/m²
			Slab Load (6”)	5.25 kN/m²	Self Wt. of slab = 0.15*25 =3.75kN/m² Slab Thickness = 0.150m Floor Finish of Slab = 1.5kN/m² Self Wt. of Slab = 5.25 kN/m²
		Live Load	Floor Load	1.5 kN/m²	IS 875 – (PART -2) - 1987
			Staircase	3 kN/m	
	Head Room Level			9.68 kN/m	=(2.80-0.38)*0.2*20 = 9.68 kN/m

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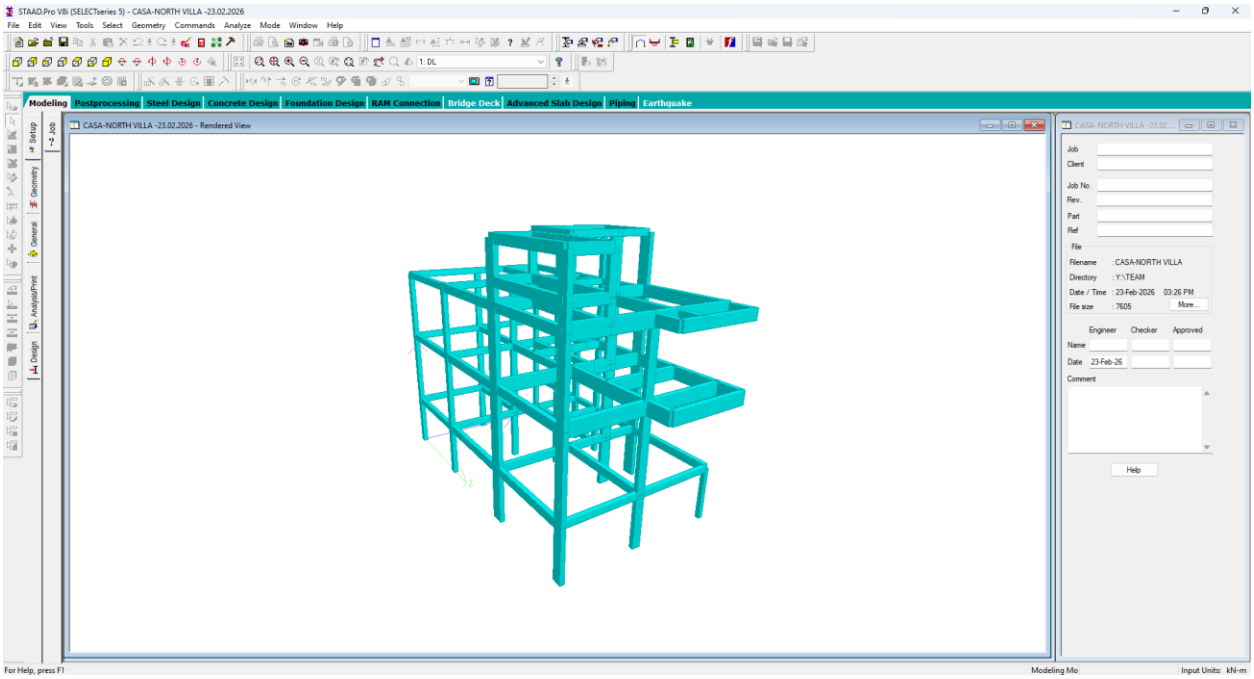
					Ht. of the wall = 2.50m Width of the wall = 0.2m Unit Weight of Brick = 20kN/m^3 Reduction Factor = Average Beam Depth is 0.38m
			Slab Load (5”)	4.625 kN/m²	Self Wt. of slab = 0.125*25 =3.125kN/m² Slab Thickness = 0.125m Floor Finish of Slab = 1.5kN/m² Self Wt. of Slab = 4.625 kN/m²
			Slab Load (6”)	5.25 kN/m²	Self Wt. of slab = 0.15*25 =3.75kN/m² Slab Thickness = 0.150m Floor Finish of Slab = 1.5kN/m² Self Wt. of Slab = 5.25 kN/m²
		Live Load	Floor Load	2 kN/m²	IS 875 – (PART -2) - 1987

5. LOAD COMBINATIONS

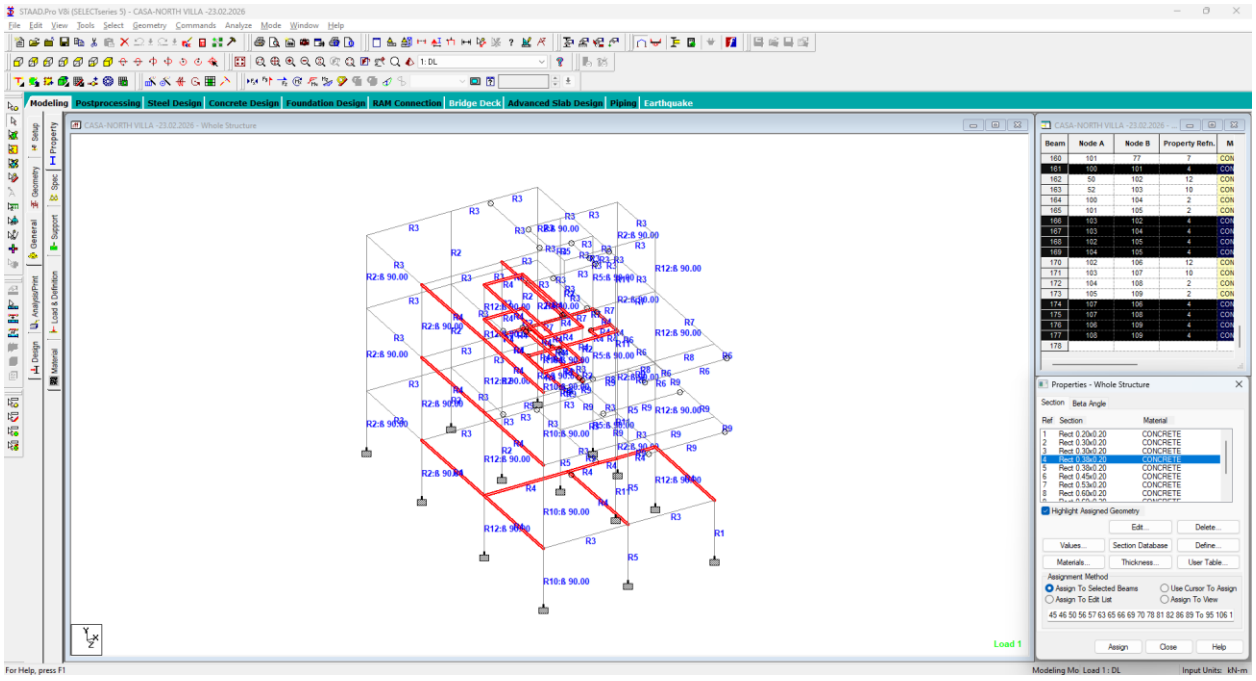
The load combinations producing the most critical conditions on the frames are taken into account. The load combinations indicated in IS 875:1987 (Part 5) are adopted for the design of the framed structure. The load combinations with appropriate load factor a given below.

- D.L + L.L
- 1.5D.L + 1.5L.L

6.STAAD IMAGES



WHOLE STRUCTURE



PROPERTIES OF THE STRUCTURE

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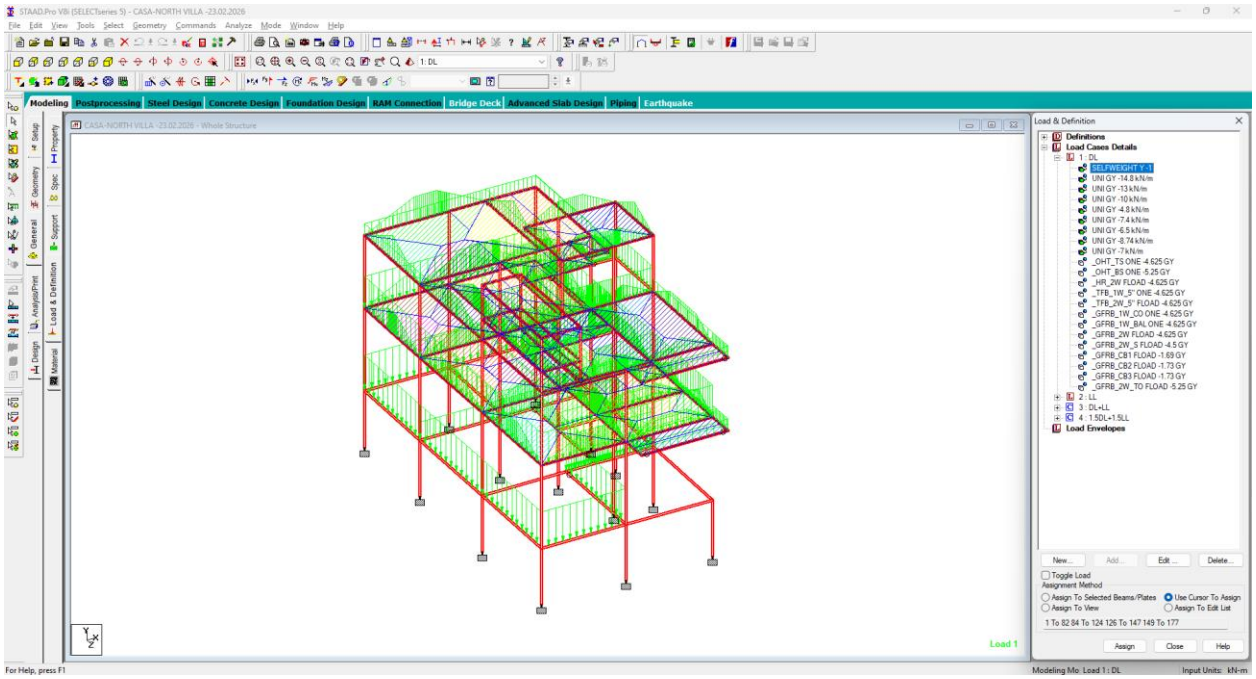
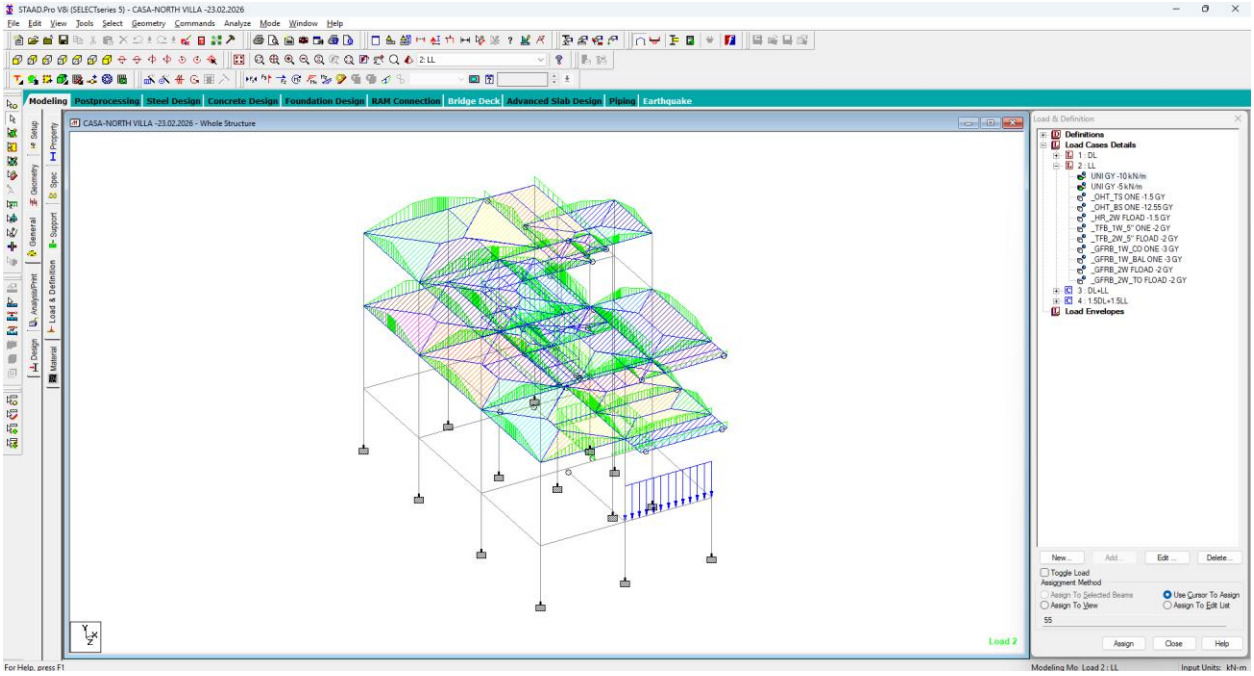


DEAD LOAD OF STRUCTURE



LIVE LOAD OF STRUCTURE

METIS STRUCTURES

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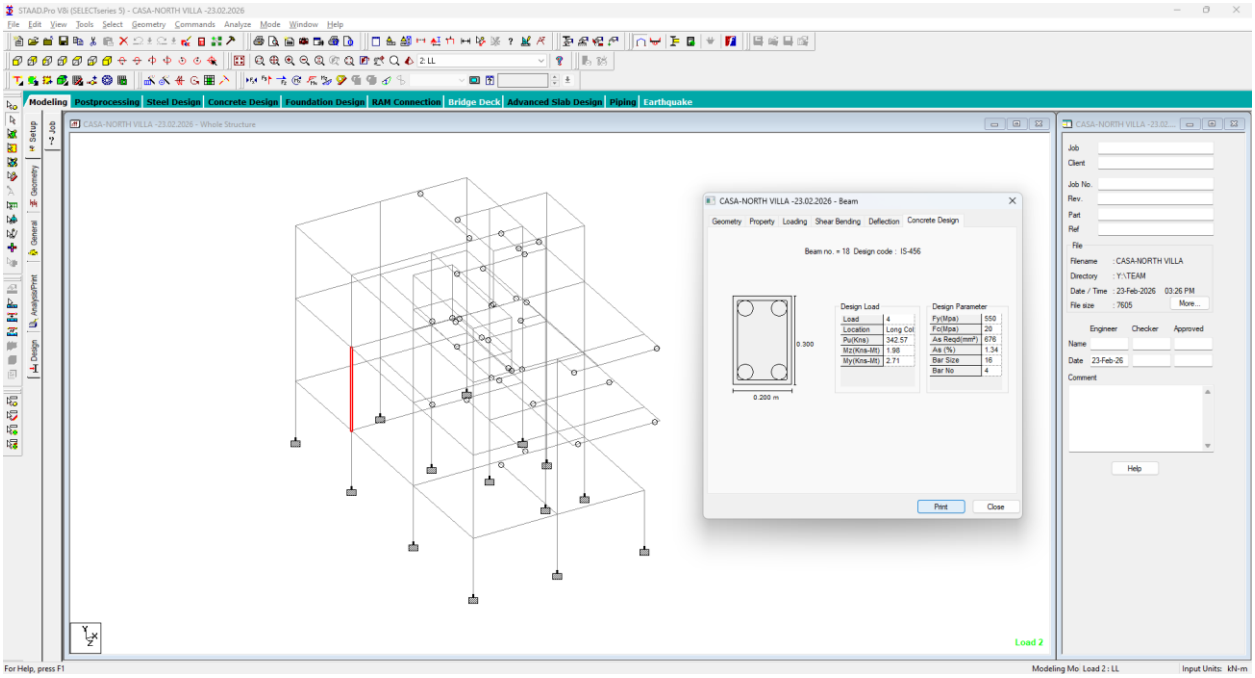
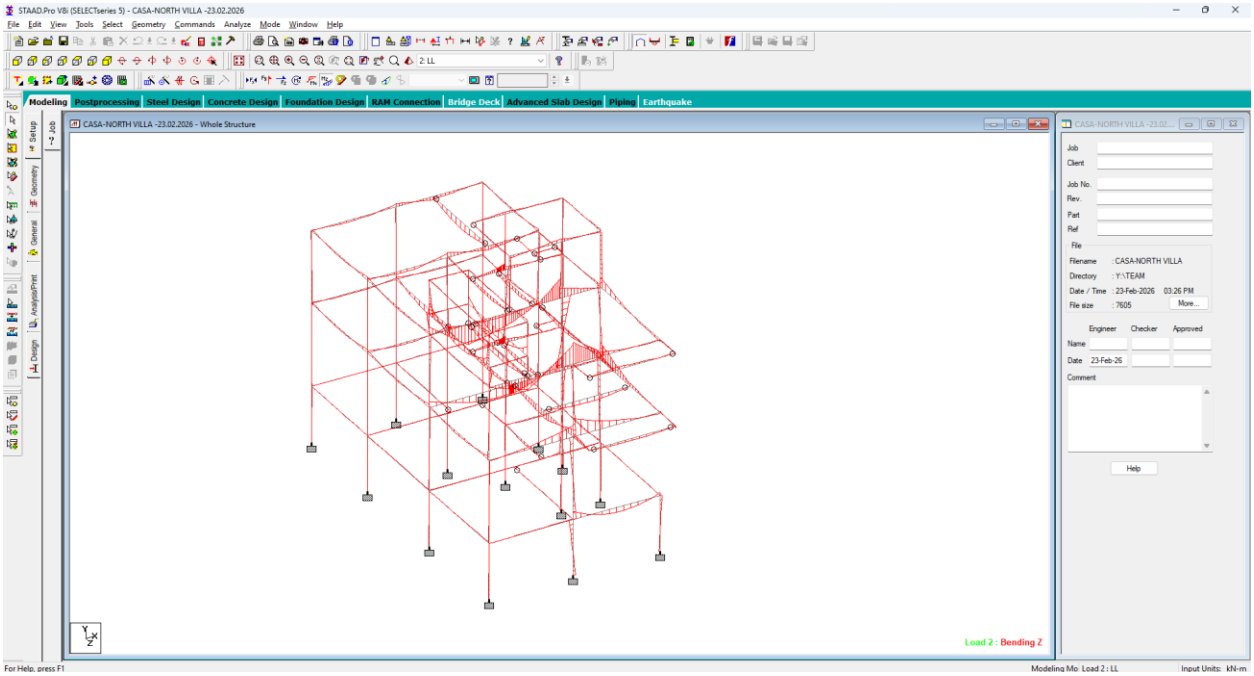
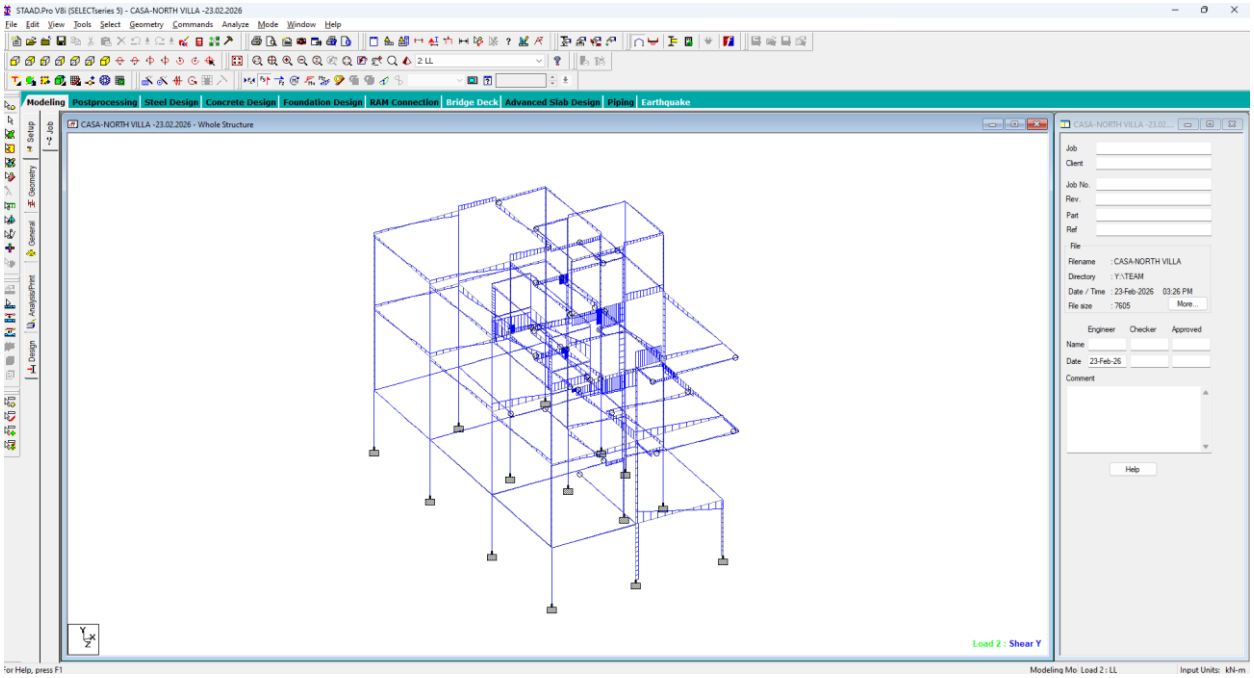


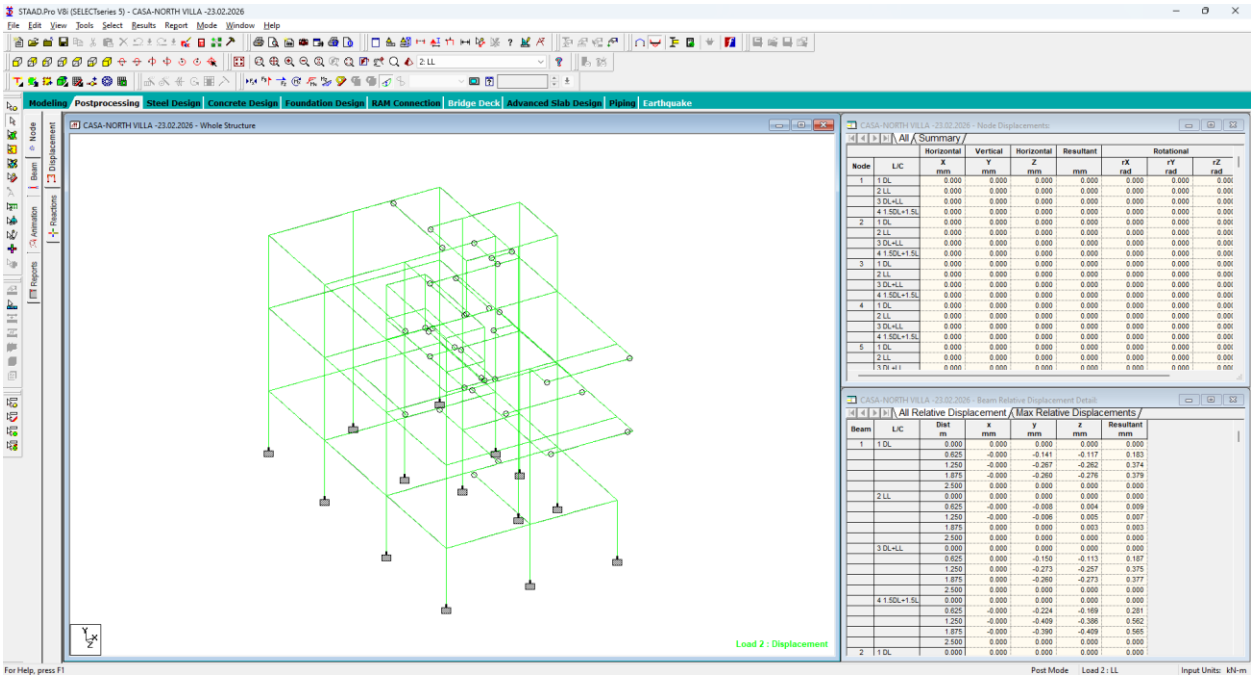
COLUMN MOMENT & AST



BENDING MOMENT OF THE STRUCTURE



SHEAR FORCE OF THE STRUCTURE



DEFLECTION OF THE STRUCTURE

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7. DESIGN OF FOOTING

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ISOLATED FOOTING DESIGN

Data

Grade of concrete	f_{ck}	=	20	N/mm^2
Grade of steel	f_y	=	550	N/mm^2
Lateral load at X-axis	Hx	=	5	kN
Lateral load at Z -axis	Hz	=	5	kN
Axial load	P	=	399	kN
Moment at column base (about X axis)	M_x	=	5	kNm
Moment at column base (about Z axis)	M_z	=	5	kNm
$M_{x1} = M_x + H_z.D$	M_{x1}	=	6.90	kNm
$M_{z1} = M_z + H_x.D$	M_{z1}	=	6.90	kNm
Net S.B.C of soil		=	340.00	kN/m^2
Gross S.B.C of soil	q_a	=	367.00	kN/m^2
Column dimension along X- axis		=	200.00	mm
Column dimension along Z- axis		=	380.00	mm
Unit weight of Soil		=	18.00	kN/m^3
Depth of footing below NGL		=	1.50	m
Volume of footing		=	0.535	m^3
Volume of filling		=	1.577	m^3
Weight of footing		=	13.376	kN
Weight of filling		=	28.385	kN
Clear cover		=	50.00	mm
Moment of resistance		=	0.130	$f_{ck}bd^2$

Area of footing

Weight of footing + backfill		=	10.47	% of P_u	
Eccentricity along Z direction	e_z	=	11.34	mm	
Eccentricity along X direction	e_x	=	11.34	mm	
Width assumed (B, dim. || X axis)		=	**1.10**	m	**3.61**
Length of the footing required (L, dim. || Z axis)		=	1.09	m	
Length of the footing provided (L, dim. || Z axis)		=	**1.28**	m	**4.20**
Area of footing required		=	1.20	m^2	
Area of footing provided		=	**1.408**	m^2	
Cantilever Projection in the shorter direction		=	0.450	m	
Cantilever Projection in the longer direction		=	0.450	m	

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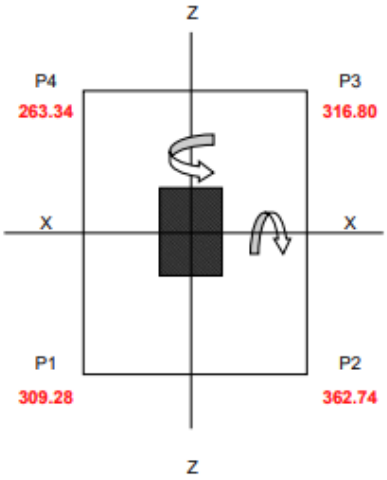
Pressure Values at all four corners



$P1 = P/A + 6*M_x/B*L^2 - 6*M_y/L*B^2$

$P2 = P/A + 6*M_x/B*L^2 + 6*M_y/L*B^2$

$P3 = P/A - 6*M_x/B*L^2 + 6*M_y/L*B^2$

$P4 = P/A - 6*M_x/B*L^2 - 6*M_y/L*B^2$

Pressure calculation about X - axis

Maximum upward intensity of Soil pressure	q_{max}	=	362.742	kN/m^2	
Minimum upward intensity of Soil pressure	q_{min}	=	263.339	kN/m^2	No tension
Length of footing in contact with soil	L	=	1.280	m	
Maximum loss of contact		=	0.0%		< 30% ok
Effective area of footing		=	1.408	m^2	> Required
Effective upward intensity of Soil pressure	q_{max}		362.74	kN/m^2	< SBC
Overturning moment (M)		=	6.90	kN.m	
Eccentricity of resultant vertical force		=	0.02	m	< L/6
Factor of Safety against overturning	F.S	=	76.654		> 1.50 Ok
Factored Maximum pressure(Pmax) for M_x	P_{max-x}	=	499.624	kN/m^2	
Factored Minimum pressure(Pmin) for M_x	P_{min-x}	=	350.518	kN/m^2	

Pressure calculation about Z - axis

Maximum upward intensity of Soil pressure	q_{max}	=	362.742	kN/m^2	
Minimum upward intensity of Soil pressure	q_{min}	=	263.339	kN/m^2	No tension
Length of footing in contact with soil	L	=	1.100	m	
Maximum loss of contact		=	0.0%		< 30% ok
Effective area of footing		=	1.408	m^2	> Required
Effective upward intensity of Soil pressure	q_{max}		362.74	kN/m^2	<SBC
Overturning moment (M)		=	6.90	kN.m	
Eccentricity of resultant vertical force		=	0.02	m	< L/6
Factor of Safety against overturning	F.S	=	10.765		> 1.50 Ok
Factored Maximum pressure(Pmax) for M_x	P_{max-x}	=	499.624	kN/m^2	
Factored Minimum pressure(Pmin) for M_x	P_{min-x}	=	350.518	kN/m^2	

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Bending moment about X - axis

Pressure Intensity at the face of the Column		=	447.204	kN/m^2
Bending moment about X-axis		=	53.70	kNm
Design Bending moment	M_{ux}	=	53.70	kNm

Bending moment about Z - axis

Pressure Intensity at the face of the Column		=	438.63	kN/m^2
Bending moment about Z-axis		=	62.11	kNm
Design Bending moment	M_{uy}	=	62.11	kNm
Effective depth required along longer span	d_{req}	=	136.92	mm
Effective depth required along shorter span	d_{req}	=	136.51	mm
Overall depth required		=	191.92	mm
Overall depth provided	D	=	380.00	mm
Overall depth at the end		=	380.00	mm
Effective depth provided along longer span		=	325.00	mm
Effective depth provided along shorter span		=	315.00	mm

Area of reinforcement

Longer span

Percentage of reinforcement required		=	0.099	%
Area of reinforcement required		=	355.02	mm^2
Mimimum area of reinforcement required		=	501.60	mm^2
Diameter of reinforcement		=	10	mm
Spacing of reinforcement required		=	172.2	mm
Spacing provided		=	150.0	mm
Area of reinforcement provided		=	576.2	mm^2
Percentage of reinforcement provided		=	0.161	%

Provide 10 mm diameter bars at 150 mm C/C spacing

Shorter span

Percentage of reinforcement required		=	0.105	%
Area of reinforcement		=	424.38	mm^2
Mimimum area of reinforcement		=	583.68	mm^2
Diameter of reinforcement		=	10	mm
Spacing of reinforcement required		=	172.2	mm
Spacing provided		=	150.0	mm
Area of reinforcement provided		=	670.5	mm^2
Percentage of reinforcement provided		=	0.166	%

Provide 10 mm diameter bars at 150 mm C/C spacing

Check for one way Shear

Longer span:

Shear force V1		=	78774.91	N
Nominal shear stress		=	0.189	N/mm^2
Permissible Shear stress for Pt		=	0.297	N/mm^2

Safe in one way Shear

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Shorter span:

Shear force V1		=	72835.40 N
Nominal shear stress		=	0.210 N/mm^2
Permissible Shear stress for Pt		=	0.301 N/mm^2

Safe in one way Shear

Check for two way Shear

Distance of section from the face of the column		=	162.50 mm
width of punching square shorter direction	b1	=	525.00 mm
Width of punching square longer direction	b2	=	705.00 mm
Effective depth of section	d1	=	325.00 mm
Shear force at the critical section	V_{u2}	=	441.17 kN
Nominal shear stress	τ_v	=	0.552 N/mm^2
Permissible Shear stress	$ks*\tau_{c2}$	=	1.118 N/mm^2

Safe in two way shear

Transfer of forces at Column base

Design Bond stress		=	1.20 N/mm^2
Required development Length		=	498.44 mm
Length available		=	385.00 mm
Minimum extension of Column bars into footing beyond bend		=	153.44 mm

Quantity report

Volume of footing		=	0.5350 m^3
Total approximate steel quantity		=	13.017 Kg

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8. DESIGN OF BEAMS

DETAILS OF BEAM SECTION:

Grade of Concrete	f_{ck}	20.00
Grade of Steel (Main bar)	f_y	550.00
Grade of Steel (Stirrups)	f_{ys}	550.00
Young's modulus of steel	E_s	200000.00
Modulus of elasticity of concrete	E_c	22360.68
Modulus of rupture of concrete	f_{cr}	3.13
Shrinkage strain of concrete	ϵ_{cs}	0.0003
Creep coefficient (After 28 days)	θ	1.60
Clear Cover	d_c	25.00
End Panel Cover	d_{ce}	25.00

SYMBOLS USED:

M_u = Moment from Analysis M_e = Equivalent moment at column face = M_u -(V_u*B_c/ Nominal Shear Stress ($S_{v\,i}$) = V_u/bd

Where B_c-Column dimension Percentage of Steel (P_t=A_{st}x100/bd)

Depth of Balanced N.A - $X_{u\,max}$ = 0.0035/(0.0055+fy/1.15*E_s)d S_c - Design Shear Stress ,$S_{v\,Max}$ - Maximum Shear Stress (Page:73, IS 456:2000)

Moment of Resistance - M_{ur} = 0.36 f_{ck} b $X_{u\,max}$(d-0.42X_{umax}) Shear Resistance of Beam Section (V_{cs}) = S_c.b.d/1000

For Singly Reinforced Beams (M_{ur} > M_u) Spacing of Stirrups (S_v) = 0.87.f_{ys}.d.A_{sv}/(V_u-V_c)1000 & Max Spacing(S_{Max}) = 0.75d

Area of Tension Steel (A_{st}) = 0.5 f_{ck}/f_y(1-SQRT(1-4.6.M_u.10^6/f_{ck}.b.d^2)).b.d

Minimum Steel Required $A_{st\,min}$=0.85/f_y *bd

Beam No / Moment Location		MAIN REINFORCEMENT																		SHEAR REINFORCEMENT				
		Max.BM (M_u)		Max. SF (V_u)	Beam Size/Span		Bottom Reinforcement							Top Reinforcement										
		Bottom	Top		b	D	Thro# (Ist Layer)		Thro# (IInd Layer)		Curtail (Ist Layer)		Total Layer	Thro# (Ist Layer)		Thro# (IIIrd Layer)		Curtail (Ist Layer)		Total Layer	Dia of bar	S_r	S_{Max}	S_p	
		kNm	kNm	kN	mm	mm	No	Dia	No	Dia	No	Dia		No	Dia	No	Dia	No	Dia		mm	mm	mm^2	mm^2	
GFRB1	S		23	52	200	300	2	12					1	2	12					1	8	462.3	201.8	200	27	1
	M	25			200	300	2	12					1	2	12					1	8			200	7	1
	S		48	65	200	300	2	12					1	2	12			2	16	1	8	431.2	200.3	200	175	0.36
GFRB2	S		50	70	200	300	2	12					1	2	12			2	16	1	8	369.2	200.3	175	157	0.36
	M	30			200	300	2	12			2	12	1	2	12					1	8			175	182	0.5
	S		31	60	200	300	2	12					1	2	12			2	12	1	8	453.1	201.8	175	171	0.5
GFRB3	S		21	46	200	300	2	12					1	2	12					1	8	588.4	201.8	175	46	1
	M	25			200	300	2	12					1	2	12					1	8			175	7	1
	S		49	63	200	300	2	12					1	2	12			2	16	1	8	462.2	200.3	175	166	0.36
GFRB4	S		68	135	200	380	2	12					1	2	12			2	16	1	8	178.9	260.3	200	129	0.36
	M	45			200	380	2	12			2	12	1	2	12					1	8			200	146	0.5
	S		33	63	200	380	2	12					1	2	12			2	12	1	8	645.0	261.8	200	236	0.5
GFRB5	S		5	50	200	380	2	12					1	2	12					1	8	762.3	261.8	175	196	1
	M	47			200	380	2	12			2	12	1	2	12					1	8			175	130	0.5
	S		25	48	200	380	2	12					1	2	12					1	8	838.5	261.8	175	66	1

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9. CONCLUSION

1. All the Columns are designed using Staad pro and manually checked using Excel sheets.

2. The design of Foundation, Beams were done using Excel sheets where the Moments & Shear forces values are taken from Staad pro.