CE 332 - Course Project

Structural Design Report

Title of the project (give a suitable title)

Group (number ?)

Prepared by:

Name of the members with roll numbers

Course instructor

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Indian Institute of Technology, Bombay

Spring 2020

Contents

Abstract

Write an abstract for the project in 350 to 500 words.

It shall include the project description/scope, assumptions, approach, methodology, software used etc. It shall also highlight the challenges faced and how were they addressed, unique feature of the project etc.

Chapter 1

Problem Statement

Describe the problem statement in detail. Give general arrangement of the structure with proper and consistent dimensioning.

Attach representative drawings/images that give an overall idea of the structure.

The description shall be clear and concise.

Provide additional information/assumption(s) (example, soil bearing capacity etc.), wherever necessary.

Note: The problem statement in brief will be uploaded on moodle.

Chapter 2

Design Preamble

The design preamble shall include (at-least) the following sections

2.1 General information

- Assumptions and approximations
- Loads being considered
- Methodology
- List of references to various IS/design codes, manuals, books etc. in a tabular format (refer Figure 2.1)

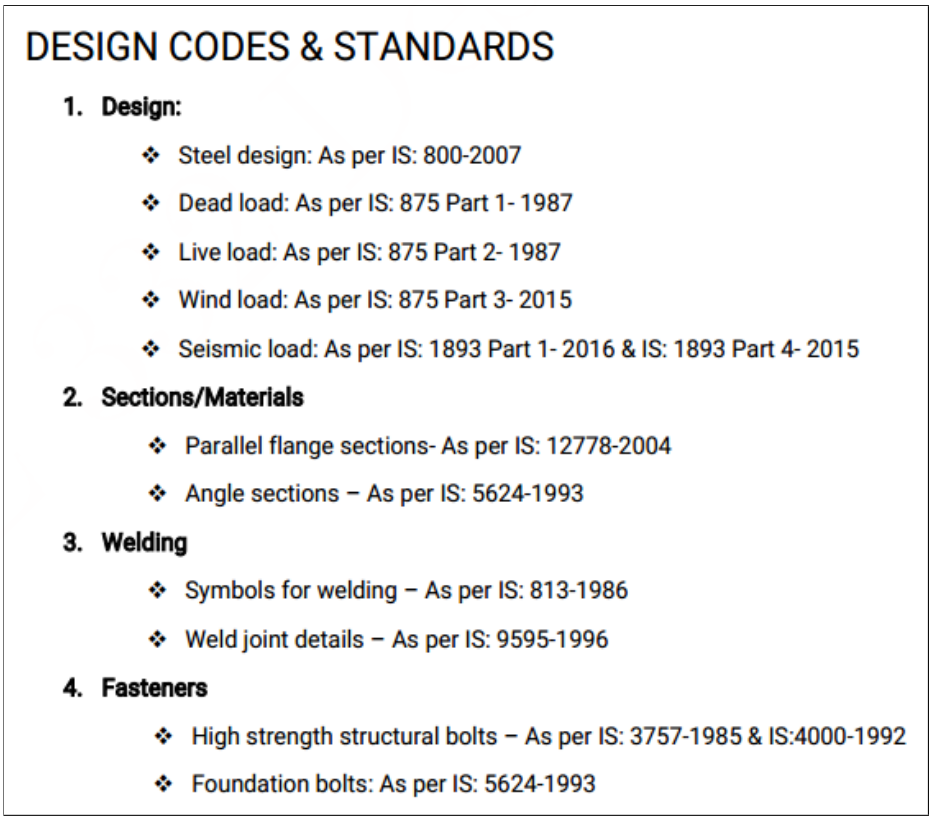


Figure 2.1: list of references

2.2 Structural Steel

Give a list/table mentioning the type of structural steel sections used (example. ISMB, ISHB, Parallel Flange Sections, Channels, Angles etc.).

List out use of built-up sections (if any).

Mention the Grade of steel used.

Note: Use of only Indian steel sections is allowed. The data of new/upcoming parallel flange sections will be uploaded on moodle.

Steel sections:

For Columns:	1. ISWPB 300 × 300 (H) @ 237.92 kg/m 2. ISWPB 280 (B) @ 103.13 kg/m 3. ISWPB 240 × 240 (B) @ 83.2 kg/m
For Beams	1. ISNPB 250 × 150 (M) @ 39.78 kg/m 2. ISNPB 240 × 120 (H) @ 34.32 kg/m 3. ISNPB 200 × 150 @ 30.46 kg/m 4. ISNPB 180 × 90 (H) @ 21.27 kg/m

Figure 2.2: details of steel sections

2.3 Bolts and Nuts

Give a list/table mentioning all the type and diameter of bolts used in the project.

Mention the Grade and Property Class of the bolts used.

In case of high-strength (HSFG) bolts used describe the surface preparation required.

Add representative images (if any)

2.4 Welding and Consumables

Mention the type(s) of weld used. Give details of the various consumables etc.

Recommend good welding procedures to be adopted for shop/field fabrication.

Add representative images (if any)

2.5 Other Materials

Any other materials/consumables used in the project apart from that mentioned in Sections 3.1, 3.2 and 3.3 shall be mentioned here in detail and with representative images (if any). (Example. roof covering, wall panels, tension rods/cables etc. refer Figure 2.3)

MATERIAL FOR CONSTRUCTION

Main frame members like columns, beams, bracing systems, and baseplates(hinged)	High tensile steel (E350BR) structural sections and plates
Wall cladding, Parapet	Brick masonry
Floor (1mm profile sheet as integral part of RC slab – load to be considered acc.)	RC slab

Figure 2.3: material description

Chapter 3

Loads and Forces

3.1 Gravity Loads

3.1.1 Dead Load

Give a detailed calculation of the various **Dead Loads** acting on the structure. Incorporate appropriate factors and load combination(s) (if any).

Note: refer Figure 3.1 for a sample calculation

1. Dead Load

It is the Load due to the self weight of the structural elements (steel framework, flooring, brick masonry, cladding etc). It also includes the load due to the architectural elements like floor finish. The RC Slab floor load, wall loads are distributed on the beams, which further transfer the vertical load to the columns and through columns the load is transferred to the foundation.

Floor Load:

The floor load taken by beams is calculated by distributing by load in trapezoidal form. Dead Load due to floor:

RC slab= 0.125m* 25kN/m^2 = 3.125 kn/m^2
25mm thick mortar = 0.025m* 24kN/m^2 = 0.6 kn/m^2
6mm thick tile = 0.006m* 20kN/m^2 = 0.12 kn/m^2

Total = 3.845 => 3.85 kn/m^2

Dead Load due to slab = (Contributing Area × 3.85)

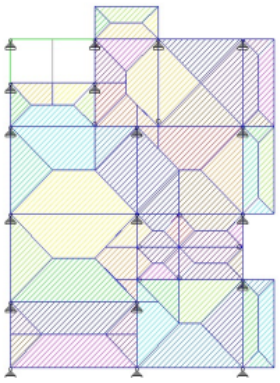


Figure 3.1: sample dead load calculation

3.1.2 Live Load

Give a detailed calculation of the **Live Load** acting on the structure, in the form of table. Incorporate appropriate factors and load combination(s) (if any).

3.2 Wind/Lateral Load

Give a detailed calculation of the **Wind/Lateral Load** acting on the structure, in the form of table. Incorporate appropriate factors and load combination(s) (if any).

3.3 Load Combination

Mention the appropriate load combinations adopted in the design, in the form of table.

Chapter 4

Analysis and Design

4.1 Analysis

Describe the method of structural analysis adopted. Highlight the assumptions, forms of construction assumed etc.

Mention the name of the software used (if any).

4.2 Design

Highlight the philosophy adopted for design. Comment on how the serviceability aspect(s) have been taken care of in the project wherever required.

Chapter 5

Modelling

5.1 Software Model: Details

Give a detailed description on the analytical/software model. It shall include the following points:

- boundary conditions assumed
- type of connections assumed

5.2 Software Model: Images

Give the representative images (2D and 3D) of the structure obtained from the software. Refer Figure 5.1 and Figure 5.2 as sample

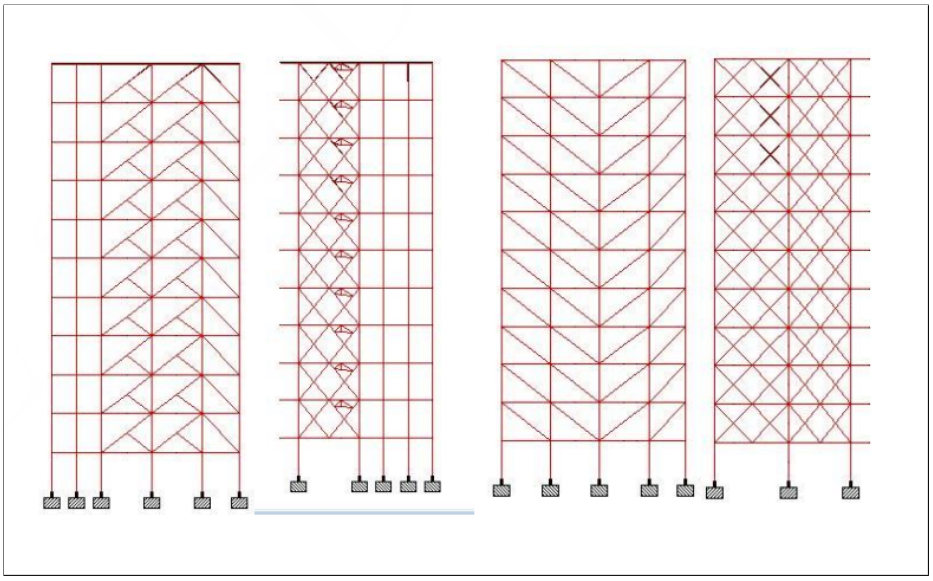


Figure 5.1: line model of a structure

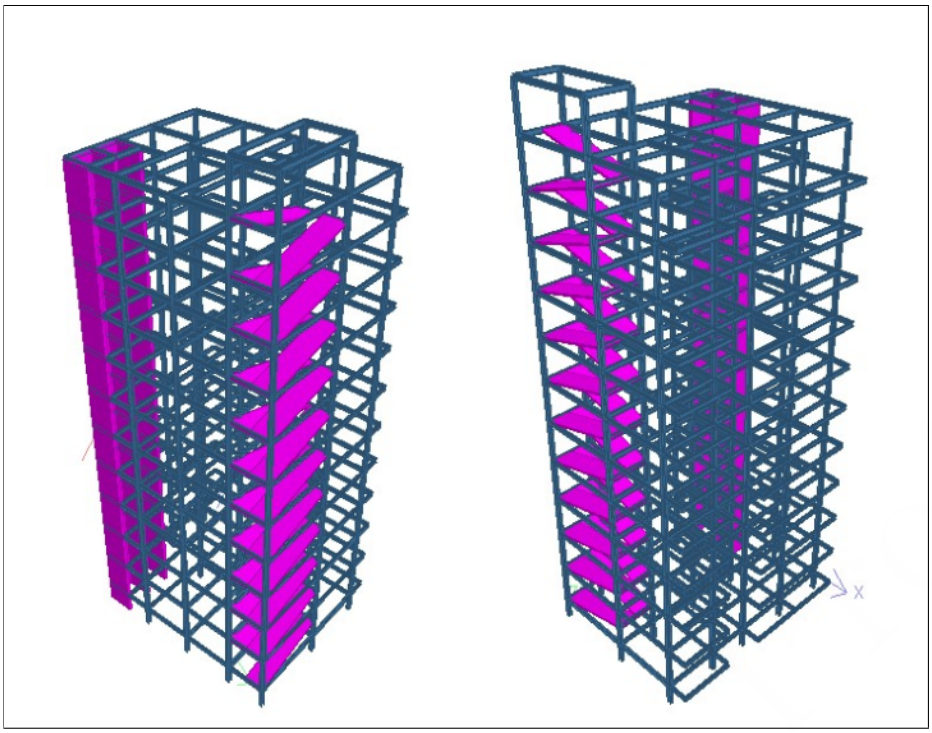


Figure 5.2: 3D rendered view of a model

Chapter 6

Structural Design

Give a detailed description of the structural design inputs, outputs/results obtained from the software. Give one detailed calculation of the each structural component.

Give details (design checks, utility ratio, serviceability checks etc.) of the following member types as per your project requirement:

- Beams
- Columns
- Purlin
- Base plate
- Truss members
- etc.

Reference images given below:

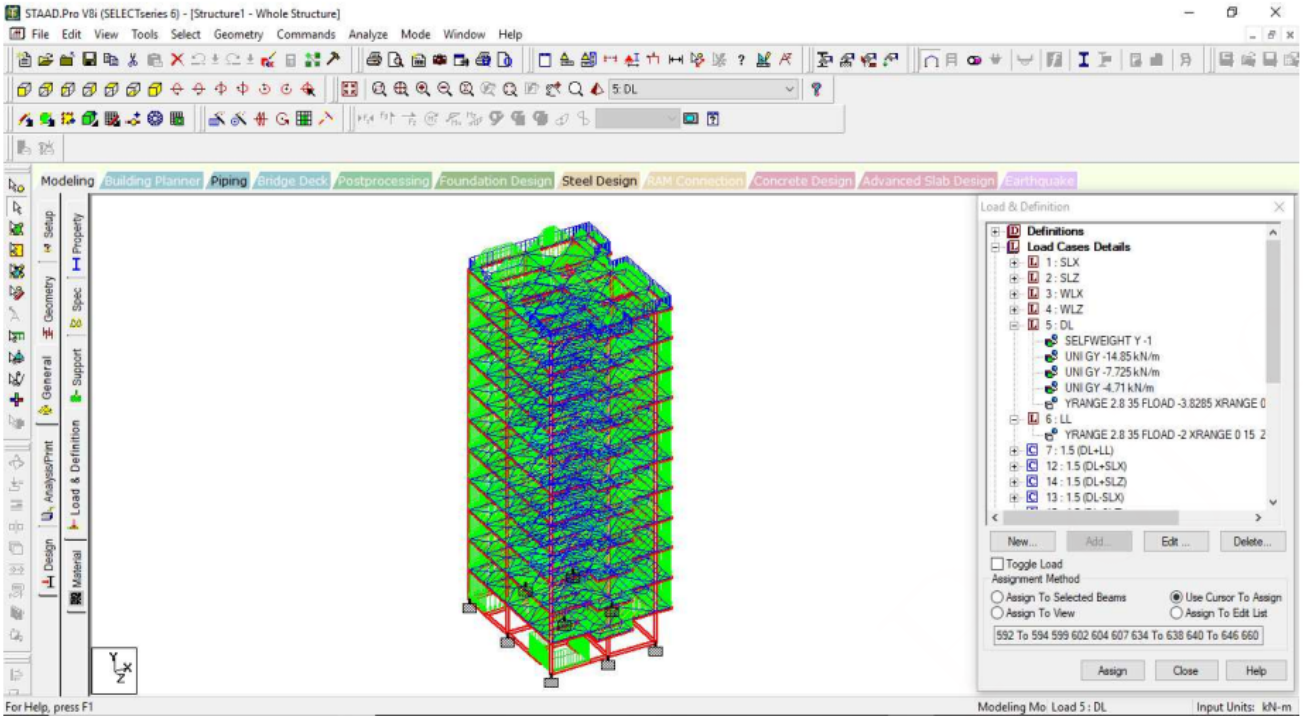


Figure 6.1: model with different load types

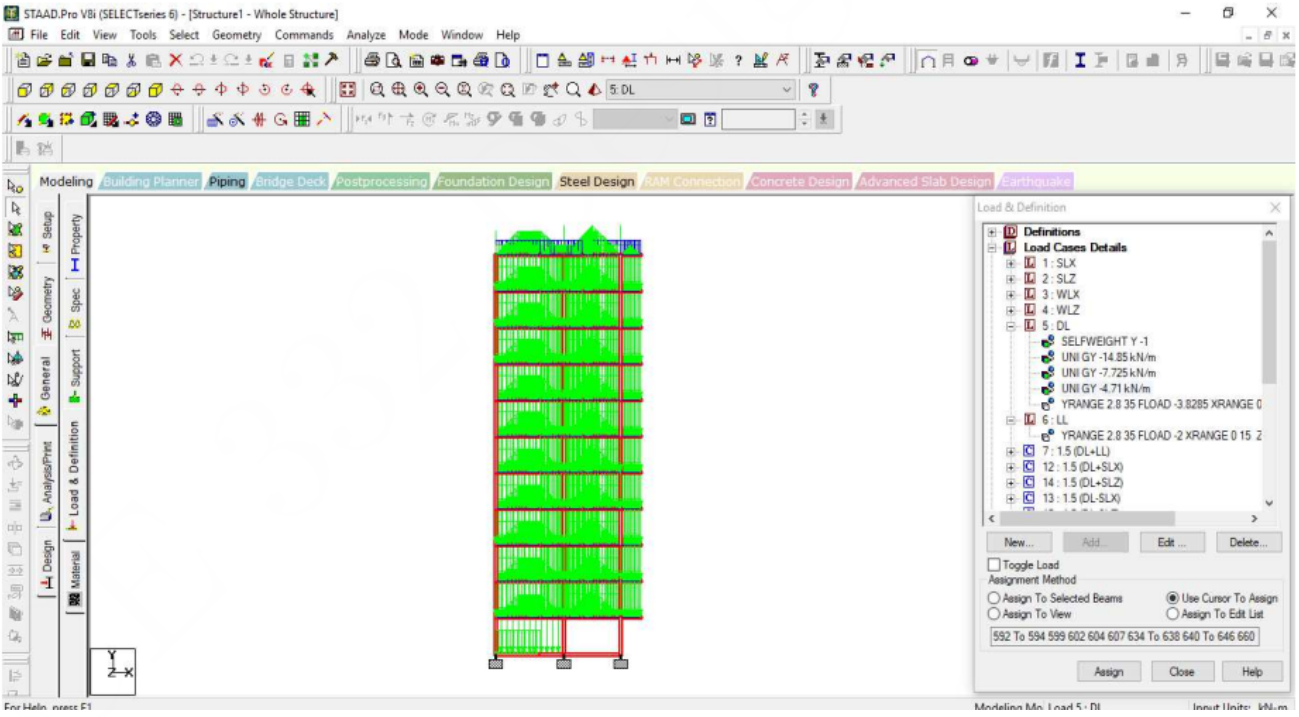


Figure 6.2: model with floor loads

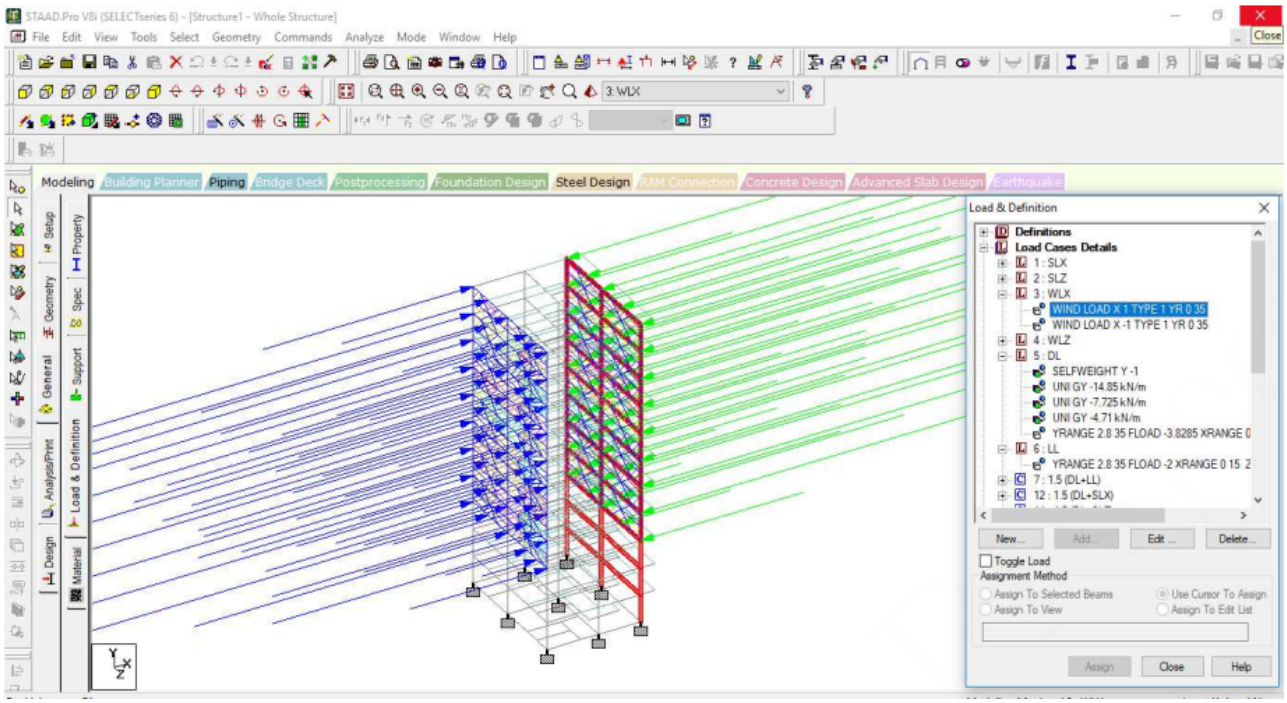


Figure 6.3: model with wind load

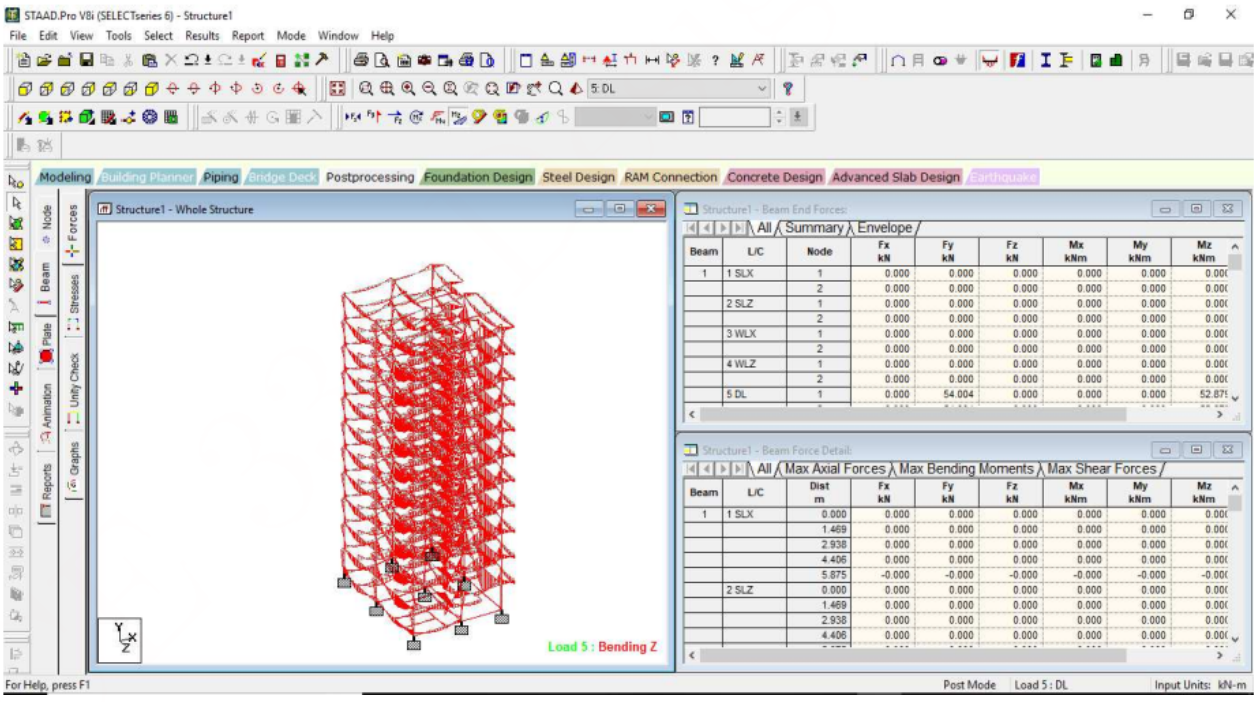


Figure 6.4: model with load combinations

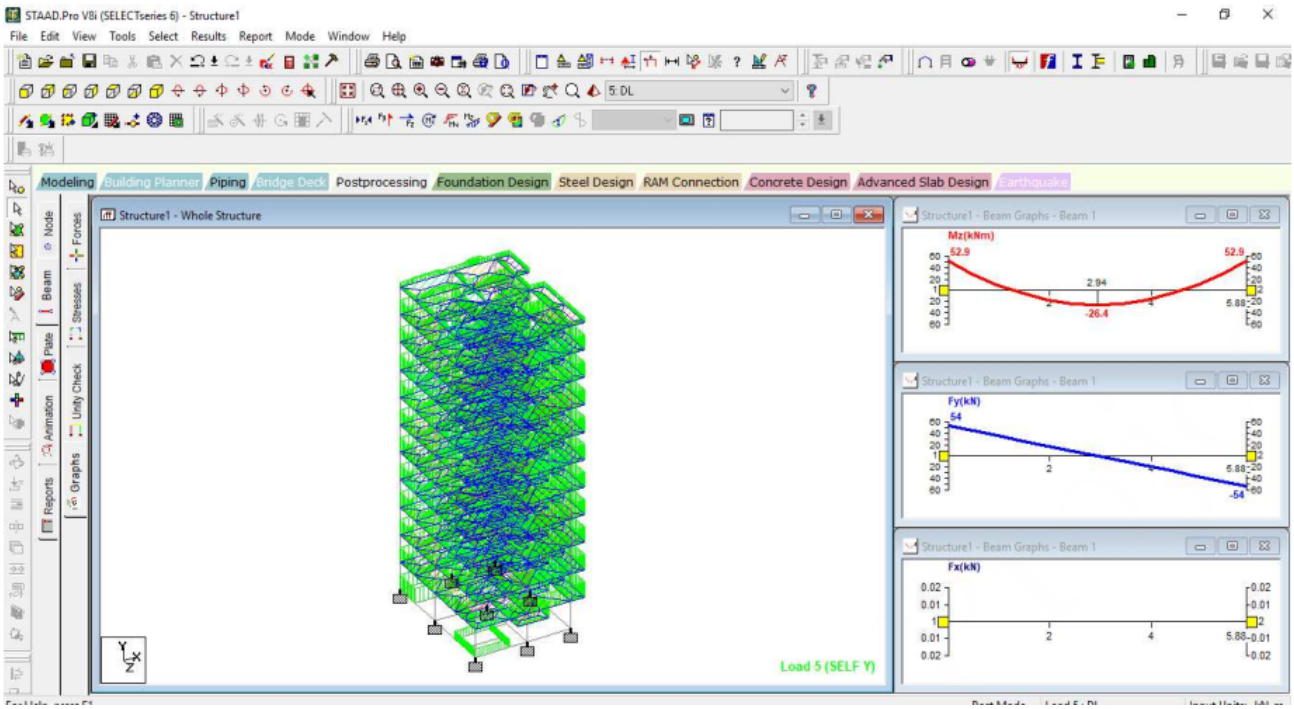


Figure 6.5: shear force and bending moment

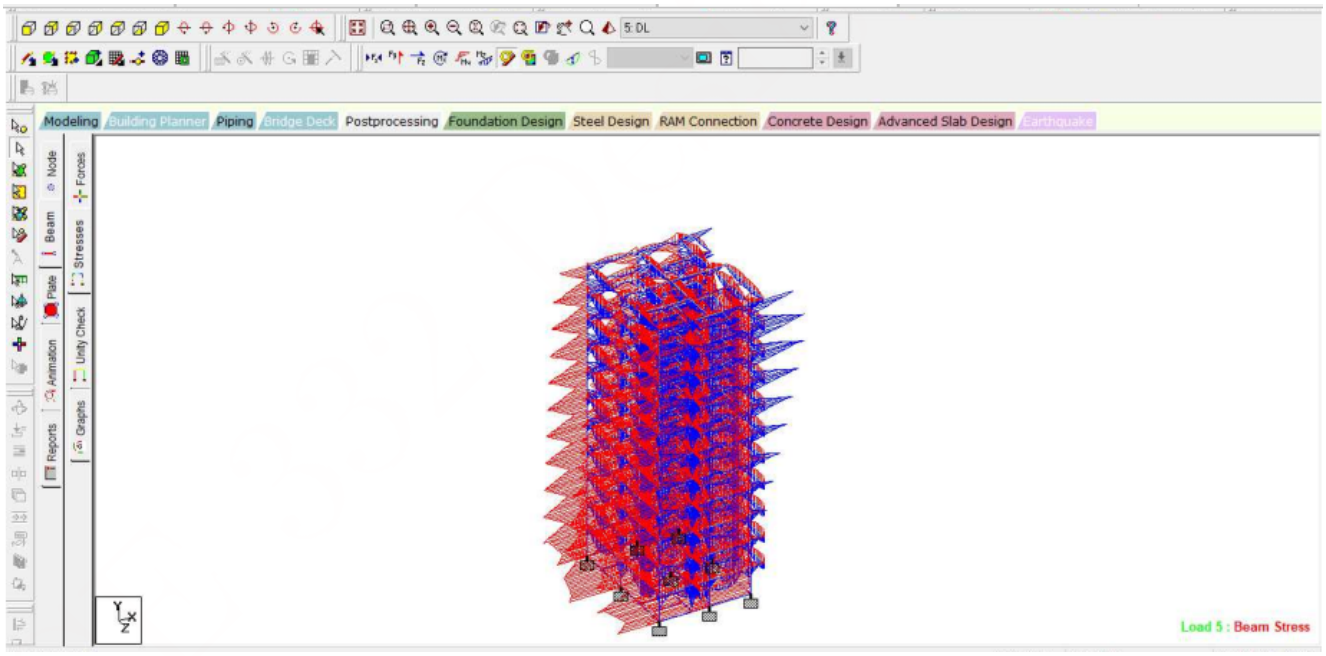


Figure 6.6: shear force and bending moment

BEAM DESIGN

INPUT		
Grade of steel	Fe500	
Yield Stress (f_y)	500	MPa
F.O.S. For yielding (γ_{m0})	1.1	
Shear Force , V	93.79	kN
Bending Moment	184.39	kN-m
Length of the beam	5.875	m
Unit weight (w)	76.3	kN/m
TRIAL SECTION	NPB 500x200 (M-90.69)	
Weight per metre, w	906.9	N/m
Sectional Area, A	11553	mm^2
Depth of section,h	500	mm
Width of Flange, bf	200	mm
Thickness of Flange, tf	16	mm
Thickness of Web, tw	10.2	mm
Moment of Inertia @ zz, I_{zz}	4.82E+08	mm^4
Moment of Inertia @ yy, I_{yy}	21416800	mm^4
Radii of Gyration @ zz, r_{zz}	204.3	mm
Radii of Gyration @ yy, r_{yy}	43.1	mm
Root, r_1	21	mm
h_1	424.1	mm
Plastic Section Moduli @ zz, Zp_{zz}	2194270	mm^3
Plastic Section Moduli @ yy, Zp_{yy}	335900	mm^3
Elastic Section modulus(Z_e)	2359800	mm^3
Plastic Section Modulus Z_p - $M\gamma_{m0}/f_y$	405658	mm^3
Depth of web d_w	426	mm
stiff bearing length, b1	75	mm
E	200000	Mpa

OUTPUT				
Section classification & adequacy of section				
ε		0.70711		
b/t_f		6.25	PLASTIC SECTION	
d/t_w		41.7647		
Self Weight of the Section		1.36035	kN-m	
Maximum bending moment		190.259	kN-m	
Plastic Section Modulus required		418570	mm^3	SAFE
Design shear strength of the section				
Design shear strength,V_d		1338.4	kN	SAFE
$0.6V_d$		803.042	kN	
Check for design capacity of the section				
d/t_w		41.7647	SAFE	
β_b		1		
$M_d=\beta_b Zpfy/\gamma m0$		997.395	kN-m	SAFE
Check for deflection				
Actual deflection	δ=(5WL4)/384EI	12.2781	mm	
Allowable maximum deflection	δ_{max}=L/300	19.5833	mm	SAFE
Check for web buckling at support				
I_{eff}		6632.55	mm^4	
f_{cd}		143.746	N/mm^2	
A_b		3315	mm^2	SAFE
Buckling resistance		476.519	kN	
Check for web bearing				
n_2 [2.5*(Root radius + flange thickness)]		85.5	mm	SAFE
F_w		744.136	kN	

Figure 6.7: beam design

BEAM - COLUMN

Length (L)	10	fixed				
Effective length	6.5	m		KLx	46.509	
Factored axial load (N)	8238.1	kN		Kly	81.011	
f_y	500	Mpa		buckling class		a
E	200000	Mpa		alphaz	0.21	
γ_{m0}	1.1			buckling class		b
Moment	Mz	My		alpha y	0.34	
Top	168	87				
Bottom	135	85				
Section	WPB 300x300			No. of section		2
d	340	mm		hf	324	mm
B_f	12	mm				
T_f	16	mm				
T_w	9.5	mm				
A_g	30309	mm2				
I_{zz}	1.18E+09	mm4				
I_{yy}	3.9E+08	mm4				
Z_{pz}	6964821	mm3				
Z_{py}	32520304	mm3				
r_z	139.7586	mm				
r_y	80.2356	mm				
M_{dy}	14781.96	kNm				
M_{dz}	3165.828	kNm				
N_d	27553.64	kN				
n	0.3					
α_1	1.5					
α_2	2					
α_{LT}	0.21					
M_{ndy}	14527.71					
M_{ndz}	2459.848		$M_{ndz} = 1.11M_{dz}(1-n)$		M_{ndz}	2460
Section strength check	0.005128					
	0.358952	SAFE				

OVERALL MEMBER STRENGTH					
$\lambda = \sqrt{\frac{f_y\left(KL/r\right)^2}{\pi^2 E}}$	λ_z	0.74			
	λ_y	1.29			
$\phi = 0.5[1 + \alpha(\lambda - 0.2) + \lambda^2]$	ϕ_z	0.8494			
	ϕ_y	1.54795			
$\chi = \frac{1}{[\phi + (\phi^2 - \lambda^2)^{0.5}]}$	χ_z	0.78964638			
	χ_y	0.41605148			
$f_{cd} = \chi f_y / \gamma_{m0}$	f_{cdy}	189.114307			
	f_{cdz}	358.930175			
$P_d = f_{cd} A_g$	P_{dy}	11463.7311	kN		
	P_{dz}	21757.6293	kN		
$M_d = \beta_b Z_p f_{bd}$	M_{dy}	14781.9564			
$M_{cr} = \frac{\pi^2 E I_y h_f}{2L_{LT}^2}\left[1 + \frac{1}{20}\left(\frac{L_{LT}/r_y}{h_f/t_f}\right)^2\right]^{0.5}$	M_{cr}	3962938638	N-mm	3E+09	1.3417248
$\lambda_{lt} = \sqrt{\beta_b Z_p f_y / M_{cr}}$	λ_{lt}	0.93741374	1.026885299		
$\emptyset_{lt} = 0.5[1 + \alpha_{LT}(\lambda_{LT} - 0.2) + \lambda_{LT}^2]$	$\emptyset_{lt}$	1.0168007			
$\chi_{LT} = 1/[\emptyset_{LT} + (\emptyset_{LT}^2 - \lambda_{LT}^2)^{0.5}]$	χ_{LT}	0.70887911		C_{my}	0.9214286
				C_{mz}	0.9908046
$f_{bdz} = \chi_{LT} f_y / \gamma_{m0}$	f_{bdz}	322.217776	kN-m	C_{mLT}	0.9214286
$M_{dz} = \beta_b Z_{pz} f_{bdz}$	M_{dz}	2244.18919			
$K_y = 1 + \frac{(\lambda_z - 0.2)P}{P_{dy}} \le 1 + 0.8P/P_{dy}$	K_y	1.57489834	$n_y = P/P_{dy}$	n_y	0.7186229
$K_z = 1 + \frac{(\lambda_z - 0.2)P}{P_{dz}} \le 1 + 0.8P/P_{dz}$	K_z	1.20446042	$n_z = P/P_{dz}$	n_z	0.3786304
$K_{LT} = 1 - \frac{0.1\lambda_{LT} n_y}{(C_{mLT} - 0.25)}$ $\ge 1 - \frac{0.1 n_y}{(C_{mLT} - 0.25)}$	K_{LT}	0.89966959			
$\frac{P}{P_{dy}} + K_y \frac{C_{my} M_y}{M_{dy}} + K_{LT} \frac{M_z}{M_{dz}} \le 1.0$	0.794513	SAFE			
$\frac{P}{P_{dz}} + 0.6K_y \frac{C_{my} M_y}{M_{dy}} + K_{LT} \frac{C_{mz} M_z}{M_{dz}} \le 1.0$	0.473092				

Figure 6.8: beam-column design

GUSSET BASE PLATE

INPUT		
Grade of Steel	Fe500	
Grade of Concrete	M25	
f_u	540	MPa
f_y	410	MPa
fck	25	MPa
Moment	165	kNm
Axial load	8238.1	kN
Section	WPB 300x300	
h	340	mm
b_f	310	mm
No.of section	2	
Max height of gusset outstand	1000	mm
Min height of gusset outstand	600	mm
$L_{provided}$	1500	mm
$B_{provided}$	1500	mm
Weld thickness	5	mm

OUTPUT			
SIZE OF THE BASE PLATE			
e	20.029	mm	
$L_{required}$	120.17	mm	
$B_{required}$	977	mm	
Plate of size	1500	1500	
Area (A)	2E+06	mm^2	
Modulus Z	6E+08	mm^3	
p_{max}	3.9547	N/mm^2	
p_{min}	3.368	N/mm^2	
Checked Against Local Buckling			
Ɛ	0.7809		
D/t	21.25		
84Ɛ	65.593		
Gusset outstand	580	mm	Ok
13.6*Ɛ*t	169.92	mm	
Max gusset outstand	750	mm	SEMI COMPACT
h_{avg}	750	mm	
Base pressure at X-X	2.4256	N/mm2	
V	1387.7	kN	OK
0.6*Vn	1549.4	kN	
Vn= Vp	2582.3	kN	
M_x	434.59	kNm	OK
Mg	993.94	kNm	
SIZE OF BASE PLATE	1500	1500	SATISFIED
GUSSET PLATE TO COLUMN WELD			
Load per weld	4779.1		
Length of weld	2324	mm	
Load per mm	2.0564	kN/mm	
Load on one weld for gusset plate and base	1.9774	kN/mm	
THICKNESS OF THE BASE PLATE			
M_B	178556	N-mm	
M_C	363193	N-mm	
t	11.633	mm	

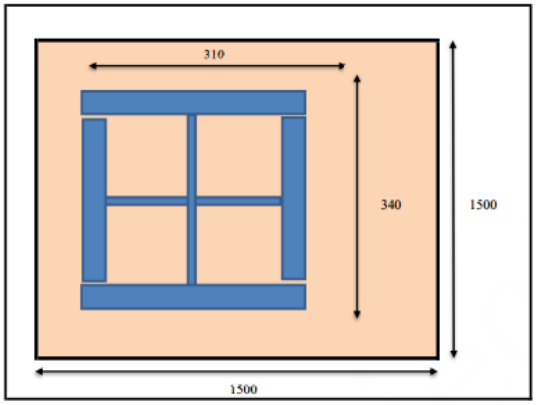


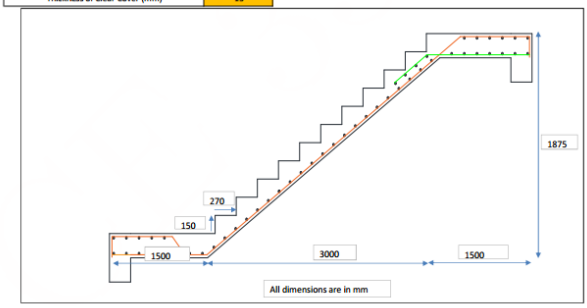
Figure 6.9: base plate design

STAIR CASE DESIGN (Dog Legged)

INPUT	
Height of one floor (mm)	3750
Height of one Riser (mm)	150
Size of one Tread (mm)	270
Width of the Stair (mm)	1600
Bearing of the flight (mm)	150
Assume the value between 40-50 to calculate the waist slab thickness	47
Ceiling Finish (mm)	12.5
Top Finish (mm)	12.5
Live Load (N/mm²)	3000
Grade of Steel (fy)	250
Grade of Concrete (fck)	M 20
Diameter of Main reinfocements (mm)	12
Diameter of Distribution reinfocements (mm)	8
Thickness of Clear Cover (mm)	15

RESULT		
Provide Main reinf.	12 mm bars @	90 mm c/c
Provide Dist. Reinf.	8 mm bars @	150 mm c/c
Overall Depth of waist SLAB		220 mm
With Clear Cover		15 mm
No. of **Risers** required (in each flight)		12
No. of **Treads** required (in each flight)		11

CHECKS	
Check for Moment	
Effective depth Required (mm)	127.391543
Overall depth required (mm)	148.391543
Overall depth	SAFE



CALCULATION	
Height of each flight (mm)	1875
No. of Risers required (in each flight)	12
Actual height of each Riser (mm)	156.25
No. of Treads required (in each flight)	11
Length of one flight (mm)	2970
Effective Horizontal Span (meter)	4.645
Thickness of waist slab (mm)	220
Dead Load of waist Slab (N/mm²)	5500
Load of Ceiling Finish (N/mm²)	300
Total Load ON PLAN due to waist slab and ceiling finish (N/mm²)	6701.191531
Dead Load of Steps (N/mm²)	1953.125
Load due to finishing (N/mm²)	300
TOTAL LOAD (N/mm²)	11954.31653
Ultimate Moment per metre width of stairs (N.m)	48361.24356

Calculation for Spacing	
Provided Overall Depth (mm)	220
Provided effective Depth (mm)	199
Value of $\frac{Mu}{bd^2}$	1.221212686
Pt required for Main Reinf.	0.607959712
Ast req. for main reinforcement (mm²)	1209.839826
Area of one MAIN bar (mm²)	113.0973355
Spacing of Main reinf. Bars (mm)	93.48124692
Pt required for Dist. Reinf.	0.15
Ast req. for dist. reinforcement (mm²)	330
Area of one DISTRIBUTION bar (mm²)	50.26548246
Spacing of Main reinf. Bars (mm)	152.3196438

Fy	X_u max/d	Ultimate Moment	Depth required (mm)	Pt for dist. Steel
250	0.53	2980 X d²	127.391543	0.15%
415	0.48	2760 X d²	132.3714082	0.12%
500	0.46	2680 X d²	134.3325729	0.12%

Figure 6.10: staircase design

Chapter 7

Connection Design

7.1 Connection Type

Recommend the type of connection(s) to be used for the erection purpose (example. beam-column shear connection using fin plate, fixed base plate with gussets and anchor bolts etc)

Give a representative image of each connection type

7.2 Connection Design and Detailing

Give details of the connection design and detailing with sample calculations. Give one sample calculation for each type of connection adopted.

7.3 Fabrication Drawings

Give fabrication drawing for each type of connection adopted. Reference images attached below:

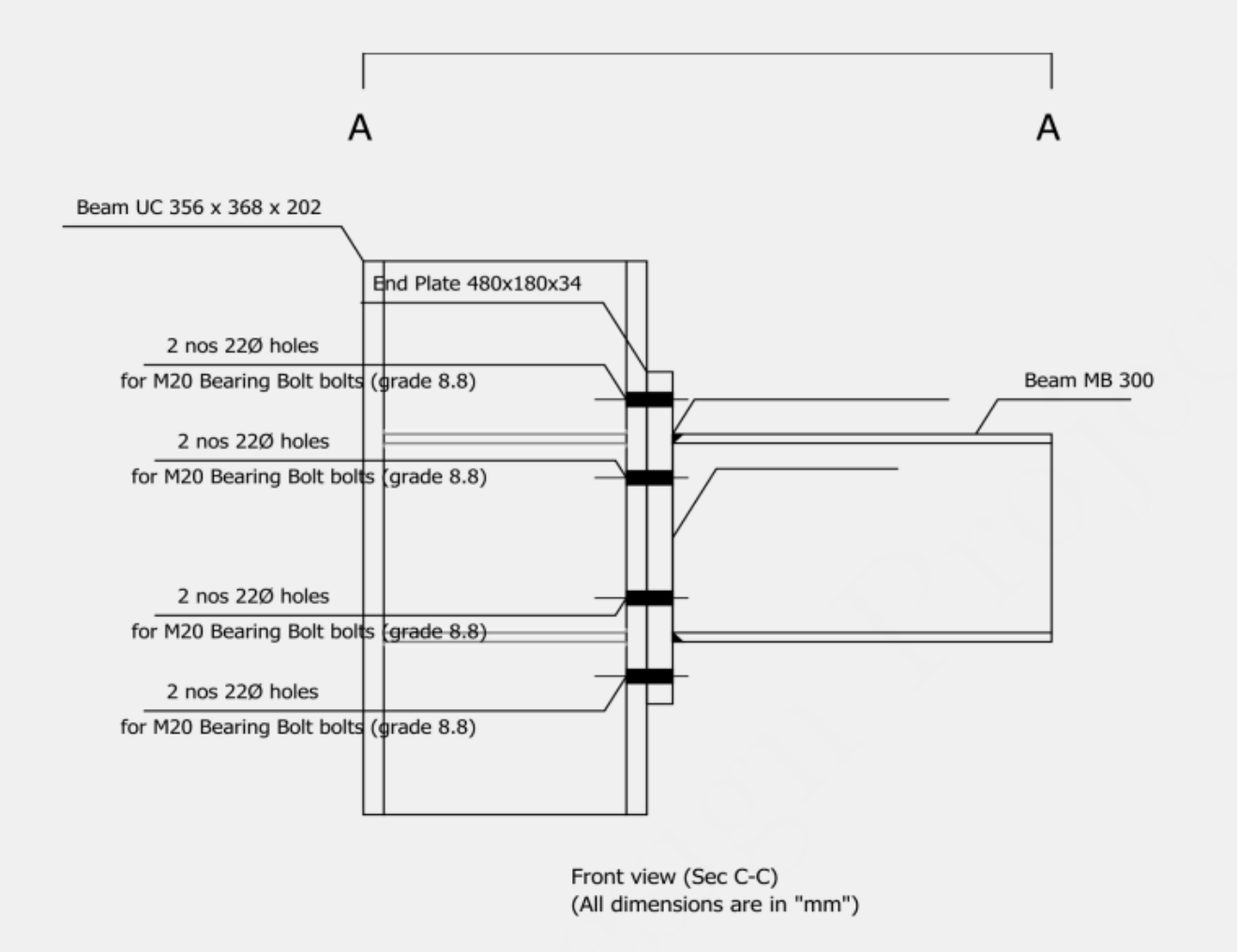


Figure 7.1: beam to column connection: 2D drawing

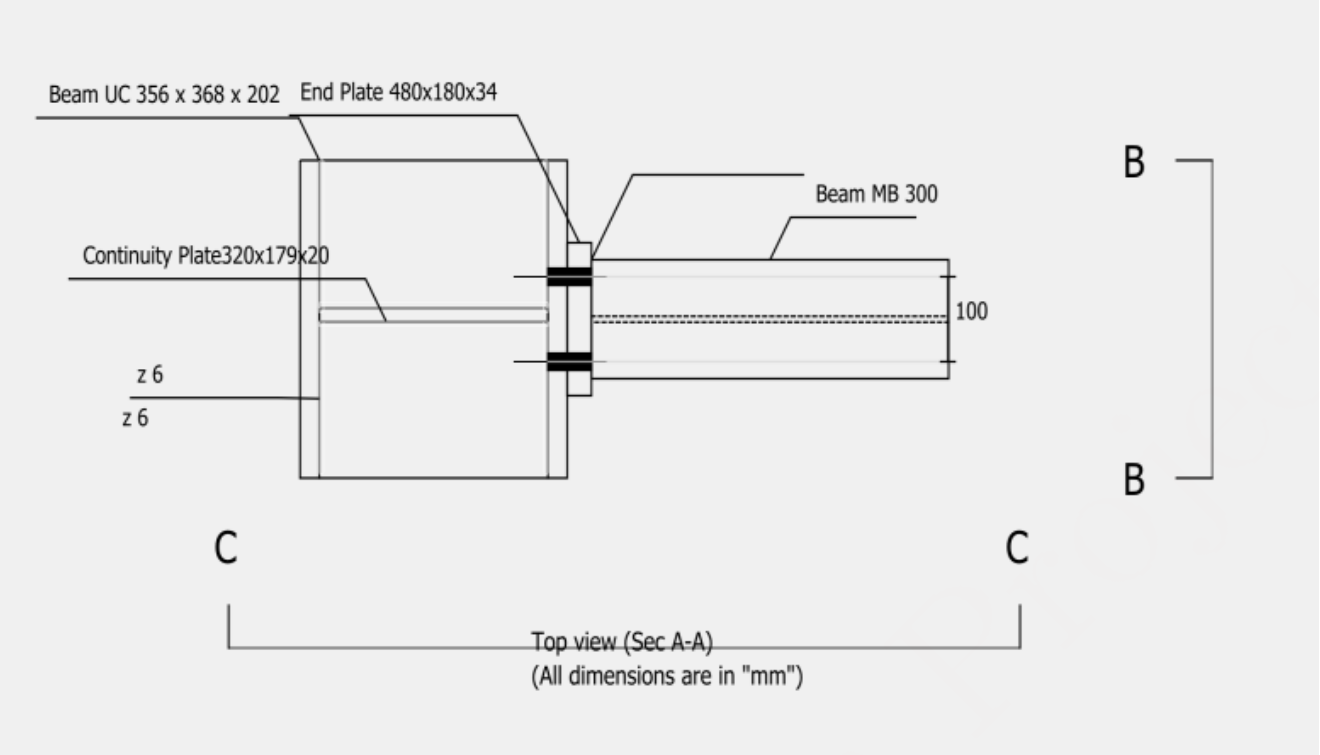


Figure 7.2: beam to column connection: 2D drawing

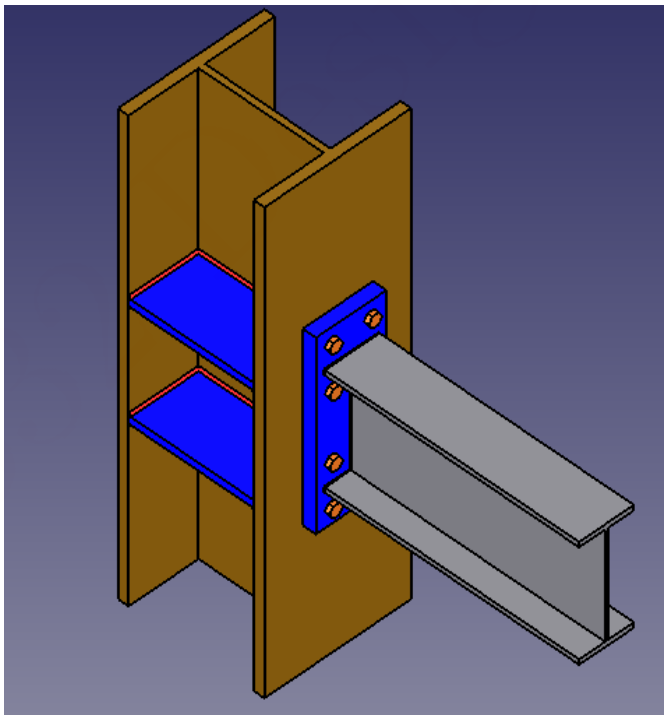


Figure 7.3: beam to column connection: 3D model

Chapter 8

Bill of Quantities

Give details of bill of quantities for each of the structural components in the form of table.

COLUMN						
Member No.	Member Length (m)	Section Provided	Member Weight (Kg/m)	Member Weight (Kg)	No. of similar member	Total Weight (Kg)
C1	33	2 WPB 300 x 300	237.92	7851.36	1	7851.36
C2	33	2 WPB 300 x 300	237.92	7851.36	1	7851.36
C3	33	2 WPB 300 x 300	237.92	7851.36	1	7851.36
C4	33	2 WPB 300 x 300	237.92	7851.36	1	7851.36
C5	33	2 WPB 300 x 300	237.92	7851.36	1	7851.36
C6	33	2 WPB 300 x 300	237.92	7851.36	1	7851.36
C7	33	2 WPB 300 x 300	237.92	7851.36	1	7851.36
C8	33	2 WPB 300 x 300	237.92	7851.36	1	7851.36
C9	33	2 WPB 300 x 300	237.92	7851.36	1	7851.36
					Total	**70662.2**

Figure 8.1: sample BOQ

Appendix A

Structural Drawings

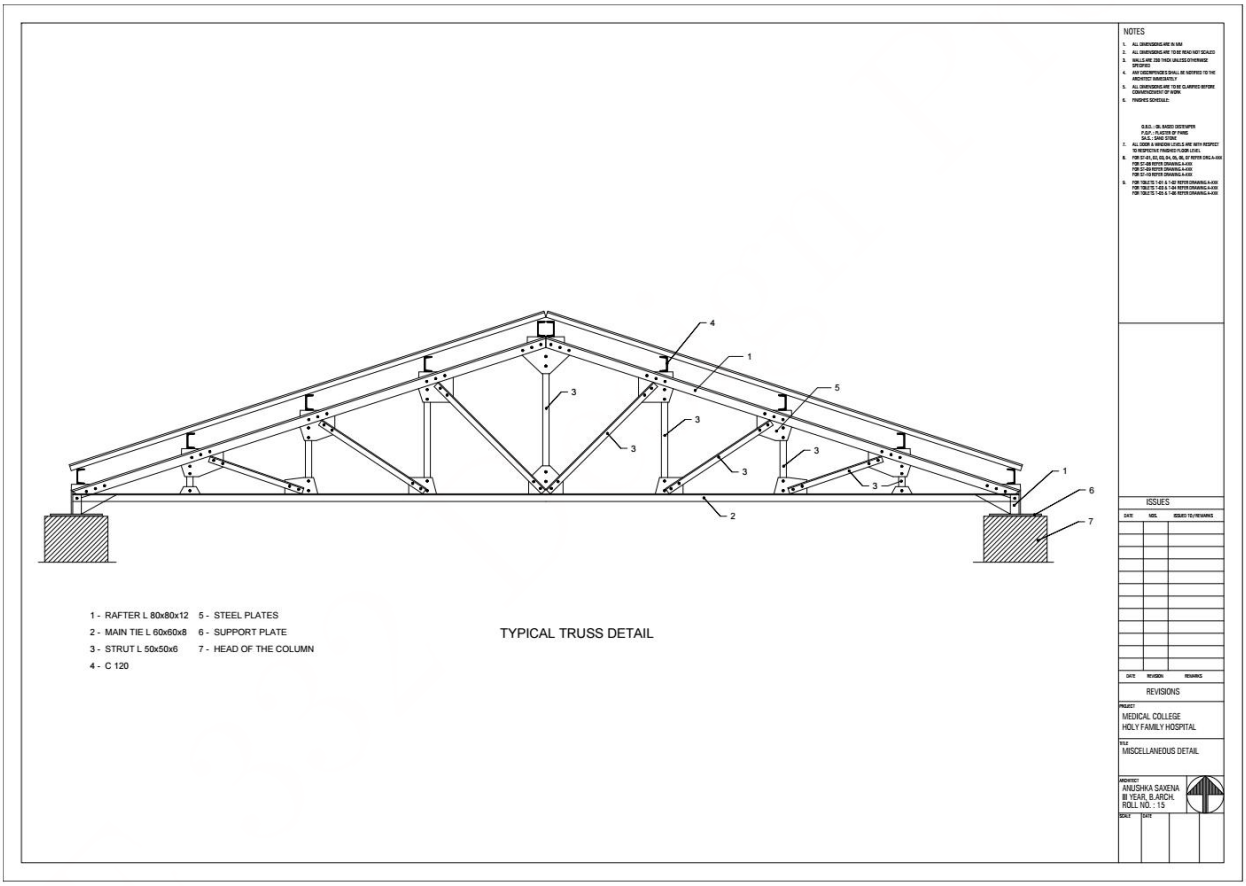


Figure A.1: sample structural design drawing

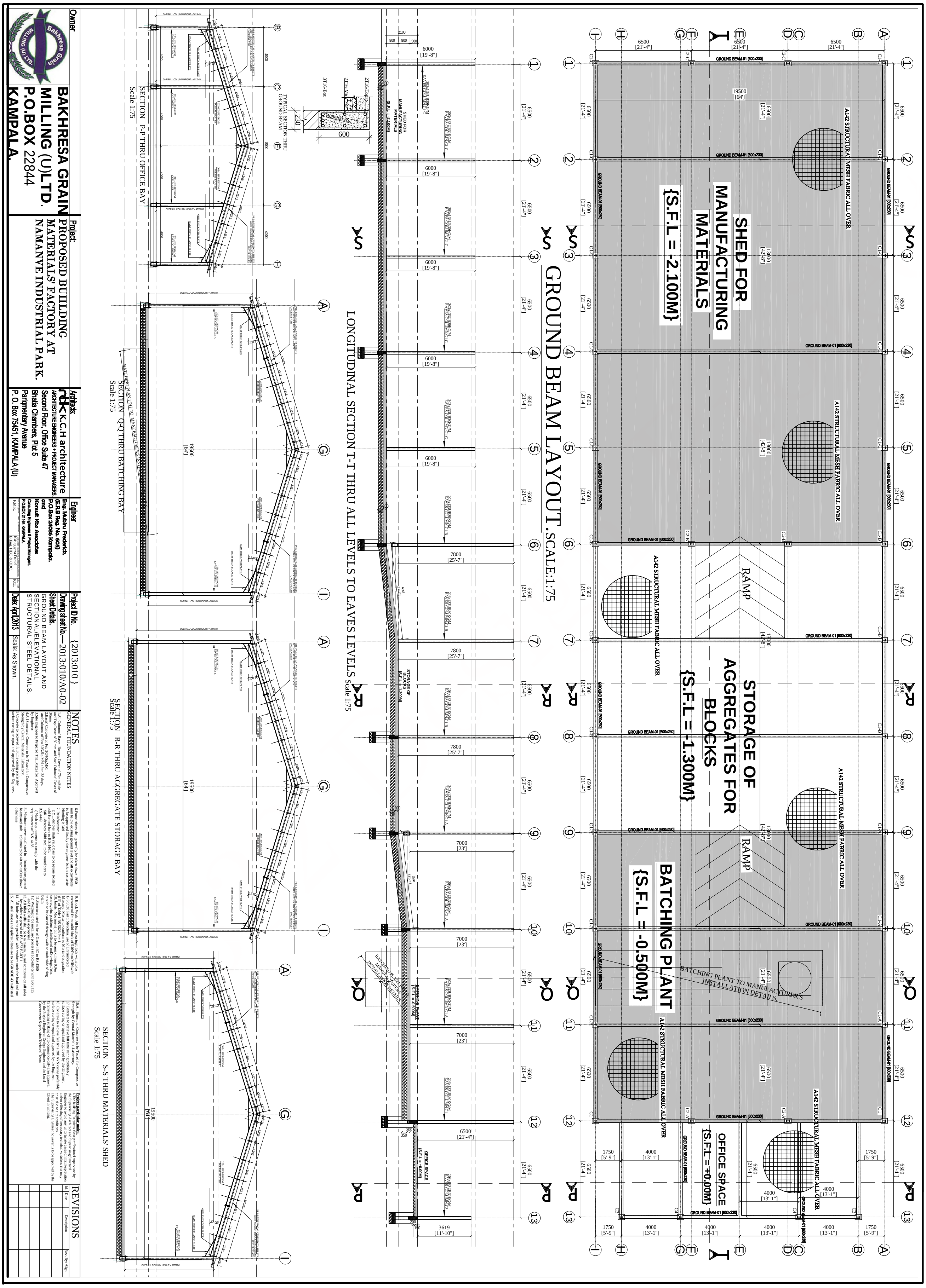


Figure A.2: sample structural design drawing

Appendix B

Connection Drawings

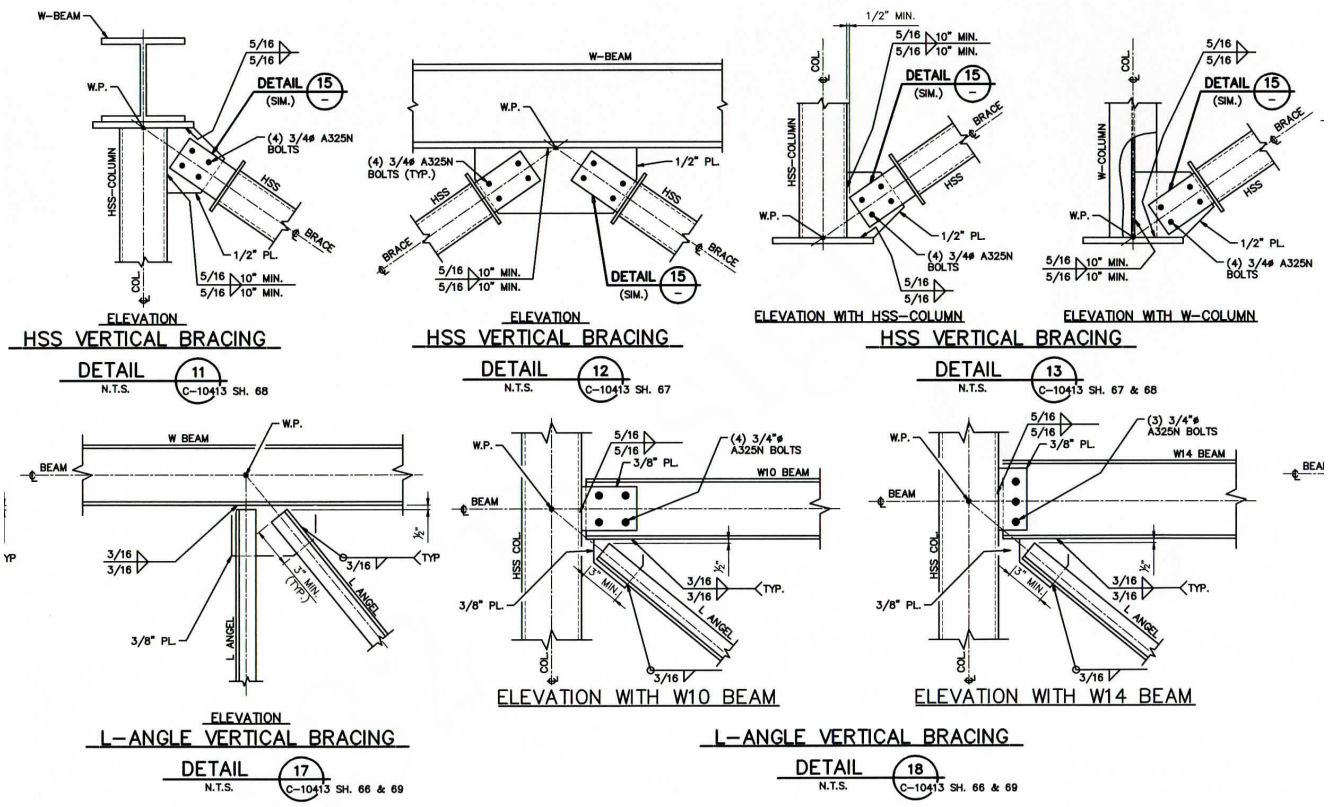


Figure B.1: sample connection design and detailing drawing