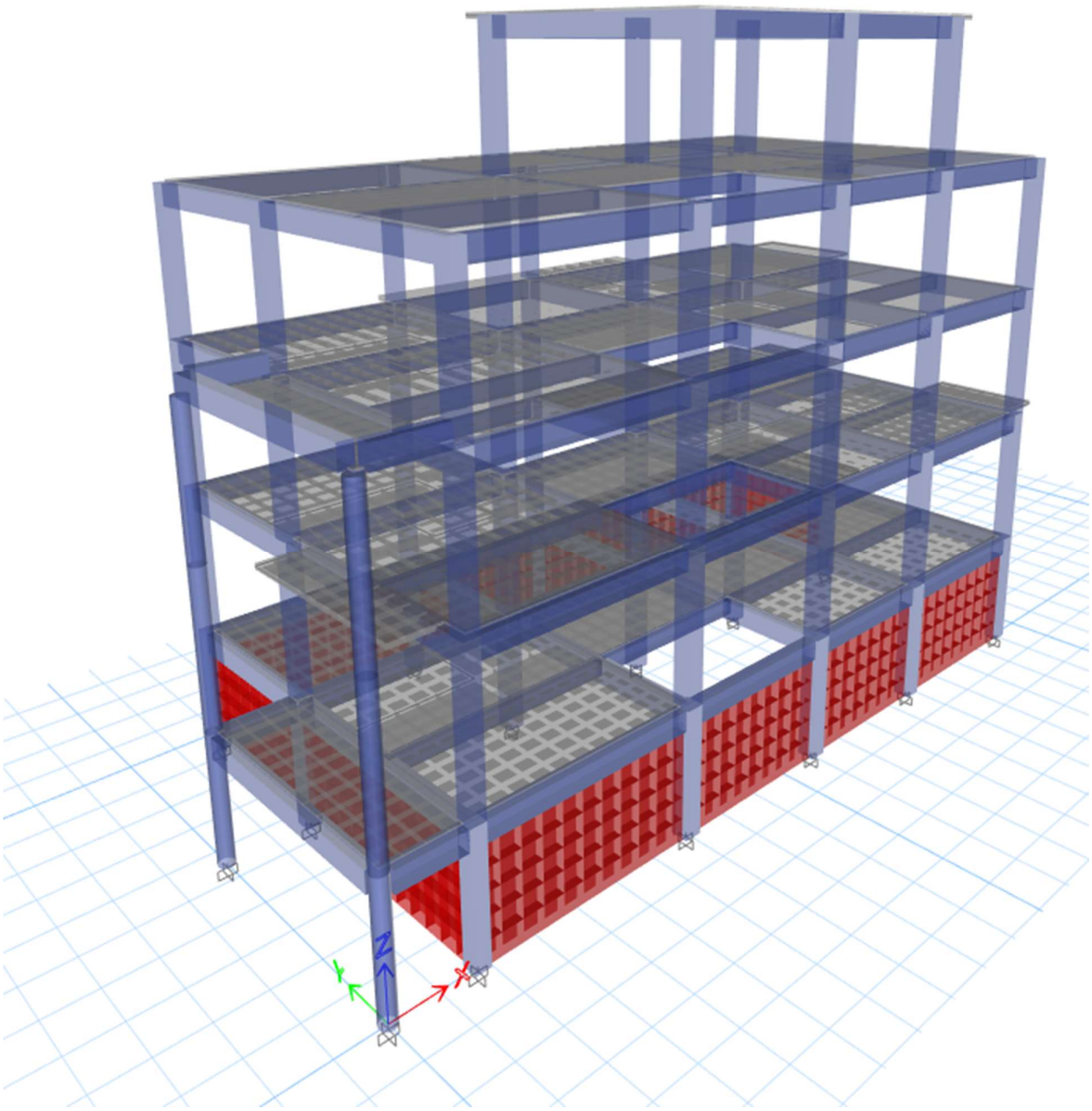
STRUCTURE ANALYSIS REPORT
Residential Building



Date: June, 2021

Contents

1 INTRODUCTION

1.1 General

The proposed Residential building is located at ********** owned by Mr. **********. The plinth area of purposed building is 2005.11 sq.ft. This report is intended to elaborate the structural analysis and ductile design of the purposed building as per the IS456-2000 and NBC105-2020.

1.2 Salient Features

Project Information:

Owner :**********

Building Type : Residential Building

Location : ******

Land Area : 11784.62 sq.ft.

Plinth Area : 2005.11 sq.ft

Building Features:

Type of Structure:	RCC Framed Structure
Storey:	Basement+ 3.5 Storey
Storey Height:	3.175 m
Total Height:	15.748 m

Site Condition:

Soil Type:	D
Seismic Zone :	Kathmandu
Safe Bearing Capacity:	164.19 KN/m^2

1.3 Layout of building

The layout of building was carried out based on the IS 12800 (Part I): 1993 (reaffirmed 1998). This building is a Four storey with average floor height of 10ft 5in. The detail dimensions used for the structural analysis are taken from the drawing of the proposed building.

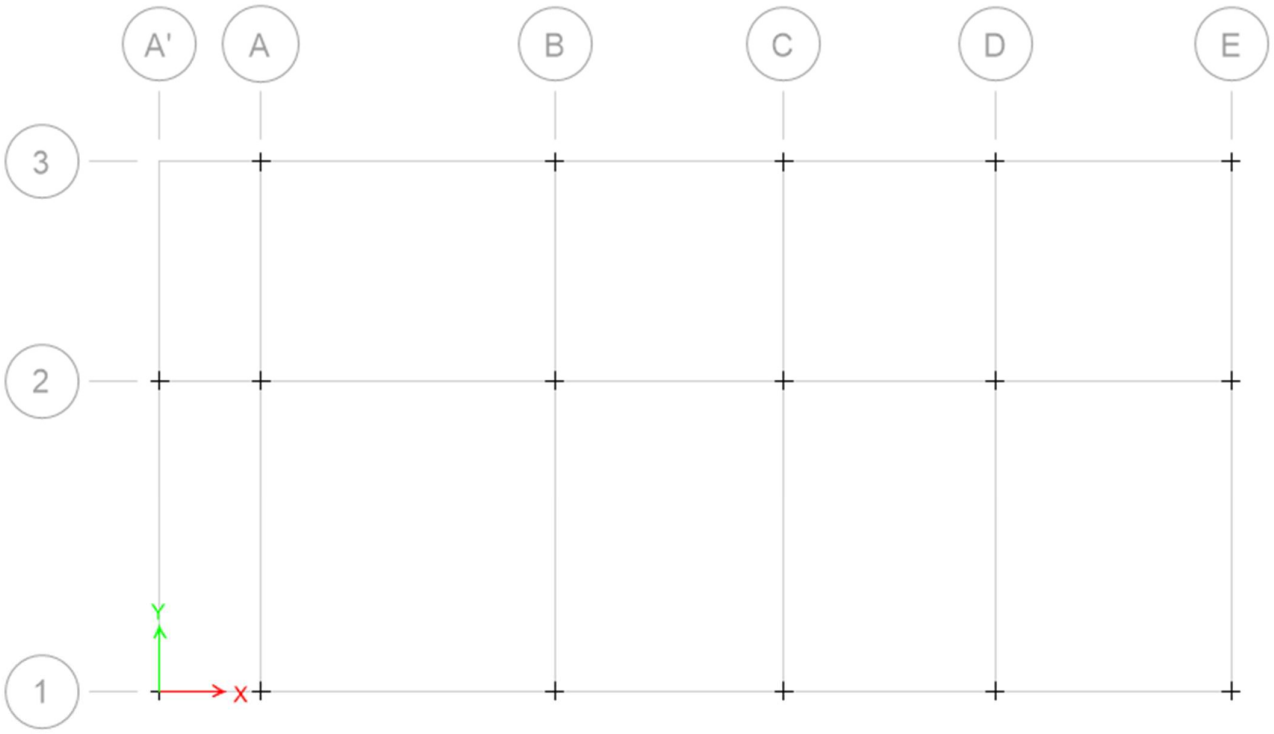


Figure 1-1 : Building layout grid plan for modeling in ETABS

2 STRUCTURAL ANALYSIS

2.1 INTRODUCTION

The structural analysis of the building frame is carried out by means of a structural analysis and design software, ETABS 18 and some components by manual calculations. Seismic loads are applied according to the NBC105-2020. Analysis is performed for different load combinations as prescribed in this code. Seismic coefficient method is carried out during the analysis. Importance factor of 1.0 is adopted with the overstrength factor of 1.5 and Ductility factor of 4 for limit state and overstrength factor of 1.25 for serviceability state in the calculation of seismic coefficient for zone having the zone factor of 0.35 and very soft soil type.

The structural analysis was followed by a RC design for the building frame. Member sizing and spacing has been performed by successive analysis and corresponding design. The RC design has been performed with the help of the software ETABS 18. The design is done according to IS456:2000 and detailing is done according to NBC105-2020. The design calculation according to the algorithm of ETABS 18 has been followed again which follows the IS codes IS-456:2000 and NBC105-2020.

2.2 FEM Model of Purposed Building

Purposed building has been analyzed using FEM software ETABS 2018. Beams and Columns have been modeled as frame elements. Base of the structure have been restrained with fixed supports. Staircase slab has not been modeled along with the frame model of the building.

Model has been analyzed Statically and Response Spectrum (Dynamic Analysis). Materials adopted are linear elastic with the appropriate values of Modulus of Elasticity and Poisson ratio. The superstructure consists of the portal frame with beams and columns. All the calculated loads are assigned in FEM model as input parameters.

The following figure gives the overall picture of purposed building.

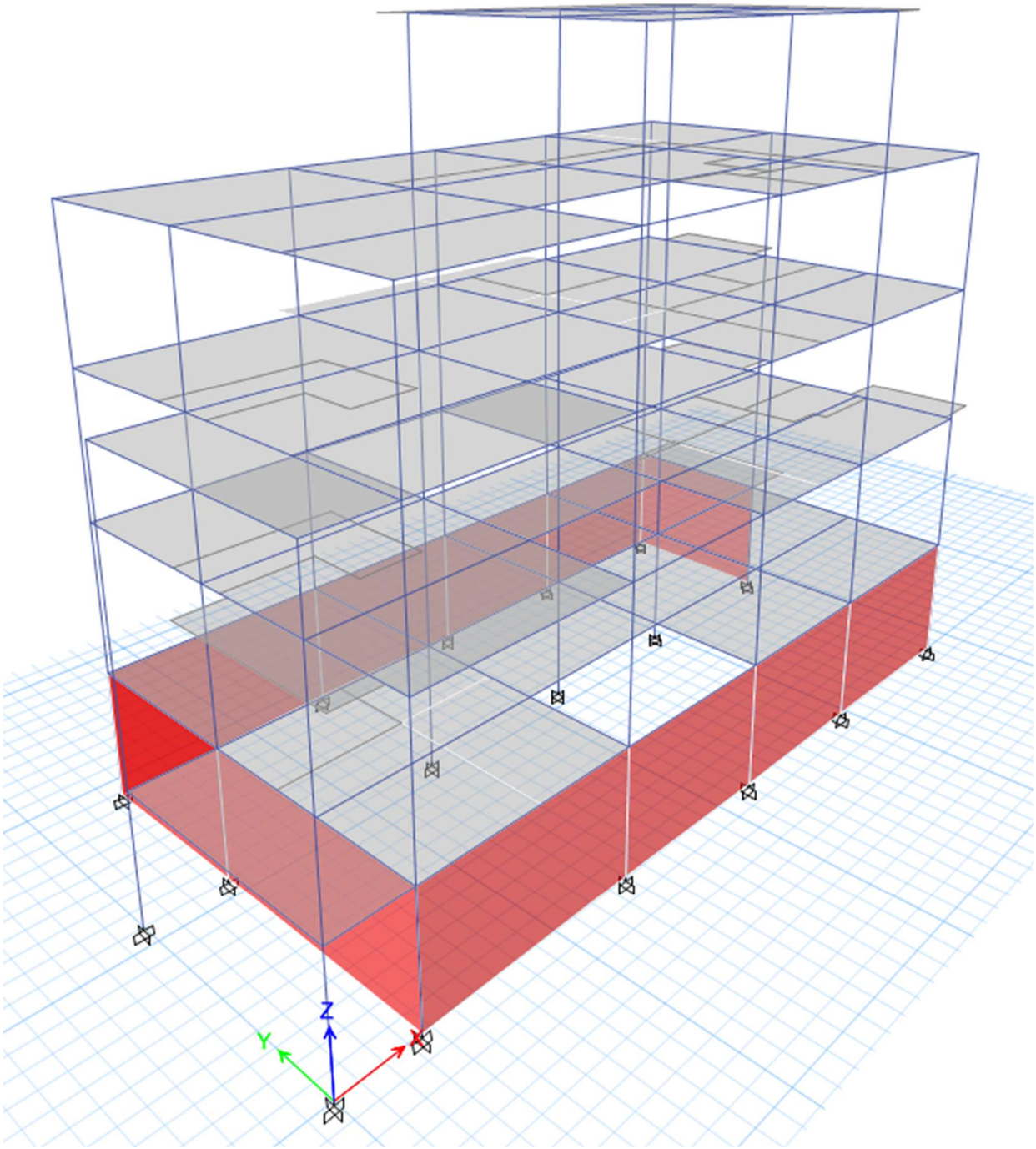


Figure 2-1 : 3D Finite Element Model of Purposed Building

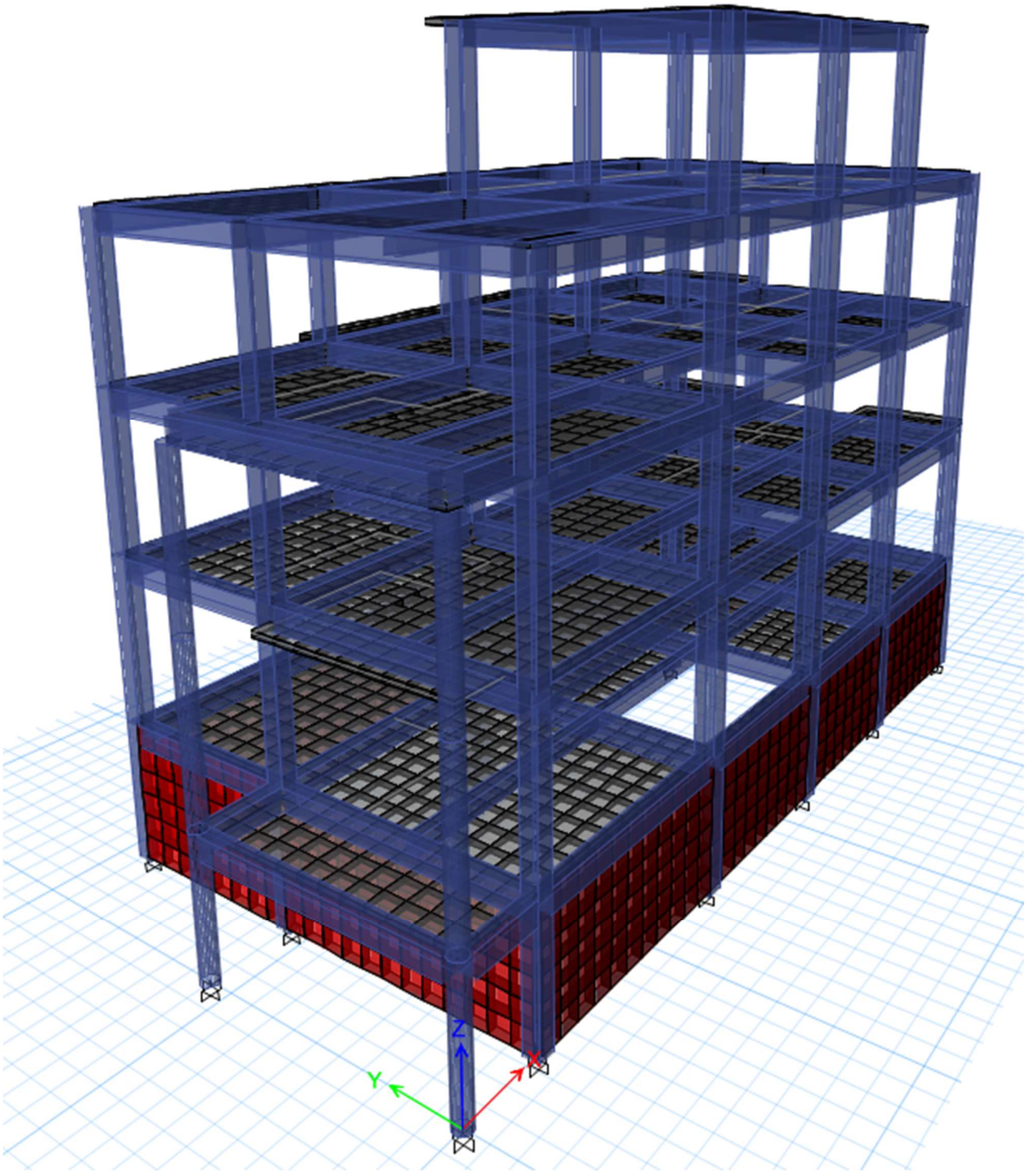


Figure 2-2 : 3D model side Extrude view

INPUT DATA FOR THE ANALYSIS

For the analysis of the superstructure frame of the purposed building different types of materials has been used. Some of the major properties required for analysis are enlisted below:

2.3 Material Properties

2.3.1 Concrete

Table 1 : Concrete properties

Grade	*M25*
Unit weight	25 kN/m^3
Modulus of Elasticity	5000xsqrt(fck)=25000 N/mm2
Poisson's ratio	0.2

2.3.2 Steel

Table 2: Steel properties

Grade	*Fe 500 for main bars and stirrups*
Unit weight	78.5 kN/m^3
Modulus of Elasticity	200000 N/mm^2
Poisson's ratio	0.3

Table 3: Material Density

Material	*Density (kN/m3)*
Concrete	25
Steel	78.5
Soil	18
Brick	18.85

Table 4: Frame sections

Section Name	*Material*	*Cover, m*	*Shape*	*Depth, m*	*Width, m*
Column	M25	0.04	Rectangular	0.4064	0.4064
Column	M25	0.04	Rectangular	0.3556	0.3556
Column	M25	0.04	Circular	0.3556	
Beam	M25	0.04	Rectangular	0.4572	0.3048
Secondary Beam	M25	0.04	Rectangular	0.3556	0.2286
Slab	M25	0.02	Rectangular	0.127	1.00
Staircase slab	M25	0.02	Rectangular	0.125	1.00
Wall	M25	0.02	Rectangular	0.2032	1.00

Table 5: Effective Stiffness of Frame Sections

Section	*Flexural Stiffness*	*Shear Stiffness*
Column	$0.70\ E_c\ I_g$	$0.40\ E_c\ A_w$
Beam	$0.35\ E_c\ I_g$	$0.40\ E_c\ A_w$
Wall-Cracked	$0.50\ E_c\ I_g$	$0.40\ E_c\ A_w$

2.4 LOADINGS

2.4.1 General information

Soil type : D

Seismic importance factor : 1.0

Seismic zone : Kathmandu

Overstrength Factor : 1.5 (Limit State), 1.25 (Serviceability State)

Ductility Factor : 4

Seismic zone factor : 0.35

Eccentricity : 0.10

2.4.2 Load Calculations

Live Load (IS875 Part 2)

Live Load : 2 KN/m^2

Live Load (Staircase) : 3 KN/m^2

Live Load Roof : 1.5 KN/m^2

Dead Load (IS875 Part 1)

Wall Load Calculation				
Unit Weight of Wall		18.85	KN/m^3	
Wall Type	**Opening %**	**Height (m)**	**Thickness (m)**	**Load (KN/m)**
Ground Floor				
9" Wall	0	2.90	0.23	12.5850894
9" Wall (20% Opening)	20	2.90	0.23	10.06807152
4" Wall	0	3.23	0.1	6.084403
4" Wall (20% Opening)	20	3.23	0.1	4.8675224
1F,2F				
9" Wall	0	2.73	0.23	11.8142375
9" Wall (20% Opening)	20	2.73	0.23	9.45139
4" Wall	0	3.05	0.1	5.74925
4" Wall (20% Opening)	20	3.05	0.1	4.5994
Parapet				
9" Parapet	0	1.00	0.23	4.3355

Floor Finish Calculation		
Unit Weight (Granite)	26.7	KN/m^3
Unit Weight (Mortar Screeding)	21	KN/m^3
Granite Thickness	20	mm
Mortar Thickness	25	mm
Floor Finish (Granite)	1.059	KN/m^2
Unit Weight (Parquet/Hardwood)	0.2	KN/m^2
Unit Weight (Mortar Screeding)	21	KN/m^3
Mortar Thickness	25	mm
Floor Finish (Parquet/Hardwood)	0.725	KN/m^2
Unit Weight (Floor Tiles)	0.2	KN/m^2
Unit Weight (Mortar Screeding)	21	KN/m^3
Mortar Thickness	25	mm
Floor Finish (Tiles)	0.725	KN/m^2

Water Tank Load Calculation		
Water Tank Volume	2000	Litres
Unit Weight Water	10	KN/m^3
Total Tank Weight	20	KN
Dissipation Area	16.608	m2
Water Tank Load	**1.2042**	**KN/m^2**

Staircase Load Calculation		
Flight Intermediate		
Unit Weight (Concrete)	25	KN/m^3
Riser	0.1778	m
Tread	0.254	m
Total Number of Tread	5	
Thickness of Slab	0.125	m
Length of Landing 1 (L1)	1.397	m
Uniform Load Factor for L1	0.5	
Length of Landing 2 (L2)	1.397	m
Uniform Load Factor for L1	0.5	
Length of Flight (F1)	1.27	m
Floor Finish	1.059	KN/m^2
Live Load	3	KN/m^2
Dead Load		
Landing 1	4.184	KN/m per m width
Landing 2	4.184	KN/m per m width
Flight	4.184	KN/m per m width
Steps	2.2225	KN/m per m width
Total Dead Load	13.9813	KN per m width
Reaction Dead 1	6.990652	KN per m width
Reaction Dead 2	6.990652	KN per m width
Live Load		
Live Load	3	KN/m per m width
Total Live Load	8.001	KN per m width
Reaction Live 1	4.0005	KN per m width
Reaction Live 2	4.0005	KN per m width
Flight 1,2		
Unit Weight (Concrete)	25	KN/m^3
Riser	0.1778	m
Tread	0.254	m
Total Number of Tread	5	
Thickness of Slab	0.125	m
Length of Landing 1 (L1)	0	m
Uniform Load Factor for L1	0.5	
Length of Landing 2 (L2)	1.397	m
Uniform Load Factor for L1	0.5	
Length of Flight (F1)	1.524	m
Floor Finish	1.059	KN/m^2
Live Load	3	KN/m^2

Dead Load		
Landing 1	4.184	KN/m per m width
Landing 2	4.184	KN/m per m width
Flight	4.184	KN/m per m width
Steps	2.2225	KN/m per m width
Total Dead Load	12.68603	KN per m width
Reaction Dead 1	7.915369	KN per m width
Reaction Dead 2	4.770661	KN per m width
Live Load		
Live Load	3	KN/m per m width
Total Live Load	6.6675	KN per m width
Reaction Live 1	3.880402	KN per m width
Reaction Live 2	2.787098	KN per m width

2.4.3 Load Pattern

Different loadings are applied in the frame model. Slab Floor Finish and Live load are calculated and applied manually in the model. The following sets of loads pattern were defined for the analysis in ETABS 18.

Table 6 : Load pattern

Load Pattern	Design Type	Self Wt Multiplier	Auto Load
Dead	Dead	1	
Live Load	Live load	0	
Live Roof	Live Roof	0	
Eqx	Quake	0	User Coefficient
Eqy	Quake	0	User Coefficient
Eqx-SL	Quake	0	User Coefficient
Eqy-SL	Quake	0	User Coefficient
Wall Load	Dead	0	
Floor Finish	Dead	0	
Staircase Dead	Dead	0	
Staircase Live	Live	0	
Soil Pressure	Other	0	

2.4.4 Load cases definition

The load cases considered for the analysis is shown below.

Table 7 : Load case

Case	Type	Design Type	Factor
Dead	Lin Static	DEAD	1
Modal	Lin Modal	OTHER	1
Live Load	Lin Static	LIVE	1
Live Roof	Lin Static	LIVE	1
Eqx	Lin Static	QUAKE	1
Eqy	Lin Static	QUAKE	1
Eqx-SL	Lin Static	QUAKE	1
Eqy-SL	Lin Static	QUAKE	1
Wall Load	Lin Static	DEAD	1
Floor Finish	Lin Static	DEAD	1
RSX	Response Spectrum	QUAKE	1
RSY	Response Spectrum	QUAKE	1
Staircase Dead	Lin Static	DEAD	1
Staircase Live	Lin Static	LIVE	1
Soil Pressure	Lin Static	OTHER	1

2.4.5 General loading combinations

As per IS 1893(part I):2016, the following load combinations are considered for analysis:

1.2DL+1.5LL

DL+ λLL ± EQx, DL+ λLL ± EQy

DL+ λLL ± RSx, DL+ λLL ± RSy

Earthquake loads are considered for +X, -X, +Y and –Y directions.

λ = 0.3

2.4.6 Dead load

The dead load of the structural members is automatically taken by the ETABS 18 software. The additional dead loads are assigned in the ETABS using the calculations and the code referred are NS and IS codes.

2.4.7 SEISMIC ANALYSIS

Seismic Coefficient Method

The building is designed and to be constructed to resist the effects of design lateral force specified in NBC105-2020 as a minimum. The design lateral force is computed for the building as a whole. This design lateral force is distributed to the various floor levels. The overall design seismic force thus obtained at each level is distributed to individual lateral load resisting elements depending upon the floor diaphragm action. For our case the seismic forces were left to be determined by program itself.

Table 8: NBC105-2020 (Seismic Coefficient Calculation)

Height of Building (H) (m)	9.703 m
Type of Building	Concrete MRF
Time Period (T) =0.075*$H^{0.75}$*1.25	0.515 sec
Time Period (Rayleigh Method)	0.822 sec
Zone Factor (Z)	0.35
Importance Factor (I)	1
Soil Type	Soil Type D
$C_h(T)$	2.250
C(T) = $C_h(T)$x Zx I	0.788
Ultimate Limit State	
Ductility Factor (R_μ)	4
Overstrength Factor (Ω_u)	1.5
Design Coefficient ($C_d(T_1)$)	0.131
Serviceability Limit State	
$C_s(T)$	0.1575
Overstrength Factor (Ω_u)	1.25
Design Coefficient ($C_d(T_1)$)	0.126
Base Shear Distribution Exponent (k)	1.008

Table 9 : Time Period (Rayleigh Method)

Floor	F (KN)	W (Kg)	d_x (mm)	Fd	Wd^2
GF	102.87	225444	0.167	0.0172	6.3E-05
1F	221.53	222540	13.985	3.0981	0.43524
2F	352.64	233793	26.7777	9.4429	1.6764
RF	360.17	178070	34.92	12.577	2.1714
SC	136.51	53786.5	40.055	5.4678	0.86295
			Σ	30.603	5.14606
				T_x	0.82262

Floor	F (KN)	W (Kg)	d_y (mm)	Fd	Wd^2
GF	102.87	225444	0.528	0.0543	0.00063
1F	221.53	222540	16.589	3.675	0.61242
2F	352.64	233793	31.678	11.171	2.3461
RF	360.17	178070	41.67	15.008	3.09199
SC	136.51	53786.5	48.269	6.5891	1.25317
			Σ	36.497	7.30431
				T_y	0.89744

Table 10 : Auto Seismic-NBC105-2020 (Ultimate Limit State)

Load Pattern	Type	Direction	Time Period	Eccentricity	C	K	Weight Used	Base Shear
				%			kN	kN
EQX	Seismic	X	0.515		0.131	1.008	8959.6772	1173.7177
EQX	Seismic	X + Ecc. Y	0.515	10	0.131	1.008	8959.6772	1173.7177
EQX	Seismic	X - Ecc. Y	0.515	10	0.131	1.008	8959.6772	1173.7177
EQY	Seismic	Y	0.515		0.131	1.008	8959.6772	1173.7177
EQY	Seismic	Y + Ecc. X	0.515	10	0.131	1.008	8959.6772	1173.7177
EQY	Seismic	Y - Ecc. X	0.515	10	0.131	1.008	8959.6772	1173.7177

Table 11 : Auto Seismic-NBC105-2020 (Serviceability Limit State)

Load Pattern	Type	Direction	Time Period	Eccentricity	C	K	Weight Used	Base Shear
				%			kN	kN
EQX	Seismic	X	0.515		0.126	1.008	8959.6772	1128.9193
EQX	Seismic	X + Ecc. Y	0.515	10	0.126	1.008	8959.6772	1128.9193
EQX	Seismic	X - Ecc. Y	0.515	10	0.126	1.008	8959.6772	1128.9193
EQY	Seismic	Y	0.515		0.126	1.008	8959.6772	1128.9193
EQY	Seismic	Y + Ecc. X	0.515	10	0.126	1.008	8959.6772	1128.9193
EQY	Seismic	Y - Ecc. X	0.515	10	0.126	1.008	8959.6772	1128.9193

Dynamic Analysis (Response Spectrum Method)

The Building was analyzed as per the dynamic analysis procedure prescribed by NBC105-2020. Response Spectrum method for the analysis procedure was followed. The spectral shape factor vs time period curve for very soft soil condition was utilized for calculation of the seismic demand. Number of modes considered during the analysis were such that minimum of 90% mass participation is obtained. The Base Shear obtained for dynamic analysis was scaled so as to meet demand as per equivalent static method.

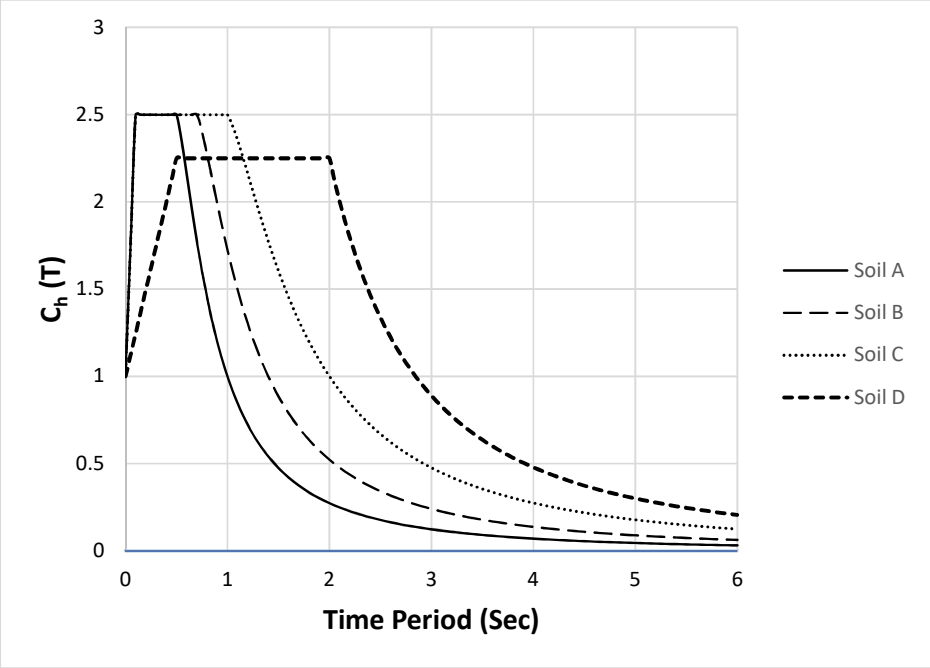


Figure 2-3: Spectral Shape Factor for Response Spectrum Method (NBC105-2020)

Table 12 : Mass source

Mass From	***Load***	***Multiplier***
Loads	DEAD	1
Loads	Live	0.3
Loads	Live Roof	0

2.4.8 Loading subjected to frame structure

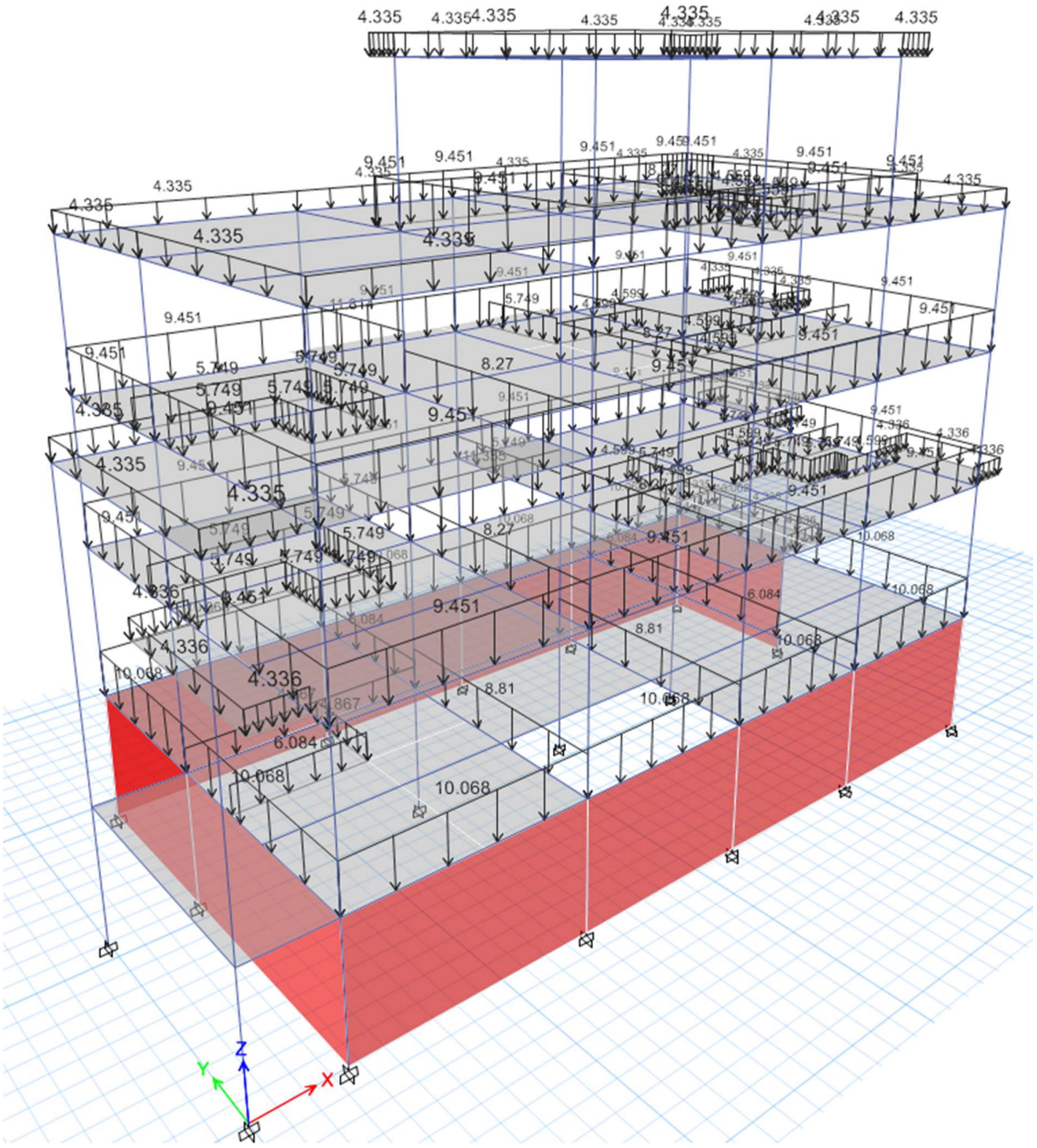


Figure 2-4 : Wall dead load

3 ANALYSIS OUTPUT

This chapter provides analysis results.

3.1 Structure Results

Table 3.1 - Base Reactions

TABLE: Base Reactions							
Output Case	Step Number	FX	FY	FZ	MX	MY	MZ
		kN	kN	kN	kN-m	kN-m	kN-m
EQx	1	-1173.7177	0	0	0	-11666.0634	5174.0106
EQx	2	-1173.7177	0	0	0	-11666.0634	5871.0652
EQx	3	-1173.7177	0	0	0.00000113	-11666.0634	4476.9561
EQy	1	0	-1173.7177	0	11666.0635	7.516E-07	-12321.2739
EQy	2	0	-1173.7177	0	11666.0635	0.000005049	-13676.8941
EQy	3	0	-1173.7177	0	11666.0635	-0.000003545	-10965.6537
EQx-SL	1	-1128.9193	0	0	0	-11220.7938	4976.5293
EQx-SL	2	-1128.9193	0	0	0	-11220.7938	5646.9787
EQx-SL	3	-1128.9193	0	0	0.000001087	-11220.7938	4306.0799
EQy-SL	1	0	-1128.9193	0	11220.7939	0.000000723	-11850.9963
EQy-SL	2	0	-1128.9193	0	11220.7939	0.000004856	-13154.8752
EQy-SL	3	0	-1128.9193	0	11220.7939	-0.00000341	-10547.1173
RSx		1173.7177	21.7996	2.0215	201.3361	12436.4949	5567.9402
RSy		21.7068	1173.7169	12.9953	12434.2669	338.1611	14076.0365

Table 3.2 - Centers of Mass and Rigidity

TABLE: Centers Of Mass And Rigidity									
Story	Diaphragm	XCCM	YCCM	XCR	YCR	ex	ey	ex	ey
		m	m	m	m	m	m	%	%
1F	D2	10.416	4.5138	10.2221	4.5023	0.1939	0.0115	1.103159	0.117905
2F	D3	9.9688	4.5879	10.3871	4.5841	-0.4183	0.0038	2.379842	0.03896
RF	D4	10.8637	4.1615	10.4404	4.6142	0.4233	-0.4527	2.408288	4.641363
SC	D5	11.139	2.9521	10.772	3.6829	0.367	-0.7308	2.08798	7.492618

Table 3.3 - Diaphragm Center of Mass Displacements

TABLE: Diaphragm Center Of Mass Displacements						
Story	Diaphragm	Output Case	Step Number	UX	UY	RZ
				mm	mm	rad
SC	D5	EQx	1	40.055	0.144	0.000246
SC	D5	EQx	2	39.325	-0.185	-0.000259
SC	D5	EQx	3	40.785	0.474	0.000752
RF	D4	EQx	1	34.92	0.072	0.000237
RF	D4	EQx	2	34.729	-0.12	-0.000188

RF	D4	EQx	3	35.11	0.265	0.000661
2F	D3	EQx	1	26.777	-0.065	0.000134
2F	D3	EQx	2	26.776	0.068	-0.000195
2F	D3	EQx	3	26.778	-0.198	0.000464
1F	D2	EQx	1	13.985	-0.011	0.000055
1F	D2	EQx	2	13.976	-0.022	-0.000118
1F	D2	EQx	3	13.993	0.001	0.000229
GF	D1	EQx	1	0.167	0.0004618	0.000001
GF	D1	EQx	2	0.167	-0.008	-0.000001
GF	D1	EQx	3	0.168	0.009	0.000003
SC	D5	EQx-SL	1	38.527	0.139	0.000237
SC	D5	EQx-SL	2	37.824	-0.178	-0.000249
SC	D5	EQx-SL	3	39.229	0.455	0.000723
RF	D4	EQx-SL	1	33.587	0.07	0.000228
RF	D4	EQx-SL	2	33.404	-0.116	-0.000181
RF	D4	EQx-SL	3	33.77	0.255	0.000636
2F	D3	EQx-SL	1	25.755	-0.062	0.000129
2F	D3	EQx-SL	2	25.754	0.065	-0.000188
2F	D3	EQx-SL	3	25.756	-0.19	0.000447
1F	D2	EQx-SL	1	13.451	-0.01	0.000053
1F	D2	EQx-SL	2	13.443	-0.021	-0.000114
1F	D2	EQx-SL	3	13.459	0.001	0.00022
GF	D1	EQx-SL	1	0.161	0.0004442	0.000001
GF	D1	EQx-SL	2	0.16	-0.008	-0.000001
GF	D1	EQx-SL	3	0.162	0.009	0.000003
SC	D5	EQy	1	0.222	48.269	0.000197
SC	D5	EQy	2	1.578	48.88	0.001105
SC	D5	EQy	3	-1.134	47.658	-0.00071
RF	D4	EQy	1	0.038	41.67	0.000147
RF	D4	EQy	2	0.391	42.031	0.000937
RF	D4	EQy	3	-0.315	41.309	-0.000643
2F	D3	EQy	1	-0.013	31.678	0.000102
2F	D3	EQy	2	-0.011	31.427	0.000725
2F	D3	EQy	3	-0.014	31.929	-0.00052
1F	D2	EQy	1	0.009	16.589	0.000053
1F	D2	EQy	2	0.024	16.613	0.000385
1F	D2	EQy	3	-0.006	16.566	-0.000278
GF	D1	EQy	1	0.009	0.528	0.000016
GF	D1	EQy	2	0.01	0.545	0.00002
GF	D1	EQy	3	0.007	0.512	0.000012
SC	D5	EQy-SL	1	0.213	46.427	0.00019
SC	D5	EQy-SL	2	1.517	47.014	0.001063
SC	D5	EQy-SL	3	-1.091	45.839	-0.000683

RF	D4	EQy-SL	1	0.036	40.079	0.000141
RF	D4	EQy-SL	2	0.376	40.427	0.000901
RF	D4	EQy-SL	3	-0.303	39.732	-0.000619
2F	D3	EQy-SL	1	-0.012	30.469	0.000099
2F	D3	EQy-SL	2	-0.011	30.228	0.000697
2F	D3	EQy-SL	3	-0.014	30.711	-0.0005
1F	D2	EQy-SL	1	0.009	15.956	0.000051
1F	D2	EQy-SL	2	0.024	15.979	0.00037
1F	D2	EQy-SL	3	-0.006	15.933	-0.000267
GF	D1	EQy-SL	1	0.008	0.508	0.000016
GF	D1	EQy-SL	2	0.01	0.524	0.00002
GF	D1	EQy-SL	3	0.007	0.493	0.000012
SC	D5	RSx		45.166	0.943	0.001694
RF	D4	RSx		38.615	0.708	0.001486
2F	D3	RSx		29.305	1.045	0.001128
1F	D2	RSx		15.165	0.33	0.00058
GF	D1	RSx		0.172	0.019	0.000007
SC	D5	RSy		2.663	53.672	0.001596
RF	D4	RSy		1.097	46.239	0.001372
2F	D3	RSy		0.532	34.932	0.001066
1F	D2	RSy		0.292	18.025	0.000558
GF	D1	RSy		0.011	0.564	0.000022
			Max (SL)	**39.229**	**47.014**	**mm**
			Max (UL)	**45.166**	**53.672**	**mm**
			Limit (SL)	**94.488**	**94.488**	**mm**
			Limit (UL)	**393.7**	**393.7**	**mm**

3.2 Story Results

Table 3.4 - Story Drifts

TABLE: Story Drifts					
Story	**Output Case**	**Step Number**	**Direction**	**Drift**	**Label**
SC	EQx	1	X	0.001536	25
SC	EQx	2	X	0.001595	24
SC	EQx	3	X	0.001619	25
RF	EQx	1	X	0.002681	10
RF	EQx	2	X	0.002541	10
RF	EQx	3	X	0.00282	10
2F	EQx	1	X	0.004145	17
2F	EQx	2	X	0.004145	5
2F	EQx	3	X	0.004373	17
1F	EQx	1	X	0.004194	17

1F	EQx	2	X	0.00429	5
1F	EQx	3	X	0.004427	17
GF	EQx	1	X	0.00006	17
GF	EQx	2	X	0.00006	5
GF	EQx	3	X	0.000064	17
SC	EQx-SL	1	X	0.001478	25
SC	EQx-SL	2	X	0.001534	24
SC	EQx-SL	3	X	0.001558	25
RF	EQx-SL	1	X	0.002578	10
RF	EQx-SL	2	X	0.002444	10
RF	EQx-SL	3	X	0.002713	10
2F	EQx-SL	1	X	0.003987	17
2F	EQx-SL	2	X	0.003987	5
2F	EQx-SL	3	X	0.004206	17
1F	EQx-SL	1	X	0.004034	17
1F	EQx-SL	2	X	0.004127	5
1F	EQx-SL	3	X	0.004258	17
GF	EQx-SL	1	X	0.000058	17
GF	EQx-SL	2	X	0.000058	5
GF	EQx-SL	3	X	0.000061	17
SC	EQy	1	Y	0.002138	26
SC	EQy	2	Y	0.002316	26
SC	EQy	3	Y	0.002143	24
RF	EQy	1	Y	0.003232	10
RF	EQy	2	Y	0.00368	10
RF	EQy	3	Y	0.003453	11
2F	EQy	1	Y	0.004917	46
2F	EQy	2	Y	0.005807	46
2F	EQy	3	Y	0.00556	17
1F	EQy	1	Y	0.004884	15
1F	EQy	2	Y	0.005726	15
1F	EQy	3	Y	0.005688	17
GF	EQy	1	Y	0.000234	15
GF	EQy	2	Y	0.000253	15
GF	EQy	3	Y	0.000216	15
SC	EQy-SL	1	Y	0.002056	26
SC	EQy-SL	2	Y	0.002228	26
SC	EQy-SL	3	Y	0.002061	24
RF	EQy-SL	1	Y	0.003108	10
RF	EQy-SL	2	Y	0.003539	10
RF	EQy-SL	3	Y	0.003321	11
2F	EQy-SL	1	Y	0.004729	46
2F	EQy-SL	2	Y	0.005586	46

2F	EQy-SL	3	Y	0.005347	17
1F	EQy-SL	1	Y	0.004698	15
1F	EQy-SL	2	Y	0.005507	15
1F	EQy-SL	3	Y	0.005471	17
GF	EQy-SL	1	Y	0.000225	15
GF	EQy-SL	2	Y	0.000244	15
GF	EQy-SL	3	Y	0.000207	15
SC	RSx		X	0.001832	25
SC	RSx		Y	0.000342	26
RF	RSx		X	0.003252	10
RF	RSx		Y	0.00104	1
2F	RSx		X	0.005067	17
2F	RSx		Y	0.001873	17
1F	RSx		X	0.005026	17
1F	RSx		Y	0.001859	17
GF	RSx		X	0.000068	17
GF	RSx		Y	0.000028	15
SC	RSy		Y	0.002624	26
RF	RSy		Y	0.004226	10
2F	RSy		Y	0.006707	46
1F	RSy		Y	0.006447	15
GF	RSy		X	0.000039	17
GF	RSy		Y	0.000265	15
			Max (SL)	**0.005586**	
			Max (UL)	**0.006707**	
			Limit (SL)	**0.006**	
			Limit (UL)	**0.025**	

Table 3.5 - Story Maximum over Minimum Displacements

TABLE: Story Max Over Min Displacements				
Story	**Output Case**	**Maximum**	**Minimum**	**Ratio**
		mm	mm	
SC	EQx	40.783	39.216	1.039958
RF	EQx	35.905	33.677	1.066158
2F	EQx	27.394	26.129	1.048414
1F	EQx	14.233	13.715	1.037769
SC	EQy	49.163	47.455	1.035992
RF	EQy	42.866	40.341	1.062591
2F	EQy	32.606	30.842	1.057195
1F	EQy	17.049	16.13	1.056975
			Max	**1.066158**
			Limit	**1.5**

Table 3.6 - Story Forces

TABLE: Story Forces									
Story	Output Case	Step Number	Location	P	VX	VY	T	MX	MY
				kN	kN	kN	kN-m	kN-m	kN-m
SC	EQx	1	Top	0.000	-136.507	0.000	413.389	0.000	0.000
SC	EQx	1	Bottom	0.000	-136.507	0.000	413.389	0.000	-433.410
SC	EQx	2	Top	0.000	-136.507	0.000	461.754	0.000	0.000
SC	EQx	2	Bottom	0.000	-136.507	0.000	461.754	0.000	-433.410
SC	EQx	3	Top	0.000	-136.507	0.000	365.025	0.000	0.000
SC	EQx	3	Bottom	0.000	-136.507	0.000	365.025	0.000	-433.410
SC	EQy	1	Top	0.000	0.000	-136.507	-1542.529	0.000	0.000
SC	EQy	1	Bottom	0.000	0.000	-136.507	-1542.529	433.410	0.000
SC	EQy	2	Top	0.000	0.000	-136.507	-1608.387	0.000	0.000
SC	EQy	2	Bottom	0.000	0.000	-136.507	-1608.387	433.410	0.000
SC	EQy	3	Top	0.000	0.000	-136.507	-1476.670	0.000	0.000
SC	EQy	3	Bottom	0.000	0.000	-136.507	-1476.670	433.410	0.000
SC	EQx-SL	1	Top	0.000	-131.297	0.000	397.611	0.000	0.000
SC	EQx-SL	1	Bottom	0.000	-131.297	0.000	397.611	0.000	-416.868
SC	EQx-SL	2	Top	0.000	-131.297	0.000	444.130	0.000	0.000
SC	EQx-SL	2	Bottom	0.000	-131.297	0.000	444.130	0.000	-416.868
SC	EQx-SL	3	Top	0.000	-131.297	0.000	351.092	0.000	0.000
SC	EQx-SL	3	Bottom	0.000	-131.297	0.000	351.092	0.000	-416.868
SC	EQy-SL	1	Top	0.000	0.000	-131.297	-1483.654	0.000	0.000
SC	EQy-SL	1	Bottom	0.000	0.000	-131.297	-1483.654	416.868	0.000
SC	EQy-SL	2	Top	0.000	0.000	-131.297	-1546.999	0.000	0.000
SC	EQy-SL	2	Bottom	0.000	0.000	-131.297	-1546.999	416.868	0.000
SC	EQy-SL	3	Top	0.000	0.000	-131.297	-1420.309	0.000	0.000
SC	EQy-SL	3	Bottom	0.000	0.000	-131.297	-1420.309	416.868	0.000
SC	RSx		Top	0.829	149.859	3.281	490.842	2.992	13.102
SC	RSx		Bottom	0.829	149.859	3.281	490.842	11.608	482.074
SC	RSy		Top	1.293	4.332	153.534	1824.638	6.567	15.149
SC	RSy		Bottom	1.293	4.332	153.534	1824.638	489.383	20.172
RF	EQx	1	Top	0.000	-496.675	0.000	2019.075	0.000	-433.410
RF	EQx	1	Bottom	0.000	-496.675	0.000	2019.075	0.000	-2010.353
RF	EQx	2	Top	0.000	-496.675	0.000	2273.836	0.000	-433.410
RF	EQx	2	Bottom	0.000	-496.675	0.000	2273.836	0.000	-2010.353
RF	EQx	3	Top	0.000	-496.675	0.000	1764.315	0.000	-433.410
RF	EQx	3	Bottom	0.000	-496.675	0.000	1764.315	0.000	-2010.353
RF	EQy	1	Top	0.000	0.000	-496.675	-5401.451	433.410	0.000
RF	EQy	1	Bottom	0.000	0.000	-496.675	-5401.451	2010.353	0.000
RF	EQy	2	Top	0.000	0.000	-496.675	-5845.094	433.410	0.000
RF	EQy	2	Bottom	0.000	0.000	-496.675	-5845.094	2010.353	0.000

RF	EQy	3	Top	0.000	0.000	-496.675	-4957.808	433.410	0.000
RF	EQy	3	Bottom	0.000	0.000	-496.675	-4957.808	2010.353	0.000
RF	EQx-SL	1	Top	0.000	-477.718	0.000	1942.012	0.000	-416.868
RF	EQx-SL	1	Bottom	0.000	-477.718	0.000	1942.012	0.000	-1933.622
RF	EQx-SL	2	Top	0.000	-477.718	0.000	2187.048	0.000	-416.868
RF	EQx-SL	2	Bottom	0.000	-477.718	0.000	2187.048	0.000	-1933.622
RF	EQx-SL	3	Top	0.000	-477.718	0.000	1696.975	0.000	-416.868
RF	EQx-SL	3	Bottom	0.000	-477.718	0.000	1696.975	0.000	-1933.622
RF	EQy-SL	1	Top	0.000	0.000	-477.718	-5195.289	416.868	0.000
RF	EQy-SL	1	Bottom	0.000	0.000	-477.718	-5195.289	1933.622	0.000
RF	EQy-SL	2	Top	0.000	0.000	-477.718	-5621.999	416.868	0.000
RF	EQy-SL	2	Bottom	0.000	0.000	-477.718	-5621.999	1933.622	0.000
RF	EQy-SL	3	Top	0.000	0.000	-477.718	-4768.579	416.868	0.000
RF	EQy-SL	3	Bottom	0.000	0.000	-477.718	-4768.579	1933.622	0.000
RF	RSx		Top	1.320	551.020	7.068	2383.086	12.750	499.606
RF	RSx		Bottom	1.320	551.020	7.068	2383.086	25.552	2232.410
RF	RSy		Top	3.698	10.094	555.888	6663.134	500.042	49.175
RF	RSy		Bottom	3.698	10.094	555.888	6663.134	2245.546	61.431
2F	EQx	1	Top	0.000	-849.314	0.000	3693.609	0.000	-2010.353
2F	EQx	1	Bottom	0.000	-849.314	0.000	3693.609	0.000	-4706.924
2F	EQx	2	Top	0.000	-849.314	0.000	4182.655	0.000	-2010.353
2F	EQx	2	Bottom	0.000	-849.314	0.000	4182.655	0.000	-4706.924
2F	EQx	3	Top	0.000	-849.314	0.000	3204.564	0.000	-2010.353
2F	EQx	3	Bottom	0.000	-849.314	0.000	3204.564	0.000	-4706.924
2F	EQy	1	Top	0.000	0.000	-849.314	-8947.368	2010.353	0.000
2F	EQy	1	Bottom	0.000	0.000	-849.314	-8947.368	4706.924	0.000
2F	EQy	2	Top	0.000	0.000	-849.314	-9855.578	2010.353	0.000
2F	EQy	2	Bottom	0.000	0.000	-849.314	-9855.578	4706.924	0.000
2F	EQy	3	Top	0.000	0.000	-849.314	-8039.158	2010.353	0.000
2F	EQy	3	Bottom	0.000	0.000	-849.314	-8039.158	4706.924	0.000
2F	EQx-SL	1	Top	0.000	-816.897	0.000	3552.632	0.000	-1933.622
2F	EQx-SL	1	Bottom	0.000	-816.897	0.000	3552.632	0.000	-4527.270
2F	EQx-SL	2	Top	0.000	-816.897	0.000	4023.011	0.000	-1933.622
2F	EQx-SL	2	Bottom	0.000	-816.897	0.000	4023.011	0.000	-4527.270
2F	EQx-SL	3	Top	0.000	-816.897	0.000	3082.253	0.000	-1933.622
2F	EQx-SL	3	Bottom	0.000	-816.897	0.000	3082.253	0.000	-4527.270
2F	EQy-SL	1	Top	0.000	0.000	-816.897	-8605.865	1933.622	0.000
2F	EQy-SL	1	Bottom	0.000	0.000	-816.897	-8605.865	4527.270	0.000
2F	EQy-SL	2	Top	0.000	0.000	-816.897	-9479.411	1933.622	0.000
2F	EQy-SL	2	Bottom	0.000	0.000	-816.897	-9479.411	4527.270	0.000
2F	EQy-SL	3	Top	0.000	0.000	-816.897	-7732.319	1933.622	0.000
2F	EQy-SL	3	Bottom	0.000	0.000	-816.897	-7732.319	4527.270	0.000
2F	RSx		Top	1.202	951.173	17.570	4445.036	25.429	2246.656

2F	RSx		Bottom	1.202	951.173	17.570	4445.036	73.124	5241.614
2F	RSy		Top	4.021	17.453	954.032	11328.423	2250.109	81.080
2F	RSy		Bottom	4.021	17.453	954.032	11328.423	5251.154	116.954
1F	EQx	1	Top	0.000	-1070.847	0.000	4697.902	0.000	-4706.924
1F	EQx	1	Bottom	0.000	-1070.847	0.000	4697.902	0.000	-8297.259
1F	EQx	2	Top	0.000	-1070.847	0.000	5333.508	0.000	-4706.924
1F	EQx	2	Bottom	0.000	-1070.847	0.000	5333.508	0.000	-8297.259
1F	EQx	3	Top	0.000	-1070.847	0.000	4062.297	0.000	-4706.924
1F	EQx	3	Bottom	0.000	-1070.847	0.000	4062.297	0.000	-8297.259
1F	EQy	1	Top	0.000	0.000	-1070.847	-11274.689	4706.924	0.000
1F	EQy	1	Bottom	0.000	0.000	-1070.847	-11274.689	8297.259	0.000
1F	EQy	2	Top	0.000	0.000	-1070.847	-12496.270	4706.924	0.000
1F	EQy	2	Bottom	0.000	0.000	-1070.847	-12496.270	8297.259	0.000
1F	EQy	3	Top	0.000	0.000	-1070.847	-10053.107	4706.924	0.000
1F	EQy	3	Bottom	0.000	0.000	-1070.847	-10053.107	8297.259	0.000
1F	EQx-SL	1	Top	0.000	-1029.975	0.000	4518.593	0.000	-4527.270
1F	EQx-SL	1	Bottom	0.000	-1029.975	0.000	4518.593	0.000	-7980.570
1F	EQx-SL	2	Top	0.000	-1029.975	0.000	5129.939	0.000	-4527.270
1F	EQx-SL	2	Bottom	0.000	-1029.975	0.000	5129.939	0.000	-7980.570
1F	EQx-SL	3	Top	0.000	-1029.975	0.000	3907.247	0.000	-4527.270
1F	EQx-SL	3	Bottom	0.000	-1029.975	0.000	3907.247	0.000	-7980.570
1F	EQy-SL	1	Top	0.000	0.000	-1029.975	-10844.357	4527.270	0.000
1F	EQy-SL	1	Bottom	0.000	0.000	-1029.975	-10844.357	7980.570	0.000
1F	EQy-SL	2	Top	0.000	0.000	-1029.975	-12019.313	4527.270	0.000
1F	EQy-SL	2	Bottom	0.000	0.000	-1029.975	-12019.313	7980.570	0.000
1F	EQy-SL	3	Top	0.000	0.000	-1029.975	-9669.401	4527.270	0.000
1F	EQy-SL	3	Bottom	0.000	0.000	-1029.975	-9669.401	7980.570	0.000
1F	RSx		Top	1.835	1154.093	21.425	5447.599	71.064	5267.446
1F	RSx		Bottom	1.835	1154.093	21.425	5447.599	140.741	9108.659
1F	RSy		Top	6.884	21.126	1157.132	13821.973	5251.478	166.757
1F	RSy		Bottom	6.884	21.126	1157.132	13821.973	9098.901	214.420
GF	EQx	1	Top	0.000	-1173.718	0.000	5174.011	0.000	-8297.259
GF	EQx	1	Bottom	0.000	-1173.718	0.000	5174.011	0.000	-11666.063
GF	EQx	2	Top	0.000	-1173.718	0.000	5871.065	0.000	-8297.259
GF	EQx	2	Bottom	0.000	-1173.718	0.000	5871.065	0.000	-11666.063
GF	EQx	3	Top	0.000	-1173.718	0.000	4476.956	0.000	-8297.259
GF	EQx	3	Bottom	0.000	-1173.718	0.000	4476.956	0.000	-11666.063
GF	EQy	1	Top	0.000	0.000	-1173.718	-12321.274	8297.259	0.000
GF	EQy	1	Bottom	0.000	0.000	-1173.718	-12321.274	11666.064	0.000
GF	EQy	2	Top	0.000	0.000	-1173.718	-13676.894	8297.259	0.000
GF	EQy	2	Bottom	0.000	0.000	-1173.718	-13676.894	11666.064	0.000
GF	EQy	3	Top	0.000	0.000	-1173.718	-10965.654	8297.259	0.000
GF	EQy	3	Bottom	0.000	0.000	-1173.718	-10965.654	11666.064	0.000

GF	EQx-SL	1	Top	0.000	-1128.919	0.000	4976.529	0.000	-7980.570
GF	EQx-SL	1	Bottom	0.000	-1128.919	0.000	4976.529	0.000	-11220.794
GF	EQx-SL	2	Top	0.000	-1128.919	0.000	5646.979	0.000	-7980.570
GF	EQx-SL	2	Bottom	0.000	-1128.919	0.000	5646.979	0.000	-11220.794
GF	EQx-SL	3	Top	0.000	-1128.919	0.000	4306.080	0.000	-7980.570
GF	EQx-SL	3	Bottom	0.000	-1128.919	0.000	4306.080	0.000	-11220.794
GF	EQy-SL	1	Top	0.000	0.000	-1128.919	-11850.996	7980.570	0.000
GF	EQy-SL	1	Bottom	0.000	0.000	-1128.919	-11850.996	11220.794	0.000
GF	EQy-SL	2	Top	0.000	0.000	-1128.919	-13154.875	7980.570	0.000
GF	EQy-SL	2	Bottom	0.000	0.000	-1128.919	-13154.875	11220.794	0.000
GF	EQy-SL	3	Top	0.000	0.000	-1128.919	-10547.117	7980.570	0.000
GF	EQy-SL	3	Bottom	0.000	0.000	-1128.919	-10547.117	11220.794	0.000
GF	RSx		Top	2.022	1173.718	21.800	5567.940	140.170	9116.350
GF	RSx		Bottom	2.022	1173.718	21.800	5567.940	201.336	12436.495
GF	RSy		Top	12.995	21.707	1173.717	14076.037	9098.751	302.154
GF	RSy		Bottom	12.995	21.707	1173.717	14076.037	12434.267	338.161

Table 3.7 - Story Stiffness

TABLE: Story Stiffness								
Story	**Output Case**	**Step Number**	**Shear X**	**Drift X**	**Stiff X**	**Shear Y**	**Drift Y**	**Stiff Y**
			kN	mm	kN/m	kN	mm	kN/m
SC	EQx	1	136.5072	4.847	28161.635	0	0.028	0
RF	EQx	1	496.6747	8.03	61855.312	0	0.475	0
2F	EQx	1	849.3137	12.787	66419.4	0	0.439	0
1F	EQx	1	1070.8468	13.807	77557.787	0	0.299	0
GF	EQx	1	1173.7177	0.167	7019271.899	0	0.007	0
SC	EQx	2	136.5072	4.84	28206.436	0	0.171	0
RF	EQx	2	496.6747	8.032	61833.398	0	0.047	0
2F	EQx	2	849.3137	12.8	66354.89	0	0.426	0
1F	EQx	2	1070.8468	13.832	77417.499	0	0.65	0
GF	EQx	2	1173.7177	0.167	7032172.673	0	0.009	0
SC	EQx	3	136.5072	4.855	28116.977	0	0.228	0
RF	EQx	3	496.6747	8.027	61877.242	0	0.914	0
2F	EQx	3	849.3137	12.775	66484.035	0	1.304	0
1F	EQx	3	1070.8468	13.782	77698.583	0	1.247	0
GF	EQx	3	1173.7177	0.168	7006418.373	0	0.02	0
SC	EQy	1	0	0.097	0	136.5072	6.569	20780.451
RF	EQy	1	0	0.139	0	496.6748	9.88	50271.091
2F	EQy	1	0	0.141	0	849.3137	15.117	56182.277
1F	EQy	1	0	0.109	0	1070.8468	16.023	66833.091
GF	EQy	1	0	0.045	0	1173.7177	0.519	2263365.315

SC	EQy	2	0	0.337	0	136.5072	6.625	20605.259
RF	EQy	2	0	0.607	0	496.6748	9.86	50374.923
2F	EQy	2	0	0.885	0	849.3137	15.016	56559.015
1F	EQy	2	0	1.06	0	1070.8468	15.733	68062.395
GF	EQy	2	0	0.057	0	1173.7177	0.532	2205339.711
SC	EQy	3	0	0.154	0	136.5072	6.513	20958.648
RF	EQy	3	0	0.34	0	496.6748	9.9	50167.687
2F	EQy	3	0	0.596	0	849.3137	15.218	55810.526
1F	EQy	3	0	0.843	0	1070.8468	16.312	65647.406
GF	EQy	3	0	0.033	0	1173.7177	0.505	2324526.904
SC	EQx-SL	1	131.297	4.662	28161.635	0	0.027	0
RF	EQx-SL	1	477.7177	7.723	61855.312	0	0.456	0
2F	EQx-SL	1	816.8971	12.299	66419.4	0	0.423	0
1F	EQx-SL	1	1029.9748	13.28	77557.787	0	0.287	0
GF	EQx-SL	1	1128.9193	0.161	7019271.899	0	0.006	0
SC	EQx-SL	2	131.297	4.655	28206.436	0	0.165	0
RF	EQx-SL	2	477.7177	7.726	61833.398	0	0.045	0
2F	EQx-SL	2	816.8971	12.311	66354.89	0	0.41	0
1F	EQx-SL	2	1029.9748	13.304	77417.499	0	0.625	0
GF	EQx-SL	2	1128.9193	0.161	7032172.673	0	0.009	0
SC	EQx-SL	3	131.297	4.67	28116.977	0	0.219	0
RF	EQx-SL	3	477.7177	7.72	61877.242	0	0.879	0
2F	EQx-SL	3	816.8971	12.287	66484.035	0	1.255	0
1F	EQx-SL	3	1029.9748	13.256	77698.583	0	1.2	0
GF	EQx-SL	3	1128.9193	0.161	7006418.373	0	0.02	0
SC	EQy-SL	1	0	0.093	0	131.297	6.318	20780.451
RF	EQy-SL	1	0	0.134	0	477.7177	9.503	50271.091
2F	EQy-SL	1	0	0.136	0	816.8971	14.54	56182.277
1F	EQy-SL	1	0	0.105	0	1029.9748	15.411	66833.091
GF	EQy-SL	1	0	0.043	0	1128.9193	0.499	2263365.315
SC	EQy-SL	2	0	0.324	0	131.297	6.372	20605.259
RF	EQy-SL	2	0	0.584	0	477.7177	9.483	50374.923
2F	EQy-SL	2	0	0.851	0	816.8971	14.443	56559.015
1F	EQy-SL	2	0	1.02	0	1029.9748	15.133	68062.395
GF	EQy-SL	2	0	0.054	0	1128.9193	0.512	2205339.711
SC	EQy-SL	3	0	0.148	0	131.297	6.265	20958.648
RF	EQy-SL	3	0	0.327	0	477.7177	9.522	50167.687
2F	EQy-SL	3	0	0.574	0	816.8971	14.637	55810.526
1F	EQy-SL	3	0	0.811	0	1029.9748	15.689	65647.406
GF	EQy-SL	3	0	0.032	0	1128.9193	0.486	2324526.904
SC	RSx		149.8591	5.598	26769.763	3.2813	0.607	0
RF	RSx		551.0196	9.407	58573.829	7.0684	1.741	0
2F	RSx		951.1731	15.038	63249.873	17.5698	3.119	0

1F	RSx		1154.0929	15.898	72595.062	21.4246	3.272	0
GF	RSx		1173.7177	0.182	6437428.14	21.7996	0.045	0
SC	RSy		4.3315	0.552	0	153.5342	7.822	19629.493
RF	RSy		10.0938	0.91	0	555.8881	12.281	45262.38
2F	RSy		17.4534	1.435	0	954.0321	19.199	49690.769
1F	RSy		21.1262	1.685	0	1157.1324	19.695	58753.436
GF	RSy		21.7068	0.062	0	1173.7169	0.578	2031781.2

3.3 Modal Results

Table 3.8 - Modal Participating Mass Ratios

TABLE: Modal Participating Mass Ratios								
Case	**Mode**	**Period**	**UX**	**UY**	**UZ**	**SumUX**	**SumUY**	**SumUZ**
		sec						
Modal	1	0.89	0.0001	0.6704	0	0.0001	0.6704	0
Modal	2	0.817	0.6512	0.0004	0.000001012	0.6513	0.6707	0.000001402
Modal	3	0.73	0.0209	0.0032	0	0.6722	0.6739	0.000001447
Modal	4	0.307	0.000002853	0.062	0.00004781	0.6722	0.7359	0.00004926
Modal	5	0.281	0.0561	0	0.00000625	0.7282	0.7359	0.0001
Modal	6	0.248	0.0019	0.0002	7.595E-07	0.7301	0.7362	0.0001
Modal	7	0.194	0.0004	0.0232	0.0002	0.7305	0.7594	0.0003
Modal	8	0.184	0.0144	0.0016	0.00004759	0.745	0.761	0.0003
Modal	9	0.171	0.0063	0.0007	0.00002151	0.7513	0.7618	0.0003
Modal	10	0.138	0.0006	0.01	0.0006	0.7519	0.7718	0.0009
Modal	11	0.136	0.0078	0.0007	0.00003753	0.7597	0.7725	0.001
Modal	12	0.106	0.0003	0.00001785	0.0001	0.76	0.7725	0.0011
Modal	13	0.054	0.0001	0.1553	0.0037	0.7601	0.9278	0.0048
Modal	14	0.042	6.908E-07	0.0679	0.0145	0.7601	0.9957	0.0193
Modal	15	0.03	0.238	0.0001	0.00003112	0.9981	0.9958	0.0193

3.4 BMD, SFD, AFD and Story Response Plots

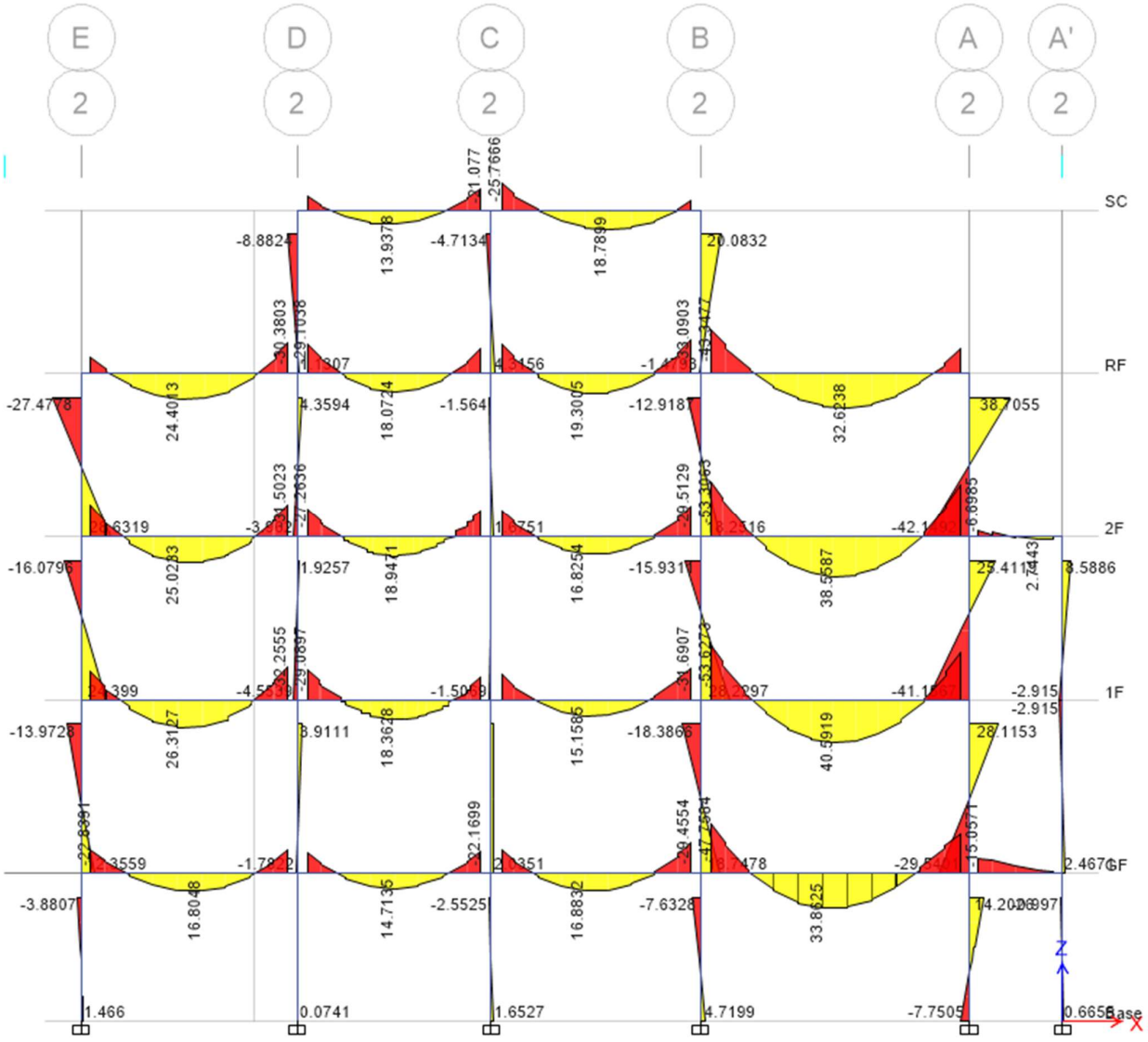


Fig: BMD for Frame 2-2 (1.2DL+1.5LL)

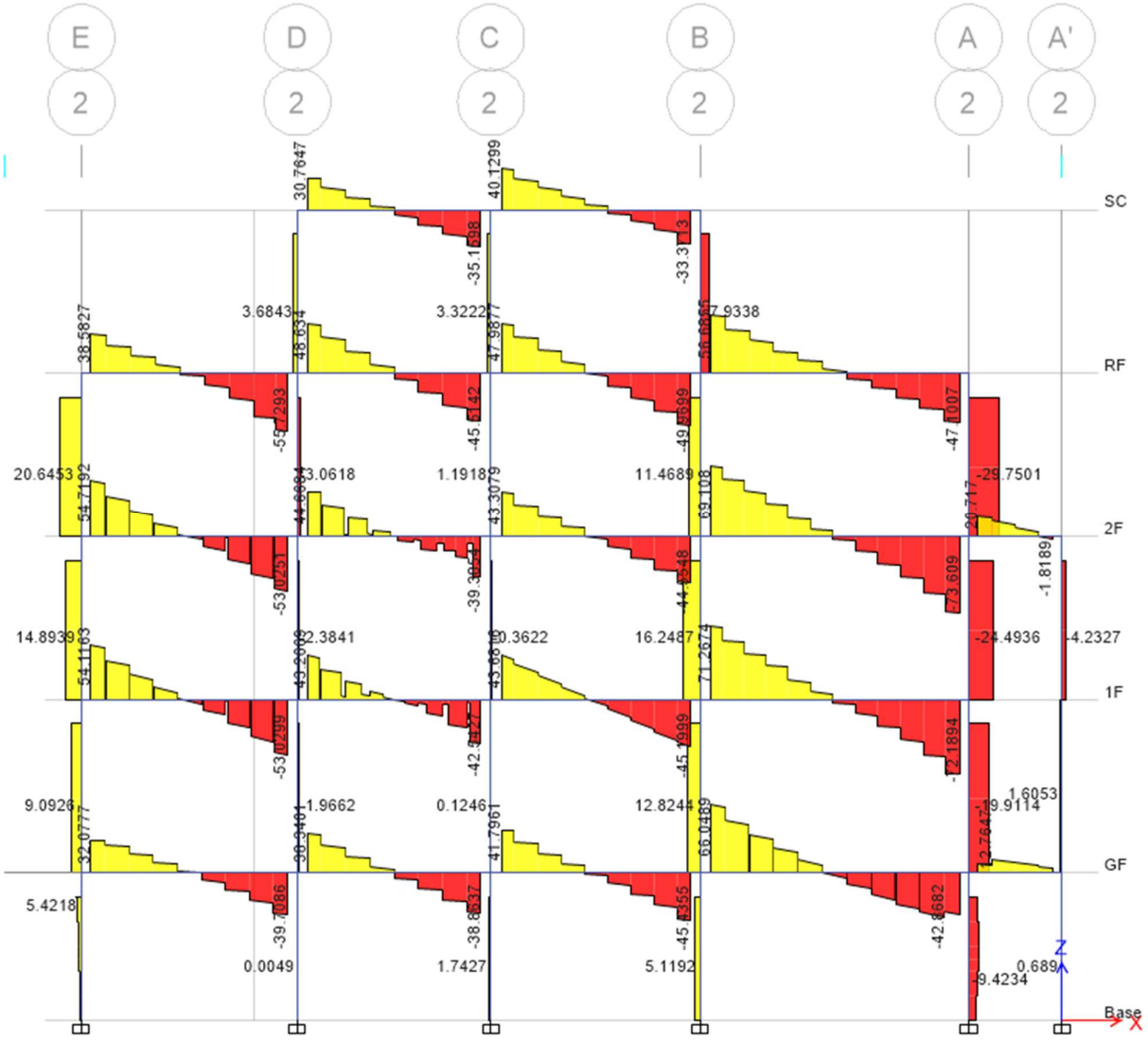


Fig: SFD for Frame 2-2 (1.5DL+LL)

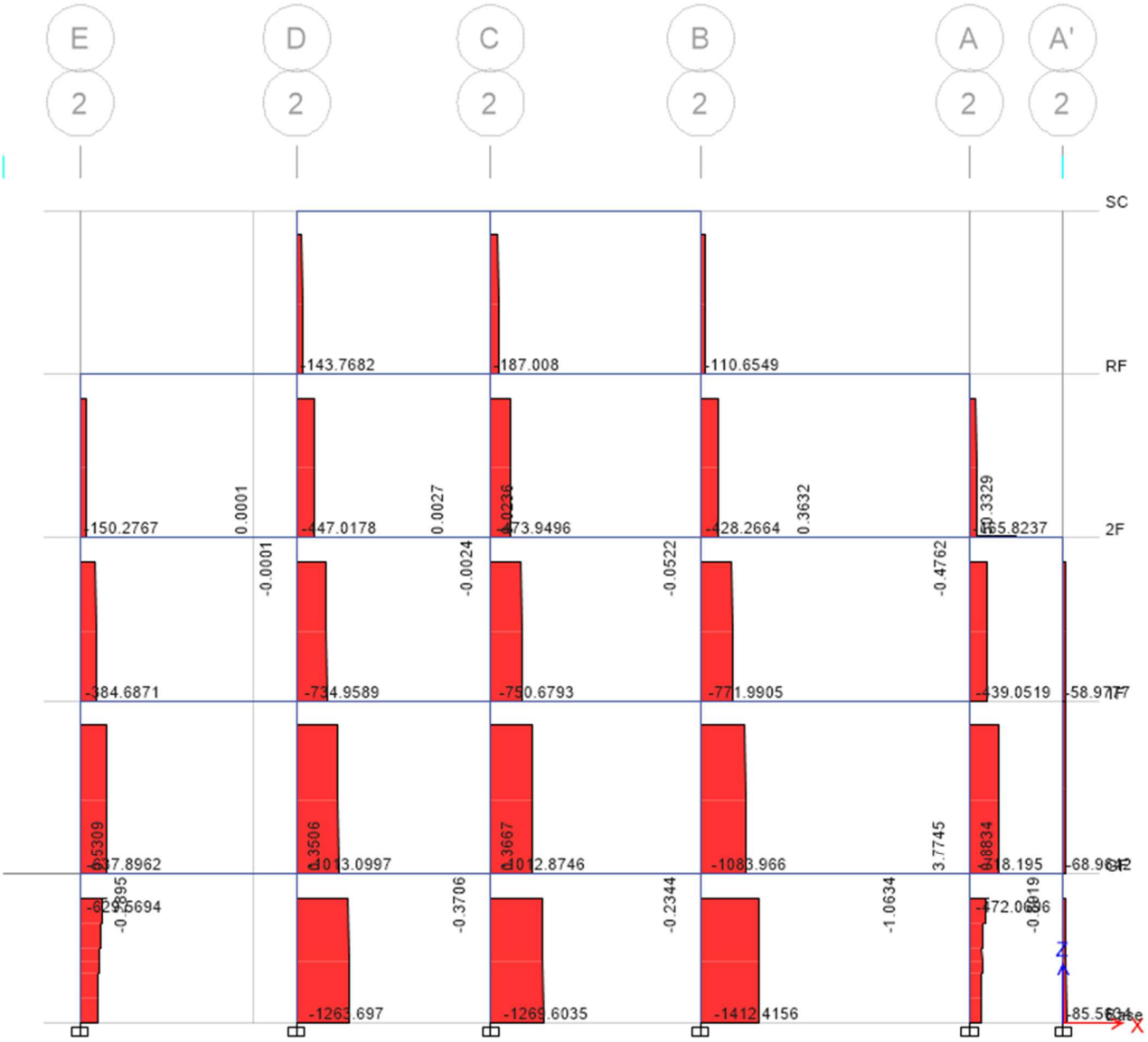


Fig: AFD for Frame 2-2 (1.5DL+LL)

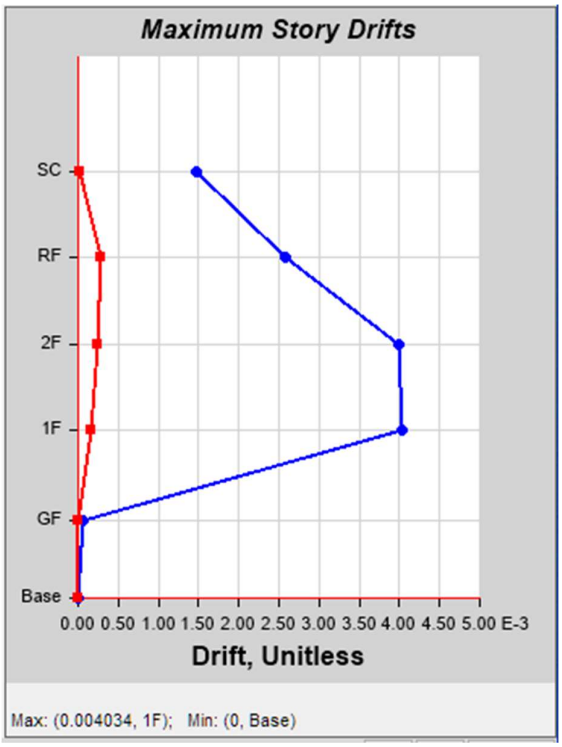


Fig: Story Drift for EQx (Serviceability State)

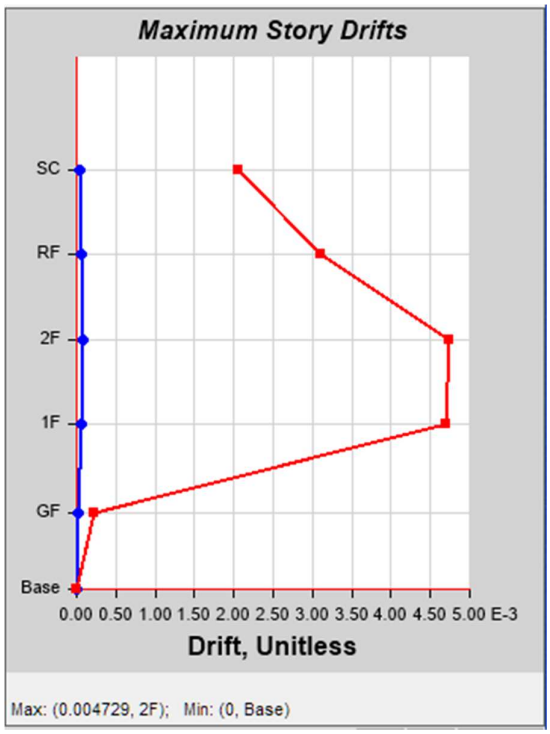


Fig: Story Drift for EQy (Serviceability State)

4 DESIGN OF THE STRUCTURAL ELEMENTS

4.1 Design of column

4.1.1 Column-Superstructure

All the columns are designed as rectangular reinforced concrete column. The size of column throughout the superstructure is 355.6mmx355.6mm and 406.4mmx406.4mm. The columns are fixed at the top and the bottom. Columns are designed according to their axial and flexural demand as evaluated by the program. Manual Calculation for sample column members is done for verification with result from the software. NBC105-2020 code allows for a maximum of 4% reinforcement steel. For all columns concrete cube strength of 25N/mm^2 shall be used. The columns are designed from the computations made by ETABS using IS456-2000 and this is used for the detail design and drawing.

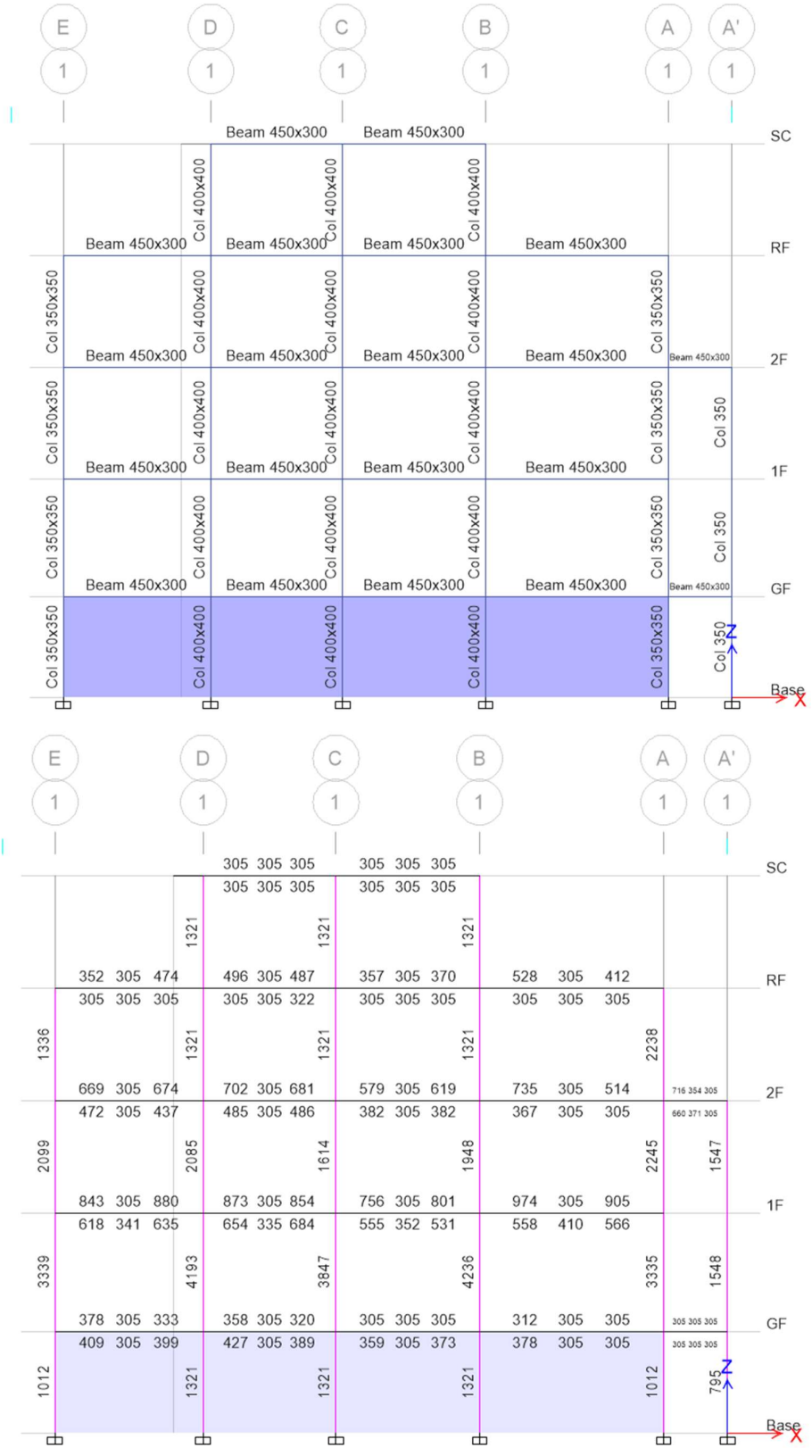


Figure 4-1 : Column section and reinforcement area at grid 1-1

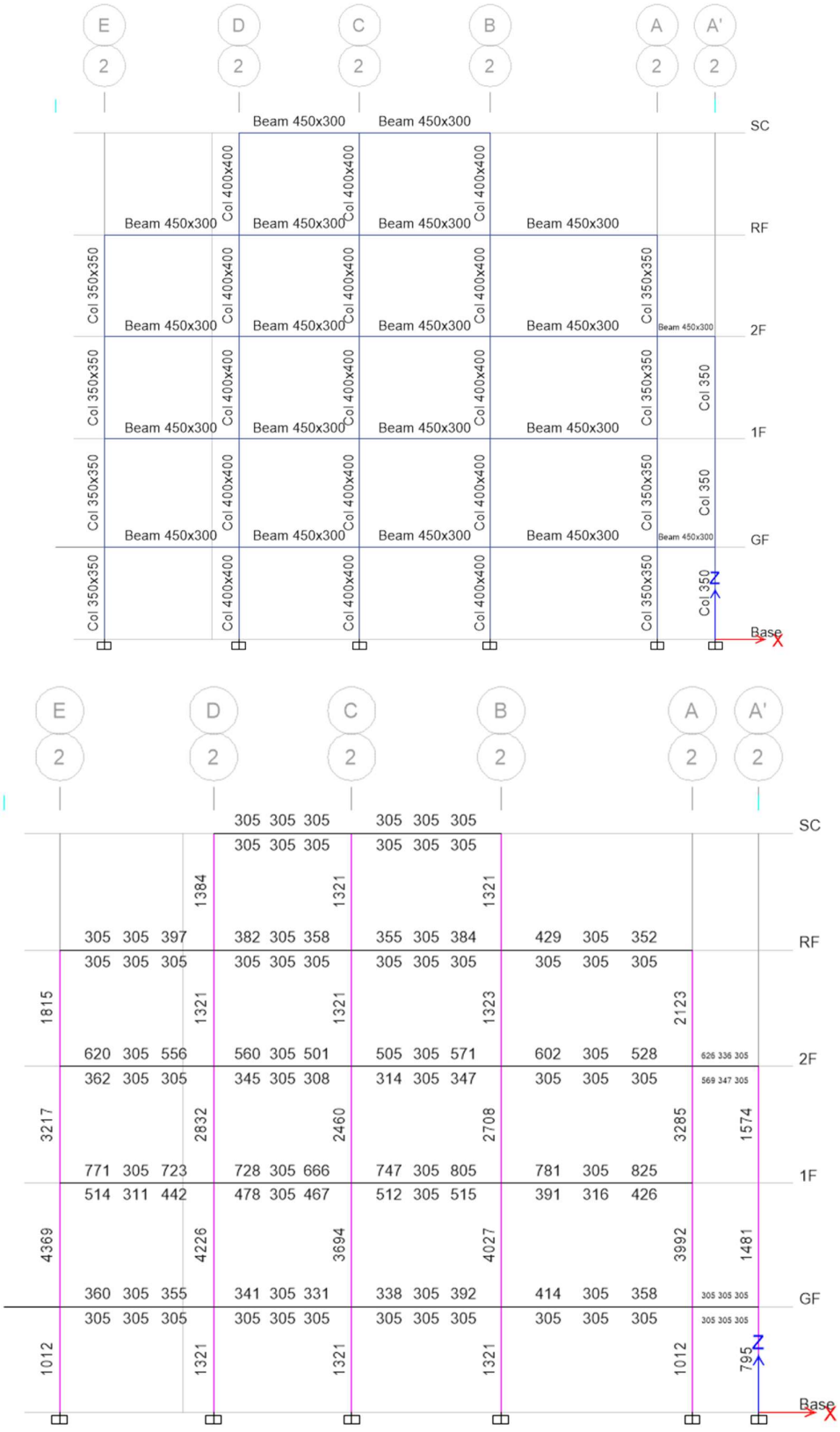


Figure 4-2 : Column section and reinforcement area at grid 2-2

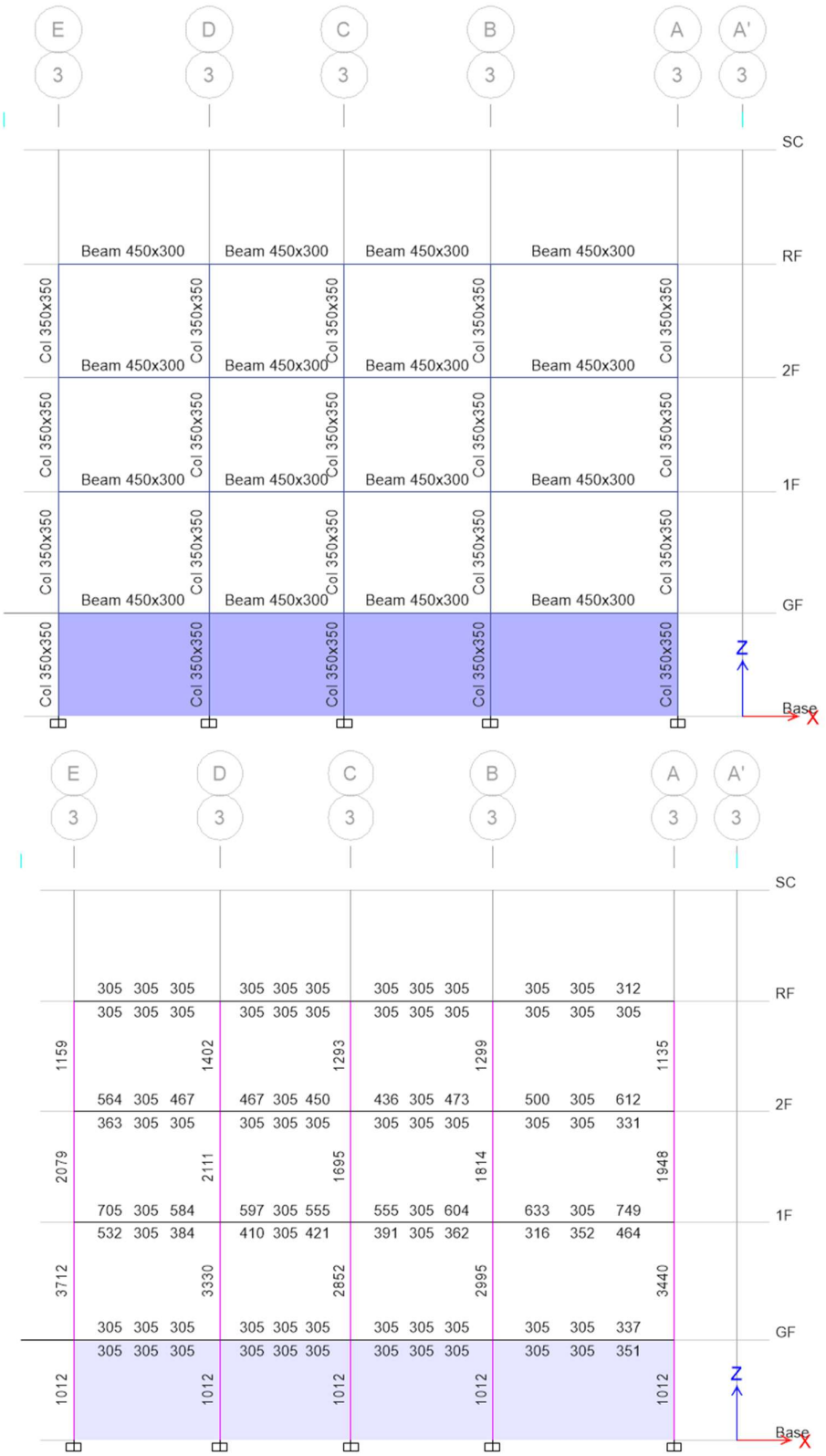
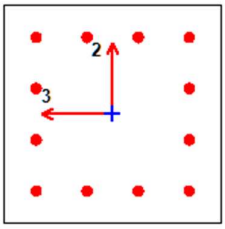


Figure 4-3 : Column section and reinforcement area at grid 3-3

ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Column Section Design



Column Element Details Type: Ductile Frame (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
1F	C7	53	Col 400x400	DL+0.3LL-RSx	0	3352.8	0.659

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
406.4	406.4	60	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
25000	25	1	500	500

Design Code Parameters

γ_c	γ_s
1.5	1.15

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm²	Rebar % %
524.4523	-59.5	225.8721	10.489	10.489	4236	2.56

Axial Force and Biaxial Moment Factors

	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	0.821088	2895.6	92.3486	0	10.489
Minor Bend(M2)	0.908036	2895.6	-23.8	0	10.489

Shear Design for V_{u2} , V_{u3}

	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
Major, V_{u2}	115.274	149.5884	56.3111	106.9616	450.47
Minor, V_{u3}	75.8653	149.5884	56.3111	75.8653	450.47

Joint Shear Check/Design

	Joint Shear Force kN	Shear V_{Top} kN	Shear $V_{u,Tot}$ kN	Shear V_c kN	Joint Area cm²	Shear Ratio Unitless
Major Shear, V_{u2}	N/A	N/A	N/A	N/A	N/A	N/A
Minor Shear, V_{u3}	N/A	N/A	N/A	N/A	N/A	N/A

(1.4) Beam/Column Capacity Ratio

Major Ratio	Minor Ratio
N/A	N/A

Additional Moment Reduction Factor k (IS 39.7.1.1)

A_g cm²	A_{sc} cm²	P_{uz} kN	P_b kN	P_u kN	k Unitless
1651.6	42.4	3446.64	826.4976	524.4523	1

Additional Moment (IS 39.7.1)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	Yes	0.864	406.4	5.85	12	No	0
Minor Bending (M_2)	Yes	0.864	406.4	6.47	12	No	0

Notes:

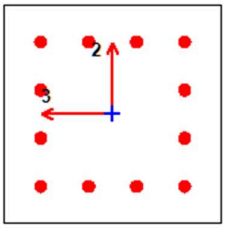
N/A: Not Applicable

N/C: Not Calculated

N/N: Not Needed

ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Column Section Design



Column Element Details Type: Ductile Frame (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
1F	C3	49	Col 350x350	DL+0.3LL-RSy	0	3352.8	0.76

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
355.6	355.6	60	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
25000	25	1	500	500

Design Code Parameters

γ_c	γ_s
1.5	1.15

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm²	Rebar % %
100.6147	129.6253	-24.9932	2.0123	2.0123	2852	2.26

Axial Force and Biaxial Moment Factors

	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	0.733439	2895.6	-9.9973	0	2.0123
Minor Bend(M2)	0.82087	2895.6	52.3313	0	2.0123

Shear Design for V_{u2} , V_{u3}

	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
Major, V_{u2}	71.8938	109.6472	42.0464	71.8938	394.16
Minor, V_{u3}	66.7269	109.6472	42.0464	58.0162	394.16

Joint Shear Check/Design

	Joint Shear Force kN	Shear V_{Top} kN	Shear $V_{u,Tot}$ kN	Shear V_c kN	Joint Area cm²	Shear Ratio Unitless
Major Shear, V_{u2}	N/A	N/A	N/A	N/A	N/A	N/A
Minor Shear, V_{u3}	N/A	N/A	N/A	N/A	N/A	N/A

(1.4) Beam/Column Capacity Ratio

Major Ratio	Minor Ratio
N/A	N/A

Additional Moment Reduction Factor k (IS 39.7.1.1)

A_g cm²	A_{sc} cm²	P_{uz} kN	P_b kN	P_u kN	k Unitless
1264.5	28.5	2491.9911	567.8029	100.6147	1

Additional Moment (IS 39.7.1)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	Yes	0.864	355.6	5.972	12	No	0
Minor Bending (M_2)	Yes	0.864	355.6	6.684	12	No	0

Notes:

N/A: Not Applicable

N/C: Not Calculated

N/N: Not Needed

4.2 Beam superstructure

All beams are designed for major direction flexure, shear and torsion only. The beam design procedure involved the following steps:

- Design of longitudinal reinforcement
- Design of shear reinforcement

The design of beams on ETABS is based on IS 456 and NBC105-2020. All the details of the beams have been taken from the values designed by ETABS. Manual Calculation for sample Beam members is done for verification with result from the software The output value of reinforcement from ETABS analysis for different level of beams is listed below in respective diagrams.

Figure 4-4: Beam sections and reinforcement at GF

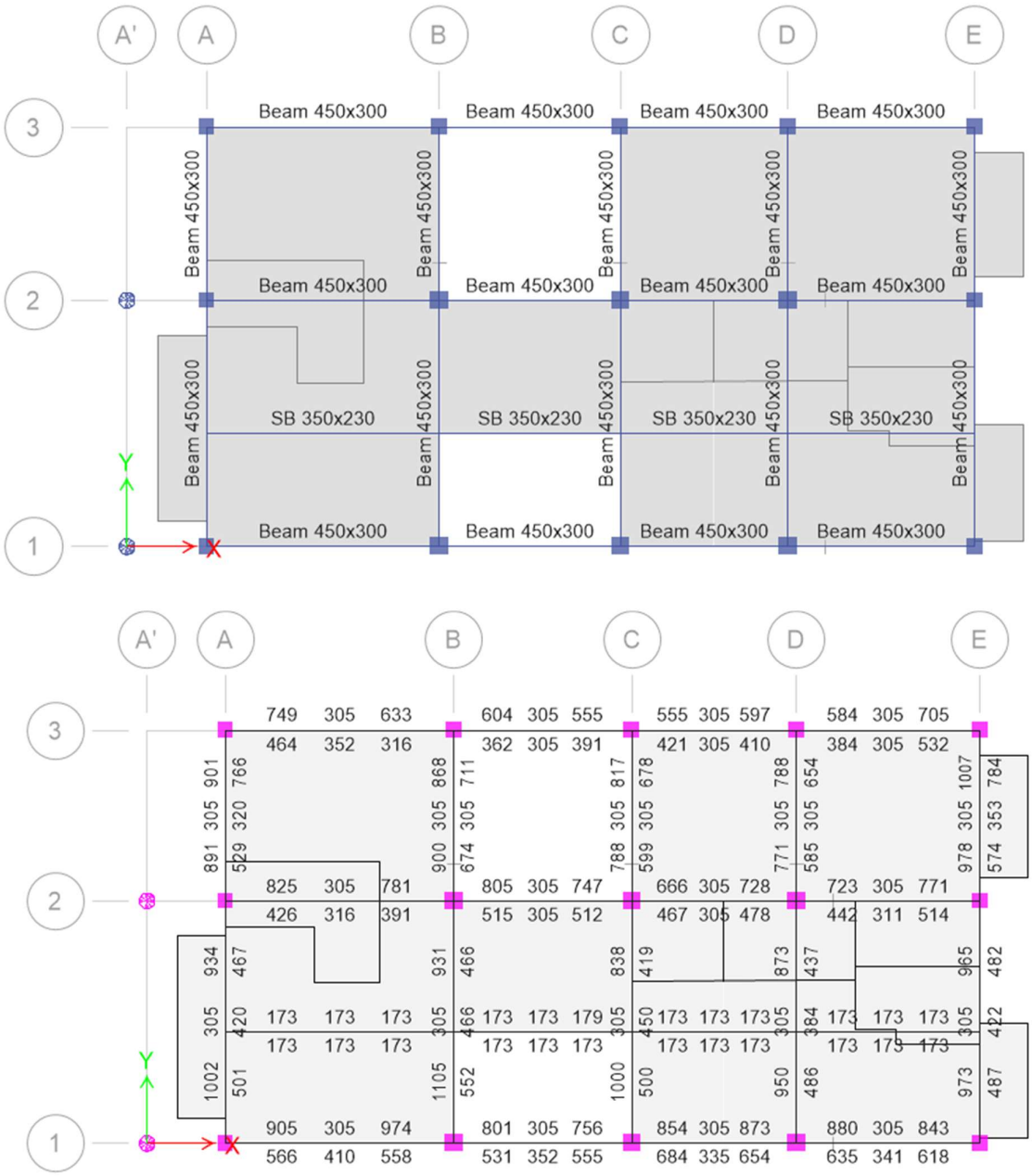


Figure 4-5: Beam sections and reinforcement at 1F

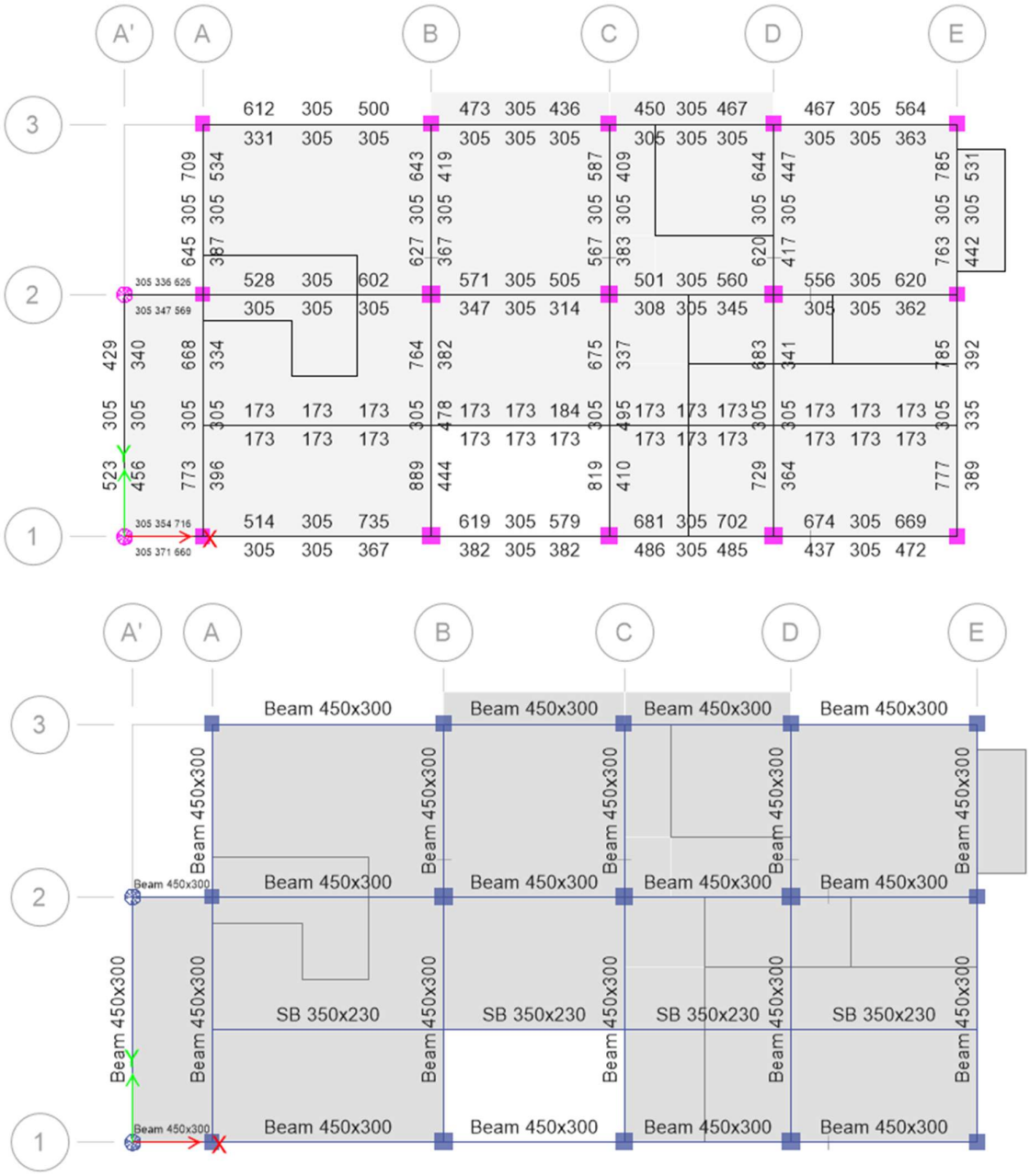


Figure 4-6: Beam sections and reinforcement at 2F

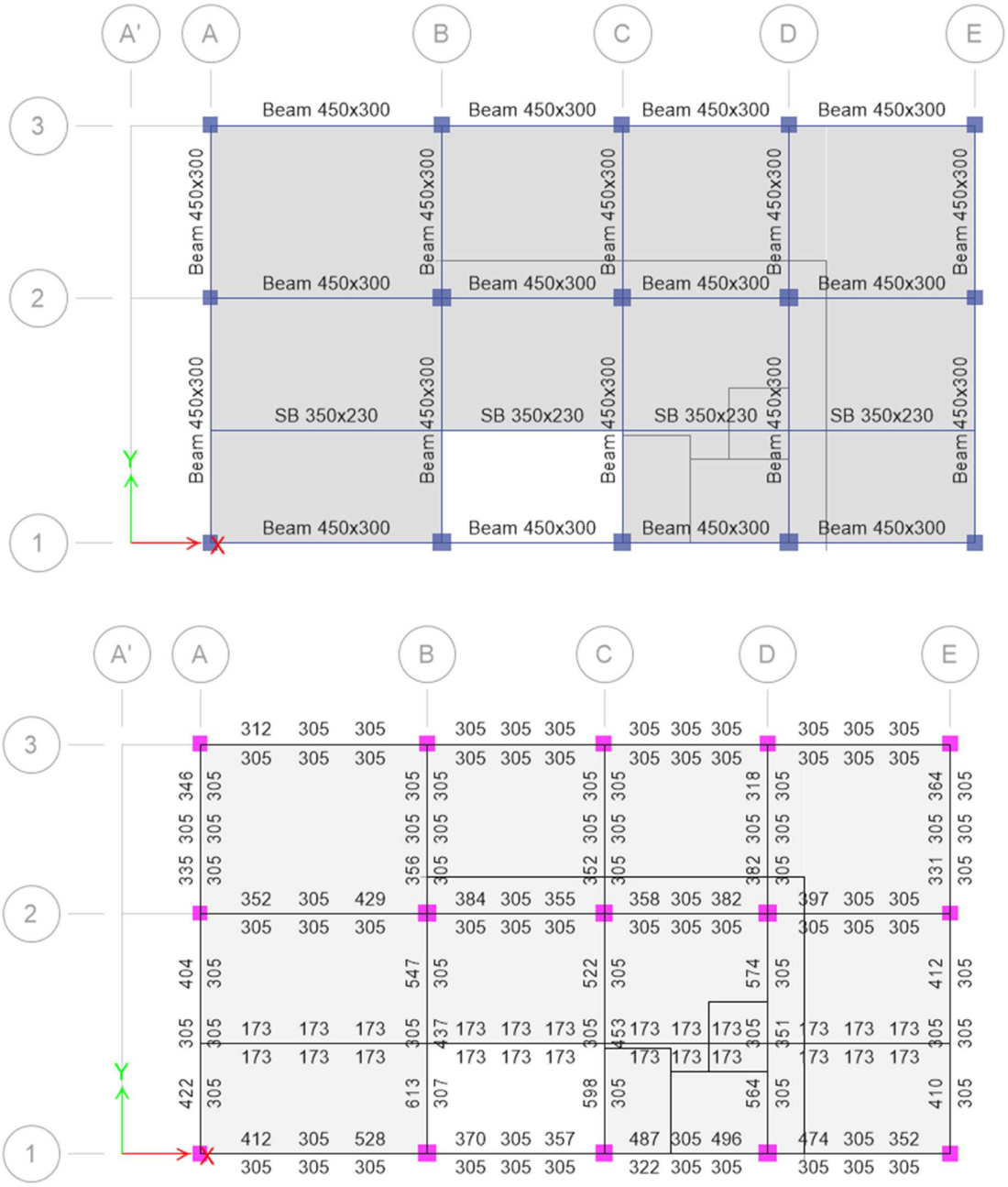


Figure 4-7: Beam sections and reinforcement at RF

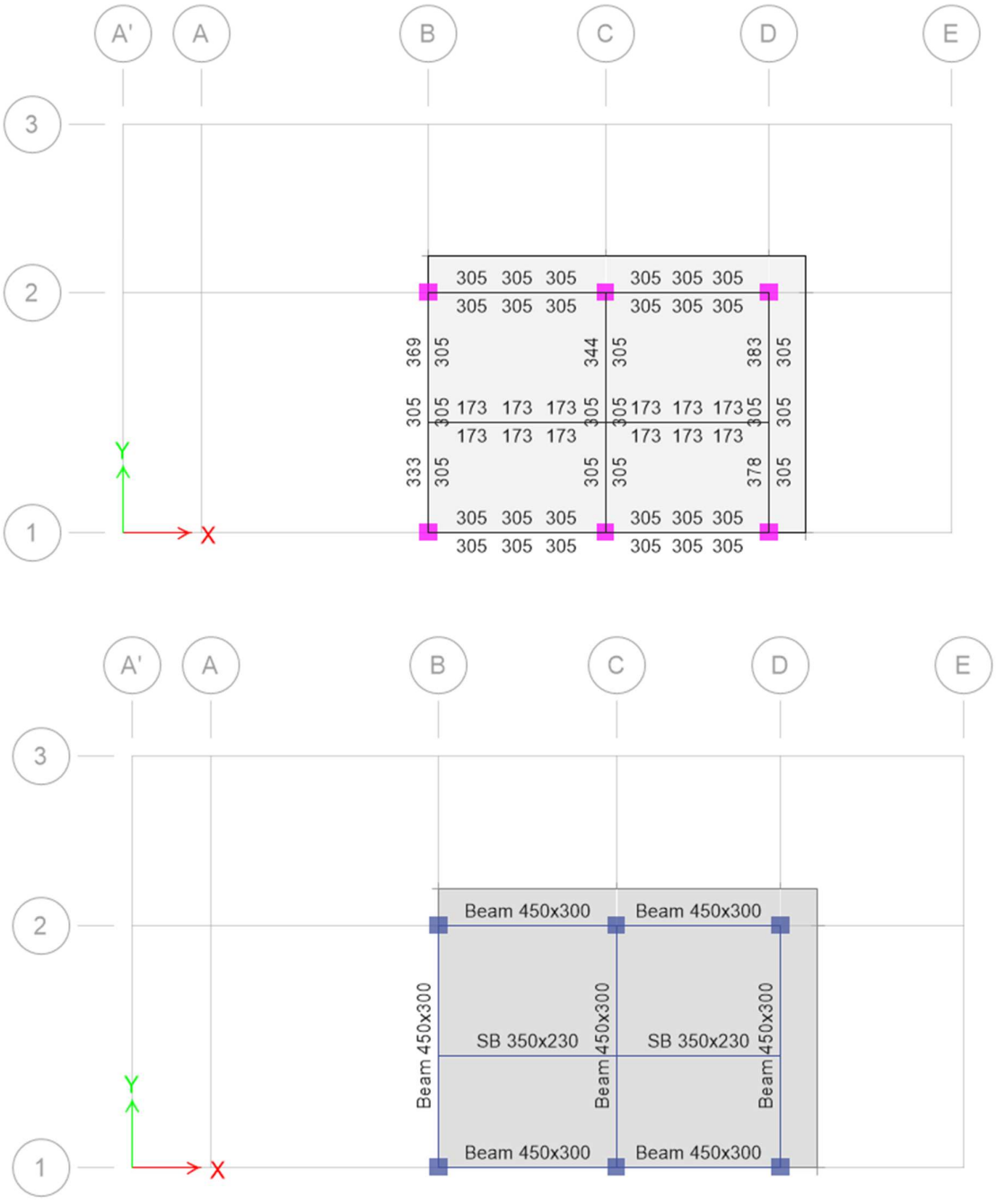
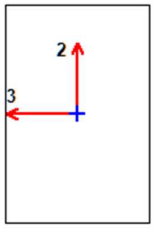


Figure 4-8: Beam sections and reinforcement at SC

ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Beam Section Design



Beam Element Details Type: Ductile Frame (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
1F	B12	73	Beam 450x300	DL+0.3LL-RSx	177.8	5207	1

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
304.8	457.2	304.8	0	40	40

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
25000	25	1	500	500

Design Code Parameters

γ_c	γ_s
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-100.9891	16.2541	71.6796	-1.2417

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-100.9891	23.9031	0	-124.8922

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-124.8922		749	1	749	305
Bottom (-2 Axis)		0	464	464	1	375

Shear Force and Reinforcement for Shear, V_{u2} & T_u

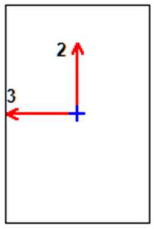
Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
90.9292	0	176.2525	53.9787	1170.69

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
16.2541	71.6796	244.8	397.2	688.33

ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Beam Section Design



Beam Element Details Type: Ductile Frame (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
1F	B15	254	Beam 450x300	DL+0.3LL-RSy	203.2	5521.8	1

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
304.8	457.2	304.8	0	40	40

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
25000	25	1	500	500

Design Code Parameters

γ_c	γ_s
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-152.5207	16.6158	112.6722	-0.6638

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-152.5207	24.435	80.5346	-176.9557

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-176.9557		1105	1	1105	305
Bottom (-2 Axis)		80.5346	552	466	1	552

Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
134.5116	0	221.7336	70.3724	1472.78

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
16.6158	112.6722	244.8	397.2	942.42

4.3 Slab

Slab has been modeled in this building model. Slab loads and live loads were assigned manually in the model in terms of uniformly distributed load. Analysis and design of slab was done manually. All panel slabs are two-way slabs.

4.3.1 Design summary of slab

Main reinforcement	:	10 mm @ 150 c/c spacing
Distribution bar	:	8 mm @ 150c/c spacing

4.4 Staircase

Open well staircase has not been modeled with the frame structure. Analysis and design of staircase is carried out manually, ignoring the end restraint effects at the supports.

4.4.1 Design summary of staircase

Main reinforcement	:	12 mm @ 100 mm c/c spacing (Intermediate Flight)
		12 mm @ 125 mm c/c spacing (Flight 1 &3)
Distribution bar	:	8 mm @ 150 mm c/c spacing
Nose bar	:	8 mm @ 200 mm c/c spacing

4.5 Design of Foundation

The Foundation was designed using the support reaction for all load combinations as prescribed by NBC105-2020 using IS456-2000 design. Analysis required for design was conducted using FEM software SAFE 16. Type of Footing was selected according to the feasibility of the location plan.

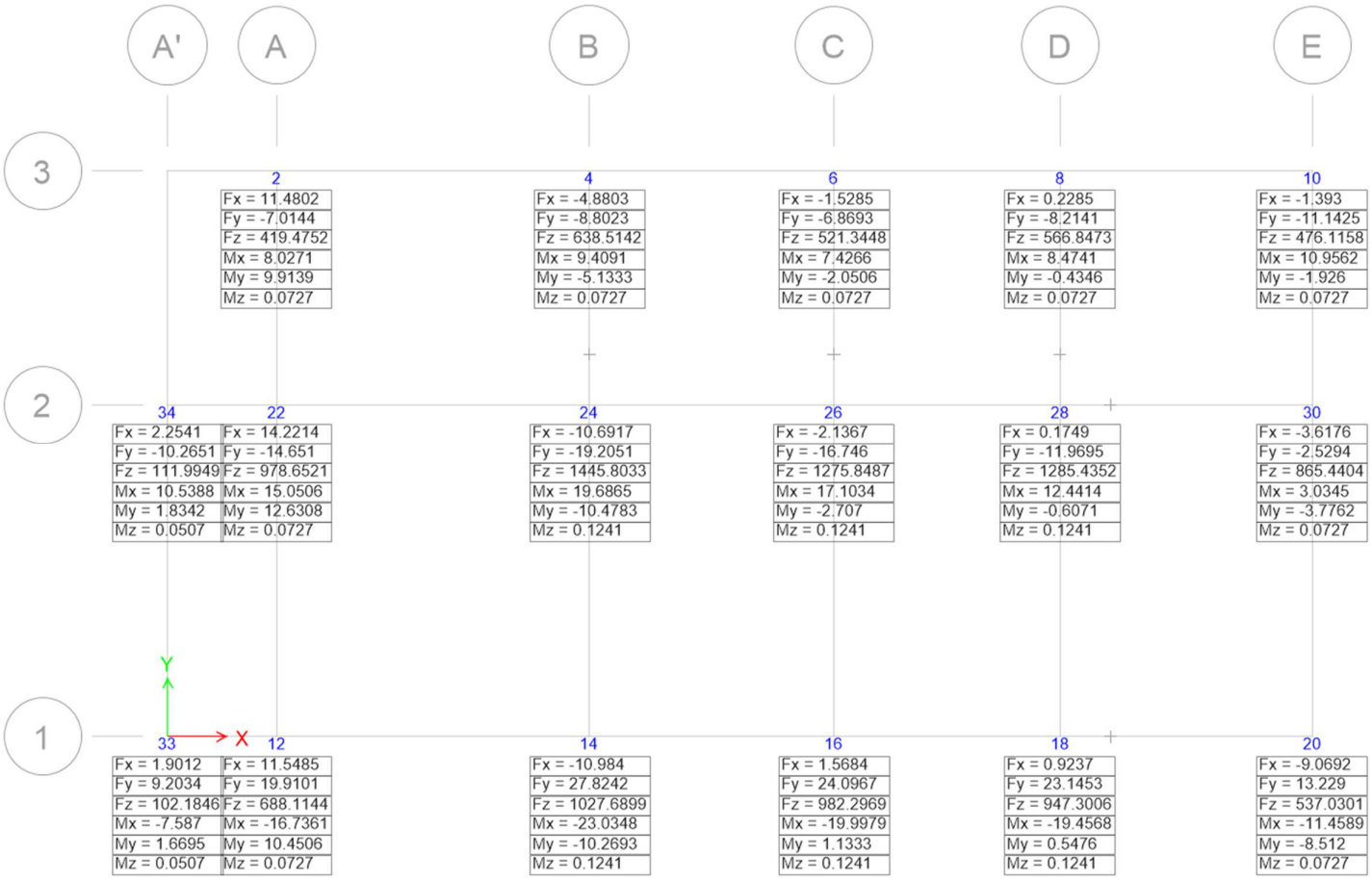


Fig: Foundation Reaction (1.2DL+1.5LL)

ANNEX I (Design Summary)

Column Design Summary

COLUMN REINFORCEMENT DETAILS												
Concrete Grade : M25, Reinforcement: Fe500												
		Column Area	Main Rebar									
			A_{st} Req.	12	16	20	25	A_{st} Pro.		% of Rebar	Remarks	Notation
				113.10	201.06	314.16	490.87					
Grid 1-1												
B	A'	99315	795			8		2513.27	1718.27	2.53	OK	C0
	A	126451	1012			12		3769.91	2757.91	2.98	OK	C1
	B	165161	1321			8	4	4476.77	3155.77	2.71	OK	C2
	C	165161	1321			8	4	4476.77	3155.77	2.71	OK	C2
	D	165161	1321			8	4	4476.77	3155.77	2.71	OK	C2
	E	126451	1012			12		3769.91	2757.91	2.98	OK	C1
B	A'	99315	1548			8		2513.27	965.27	2.53	OK	C0
	A	126451	3335			12		3769.91	434.91	2.98	OK	C1
	B	165161	4236			8	4	4476.77	240.77	2.71	OK	C2
	C	165161	3847			8	4	4476.77	629.77	2.71	OK	C2
	D	165161	4193			8	4	4476.77	283.77	2.71	OK	C2
	E	126451	3339			12		3769.91	430.91	2.98	OK	C1
B	A'	99315	1547			8		2513.27	966.27	2.53	OK	C0
	A	126451	2245			12		3769.91	1524.91	2.98	OK	C1
	B	165161	1948			8	4	4476.77	2528.77	2.71	OK	C2
	C	165161	1614			8	4	4476.77	2862.77	2.71	OK	C2
	D	165161	2085			8	4	4476.77	2391.77	2.71	OK	C2
	E	126451	2099			12		3769.91	1670.91	2.98	OK	C1
B	A'	99315	2238			8		2513.27	275.27	2.53	OK	C0
	A	126451	1321			12		3769.91	2448.91	2.98	OK	C1
	B	165161	1321			8	4	4476.77	3155.77	2.71	OK	C2
	C	165161	1321			8	4	4476.77	3155.77	2.71	OK	C2
	D	165161	1321			8	4	4476.77	3155.77	2.71	OK	C2
	E	126451	1336			12		3769.91	2433.91	2.98	OK	C1
RF												
	B	165161	1321			8	4	4476.77	3155.77	2.71	OK	C2
	C	165161	1321			8	4	4476.77	3155.77	2.71	OK	C2
	D	165161	1321			8	4	4476.77	3155.77	2.71	OK	C2

COLUMN REINFORCEMENT DETAILS												
Concrete Grade : M25, Reinforcement: Fe500												
		Column Area	Main Rebar									
			A_{st} Req.	12	16	20	25	A_{st} Pro.		% of Rebar	Remarks	Notation
				113.10	201.06	314.16	490.87					
Grid 2-2												
B	A'	99315	795			8		2513.27	1718.27	2.53	OK	C0
	A	126451	1012			8	4	4476.77	3464.77	3.54	OK	C3
	B	165161	1321			8	4	4476.77	3155.77	2.71	OK	C2
	C	165161	1321			8	4	4476.77	3155.77	2.71	OK	C2
	D	165161	1321			8	4	4476.77	3155.77	2.71	OK	C2
	E	126451	1012			8	4	4476.77	3464.77	3.54	OK	C3
GF	A'	99315	1481			8		2513.27	1032.27	2.53	OK	C0
	A	126451	3992			8	4	4476.77	484.77	3.54	OK	C3
	B	165161	4027			8	4	4476.77	449.77	2.71	OK	C2
	C	165161	3694			8	4	4476.77	782.77	2.71	OK	C2
	D	165161	4226			8	4	4476.77	250.77	2.71	OK	C2
	E	126451	4369			8	4	4476.77	107.77	3.54	OK	C3
1F	A'	99315	1574			8		2513.27	939.27	2.53	OK	C0
	A	126451	3285			12		3769.91	484.91	2.98	OK	C3
	B	165161	2708			12		3769.91	1061.91	2.28	OK	C2
	C	165161	2460			12		3769.91	1309.91	2.28	OK	C2
	D	165161	2832			12		3769.91	937.91	2.28	OK	C2
	E	126451	3217			12		3769.91	552.91	2.98	OK	C3
2F												
	A	126451	2123		4	8		3317.52	1194.52	2.62	OK	C3
	B	165161	1323		4	8		3317.52	1994.52	2.01	OK	C2
	C	165161	1321		4	8		3317.52	1996.52	2.01	OK	C2
	D	165161	1321		4	8		3317.52	1996.52	2.01	OK	C2
	E	126451	1815		4	8		3317.52	1502.52	2.62	OK	C3
RF												
	B	165161	1321		8	4		2865.13	1544.13	1.73	OK	C2
	C	165161	1321		8	4		2865.13	1544.13	1.73	OK	C2
	D	165161	1384		8	4		2865.13	1481.13	1.73	OK	C2

COLUMN REINFORCEMENT DETAILS												
Concrete Grade : M25, Reinforcement: Fe500												
		Column Area	Main Rebar									
			A_{st} Req.	12	16	20	25	A_{st} Pro.		% of Rebar	Remarks	Notation
				113.10	201.06	314.16	490.87					
Grid 3-3												
B												
	A	126451	1012			12		3769.91	2757.91	2.98	OK	C1
	B	126451	1012			12		3769.91	2757.91	2.98	OK	C1
	C	126451	1012			12		3769.91	2757.91	2.98	OK	C1
	D	126451	1012			12		3769.91	2757.91	2.98	OK	C1
	E	126451	1012			8	4	4476.77	3464.77	3.54	OK	C3
GF												
	A	126451	3440			12		3769.91	329.91	2.98	OK	C1
	B	126451	2995			12		3769.91	774.91	2.98	OK	C1
	C	126451	2852			12		3769.91	917.91	2.98	OK	C1
	D	126451	3330			12		3769.91	439.91	2.98	OK	C1
	E	126451	3712			8	4	4476.77	764.77	3.54	OK	C3
1F												
	A	126451	1948		4	8		3317.52	1369.52	2.62	OK	C1
	B	126451	1814		4	8		3317.52	1503.52	2.62	OK	C1
	C	126451	1695		4	8		3317.52	1622.52	2.62	OK	C1
	D	126451	2111		4	8		3317.52	1206.52	2.62	OK	C1
	E	126451	2079			12		3769.91	1690.91	2.98	OK	C3
2F												
	A	126451	1135		8	4		2865.13	1730.13	2.27	OK	C1
	B	126451	1299		8	4		2865.13	1566.13	2.27	OK	C1
	C	126451	1293		8	4		2865.13	1572.13	2.27	OK	C1
	D	126451	1402		8	4		2865.13	1463.13	2.27	OK	C1
	E	126451	1159		4	8		3317.52	2158.52	2.62	OK	C3

Beam Design Summary

Beam Details (GF) Concrete Grade : M25, Reinforcement Bar: FE500									
			Rebar				Area	% of Steel	
Notation	Beam size	Ast Required	no	dia	no	dia	provided	Provided	Remarks
Main Beam									
Grid A'-A'	450X300	305.00	2	16			401.92	0.30	Top TH
		305.00			2	16	401.92	0.30	Bot TH
		(96.92)	1	16			200.96	0.15	Top EX
Grid A-A	450X300	305.00	2	16			401.92	0.30	Top TH
		443.00	1	12	2	16	514.96	0.38	Bot TH
		19.08	1	16			200.96	0.15	Top EX
Grid B-B	450X300	305.00	2	16			401.92	0.30	Top TH
		467.00	1	12	2	16	514.96	0.38	Bot TH
		146.08	1	16			200.96	0.15	Top EX
Grid C-C	450X300	305.00	2	16			401.92	0.30	Top TH
		477.00	1	12	2	16	514.96	0.38	Bot TH
		141.08	1	16			200.96	0.15	Top EX
Grid D-D	450X300	305.00	2	16			401.92	0.30	Top TH
		305.00			2	16	401.92	0.30	Bot TH
		70.08	1	16			200.96	0.15	Top EX
Grid E-E	450X300	305.00	2	16			401.92	0.30	Top TH
		550.00	2	12	2	16	628.00	0.47	Bot TH
		191.08	1	16			200.96	0.15	Top EX
Grid 1-1	450X300	305.00	2	16			401.92	0.30	Top TH
		427.00	1	12	2	16	514.96	0.38	Bot TH
		(23.92)	1	16			200.96	0.15	Top EX
Grid 2-2	450X300	305.00	2	16			401.92	0.30	Top TH
		305.00			2	16	401.92	0.30	Bot TH
		12.08	1	16			200.96	0.15	Top EX
Grid 3-3	450X300	305.00	2	16			401.92	0.30	Top TH
		351.00			2	16	401.92	0.30	Bot TH
		(64.92)	1	16			200.96	0.15	Top EX

Stirrup Details At Support (Beam 450x300)		
Stirrup Required	1512	mm^2/m
Bar Dia	10	mm
No. of legs	2	
Spacing Required	103.8886	mm
Spacing Provided	100	OK
	2L-10mm bars @100mm C/C	

Stirrup Details At Mid Span (Beam 450x300)		
Stirrup Required	883	mm^2/m
Bar Dia	10	mm
No. of legs	2	
Spacing Required	177.8931	mm
Spacing Provided	150	OK
	2L-10mm bars @150mm C/C	

Secondary Beam Reinforcement (350x230)						
	Ast Req.	**Provided**				
		No	**Dia**	**No**	**Dia**	**Ast**
Top	171	3	12			339.292
Bottom	171	3	12			339.292

Beam Details (1F)
Concrete Grade : M25, Reinforcement Bar: FE500

Notation	Beam size	Ast Required	Rebar				Area provided	% of Steel Provided	Remarks
			no	dia	no	dia			
Main Beam									
Grid A-A	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		766.00	2	16	2	16	803.84	0.60	Bot TH
		374.00	2	16			401.92	0.30	Top EX
Grid B-B	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		711.00	3	12	2	16	741.04	0.55	Bot TH
		477.00	3	16			602.88	0.45	Top EX
Grid C-C	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		678.00	3	12	2	16	741.04	0.55	Bot TH
		372.00	2	16			401.92	0.30	Top EX
Grid D-D	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		654.00	3	12	2	16	741.04	0.55	Bot TH
		322.00	2	16			401.92	0.30	Top EX
Grid E-E	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		784.00	2	16	2	16	803.84	0.60	Bot TH
		379.00	2	16			401.92	0.30	Top EX
Grid 1-1	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		684.00	3	12	2	16	741.04	0.55	Bot TH

		346.00	2	16			401.92	0.30	Top EX
Grid 2-2	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		514.00	2	12	2	16	628.00	0.47	Bot TH
		197.00	1	16			200.96	0.15	Top EX
Grid 3-3	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		532.00	2	12	2	16	628.00	0.47	Bot TH
		121.00	1	16			200.96	0.15	Top EX

Stirrup Details At Support (Beam 450x300)		
Stirrup Required	2605	mm^2/m
Bar Dia	10	mm
No. of legs	4	
Spacing Required	120.5986	mm
Spacing Provided	100	OK
	4L-10mm bars @100mm C/C	

Stirrup Details At Mid Span (Beam 450x300)		
Stirrup Required	1516	mm^2/m
Bar Dia	10	mm
No. of legs	4	
Spacing Required	207.2291	mm
Spacing Provided	150	OK
	4L-10mm bars @150mm C/C	

Secondary Beam Reinforcement (350x230)						
	Ast Req.	**Provided**				
		No	**Dia**	**No**	**Dia**	**Ast**
Top	179	3	12			339.292
Bottom	171	3	12			339.292

Beam Details (2F) Concrete Grade : M25, Reinforcement Bar: FE500									
			Rebar						
Notation	**Beam size**	**Ast Required**	**no**	**dia**	**no**	**dia**	**Area provided**	**% of Steel Provided**	**Remarks**
Main Beam									
Grid A'-A'	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		456.00	2	12	2	16	628.00	0.47	Bot TH
		(105.00)					-	-	Top EX
Grid A-A	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		534.00	2	12	2	16	628.00	0.47	Bot TH
		145.00	1	16			200.96	0.15	Top EX
Grid B-B	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		478.00	2	12	2	16	628.00	0.47	Bot TH
		261.00	2	16			401.92	0.30	Top EX

Grid C-C	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		495.00	2	12	2	16	628.00	0.47	Bot TH
		191.00	1	16			200.96	0.15	Top EX
Grid D-D	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		447.00	2	12	2	16	628.00	0.47	Bot TH
		101.00	1	12			113.04	0.08	Top EX
Grid E-E	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		531.00	2	12	2	16	628.00	0.47	Bot TH
		157.00	1	16			200.96	0.15	Top EX
Grid 1-1	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		472.00	2	12	2	16	628.00	0.47	Bot TH
		107.00	1	12			113.04	0.08	Top EX
Grid 2-2	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		362.00	2	12	2	16	628.00	0.47	Bot TH
		(8.00)					-	-	Top EX
Grid 3-3	450X300	305.00	2	16	2	12	628.00	0.47	Top TH
		363.00	2	12	2	16	628.00	0.47	Bot TH
		(16.00)					-	-	Top EX

Stirrup Details At Support (Beam 450x300)		
Stirrup Required	2376	mm^2/m
Bar Dia	10	mm
No. of legs	4	
Spacing Required	132.2219	mm
Spacing Provided	100	OK
	4L-10mm bars @100mm C/C	

Stirrup Details At Mid Span (Beam 450x300)		
Stirrup Required	1055	mm^2/m
Bar Dia	10	mm
No. of legs	4	
Spacing Required	297.7813	mm
Spacing Provided	150	OK
	4L-10mm bars @150mm C/C	

Secondary Beam Reinforcement (350x230)						
	Ast Req.	**Provided**				
		No	**Dia**	**No**	**Dia**	**Ast**
Top	184	3	12			339.292
Bottom	171	3	12			339.292

Beam Details (RF) Concrete Grade : M25, Reinforcement Bar: FE500									
			Rebar				Area	% of Steel	
Notation	Beam size	Ast Required	no	dia	no	dia	provided	Provided	Remarks
Main Beam									
Grid A-A	450X300	305.00	2	16			401.92	0.30	Top TH
		305.00			2	16	401.92	0.30	Bot TH
		20.08	1	12			113.04	0.08	Top EX
Grid B-B	450X300	305.00	2	16			401.92	0.30	Top TH
		437.00	1	12	2	16	514.96	0.38	Bot TH
		211.08	2	12			226.08	0.17	Top EX
Grid C-C	450X300	305.00	2	16			401.92	0.30	Top TH
		453.00	1	12	2	16	514.96	0.38	Bot TH
		196.08	1	16			200.96	0.15	Top EX
Grid D-D	450X300	305.00	2	16			401.92	0.30	Top TH
		351.00			2	16	401.92	0.30	Bot TH
		172.08	1	16			200.96	0.15	Top EX
Grid E-E	450X300	305.00	2	16			401.92	0.30	Top TH
		305.00			2	16	401.92	0.30	Bot TH
		8.08	1	12			113.04	0.08	Top EX
Grid 1-1	450X300	305.00	2	16			401.92	0.30	Top TH
		322.00			2	16	401.92	0.30	Bot TH
		85.08	1	16			200.96	0.15	Top EX
Grid 2-2	450X300	305.00	2	16			401.92	0.30	Top TH
		305.00			2	16	401.92	0.30	Bot TH
		27.08	1	12			113.04	0.08	Top EX
Grid 3-3	450X300	305.00	2	16			401.92	0.30	Top TH
		305.00			2	16	401.92	0.30	Bot TH
		(89.92)	1	12			113.04	0.08	Top EX

Stirrup Details At Support (Beam 450x300)		
Stirrup Required	1550	mm^2/m
Bar Dia	10	mm
No. of legs	2	
Spacing Required	101.3417	mm
Spacing Provided	100	OK
	2L-10mm bars @100mm C/C	

Stirrup Details At Mid Span (Beam 450x300)		
Stirrup Required	982	mm^2/m
Bar Dia	10	mm
No. of legs	2	
Spacing Required	159.9589	mm
Spacing Provided	150	OK
	2L-10mm bars @150mm C/C	

Secondary Beam Reinforcement (350x230)						
	Ast Req.	**Provided**				
		No	**Dia**	**No**	**Dia**	**Ast**
Top	173	3	12			339.292
Bottom	173	3	12			339.292

Beam Details (SC)
Concrete Grade : M25, Reinforcement Bar: FE500

Notation	Beam size	Ast Required	Rebar				Area provided	% of Steel Provided	Remarks
			no	dia	no	dia			
Main Beam									
Grid B-B	450X300	305.00	2	16			401.92	0.30	Top TH
		305.00			2	16	401.92	0.30	Bot TH
		(32.92)	1	12			113.04	0.08	Top EX
Grid C-C	450X300	305.00	2	16			401.92	0.30	Top TH
		305.00			2	16	401.92	0.30	Bot TH
		(57.92)	1	12			113.04	0.08	Top EX
Grid D-D	450X300	305.00	2	16			401.92	0.30	Top TH
		305.00			2	16	401.92	0.30	Bot TH
		(18.92)	1	12			113.04	0.08	Top EX
Grid 1-1	450X300	305.00	2	16			401.92	0.30	Top TH
		305.00			2	16	401.92	0.30	Bot TH
		(96.92)	1	12			113.04	0.08	Top EX
Grid 2-2	450X300	305.00	2	16			401.92	0.30	Top TH
		305.00			2	16	401.92	0.30	Bot TH
		(96.92)	1	12			113.04	0.08	Top EX

Stirrup Details At Support (Beam 450x300)		
Stirrup Required	971	mm^2/m
Bar Dia	8	mm
No. of legs	2	
Spacing Required	103.5334	mm
Spacing Provided	100	OK
	2L-8mm bars @100mm C/C	

Stirrup Details At Mid Span (Beam 450x300)		
Stirrup Required	606	mm^2/m
Bar Dia	8	mm
No. of legs	2	
Spacing Required	165.8927	mm
Spacing Provided	150	OK
	2L-8mm bars @150mm C/C	

Secondary Beam Reinforcement (350x230)						
	Ast Req.	**Provided**				
		No	**Dia**	**No**	**Dia**	**Ast**
Top	173	3	12			339.292
Bottom	173	3	12			339.292

Mat Foundation Detail			
Mat Foundation Depth	**500**	**mm**	
Foundation Concrete	**M20**		
Foundation Rebar	**FE500**		
Max Pressure	**107.07**	**KN/m²**	(DL+LL)
Top Ast Along X Direction Required		811	mm²/m
Bar Dia		16	mm
Spacing Required		247.9185	mm
Spacing Provided		150	OK
		16mm bars @150mm C/C	
Bottom Ast Along X Direction Required		1204	mm²/m
Bar Dia		16	mm
Spacing Required		166.995	mm
Spacing Provided		150	OK
		16mm bars @150mm C/C	
Top Ast Along Y Direction Required		883	mm²/m
Bar Dia		16	mm
Spacing Required		227.7032	mm
Spacing Provided		150	OK
		16mm bars @150mm C/C	
Bottom Ast Along Y Direction Required		15.2	mm²/m
Bar Dia		16	mm
Spacing Required		109.5705	mm
Spacing Provided		100	OK
		16mm bars @100mm C/C	

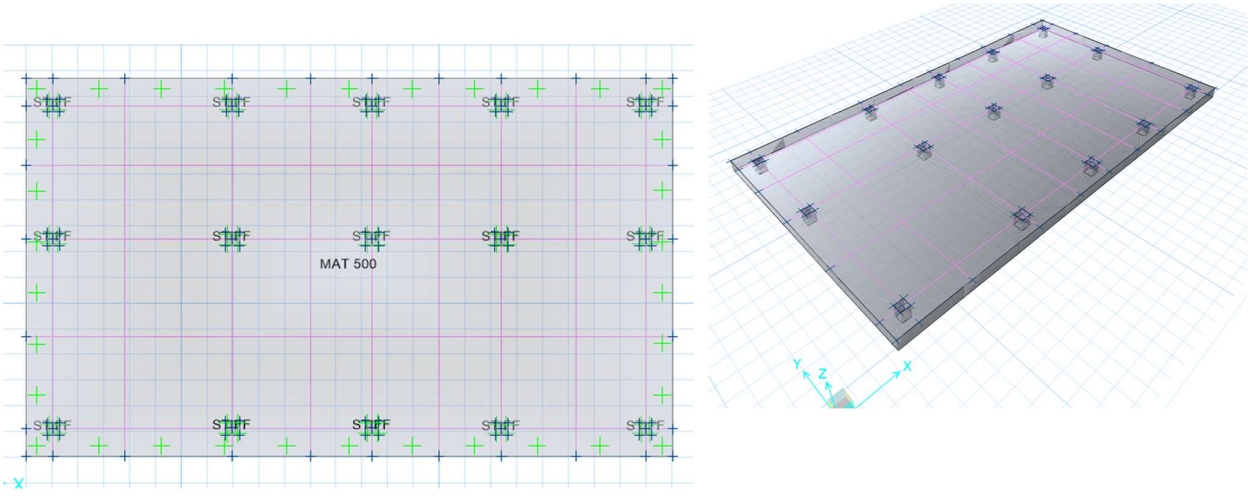


Fig: Mat Foundation Model (SAFE 16)

Foundation Detail			
Foundation Depth	**400**	**mm**	
Foundation Concrete	**M20**		
Foundation Rebar	**FE500**		
Bottom Ast Along X Direction Required		595	mm^2/m
Bar Dia		12	mm
Spacing Required		190.0796	mm
Spacing Provided		150	OK
		12mm bars @150mm C/C	
Bottom Ast Along Y Direction Required		595	mm^2/m
Bar Dia		12	mm
Spacing Required		190.0796	mm
Spacing Provided		150	OK
		12mm bars @150mm C/C	

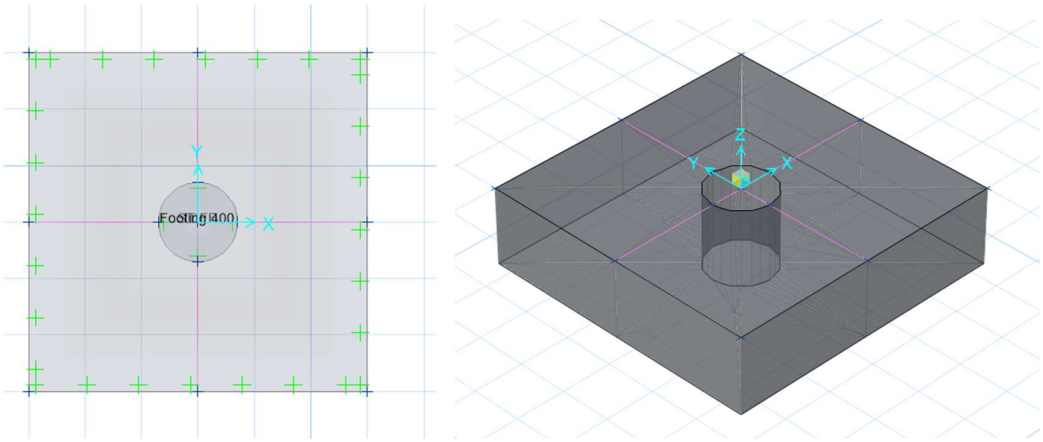


Fig: Foundation Model (SAFE 16)

Shear Wall Detail **Shear Wall Thickness: 200 mm**

Concrete: M25 **Rebar: Fe500**

Shear Wall Reinforcement (Longitudinal)				**Shear Wall Reinforcement (Transverse)**			
Ast Required	2805	mm^2		Ast Required	500	mm^2/m	
Length	5521	mm		Length	5521	mm	
Bar Size	10	mm		Bar Size	8	mm	
Spacing	309.1753			Spacing	197.8956		
Spacing Provided	150	OK		Spacing Provided	150	OK	
Longitudinal Bar				**Transverse Bar**			
10mm bars at	150mm c/c at both sides			8mm bars at	150mm c/c at both sides		

ETABS Shear Wall Design

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
GF	P6	1803.4	2760.9	5521.8	203.2	0.758

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
25000	25	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	1803.4	0	1803.4	5521.8	5521.8	203.2
Bottom	Leg 1	1803.4	0	1803.4	5521.8	5521.8	203.2

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm^2)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm^2
Top	2805	0.0025	0.0021	DL+0.3LL-RSy	401.3115	-8.0262	-537.7365	1122021
Bottom	2805	0.0025	0.0021	DL+0.3LL-RSy	669.5317	-13.3906	-164.6426	1122021

Shear Design

Station Location	ID	Rebar mm^2/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	508	DL+0.3LL-RSy	343.9486	846.4604	-816.2074	269.8843	1079.6905

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Bottom	Leg 1	508	DL+0.3LL-RSy	313.5826	405.6113	-595.168	269.0389	1078.8451

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	0	DL+0.3LL+RSy	401.3115	-537.7365	0.88	5
Top–Right	Leg 1	0	DL+0.3LL+RSy	540.4653	216.592	0.69	5
Bottom–Left	Leg 1	0	DL+0.3LL+RSy	669.5317	-164.6426	0.76	5
Botttom–Right	Leg 1	0	DL+0.3LL+RSy	699.6597	174.5746	0.79	5