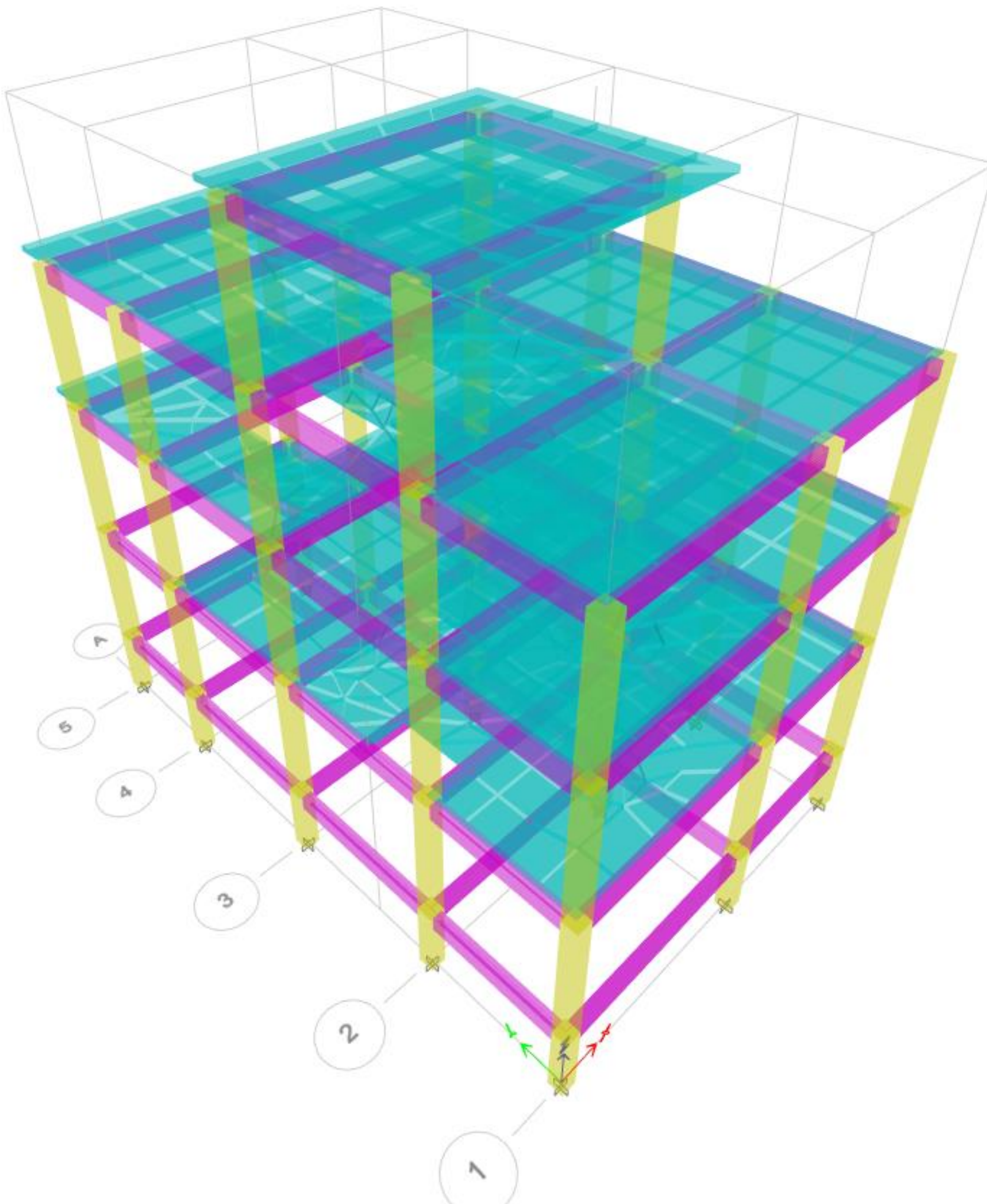
A REPORT

ON

STRUCTURAL ANALYSIS & DESIGN

OF RESIDENTIAL BUILDING



Designed By:
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SUMMARY

A	**General Information:**		
A.1	Type of Building:	Residential	
	Structure System:	RCC Frame Structure	
B	**Geometrical Configuration of Building:**		
B.1	No. of Block:	1	
B.2	No. of Story:	G+2 with Staircase Cover	
B.3	Story Height:		
	Floor Height	3.2	m
	Total Height of the Building from Ground Level	12.8	m
B.4	No. of Staircase:	2	
C	**Structural Analysis and Design Procedure:**		
C.1	Structural Analysis Software:	**ETABS V 18.1.0 and SAFE 2016 [Verified Manually]**	
C.2	Structural System:	Moment Resisting Concrete Frame	
C.3	Foundation System:	Balanced, Corner and Isolated Footing	
C.4	Loading Parameters:		
	i. Dead Load:	As per IS 875 (Part 1)-1987	
	ii. Live Load:	As per IS 875 (Part 2)-1987	
	iii. Earthquake Load	As per NBC 105:2020	
C.5	Concrete Grade Used:	M-20	MPa
C.6	Reinforcement Grade Used:	Fe-500 (TMT)	MPa
	Reinforcement Grade Used for shear:	Fe-500 (TMT)	MPa
C.7	Mechanical Properties of other construction materials used:		
	i. Brick Masonry weight	19.2	KN/m3
	ii. Steel Section	78.5	KN/m3
C.8	**Seismic Load (NBC 105:2020):**		
C.8.1	Zone Factor (Z):	0.35	Cl 4.1.4
C.8.2	Importance Factor(I):	1	Cl 4.1.5
C.8.4	Damping:	0.05	Cl 8.1.1.5
C.8.5	**Crack Section Analysis**	**Flexural Stiffness**	**Shear Stiffness**
	Beam	0.35	0.4
	Column	0.7	0.4
C.8.9	Load Combination Considered:	(NBC 105:2020) [Cl 3.6.1]	
		1.2DL+1.5LL	

		DL+λLL±Ex
		DL+λLL±Ey
		Note: λ = 0.3 (without store)
		Note: λ = 0.6 (with store)
D.	**Reinforced Concrete Design**	
D.1	Concrete Design code Referred:	IS 456:2000
D.2	Ductile Detailing code Referred:	IS 13920:2016 and NBC 105:2020
D.3	Typical design of structural elements foundation, slab, staircase, etc:	IS 456:2000

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LIST OF FIGURES

1 BACKGROUND

Building is located at Italitar-6, Budhanilkantha Municipality, Kathmandu, Nepal. The proposed Building is for Residential use. The design was carried out along with analytical modeling in compliance to NBC 105:2020.

The objective of this report is to check the building whether they are technically fit or not according to Nepal National Building Codes & other required codes. For these Purpose, the structural analysis tool EABS V 18.1.0 was used.

The design has been carried out using NBC 105: 2020, "Seismic Design of Buildings in Nepal" and ETABS (Version 18.1.0) is a product of Computer and Structures, Inc (CSI) a Structural and Earthquake Engineering Software. This software was used to create the mathematical model of the Burj Khalifa, currently the World's Tallest Building.

ETABS version 18.1.0 is used for Seismic analysis of three-dimensional structures, in which the spatial distribution of the mass and stiffness of the structure was adequate for the calculation of the significant features of structures. Frame section is used in modeling of frame defined as section design for column and thin shell element is used in modeling of slabs. Dead load of wall are calculated manually and applied to beam and slab where necessary.

Design Excel sheet is used for Design of footing. Bearing capacity is checked for service load (DL+LL) whereas analysis is done for ultimate load 1.5(DL+LL). The structural elements of reinforced concrete were designed to Limit State Theory. The major structural elements were automatically designed in the programmer to IS 456:2000 for reinforced concrete structures elements, while the certain design calculations for those not properly figured due to the limitation of program were manually carried out in accordance with the relevant latest standards.

2 MODELING AND ANALYSIS

Finite element modeling of the building, including modeling assumptions of materials, sections, and components properties. The structural system adopted in the building is the system consisting of Special moment resisting frame. The structural system is believed to perform best under seismic loading. To ensure the ductile response of the building during seismic event the overall structure has been detailed according to the latest code provision (e.g., IS 13920 and NBC 105:2020). One of the fundamental attributes required for the proper seismic response of a building during earthquake motions is that its lateral load resisting members should be tied together to act as a single unit. This provision is intended to provide continuous lateral load system that ties all parts of the structures together. It also provides for proper connection between the members of the system to transmit additional seismic forces safely.

A vertical lateral force-resisting system shall be continuous and should run from the foundation to the top of the building. The flow of seismic forces in the structure should be such that these forces are delivered through structural connections to horizontal diaphragms; the diaphragms then distribute these forces to the vertical lateral force resisting elements such as frames; these vertical elements transfer the forces into foundation; and foundation transfers the forces into the soil. The presence of discontinuity in a load path makes a building inadequate of carrying seismic forces. Therefore, the design professional should identify any gaps in the load paths and then take necessary mitigation measures to complete the load path. A continuous load path has been maintained in this building. The provision of redundancy is recommended because of the uncertainties involved in the magnitude of both seismic loads and member capacities. If any member of a lateral force resisting system fails, the redundancy of the structure will help ensure that there is another member present in the lateral force resisting system that will contribute lateral resistance to the structure. Redundancy also provides multiple locations for potential yielding, possibly distributing inelastic activity within the structure and improving the ductility and energy dissipation.

Typical characteristics of redundancy include multiple lines of resistance to distribute the lateral forces uniformly throughout a structure to reduce the shear and axial demands on any one element. If enough redundancy is not present in the structure, an analysis is required to demonstrate the adequacy of the lateral force elements. A distinction should be made between redundancy and adequacy. Simple meaning of redundancy is “more than one”. One line of moment frame can be adequate to carry the entire design lateral load, but is not redundant.

The structural elements of reinforced concrete are designed to Limit State Theory, while the structural steel elements are designed to the Permissible / Working Stress Theory if require. The major structural elements are automatically designed by the feature included in the program to IS 456 and IS 800 for reinforced concrete structures and structural steel elements respectively, while the certain design calculations for those not properly figured due to the limitation of program are manually carried out in accordance with the relevant latest standards. The following matrix shows general architectural configuration and geotechnical investigation information.

3 FLOOR PLAN AND SECTION

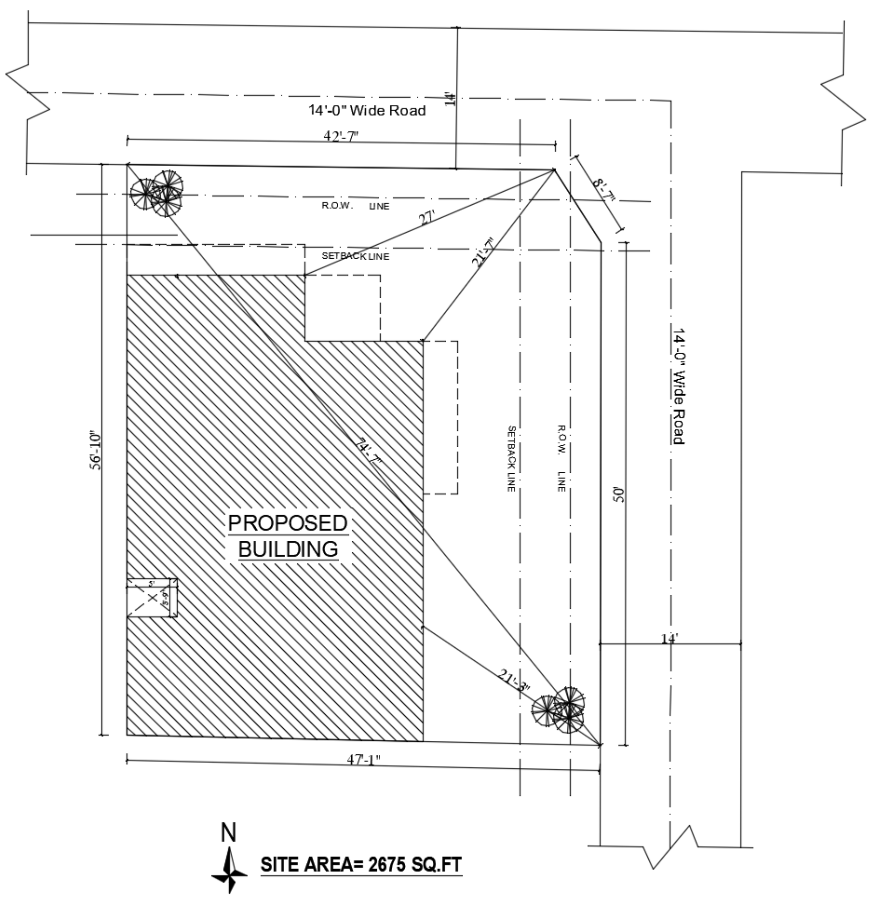


Figure 1: Site Plan

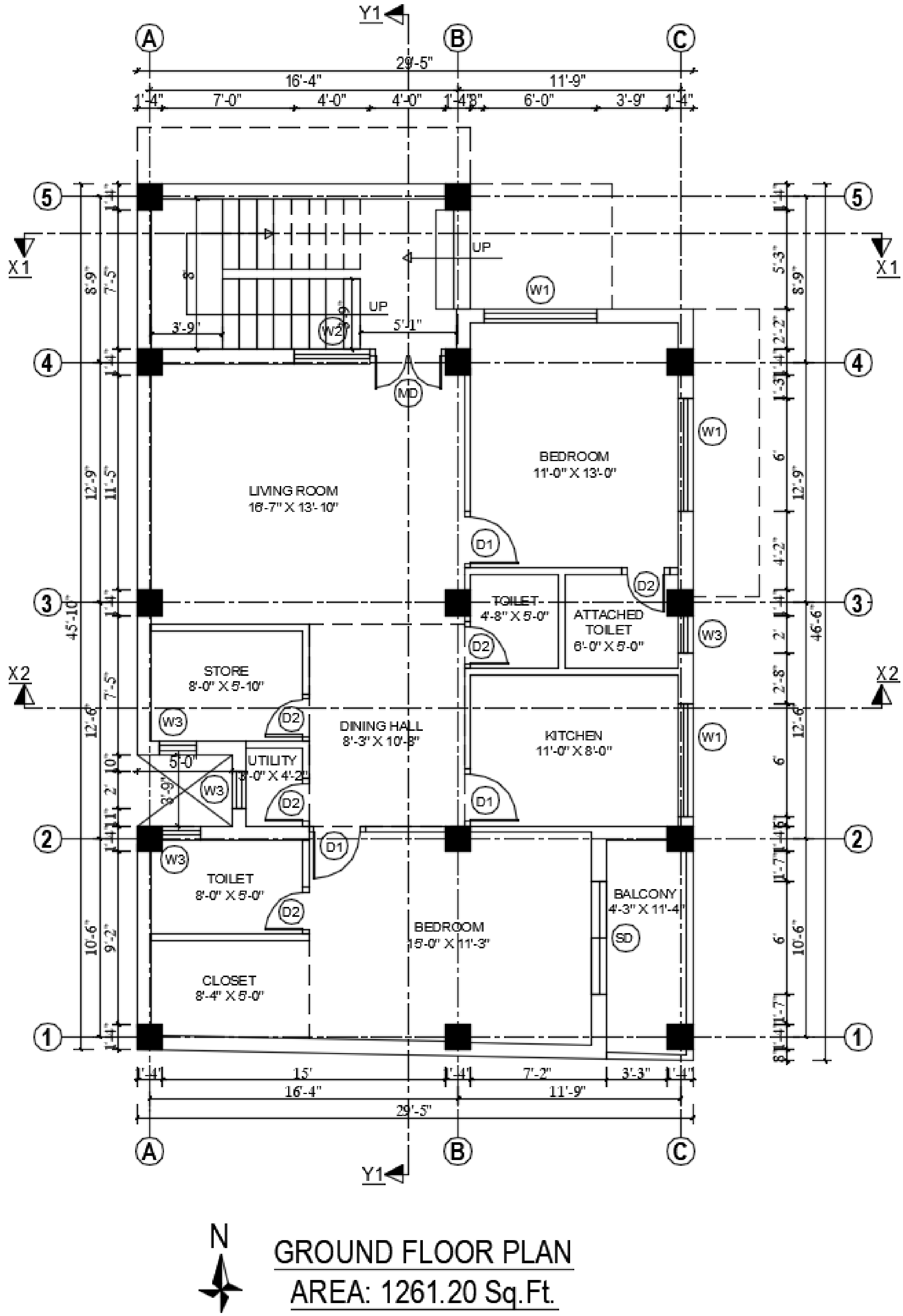


Figure 2: Floor Plan

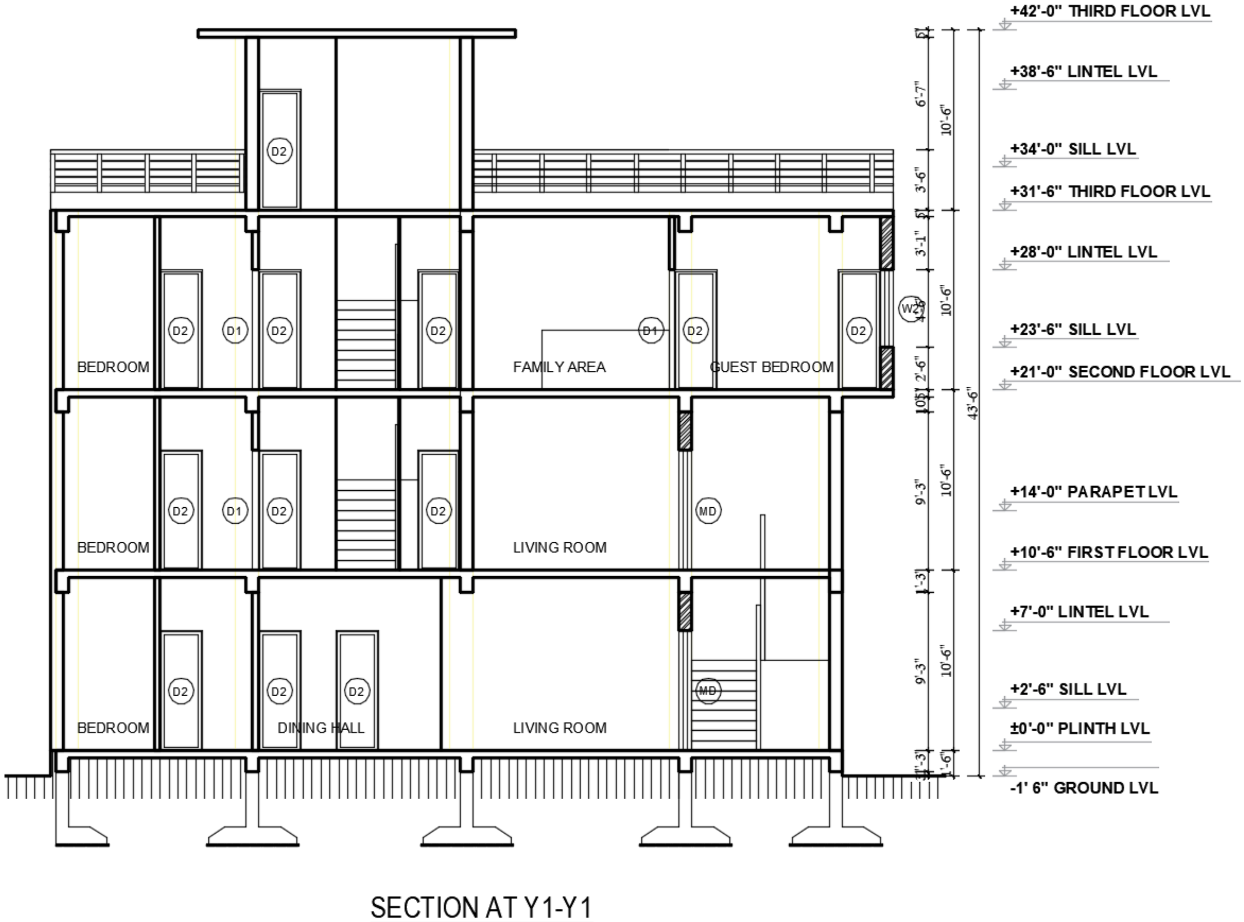


Figure 3: Cross-Section of the Building

4 EXTERNAL LOAD CALCULATION

Gravity	Super Dead Load	IS 875-part 1	Density Kn/m^3	Height (m)	Thickness (m)	Total Load	Unit
	Full Brick Masonry	Table 1-36,13,24,40	18.85	2.82	0.230	12.23	
	Wall Plaster	Table 1- 25,42	20.40	2.82	0.027	1.56	
WL	Full Brick Masonry Without opening					**13.79**	**kN/m**
WL	Full Brick Masonry With opening		75% without opening--as per designer			**10.34**	**kN/m**
	Full Brick Masonry Parapet wall		18.85	0.9	0.12	2.04	
	Wall Plaster Parapet wall		20.40	0.9	0.027	0.50	
WL	Parapet wall					**2.54**	KN/m
	Partition wall	Table-2 ,9				1.91	KN/m^2
	Half Brick Masonry		18.85	2.82	0.12	6.37	
	Wall Plaster		20.40	2.82	0.027	1.55	
WL	Half Brick Masonry Without opening					**7.92**	KN/m
WL	Half Brick Masonry With opening		75% without opening--as per designer			**5.94**	KN/m
	Ceiling 13mm Cement plaster	Table 2 -1				0.25	KN/m^2
	Ceiling 6mm Cement plaster		20.40	1	0.006	0.13	KN/m^2
	concrete Screeding 38mm	Table 1- 20	20.50	1	0.038	0.78	KN/m^2
	Granite 18mm	Table 1- 47	27.45	1	0.018	0.50	KN/m^2

	Marble 18mm	Table 1- 47	20.50	1	0.018	0.37	KN/m^2
	Mortar sceeding 10mm	Table 2 -8				0.21	KN/m^2
	clay floor tile 25.4mm Exclude Screeding	Table 2 -7				0.20	KN/m^2
	Water Proofing 10mm bitumen's Macadam	Table 2 -8				0.22	KN/m^2
FF	Floor Finishing					**1.44**	KN/m^2
RF	Roof Finishing			0.9		**1.66**	KN/m^2
	Store material for store Room	Table 3					
WT	Water tank load 1000Lit =1m3	Table 2 -54	**9.81**				
	Water tank weight 50kg		**0.49**				
	Total weight dia of tank 1m		**0.78**			**11.08**	KN/m^2
Gravity	**Live Load**	**IS 875-part 2**				**Total Load**	**Unit**
	All rooms and Kitchen	Table 1 -clause 3				2	KN/m^2
	Toilet and Bathrooms	Table 1 -clause 3				2	KN/m^2
	Corridors, passages, Staircase including Fire escape and Store room	Table 1 -clause 3				3	KN/m^2
	Balconies	Table 1 -clause 3				3	KN/m^2
	Accessible roof	Table 2 -clause 4				1	KN/m^2
	Inaccessible roof for mumty	Table 2 -clause 4				0.75	KN/m^2
	Roof used for promenade for terrace	Table 2 -clause 4				3	KN/m^2

	---value not in code as per designer			
	Roof used for incidental assembly (without fix seat)	Table 2 -clause 4	5	KN/m^2

5 EARTHQUAKE LOAD

CALCULATION OF SESMIC COEFFICENT AS PER NBC 105-2020		
INPUT		
Location of Building	**Kathmandu**	
Type of Structure	**Moment Resisting Frame Systems**	
Type of Building	**Reinforced Concrete Moment Resisting Frame**	
Seismic Zoning Factor (Z) Table 4-5 NBC (105-2020)	**0.35**	
Importance Classes	1	
Structure	Ordinary Structures (those not falling in classes II and III)	
Importance Factor (I) Table 4-6 NBC (105-2020)	**1**	
5.3 DUCTILITY FACTOR (Rμ)		
5.3.1 Ultimate Limit State (Rμ)	**4**	
5.3.2 Serviceability Limit State (Rs)	**1**	
5.4 OVERSTRENGTH FACTOR (Ωu)		
5.4.1 Ultimate Limit State Ωu	**1.5**	
5.4.2 Serviceability Limit State Ωs	**1.25**	
H = Height of the building from foundation or from top of a rigid basement. (m)	**14.45**	
Method of Analysis	**Equivalent Static Method**	
Site Subsoil Category	**C**	
PERIODS OF VIBRATION		

Empirical Equations	T1 = kt H ¾ .... 5.1(2)	**0.552 Sec**
Type of Structure	**for Moment Resisting Concrete Frame**	**0.075**
Amplification of Approximate Period The approximate fundamental time period calculated using empirical equation in section 5 1.2 shall be increased by a factor of 1.25.	1.25	
The periods of vibration T	**0.69 Sec**	
Ch(T) = Spectral Shape factor as per 4.1.2 0=<Ti<=6	$Ch(T)$={ 1+(α−1)×TTa if T<$Ta\alpha$ if Ta≤T≤$Tc\alpha$[K+(1−K)(TcT)2](TcT)2 if Tc≤T≤6 …4.1(2)	
Lower Period of the Flat Part of the Spectrum	T_a =	0
Upper Period of the Flat Part of the Spectrum	T_c =	1
Peak Spectral Acceleration Normalized by PGA	α =	2.5
Coefficient to control the descending branch of the Spectrum	K =	1.8
	Ch(T)	**2.50**
ELASTIC SITE SPECTRA FOR HORIZONTAL LOADING		
Elastic Site Spectra	C (T1) =Ch(T1) Z I	**0.875**
ELASTIC SITE SPECTRA FOR SERVICEABILITY LIMIT STATE	Cs (T) = 0.20 C (T) .... 4.2(1)	**0.175**
HORIZONTAL BASE SHEAR COEFFICIENT For Equivalent Static Method		
6.1.1 Ultimate Limit State	Cd(T1)=C(T1)/Rμ x Ωu ……………………..6.1(1)	**0.146**
6.1.2 Serviceability Limit State	Cd(T1)=Cs(T1) /Ωs………………………..6.1(2)	**0.140**
HORIZONTAL SEISMIC BASE SHEAR		
V = Cd (T1) W .... 6.2(1)		

VERTICAL DISTRIBUTION OF SEISMIC FORCES	
Fi=WihikΣWihikni x V ……………………………………………….……6.3(1)	
k= an exponent related to the structural period as follows:	**1.13**

SPECTRAL SHAPE FACTOR FOR RESPONSE SPECTRUM METHOD

Soil Type	D	
Lower Period of the Flat Part of the Spectrum	**T_a =**	0.1
Upper Period of the Flat Part of the Spectrum	**T_c =**	1
Peak Spectral Acceleration Normalized by PGA	**α =**	2.5
Coefficient to control the descending branch of the Spectrum	**K =**	1.8

$$C_h(T) = \begin{cases} 1 + (\alpha - 1) \times \frac{T}{T_a} \; if \; T < T_a \\ \alpha \; if \; T_a \le T \le T_c \\ \alpha \left[K + (1-K)\left(\frac{T_c}{T}\right)^2\right]\left(\frac{T_c}{T}\right)^2 \; if \; T_c \le T \le 6 \end{cases} \quad \ldots 4.1(2)$$

Where,

α - peak spectral acceleration normalized by PGA

T_a and T_c - the lower and upper periods of the flat part of the spectrum

K – Coefficient that controls the descending branch of the spectrum

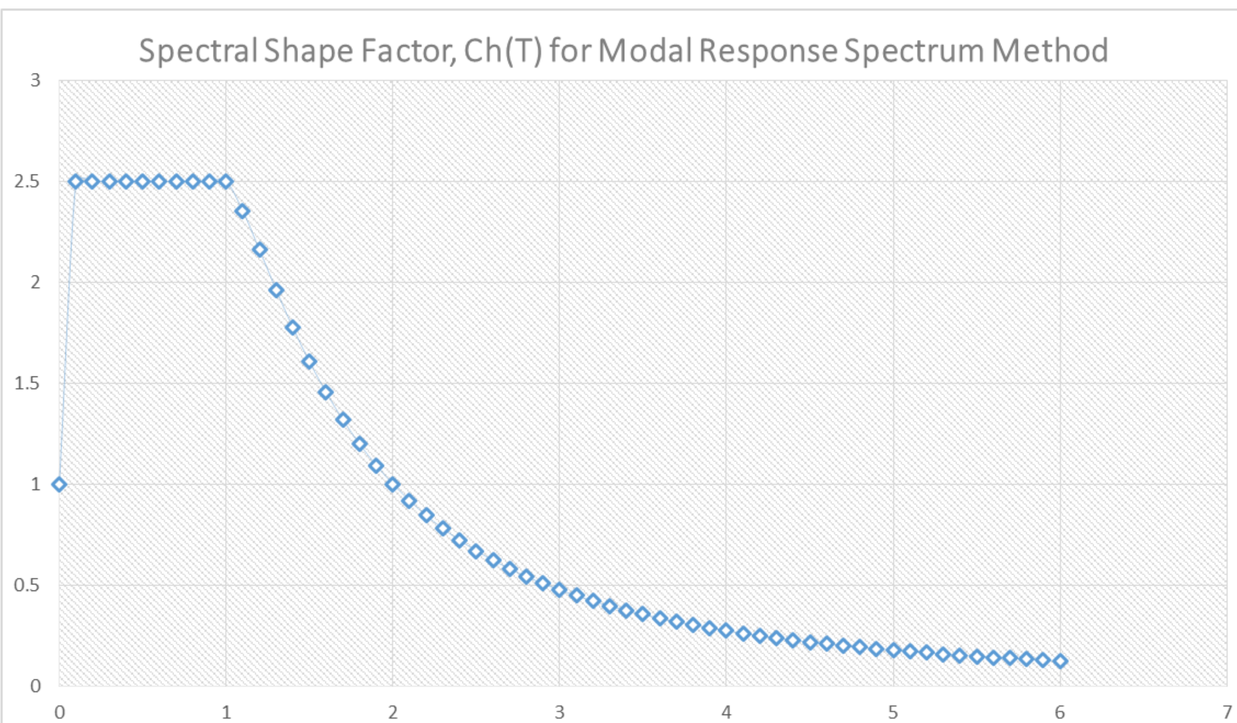


Figure 4: Spectral Shape Factor

6 LOAD COMBINDATION

Where Seismic Load effect is combined with other load effects, the following load combination has been adopted.

1.2DL+1.5LL

DL+λLL±E

Where;

DL = Dead load

LL = Live load

EL = Earthquake load

λ = 0.3 for other than Storage facilities

7 EFFECTIVE STIFFNESS OF CRACKED SECTIONS

A rational analysis shall be performed in arriving at the elastic flexural and shear stiffness properties of cracked concrete and masonry elements. In absence of such analysis, the effective stiffness of cracked sections shall be taken from NBC 105:2020.

S No.	Component	Flexural Stiffness	Shear Stiffness
1	Beam	$0.35\ E_c\ I_g$	$0.40\ E_c\ A_w$
2	Columns	$0.70\ E_c\ I_g$	$0.40\ E_c\ A_w$
3	Wall—cracked	$0.50\ E_c\ I_g$	$0.40\ E_c\ A_w$
4	Wall—uncracked	$0.80\ E_c\ I_g$	$0.40\ E_c\ A_w$

8 ETABS MODELING

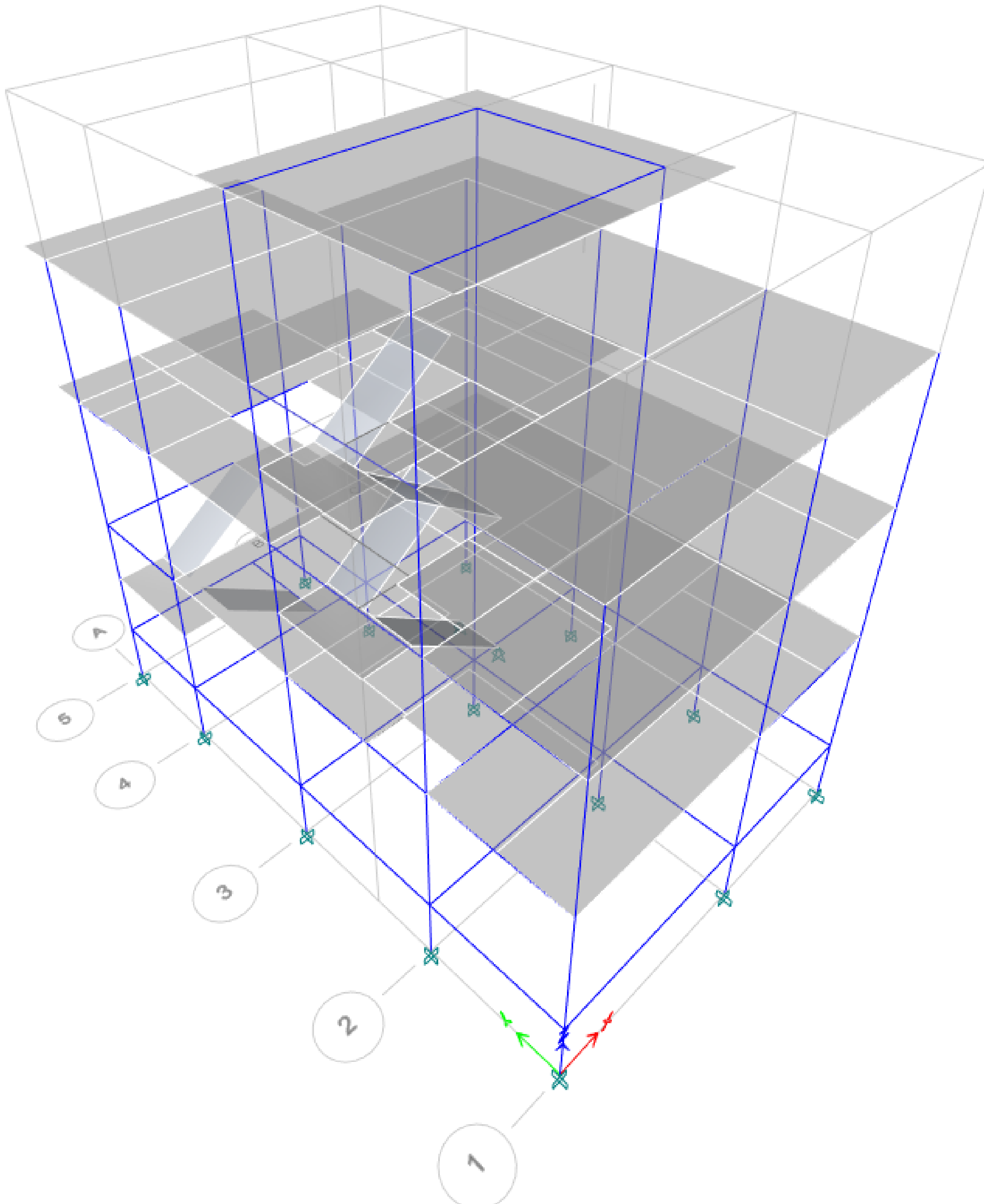


Figure 5: 3D Modeling in ETABS

9 FRAME MEMBERS

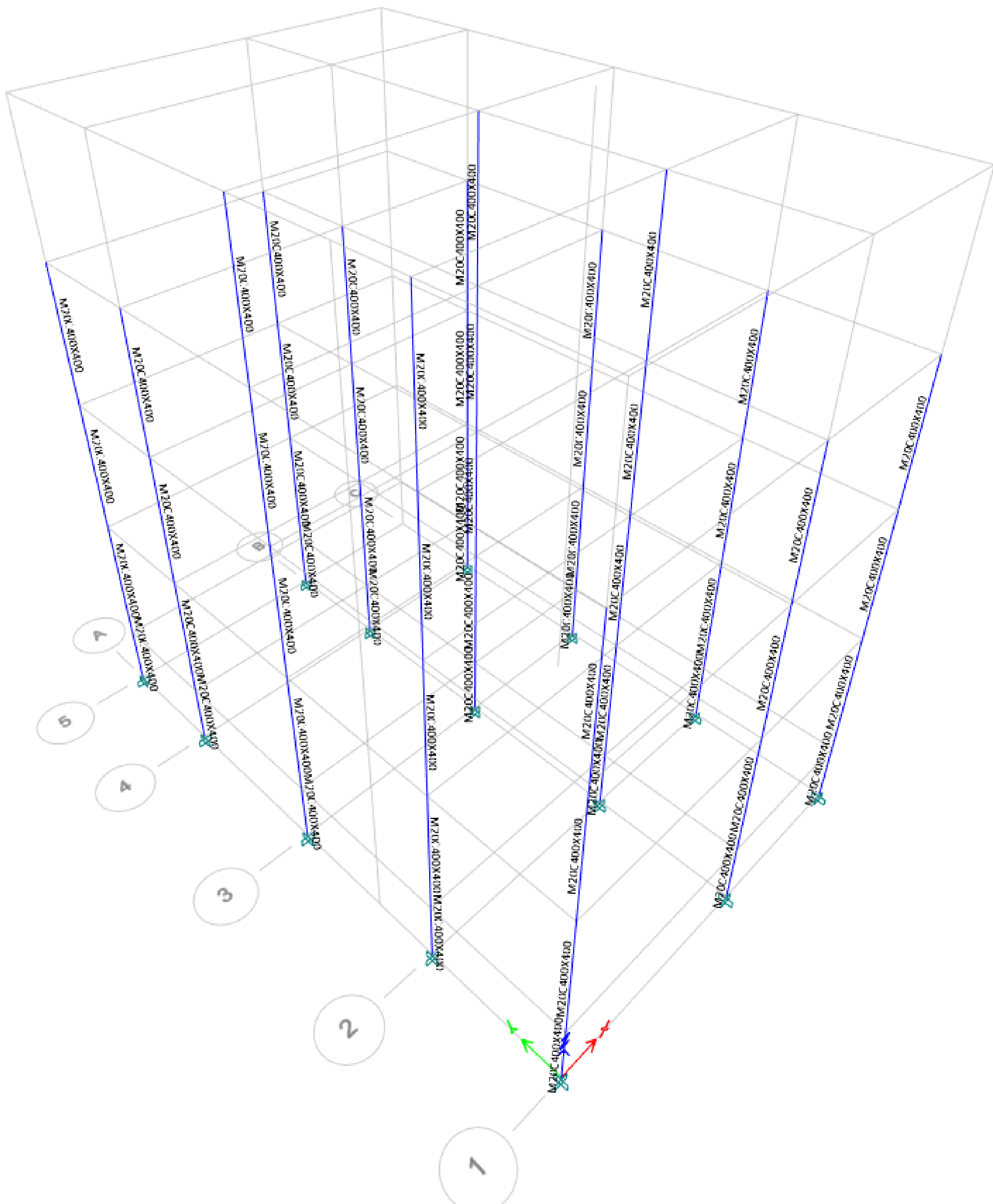


Figure 6: Column Size Assigned

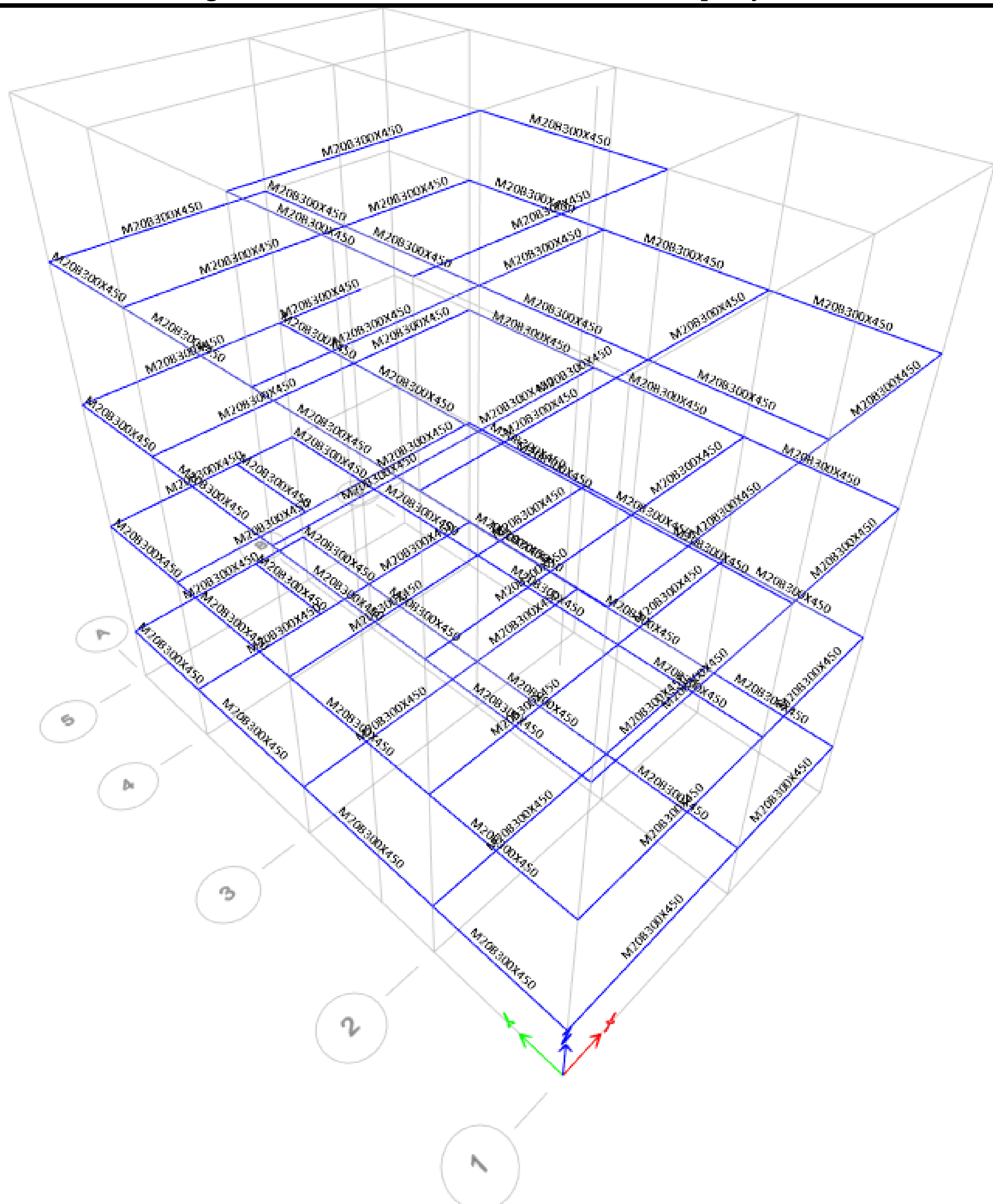


Figure 7: Beam Size Assigned

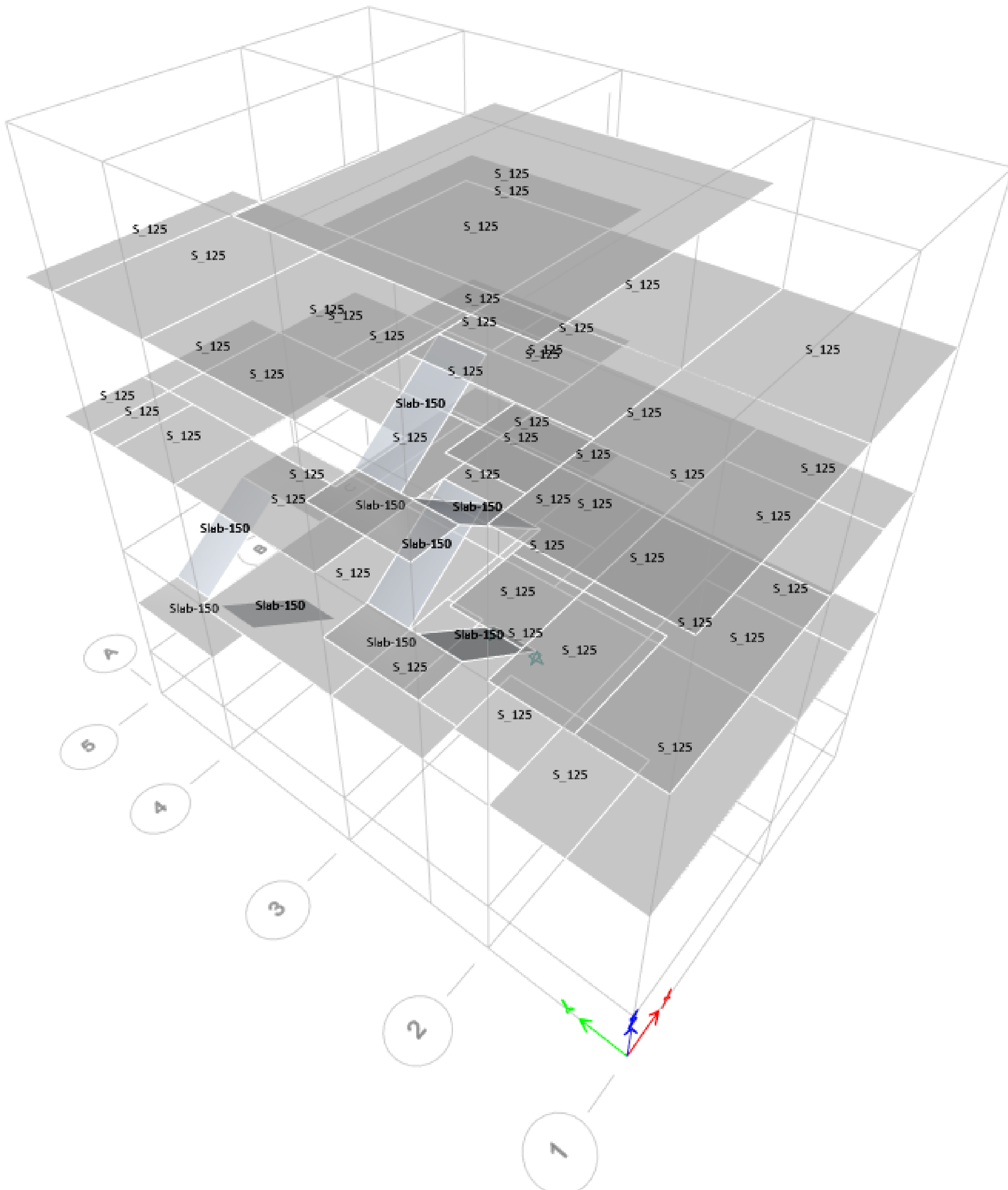


Figure 8: Slab Size Assigned

10 LOAD ASSIGNED

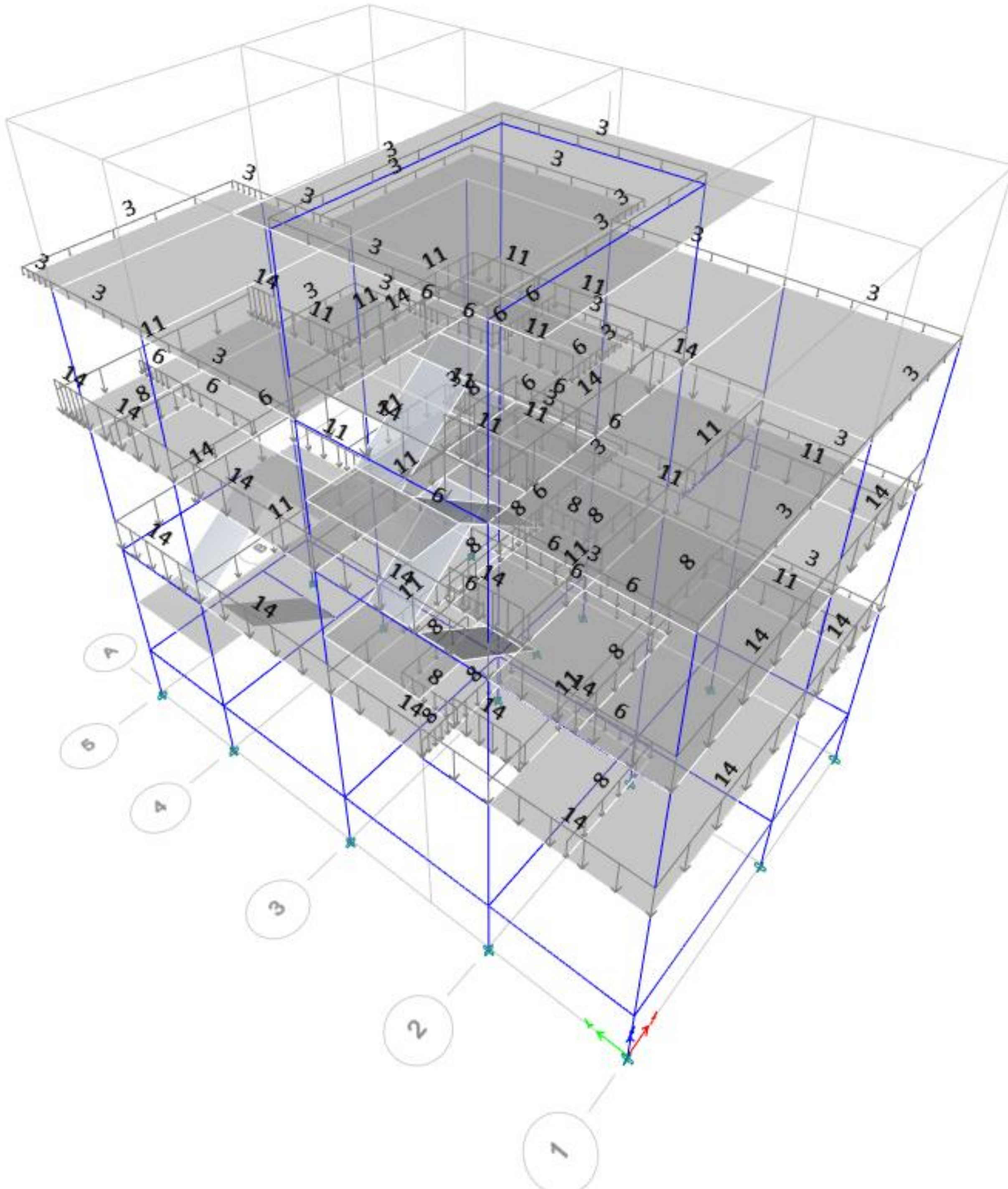


Figure 9: Wall Load Assigned

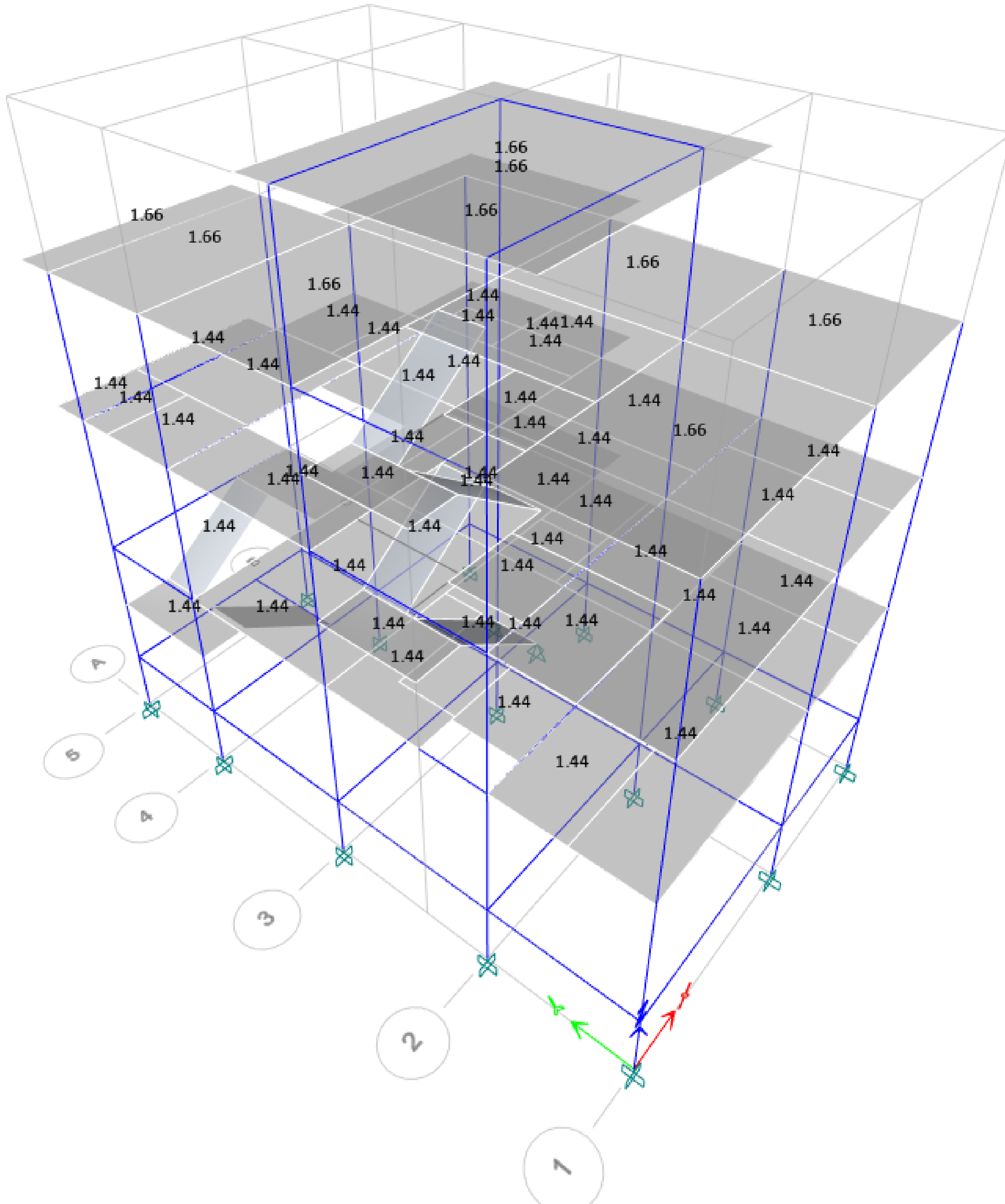


Figure 10: Floor Load Assigned

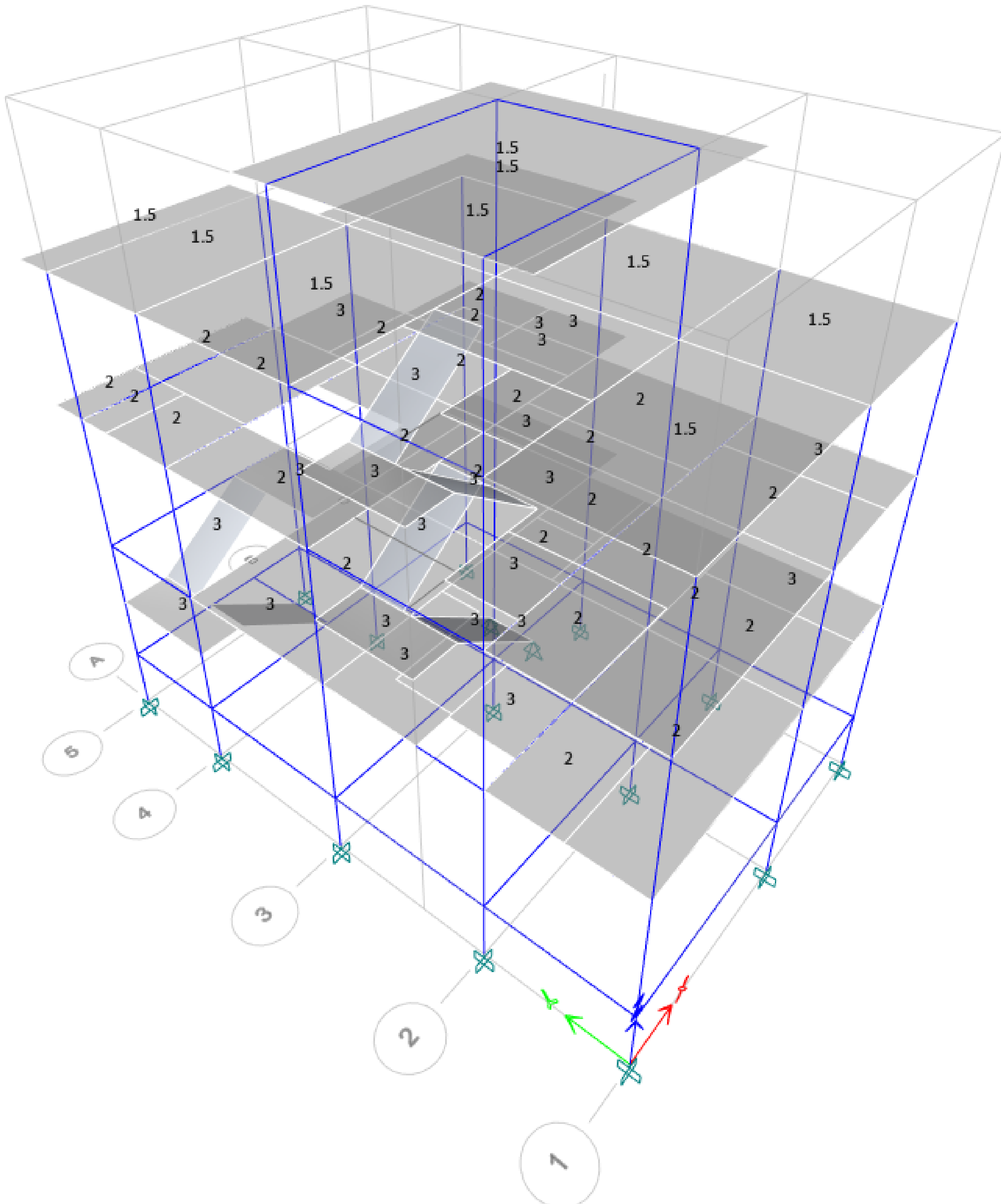


Figure 11: Live Load Assigned

11 ANALYSIS OUTPUT

11.1 EARTHQUAKE LOAD

FOR ULTIMATE LIMIT STATE (ULS)				
Load Pattern	**C**	**K**	**Weight Used**	**Base Shear**
			KN	KN
EQXu	0.146	1.1	6220.06	908.13
EQYu	0.146	1.1	6220.06	908.13
FOR SERVICEABILITY LIMIT STATE (SLS)				
EQXs	0.140	1.1	6220.06	870.81
EQYs	0.140	1.1	6220.06	870.81

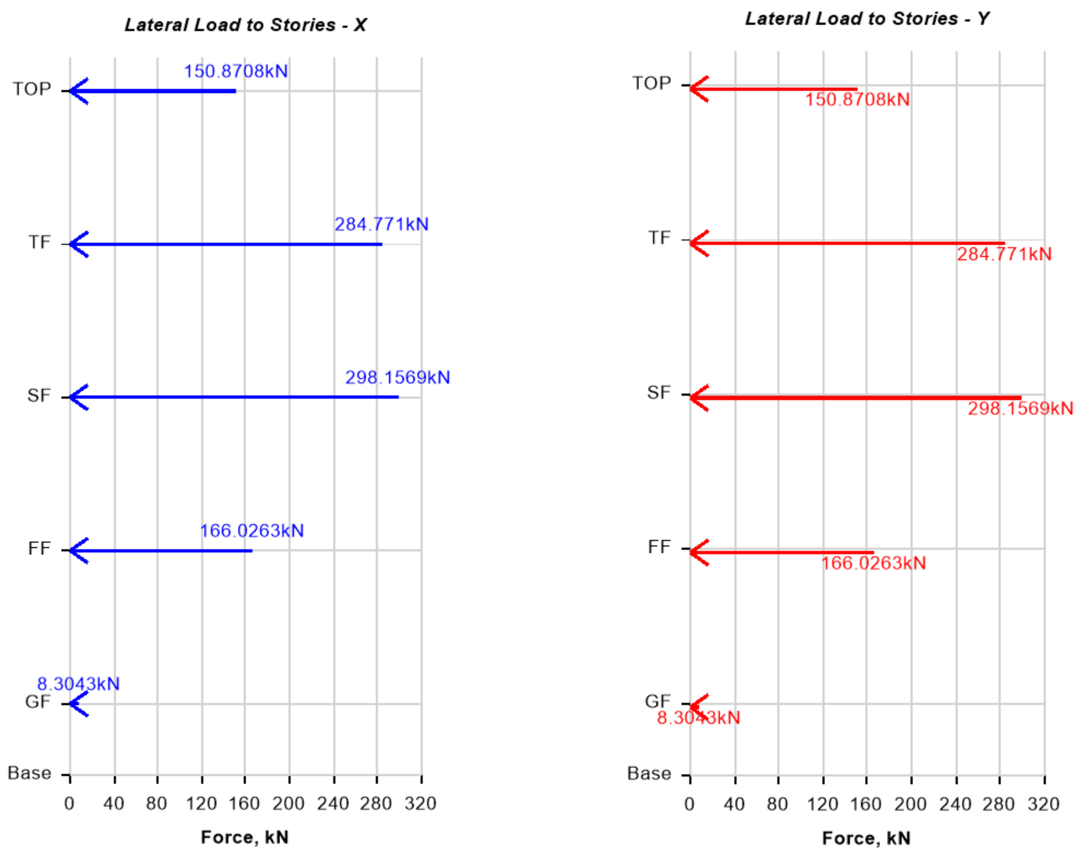


Figure 12: Lateral Load

11.2 STOREY DRIFT AND TORSIONAL IRREGULARITY (Cl.5.6.3)

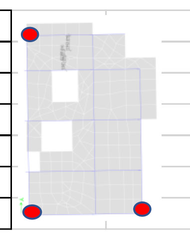
TABLE: Story Drifts (SLS) (Permissible Value=0.006)							
Story	**Output Case**	**Case Type**	**Step Type**	**Step Number**	**Direction**	**Drift**	**Label**
TOP	EQy SLS	LinStatic	Step By Step	1	Y	0.002706	22
TOP	EQy SLS	LinStatic	Step By Step	2	Y	0.002961	22
TOP	EQy SLS	LinStatic	Step By Step	3	Y	0.00292	21
TOP	EQx SLS	LinStatic	Step By Step	1	X	0.003003	7
TOP	EQx SLS	LinStatic	Step By Step	2	X	0.003094	22
TOP	EQx SLS	LinStatic	Step By Step	3	X	0.003252	7
TF	EQy SLS	LinStatic	Step By Step	1	Y	0.002351	69
TF	EQy SLS	LinStatic	Step By Step	2	Y	0.002473	117
TF	EQy SLS	LinStatic	Step By Step	3	Y	0.002598	69
TF	EQx SLS	LinStatic	Step By Step	1	X	0.002533	1
TF	EQx SLS	LinStatic	Step By Step	2	X	0.002784	69
TF	EQx SLS	LinStatic	Step By Step	3	X	0.003082	1
TF	EQx SLS	LinStatic	Step By Step	3	Y	0.000817	117
SF	EQy SLS	LinStatic	Step By Step	1	Y	0.003352	4
SF	EQy SLS	LinStatic	Step By Step	2	Y	0.003778	14
SF	EQy SLS	LinStatic	Step By Step	3	Y	0.003715	4
SF	EQx SLS	LinStatic	Step By Step	1	X	0.003841	11
SF	EQx SLS	LinStatic	Step By Step	2	X	0.003989	10
SF	EQx SLS	LinStatic	Step By Step	3	X	0.004737	11
FF	EQy SLS	LinStatic	Step By Step	1	Y	0.00361	11
FF	EQy SLS	LinStatic	Step By Step	2	Y	0.004046	11
FF	EQy SLS	LinStatic	Step By Step	3	Y	0.003926	1
FF	EQx SLS	LinStatic	Step By Step	1	X	0.004812	11
FF	EQx SLS	LinStatic	Step By Step	2	X	0.003814	11
FF	EQx SLS	LinStatic	Step By Step	3	X	0.00581	11
GF	EQy SLS	LinStatic	Step By Step	1	Y	0.001544	5
GF	EQy SLS	LinStatic	Step By Step	2	Y	0.001555	10
GF	EQy SLS	LinStatic	Step By Step	3	Y	0.001689	5
GF	EQx SLS	LinStatic	Step By Step	1	X	0.001858	1
GF	EQx SLS	LinStatic	Step By Step	2	X	0.001912	5
GF	EQx SLS	LinStatic	Step By Step	3	X	0.002231	1
					Maximum	**0.00581**	

TABLE: Story Drifts (ULS) (Permissible Value=0.025)							
Story	**Output Case**	**Case Type**	**Step Type**	**Step Number**	**Direction**	**Drift**	**Label**
TOP	EQx ULS	LinStatic	Step By Step	1	X	0.003131	7
TOP	EQx ULS	LinStatic	Step By Step	2	X	0.003226	22
TOP	EQx ULS	LinStatic	Step By Step	3	X	0.003391	7
TOP	EQy ULS	LinStatic	Step By Step	1	Y	0.002822	22

TOP	EQy ULS	LinStatic	Step By Step	2	Y	0.003088	22
TOP	EQy ULS	LinStatic	Step By Step	3	Y	0.003045	21
TF	EQx ULS	LinStatic	Step By Step	1	X	0.002641	1
TF	EQx ULS	LinStatic	Step By Step	2	X	0.002903	69
TF	EQx ULS	LinStatic	Step By Step	3	X	0.003214	1
TF	EQx ULS	LinStatic	Step By Step	3	Y	0.000852	117
TF	EQy ULS	LinStatic	Step By Step	1	Y	0.002451	69
TF	EQy ULS	LinStatic	Step By Step	2	Y	0.002579	117
TF	EQy ULS	LinStatic	Step By Step	3	Y	0.002709	69
SF	EQx ULS	LinStatic	Step By Step	1	X	0.004006	11
SF	EQx ULS	LinStatic	Step By Step	2	X	0.00416	10
SF	EQx ULS	LinStatic	Step By Step	3	X	0.00494	11
SF	EQy ULS	LinStatic	Step By Step	1	Y	0.003496	4
SF	EQy ULS	LinStatic	Step By Step	2	Y	0.00394	14
SF	EQy ULS	LinStatic	Step By Step	3	Y	0.003874	4
FF	EQx ULS	LinStatic	Step By Step	1	X	0.005018	11
FF	EQx ULS	LinStatic	Step By Step	2	X	0.003978	11
FF	EQx ULS	LinStatic	Step By Step	3	X	0.006059	11
FF	EQy ULS	LinStatic	Step By Step	1	Y	0.003765	11
FF	EQy ULS	LinStatic	Step By Step	2	Y	0.00422	11
FF	EQy ULS	LinStatic	Step By Step	3	Y	0.004095	1
GF	EQx ULS	LinStatic	Step By Step	1	X	0.001938	1
GF	EQx ULS	LinStatic	Step By Step	2	X	0.001994	5
GF	EQx ULS	LinStatic	Step By Step	3	X	0.002326	1
GF	EQy ULS	LinStatic	Step By Step	1	Y	0.00161	5
GF	EQy ULS	LinStatic	Step By Step	2	Y	0.001622	10
GF	EQy ULS	LinStatic	Step By Step	3	Y	0.001761	5
					Maximum	**0.006059**	

CHECK FOR TORSIONAL IRREGULARITY

TORSIONAL IRREGULARITY (Cl.5.5.2.1)								
STOREY	X-DIRECTION		RATIO (Δmax)/Δmin)>1.5		X-DIRECTION		RATIO (Δmax)/Δmin)>1.5	
	Δmin	Δmax			Δmin	Δmax		
TF	5.563	48.966	8.80	OK	2.074	36.675	17.68	OK
SF	4.262	38.682	9.08	OK	1.266	28.005	22.12	OK
FF	0.179	22.873	127.78	OK	0.299	15.612	52.21	OK
GF	0.015	3.485	232.33	OK	0.056	2.641	47.16	OK



11.3 STOREY STIFFNESS AND SOFT STOREY

TABLE: Story Stiffness							
Story	**Output Case**	**Shear X**	**Drift X**	**Stiff X**	**Shear Y**	**Drift Y**	**Stiff Y**
		kN	mm	kN/m	kN	mm	kN/m
TOP	EQy SLS	0	0.136	0	144.6706	8.479	17062.248
TF	EQy SLS	0	0.542	0	417.7388	8.032	52011.334
SF	EQy SLS	0	0.554	0	703.6426	10.678	65896.264
FF	EQy SLS	0	0.186	0	862.8459	11.446	75384.062

GF	EQy SLS	0	0.124	0	870.8089	2.17	401294.585
TOP	EQx SLS	144.6706	9.469	15279.108	0	0.184	0
TF	EQx SLS	417.7388	8.431	49545.301	0	0.559	0
SF	EQx SLS	703.6426	11.063	63602.502	0	0.865	0
FF	EQx SLS	862.8459	11.704	73721.722	0	1.62	0
GF	EQx SLS	870.8089	2.456	354518.883	0	0.25	0
TOP	EQx ULS	150.8708	9.874	15279.108	0	0.192	0
TF	EQx ULS	435.6418	8.793	49545.301	0	0.582	0
SF	EQx ULS	733.7987	11.537	63602.502	0	0.902	0
FF	EQx ULS	899.825	12.206	73721.722	0	1.69	0
GF	EQx ULS	908.1293	2.562	354518.883	0	0.261	0
TOP	EQy ULS	0	0.142	0	150.8708	8.842	17062.248
TF	EQy ULS	0	0.565	0	435.6418	8.376	52011.334
SF	EQy ULS	0	0.578	0	733.7987	11.136	65896.264
FF	EQy ULS	0	0.193	0	899.825	11.937	75384.062
GF	EQy ULS	0	0.129	0	908.1293	2.263	401294.585
TOP	RSx	162.2186	11.151	14547.85	44.8857	3.836	11702.335
TF	RSx	416.392	9.823	42388.915	139.8457	4.87	28718.265
SF	RSx	719.2825	15.462	46520.317	253.5763	8.105	31286.202
FF	RSx	900.5499	16.776	53679.613	314.5396	8.499	37008.617
GF	RSx	906.1568	3.381	268029.451	316.6046	1.535	206208.351
TOP	RSy	48.399	3.882	12468.053	153.9156	9.872	15590.89
TF	RSy	130.4241	3.502	37239.826	412.6451	9.104	45324.858
SF	RSy	222.7934	5.285	42154	722.7234	11.937	60546.78
FF	RSy	279.5238	6.142	45511.018	900.8375	12.997	69313.22
GF	RSy	281.4263	1.217	231273.507	906.5538	2.49	364102.934

Check for Soft Storey (As per Cl.5.5.1.2)					
Level	**Stiffness**	**K_i/K_{i+1}**	**Checks**	**$K_i/(K_{i+1} + K_{i+2} + K_{i+3})/3$**	**Checks**
	KN/m	**0.7**		**0.8**	
TOP	15279.108	-	-	-	-
TF	49545.301	3.24	**OK**	-	-
SF	63602.502	1.28	**OK**	-	-
FF	73721.722	1.16	**OK**	1.72	**OK**
GF	354518.88	4.81	**OK**	5.69	**OK**

11.4 CENRE OF MASS AND RIGIDITY, MASS IRREGULARITY & ECCENTRICITY

TABLE: Centers of Mass and Rigidity						
Story	**Cum Mass X**	**Cum Mass Y**	**XCCM**	**YCCM**	**XCR**	**YCR**
	kg	kg	m	m	m	m
FF	191802.61	191802.61	4.3066	6.1151	3.9387	7.4509

SF	203978.96	203978.96	4.2119	6.8259	3.8526	7.4065
TF	133434.2	133434.2	3.9876	6.4878	3.8843	7.0367
TOP	54258.86	54258.86	2.8299	5.232	3.0339	5.792

Check for Mass Irregularity (As per Cl.5.5.1.5)			
Storey of Building	**Mass X or Y**	**Check Status with Respect to Storey Above**	**Check Status with Respect to Storey Above**
TOP	54258.86	-	-
TF	133434.2	-	OK
SF	203978.96	OK	-
FF	191802.61	OK	-
GF	-	-	-

BUILDING ECCENTRICITY CHECK (IRREGULARITY)												
STOREY	**XCCM**	**YCCM**	**XCR**	**YCR**	Eccentricity		Dimension in X-Direction	Dimension in Y-Direction	ex/Dx Result		ey/Dy Result	
	m	m	m	m	ex	ey			%		%	
FF	4.3066	6.1151	3.9387	7.4509	0.37	1.34	8.661	13.665	4.25	OK	9.78	OK
SF	4.2119	6.8259	3.8526	7.4065	0.36	0.58	8.661	13.665	4.15	OK	4.25	OK
TF	3.9876	6.4878	3.8843	7.0367	0.10	0.55	8.661	13.665	1.19	OK	4.02	OK
TOP	2.8299	5.232	3.0339	5.792	0.20	0.56	8.661	13.665	2.36	OK	4.10	OK

11.5 MODAL PARTICIPATING MASS RATIOS

TABLE: Modal Participating Mass Ratios						
Case	**Mode**	**Period**	**SumUX**	**SumUY**	**SumRX**	**SumRY**
		sec				
Modal	1	0.845	0.7002	0.0477	0.0062	0.1394
Modal	2	0.797	0.7345	0.8461	0.1598	0.146
Modal	3	0.655	0.8462	0.8504	0.162	0.1612
Modal	4	0.342	0.9077	0.8504	0.1625	0.5919
Modal	5	0.328	0.9078	0.9135	0.6089	0.592
Modal	6	0.25	0.9092	0.9135	0.6089	0.5947
Modal	7	0.208	0.9271	0.9358	0.723	0.6867
Modal	8	0.203	0.9545	0.9511	0.8134	0.8316
Modal	9	0.188	0.9548	0.9555	0.8326	0.8316
Modal	10	0.131	0.9582	0.961	0.844	0.839
Modal	11	0.128	0.9639	0.9632	0.8485	0.8507
Modal	12	0.121	0.9645	0.9636	0.8498	0.8521
Modal	13	0.041	0.9645	0.979	0.9171	0.8521
Modal	14	0.038	0.9804	0.979	0.9171	0.9209
Modal	15	0.036	0.9913	0.979	0.9171	0.9638
Modal	16	0.035	0.9936	0.9793	0.9182	0.9736
Modal	17	0.035	0.9941	0.9799	0.9209	0.9754
Modal	18	0.032	0.9941	0.9989	0.9954	0.9755
Modal	19	0.032	0.9985	0.9989	0.9954	0.9933
Modal	20	0.032	0.9986	0.999	0.996	0.9935

11.6 BASE REACTIONS

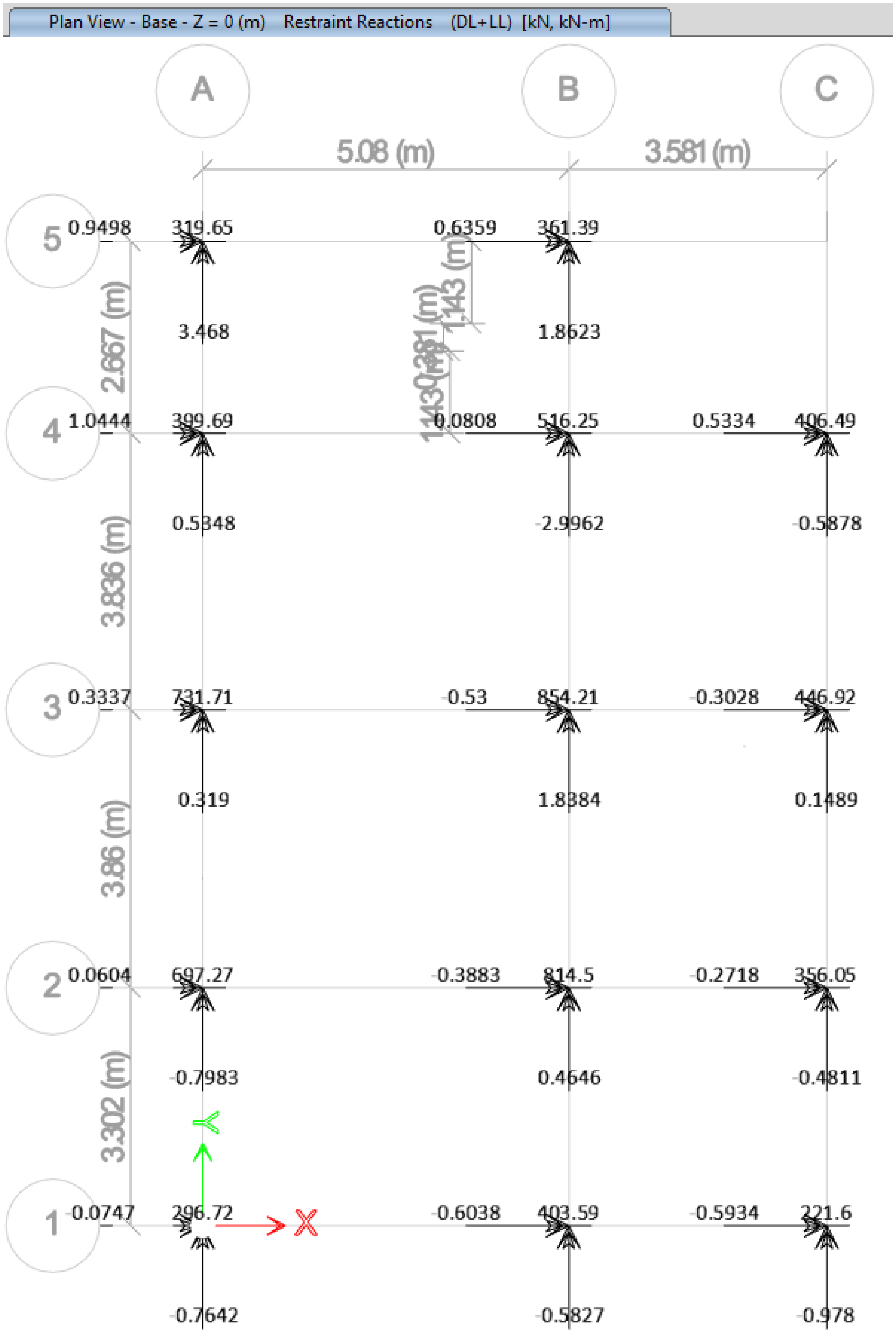


Figure 13: Support Reaction

11.7 AXIAL LOAD

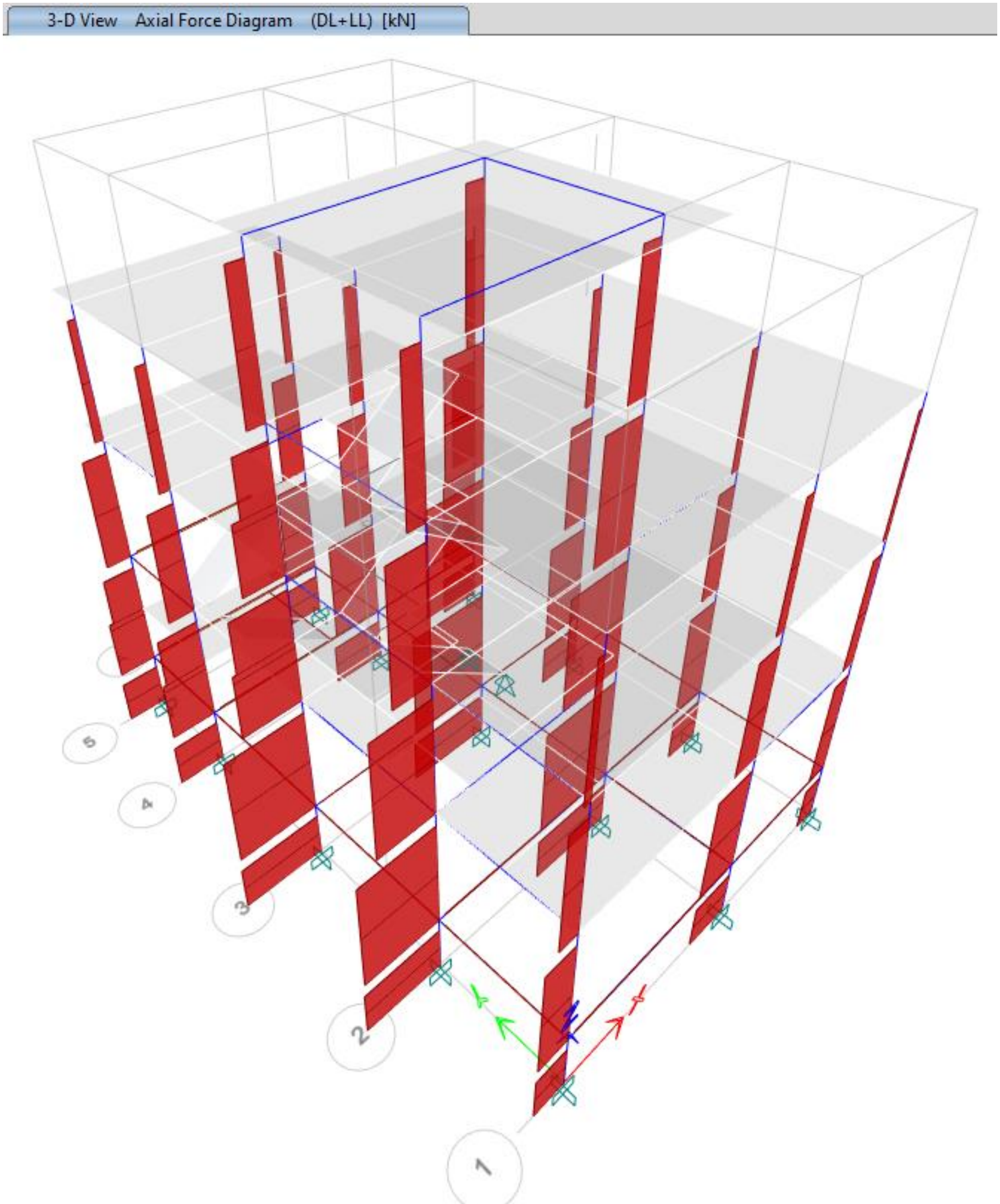


Figure 14: Axial Load Diagram

11.8 SHEAR FORCE DIAGRAM

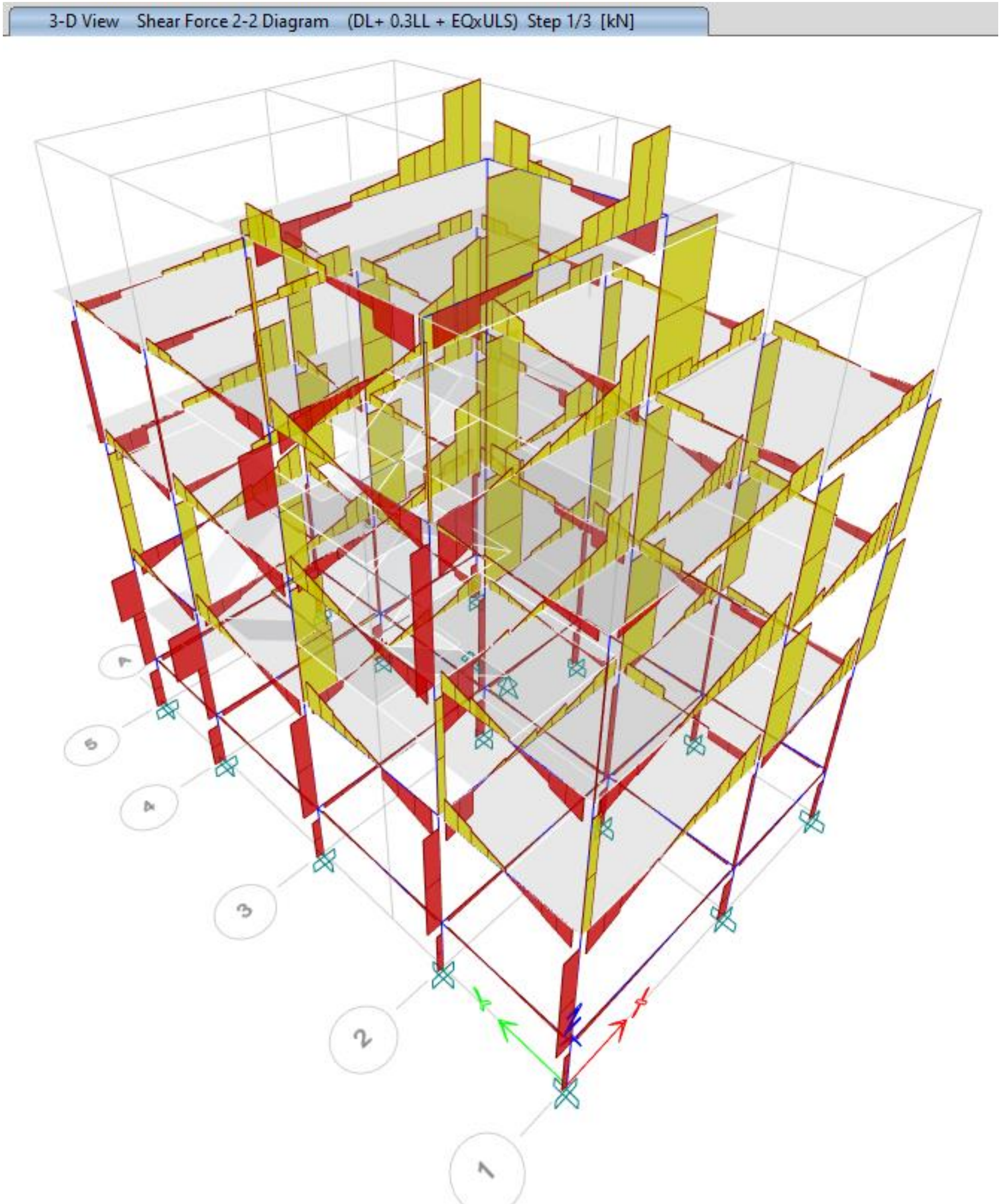


Figure 15: Shear Force Diagram of Beam

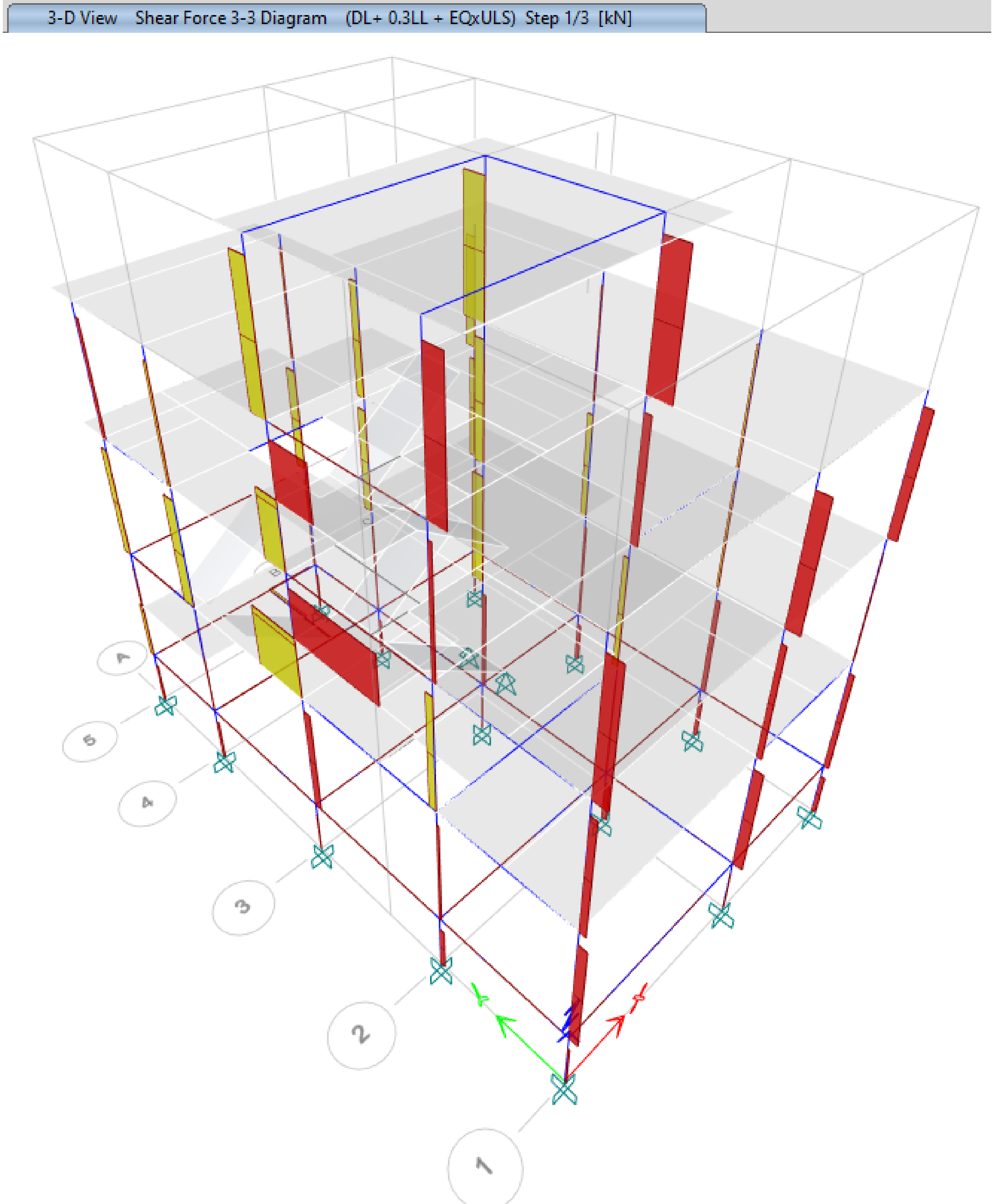


Figure 16: Shear Force Diagram of Column

11.9 MOMENT DIAGRAM

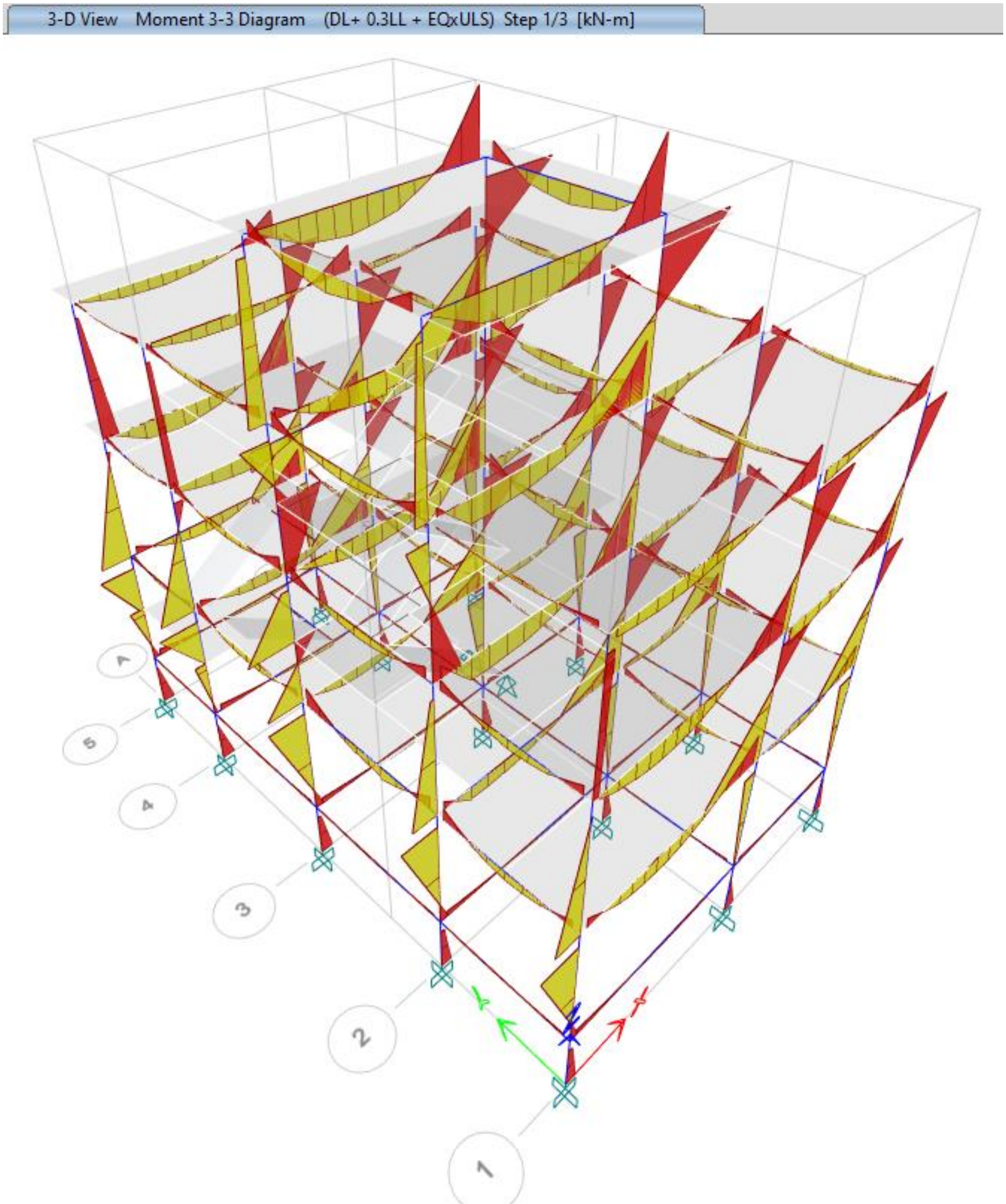


Figure 17: Moment Diagram of Beam

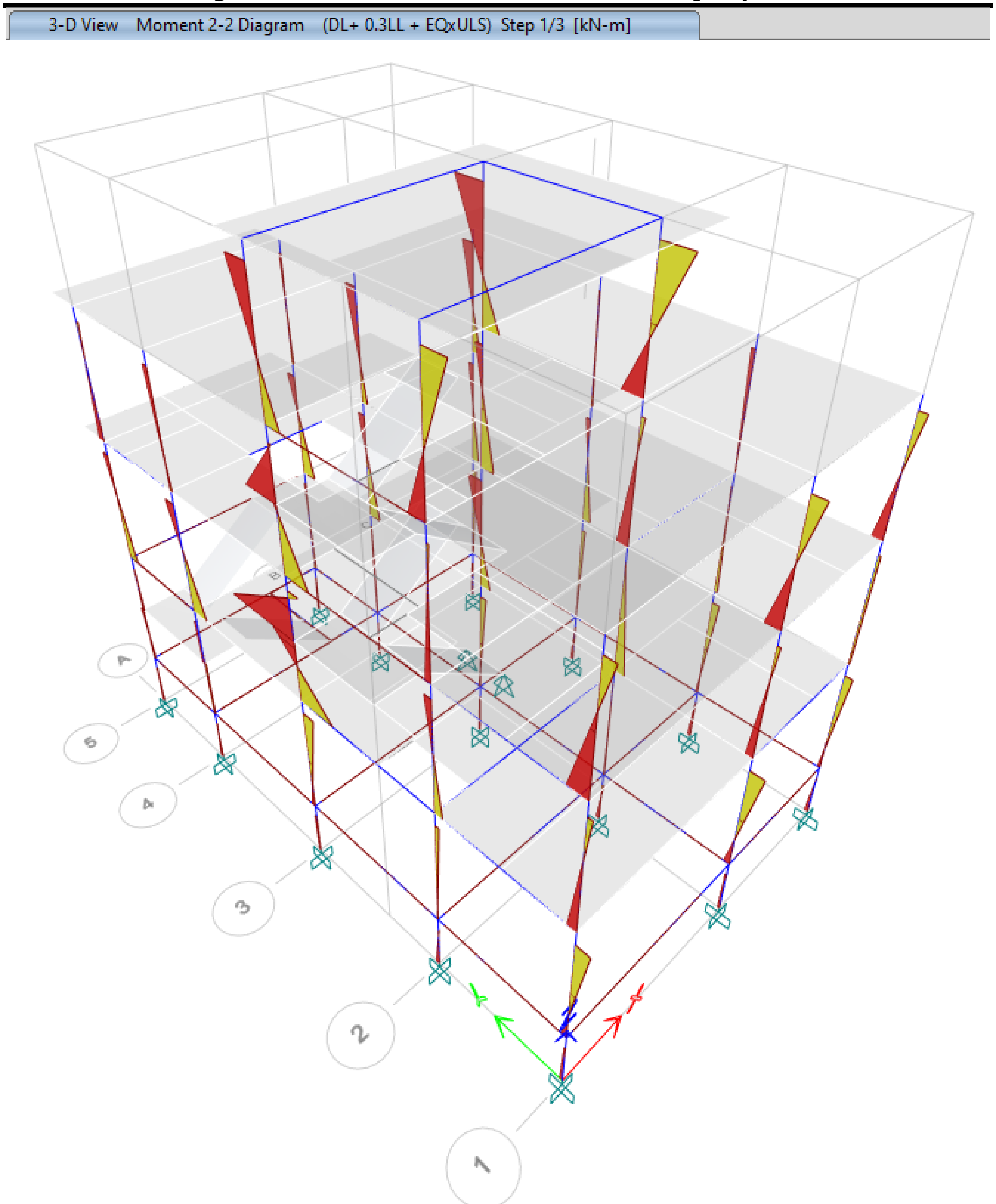


Figure 18: Moment Diagram of Column

12 DESIGN RESULTS

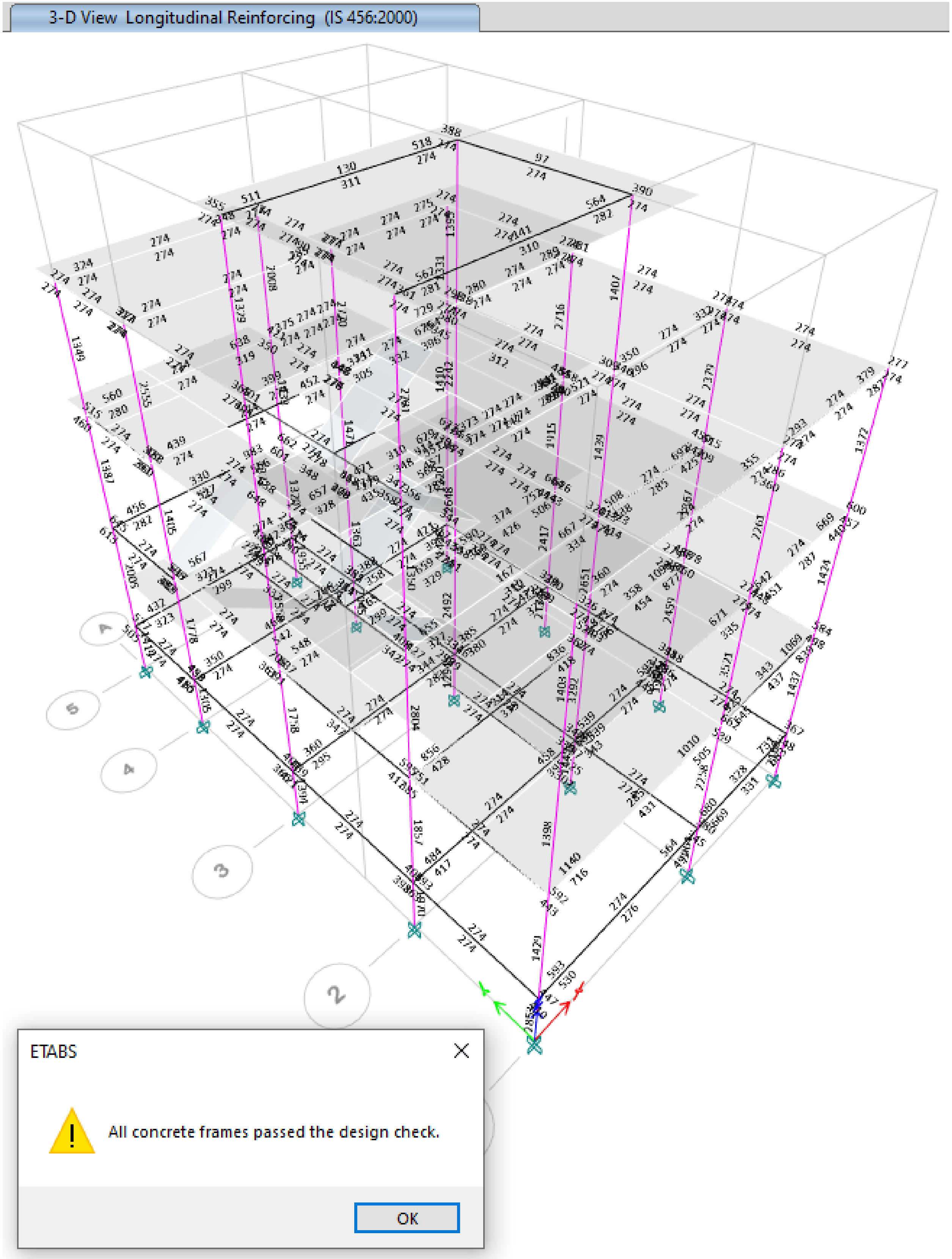


Figure 19: Design Verification of Structural Member

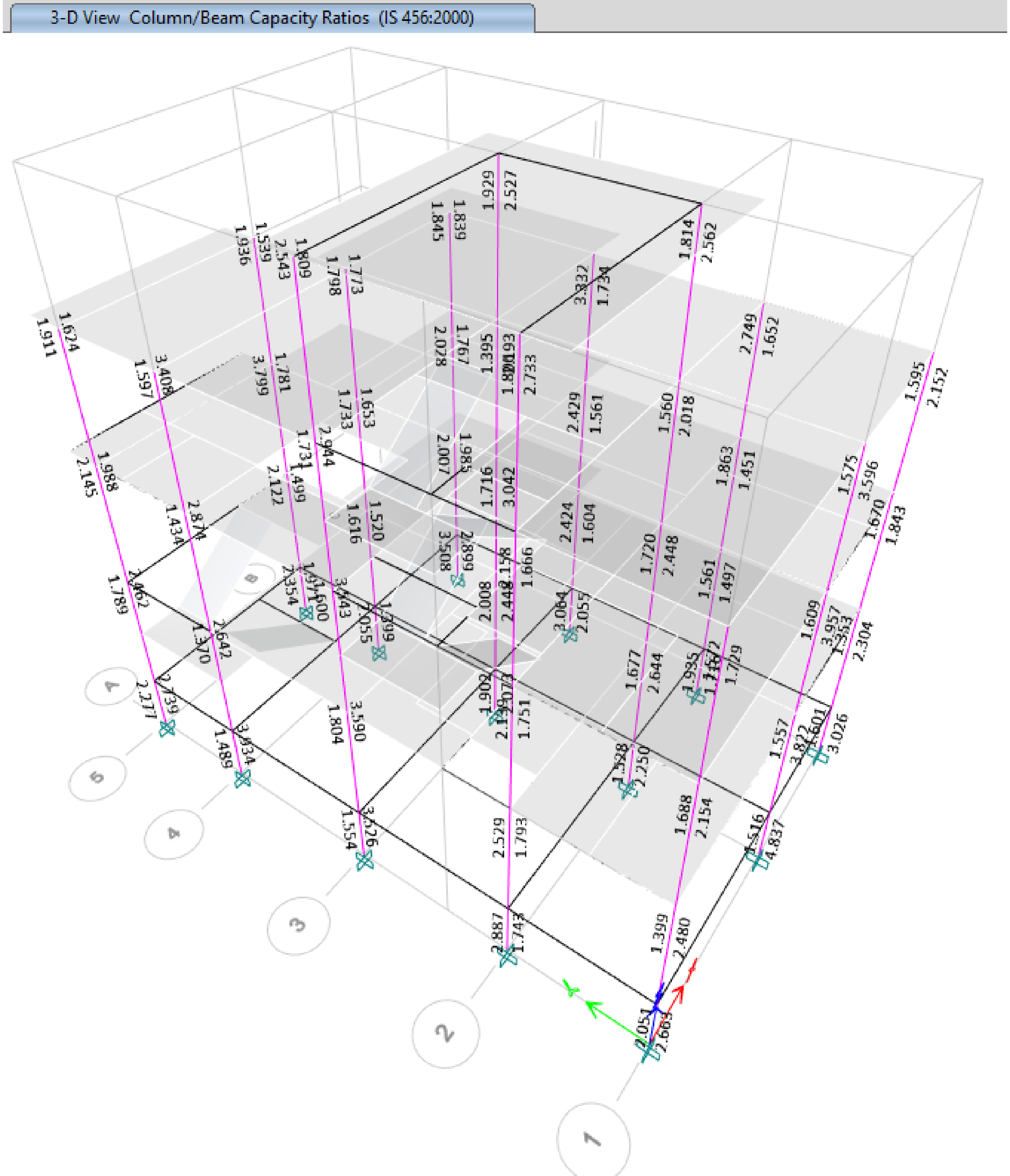


Figure 20: Column-Beam Capacity Ratio (Compliance $\frac{\sum M_c}{\sum M_b} > 1.2$*)*

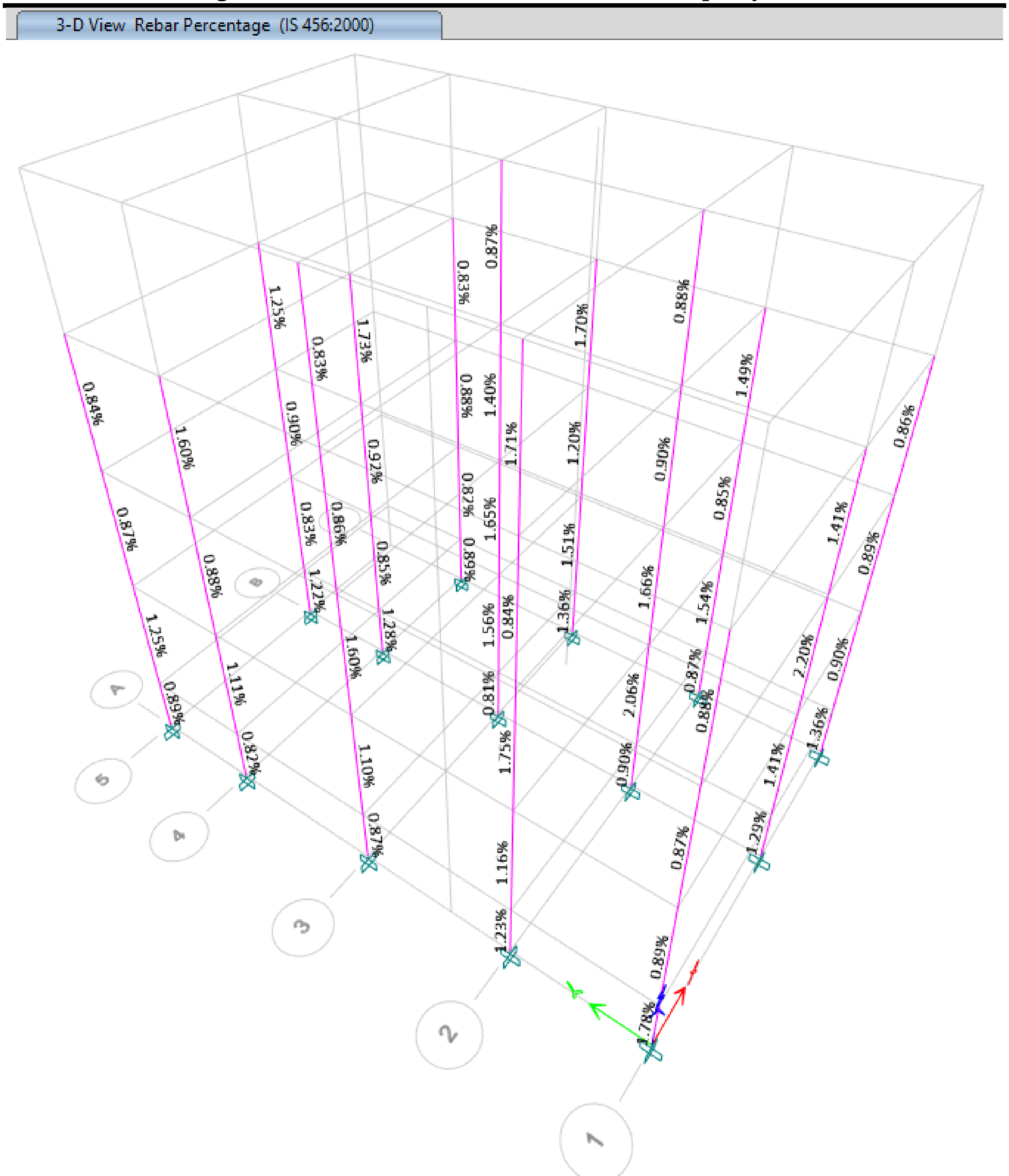


Figure 21: Column Longitudinal Reinforcement Output

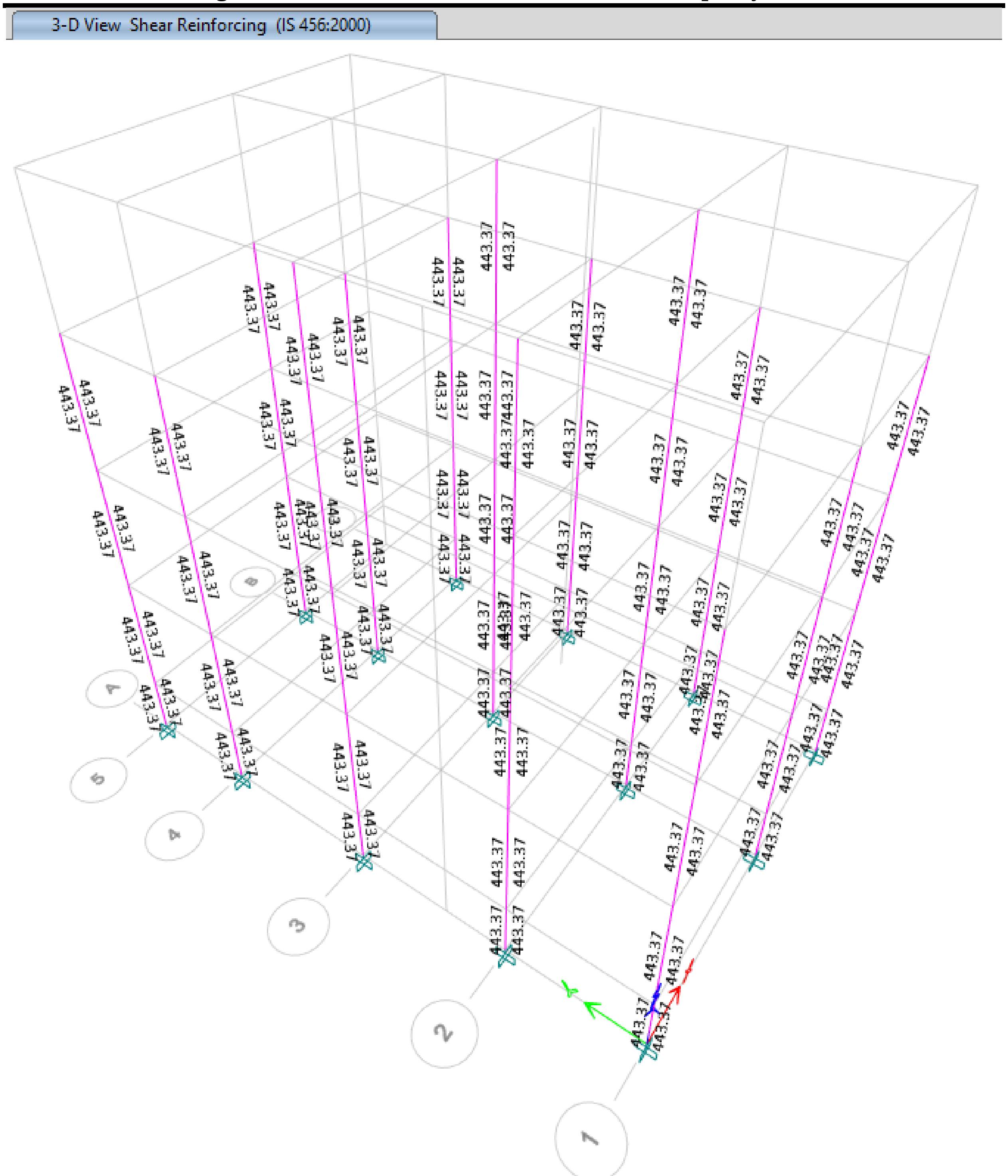


Figure 22: Column Shear Reinforcement Output

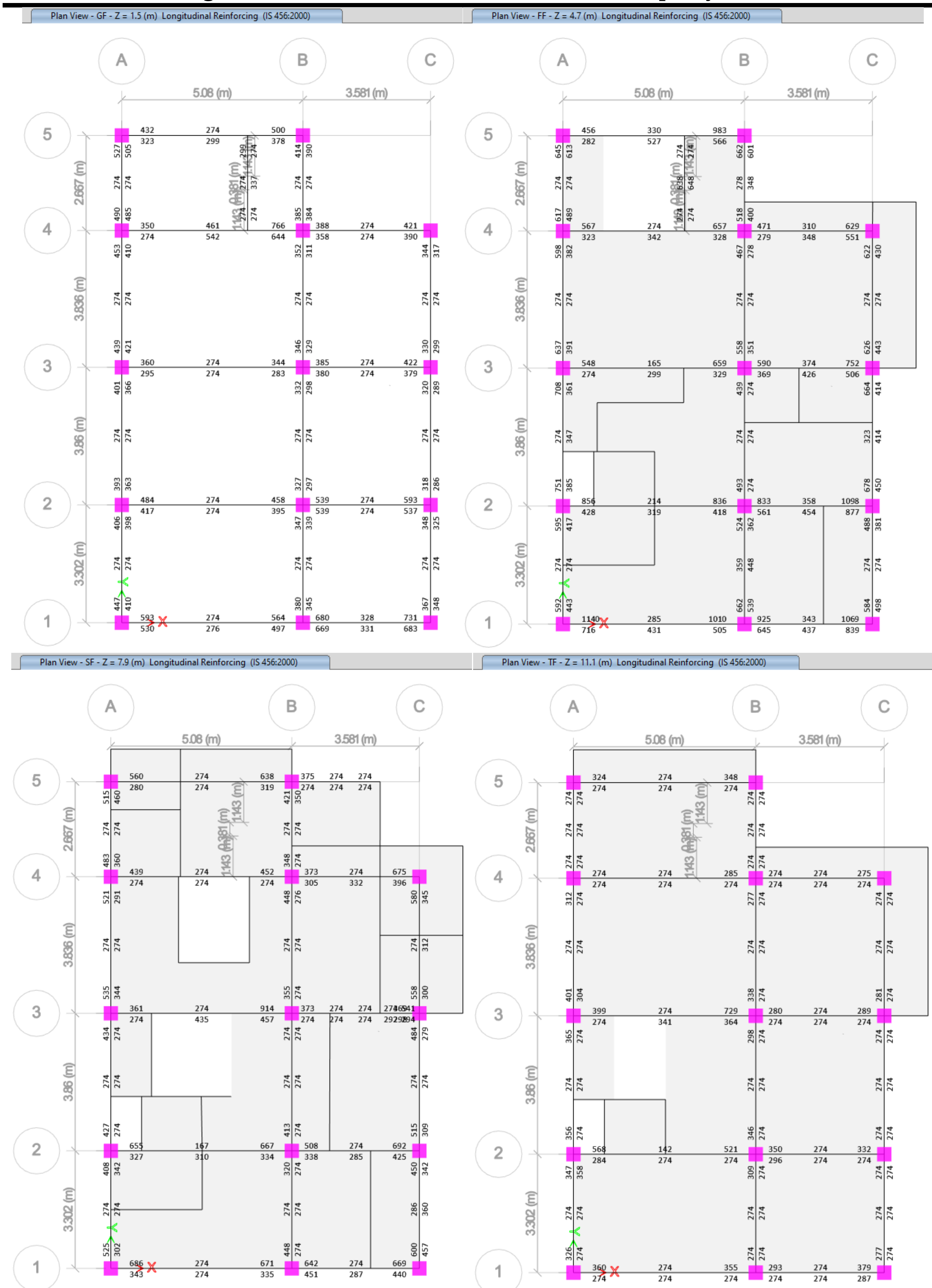


Figure 23: Beam Longitudinal Reinforcement Output

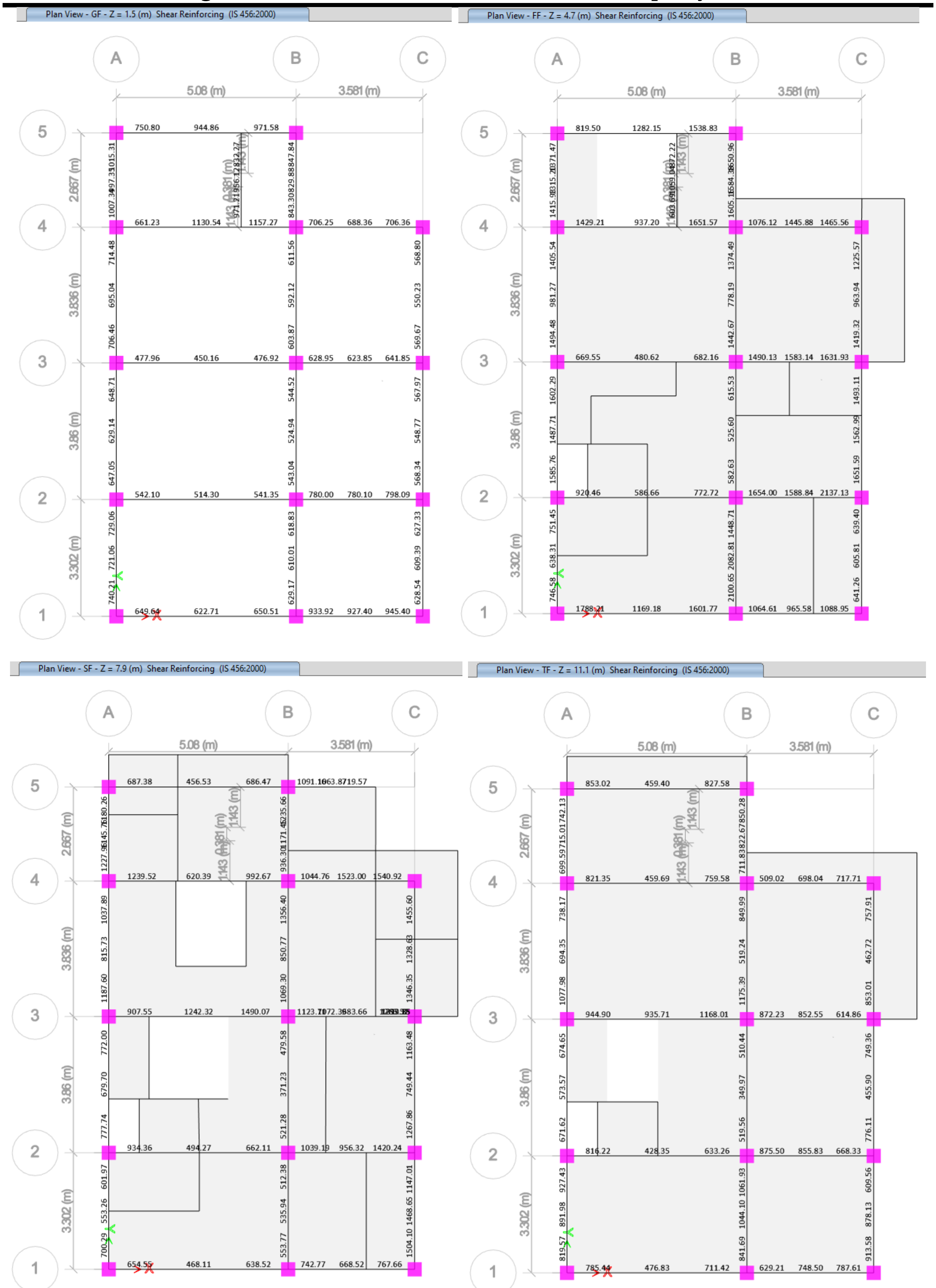


Figure 24: Beam Shear Reinforcement Output

13 FOOTING DESIGN IN SAFE 2016

13.1 SIZE OF MEMBER

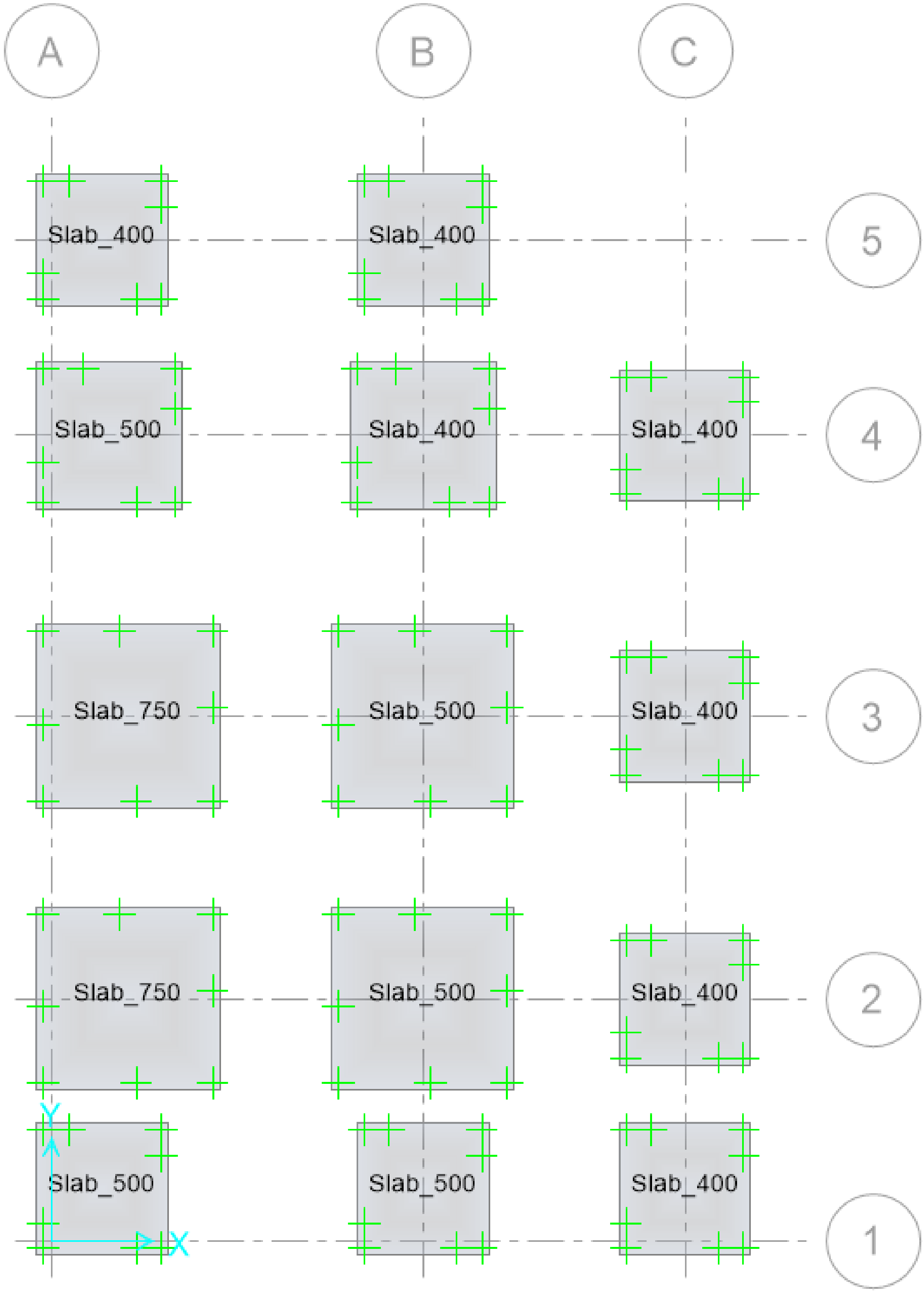


Figure 25: Footing Slab Depth

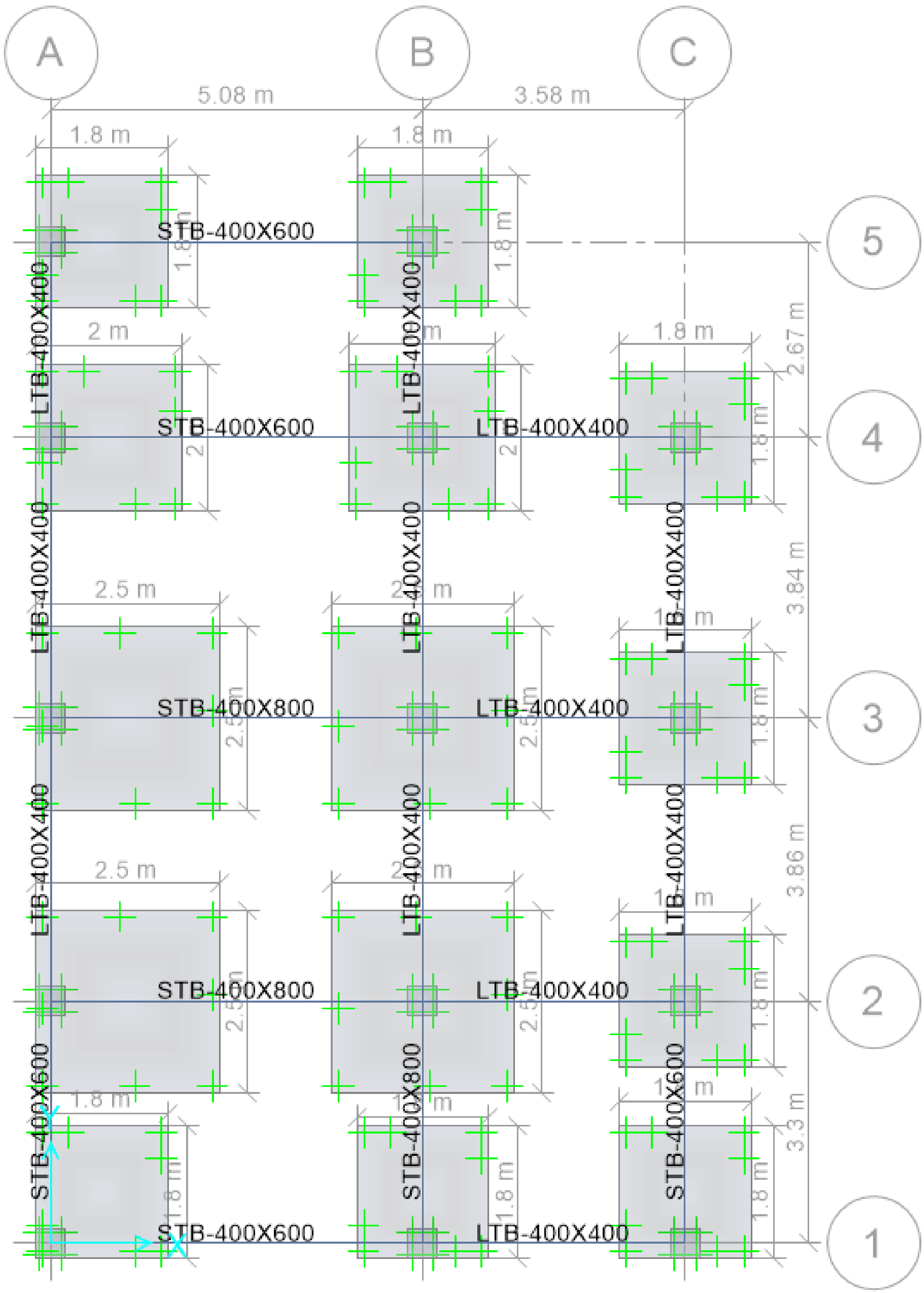


Figure 26: Footing Slab and Beam Size

13.2 CHECK FOR PUNCHING

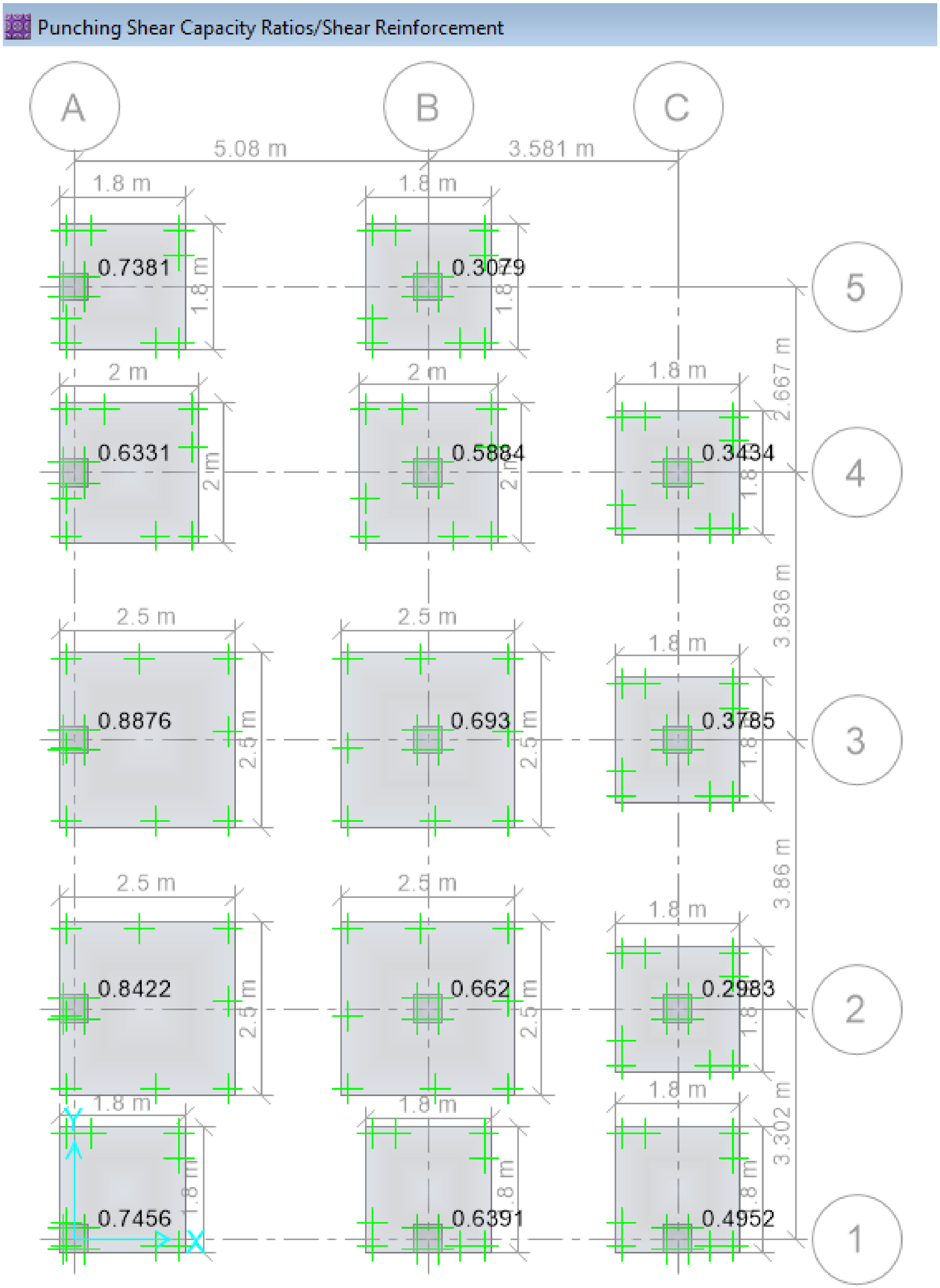


Figure 27: Check for Punching

13.3 CHECK FOR UPWARD PRESSURE

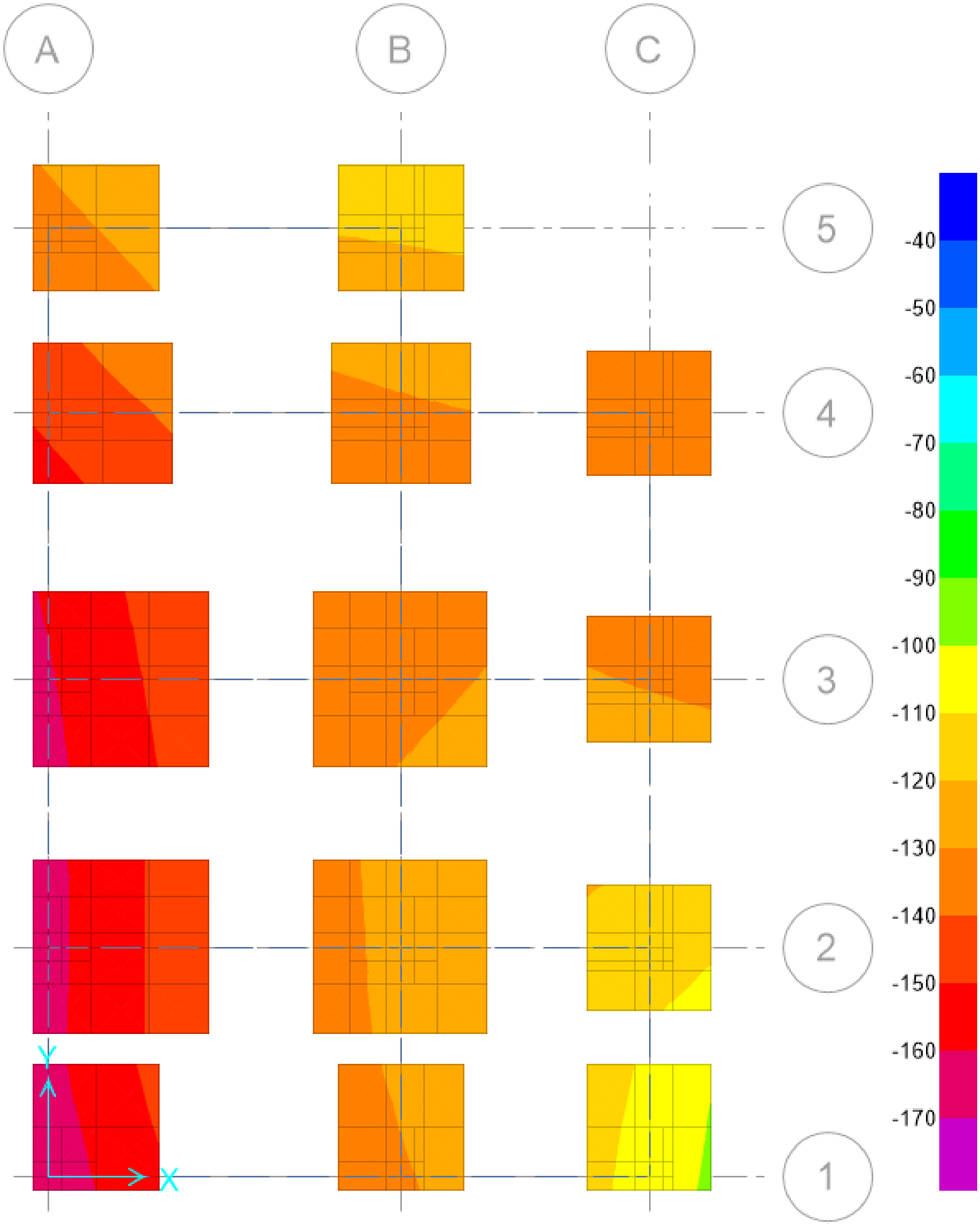


Figure 28: Check for Upward Pressure

The Subgrade Modulus is 24000KN/m^3

13.4 DESIGN OUTPUT

SLAB REINFORCEMENT

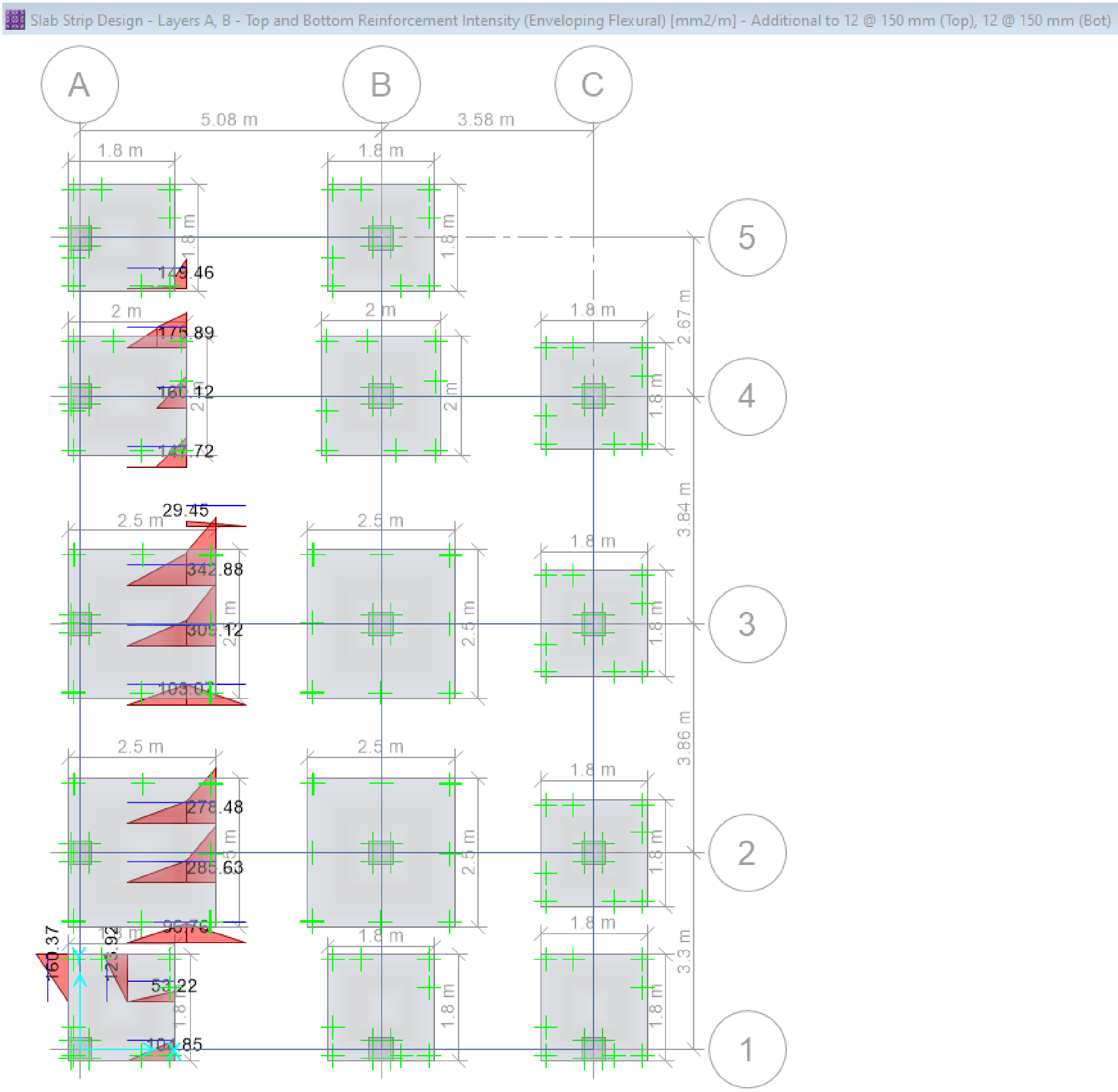


Figure 29: Footing Slab Reinforcement Detail

STRAP BEAM REINFORCEMENT

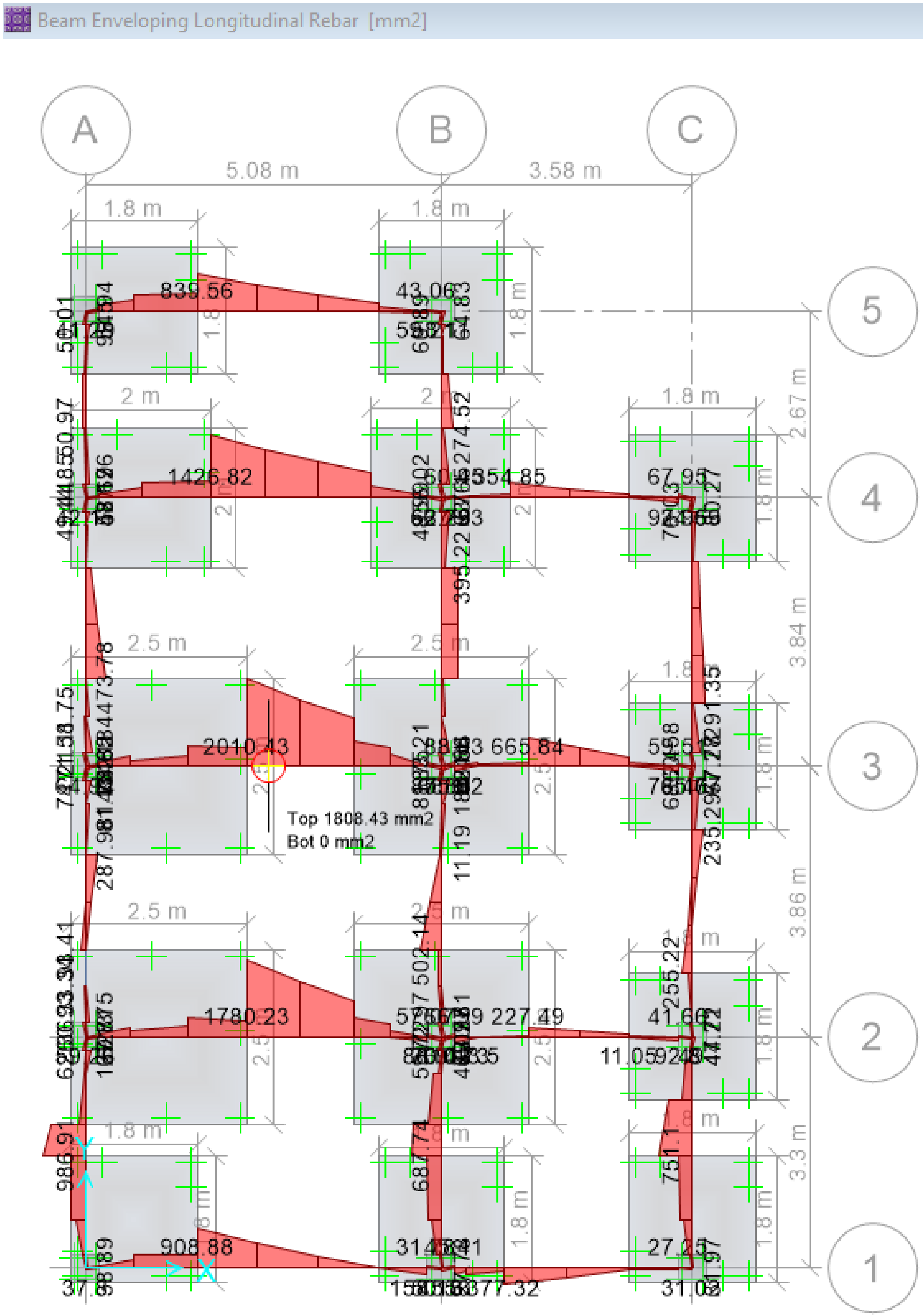


Figure 30: Footing Beam Longitudinal Reinforcement Detail

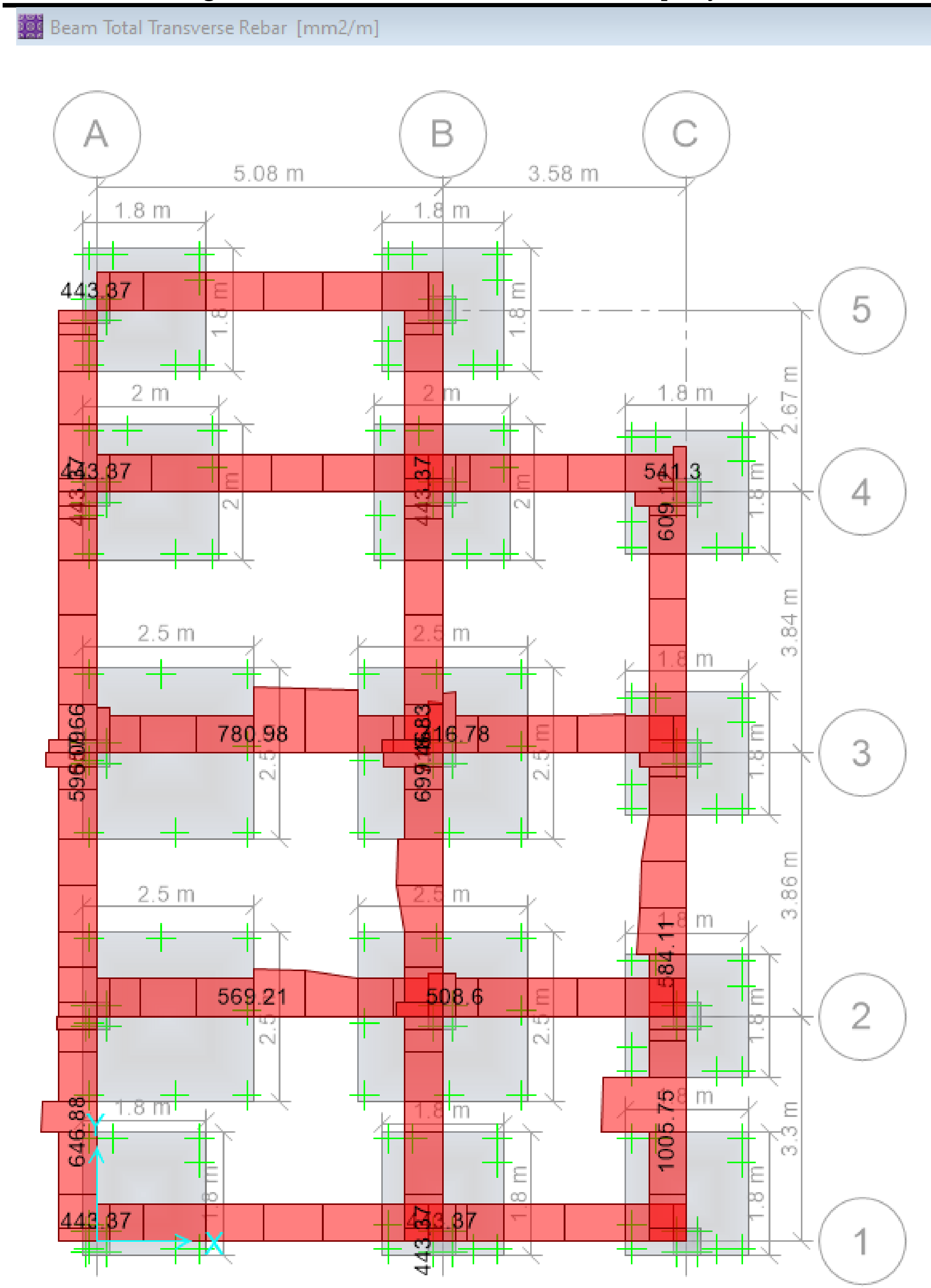


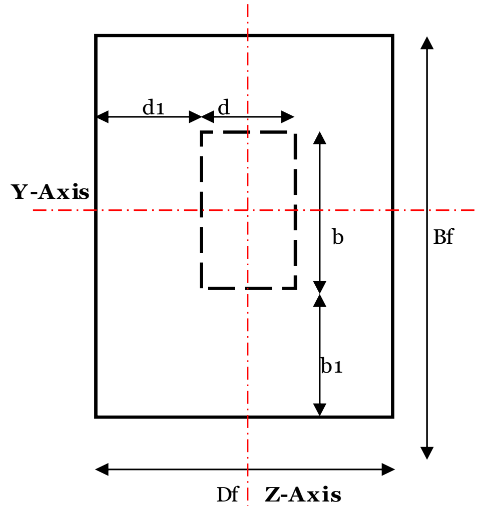
Figure 31: Footing Beam Transverse Reinforcement Detail

13.4 FOOTING MANUAL CHECK SAMPLE

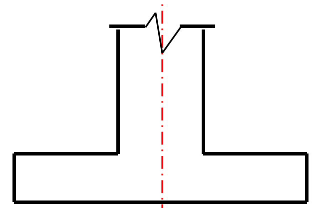
ISOLATED FOOTING CHECK

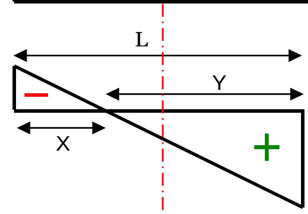
Design of Reinforced Concrete Isolated Pad Foundation

Data:	Column no.	C-4, C-3	
	load case	DL+LL	
	Concrete grade, M	20	
	Steel grade, Fe	500	
	Axial load, kN	450	kN
	My, kNm	1	kNm
	Mz, kNm	1	kNm
	Column size, b	400	mm
	Column size, d	400	mm
	SBC of soil, kN/m2	150	kN/m2
	Design factor	1	



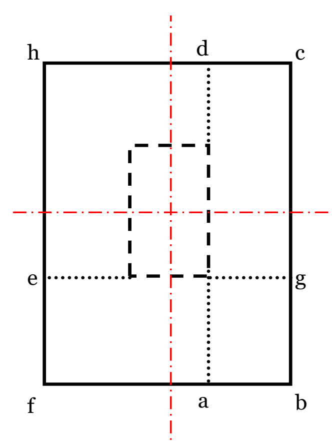
Pressure:	Axial load	450	kN
	App. Self weight	45	kN
	Total weight	495	kN
	Area of footing	3.30	m2
	size of footing, Bf	2	mt, for My (this should be longer)
	size of footing, Df	2	mt, for Mz
	Projection, b1	0.800	mt
	Projection, d1	0.800	mt
	Footing Pressure,		
	Pmax = P/A + My/Zy + Mz/Zz		
	Pmax	114.00	kN/m2
	Pmin = P/A - My/Zy - Mz/Zz		
	Pmin	111.00	kN/m2
Eccentricity:			
	Y	1.01	mt
	X	0.99	mt
	L	2	mt
	2/3 L	1.33	mt





Pressure Distribution Diagram

Flexure design:			
	For section efbg		
	pressure@f	112.50	kN/m2
	pressure@b	114.00	kN/m2
	Moment@eg. Meg	36.48	kNm
	Mu	36.48	kNm
	d req	117.10	mm
	d provided	400	mm
	Mu/bd2	0.23	N/mm2
	pt	0.120	%
	Ast	480.0	mm2/ mt width
	provide	12#	150 C/C



Shear Chk.

One way Shear : At distance d from face of column.

Vu	136.80	kN

Vuc	208.19	kN	Safe

Two way Shear : At distance d/2 from face of column.

Perimeter	3200	mm	
S.F. at this section	414.96	kN	
Stress	0.32	N/mm2	
Permissible stress	0.72	N/mm2	Safe

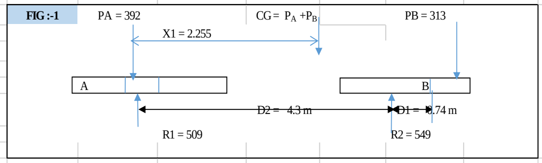
Check in other direction :

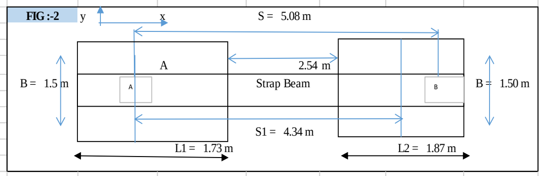
For section abcd

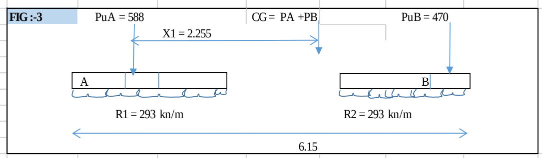
pressure@b	114.00	kN/m2
pressure@c	112.50	kN/m2
Moment@ad, Mad	36.48	kNm
Mu	36.48	kNm
d req	117.10	mm
d provided	400	mm
M/bd2	0.23	
pt	0.120	%
Ast	480.0	mm2/ mt width
provide	12#	150 C/C

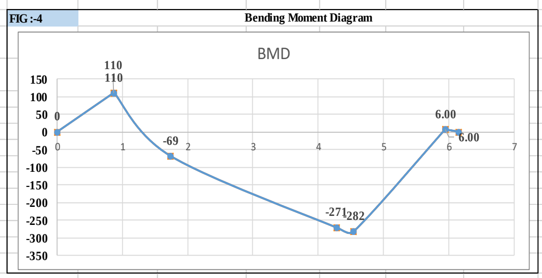
BALANCED FOOTING CHECK

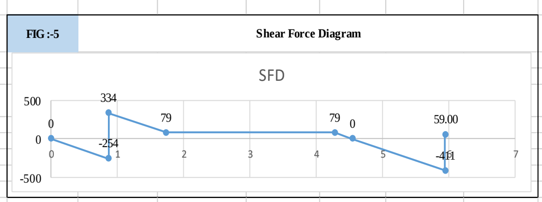
1	DESIGN OF FOOTING PART			
A	**Loading Condition (Service) & Column Size**	**Width (B)**	**Depth (D)**	
	Outer Column B Size (mm)	400.00	400	
	Internal Column A Size (mm)	400.00	400	
	Characteristic Load Inner Column P_A (kN)	392.00		
	Characteristic Load Outer Column PB (kN)	313.00		
	Center Line Column are Spaced S (m)	5.08		
	Safe Bearing Capacity _SBC (kN/m^2)	150.00		
	Steel fy	500.00		
	concret fck	20.00		
	Clear cover (mm)	50.00		
B	**Preliminary Dimensioning of Outer Footing (F-1)**			
	Selfweight of Footing + Surcharge = 15% of the Total Vertical Load	105.75	m^2	
	Total Load	810.75	kN	
	Footing Area Required A = Total Load/ SBC	5.41	m^2	
	Assume Width B	1.50	m	
	Footing Area Required = B*(L1+L2) = (L1+L2)	3.60	m	
C	**Calculated the Centroids of Loads (From Service Load) on Column A and B From a Distance Column A**			
	X1= CG of loads = PB x S / (PA +PB) from W1	2.26		
	Now Taking the Moment of Footing Area about the Center of Column-A			
	B*L2*(S+ half of Column Width C - L2/2) = Total Area x CG distance(x1)			
	The above Quardic equaation solve find L2			
	L-2 Outer Footing	1.87	m	
		8.69	m	
	L-1 Inner Footing	1.73	m	
		-5.09	m	
Final Size of Footing Adopted for Design as mentioned below				
	L1 Inner Footing	**1.73**	**m**	
	L2 Outer Footing	**1.87**	**m**	
	B for Both Footing	**1.50**	**m**	
C.1	**Check Factor of Service Against Over Trun**			
	Fix the Fulcrum at From end of near B	0.94		
	Distance D1 of R2 from Pb	0.74	m	
	Distance D2 of R2 from Pa	4.34	m	
	FOS = Pa *D2/Pb*D1 >1.5	7.40		
		OK		
D	**Computation of Reaction**			
	Horizontal width of Column in Eccentric Footing	0.40	m	
	Ecentricity € =L2/2- (Horizontal Width of Column in Eccentricity Footing/2)	0.74	m	
	S1 =S - e	4.34	m	
	Load Factor For Ultimate Load	1.50		
	Ultimate Load at Column (PuA)	588.00	m	
	Ultimate Load at Column (PuB)	469.50	m	
	From the Actual loads and Force Equilibrium, the Relation below			
	RB/R2 = Pub * S/S1			
	R1 = PuA+PuB- R2	508.55	kN	
	R2 = Pub * S/S1	548.95	kN	
	qu =(PuA+ Pub)/B*(L1+L2)	195.65	kN/m^2	
	Now converting Point reaction in to uniform loading (kN/m)			
	R1	293.47	kN/m	
	R2	293.49	kN/m	
E	**Check for Depth**			
E.1	**Depth Check From Bending Moment**			
	Ultimate Bending Moment Mux Consider for Footing A	110.16	kN -m	
	Ultimate Bending Moment Mux Consider for Footing B	281.64	kN -m	
	Footing A Muy = qu *L1/2 *(B- C/2)^2, C is Column Width	51.28	kN -m	
	Footing B Muy= qu*L2/2*(B- C/2)^2 , C is Column Width	77.31	kN -m	
	Depth Footing A, d = Sqrt (Moment/k*fck*b)	166.16	mm	
	Depth Footing B, d = Sqrt (Moment/k*fck*b)	265.68	mm	
	Lets Adopted the Rebar to be used for Both Footing	**16.00**	m	
	hence over all depth (D) = depth from bend+dia/2+clear cover			
	Depth Footing A, D = sqrt(Moment /k*fck*b)	224.16	mm	
	Depth Footing B, D = sqrt(Moment /k*fck*b)	323.68	mm	
	Footing A			
	Reinforcemnt Required in mm^2 = $A_{st,req.}$			
	Ast req. = [0.5*fck*b*d/fy][(1-sqrt(1-4.6Mu/fck*b*d2)]	**1878.96**	mm^2	
	Reinforcement provided Column A	dia (mm)	Nos	
		16.00	10	
		2009.60	mm^2	
	Footing B			
	Reinforcemnt Required in mm^2 = $A_{st,req.}$			
	Ast req. = [0.5*fck*b*d/fy][(1-sqrt(1-4.6Mu/fck*b*d2)]	**3004.39**	mm^2	
	Reinforcement provided column A	dia (mm)	nos	
		16.00	15	
		3014.40	mm^2	
E.2	**Depth Check From 2-Way Shear**			
	2-Way Shear, also Commanly known as Punching Shear, of the Footing is Calclated at the Distance from the Face of Column, Where d is Depth of Footing.			
	Ultimate Shear Force Consider for Column A	333.72	kN	
	Ultimate Shear Force Consider for Column B	410.80	kN	
	Here, Max. Cosider for Ease Although SF @ d/2 from the face of Column would Lead to the Economic Section.			
	IS 456 _ 31.6.3 Permissible Shear Stress	ks * τc*		
	τc*=0.25 Sqrt fck	1.12		
	ks = min (1, 0.5 + βc)			
	βc, Ratio of Short Side to Long side of the Column / Capital	1.50		
	ks	1.00		
	τc =τc* x Ks	1.12	N/mm2	
	Adopted depth to satisfy puching shear under Column A	250.00	mm	**OK**
	Adopted depth to satisfy puching shear under Column B	350.00	mm	**OK**
	Nominal Punching Shear stress below under col. A			
	τv = [qu*{(L*B)(shear force)- (l+d)*(b+d)}]/[2*{(l+d)+(b+d)}*d]	0.51		
	τv < τc	**OK**	**For Column A**	
	τv < τc	**OK**	**For Column B**	





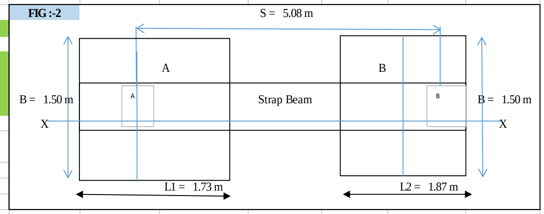






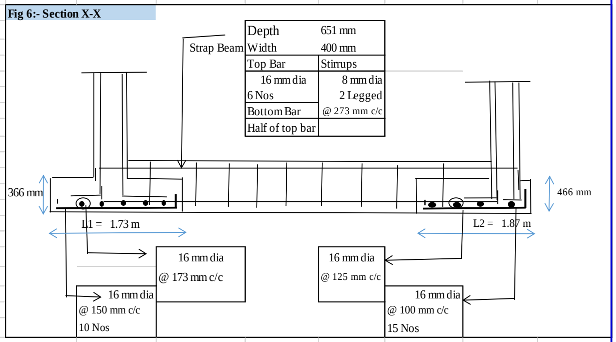
E3	**Depth check from 1-Way Shear**			
Footing A	1 way shear, of the Footing is Calclated at the Distance from the Face of Column d, where d is Depth of Footing A			
	Assume % Steel	0.37		
	Interpolation for % Steel	**τc**	**p%**	
	0.415702732	**0.50**	**0.48**	
		0.25	**0.36**	
	Assume Thickness 300mm> for k =1	1.00	if thick <300, then K >1 and d decreased---we consider for safe zone K =1	
	k * τc	**0.42**	N/mm2	
	τv			
	[qu * L *((B-b)/2- d)]/ [B * d]			
	(B-b)/2 = m	0.55	mm	
	qu	195.65	kN/m^2	
		0.20	N/mm^2	
	d = (qu * m)/ (qu + τc)	176.02	mm	
	Depth Required For One Way Shear	**OK**	176.02	mm
		For Column A		
Footing B	1 Way Shear, of the Footing is Calclated at the Distance from the face of Column d, where d is Depth of Footing B			
	Assume % Steel	0.43		
	Interpolation for % Steel	**τc**	**p%**	
	0.454	**0.50**	**0.49**	
		0.25	**0.36**	
	Assume Thickness 300mm> for k =1	1.00	if thick <300, then K >1 and d decreased---we consider for safe zone K =1	
	k * τc	**0.45**	N/mm2	
	τv			
	[qu * L *((B-b)/2- d)]/ [B * d]			
	(B-b)/2 = m	0.55	mm	
	qu	195.65	kN/m^2	
		0.20	N/mm^2	
	d = (qu * m)/ (qu + τc)	165.58	mm	
	Depth Required For one way shear	**OK**	165.58	mm
		For Column B		
	For Footing B Punching Shear is Governs the Depth of Footing not Bending Moment	**Adopted Depth**	**250.00**	**Footing A**
	For Footing B Punching Shear is Governs the Depth of Footing not Bending Moment	**Adopted Depth**	**350.00**	**Footing B**

FIG :-2



F	**Footing Design Summary**	**Footing A**	**Footing B External**
	Effective Depth d (mm)	308.00	408.00
	Dia of Bar (mm)	16.00	16.00
	Overall Depth D (mm)	366.00	466.00
	Reinforcment Area Provided mm2	2009.60	3014.40
	% Steel	0.37	0.43
	No of bars	10.00	15.00
	Spacing along B Required (mm)	173.29	124.70
	Spacing along L1/L2 Required (mm)	150.00	100.00

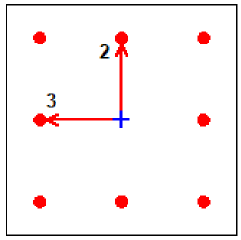
Fig 6:- Section X-X



2	**DESIGN OF STRAP BEAM PART**			
A	**Design of Main Reinforcement at Top**			
	Assume Width of Beam b	400.00	mm	
	Assume Depth of Beam d_b	600.00	mm	
	Clear Cover	35.00	mm	
	Ultimate BM in Beam Mu	270.88	kN-m	
	Ultimate SF in Beam	79.45	kN	
		k	0.133	
	Mu, max =K *fck*b*d2	383.04		
	Under Reinforcement Mu< Mu, max	**OK**		
	Hence, Design Singly Reinforcement Beam but with Nominal Bar at Top			
	Reinforcemnt Required in mm^2 = $A_{st, require}$	Bar Dia (mm)	16.00	
	Ast req. = [0.5*fck*b*d/fy][(1-sqrt(1-4.6Mu/fck*b*d2)]	1184.56	mm^2	
	Area of Tension Reinforcement provided at Top	**Dia (mm)**	**Nos**	
		16.00	**6**	
		1205.76	$\mathbf{mm^2}$	
	Xu max	276.00	mm	
	Xu actual =(0.87*fy*Ast)/(0.36*fck*b)	182.12	mm	
	Xu Actual < Xu max section is under reinforcement	**OK**		
B	**Design of Shear Reinforcement**			
Case 1	Nominal Spacing Reinforcement of 8 mm dia	τv < τc		
Case 2	Provide Shear Reinforcement by Design	τc < τv < τc,max		
Case 3	Redesign Section	τv < τc,max		
i	τc,max	2.80		
ii	τv	0.33	N/mm2	
iii	τc	0.48		
	% Steel	0.50		
	Interpolation for % Steel	**τc**	**p%**	
	0.48	**0.75**	**0.56**	
		0.50	**0.48**	
	Check Case 3	**OK**		
	Check Case 2	**Nominal Spacing Reinforcement Case 1**		
	Check Case 1	**Nominal Spacing Reinforcement of 8 mm dia**		
		Dia (mm)	Legged	
	For 2-legged Stirrups dia of Bar mm	8.00	2.00	
	Asv	50.24	mm^2	
	design spacing = 0.87*fy*Asv*d_b*/V*1000	330.09	mm	
	Spacing should be not less than			
	1__0.75d	450.00	mm	
	2_ 300mm	300.00	mm	
	3_ design spacing	330.09	mm	
	Spacing of Striupps c/c	273.18	mm	
	Stirrups Dia of Bar (mm)	8.00	2 Legged	
	Width of Beam b	400.00	mm	
	Depth of Beam D	651.00	mm	
	Nominal Spacing =0.87*fy*Asv/(0.4*b)	273.18	mm	

14 COLUMN DESIGN IN ETABS

IS 456:2000 Column Section Design Summary



Column Element Details Type: Sway Special (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
FF	C16	123	M20C400X400	DL+ 0.3LL + RSy	2750	3200	0.7

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
400	400	58	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	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 mm^2	Rebar % %
674.8814	-69.0404	-123.1495	13.4976	13.4976	2492	1.56

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)	0.835203	2750	17.3413	0	13.4976
Minor Bend(M2)	0.825155	2750	39.1139	0	13.4976

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 mm^2/m
Major, V_{u2}	76.9684	122.8268	54.7195	76.9684	443.37
Minor, V_{u3}	63.1242	122.8268	54.7195	63.1242	443.37

Joint Shear Check/Design

	Joint Shear Force kN	Shear V_{Top} kN	Shear $V_{u,Tot}$ kN	Shear V_c kN	Joint Area cm^2	Shear Ratio Unitless
Major Shear, V_{u2}	0	54.9774	391.8367	1073.3126	1600	0.365
Minor Shear, V_{u3}	0	45.0887	316.7016	1073.3126	1600	0.295

(1.4) Beam/Column Capacity Ratio

Major Ratio	Minor Ratio
0.685	0.562

Additional Moment Reduction Factor k (IS 39.7.1.1)

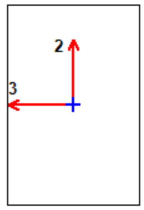
A_g cm^2	A_{sc} cm^2	P_{uz} kN	P_b kN	P_u kN	k Unitless
1600	24.9	2374.4082	624.6785	674.8814	0.971308

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	0.859	400	5.742	12	No	0
Minor Bending (M_2)	Yes	0.859	400	5.673	12	No	0

15 BEAM DESIGN IN ETABS

IS 456:2000 Beam Section Design



Beam Element Details Type: Sway Special (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
FF	B15	20	M20B300X450	DL+ 0.3LL + RSx	200	5080	1

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
300	450	300	0	25	25

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	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
-131.1938	0.0462	126.9385	0

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-131.1938	0.0679	47.1638	-131.2617

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)	-131.2617		856	0	856	274
Bottom (-2 Axis)		47.1638	428	270	0	428

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
140.671	0	140.9175	63.7673	918.81

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
0.0462	126.9385	270	420	0

DESIGN OF SLAB

Here the aspect ratio Ly/Lx is less than 2 hence the slab is designed as a two way slab.

<u>TwoAdjacentEdgesDisContinuous</u>:

Basic dimensions of slab =

Lx	Ly
4	5

Basic Ly/Lx ratio = 1.250 <2

Hence designed as two way slab

Clear cover to reinforcement	d'	=	15 mm
Provided overall depth	D	=	125.00 mm
Effective depth	d	=	106.00 mm
Diameter of bar	f	=	8 mm (20)
Select Grade of Concrete	fck	=	20 N/mm²
Select Grade of Steel	fy	=	500 0 N/mm²

Load calculation :

Dead load of the slab	DL	=	3.125 kN/m²
Floor finish(Roof finish)	FF	=	1.7 kN/m²
Live load	LL	=	2 kN/m²
Total load	TL	=	6.825 kN/m²

<u>Moment and Area of Steel calculations:</u>

Span	Moment Coefficient		Mu kN.m	Mu/bd² N/mm²	Pt %	Ast reqd mm²	Min Ast mm²	Dia of bar mm	Spacing mm	Ast pro mm²	
shorter	$a_{x\ neg}$	0.078	12.78	1.14	0.28%	298.05	127.2	8	150	335.10	**SAFE**
	$a_{x\ pos}$	0.059	9.58	0.85	0.21%	219.15	127.2	8	150	335.10	**SAFE**
longer	$a_{y\ neg}$	0.045	7.43	0.66	0.16%	167.67	127.2	8	150	335.10	**SAFE**
	$a_{y\ pos}$	0.034	5.57	0.50	0.12%	124.43	127.2	8	150	335.10	**SAFE**

Check for Deflection

The effective depth provided = 106.000 mm

From figure 3 of I.S 456:1978 modification factor is

Modification factor = 1.52

Required depth under deflection consideration = 105.61 mm

HENCE SAFE

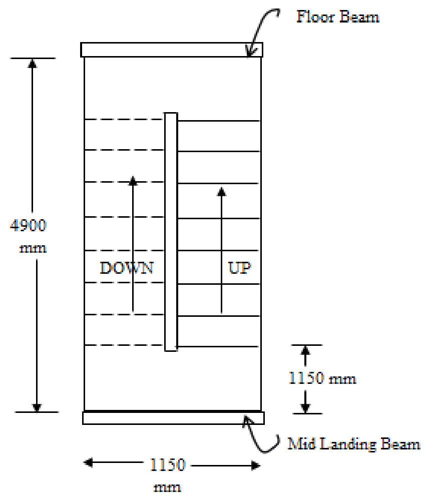
17 DESIGN OF STAIRCASE

DESIGN OF DOG LEGGED STAIRCASE

Data

Internal Dimensions

Length	=	4.9	m
Width	=	1.15	m
Floor Height	=	3.2	m
Fck	=	20	N/mm^2
Fy	=	500	N/mm^2
Riser	=	175	mm
Tread	=	275	mm
Landing width	=	1150	mm
Effective Span	=	4	m
Height of each flight	=	1.6	m
No. of risers in each flight		9	Nos
No. of Tread in each flight		8	Nos



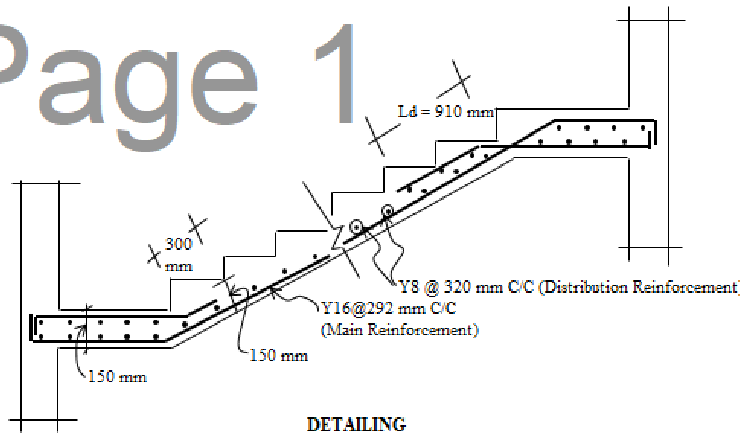
PLAN

Design

d	=	127	mm Required
D	=	150	mm
d	=	129	mm

Loads

DL of waist slab	=	3.75	kN/m^2
DL on horizontal are	=	4.44	kN/m^2
DL of steps	=	2.1875	kN/m^2
LL	=	3	kN/m^2
FF	=	1.5	kN/m^2
Total load	=	11.13	kN/m^2
Factored load	=	16.7	(of one flight)



DETAILING

BM and SF

Mu	=	33	kN-m
Vu	=	33	kN
d from BM consideration		110	mm
k	=	2.007	
pt	=	0.532	%
Ast	=	687	mm^2

Main Reinforcement

Dia	=	16	mm
Spacing	=	292	mm

Distribution Steel

Ast	=	155	mm^2
Dia of bar	=	8	mm
Spacing	=	320	mm

Development Length

Ld	=	$Ld = (\varnothing \times \sigma s) / (4 \times T_{bd})$	
Therefore, Ld	=	906	mm
Provide, Ld	=	910	mm

18 REFERENCES

- NBC-105:2020 Seismic Design of Buildings in Nepal
- IS 456- 2000Code of practice for plain and reinforced Concrete
- IS 1893-2016Criteria for Earthquake Resistant Design of Structures
- IS 13920-2016 Code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces
- IS 875(Part 1):1987, Code of practice for design loads (other than earthquake) for buildings and structures Part 1 Dead loads - Unit weights of building material and stored materials (second revision) (Incorporating IS:1911-1967)
- IS 875(Part 2):1987, Code of practice for design loads (other than earthquake) for buildings and structures: Part 2 Imposed loads (second revision)
- IS 875(Part 3):1987, Code of practice for design loads (other than earthquake) for buildings and structures: Part 3 Wind loads (second revision)
- IS 875(Part 4):1987, Code of practice for design loads (other than earthquake) for buildings and structures Part 4 Snow loads (second revision)
- IS 875(Part 5):1987, Code of practice for design loads (other than earthquake) for buildings and structures Part 5 Special loads and load combinations (second revision) SP 24 Explanatory Handbook on IS-456
- SP 34 (S&T) Handbook on concrete reinforcement and detailing
- SP 16 Handbook on Design Aids for Reinforced Concrete to IS 456:1978
- IS 4326:1993 Earthquake Resistant Construction of Buildings
- IS 1904:1986 Design and Construction of Foundations in soils General Requirement
- NBC 105:2020 Seismic Design of Buildings in Nepal
- NBC 205: 1994 Mandatory Rules of Thumb Reinforced Concrete Buildings without Masonry Infill