Design of a Single Storey Residential House

A PROJECT REPORT

Submitted in partial fulfillment for the requirement of the award of the degree of

BACHELOR OF TECHNOLOGY

In

CIVIL ENGINEERING

By

DEVASMIT DUTTA

Roll No: 18CE01003

School of Infrastructure
IIT Bhubaneswar
25th April 2021

Content **PAGE No.**

1. ***Introduction*** *4*

1.1 Problem Statement

1.2 Assumptions and notations

1.3 Codel Provisions used for Design

2. ***Plan and Layout*** *6*

2.1 Functional Plan

2.2 Beam-Column Grid Plan

2.3 Foundation Layout

2.4 3-D Rendered View

3. ***Loads*** *11*

3.1 Design Loads for Residential Buildings

3.2 Dead Load

3.3 Live Load

3.4 Wind Load

3.5 Seismic Load

3.6 Load Combinations

4. Analysis of Results, Comparison, Grouping of members, and Reinforcement detailing ***24***

4.1 Beams (Design and Detailing)

4.2 Columns (Design and Detailing)

4.3 Slabs (Design and Detailing)

4.4 Foundation (Design and Detailing)

5. Annexure: STAAD Pro Command File attached in separate document via e-mail

1.1 Problem Statement

Fix a building Plan for a residential building as per the following given data:

● Land area = 5000 ft2

● Built-up area = 1500-2000 ft2

● Building type: Framed RCC structure with fly-ash brick walls

● Location of building: Student's Hometown

● Terrain: Flat or Hilly depending on the location

Plan: -

A) Number of bedrooms: 2

B) Drawing Room

C) Dining Hall

D) Pooja Room

E) Number of washrooms (with water closet): 2

F) Study Room

E) Kitchen

F) Store Room

G) Balconies: 2

Size:

1) Master Bed-Room - 4.63 x 4.13 m sq.

2) Guest Bed-Room – 4.63 x 1.85 m sq.

3) Pooja Room – 2.72 x 2 m sq.

4) Store Room – 3 x 2.25 m sq.

5) Kitchen – 4 x 5 m sq.

6) Study Room – 4 x 1.68 m sq.

7) Washroom - 4.63 x 2.08 m sq.

4 x 1.55 m sq.

8) Balcony – 4.1 x 1.88 m sq.

7.45 x 2.25 m sq.

1.2 Assumptions and notations: -

1) The Grade of concrete used is M25 as f_{ck}= characteristic compressive strength of concrete.

2) Grade of steel is Fe415 and Fe 500 as f_y=yield strength of steel.

3) We are not doing any complex response spectrum analysis of the Loading conditions, in STAAD Pro software, only simple analysis for example typical bending moment diagrams, and axial and shear force, and deflected shape analysis are to be taken into consideration.

4) E= Modulus of elasticity of steel, $2*10^5$ Mpa

5)A_{st}=Area of tensile reinforcement

1.3 Codel Provisions used for Design

A) IS 456- Plain and RC concrete

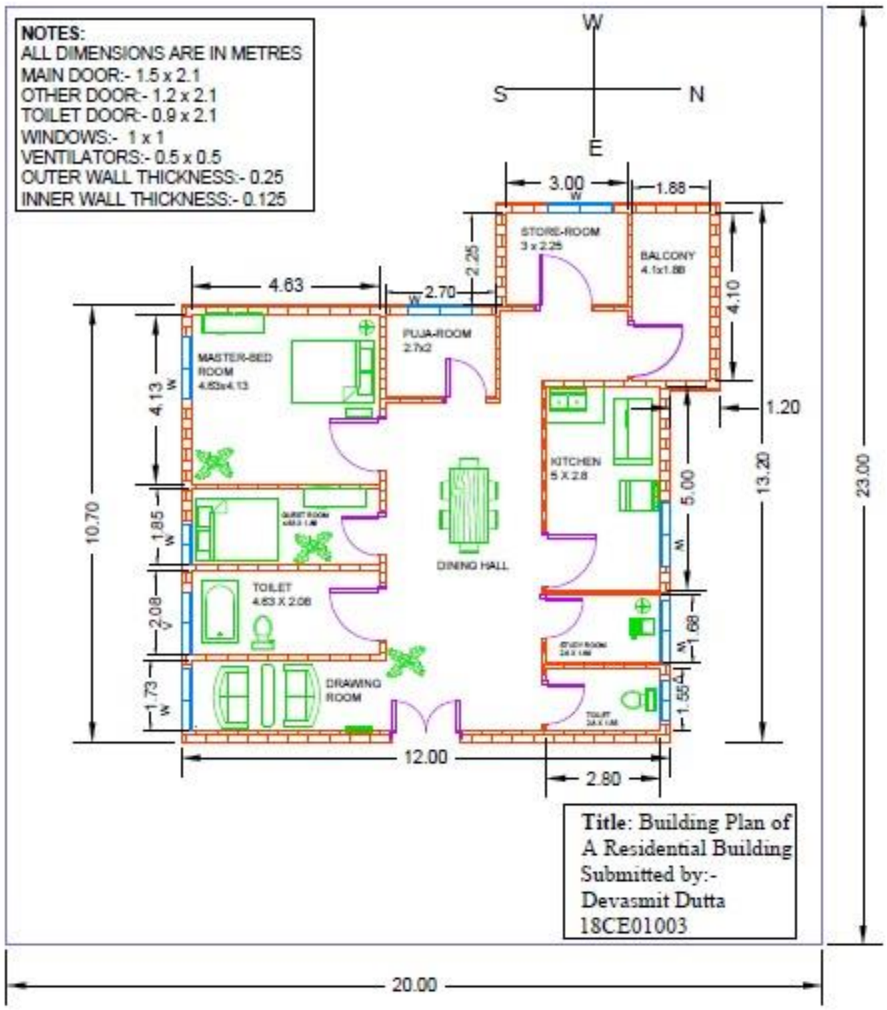
B) IS 1256 – Building Bye-Laws

C) IS 875 Part 3 – Wind Load

D) IS 875 Part 2 - Imposed Load

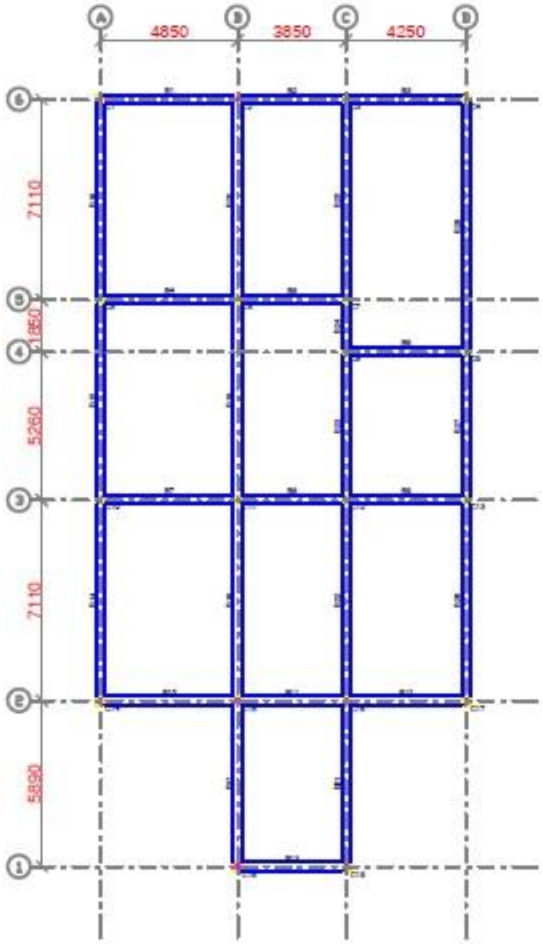
E) IS 1893-2016 – Earthquake Resistant Design

2.1 Functional Plan

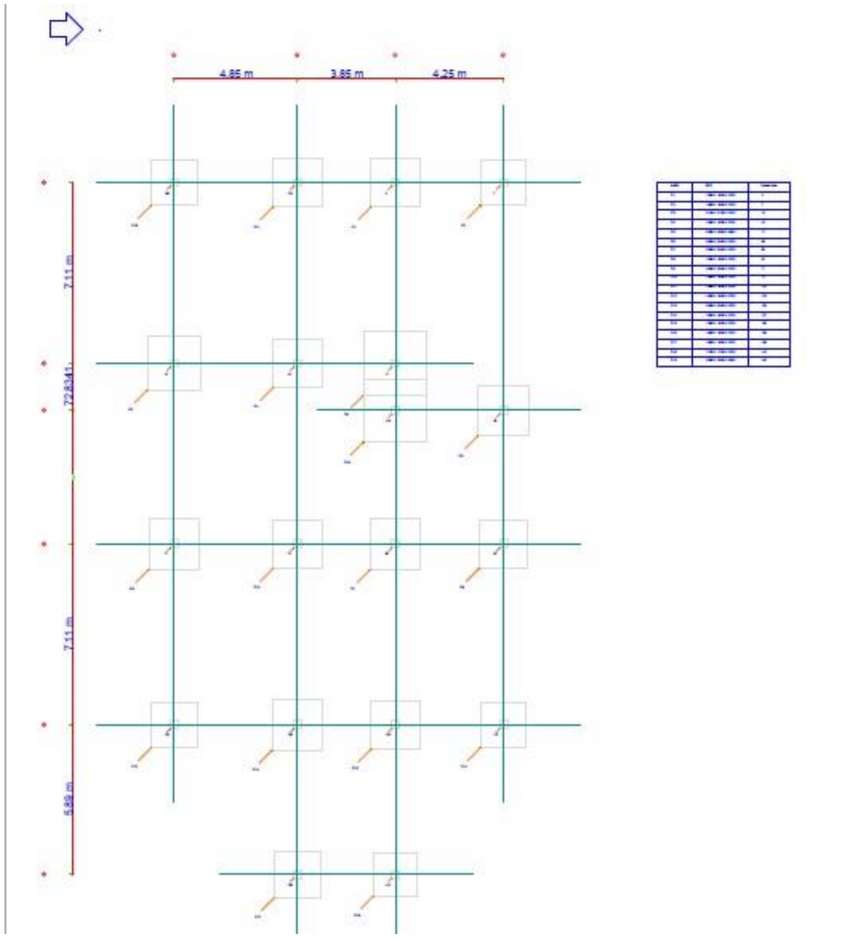


Note: The configuration of above Plan was later updated with slight modifications (basically 1 Balcony was added beside the master bedroom, the outside wall of kitchen, study room, and toilet, was extended and the entrance some portion was extended a bit), as shown below in Staad-Pro 3D-Rendering View, to have correct output after running analysis in Staad-Pro.**

2.2 Beam-Column Grid Plan



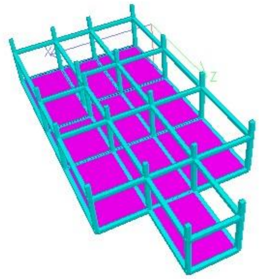
2.3 Foundation Layout

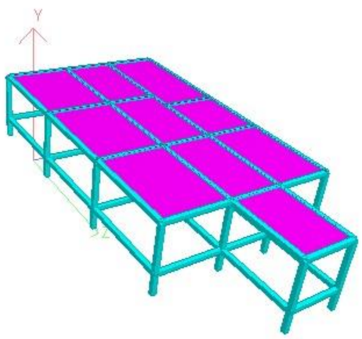


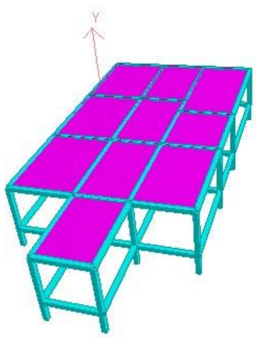
Note here two footings were found to be overlapping despite having made changes to the dimensional parameters of the footing, to bring them isolated

MARK	SIZE	Column Nos.
FI1	1.900 X 1.900 X 0.700	3
FI2	1.800 X 1.800 X 0.700	7
FI3	2.100 X 2.100 X 0.700	15
FI4	1.900 X 1.900 X 0.700	16
FI5	2.500 X 2.500 X 0.800	17
FI6	2.000 X 2.000 X 0.700	35
FI7	2.000 X 2.000 X 0.700	60
FI8	1.900 X 1.900 X 0.700	62
FI9	2.000 X 2.000 X 0.700	71
FI10	1.900 X 1.900 X 0.700	72
FI11	1.900 X 1.900 X 0.700	122
FI12	1.800 X 1.800 X 0.700	123
FI13	2.000 X 2.000 X 0.700	125
FI14	1.800 X 1.800 X 0.700	127
FI15	1.900 X 1.900 X 0.700	130
FI16	1.800 X 1.800 X 0.700	138
FI17	1.800 X 1.800 X 0.700	139
FI18	1.700 X 1.700 X 0.700	142
FI19	2.500 X 2.500 X 0.900	145

2.4 3-D Rendered View







3.1 Design Loads for Residential Buildings

As per the design philosophy, particularly, there are following loads to be taken into consideration for the design of single Storey residential house: -

1) *Dead Load*: This includes the self-weight of the columns, beams and slabs, and parapet walls. Basically, this is the load which remains identical and constant throughout the design life period of the building. Basically, the slab exerts a dead load as self-weight along with the floor finish. We primarily refer to IS-Code 875 (Part 1) for dead load analysis.

2) *Live Load: -* Generally, Live load is another terminology used for the imposed load purposes. We generally refer to IS-Code 875 (Part 2) for identifying the type of functionality of structures and their live load pressure values.

3) *Wind Load*: - Wind load is one of the most important loads, especially to be considered for the sea-shore and coastal regions of different parts of the country. We generally refer to the IS-Code 875 (Part 3) for analysis purposes.

4) *Seismic Load: -* Seismic load is generally applied as per the guidelines given by the IS-Code 1893-2016. More details are given in section **3.5** part.

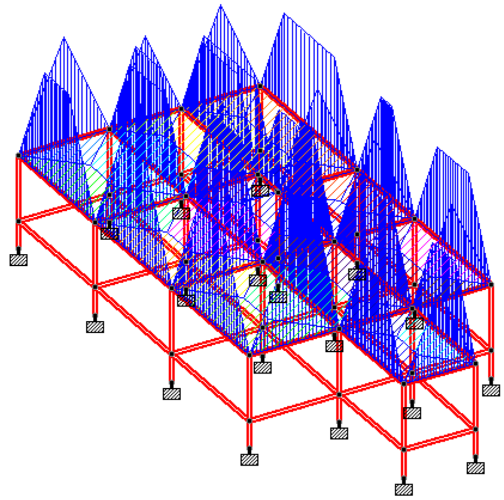
3.2 Dead Load

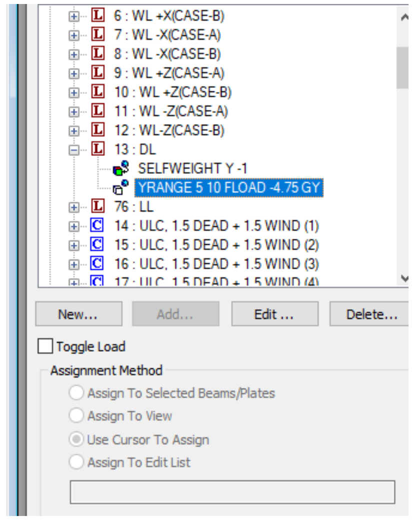
As per the guidelines of the IS-Code 875(Part-1) following are the abstracts used for manual analysis: -

The dead load is basically assigned to all the members of the structure using the Staad command self-weight in Dead Load type. Here, we calculate as, self-weight just like in seismic load, by multiplying unit weight with the required area and the length of the member, and then only the roof slab dead load is added as:

0.15*25 +1(due to floor finish) =4.75 kN/m2 is added as roof floor load.

Following snap, explains this,





3.3 Live Load

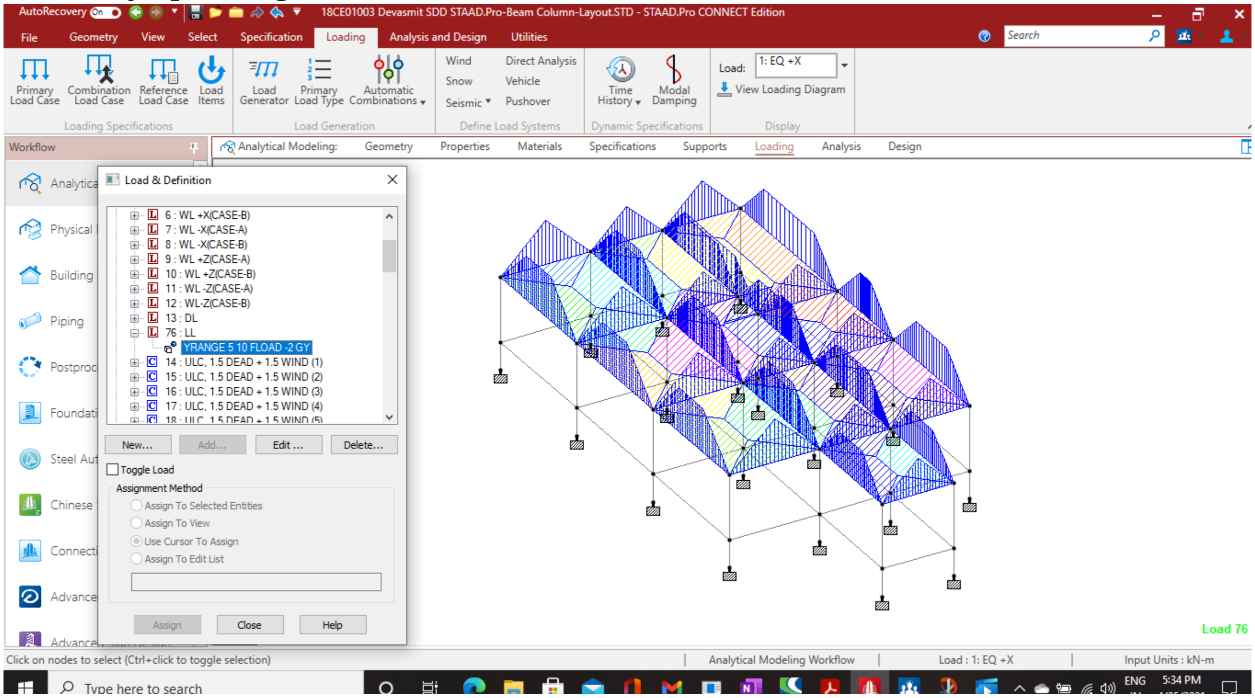
As per the guidelines of the IS-Code 875(Part-2) following are the abstracts used for manual analysis: -

The live load as per codal provisions depends on the occupancy of the structure.

In my model, I have taken as 2 kN/m2 as the load pressure.

Below, diagram from staad, shows the load distribution as taken by the various plate elements depending on the Ly/Lx ratio that is whether One-way spanning or

Two-way spanning.



3.4 Wind Load

As per the guidelines of the IS-Code 875(Part-3) following are the abstracts used for manual analysis: -

The basic equation for the Design wind Speed is:

$V_z = V_b * k1 * k2 * k3 * k4$,

where, V_b is selected based on Zone Identification in Fig-1 from the code. Then, the risk coefficient or probability factor, k1, based on design life, terrain roughness and height factor, k2, based on terrain category, topography factor, k3, based on upwind slope, and Importance factor for cyclonic factor, k4, based on location of structure, is selected accordingly.

In my case, my structure is located in North-Eastern Region, in the city of Guwahati, in Assam.

After this, the design wind pressure is calculated as:

$P_z = 0.6 * V_z^2$

and after multiplying P_z with appropriate factors we get the design wind pressure, $P_d = K_d * K_a * K_c * P_z$

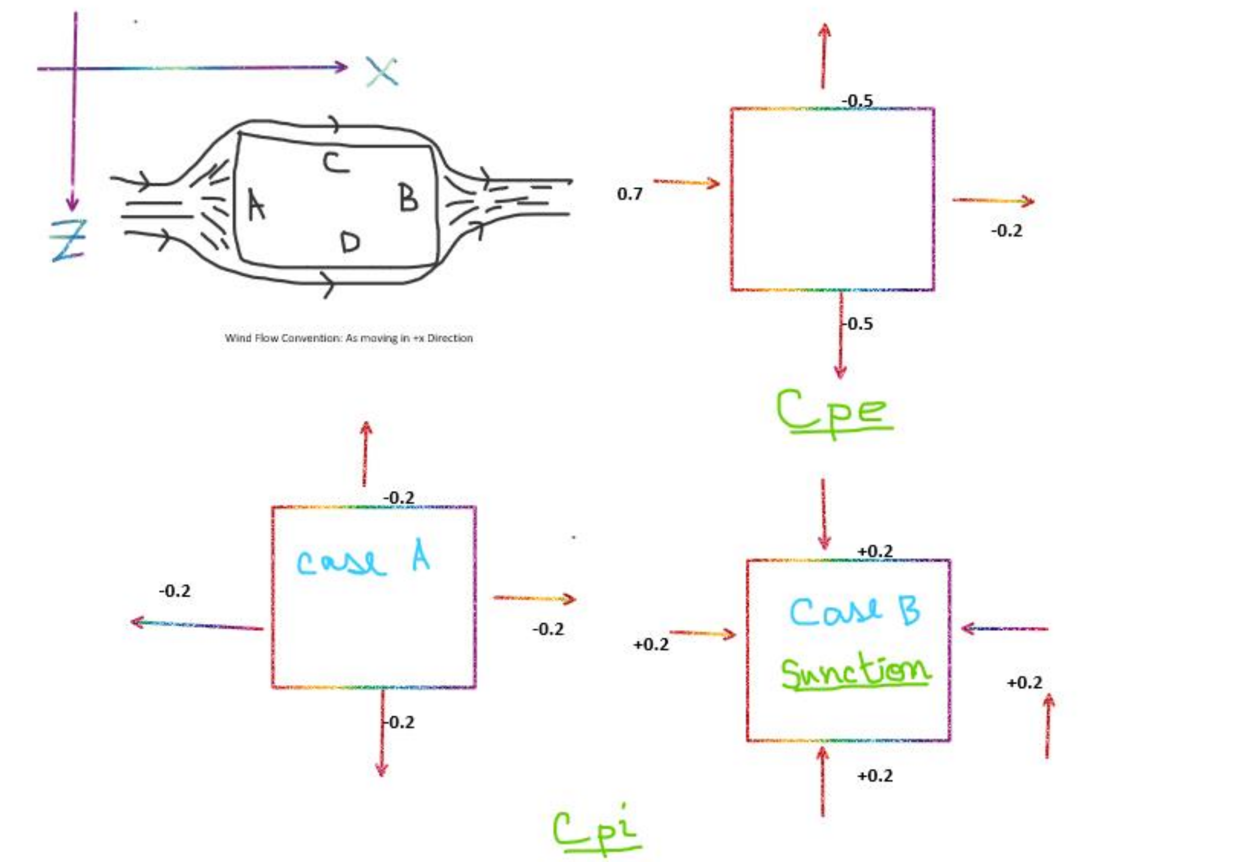
Where, Ka is selected based on tributary area, and Kd is wind directional factor, and Kc is combinational factor, generally taken as 1.

After this once we are done with the Pd, the next job is to find the Force as:

$F(kN) = (C_{pe} - C_{pi}) * A_c * P_d$,

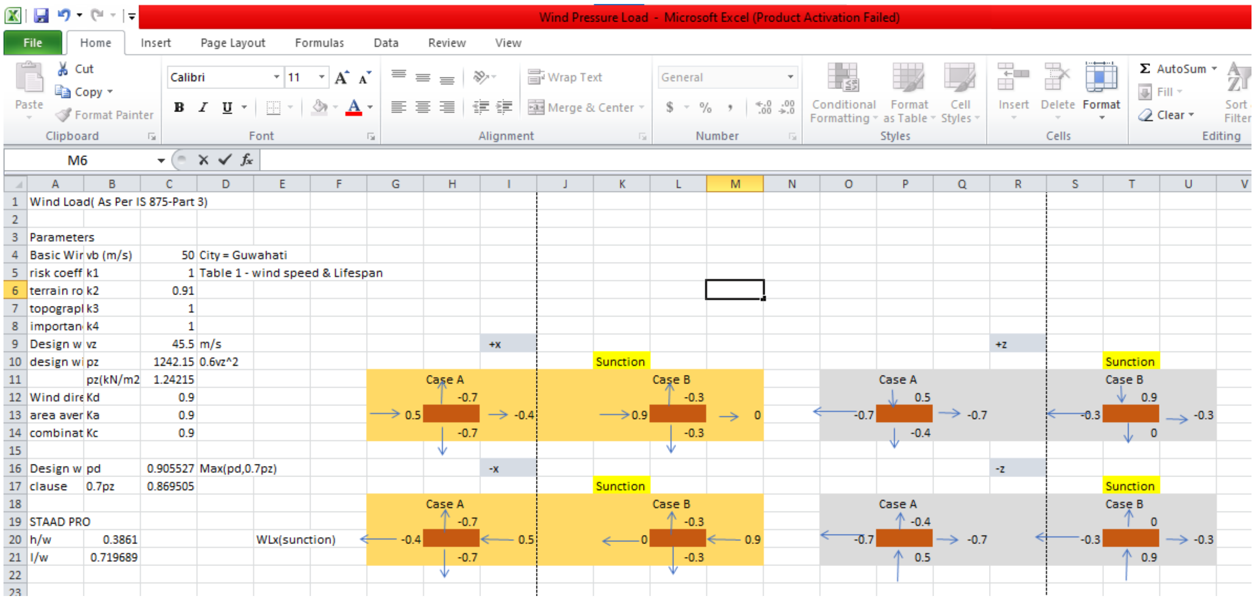
where C_{pe} and C_{pi} are the external and internal pressure coefficients respectively. Based on the H/W and L/W of the structure, the Cpe values are taken accordingly.

The following diagram expresses the functionality, of the convention--



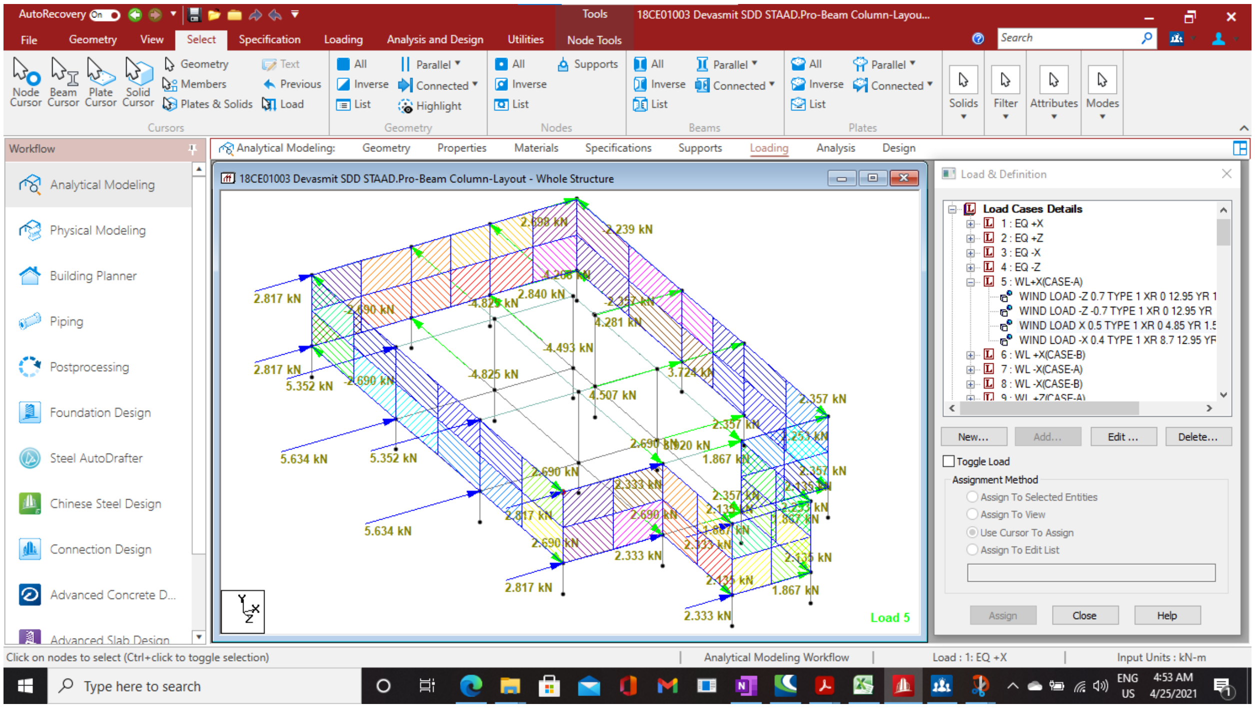
Therefore, there will be total 8 wind load cases, as we can see below. Also, one important point is that Cpi is taken as 0.2, considering the area of opening to be less than 5% of the wall area, as per guidelines.

The below snapshot taken from excel sheet expedites the calculations which approximately is consistent with the staad pro values as shown below: -



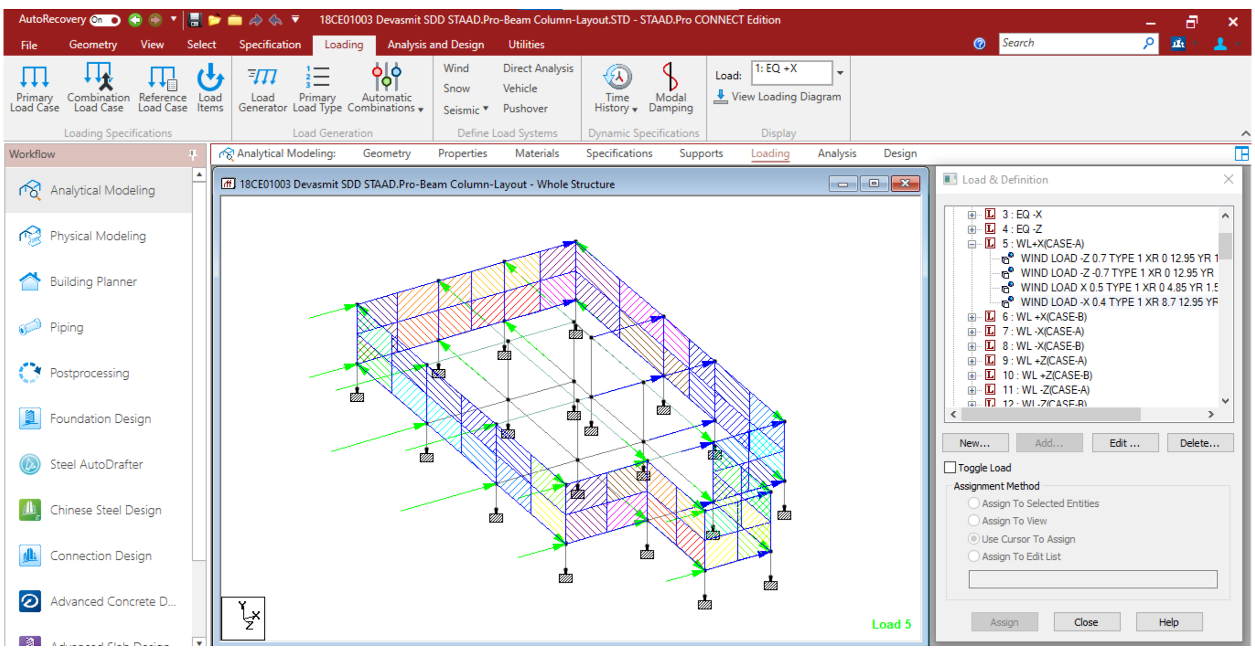
Design of Wind Load	Case	Face a	Face b	Face c	Face d	Face e	Face f	Face g	Face h	
+ x	A	32.11101	27.2936	25.6888	8.95736	7.093627	8.114314	8.867034	10.22193	
	B	57.79981	11.69726	0	3.838869	0	3.477563	15.96066	4.380826	
-x	A	25.6888	27.2936	32.11101	8.95736	8.867034	8.114314	7.093627	10.22193	
	B	0	11.69726	57.79981	3.838869	15.96066	3.477563	0	4.380826	
+Z	A	44.95541	19.49543	44.95541	5.118491	12.41385	4.636751	12.41385	5.841102	
	B	19.2666	35.09177	19.2666	0	5.32022	0	5.32022	0	
-Z	A	44.95541	15.59634	44.95541	6.398114	12.41385	5.795939	12.41385	7.301377	
	B	19.2666	0	19.2666	11.51661	5.32022	10.43269	5.32022	13.14248	

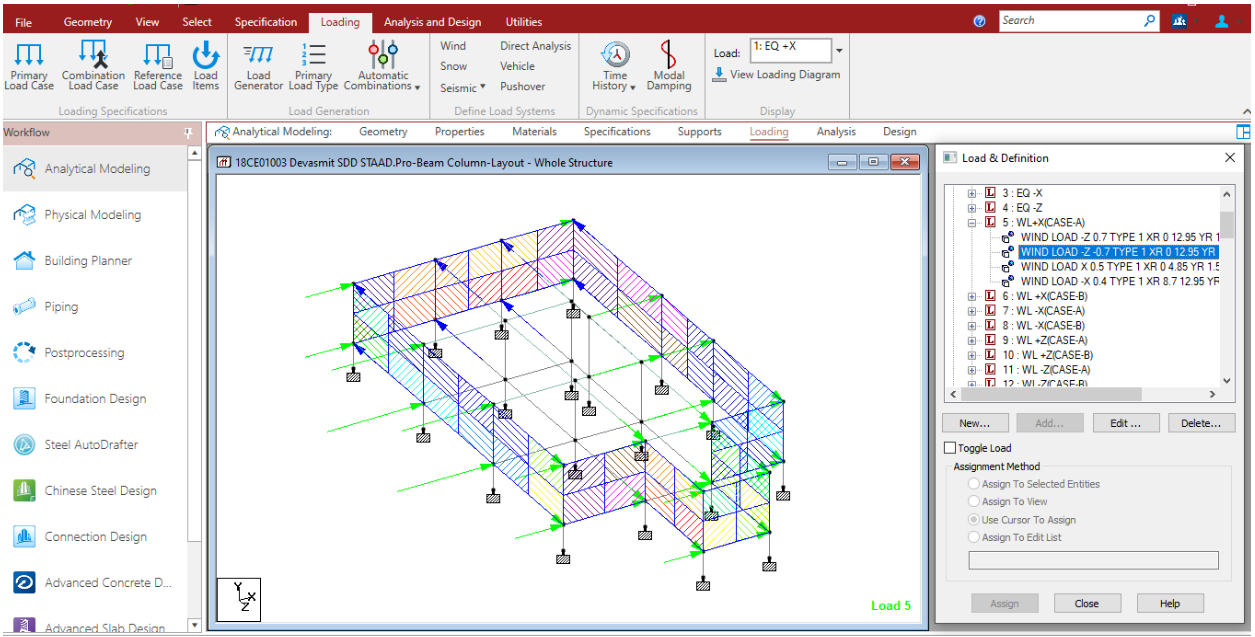
For example, for illustration, as we can see on face A along +x direction and case A, the net total force is 32.11101 kN.

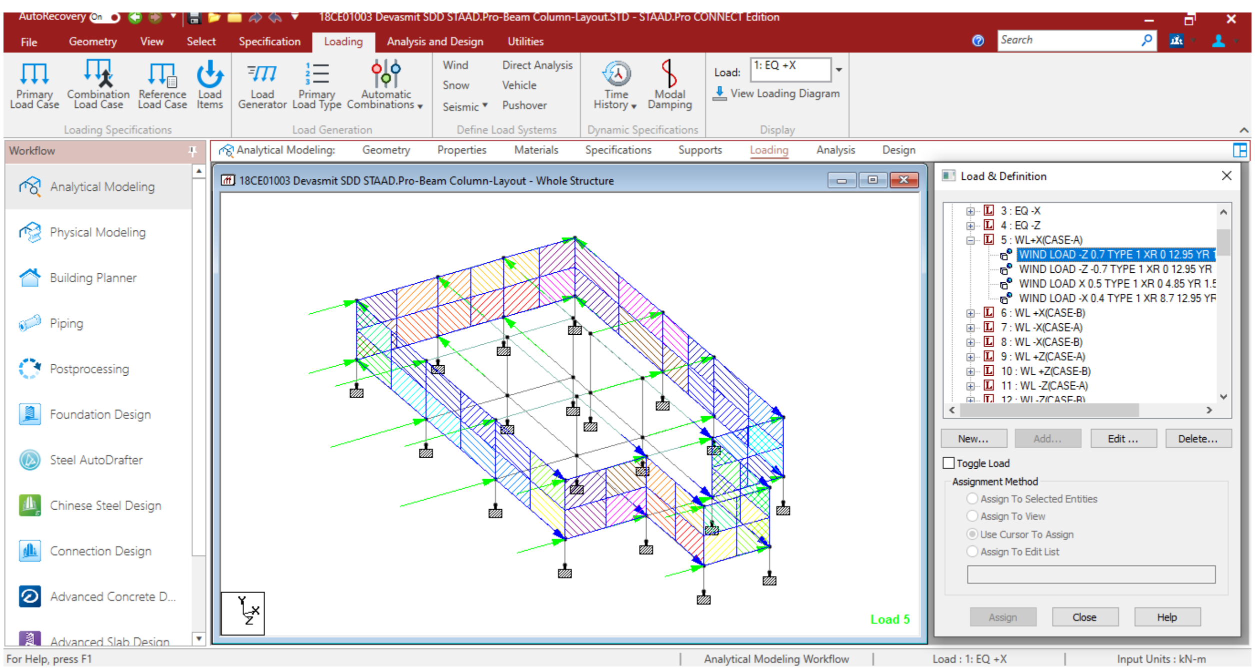


Also, from, Staad, we got, total force acting after adding the **blue arrows** as 33.24 kN, which is almost consistent with our manual analysis.

For more illustration, following pictures taken from staad shows the load distribution throughout the tributary area of the walls.







3.5 Seismic Load

As per the guidelines of the IS-Code 1893-2016 following are the abstracts used for manual analysis: -

The earthquake load is one of the most important loads particularly for the structures located in the Zone-5 and Zone-4. The land cover of India, is basically divided into 4 zones from II-V. The basic assumptions used in the analysis of seismic load is that it is a simple static analysis, as compared to other dynamic time history analysis.

So, basically, the governing equation for calculating the earthquake load involves the following:

$A_h = (Z/2) * (S_a/g)/(R/I)$,

F (kN) = Seismic Weight * Ah

Where, the load gets acted into +x ,–x, and +z, -z directions respectively.

Here, Z= is our seismic zone factor (as per my model, it is 0.36, since my region comes under the Zone-V, which is very much vulnerable to earthquake).

Sa/g which is the design acceleration coefficient is selected by the required soil type used for analysis. And simultaneously, R, response reduction factor and I, importance factor is selected based on the type and functionality of the structure.

Now, our seismic load weight is calculated based on the following:

DL= 0.3*0.3*Σ Length of individual members* 25 + 0.3*0.3*Height of the column *25 *(½)*No of columns + Plan area * (0.15*25+ floor finish) + perimeter of the parapet wall provided*0.25*1*18.

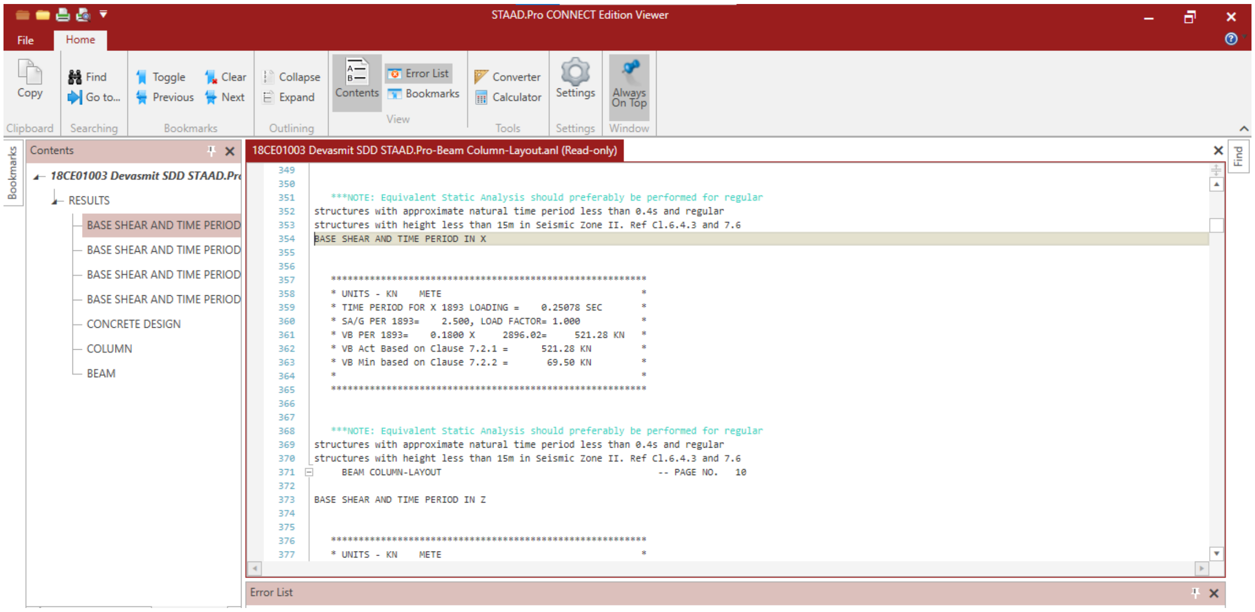
Then, $W_{seismic}$=DL+ 0.25*LL

Below snap taken from google sheets, shows the manual calculation done:

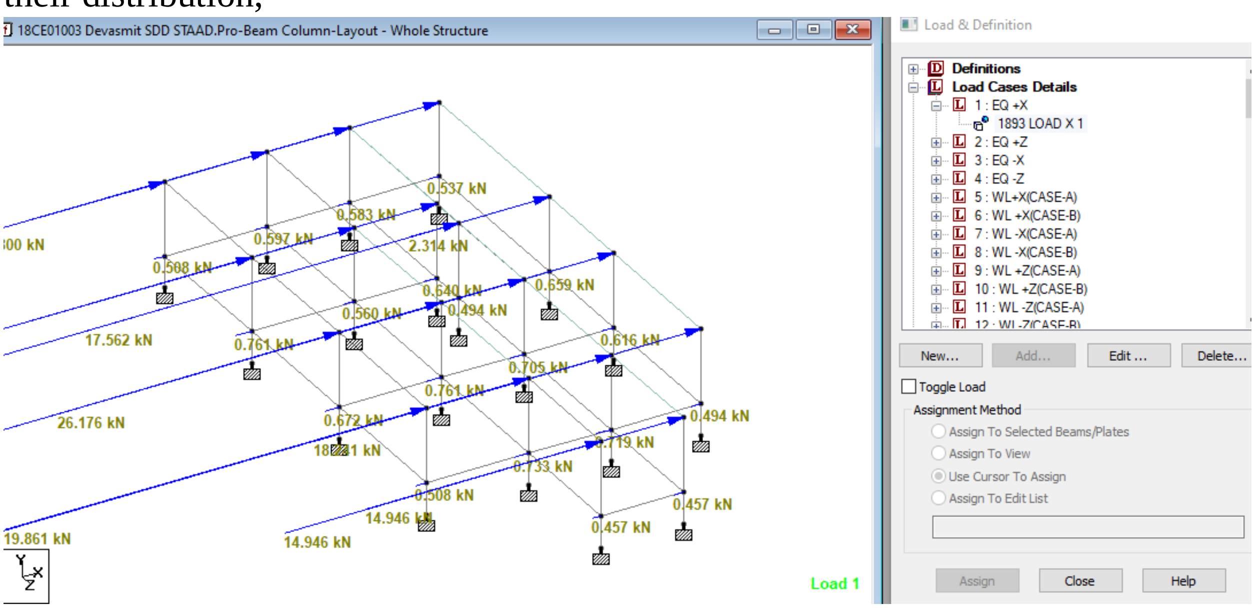
Column	DL Col.	Beam	DL Beam.	DL Slab	DL Parapet	LL		DL TOTAL	VB-x	Tx	Ty	VB-z
A6	5.625	A6A5	15.9975	1421.00525	361.71	149.5795		106.875	490.842855	0.08753377726	0.06037629978	490.842855
A5	5.625	A5A3	16.0425					687.735				
A3	5.625	A3A2	15.9975					1421.00525				
A2	5.625	B6B5	15.9975					361.71				
B6	5.625	B5B3	16.0425					149.5795				

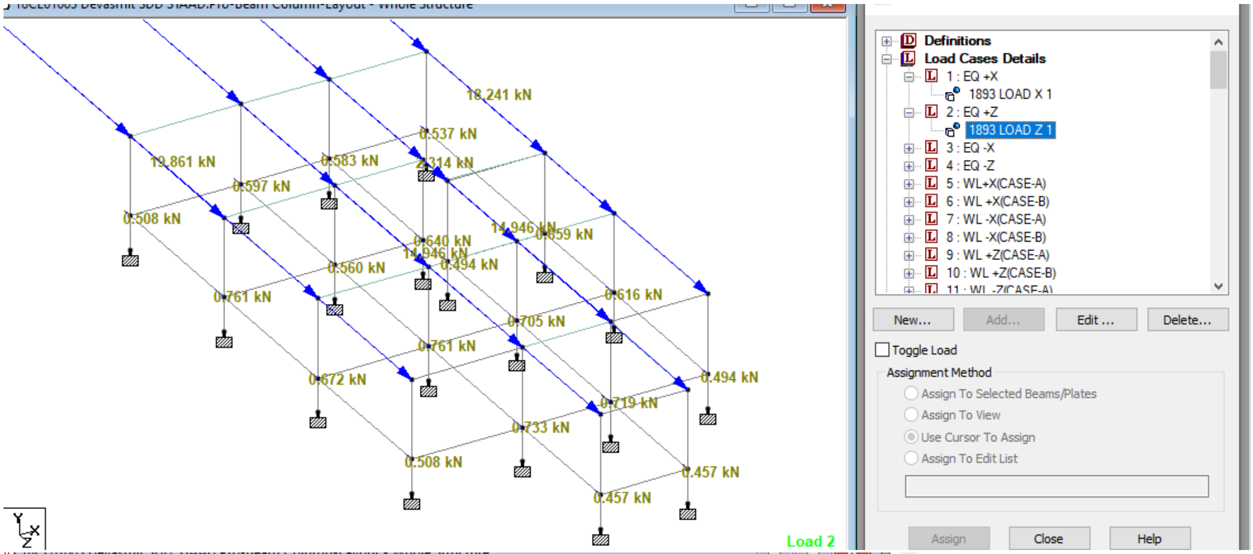
B5	5.625	B3B2	15.9975				Sum: -	2726.90475				
B3	5.625	B2B1	13.2525									
B2	5.625	C6C5	15.9975									
B1	5.625	C5C4	4.1625									
C6	5.625	C4C3	11.88									
C5	5.625	C3C2	15.9975									
C4	5.625	C2C1	13.2525									
C3	5.625	D6D4	20.16									
C2	5.625	D4D3	11.88									
C1	5.625	D3D2	15.9975									
D6	5.625	6AB	10.9125									
D4	5.625	6BC	8.6625									
D3	5.625	6CD	9.5625									
D2	5.625	5AB	10.9125									
	106.875	5BC	8.6625									
		4CD	9.5625									
		3AB	10.9125									
		3BC	8.6625									
		3CD	9.5625									
		2AB	10.9125									
		2BC	8.6625									
		2CD	9.5625									
		1BC	8.6625									
			687.735									

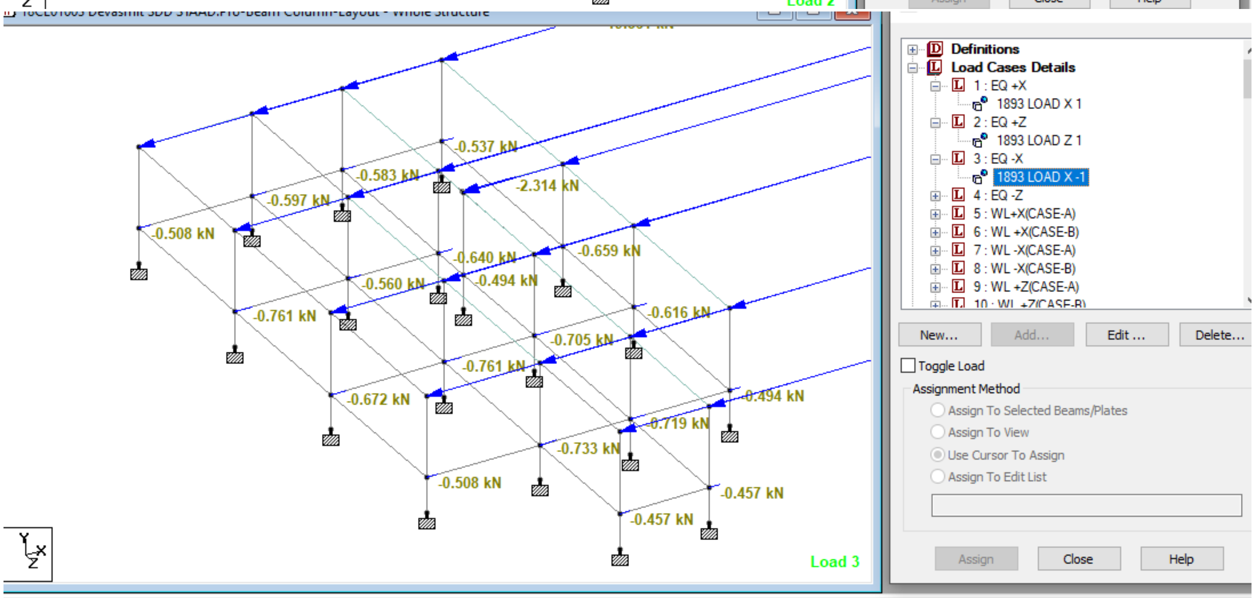
Also, for example, the STAAD pro analysis results shows the final V $_{\text{baseshear}}$ is about 521.28kN, for V $_{\text{baseshear}}$ in +x, which is almost consistent, with our manual calculation about 490 kN, although there is variation of slight error from software results.

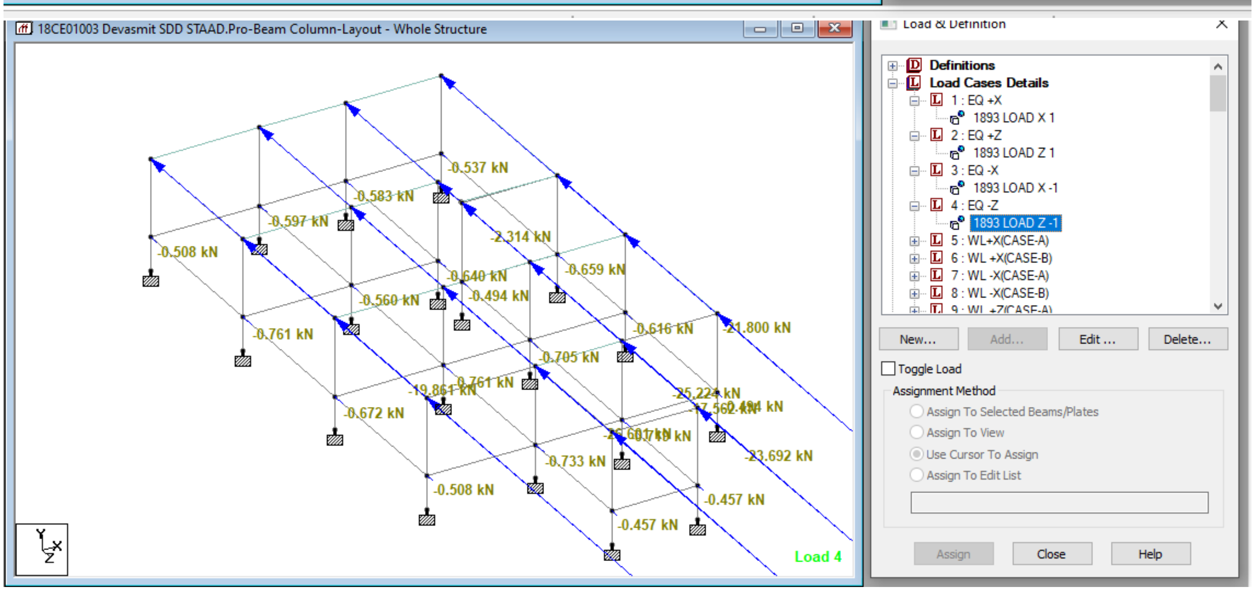


Following load generation as nodal load show the point of generation of loads and their distribution,




18.241 kN
0.537 kN
19.861 kN
0.583 kN
2.314 kN
0.597 kN
0.508 kN
14.946 kN
0.659 kN
0.640 kN
14.946 kN
0.494 kN
0.560 kN
0.761 kN
0.616 kN
0.705 kN
0.761 kN
0.672 kN
0.494 kN
0.719 kN
0.733 kN
0.508 kN
0.457 kN
0.457 kN
Load 2
Definitions
Load Cases Details
1 : EQ +X
1893 LOAD X 1
2 : EQ +Z
1893 LOAD Z 1
3 : EQ -X
4 : EQ -Z
5 : WL+X(CASE-A)
6 : WL +X(CASE-B)
7 : WL -X(CASE-A)
8 : WL -X(CASE-B)
9 : WL +Z(CASE-A)
10 : WL +Z(CASE-B)
New...
Add...
Edit ...
Delete...
Toggle Load
Assignment Method
Assign To Selected Beams/Plates
Assign To View
Use Cursor To Assign
Assign To Edit List
Assign
Close
Help

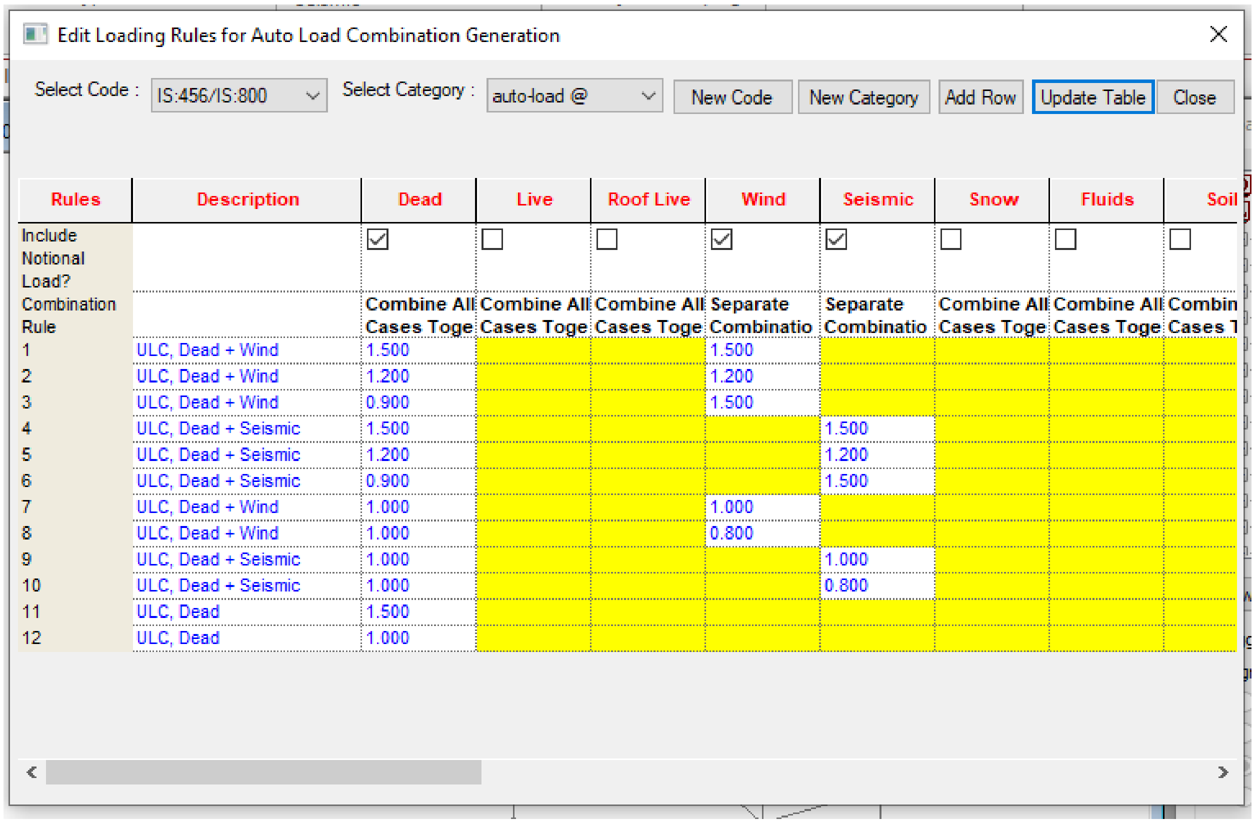

-0.537 kN
-0.583 kN
-2.314 kN
-0.597 kN
-0.508 kN
-0.640 kN
-0.659 kN
-0.560 kN
-0.494 kN
-0.761 kN
-0.616 kN
-0.705 kN
-0.761 kN
-0.672 kN
-0.494 kN
-0.719 kN
-0.733 kN
-0.508 kN
-0.457 kN
-0.457 kN
Load 3
Definitions
Load Cases Details
1 : EQ +X
1893 LOAD X 1
2 : EQ +Z
1893 LOAD Z 1
3 : EQ -X
1893 LOAD X -1
4 : EQ -Z
5 : WL+X(CASE-A)
6 : WL +X(CASE-B)
7 : WL -X(CASE-A)
8 : WL -X(CASE-B)
9 : WL +Z(CASE-A)
New...
Add...
Edit ...
Delete...
Toggle Load
Assignment Method
Assign To Selected Beams/Plates
Assign To View
Use Cursor To Assign
Assign To Edit List
Assign
Close
Help


18CE01003 Devasmit SDD STAAD.Pro-Beam Column-Layout - Whole Structure
-0.537 kN
-0.583 kN
-0.597 kN
-2.314 kN
-0.508 kN
-0.640 kN
-0.659 kN
-0.560 kN
-0.494 kN
-0.761 kN
-0.616 kN
-21.800 kN
-0.705 kN
-0.672 kN
-0.733 kN
-23.692 kN
-0.508 kN
-0.457 kN
-0.457 kN
Load 4
Load & Definition
Definitions
Load Cases Details
1 : EQ +X
1893 LOAD X 1
2 : EQ +Z
1893 LOAD Z 1
3 : EQ -X
1893 LOAD X -1
4 : EQ -Z
1893 LOAD Z -1
5 : WL+X(CASE-A)
6 : WL +X(CASE-B)
7 : WL -X(CASE-A)
8 : WL -X(CASE-B)
New...
Add...
Edit ...
Delete...
Toggle Load
Assignment Method
Assign To Selected Beams/Plates
Assign To View
Use Cursor To Assign
Assign To Edit List
Assign
Close
Help

<u>3.6 Load Combinations</u>

As per the guidelines of the IS-Code 456 following are the abstracts used for manual analysis: -

The various load combinations factors used for the analysis are tabulated below, as taken snap from staad auto load combination table:



Rules	Description	Dead	Live	Roof Live	Wind	Seismic	Snow	Fluids	Soil
Include Notional Load?		☑	☐	☐	☑	☑	☐	☐	☐
Combination Rule		Combine All Cases Toge	Combine All Cases Toge	Combine All Cases Toge	Separate Combinatio	Separate Combinatio	Combine All Cases Toge	Combine All Cases Toge	Combin Cases T
1	ULC, Dead + Wind	1.500			1.500				
2	ULC, Dead + Wind	1.200			1.200				
3	ULC, Dead + Wind	0.900			1.500				
4	ULC, Dead + Seismic	1.500				1.500			
5	ULC, Dead + Seismic	1.200				1.200			
6	ULC, Dead + Seismic	0.900				1.500			
7	ULC, Dead + Wind	1.000			1.000				
8	ULC, Dead + Wind	1.000			0.800				
9	ULC, Dead + Seismic	1.000				1.000			
10	ULC, Dead + Seismic	1.000				0.800			
11	ULC, Dead	1.500							
12	ULC, Dead	1.000							

So, therefore,

S no	DL	WL	EL	Total
Limit State of collapse				
1	1.5	1.5		8
2	1.2	1.2		8
3	0.9	1.5		8
4	1.5		1.5	4
5	1.2		1.2	4
6	0.9		1.5	4
Limit state of serviceability				
7	1	1		8

8	1	0.8		8
9	1		1	4
10	1		0.8	4
11	1			1
12	1.5			1
				62

And then 62 + 14(individual load cases without Multiplying factors of safety) load cases details, = 76 total load details will be generated.

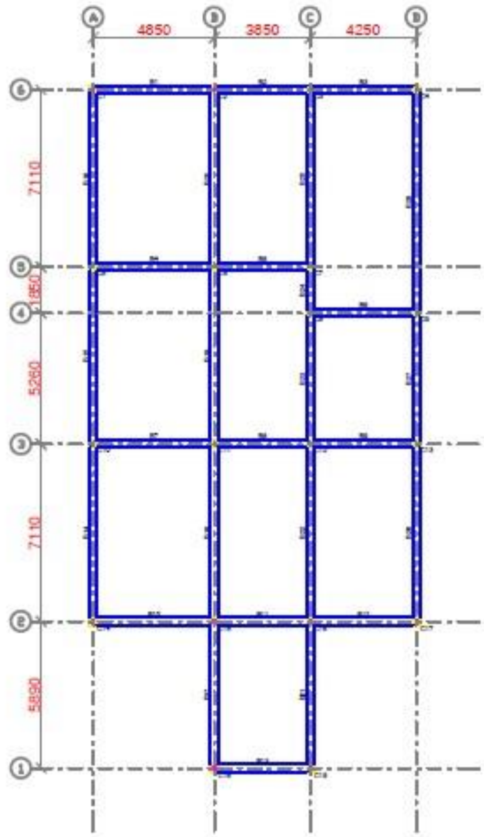
In all above analysis, we follow the Principle of LSD, Limit State of Design, over other Principles like WSD, working stress design, and ULM, ultimate load. method. The basic reason behind is that LSD takes into account the partial factor of safeties for both load and capacity design, as a result we get a better probabilistic design in the longer run. Also, limit state of design, requires the structure to satisfy the ultimate limit state (ULS) and serviceability limit state (SLS).

The ULS requires the physical situation where it involves either the excessive deformations leading and approaching collapse of the component under consideration or the structure as a whole, as a relevant, or deformations exceeding pre-agreed values.

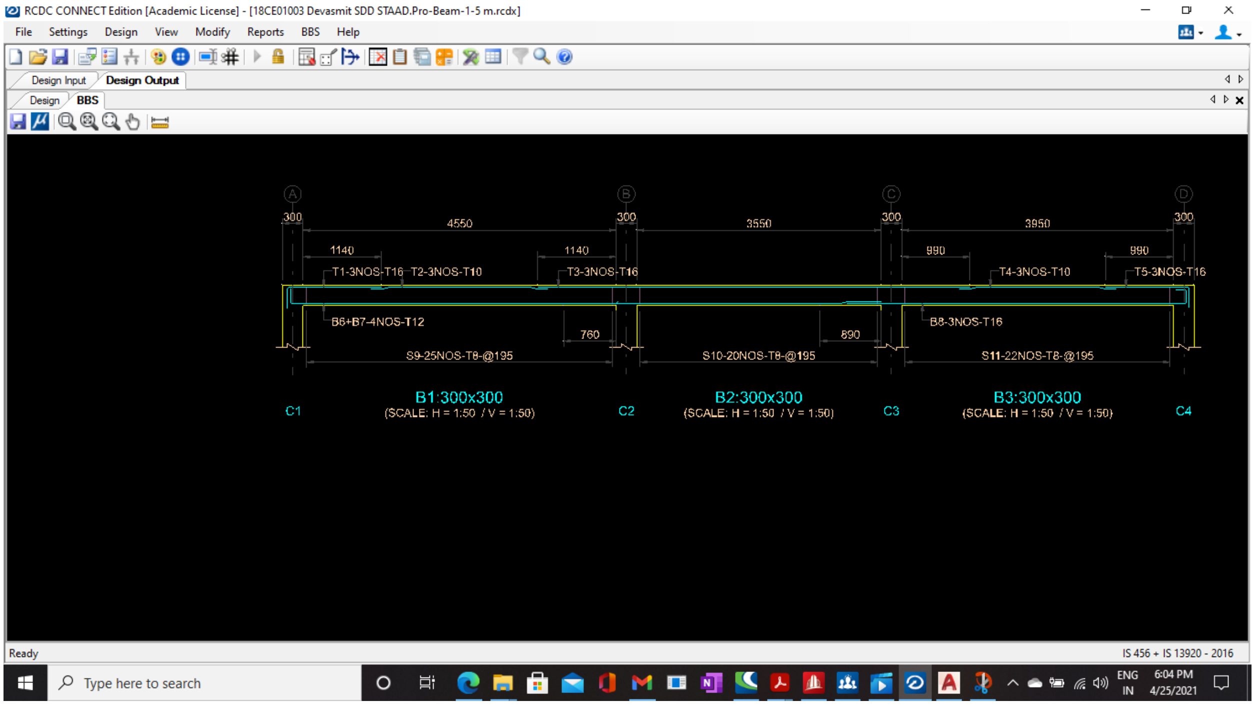
The criteria for SLS, involves various stress limits, deformation limits (deflections, rotations, curvature), flexibility (or rigidity) limits, dynamic behavior limits, as well as crack growth control requirements (crack width), and other arrangements concerned with the durability of the structure and its level of everyday service level and human comfort achieved, and its abilities to fulfill its everyday functionality.

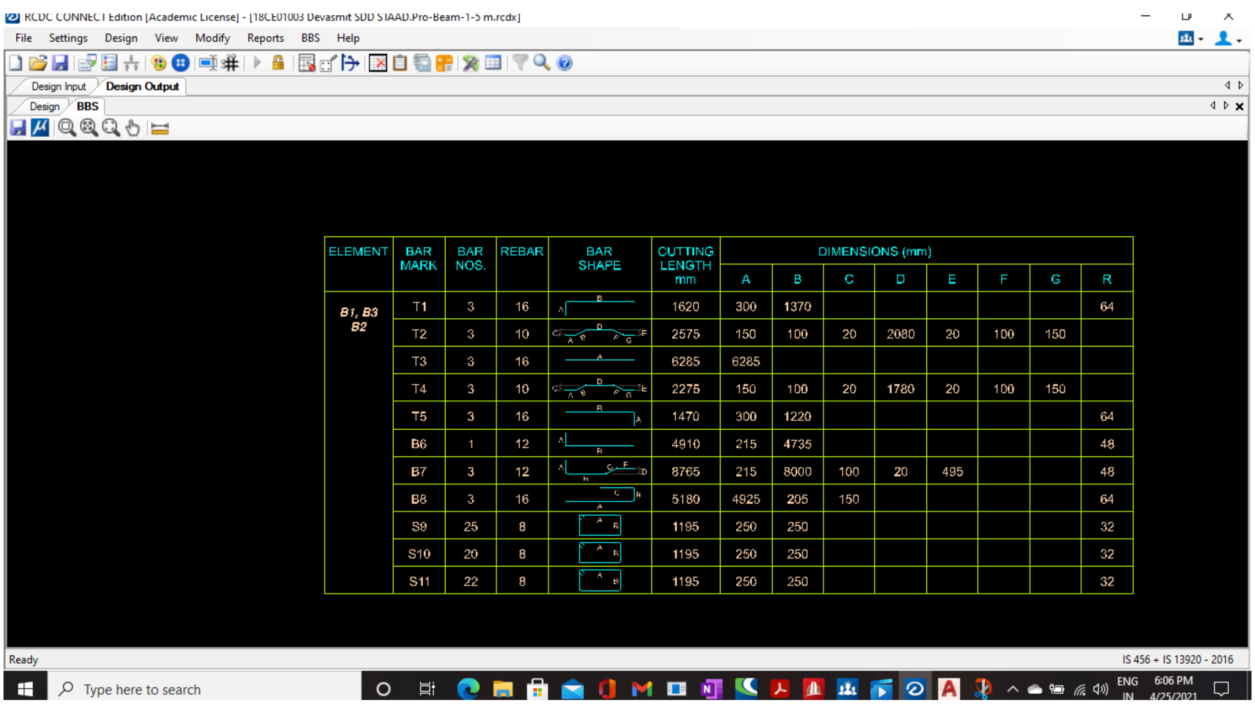
4.1 Beams (Design and Detailing): -

Beam layout (blue lines) generated by RCDC



Some examples of detailing drawing of section and elevation of beams:



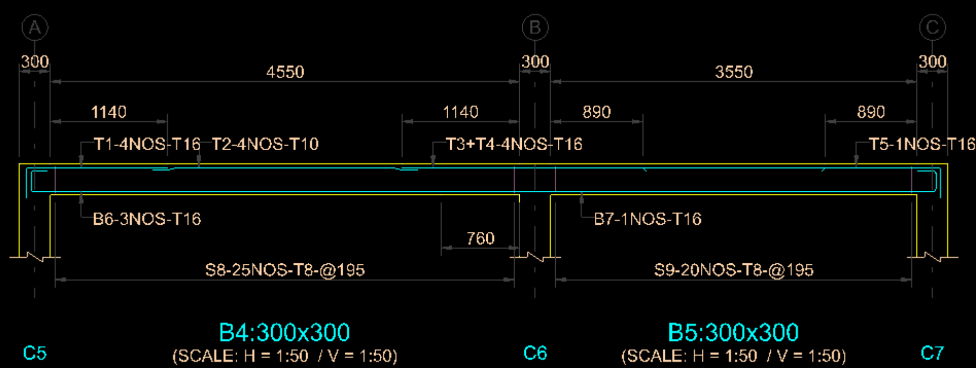


ELEMENT	BAR MARK	BAR NOS.	REBAR	BAR SHAPE	CUTTING LENGTH mm	DIMENSIONS (mm)							
						A	B	C	D	E	F	G	R
B1, B3 B2	T1	3	16		1620	300	1370						64
	T2	3	10		2575	150	100	20	2080	20	100	150	
	T3	3	16		6285	6285							
	T4	3	10		2275	150	100	20	1780	20	100	150	
	T5	3	16		1470	300	1220						64
	B6	1	12		4910	215	4735						48
	B7	3	12		8765	215	8000	100	20	495			48
	B8	3	16		5180	4925	205	150					64
	S9	25	8		1195	250	250						32
	S10	20	8		1195	250	250						32
	S11	22	8		1195	250	250						32

Academic license user IN
CONNECTED USER: hp

SUMMARY : B1, B3, B2

REBAR	8	10	12	16	TOTAL
LGT(m)	80	15	31	44	170
WT(kg)	31	9	28	68	136

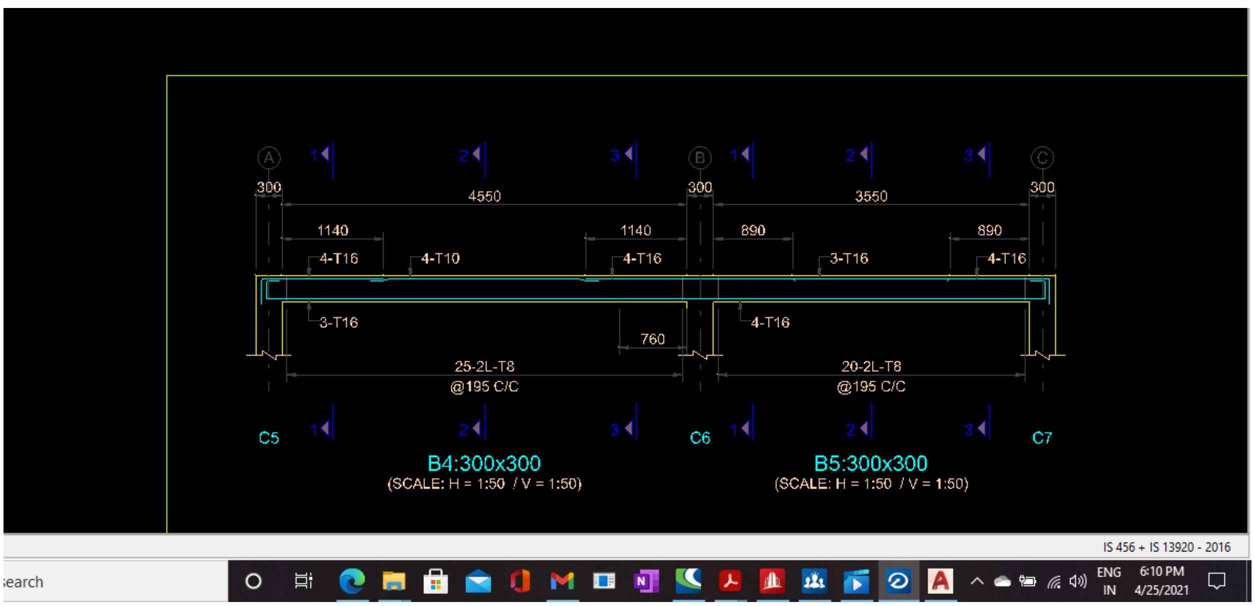


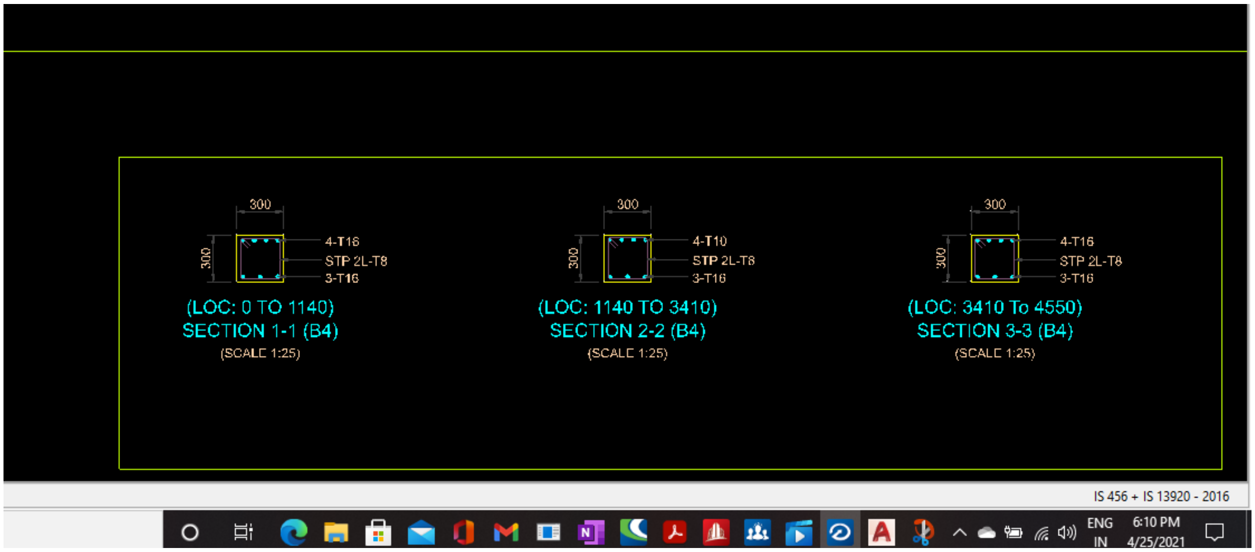
ELEMENT	BAR MARK	BAR NOS.	REBAR	BAR SHAPE	CUTTING LENGTH mm	DIMENSIONS (mm)							
						A	B	C	D	E	F	G	R
B4, B5	T1	4	16		1620	300	1370						64
	T2	4	10		2575	150	100	20	2080	20	100	150	
	T3	1	16		2330	2330							
	T4	3	16		5475	300	5225						64
	T5	1	16		1370	300	1120						64
	B6	3	16		9280	150	205	8765	205	150			64
	B7	1	16		4645	4390	205	150					64
	S8	25	8		1195	250	250						32
	S9	20	8		1195	250	250						32

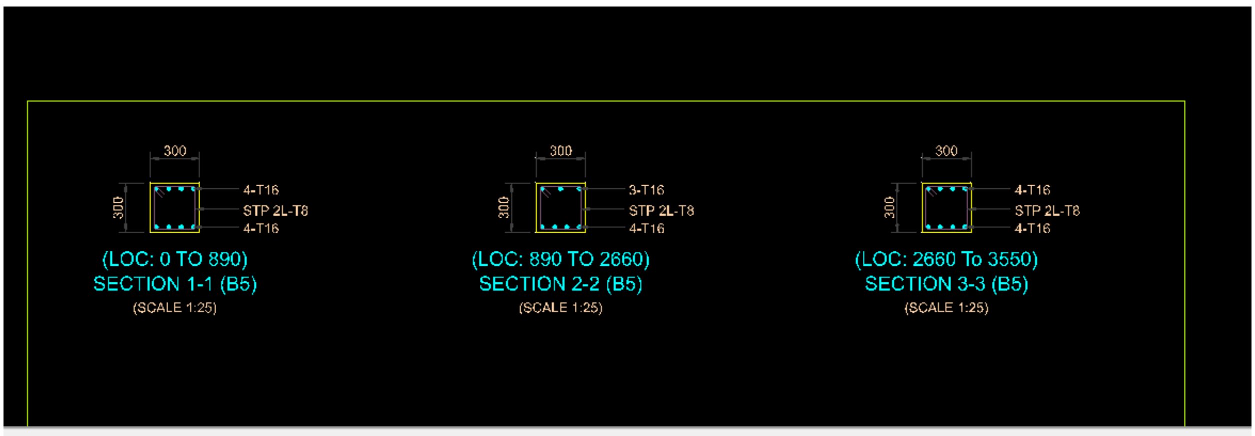
Academic license user IN
CONNECTED USER: hp

SUMMARY : B4, B5

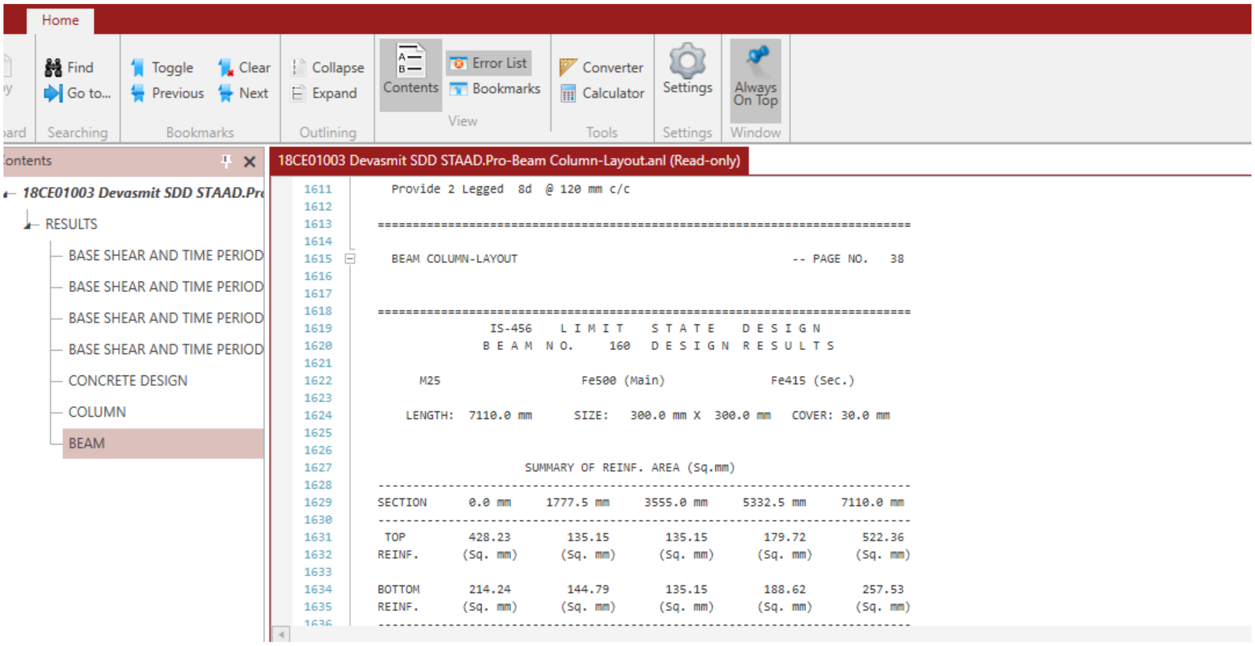
REBAR	8	10	16	TOTAL
LGT(m)	54	10	58	122
WT(kg)	21	6	93	120

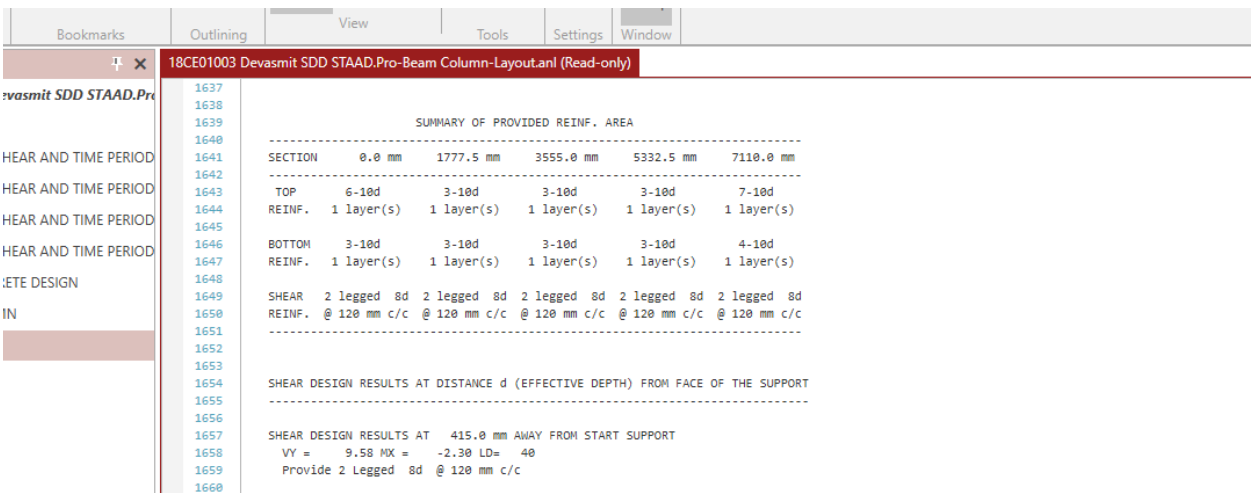




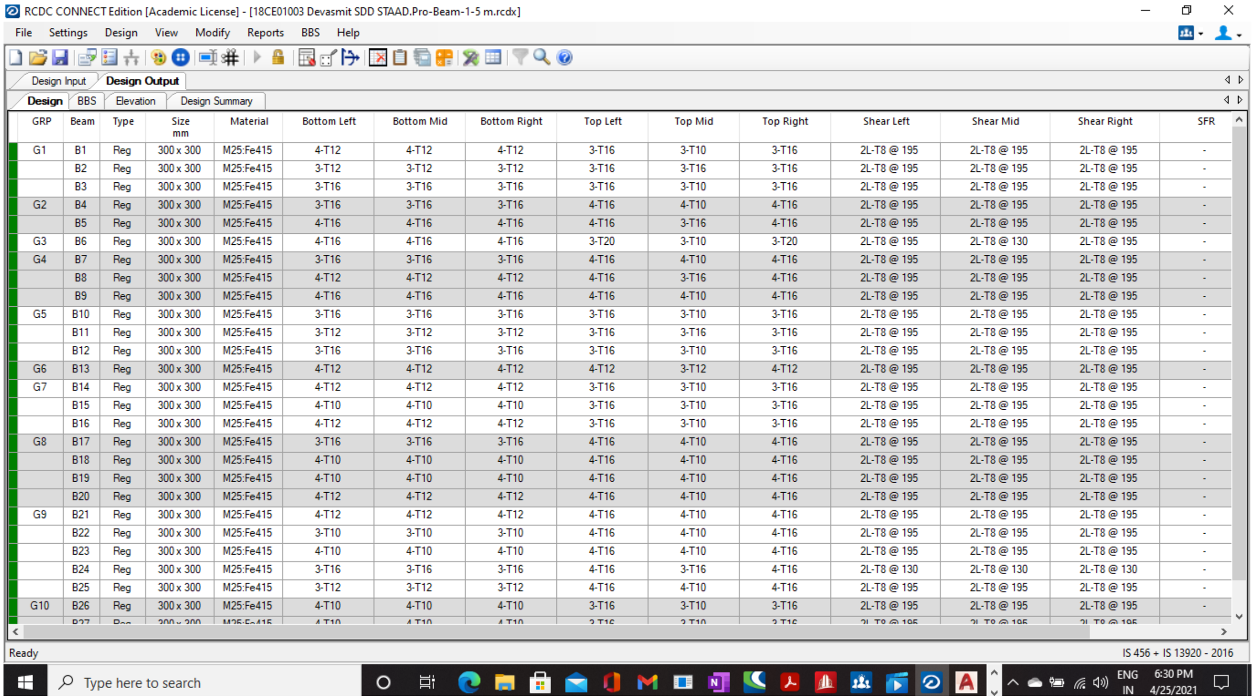


Example of staad output reinforcement layout of main and transverse bars:



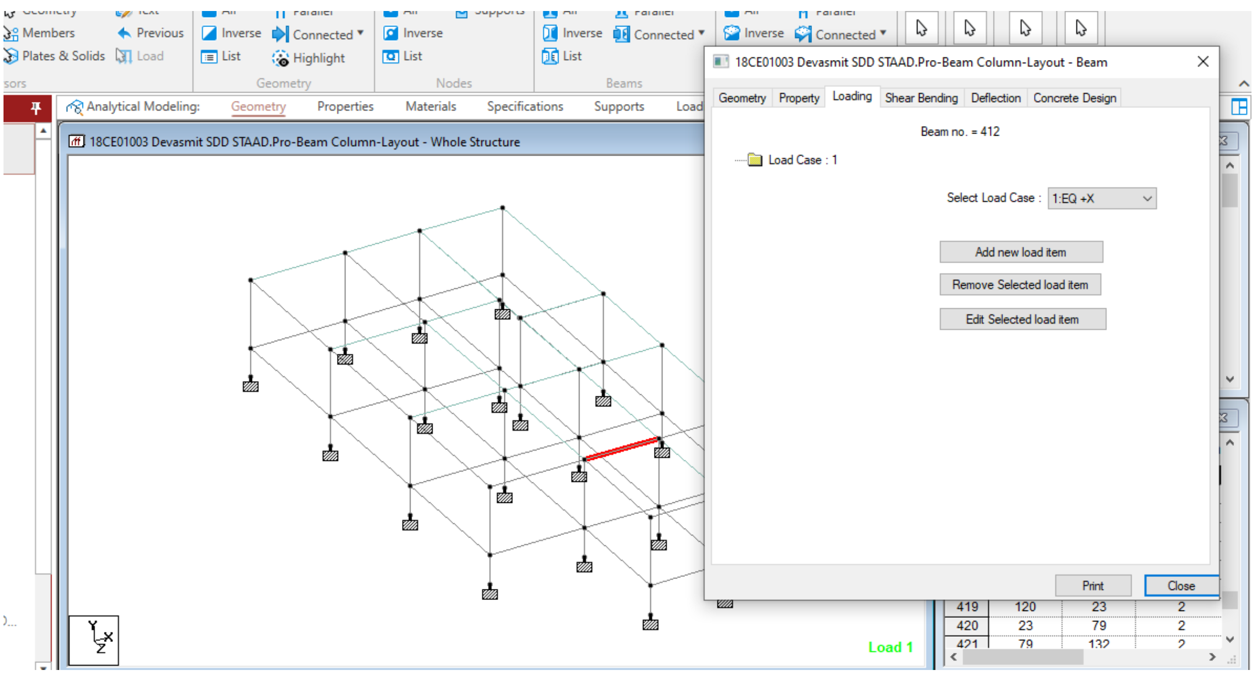


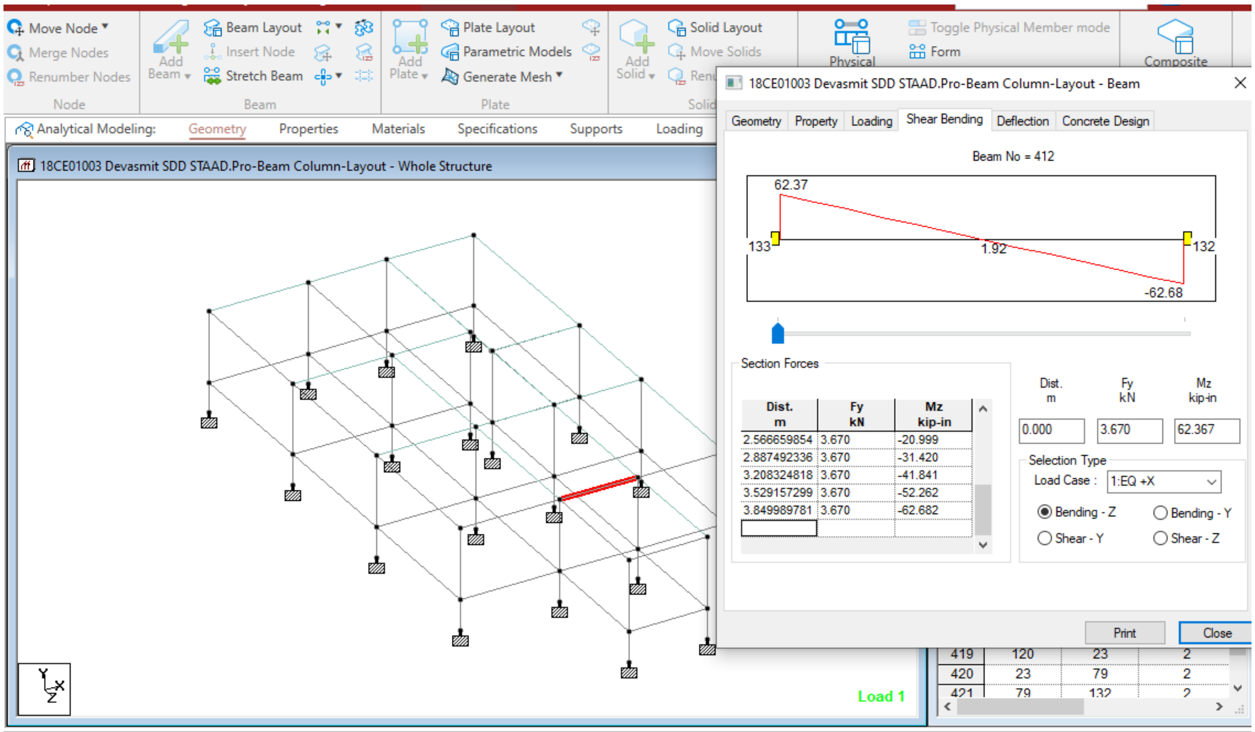
Grouping of members:

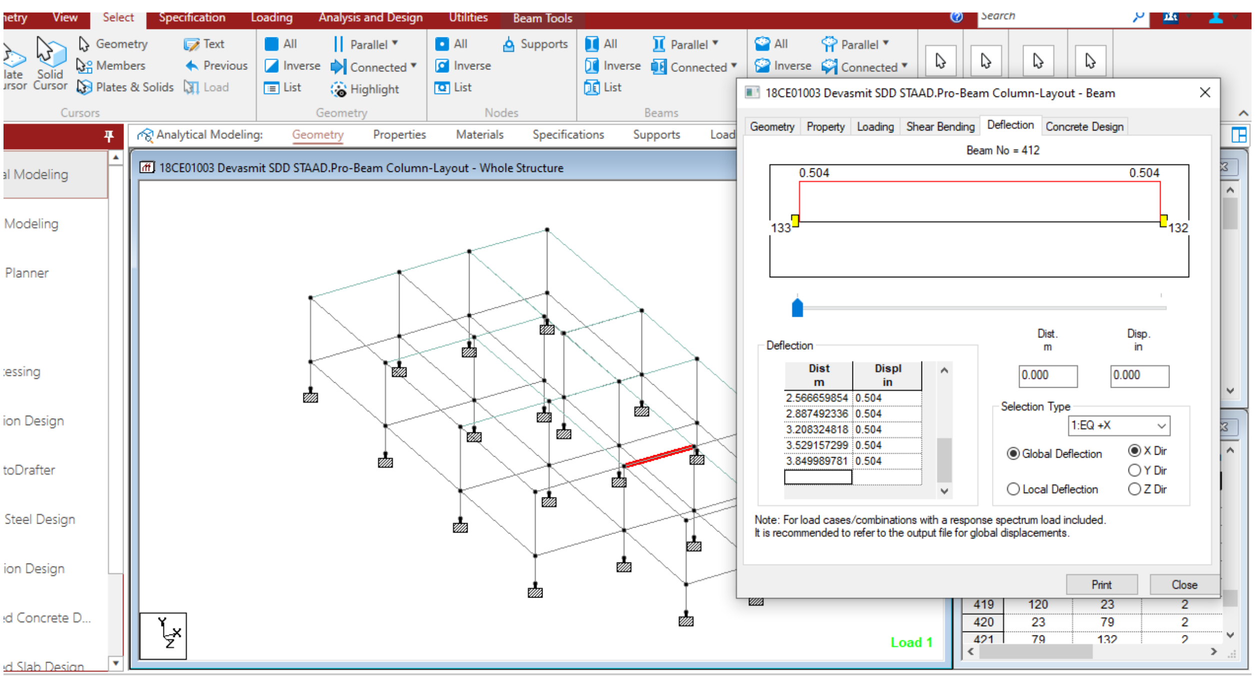


GRP	Beam	Type	Size mm	Material	Bottom Left	Bottom Mid	Bottom Right	Top Left	Top Mid	Top Right	Shear Left	Shear Mid	Shear Right	SFR
G1	B1	Reg	300 x 300	M25:Fe415	4-T12	4-T12	4-T12	3-T16	3-T10	3-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
	B2	Reg	300 x 300	M25:Fe415	3-T12	3-T12	3-T12	3-T16	3-T16	3-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
	B3	Reg	300 x 300	M25:Fe415	3-T16	3-T16	3-T16	3-T16	3-T10	3-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
G2	B4	Reg	300 x 300	M25:Fe415	3-T16	3-T16	3-T16	4-T16	4-T10	4-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
	B5	Reg	300 x 300	M25:Fe415	4-T16	4-T16	4-T16	4-T16	3-T16	4-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
G3	B6	Reg	300 x 300	M25:Fe415	4-T16	4-T16	4-T16	3-T20	3-T10	3-T20	2L-T8 @ 195	2L-T8 @ 130	2L-T8 @ 195	-
G4	B7	Reg	300 x 300	M25:Fe415	3-T16	3-T16	3-T16	4-T16	4-T10	4-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
	B8	Reg	300 x 300	M25:Fe415	4-T12	4-T12	4-T12	4-T16	3-T16	4-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
	B9	Reg	300 x 300	M25:Fe415	4-T16	4-T16	4-T16	4-T16	4-T10	4-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
G5	B10	Reg	300 x 300	M25:Fe415	3-T16	3-T16	3-T16	3-T16	3-T10	3-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
	B11	Reg	300 x 300	M25:Fe415	3-T12	3-T12	3-T12	3-T16	3-T16	3-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
	B12	Reg	300 x 300	M25:Fe415	3-T16	3-T16	3-T16	3-T16	3-T10	3-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
G6	B13	Reg	300 x 300	M25:Fe415	4-T12	4-T12	4-T12	4-T12	3-T12	4-T12	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
G7	B14	Reg	300 x 300	M25:Fe415	4-T12	4-T12	4-T12	3-T16	3-T10	3-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
	B15	Reg	300 x 300	M25:Fe415	4-T10	4-T10	4-T10	3-T16	3-T10	3-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
	B16	Reg	300 x 300	M25:Fe415	4-T12	4-T12	4-T12	3-T16	3-T10	3-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
G8	B17	Reg	300 x 300	M25:Fe415	3-T16	3-T16	3-T16	4-T16	4-T10	4-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
	B18	Reg	300 x 300	M25:Fe415	4-T10	4-T10	4-T10	4-T16	4-T10	4-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
	B19	Reg	300 x 300	M25:Fe415	4-T10	4-T10	4-T10	4-T16	4-T10	4-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
	B20	Reg	300 x 300	M25:Fe415	4-T12	4-T12	4-T12	4-T16	4-T10	4-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
G9	B21	Reg	300 x 300	M25:Fe415	4-T12	4-T12	4-T12	4-T16	4-T10	4-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
	B22	Reg	300 x 300	M25:Fe415	3-T10	3-T10	3-T10	4-T16	4-T10	4-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
	B23	Reg	300 x 300	M25:Fe415	4-T10	4-T10	4-T10	4-T16	4-T10	4-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
	B24	Reg	300 x 300	M25:Fe415	3-T16	3-T16	3-T16	4-T16	3-T16	4-T16	2L-T8 @ 130	2L-T8 @ 130	2L-T8 @ 130	-
	B25	Reg	300 x 300	M25:Fe415	3-T12	3-T12	3-T12	4-T16	4-T10	4-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-
G10	B26	Reg	300 x 300	M25:Fe415	4-T10	4-T10	4-T10	3-T16	3-T10	3-T16	2L-T8 @ 195	2L-T8 @ 195	2L-T8 @ 195	-

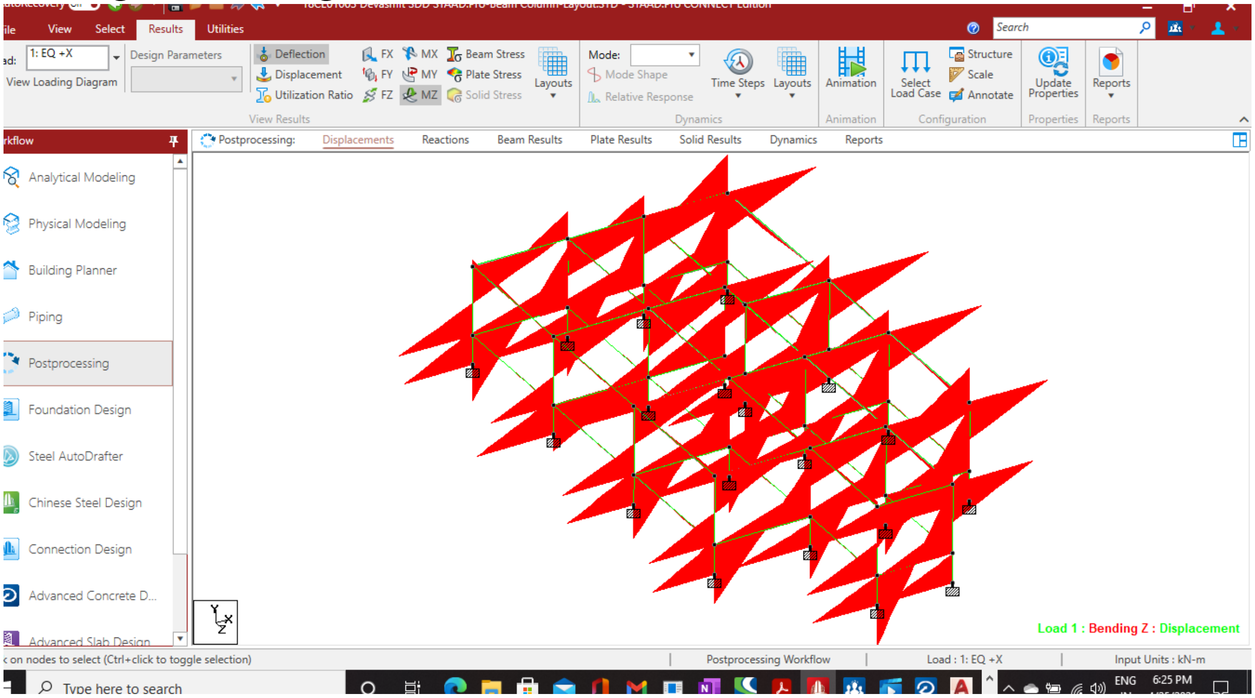
Shear bending diagram and deflected shape of a member:



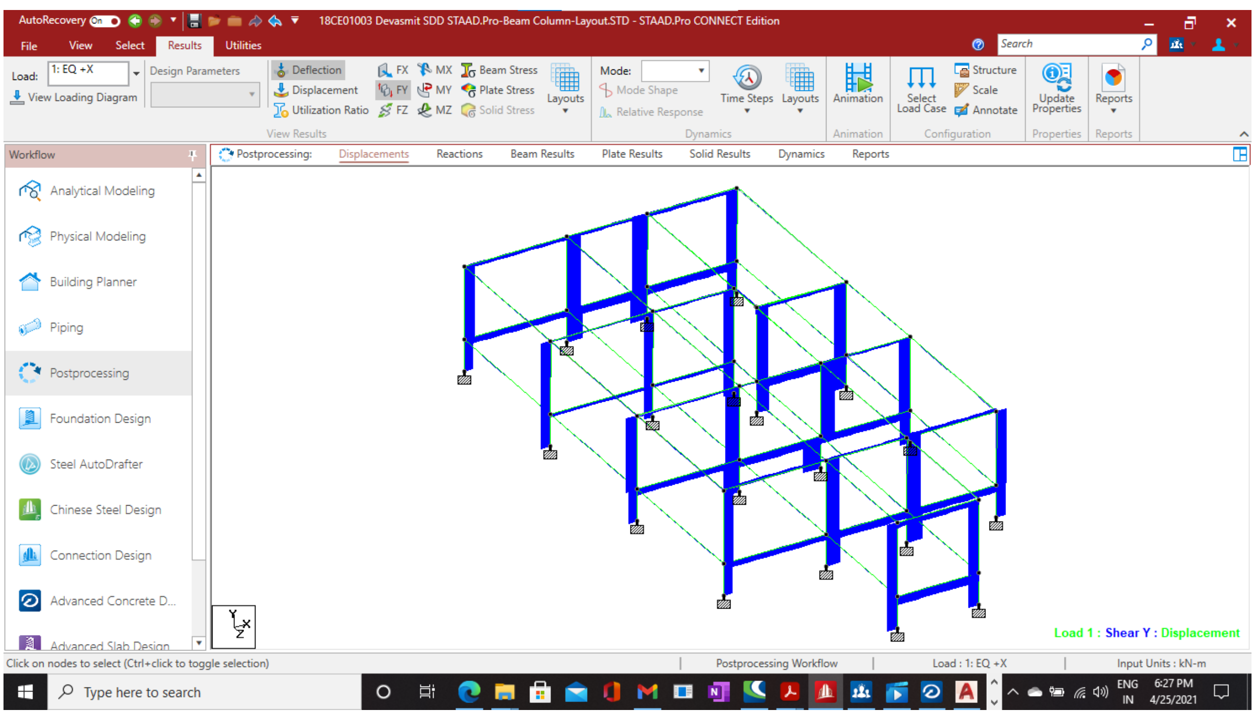

18CE01003 Devasmit SDD STAAD.Pro-Beam Column-Layout - Whole Structure
18CE01003 Devasmit SDD STAAD.Pro-Beam Column-Layout - Beam
Geometry
Property
Loading
Shear Bending
Deflection
Concrete Design
Beam No = 412
62.37
133
1.92
132
-62.68
Section Forces
Dist. m
Fy kN
Mz kip-in
2.566659854 3.670 -20.999
2.887492336 3.670 -31.420
3.208324818 3.670 -41.841
3.529157299 3.670 -52.262
3.849989781 3.670 -62.682
0.000
3.670
62.367
Selection Type
Load Case :
1:EQ +X
Bending - Z
Bending - Y
Shear - Y
Shear - Z
Print
Close
Load 1

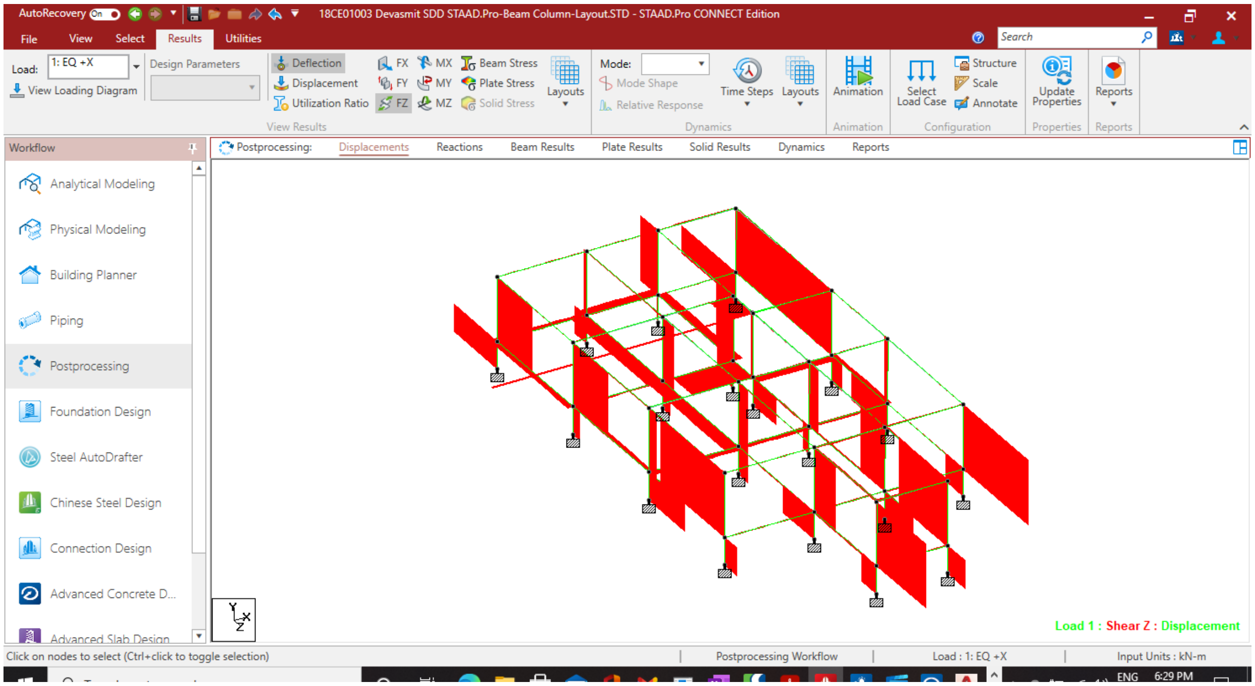

18CE01003 Devasmit SDD STAAD.Pro-Beam Column-Layout - Whole Structure
18CE01003 Devasmit SDD STAAD.Pro-Beam Column-Layout - Beam
Geometry
Property
Loading
Shear Bending
Deflection
Concrete Design
Beam No = 412
0.504
0.504
133
132
Deflection
Dist m
Displ in
2.566659854 0.504
2.887492336 0.504
3.208324818 0.504
3.529157299 0.504
3.849989781 0.504
0.000
0.000
Selection Type
1:EQ +X
Global Deflection
Local Deflection
X Dir
Y Dir
Z Dir
Note: For load cases/combinations with a response spectrum load included.
It is recommended to refer to the output file for global displacements.
Print
Close
Load 1

Bending moment diagram



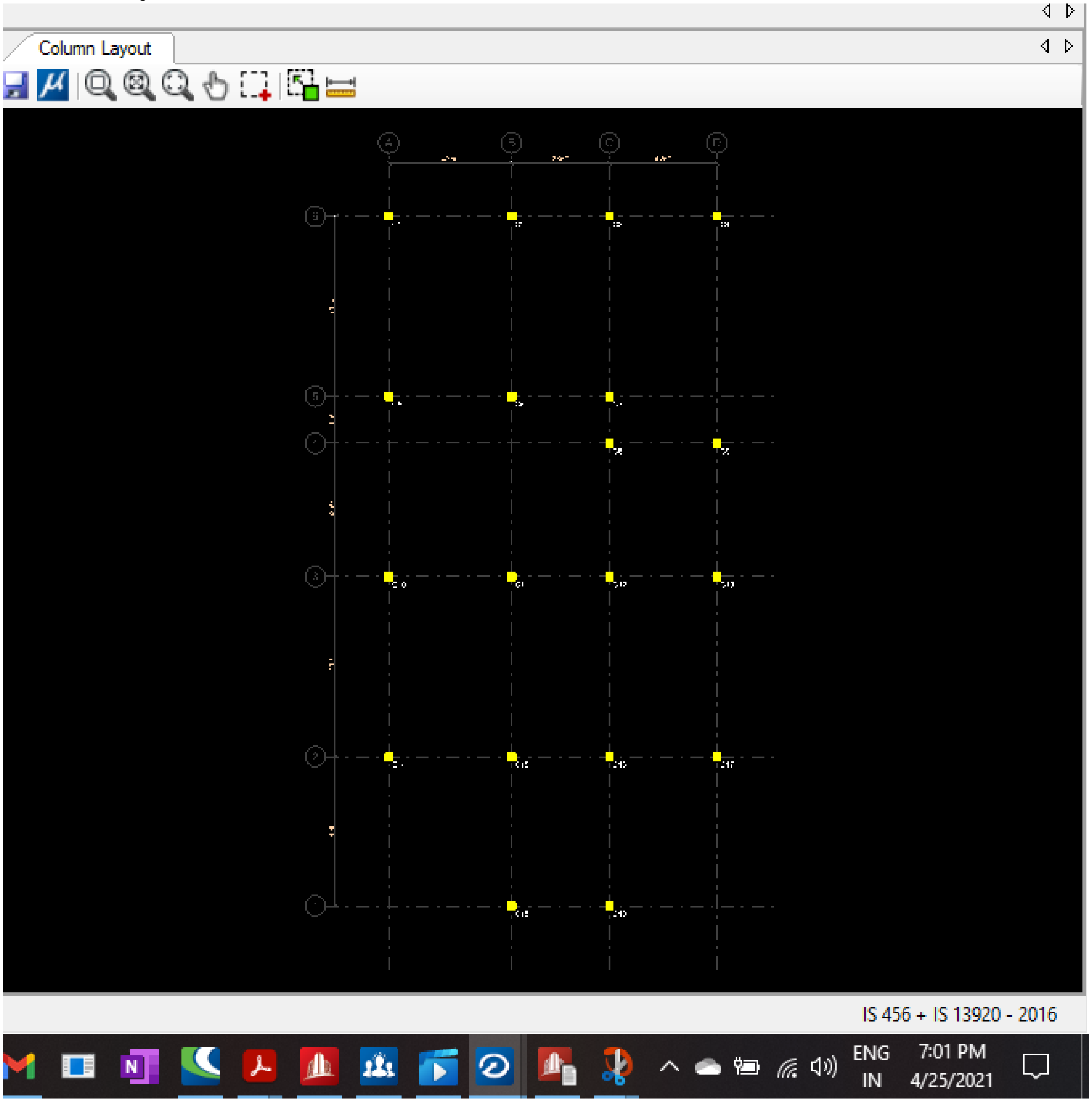
Shear force diagram:



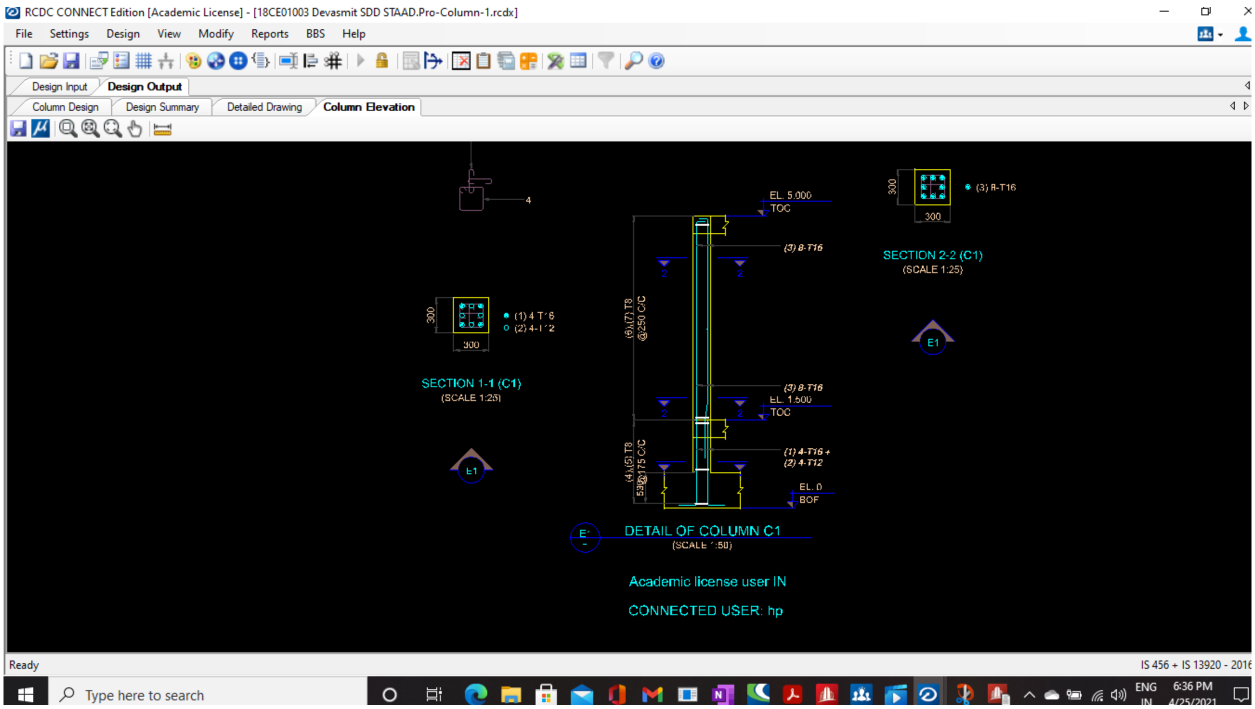


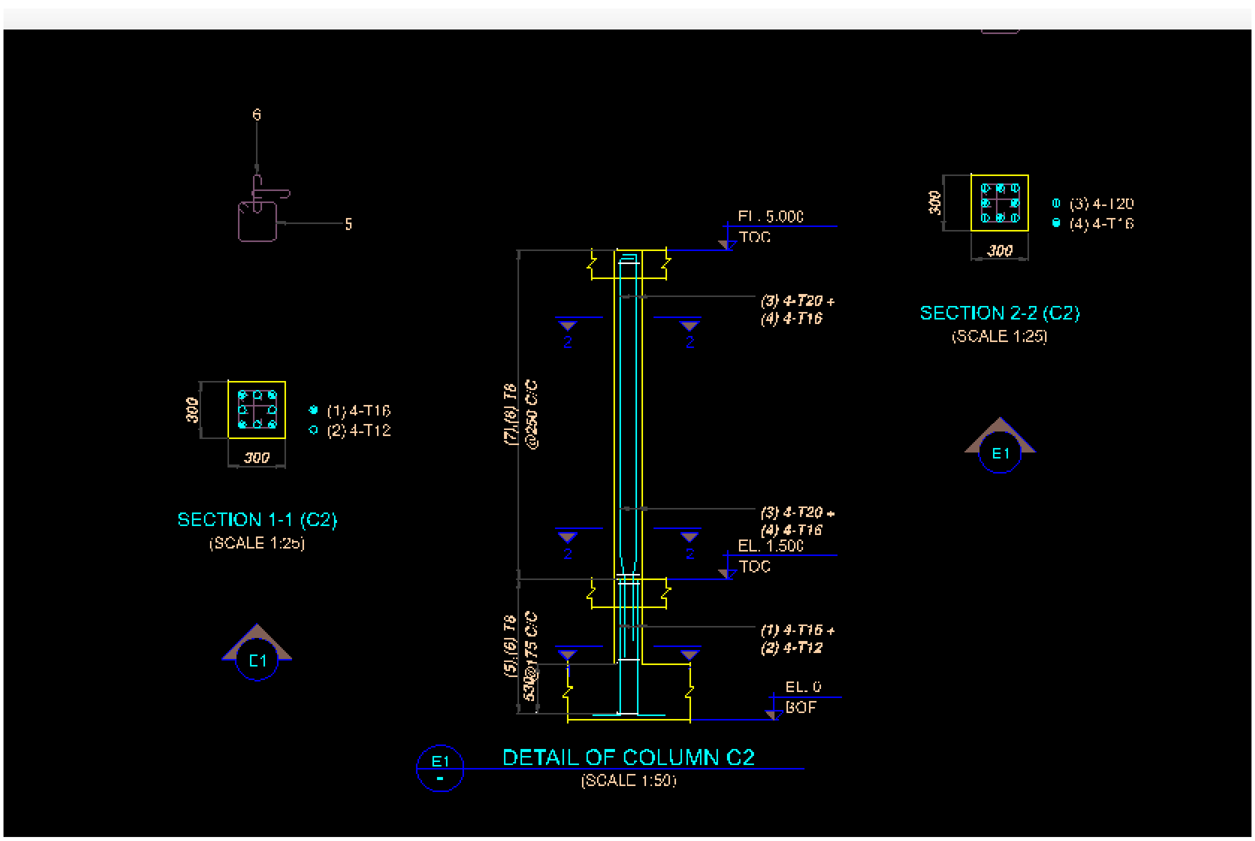
4.2 Columns (Design and Detailing): -

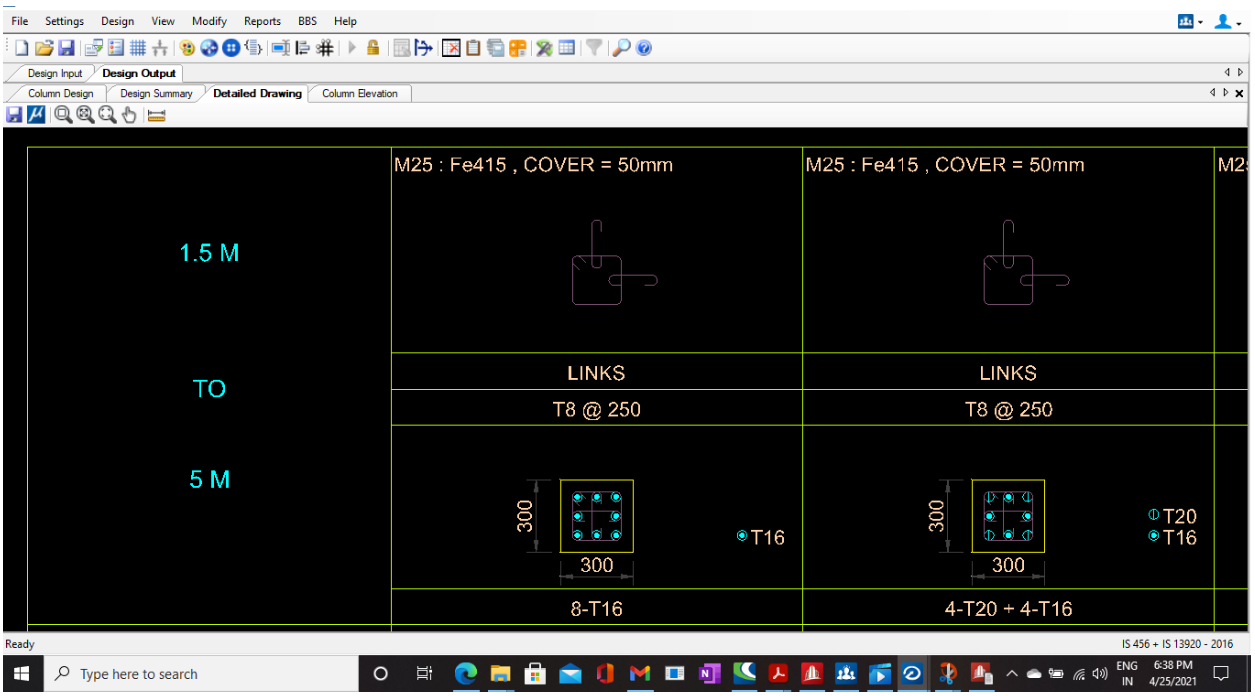
Column layout: -

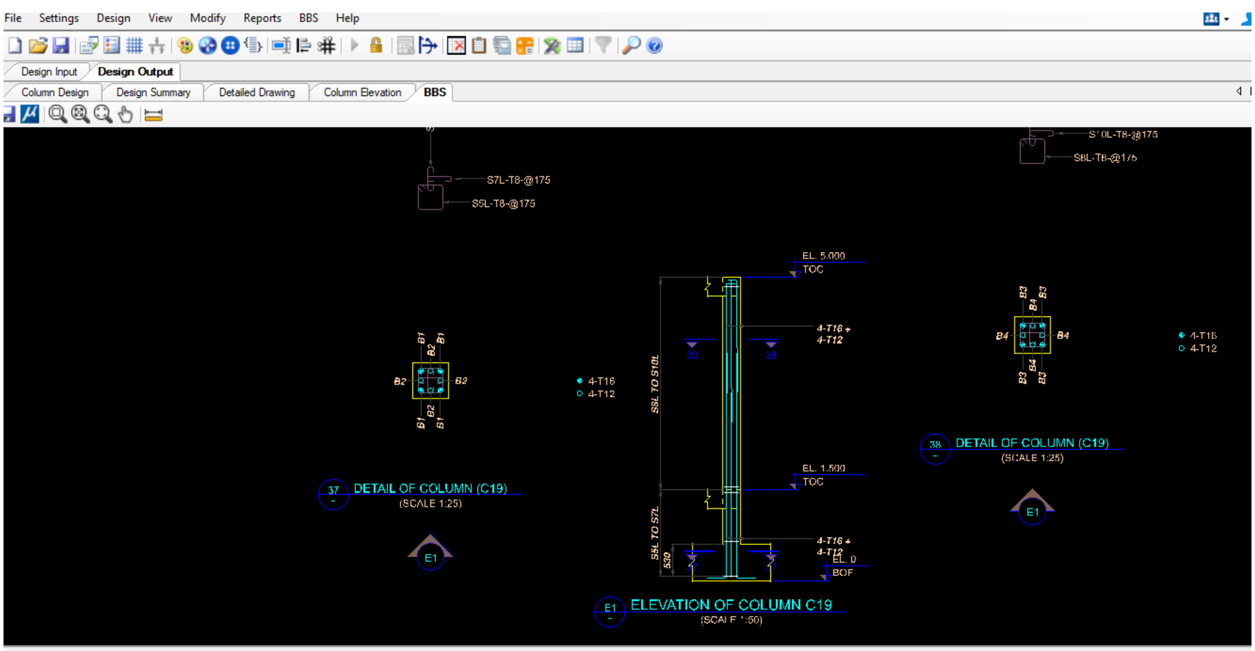


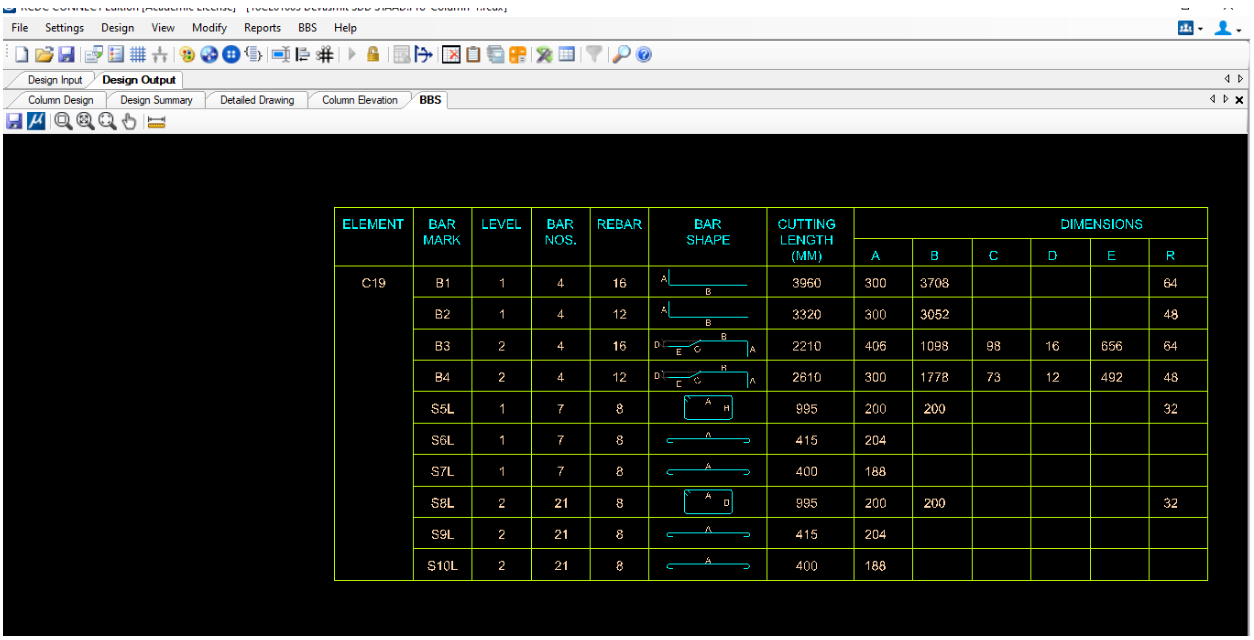
Some snaps of Detailing and reinforcement generated by RCDC: -


RCDC CONNECT Edition [Academic License] - [18CE01003 Devasmit SDD STAAD.Pro-Column-1.rcdx]
File Settings Design View Modify Reports BBS Help
Design Input Design Output
Column Design Design Summary Detailed Drawing Column Elevation
EL. 5.000
TOC
(3) 8-T16
(3) 8-T16
EL. 1.500
TOC
(1) 4-T16 +
(2) 4-T12
EL. 0
BOF
(3) 8-T16
300
300
SECTION 2-2 (C1)
(SCALE 1:25)
E1
SECTION 1-1 (C1)
(SCALE 1:25)
DETAIL OF COLUMN C1
Academic license user IN
CONNECTED USER: hp
Ready
IS 456 + IS 13920 - 2016
Type here to search
ENG
6:36 PM

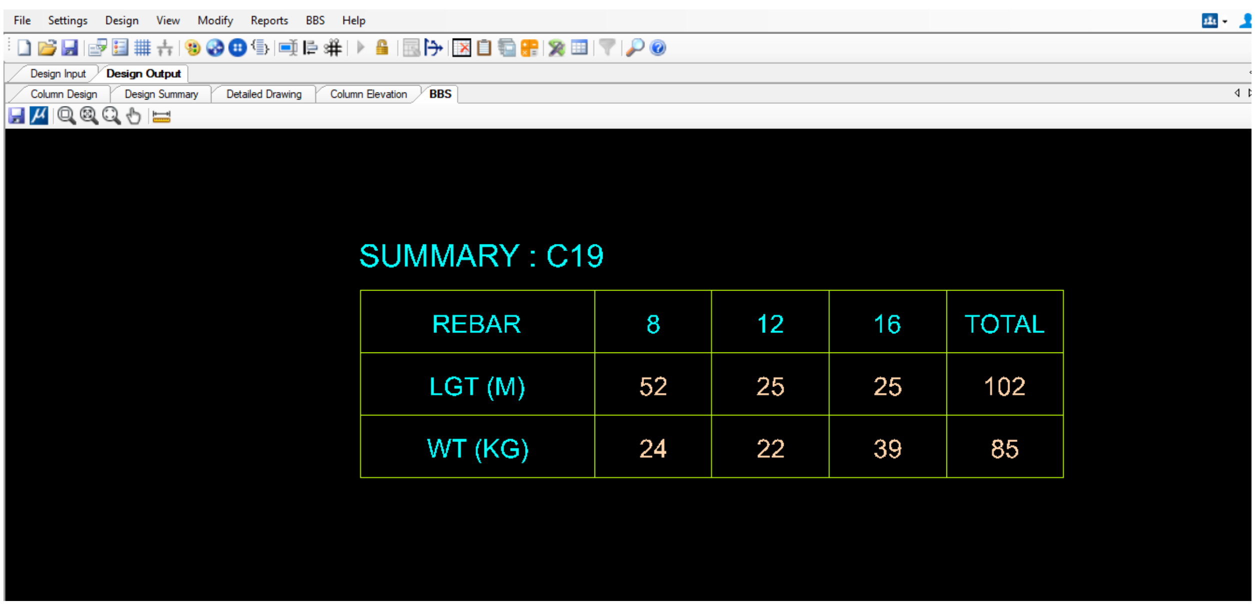

6
5
EL. 5.000
TOC
(3) 4-T20 +
(4) 4-T16
(7),(6) T8
@250 C/C
(3) 4-T20 +
(4) 4-T16
EL. 1.500
TOC
(5),(6) T8
530@175 C/C
(1) 4-T16 +
(2) 4-T12
EL. 0
BOF
300
300
(3) 4-T20
(4) 4-T16
SECTION 2-2 (C2)
(SCALE 1:25)
E1
300
300
(1) 4-T16
(2) 4-T12
SECTION 1-1 (C2)
(SCALE 1:25)
E1
E1
DETAIL OF COLUMN C2
(SCALE 1:50)


File
Settings
Design
View
Modify
Reports
BBS
Help
Design Input
Design Output
Column Design
Design Summary
Detailed Drawing
Column Elevation
M25 : Fe415 , COVER = 50mm
M25 : Fe415 , COVER = 50mm
1.5 M
TO
5 M
LINKS
T8 @ 250
LINKS
T8 @ 250
300
300
T16
300
300
T20
T16
8-T16
4-T20 + 4-T16
Ready
IS 456 + IS 13920 - 2016
Type here to search
ENG
IN
6:38 PM
4/25/2021


File
Settings
Design
View
Modify
Reports
BBS
Help
Design Input
Design Output
Column Design
Design Summary
Detailed Drawing
Column Elevation
BBS
S7L-T8-@175
S8L-T8-@175
EL. 5.000
TOC
4-T16 +
4-T12
4-T16
4-T12
DETAIL OF COLUMN (C19)
(SCALE 1:25)
DETAIL OF COLUMN (C19)
(SCALE 1:25)
EL. 1.500
TOC
EL. 0
BOF
E1
ELEVATION OF COLUMN C19



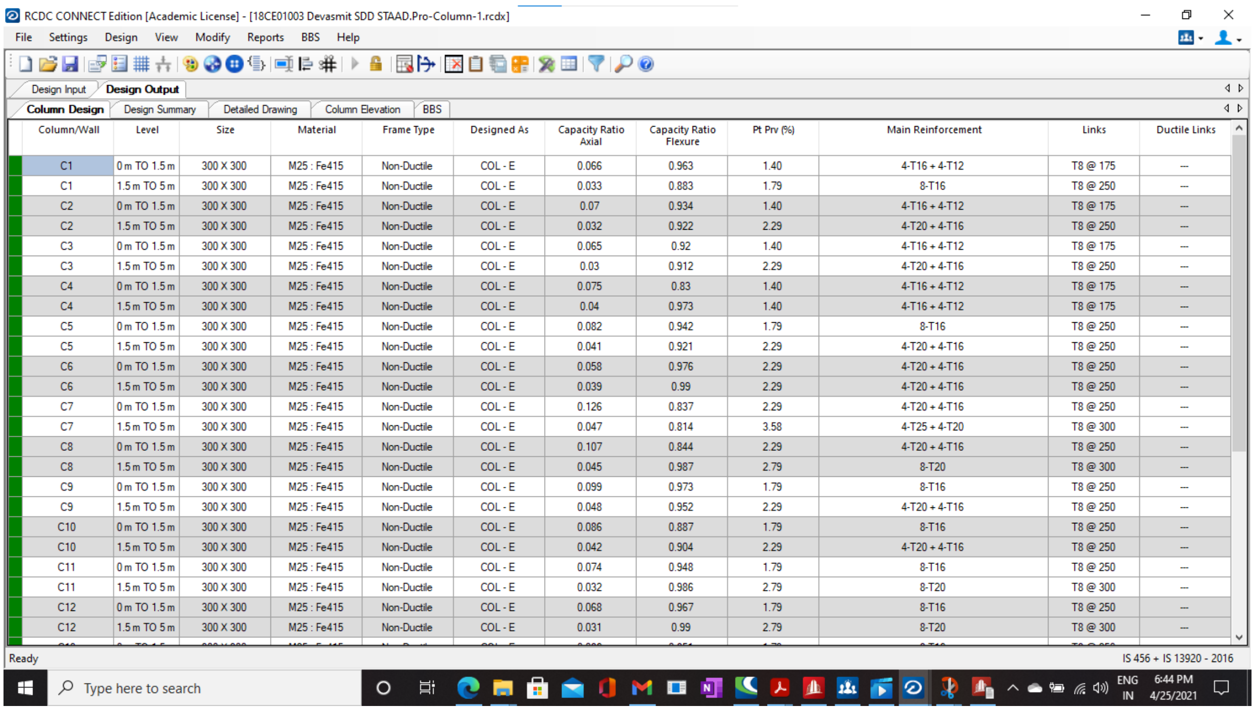
ELEMENT	BAR MARK	LEVEL	BAR NOS.	REBAR	BAR SHAPE	CUTTING LENGTH (MM)	DIMENSIONS					
							A	B	C	D	E	R
C19	B1	1	4	16		3960	300	3708				64
	B2	1	4	12		3320	300	3052				48
	B3	2	4	16		2210	406	1098	98	16	656	64
	B4	2	4	12		2610	300	1778	73	12	492	48
	S5L	1	7	8		995	200	200				32
	S6L	1	7	8		415	204					
	S7L	1	7	8		400	188					
	S8L	2	21	8		995	200	200				32
	S9L	2	21	8		415	204					
	S10L	2	21	8		400	188					



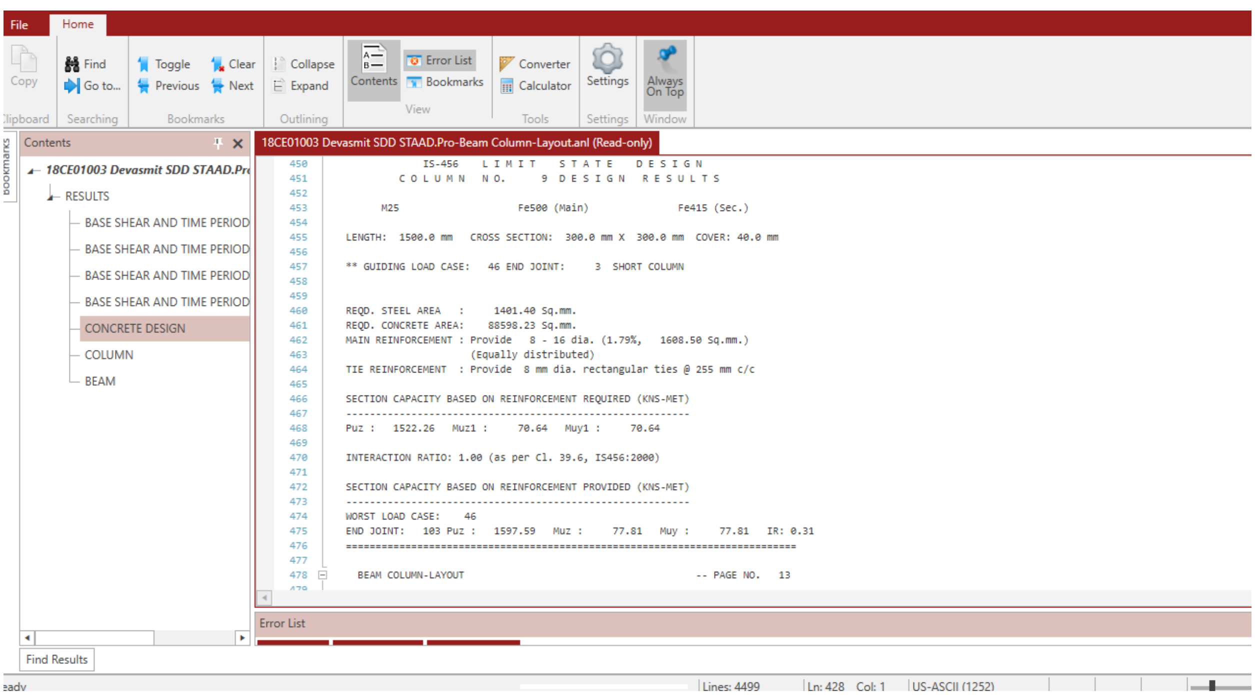
SUMMARY : C19

REBAR	8	12	16	TOTAL
LGT (M)	52	25	25	102
WT (KG)	24	22	39	85

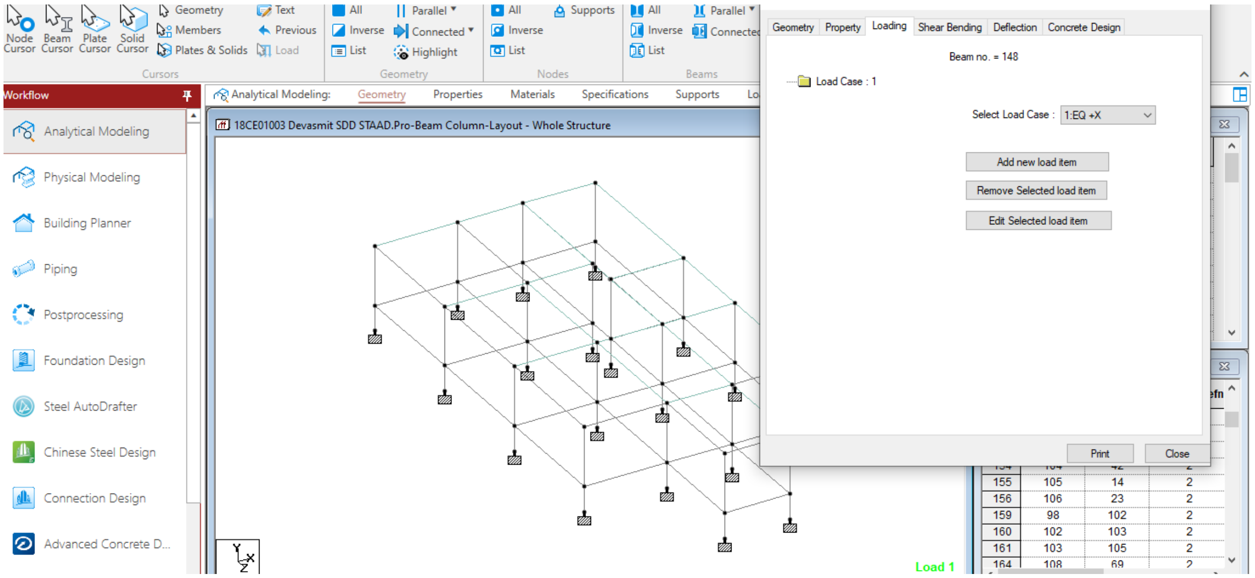
Design summary: -



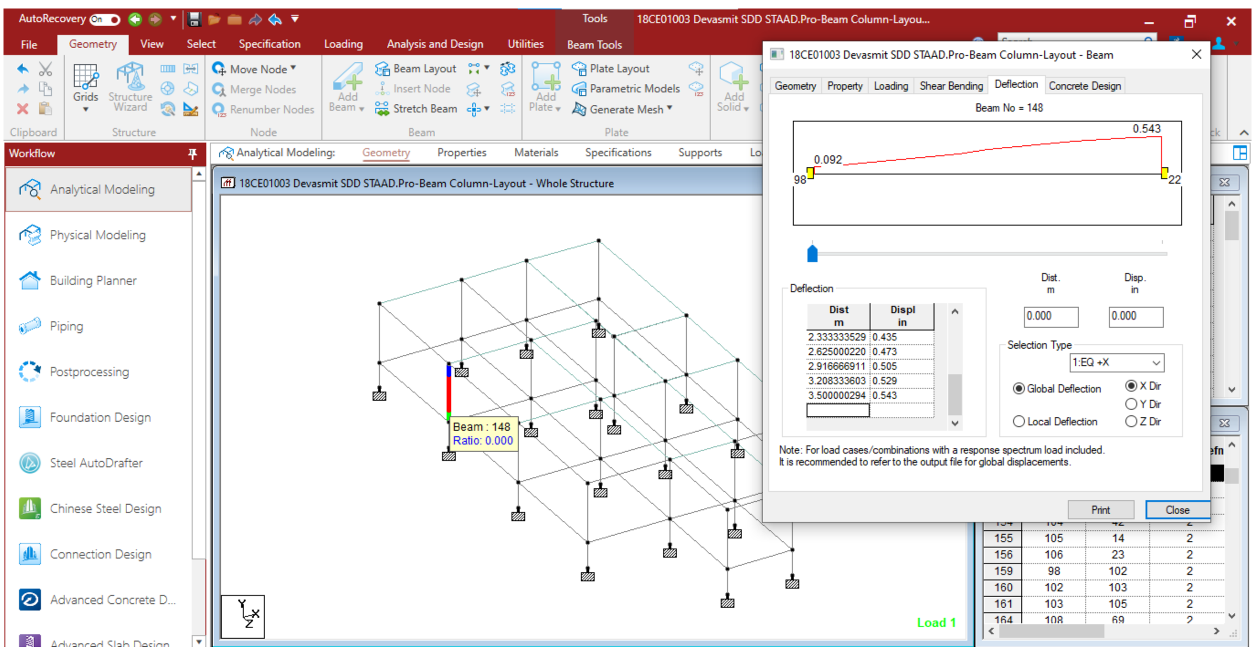
Column/Wall	Level	Size	Material	Frame Type	Designed As	Capacity Ratio Axial	Capacity Ratio Flexure	Pt Prv (%)	Main Reinforcement	Links	Ductile Links
C1	0 m TO 1.5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.066	0.963	1.40	4-T16 + 4-T12	T8 @ 175	---
C1	1.5 m TO 5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.033	0.883	1.79	8-T16	T8 @ 250	---
C2	0 m TO 1.5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.07	0.934	1.40	4-T16 + 4-T12	T8 @ 175	---
C2	1.5 m TO 5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.032	0.922	2.29	4-T20 + 4-T16	T8 @ 250	---
C3	0 m TO 1.5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.065	0.92	1.40	4-T16 + 4-T12	T8 @ 175	---
C3	1.5 m TO 5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.03	0.912	2.29	4-T20 + 4-T16	T8 @ 250	---
C4	0 m TO 1.5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.075	0.83	1.40	4-T16 + 4-T12	T8 @ 175	---
C4	1.5 m TO 5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.04	0.973	1.40	4-T16 + 4-T12	T8 @ 175	---
C5	0 m TO 1.5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.082	0.942	1.79	8-T16	T8 @ 250	---
C5	1.5 m TO 5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.041	0.921	2.29	4-T20 + 4-T16	T8 @ 250	---
C6	0 m TO 1.5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.058	0.976	2.29	4-T20 + 4-T16	T8 @ 250	---
C6	1.5 m TO 5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.039	0.99	2.29	4-T20 + 4-T16	T8 @ 250	---
C7	0 m TO 1.5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.126	0.837	2.29	4-T20 + 4-T16	T8 @ 250	---
C7	1.5 m TO 5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.047	0.814	3.58	4-T25 + 4-T20	T8 @ 300	---
C8	0 m TO 1.5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.107	0.844	2.29	4-T20 + 4-T16	T8 @ 250	---
C8	1.5 m TO 5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.045	0.987	2.79	8-T20	T8 @ 300	---
C9	0 m TO 1.5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.099	0.973	1.79	8-T16	T8 @ 250	---
C9	1.5 m TO 5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.048	0.952	2.29	4-T20 + 4-T16	T8 @ 250	---
C10	0 m TO 1.5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.086	0.887	1.79	8-T16	T8 @ 250	---
C10	1.5 m TO 5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.042	0.904	2.29	4-T20 + 4-T16	T8 @ 250	---
C11	0 m TO 1.5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.074	0.948	1.79	8-T16	T8 @ 250	---
C11	1.5 m TO 5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.032	0.986	2.79	8-T20	T8 @ 300	---
C12	0 m TO 1.5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.068	0.967	1.79	8-T16	T8 @ 250	---
C12	1.5 m TO 5 m	300 X 300	M25 : Fe415	Non-Ductile	COL - E	0.031	0.99	2.79	8-T20	T8 @ 300	---



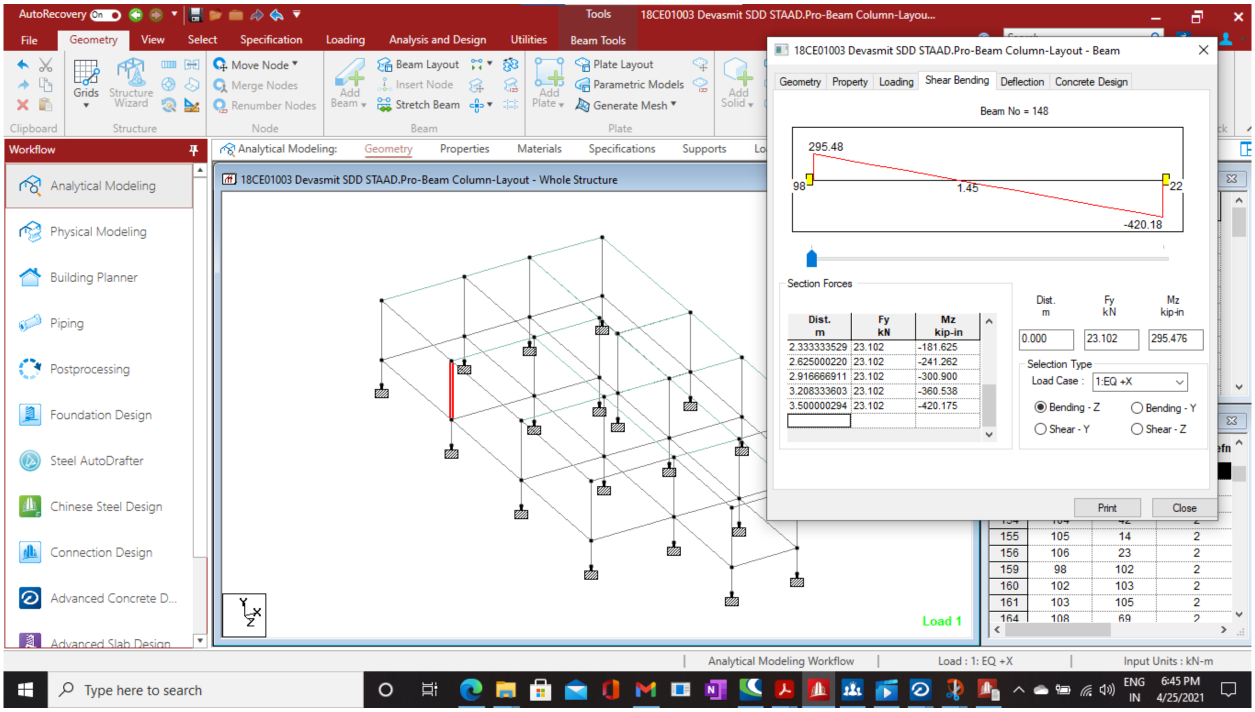

```
          IS-456    L I M I T    S T A T E    D E S I G N
       C O L U M N   N O.     9  D E S I G N   R E S U L T S

     M25                 Fe500 (Main)              Fe415 (Sec.)

 LENGTH:  1500.0 mm   CROSS SECTION:  300.0 mm X  300.0 mm  COVER: 40.0 mm

 ** GUIDING LOAD CASE:   46 END JOINT:     3  SHORT COLUMN


 REQD. STEEL AREA   :     1401.40 Sq.mm.
 REQD. CONCRETE AREA:    88598.23 Sq.mm.
 MAIN REINFORCEMENT : Provide   8 - 16 dia. (1.79%,   1608.50 Sq.mm.)
                      (Equally distributed)
 TIE REINFORCEMENT  : Provide  8 mm dia. rectangular ties @ 255 mm c/c

 SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
 ----------------------------------------------------------
 Puz :   1522.26   Muz1 :     70.64   Muy1 :     70.64

 INTERACTION RATIO: 1.00 (as per Cl. 39.6, IS456:2000)

 SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
 ----------------------------------------------------------
 WORST LOAD CASE:    46
 END JOINT:   103 Puz :   1597.59   Muz :     77.81   Muy :     77.81   IR: 0.31
 ==========================================================================

  BEAM COLUMN-LAYOUT                                   -- PAGE NO.   13
```



Deflection of a member for a specific loading: -

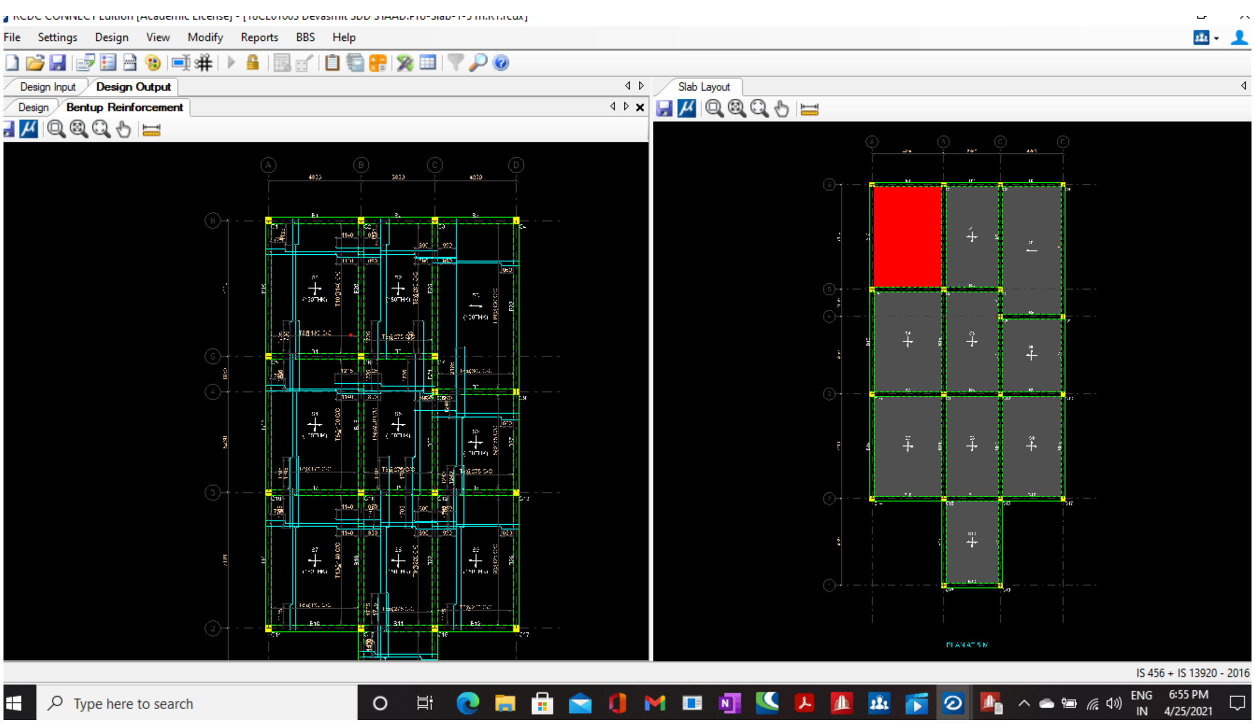


Shera bending of a member for a specific loading: -



4.3 Slabs (Design and Detailing): -

Reinforcement detailing layout of slab consisting of several plate elements: -



Design summary

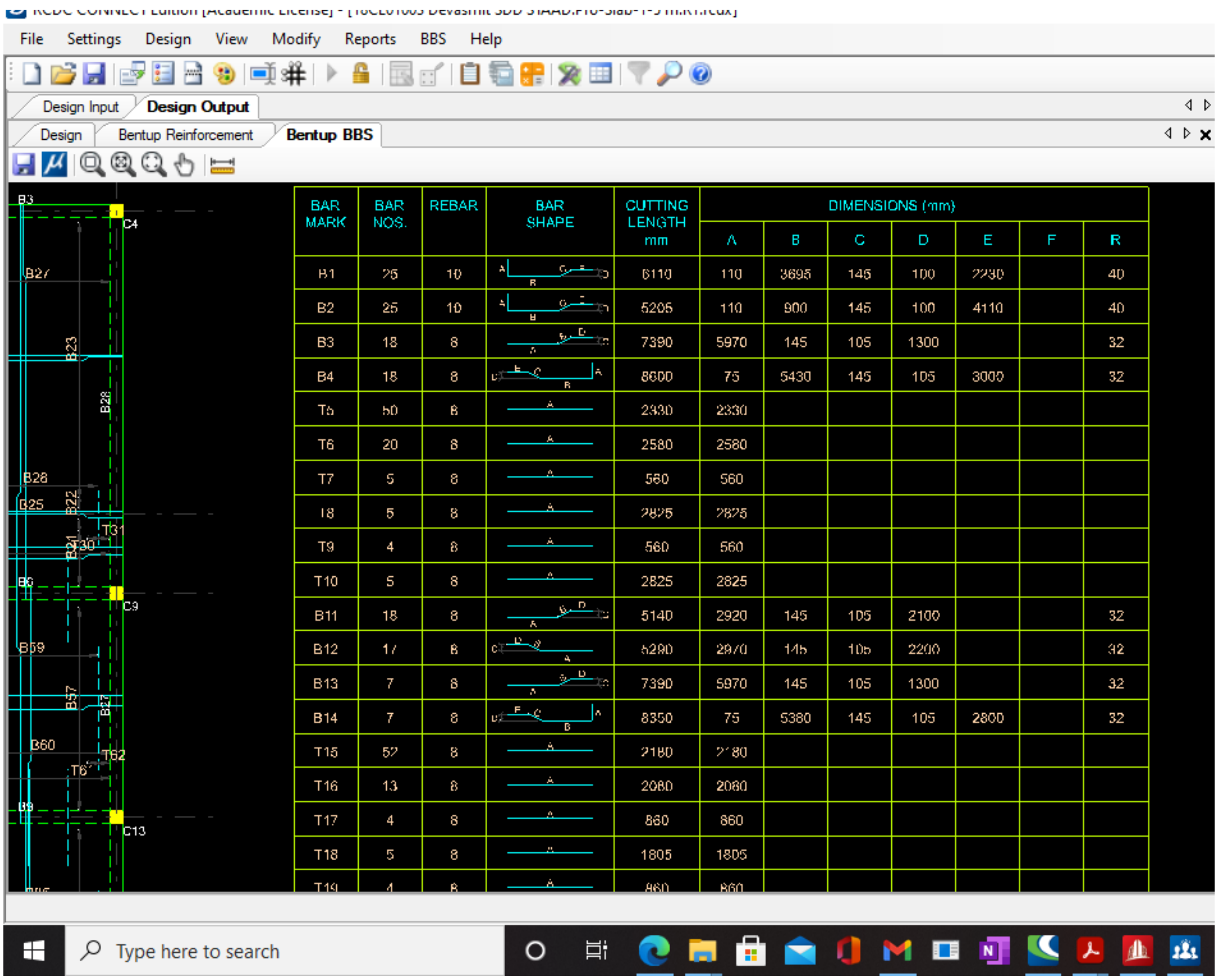
RCDC CONNECT Edition [Academic License] - [18CE01003 Devasmit SDD STAAD.Pro-Slab-1-5 m.R1.rcdx]

File Settings Design View Modify Reports BBS Help

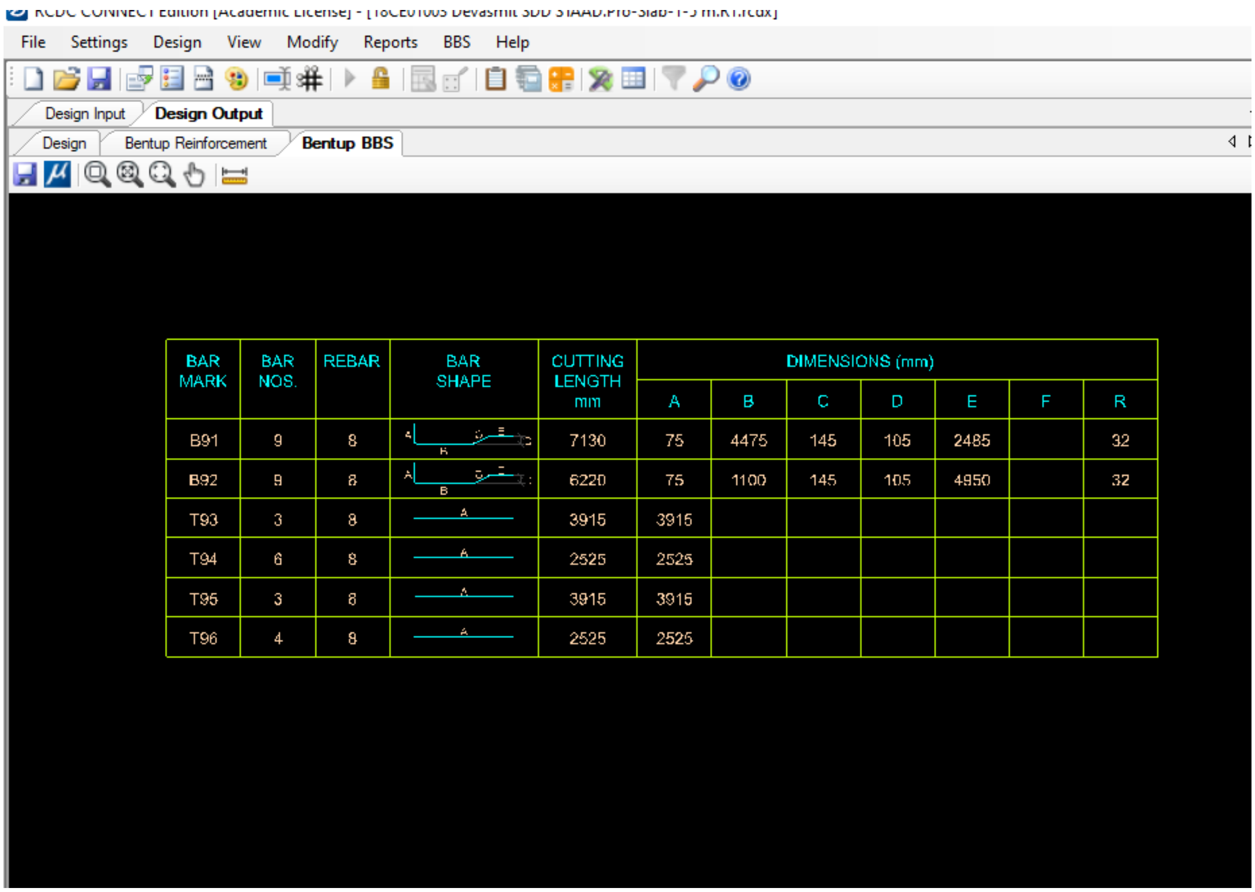
Design Input | **Design Output**

Design | Bentup Reinforcement

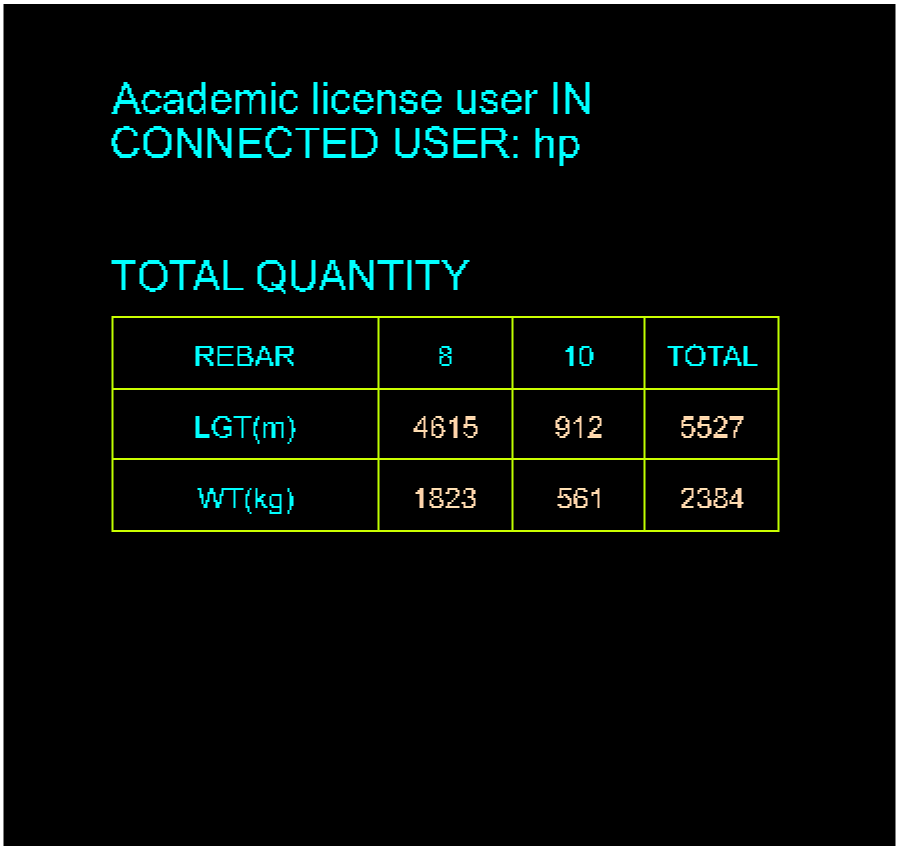
No	Slab	Thickness (mm)	Conc Grade	Steel Grade	Bottom @ Lx	Bottom @ Ly	Top @ Lx (Cont)	Top @ Lx (End)	Top @ Ly (Cont)	Top @ Ly (E
1	S1	150	M25	Fe415	T10 @ 140	T8 @ 130	T8 @ 140	---	T8 @ 240	---
2	S2	150	M25	Fe415	T8 @ 205	T8 @ 275	T8 @ 245	---	T8 @ 300	---
3	S3	150	M25	Fe415	T10 @ 130	T8 @ 300	T8 @ 135	---	---	---
4	S4	150	M25	Fe415	T8 @ 100	T8 @ 170	T8 @ 145	---	T8 @ 290	T8 @ 30
5	S5	150	M25	Fe415	T8 @ 220	T8 @ 275	T8 @ 260	---	T8 @ 300	---
6	S6	150	M25	Fe415	T8 @ 185	T8 @ 275	T8 @ 220	---	T8 @ 300	T8 @ 30
7	S7	150	M25	Fe415	T10 @ 140	T8 @ 130	T8 @ 140	---	T8 @ 240	---
8	S8	150	M25	Fe415	T8 @ 220	T8 @ 275	T8 @ 260	---	T8 @ 300	---
9	S9	150	M25	Fe415	T8 @ 125	T8 @ 220	T8 @ 145	---	T8 @ 260	---
10	S10	150	M25	Fe415	T8 @ 115	T8 @ 210	---	---	T8 @ 250	---



BAR MARK	BAR NOS.	REBAR	BAR SHAPE	CUTTING LENGTH mm	DIMENSIONS (mm)						
					A	B	C	D	E	F	R
B1	25	10		6110	110	3695	145	100	2230		40
B2	25	10		5205	110	900	145	100	4110		40
B3	18	8		7390	5970	145	105	1300			32
B4	18	8		8600	75	5430	145	105	3000		32
T5	50	8		2330	2330						
T6	20	8		2580	2580						
T7	5	8		560	560						
I8	5	8		2825	2825						
T9	4	8		560	560						
T10	5	8		2825	2825						
B11	18	8		5140	2920	145	105	2100			32
B12	17	8		5290	2970	145	105	2200			32
B13	7	8		7390	5970	145	105	1300			32
B14	7	8		8350	75	5380	145	105	2800		32
T15	52	8		2180	2'80						
T16	13	8		2080	2080						
T17	4	8		860	860						
T18	5	8		1805	1805						
T19	4	8		860	860						



BAR MARK	BAR NOS.	REBAR	BAR SHAPE	CUTTING LENGTH mm	DIMENSIONS (mm)						
					A	B	C	D	E	F	R
B91	9	8	A B C D E	7130	75	4475	145	105	2485		32
B92	9	8	A B C D E	6220	75	1100	145	105	4950		32
T93	3	8	A	3915	3915						
T94	6	8	A	2525	2525						
T95	3	8	A	3915	3915						
T96	4	8	A	2525	2525						

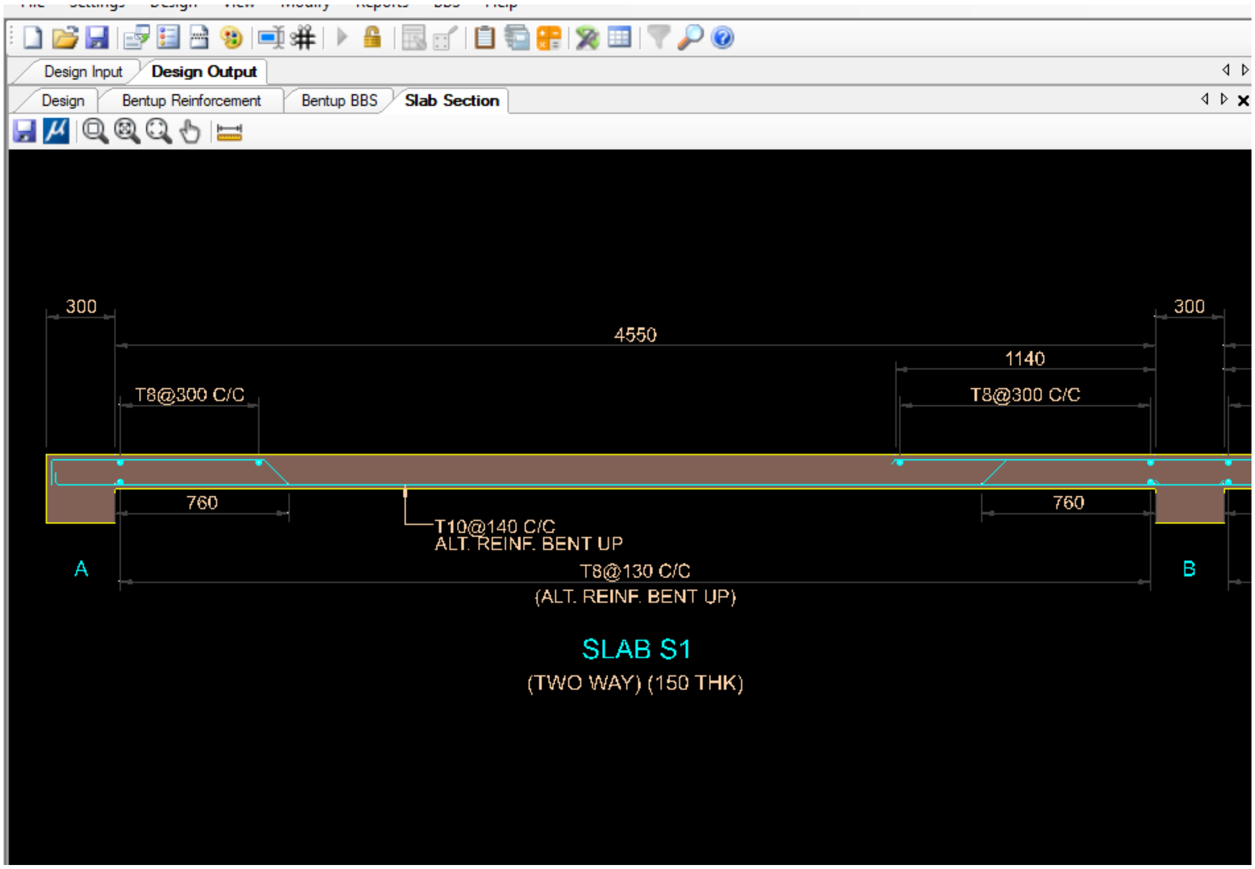


Academic license user IN
CONNECTED USER: hp

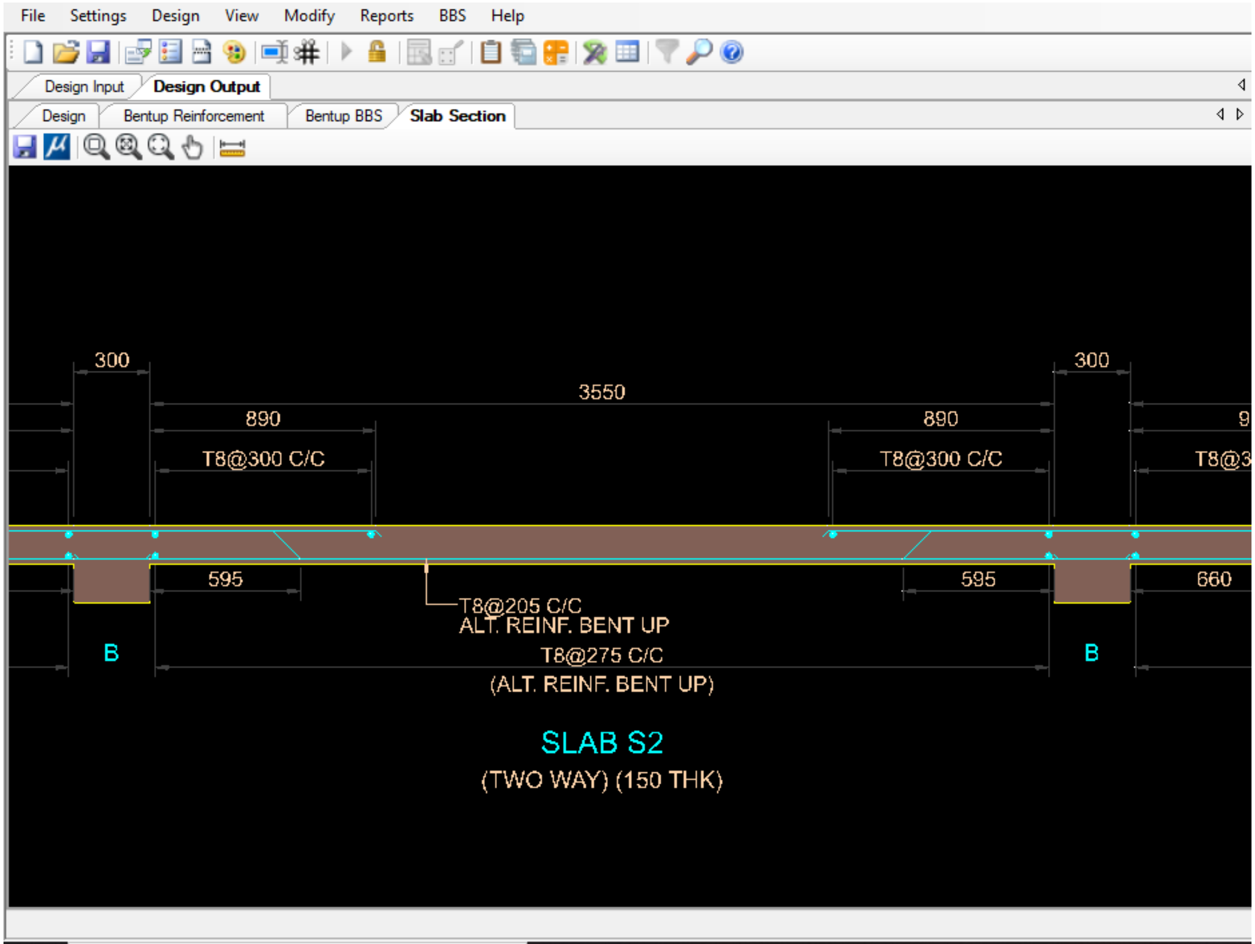
TOTAL QUANTITY

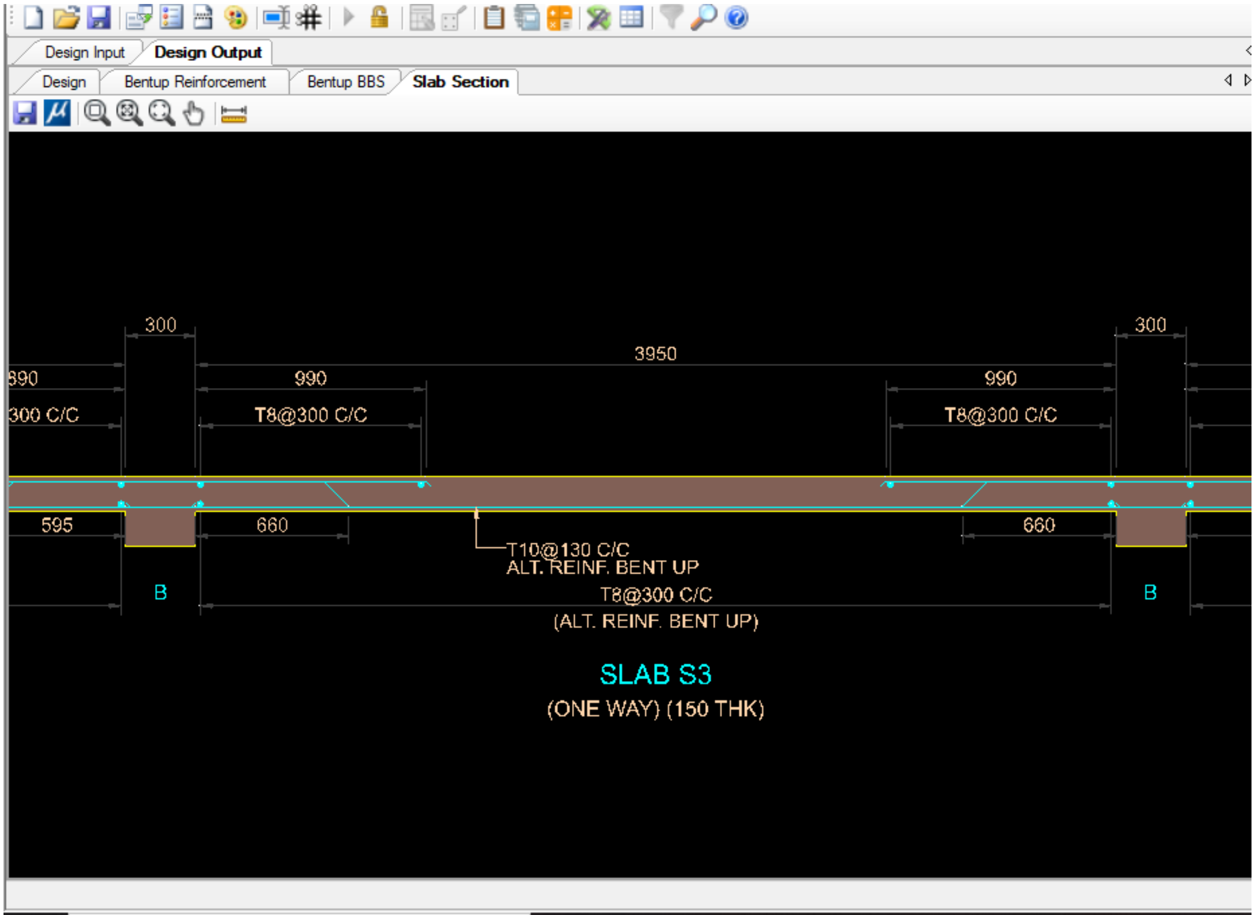
REBAR	8	10	TOTAL
LGT(m)	4615	912	5527
WT(kg)	1823	561	2384

Sectional Elevation of plate members



Design Input
Design Output
Design
Bentup Reinforcement
Bentup BBS
Slab Section
300
4550
1140
300
T8@300 C/C
T8@300 C/C
760
760
T10@140 C/C
ALT. REINF. BENT UP
A
B
T8@130 C/C
(ALT. REINF. BENT UP)
SLAB S1
(TWO WAY) (150 THK)


File
Settings
Design
View
Modify
Reports
BBS
Help
Design Input
Design Output
Design
Bentup Reinforcement
Bentup BBS
Slab Section
300
3550
890
T8@300 C/C
300
890
T8@300 C/C
595
T8@205 C/C
ALT. REINF. BENT UP
595
660
B
T8@275 C/C
(ALT. REINF. BENT UP)
B
SLAB S2
(TWO WAY) (150 THK)



4.4 Foundation (Design and Detailing): -

The design parameters involved are:

Cover and Soil

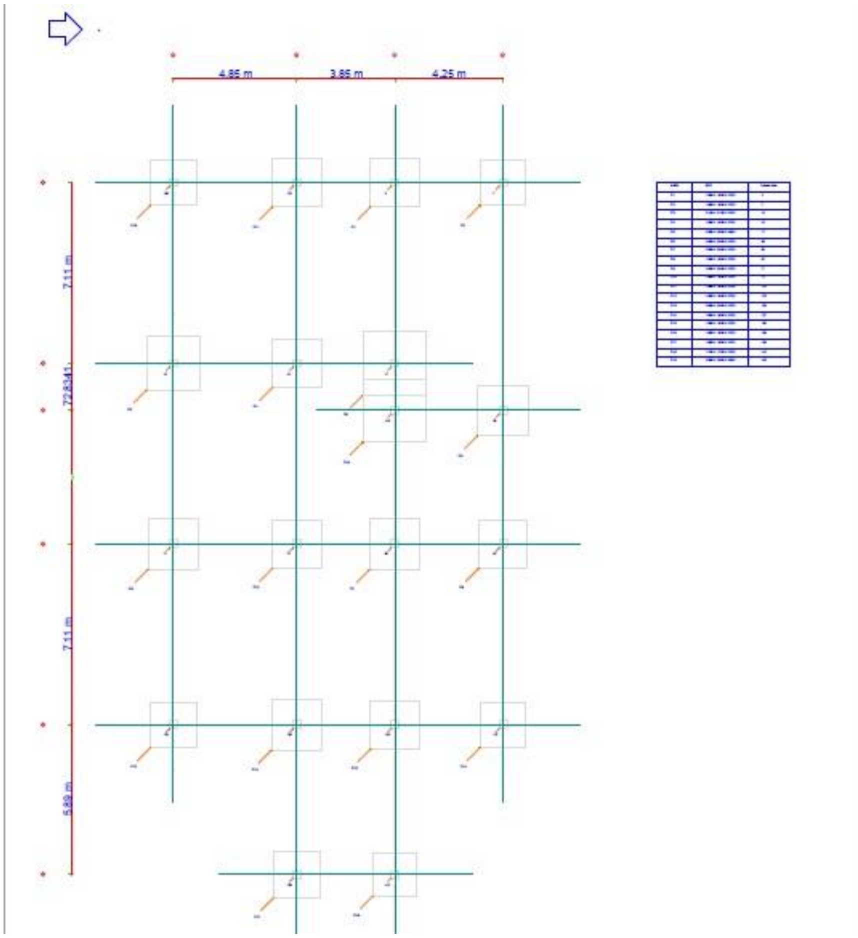
Pedestal Clear Cover	50	mm
Bottom clear cover	50	mm
Unit weight of Soil	17.6	kN/m3
Base Value of Soil bearing capacity	120	kPa
Multiplier on Soil Bearing Capacity For Ultimate Loads	1.7	
Depth of Soil above footing	500	mm
Type of Depth	Fixed Top	
Surcharge Pressure	0	kN/m2
Depth of Water Table	2000	mm
Phi value of soil Ø (in Degree)	0	
Min % of Contact Area for Service Loads	0	
Minimum % of Contact Area For Ultimate Loads	0	
Set as Default	No	

Concrete and Reinforcement

Unit weight of concrete	25	kN/m3
Minimum bar spacing	50	mm
Maximum bar spacing	450	mm
Strength of Concrete (fck)	25	N/mm2
Yield strength of steel	415	N/mm2
Min Bar Size - Footing Bottom	6	
Max Bar Size - Footing Bottom	25	
Min Bar Size - Footing Top	6	
Max Bar Size - Footing Top	25	
Minimum Pedestal Bar Size	8	
Maximum Pedestal Bar Size	40	
Pedestal Tie Bar Size	8	
Minimum Pedestal Bar Spacing	75	mm
Maximum Pedestal Bar Spacing	300	mm
Set as Default	No	

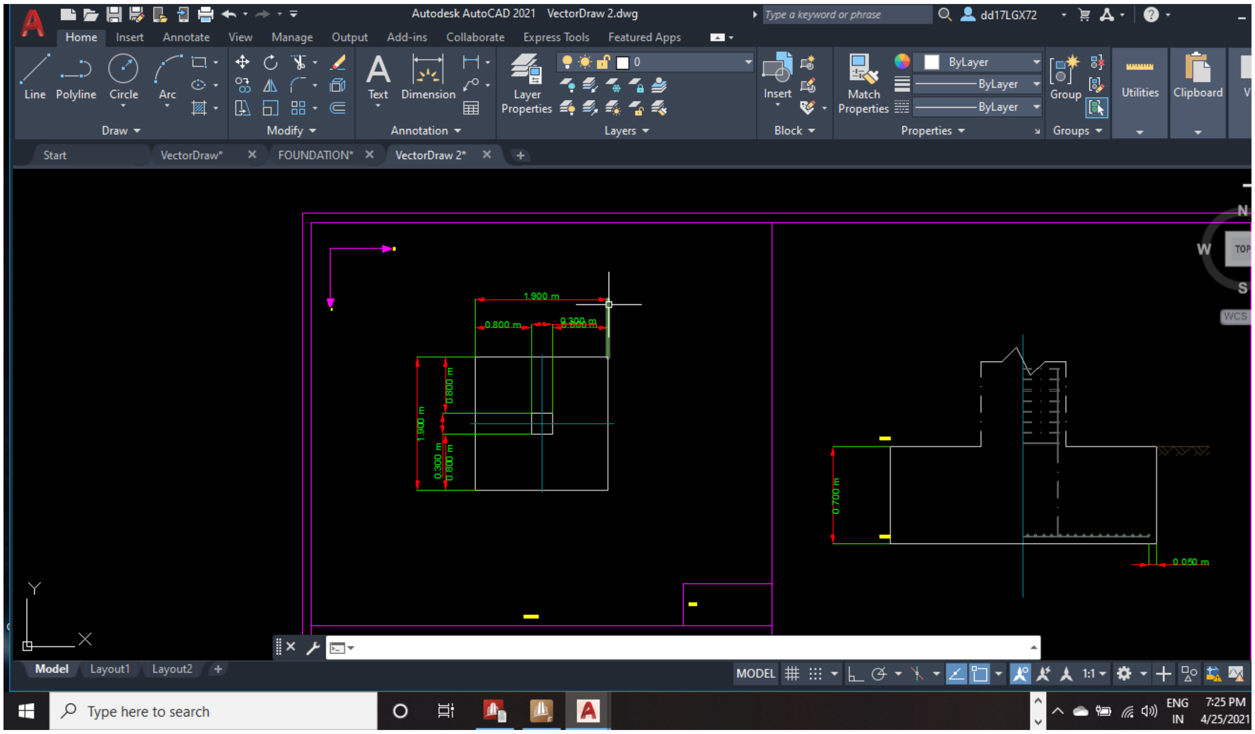
Sliding and Overturning

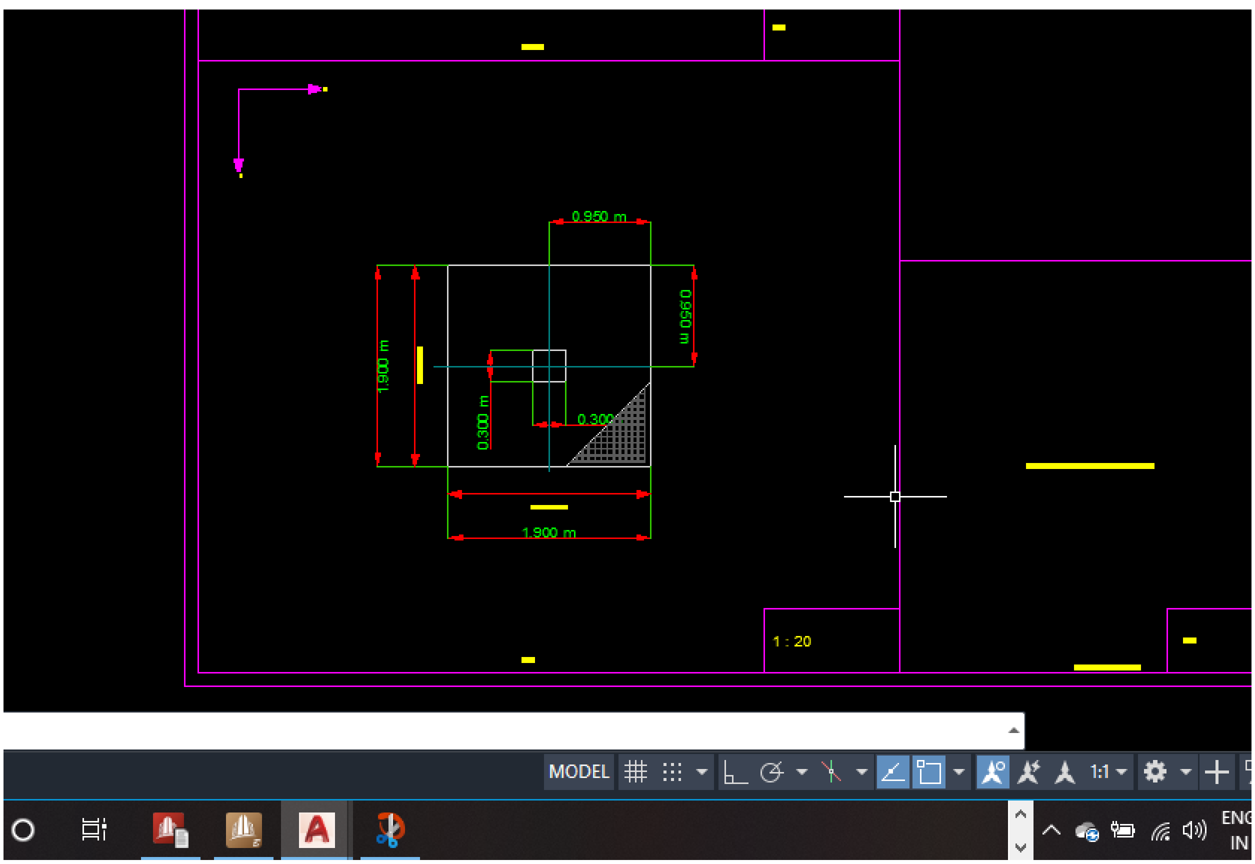
Coefficient of friction	0.5	
Factor of safety against sliding	1.5	
Factor of safety against overturning	1.5	
Consider Passive Earth Pressure	No	
Consider Cohesion Effect	No	

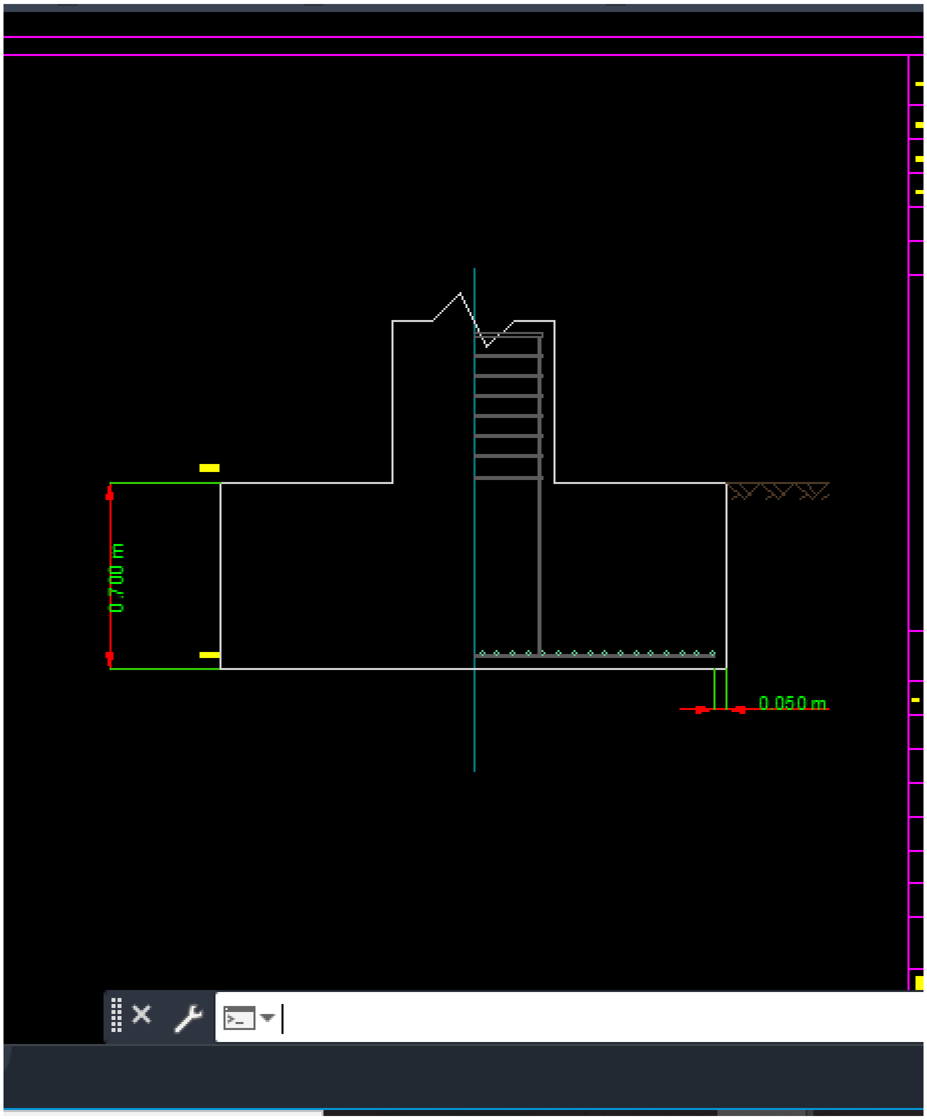


Note here two footings were found to be overlapping despite having made changes to the dimensional parameters of the footing, to bring them isolated

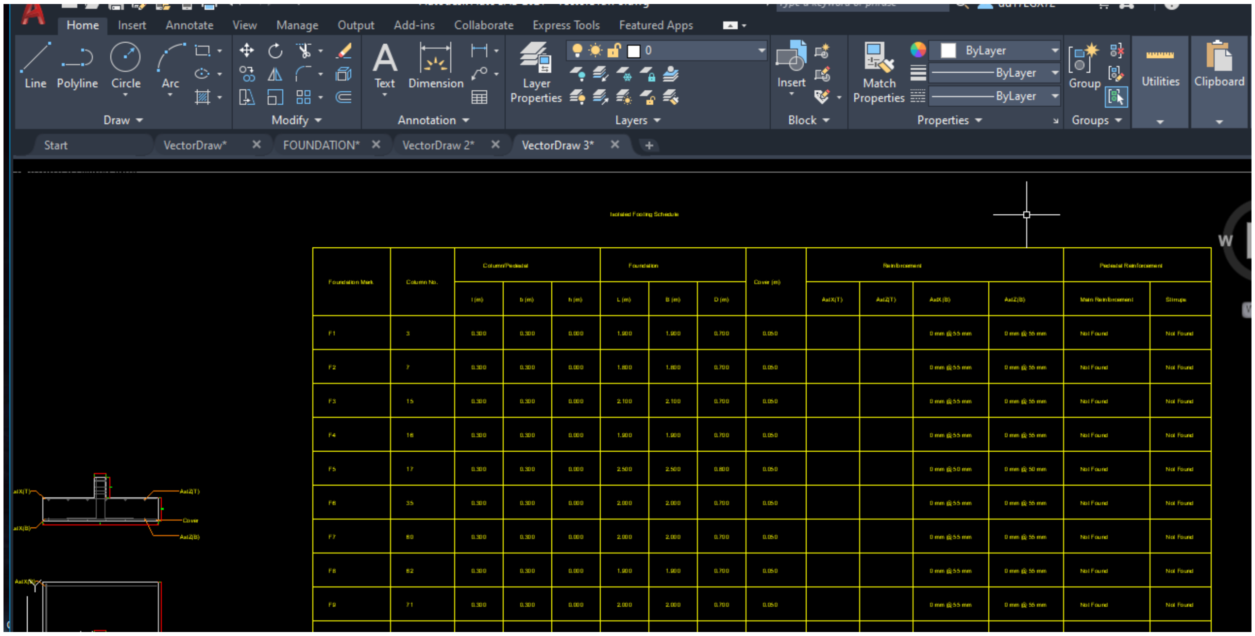
MARK	SIZE	Column Nos.
FI1	1.900 X 1.900 X 0.700	3
FI2	1.800 X 1.800 X 0.700	7
FI3	2.100 X 2.100 X 0.700	15
FI4	1.900 X 1.900 X 0.700	16
FI5	2.500 X 2.500 X 0.800	17
FI6	2.000 X 2.000 X 0.700	35
FI7	2.000 X 2.000 X 0.700	60
FI8	1.900 X 1.900 X 0.700	62
FI9	2.000 X 2.000 X 0.700	71
FI10	1.900 X 1.900 X 0.700	72
FI11	1.900 X 1.900 X 0.700	122
FI12	1.800 X 1.800 X 0.700	123
FI13	2.000 X 2.000 X 0.700	125
FI14	1.800 X 1.800 X 0.700	127
FI15	1.900 X 1.900 X 0.700	130
FI16	1.800 X 1.800 X 0.700	138
FI17	1.800 X 1.800 X 0.700	139
FI18	1.700 X 1.700 X 0.700	142
FI19	2.500 X 2.500 X 0.900	145

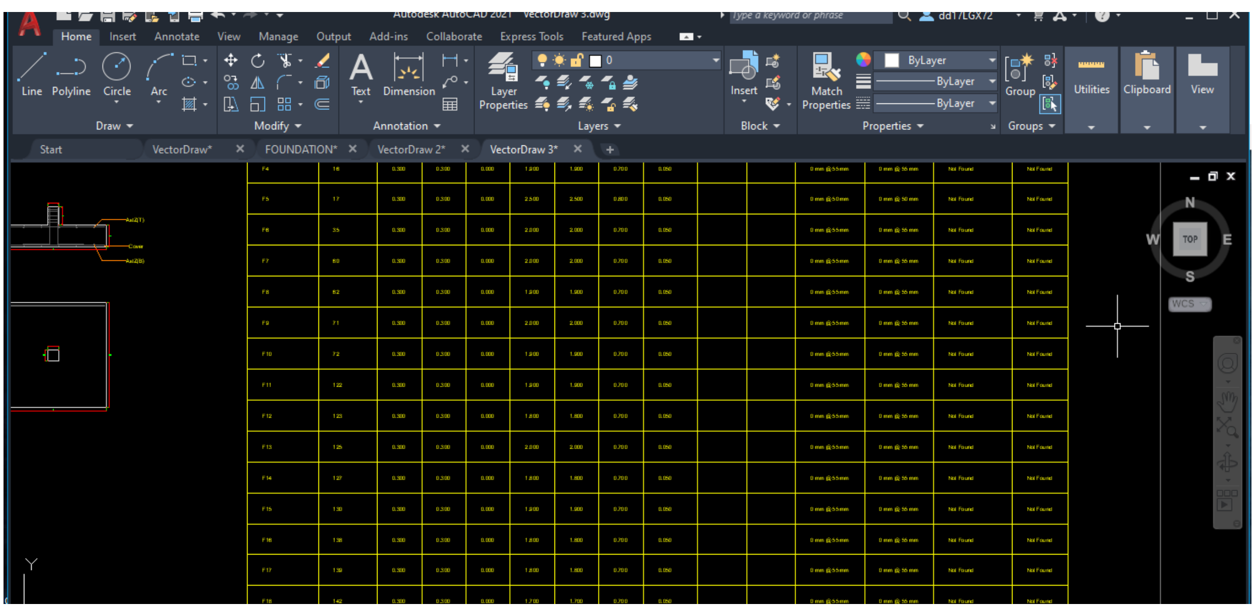

Autodesk AutoCAD 2021 VectorDraw 2.dwg
Type a keyword or phrase
dd17LGX72
Home
Insert
Annotate
View
Manage
Output
Add-ins
Collaborate
Express Tools
Featured Apps
Line
Polyline
Circle
Arc
Text
Dimension
Layer Properties
Insert
Match Properties
ByLayer
Group
Utilities
Clipboard
Draw
Modify
Annotation
Layers
Block
Properties
Groups
Start
VectorDraw*
FOUNDATION*
VectorDraw 2*
1.900 m
0.800 m
0.300 m
0.700 m
0.050 m
Model
Layout1
Layout2
MODEL
Type here to search
ENG
IN
7:25 PM
4/25/2021


0.950 m
1.900 m
0.950 m
0.300 m
0.300
1.900 m
1 : 20
MODEL
1:1
ENG
IN



Footing scheduling design summary:


Home
Insert
Annotate
View
Manage
Output
Add-ins
Collaborate
Express Tools
Featured Apps
Line
Polyline
Circle
Arc
Text
Dimension
Layer Properties
Insert
Match Properties
ByLayer
Group
Utilities
Clipboard
Draw
Modify
Annotation
Layers
Block
Properties
Groups
Start
VectorDraw*
FOUNDATION*
VectorDraw 2*
VectorDraw 3*


Autodesk AutoCAD 2021 VectorDraw 3.dwg
Type a keyword or phrase
Home
Insert
Annotate
View
Manage
Output
Add-ins
Collaborate
Express Tools
Featured Apps
Line
Polyline
Circle
Arc
Text
Dimension
Layer Properties
Insert
Match Properties
ByLayer
Group
Utilities
Clipboard
View
Draw
Modify
Annotation
Layers
Block
Properties
Groups
Start
VectorDraw*
FOUNDATION*
VectorDraw 2*
VectorDraw 3*
N
W
E
S
TOP
WCS