DESIGN BASIS REPORT

FOR

HOTEL HOLIDAY INN

AT

180 STODDARD ROAD

Submitted By

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1. Introduction

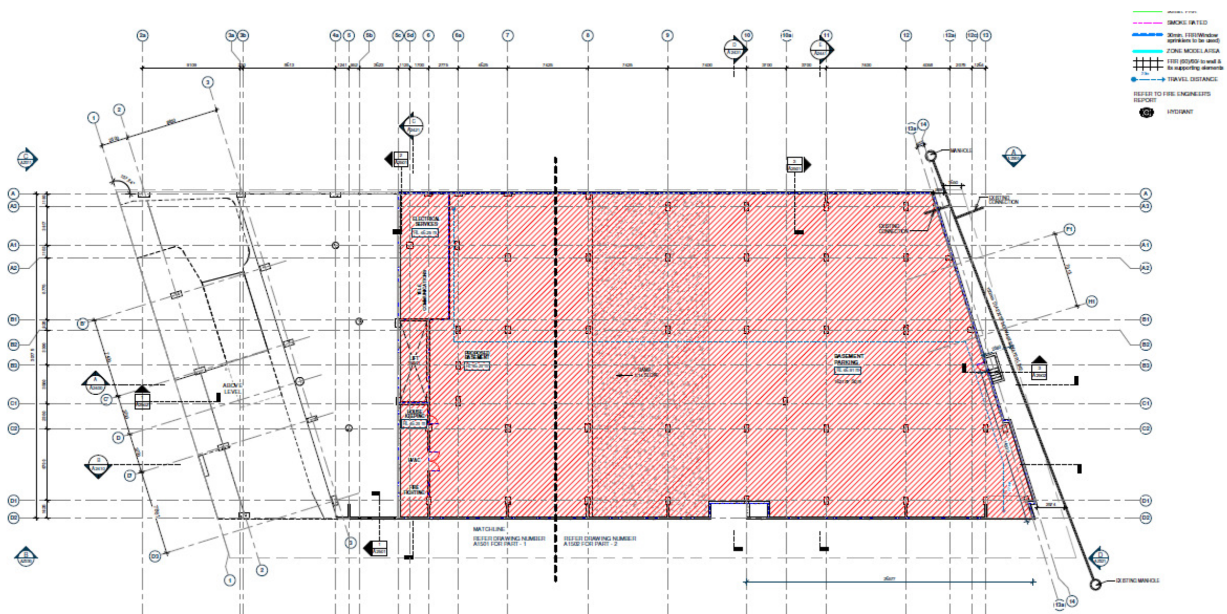
It is proposed to erect a hotel building with basement as car parking, a Mezzanine and four levelson 180-182 Stoddard Road, MT. Roskill, Auckland. The proposed building will provide visitor accommodation, hotel reception, office, café, warehouse and car parking. The Building will be constructed in cast in situ concrete material.

The site is currently used for warehouse and offices. An existing single level building occupies the site with offices, warehouses and car parking. Whole existing structure has been demolished and new structure has been proposed at same place.

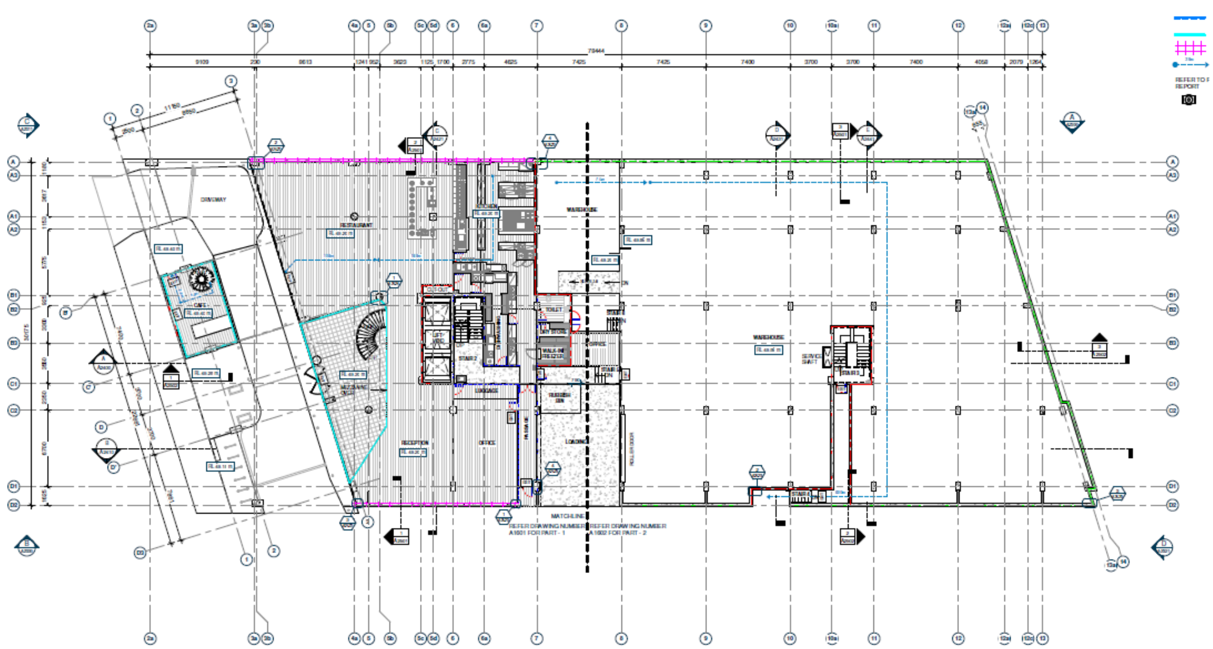
2. Geometry of Building

The Building is designed for basement as car parking plus Mezzanine plus four levels.

The plan dimensions of the building are 87.4m x 31.1m and height from ground level is 18.75 m.

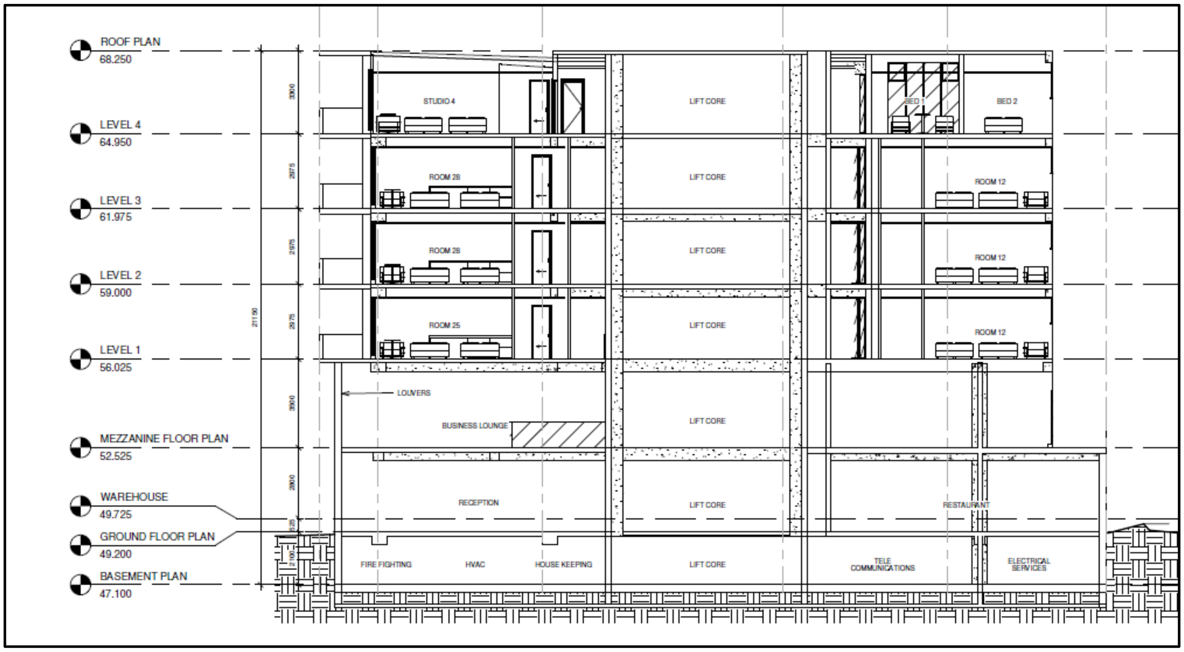


Basement Plan

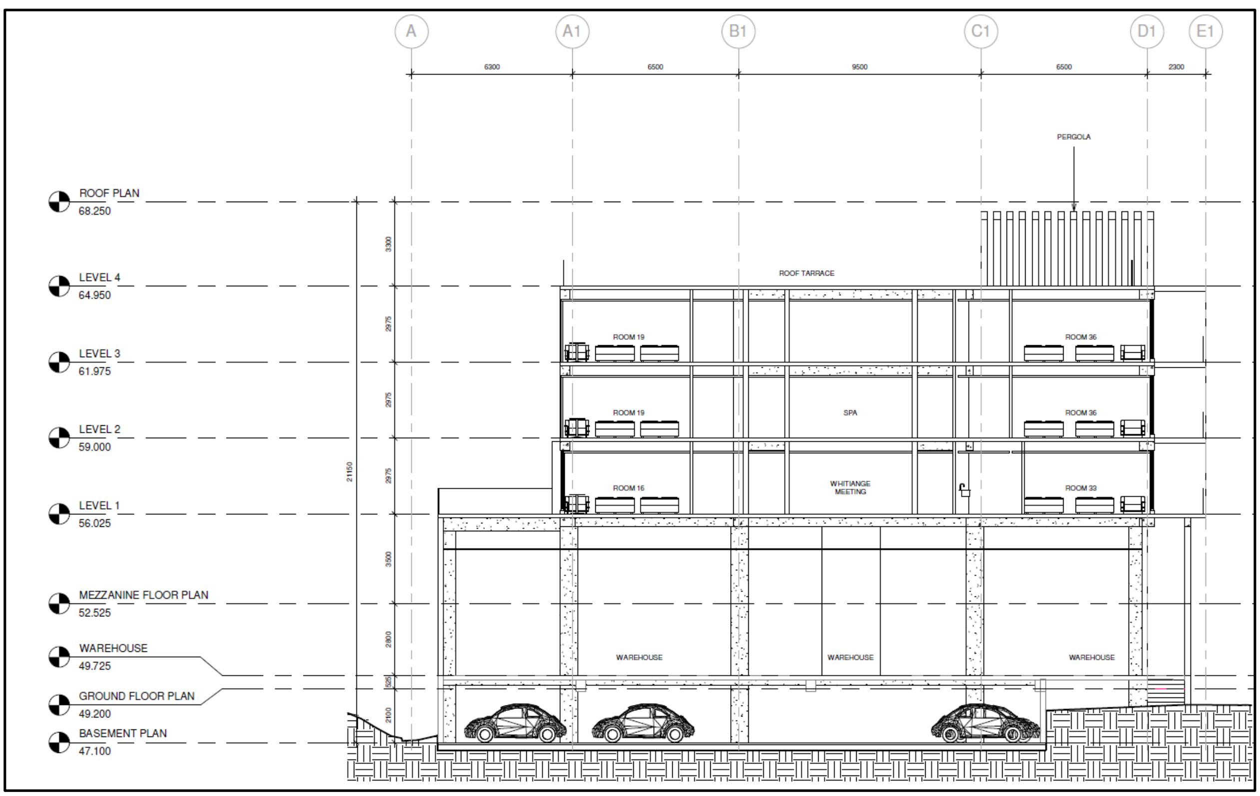


Ground floor plan

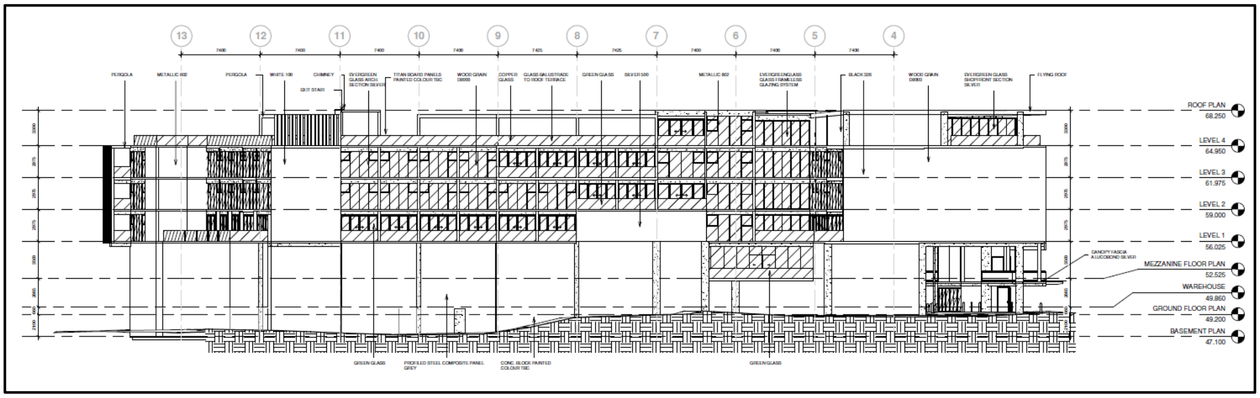
The story height of building shown in below image:



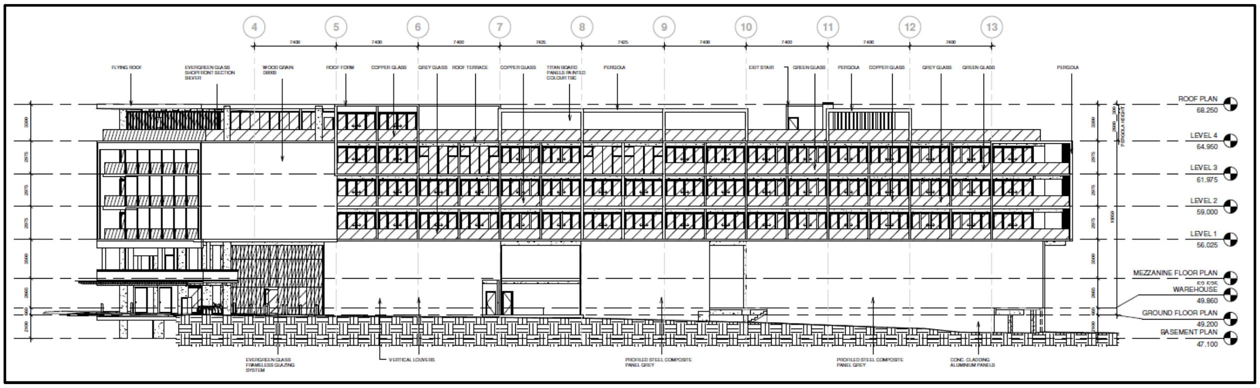
Section



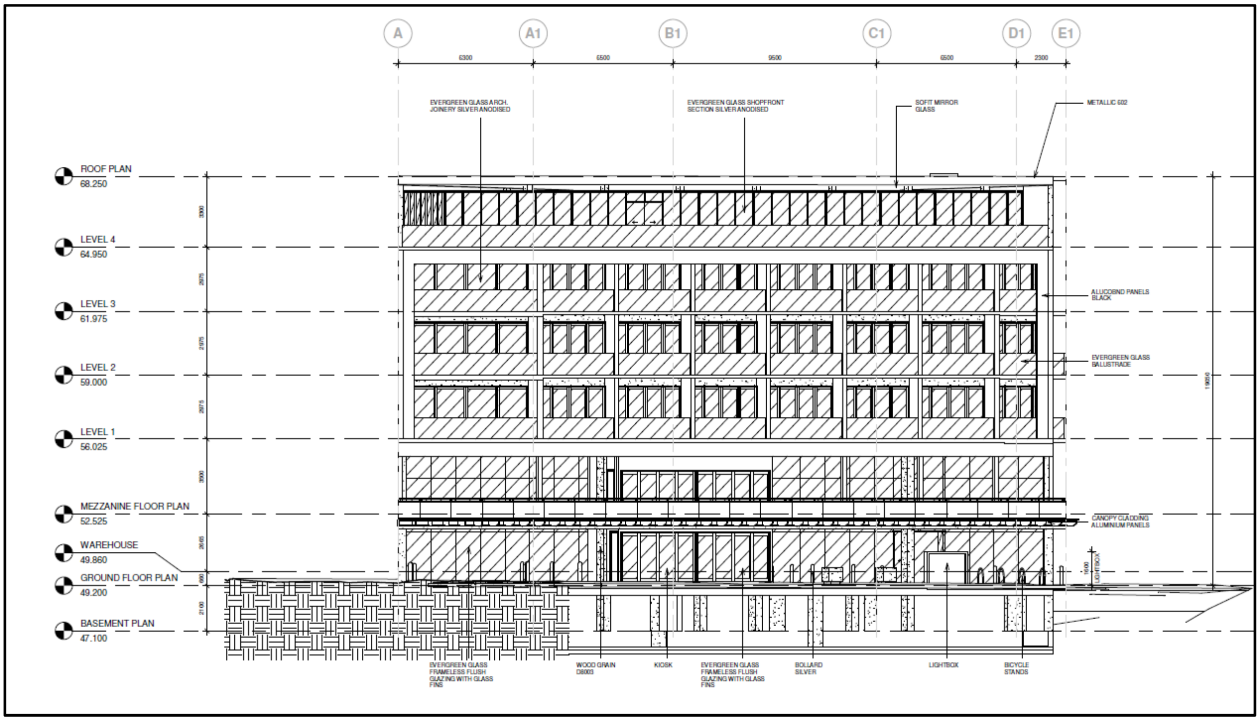
Section



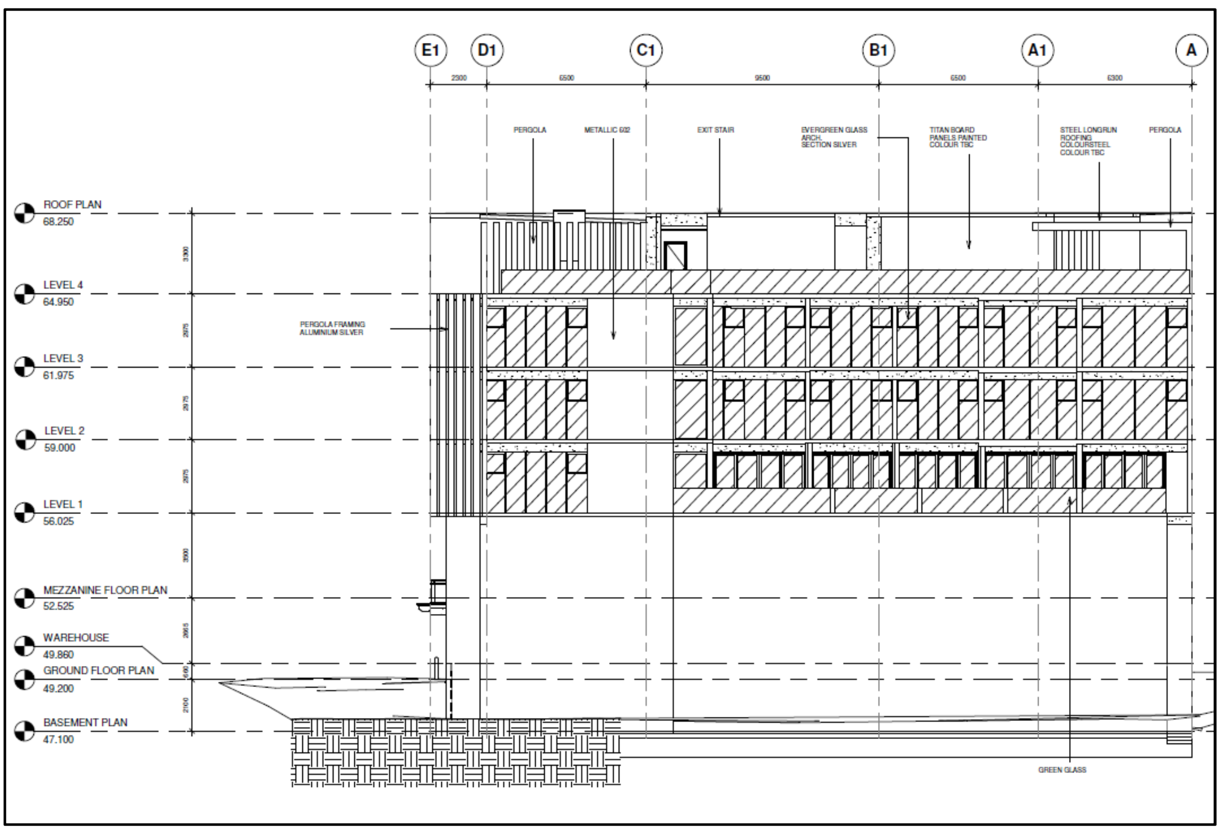
East Elevation



West Elevation



North Elevation



South Elevation

3. Structural System

The Building will be constructed in reinforced concrete cast in-situ material.

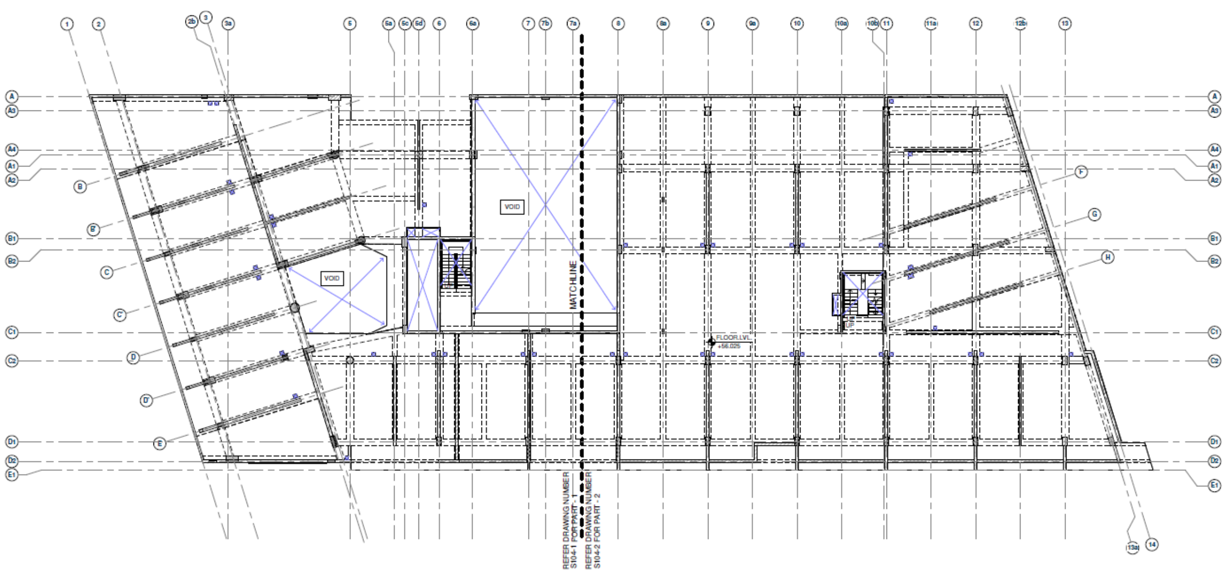
Up to level 1 structure system supported on Reinforced cast in-situ column and RCC wall start from foundation.

From level 1 cast in-situ reinforced wall will start from beam which supports the slab system. All partition wall will be 100mm/140mm thick STEEL STUD wall which will not participate in structural resistance system.

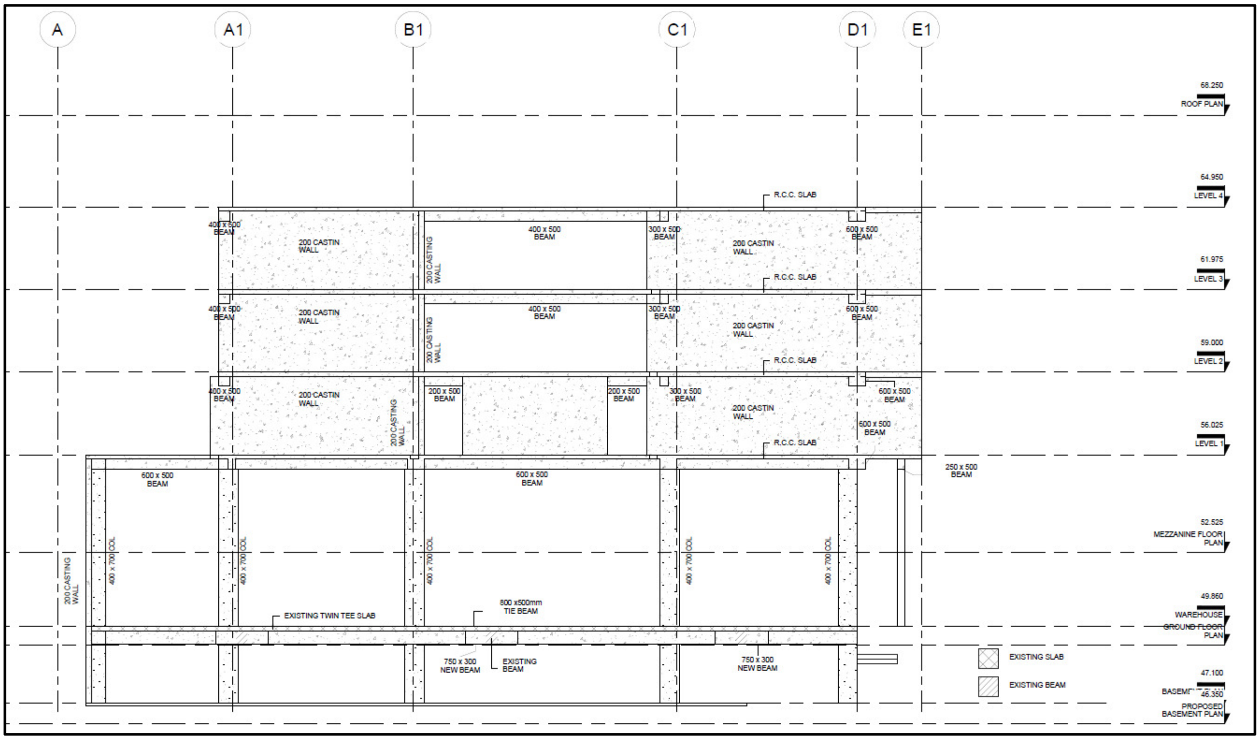
Lateral load resistance in along direction will be provided by the frame of concrete columns and beams and also by RCC wall on periphery of the building.

Lateral Load resistance on across direction will be provided by frame of concrete columns and beams and also by cast in-situ wall.

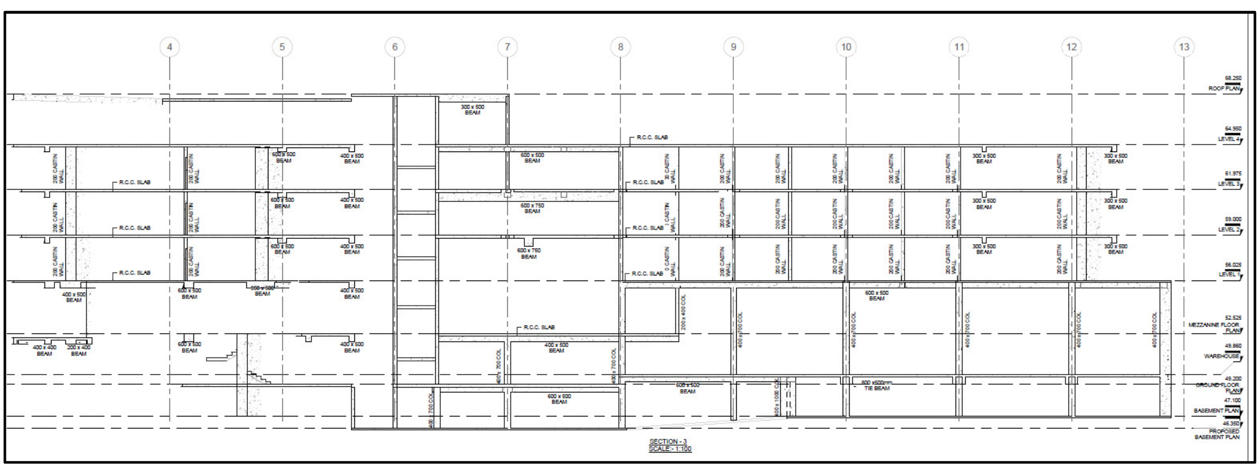
Analysis and design of entire concrete building will be carried out by 3D modeling in ETABS Structural Analysis software.



LEVEL-1 FLOOR OVERALL PLAN (LEVEL : +56.025)
SCALE: 1 : 150



Transverse Section



Long Section

4. Design Codes

BS –PART	YEAR	TITLE
AS/NZS 1170.0	**2002**	**Structural Design actions Part 0: General principles**
AS/NZS 1170.1	**2002**	**Structural Design actions Part 1: Permanent, Imposed and other actions**
AS/NZS 1170.2	**2011**	**Structural Design actions Part 2: Wind actions**
AS/NZS 1170.5	**2004**	**Structural Design actions Part 5: Earthquake actions**
NZS 3101: Part 1: 2006	**2006**	**Concrete Structures Standard Part 1: The Design of Concrete Structures**
NZS 3404: Part 1& 2: 1997	**1997**	**Steel Structures Standard Part 1 & Part 2: The Design of Steel Structures**
NZS 4229	**1999**	**Concrete Masonary Buildings not require specific engineering Design.**
NZS 4230	**2004**	**Design of Reinforced Concrete Masonary Structures**

5. Material Properties

Concrete Grade

Compressive Strength of Concrete
For foundation, Tie Beam, wall, columns, Beams and Slab = 35 N/mm^2(confirming to the clause 6.3:NZS 3109 1997)

Rebar Grade (Confirms to AS/NZS 4671)
Yield stress of main reinforcement = 500 N/mm^2 HD
And for ties = 500 N/mm^2

Structural Steel

Design yield strength for Beam fy= 300 N/mm^2
Design yield strength for Steel Post fy= 350 N/mm^2

Connection Bolts

All Bolts To be Grade 8.8 IN S300.

Density

Density of concrete = 25 kN/m^3

6. Loading

Building Design Loads will be in accordance with the more stringent of either the following criteria or as set forth by governing local and national codes. Structural design will be coordinated with architectural, mechanical and electrical drawings to ensure all loads impacting structural elements are adequately supported. Earthquake and Wind load will be as required by governing local or national codes.

6.1 Gravity Load

Cast in-situ slab system supported on main and secondary Beam up to Level 1 and on cast in-situ concrete wall on and above Level 2. This cast in-situ wall may be constructed as Precast panel wall to increase construction time.

Main Beam supported on columns and RCC wall and secondary beam supported on Main beams.

RCC wall start from foundation and cast in-situ concrete wall start from level 1.

Imposed Load in rooms, passages and other area as per NZS 1170.

Thus total loads will be transferred to the ground via the concrete cast in-situ columns and RCC wall.

6.1.1 Dead Load

Self-weight of Slab = Slab thickness x Density of Concrete

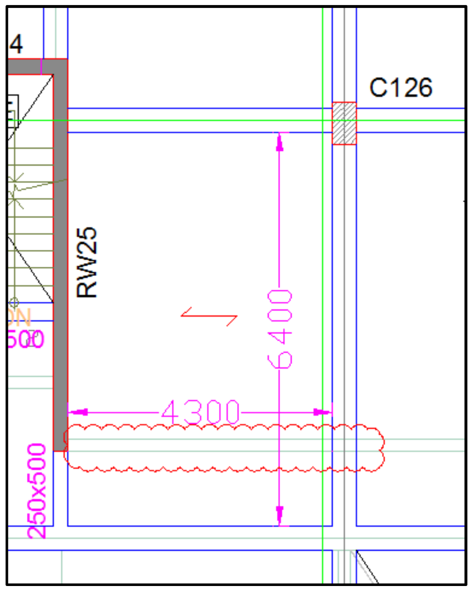
Slab thickness (mm)	Load considered (kN/m^2)
150	= 0.15 x 25 = 3.75
175	= 0.175 x 25 = 4.375
200	= 0.20 x 25 = 5
230	= 0.230 x 25 = 5.75
250	= 0.250 x 25 = 6.25
275	= 0.275 x 25 = 6.875

Floor Finish = 1.25 kN/m^2(NZS 1170.1:2002)

Wall Load:-

Load of partition wall start from slab:

Load of partition wall start from slab considered as uniformly distributed over slab. Here sample calculation for mezzanine level is shown and the same is considered for rest of the slab whereas applicable.



The partition wall is marked with cloud and length of wall is 4.3m and thickness is 0.1m as shown.

Height of wall = 3.5 (height from Mezzanine to Level 1) – 0.150 (Level 1 slab thickness)

= 3.35 m.

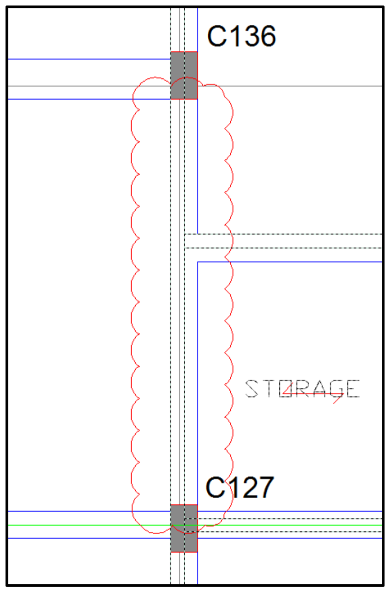
Load of wall = 4.3 x 3.35 x 0.1 x 25 (Density) = 36.01 kN

Distributed load on slab = 36.01 / (4.3 x 6.4) = 1.30 kN/m^2.

So, here we have considered 1.5 kN/m^2 of uniform load on slab for Partition wall.

Wall load on Beams:

The load of wall which starts from beam will transfer to the beam. And the load is applied per meter to the beam.
Load of wall = Height of wall x thickness of wall x Density.
Here sample calculation for Mezzanine slab is given below:



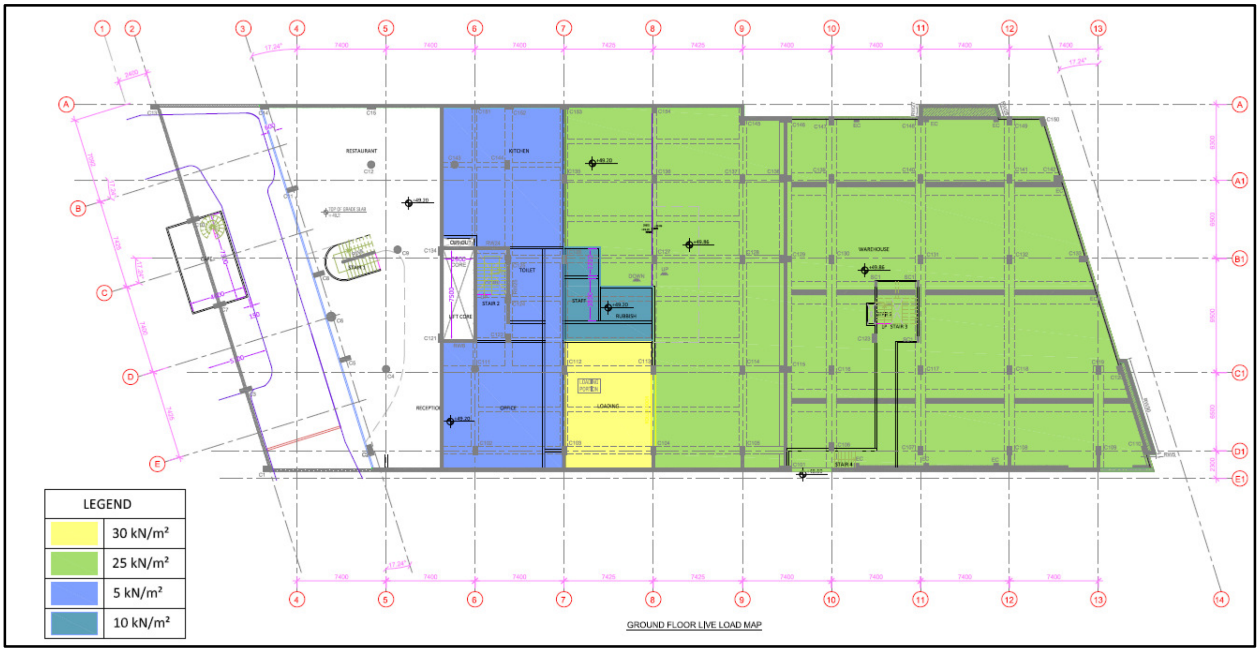
The wall is marked with cloud and thickness is 0.1m.
Height of wall = 3.5 (height from Mezzanine to Level 1) – 0.5 (Depth of Level 1 Beam)
= 3.0 m.
Load of wall = 3.0 x 0.1 x 25 (Density) = 7.5kN/m
So, uniformly distributed load of 7.5 kN/m apply on beam. Same way the rest of the beam load applies of wall.

6.1.2 Imposed Load

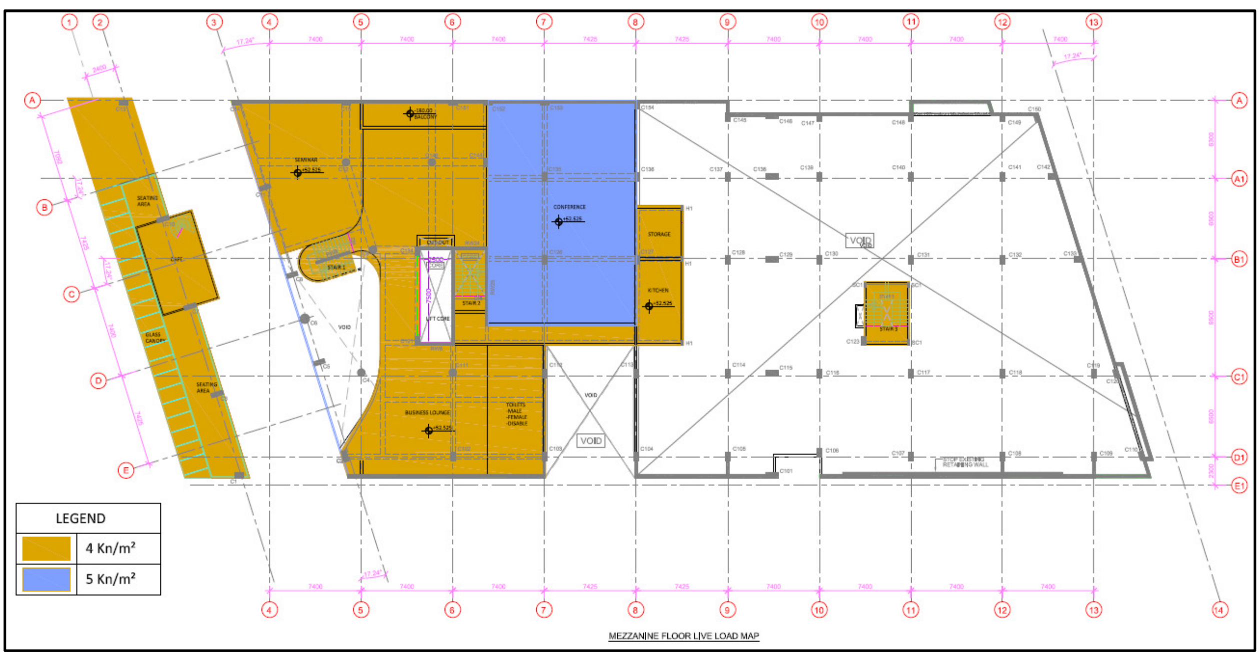
Slab Imposed Load in Rooms = 2.0kN/m2 (Table 3.1 NZS1170 Part 1)
Slab Imposed Load in Kitchen and office = 5.0 kN/m2 (Table 3.1 NZS1170 Part 1)
Slab Imposed Load in passage = 3.0 kN/m2 (Table 3.1 NZS1170 Part 1)
Slab Imposed Load in stair = 4.0 kN/m2 (Table 3.1 NZS1170 Part 1)
Roof Imposed Load = 1.5kN/m2 (Table 3.2 NZS1170 Part 1)

The location of imposed load is also mentioned in below images with value.

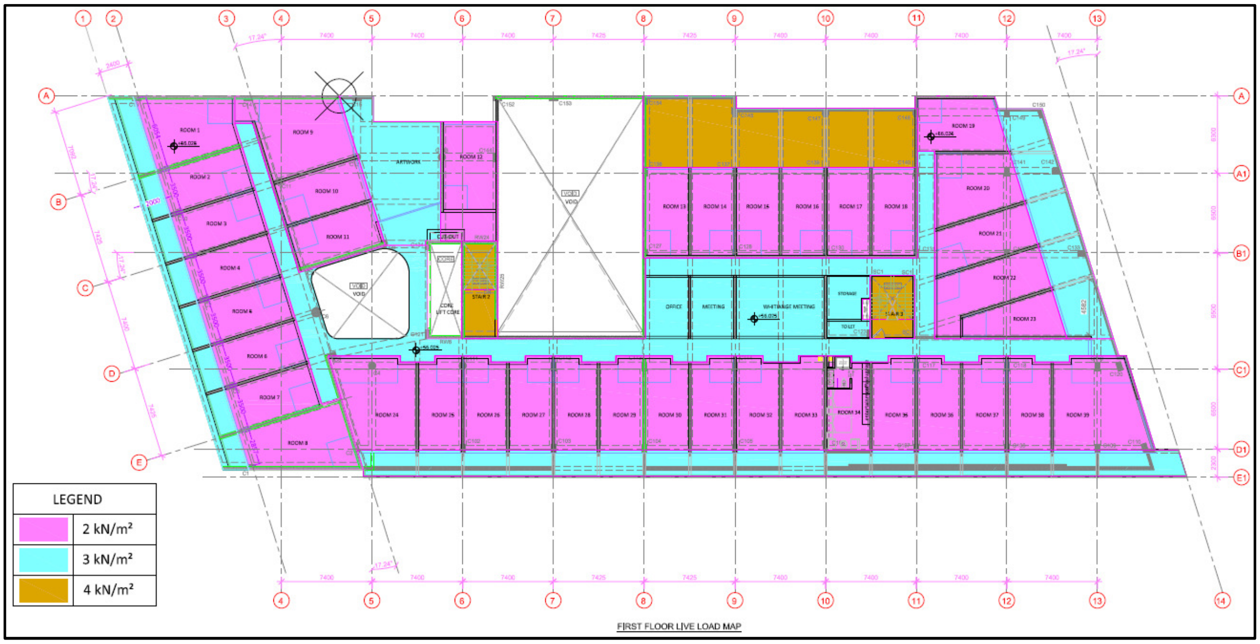
Ground Floor Imposed Load Plan



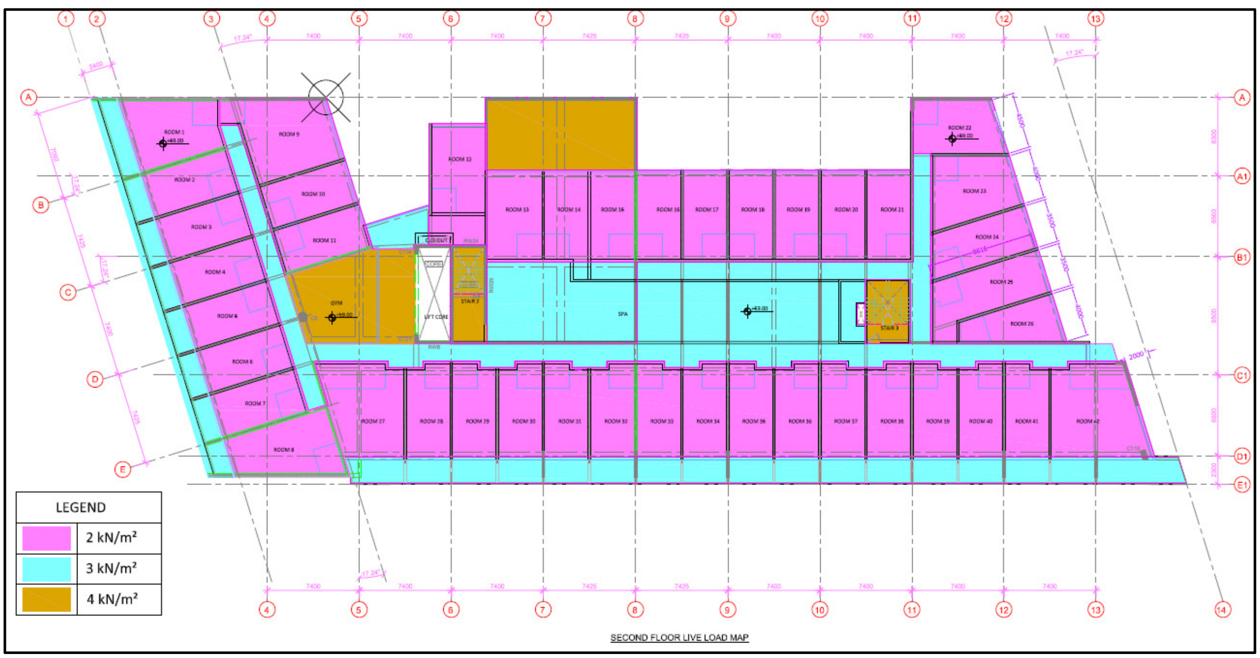
Mezzanine Floor Imposed Load Plan



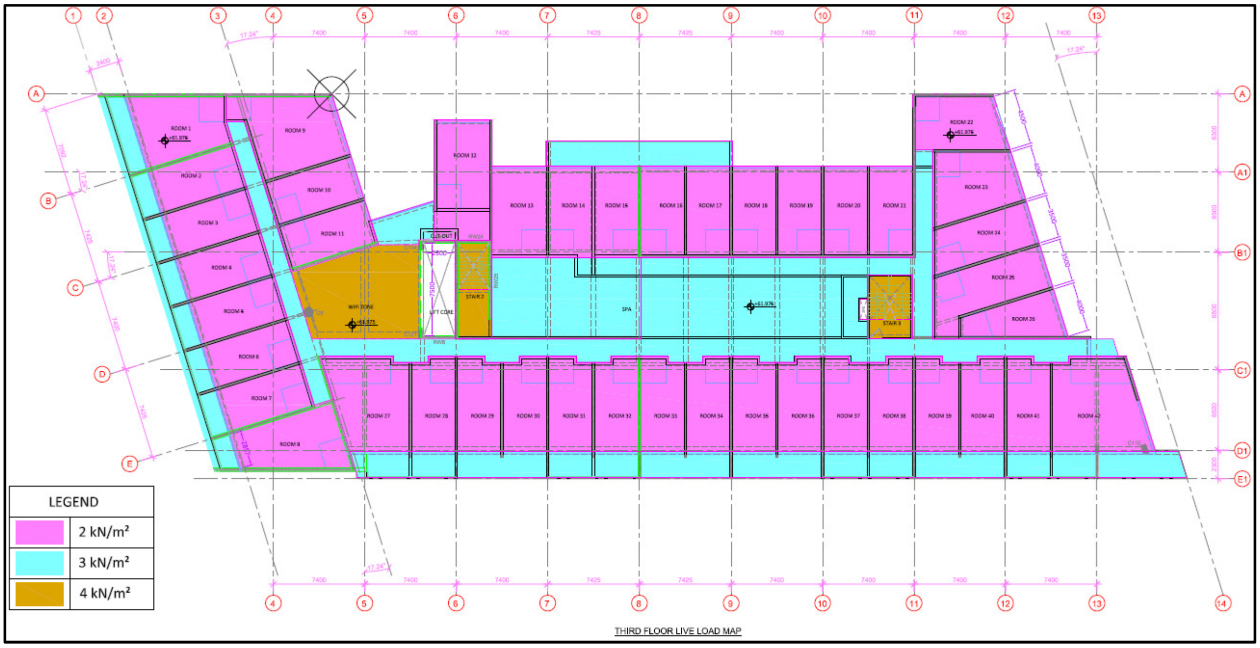
Level 1 Floor Imposed Load Plan



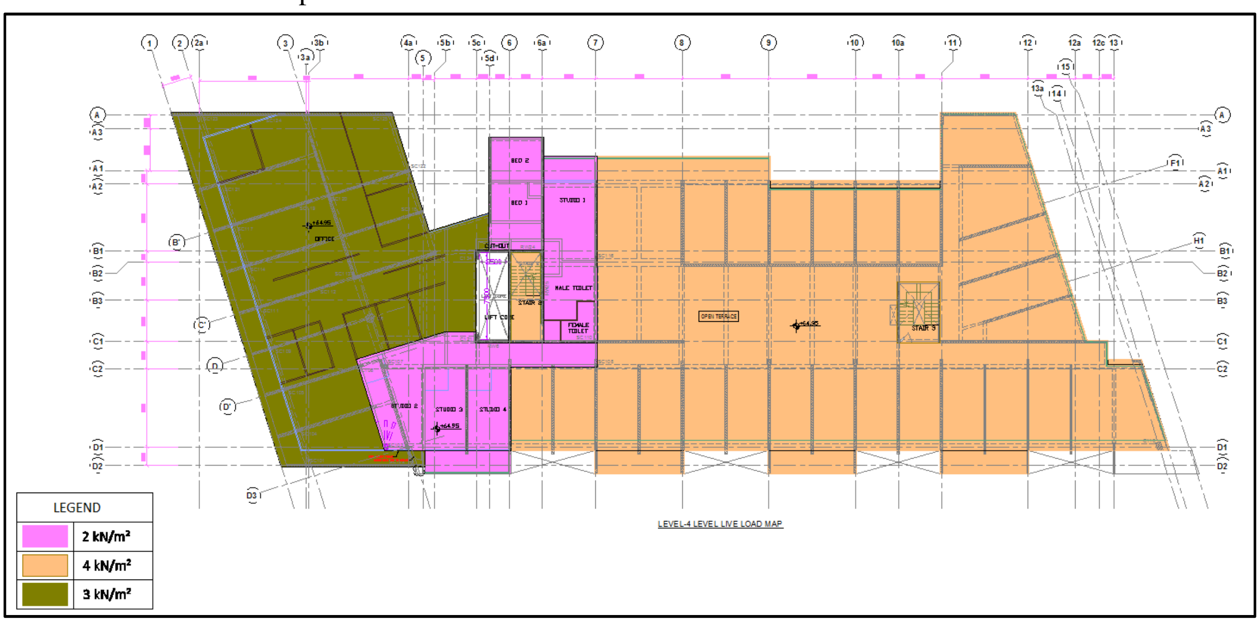
Level 2 Floor Imposed Load Plan



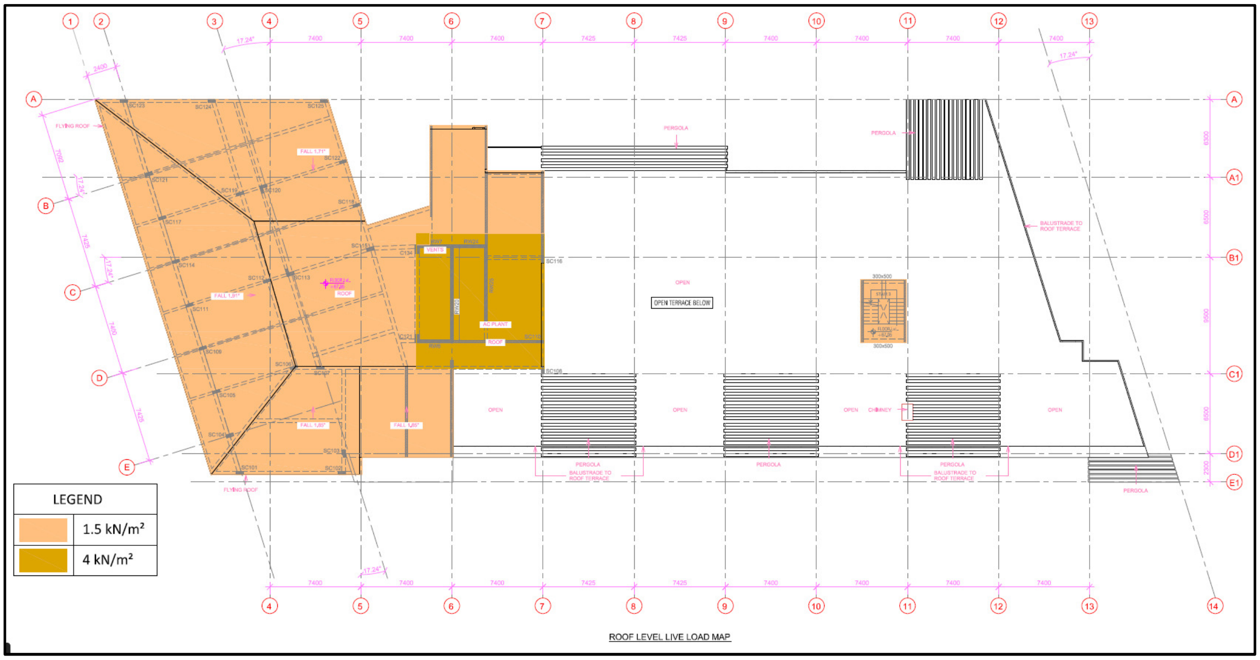
Level 3 Floor Imposed Load Plan



Level 4/Terrace Floor Imposed Load Plan

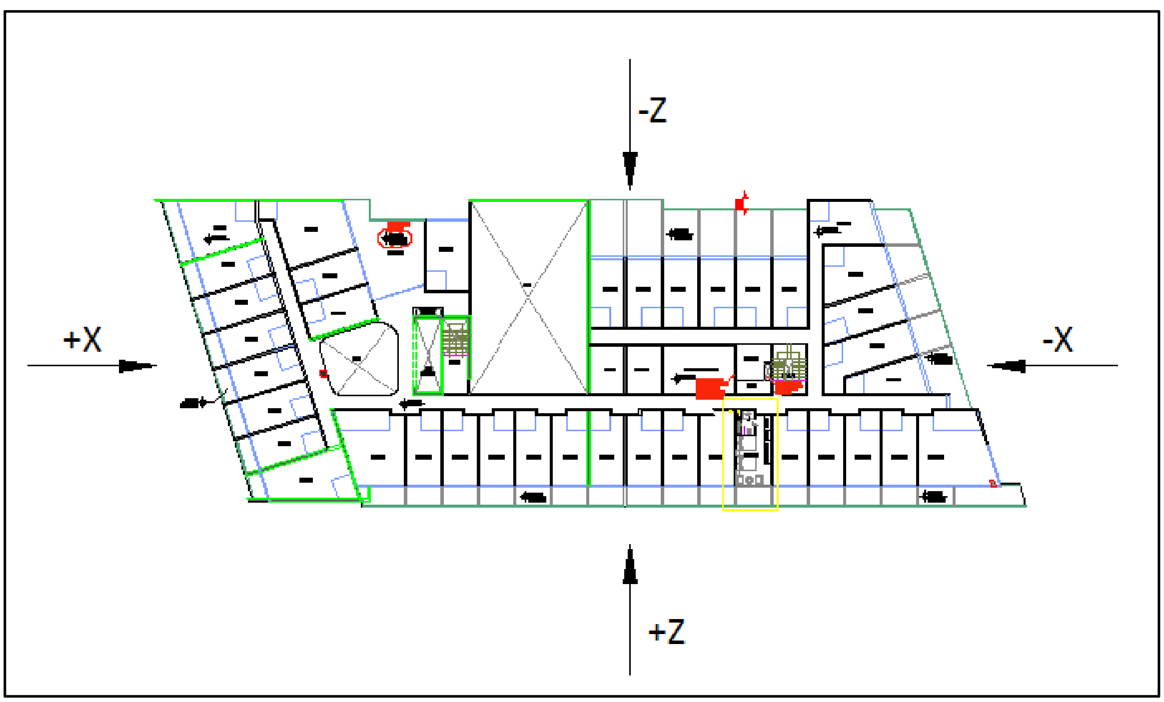


Roof Floor Imposed Load Plan



6.2 Lateral Load

The sign convection for the calculation and applying of lateral load i.e for Earthquake and wing load considered are as below.



6.2.1 Earthquake Load

- **Calculation for Horizontal design action coefficient**(clause 5.2, 1170 .5:2004)

INC HOTEL AT 180 STODDARD ROAD
Design Philosophy Report

Seismic Load as per NZS1170 Part 5 :-
Elastic Site Spectra for Horizontal Loading :

Elastic site hazard spectrum for Horizontal Loading C(T) :
C(T) = Ch (T) Z R N (T,D)
Where,

Ch (T) = The spectral shape factor Cl. 3.1.2 NZS 1170 Part 5 (Table 3.1)
R = The return period factor Rs and Ru for the appropriate limit state determined from clause 3.1.5 NZS 1170 Part 5 but limited such that ZRu does not
N (T,D) = the near-fault factor determined from Clause 3.1.6

Ch (T) = The spectral shape factor Cl. 3.1.2 NZS 1170 Part 5 (Table 3.1)
Subsoil Classification is C (Shallow soil from soil report)
The value of this factor depends upon the time period of the building. The time period considered by applying the actual Dead and imposed load to analysis software and fundamental period of vibration determined. Time period determined by igen value solution by modal mass participation and mode shapes.Time period in X and Z Direction derived by maximum mass

From the analysis software, Time period is calculated as below with respect to modal mass participation.

Table 3.11 - Modal Participating Mass Ratios (Part 1 of 2)

Case	Mode	Period sec	UX	UY	UZ	Sum UX	Sum UY	Sum UZ
Modal	1	1.177	0.0001	0	0	0.0001	0	0
Modal	2	1.142	0	0.0001	0	0.0001	0.0001	0
Modal	3	1.141	0	0.0001	0	0.0001	0.0002	0
Modal	4	1.139	0.0001	4.393E-06	0	0.0002	0.0002	0
Modal	5	1.139	4.197E-06	0.0001	0	0.0002	0.0003	0
Modal	6	1.122	0.0001	0	0	0.0003	0.0003	0
Modal	7	0.781	0	0	0	0.0003	0.0003	0
Modal	8	0.736	0	7.481E-07	0	0.0003	0.0003	0
Modal	9	0.727	0	0	0	0.0003	0.0003	0
Modal	10	0.725	0	0	0	0.0003	0.0003	0
Modal	11	0.397	0.0003	0.6052	0	0.0006	0.6055	0
Modal	12	0.33	0.077	0.1974	0	0.0776	0.8029	0
Modal	13	0.289	0.7217	0.024	0	0.7994	0.8269	0
Modal	14	0.242	0.0002	0	0	0.7995	0.8269	0
Modal	15	0.229	0.0002	3.24E-06	0	0.7997	0.8269	0
Modal	16	0.216	2.257E-05	0	0	0.7997	0.8269	0
Modal	17	0.212	0	0.0005	0	0.7997	0.8274	0
Modal	18	0.212	4.735E-05	3.453E-05	0	0.7998	0.8274	0
Modal	19	0.205	0.0002	1.268E-06	0	0.7999	0.8274	0
Modal	20	0.204	2.136E-05	0.0003	0	0.8	0.8277	0
Modal	21	0.2	0	0.0001	0	0.8	0.8278	0
Modal	22	0.199	0.0001	0.0001	0	0.8001	0.8278	0
Modal	23	0.197	0.0001	0.0001	0	0.8001	0.8279	0
Modal	24	0.194	0.0003	4.536E-05	0	0.8004	0.828	0
Modal	25	0.193	2.826E-05	2.168E-05	0	0.8005	0.828	0

Tx	0.292	Sec	in X dir - along direction
Tz	0.389	Sec	in Z dir - across direction

TABLE 3.1
SPECTRAL SHAPE FACTOR, $C_h(T)$

Period, T (seconds)	Spectral shape factor, $C_h(T)$ (g)			
	Site subsoil class			
	A Strong rock and B rock	C Shallow soil	D Deep or soft soil	E Very soft soil
0.0	1.89 (1.00)[1]	2.36 (1.33)[1]	3.00 (1.12)[1]	
0.1	1.89 (2.35)[1]	2.36 (2.93)[1]	3.00	
0.2	1.89 (2.35)[1]	2.36 (2.93)[1]	3.00	
0.3	1.89 (2.35)[1]	2.36 (2.93)[1]	3.00	
0.4	1.89	2.36	3.00	
0.5	1.60	2.00	3.00	
0.6	1.40	1.74	2.84	3.00
0.7	1.24	1.55	2.53	3.00
0.8	1.12	1.41	2.29	3.00
0.9	1.03	1.29	2.09	3.00
1.0	0.95	1.19	1.93	3.00
1.5	0.70	0.88	1.43	2.21
2.0	0.53	0.66	1.07	1.66
2.5	0.42	0.53	0.86	1.33
3.0	0.35	0.44	0.71	1.11
3.5	0.26	0.32	0.52	0.81
4.0	0.20	0.25	0.40	0.62
4.5	0.16	0.20	0.32	0.49

Ch (Tx) = 2.36

Ch (Tz) = 2.36

Z = The hazard factor determind from Clause 3.1.4 NZS 1170 Part 5 (Table 3.3)

Z = 0.13 for (Auckland)

#	Location	Z	D(km)[1]
1	Kaitaia	0.13	-
2	Paihia/Russell	0.13	-
3	Kaikohe	0.13	-
4	Whangarei	0.13	-
5	Dargaville	0.13	-
6	Warkworth	0.13	-
7	Auckland	0.13	-
8	Manakau City	0.13	-

TABLE 3.2
IMPORTANCE LEVELS FOR BUILDING TYPES—NEW ZEALAND STRUCTURES

Importance level	Comment	Examples
1	Structures presenting a low degree of hazard to life and other property	Structures with a total floor area of <30 m^2 Farm buildings, isolated structures, towers in rural situations Fences, masts, walls, in-ground swimming pools
2	Normal structures and structures not in other importance levels	Buildings not included in Importance Levels 1, 3 or 4 Single family dwellings Car parking buildings
3	Structures that as a whole may contain people in crowds or contents of high value to the community or pose risks to people in crowds	Buildings and facilities as follows: (a) Where more than 300 people can congregate in one area (b) Day care facilities with a capacity greater than 150 (c) Primary school or secondary school facilities with a capacity greater than 250 (d) Colleges or adult education facilities with a capacity greater than 500 (e) Health care facilities with a capacity of 50 or more resident patients but not having surgery or emergency treatment facilities (f) Airport terminals, principal railway stations with a capacity greater than 250 (g) Correctional institutions (h) Multi-occupancy residential, commercial (including shops), industrial, office and retailing buildings designed to accommodate more than 5000 people and with a gross area greater than 10 000 m^2 (i) Public assembly buildings, theatres and cinemas of greater than 1000 m^2 Emergency medical and other emergency facilities not designated as post-disaster Power-generating facilities, water treatment and waste water treatment facilities and other public utilities not designated as post-disaster Buildings and facilities not designated as post-disaster containing hazardous materials capable of causing hazardous conditions that do not extend beyond the property boundaries

TABLE 3.3
ANNUAL PROBABILITY OF EXCEEDANCE

Design working life	Importance level	Annual probability of exceedance for ultimate limit states			Annual probability of exceedance for serviceability limit states	
		Wind	Snow	Earthquake	SLS1	SLS2 Importance level 4 only
Construction equipment, e.g., props, scaffolding, braces and similar	2	1/100	1/50	1/100	1/25	
Less than 6 months	1 2 3 4	1/25 1/100 1/250 1/1000	1/25 1/50 1/100 1/250	1/25 1/100 1/250 1/1000	— 1/25 1/25 1/25	
5 years	1 2 3 4	1/25 1/250 1/500 1/1000	1/25 1/50 1/100 1/250	1/25 1/250 1/500 1/1000	— 1/25 1/25 1/25	— — — 1/250
25 years	1 2 3 4	1/50 1/250 1/500 1/1000	1/25 1/50 1/100 1/250	1/50 1/250 1/500 1/1000	— 1/25 1/25 1/25	— — — 1/250
50 years	1 2 3 4	1/100 1/500 1/1000 1/2500	1/50 1/150 1/250 1/500	1/100 1/500 1/1000 1/2500	— 1/25 1/25 1/25	— — — 1/500
100 years or more	1 2 3 4	1/250 1/1000 1/2500 *	1/150 1/250 1/500 *	1/250 1/1000 1/2500 *	— 1/25 1/25 1/25	— — — *

Considered based upon the criteria,

Importance Level = 3

Design Working Life = 50 years

Annual Probability of Exceedance = 1/1000 (Table 3.3 AS/NZS 1170.0:2002)

R = The return period factor Rs and Ru for the appropriate limit state determined from clause 3.1.5 NZS 1170 Part 5 but limited such that ZRu does not exceed 0.7

Rs = 0.25 (Serviceability Limit State)

Ru = 1.3 (Ultimate Limit State)

TABLE 3.5

RETURN PERIOD FACTOR

Required annual probability of exceedance	R_s or R_u
1/2500	1.8
1/2000	1.7
1/1000	1.3
1/500	1.0
1/250	0.75
1/100	0.5
1/50	0.35
1/25	0.25
1/20	0.20

Near-Fault factor N (T,D) = 1 Clause 3.1.6 NZS1170 Part 5

As Annual Probability of Exceedance >= 1/250

Elastic site hazard spectrum for Horizontal Loading C(T) :

C(T) = Ch (T) Z R N (T,D)

C(Tx) (SLS) = 2.36 X 0.13 X 0.25 X 1
= 0.077

C(Tz) (SLS) = 2.36 X 0.13 X 0.25 X 1
= 0.077

C(Tx) (ULS) = 2.36 X 0.13 X 1.3 X 1
= 0.399

C(Tz) (ULS) = 2.36 X 0.13 X 1.3 X 1
= 0.399

6.2.2 Horizontal Design Action coefficient – Equivalent Static Method

(clause 5.2.1, NZS1170.5:2004)

Horizontal Design action coefficients and Design Spectra :-

Ultimate Limit State :-

μ (Ductility Factor) = As structure is supported on column below level 1 and on castin

As per Clause 2.2.3: NZS 1170.5:2004:

μ (Ductility Factor) = 1.25

For soil Classes A ,B ,C and D

Kμ =	μ	for T1 ≥	0.7	s	
=	((μ - 1)T1 / 0.7) + 1	for T1 <	0.7	s	T1min = 0.4

Cd (T1) = C(T1)Sp / Kμ

≥ (Z/20 + 0.02)Ru but not less than 0.03Ru

Sp = Structural performance factor clause 4.4.2 NZS1170.5 2004

= 0.925 (Sp = 1.3-0.3μ)

Kμ = ((1.25 - 1)+0.4 / 0.7) + 1

1.1428571

Cd (T1x) = (0.39884X0.925)/1.14285714285714

Cd (T1x) = 0.3228

Cd (T1z) = (0.39884X0.925)/1.14285714285714

Cd (T1x) = 0.3228

Serviceability Limit State :-

μ (Ductility Factor) = 1

For soil Classes A ,B ,C and D

Kμ =	μ	for T1 ≥	0.7	s
=	((μ - 1)T1 / 0.7) + 1	for T1 <	0.7	s

Cd (T) = C(T)Sp / Kμ

Sp = Structural performance factor clause 4.4.4 NZS1170.5 2004

Sp = 0.7

Kμ = ((1 - 1)*max(0.17,0.301) / 0.7) + 1

1

Cd (T1x) (0.0767X0.7)/1

0.054

Cd (T1z) (0.0767X0.7)/1

0.054

6.2.3 Horizontal Design Action coefficient – Modal Response spectrum Method

(clause 5.2.2,NZS1170.5:2004)

Horizontal Design action coefficients and Design Spectra :-

Ultimate Limit State :-

μ (Ductility Factor) = As structure is supported on column below level 1 and

As per Clause 2.2.3: NZS 1170.5:2004:

μ (Ductility Factor) = 1.25

For soil Classes A ,B ,C and D

Kμ = μ for T1 ≥ 0.7 s

= ((μ - 1)T1 / 0.7) + 1 for T1 < 0.7 s T1min = 0.4

Cd (T) = C(T)Sp / Kμ

≥ (Z/20 + 0.02)Ru but not less than 0.03Ru

Sp = Structural performance factor clause 4.4.2 NZS1170.5 2004

= 0.925 (Sp = 1.3-0.3μ)

Kμ = ((1.25 - 1)+0.4 / 0.7) + 1

= 1.142857

Cd (T1x) = (X0.925)/1.14285714285714

Cd (T1x) = 0.3228

Cd (T1z) = (X0.925)/1.14285714285714

Cd (T1x) = 0.3228

Scaling of actions and displacements:

As per claluse 5.2.2.2 NZS 1170.5:2004,

Base shear found from modal response spectrum mehtod to be scaled with k factor,

k = 1.0 * Ve/V

Serviceability Limit State :-

μ (Ductility Factor) = 1

For soil Classes A ,B ,C and D

Kμ = μ for T1 ≥ 0.7 s

= ((μ - 1)T1 / 0.7) + 1 for T1 < 0.7 s

Cd (T) = C(T)Sp / Kμ

Sp = Structural performance factor clause 4.4.4 NZS1170.5 2004

Sp = 0.7

Kμ = ((1 - 1)*max(0.17,0.301) / 0.7) + 1

= 1

Cd (T1x) = (X0.7)/1

= 0.054

Cd (T1z) = (X0.7)/1

= 0.054

6.2.4 Wind Load

180 STODDARD

WIND LOAD CALCULATION

Wind Load as per NZS1170 Part 2 :-

Regional Wind Speed :

$V_{sit,\beta}$ = V_R X Md X (Mz,cat X Ms X Mt)

Where,

Regional Wind Speed :

V_R = Regional gust wind speed (m/s)

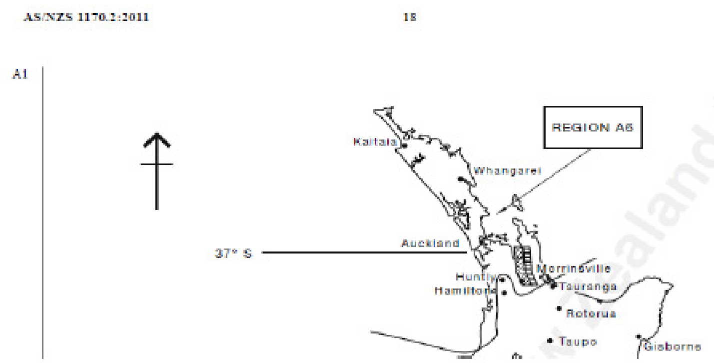
M_d = wind directional multipliers

$M_{z,cat}$ = terrain/height multiplier

Ms = shielding multiplier

Mt = topographic multiplier

As building is in Auckland, Region of Wind is A6 (As per AS/NZS 1170.2:2011)



As mentioned earlier, The importance level of building considered 3.

So, from Table 3.1 and 3.2 as mentioned earlier in EQ calculation for Importance level and annual probability of exceedence, Regional wind speed considered.

TABLE 3.1

REGIONAL WIND SPEEDS

Regional wind speed (m/s)	Region				
	Non-cyclonic			Cyclonic	
	A (1 to 7)	W	B	C	D
V_1	30	34	26	$23 \times F_C$	$23 \times F_D$
V_5	32	39	28	$33 \times F_C$	$35 \times F_D$
V_{10}	34	41	33	$39 \times F_C$	$43 \times F_D$
V_{20}	37	43	38	$45 \times F_C$	$51 \times F_D$
V_{25}	37	43	39	$47 \times F_C$	$53 \times F_D$
V_{50}	39	45	44	$52 \times F_C$	$60 \times F_D$
V_{100}	41	47	48	$56 \times F_C$	$66 \times F_D$
V_{200}	43	49	52	$61 \times F_C$	$72 \times F_D$
V_{250}	43	49	53	$62 \times F_C$	$74 \times F_D$
V_{500}	45	51	57	$66 \times F_C$	$80 \times F_D$
V_{1000}	46	53	60	$70 \times F_C$	$85 \times F_D$
V_{2000}	48	54	63	$73 \times F_C$	$90 \times F_D$
V_{2500}	48	55	64	$74 \times F_C$	$91 \times F_D$
V_{5000}	50	56	67	$78 \times F_C$	$95 \times F_D$
V_{10000}	51	58	69	$81 \times F_C$	$99 \times F_D$
V_R ($R \geq 5$ years)	$67-41R^{-0.1}$	$104-70R^{-0.045}$	$106-92R^{-0.1}$	$F_C(122-104R^{-0.1})$	$F_D(156-142R^{-0.1})$

VR considered with, Importance level as 3 and Design workign life as 50 year.

V1000 =	46	m/s	Table 3.1 NZS1170 Part 2 (For Ultimat Limit State)
V25 =	37	m/s	Table 3.1 NZS1170 Part 2 (For serviceability Limit State)
Md =	1	from Clause 3.3.2 NZS1170 Part 2 by considering any direction.	

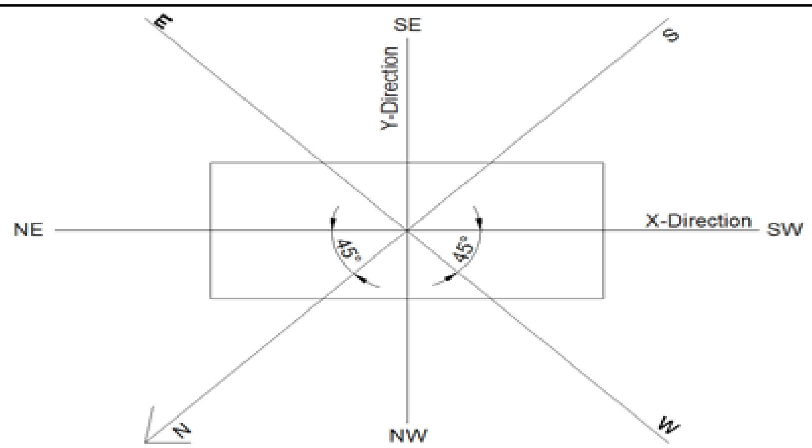


Table 3.2 NZS1170 Part 2 (WIND DIRECTION MULTIPLIER Md)

wind direction in X+, Wind direction multiplier for NE =	0.95
wind direction in X-, Wind direction multiplier for SW =	0.95
wind direction in Y+, Wind direction multiplier for NW =	0.95
wind direction in Y-, Wind direction multiplier for SE =	0.95
wind direction in N, Wind direction multiplier =	0.85
wind direction in S, Wind direction multiplier =	0.85
wind direction in E, Wind direction multiplier =	1
wind direction in W, Wind direction multiplier =	1

Wind applied at 45° angle, Vsit,β = 45°
Cos45° = 0.71
Sin45° = 0.71

Wind applied at 45° angle for NE	=	NE X Cos45°/Sin45°
	=	0.6745
Wind applied at 45° angle for SW	=	SW X Cos45°/Sin45°
	=	0.6745
Wind applied at 45° angle for NW	=	NW X Cos45°/Sin45°
	=	0.6745
Wind applied at 45° angle for SE	=	SE X Cos45°/Sin45°
	=	0.6745

Hence, Above all direction multiplier take a critical at E and W direction.

Wind direction multiplier Md considered with worst case with considering maximum cardinal direciton within a sector 45 degree in both side.

Terrain Category (Clause 4.3.1 NZS1170 Part 2)

As per topography, the terrain have open grass field and also buildings have average spaced obstruction with low height buildings.

Based upon the site condition, Terrain category considered = 2.5

TABLE 4.1

TERRAIN/HEIGHT MULTIPLIERS FOR GUST WIND SPEEDS IN FULLY DEVELOPED TERRAINS—ALL REGIONS

Height (z) m	Terrain/height multiplier ($M_{z,cat}$)			
	Terrain category 1	Terrain category 2	Terrain category 3	Terrain category 4
≤3	0.99	0.91	0.83	0.75
5	1.05	0.91	0.83	0.75
10	1.12	1.00	0.83	0.75
15	1.16	1.05	0.89	0.75
20	1.19	1.08	0.94	0.75
30	1.22	1.12	1.00	0.80
40	1.24	1.16	1.04	0.85
50	1.25	1.18	1.07	0.90
75	1.27	1.22	1.12	0.98
100	1.29	1.24	1.16	1.03
150	1.31	1.27	1.21	1.11
200	1.32	1.29	1.24	1.16

NOTE: For intermediate values of height z and terrain category, use linear interpolation.

By linear interpolation,

Height of building,h = 18.75 m

Determination of terrain/height multiplier (Mz,cal) = (1.07+0.927)/2

Table 4.1 NZS 1170 Part 2 = 0.9985

Ms = Shielding multiplier = 1 Clause 4.3.1 NZS1170 Part 2

Mt= Topographic multiplier = As per NZS.1170.2:2011, Mlee can be taken as 1.0, except in New Zealand Lee zones, and as Auckland is not under Lee zone so,

Mt=Mlee

Mt= Topographic multiplier = 1.08

Site Wind Speed

Vsit,β = Vr X Md X (Mz,cal X Ms X Mt)

V1000 = 46 x 1 x 0.9985 x 1 x 1.08

= 49.60548

V25 = 37 x 1 x 0.9985 x 1 x 1.08

= 39.91

Design wind pressure :

$$p = (0.5\ \rho_{air})\ [V_{des,\theta}]^2\ C_{fig}\ C_{dyn}$$

C_{dyn} = 1

$$C_{fig,e} = C_{p,e}\ K_a\ K_{c,e}\ K_\ell\ K_p, \text{ for external pressures}$$

$$C_{fig,i} = C_{p,i}\ K_{c,i}, \text{ for internal pressures}$$

Cpe = external force coefficient		Table 5.2 (A)/(B)/(C) NZS1170 Part 2
Cpi = Internal force coefficient		Table 5.1 (A) NZS1170 Part 2
Ka =	0.8	Table 5.4 NZS1170 Part 2
Kce=	0.9	Table 5.5 NZS1170 Part 2
Kci=	1	Table 5.5 NZS1170 Part 2
Kl=	1.5	Table 5.6 NZS1170 Part 2
Kp =	0.9	Table 5.8 NZS1170 Part 2

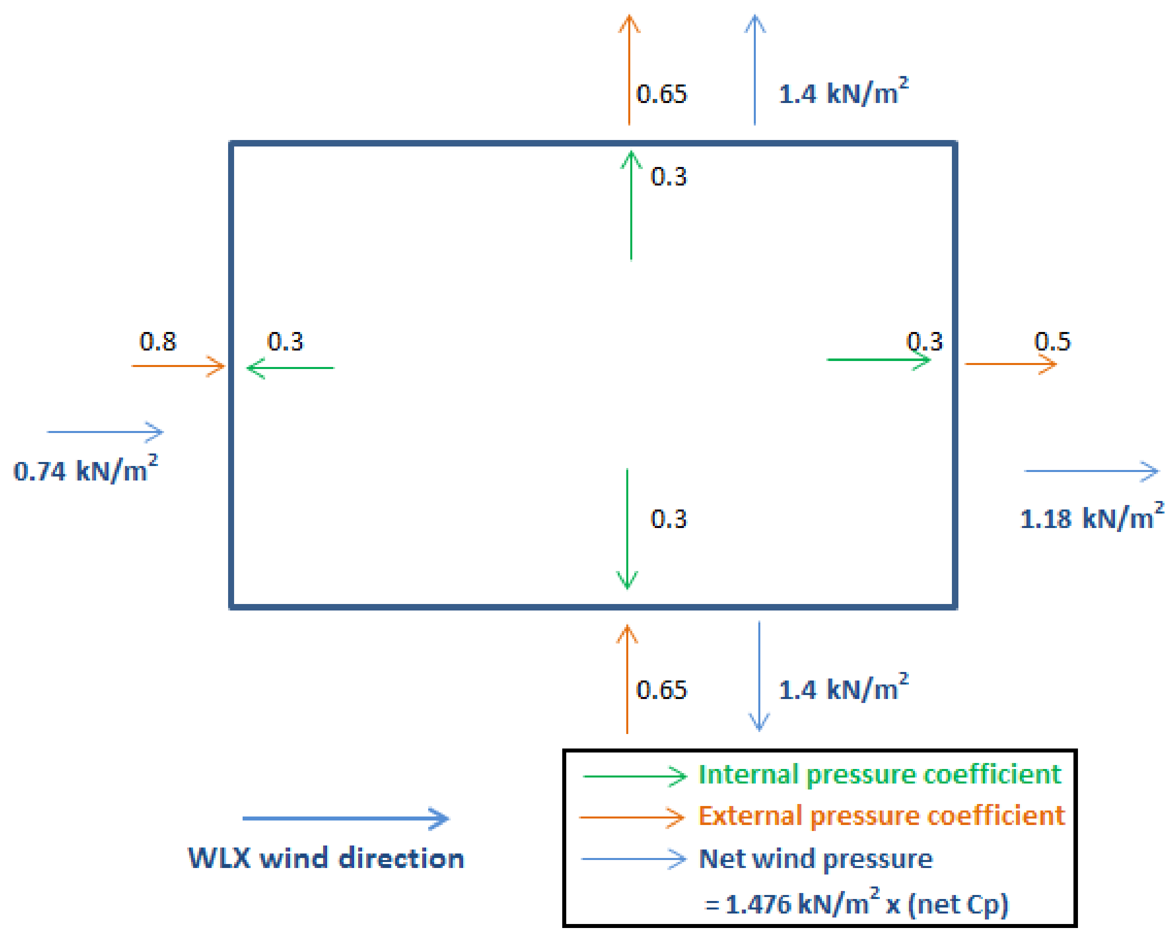
Puls = 0.6 X 49.60548^2 X (Cfig.e+Cfig,i)

Seismic loading applied in ETABS model as static loading as well as dyniemic loading. Dynimic loading has been scaled appropriatly. Time period and base shear has been software calcualted.

Base shear has been resisted by foundation at base. As per requirement foundation of various types i.e. isolated, combined or raft foundaiton has been provided.

Cladding Wall Coefficients (Along)

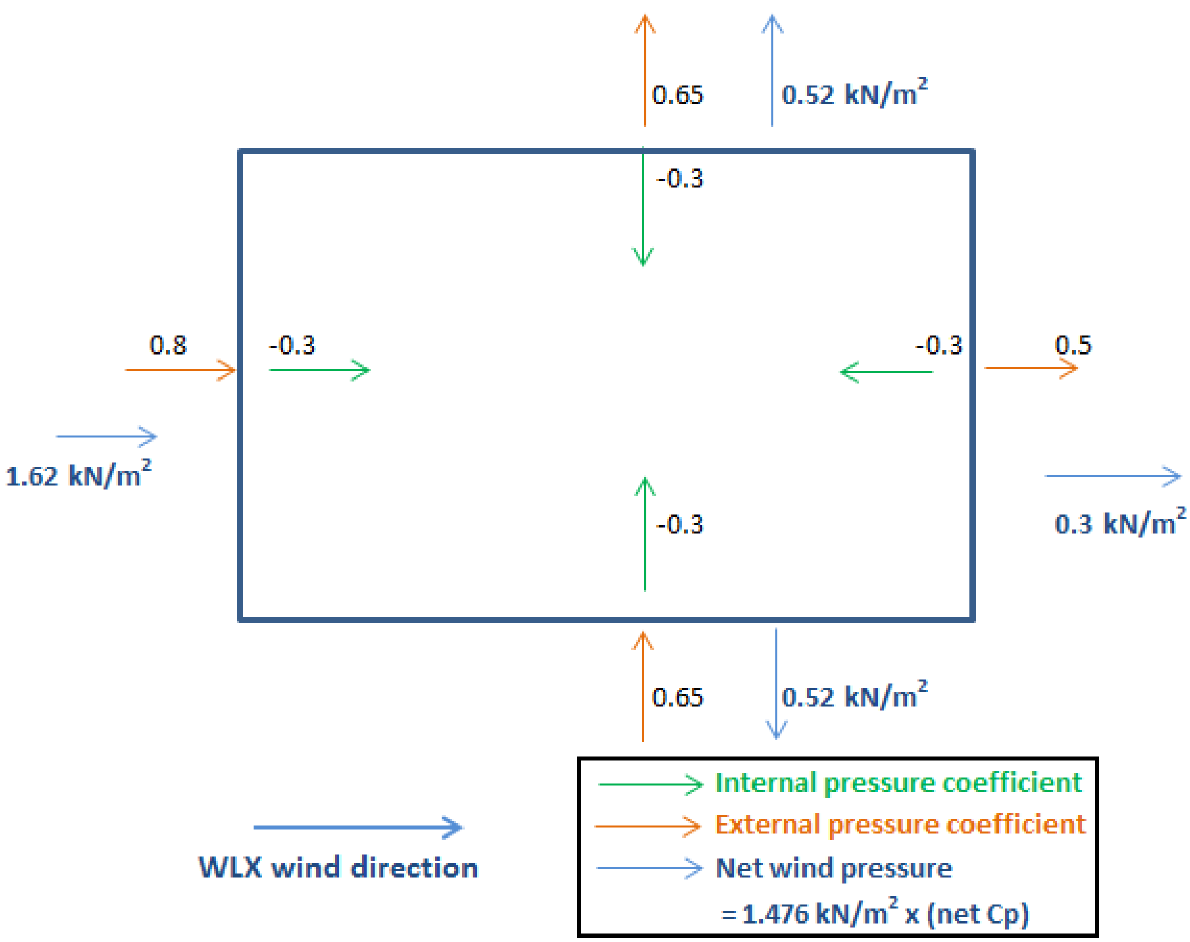
Wind pressure	1.476
Cpi	0.3
Windwar	0.8
Leeward	0.5
Side wall	0.65



WIND + X (CPE + CPI) (ALONG)

Cladding Wall Coefficients (Along)

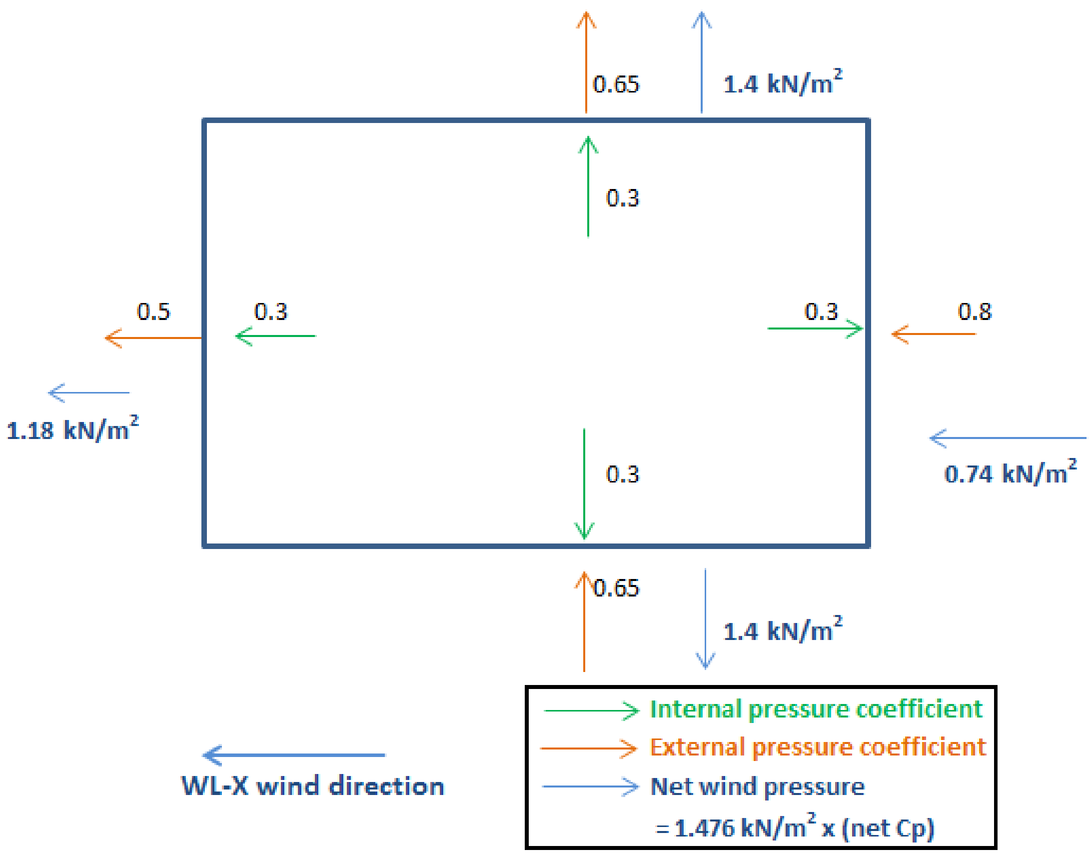
Wind pressure	1.476
Cpi	-0.3
Windward	0.8
Leeward	0.5
Side wall	0.65



WIND + X (CPE - CPI) (ALONG)

Cladding Wall Coefficients (Along)

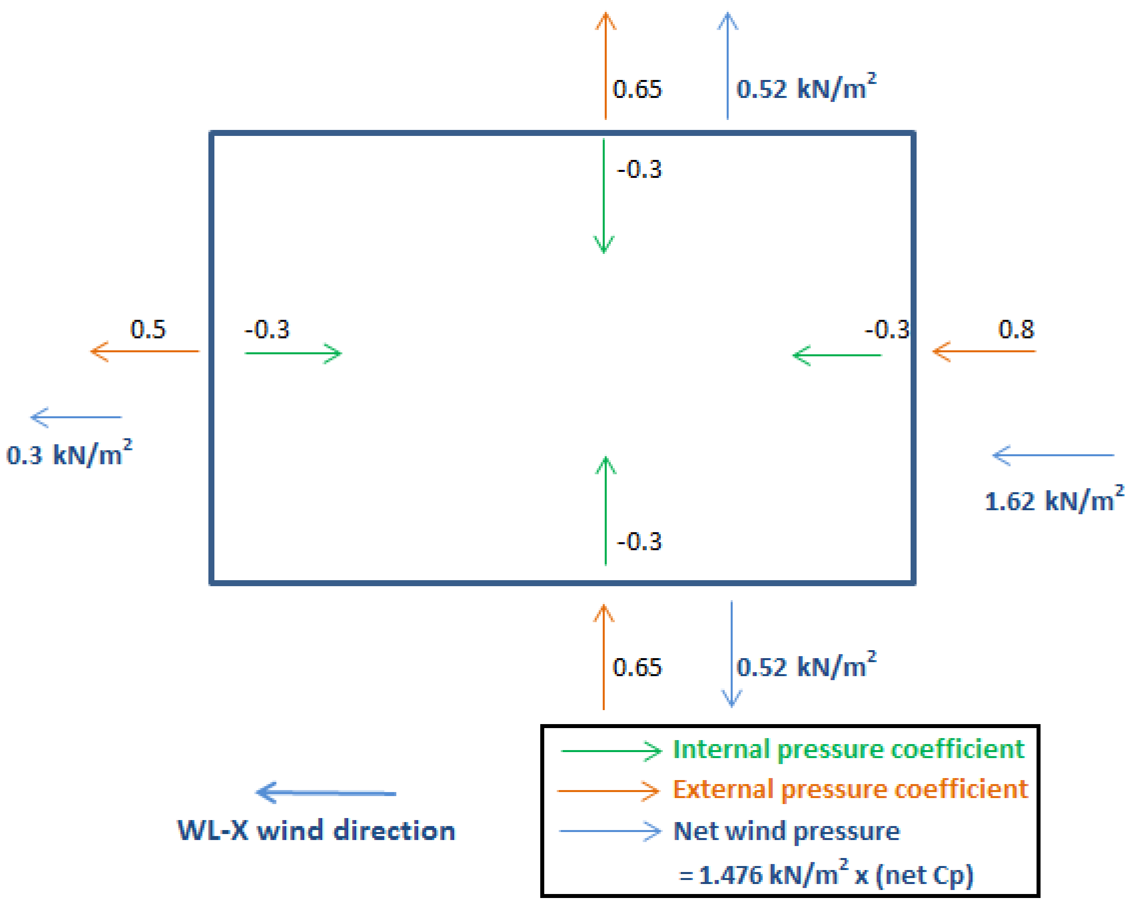
Wind pressure		1.476
Cpi	0.3	
Windwar(	0.8	
Leeward	0.5	
Side wall	0.65	



WIND - X (CPE + CPI) (ALONG)

Cladding Wall Coefficients (Along)

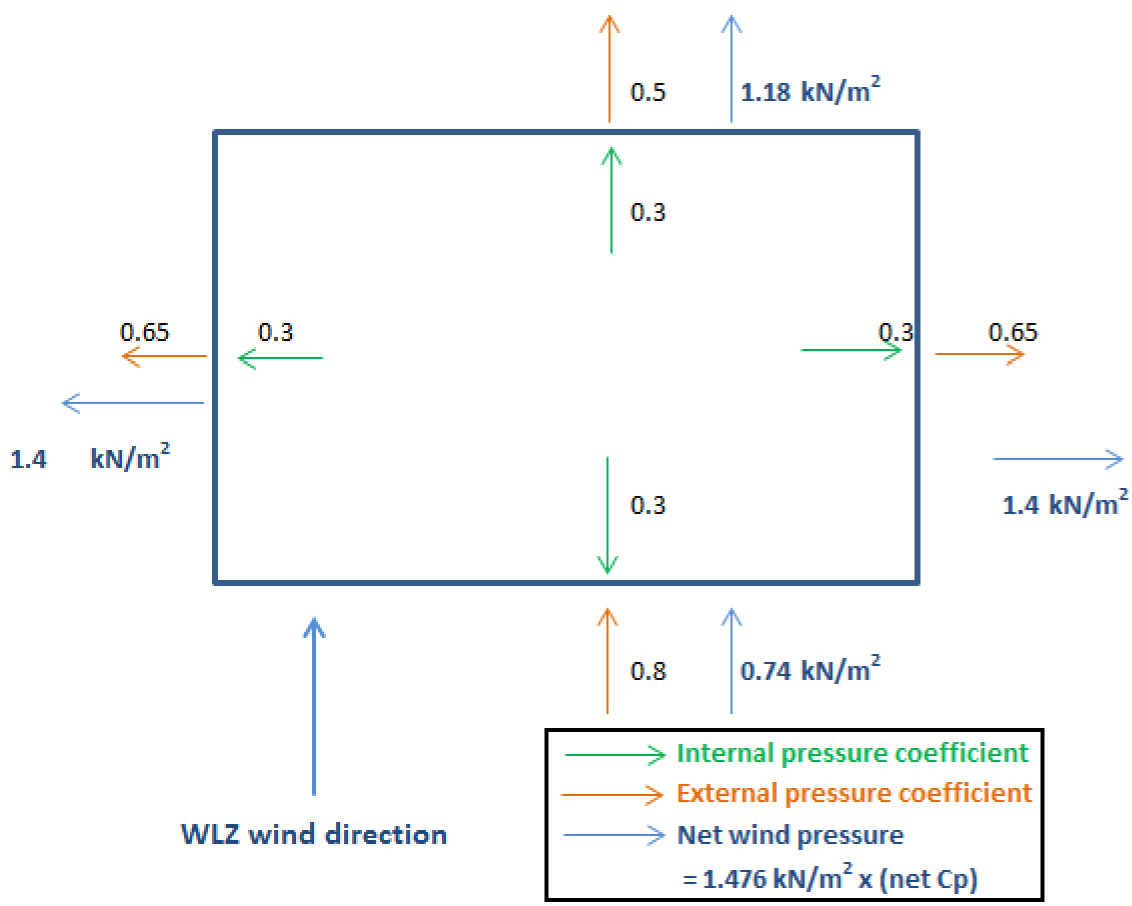
Wind pressure		1.476
Cpi	-0.3	
Windward	0.8	
Leeward	0.5	
Side wall	0.65	



WIND-X (CPE - CPI) (ALONG)

Cladding Wall Coefficients (Across)

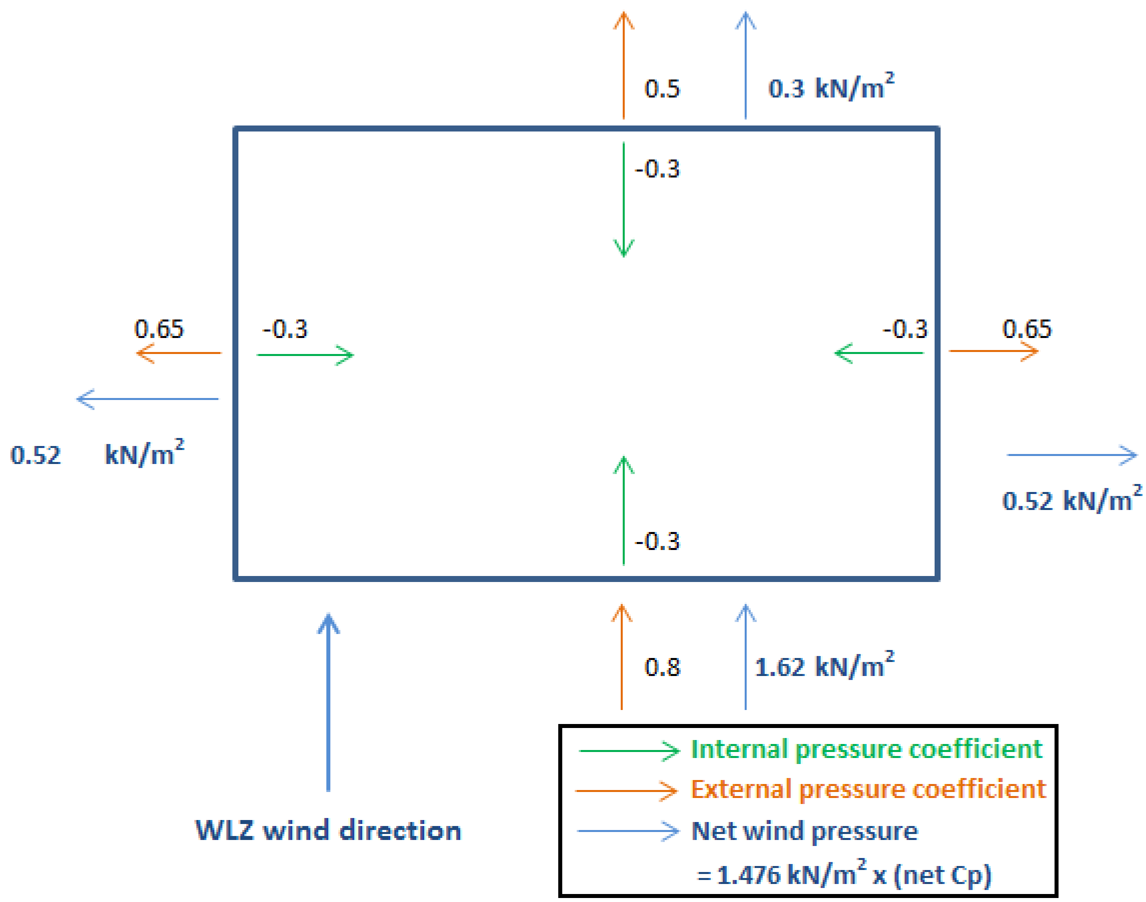
Wind pressure	1.476
Cpi	0.3
Windward	0.8
Leeward	0.5
Side wall	0.65



<u>**WIND Z (CPE + CPI)(ACROSS)**</u>

Cladding Wall Coefficients (Across)

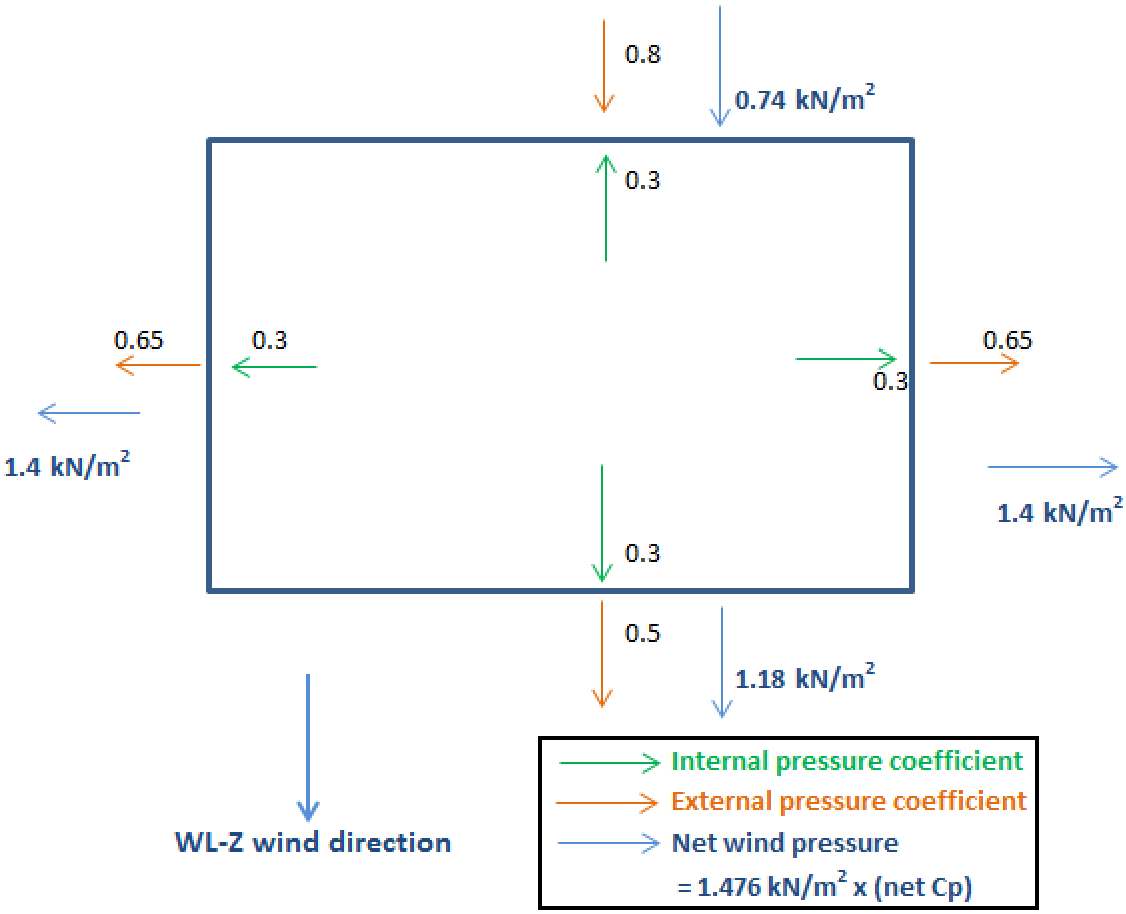
Wind pressure	1.476
Cpi	-0.3
Windward	0.8
Leeward	0.5
Side wall	0.65



WIND Z (CPE - CPI)(ACROSS)

Cladding Wall Coefficients (Across)

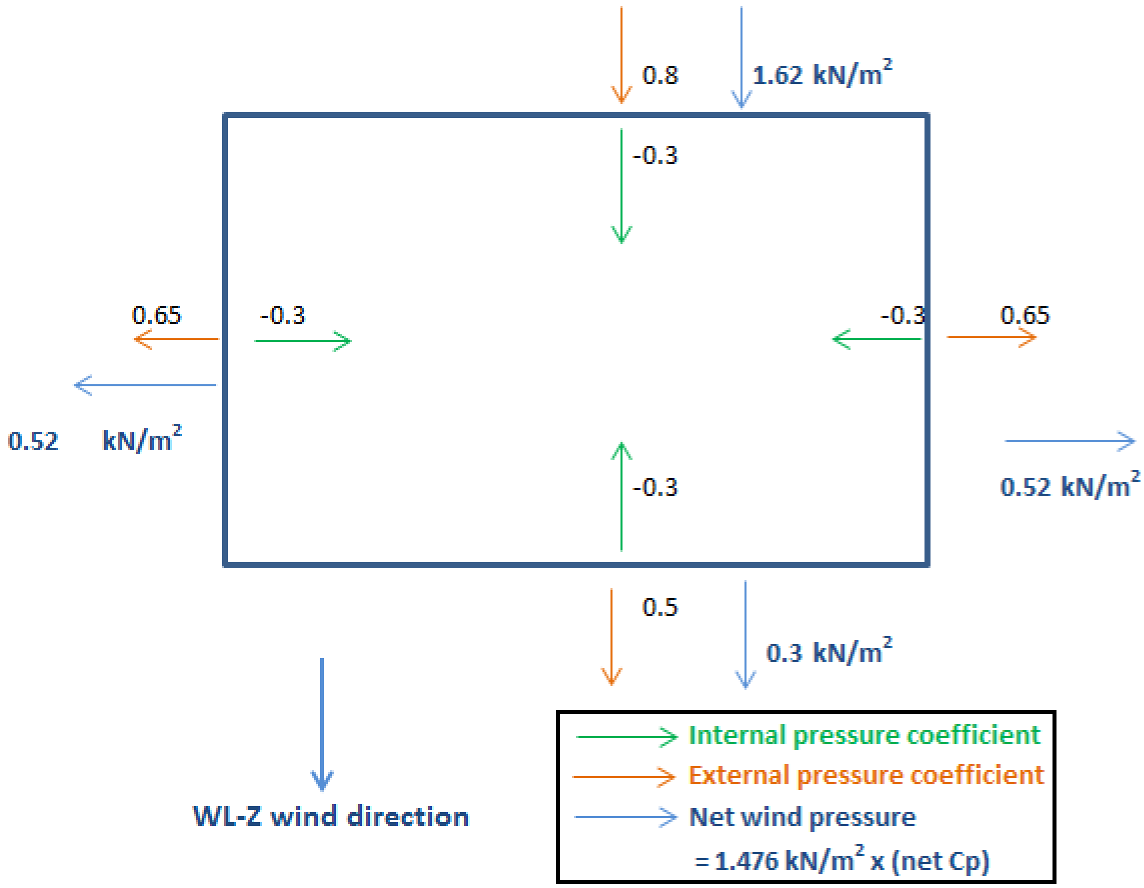
Wind pressure		1.476
Cpi	0.3	
Windward	0.8	
Leeward	0.5	
Side wall	0.65	



WIND -Z (CPE + CPI)(ACROSS)

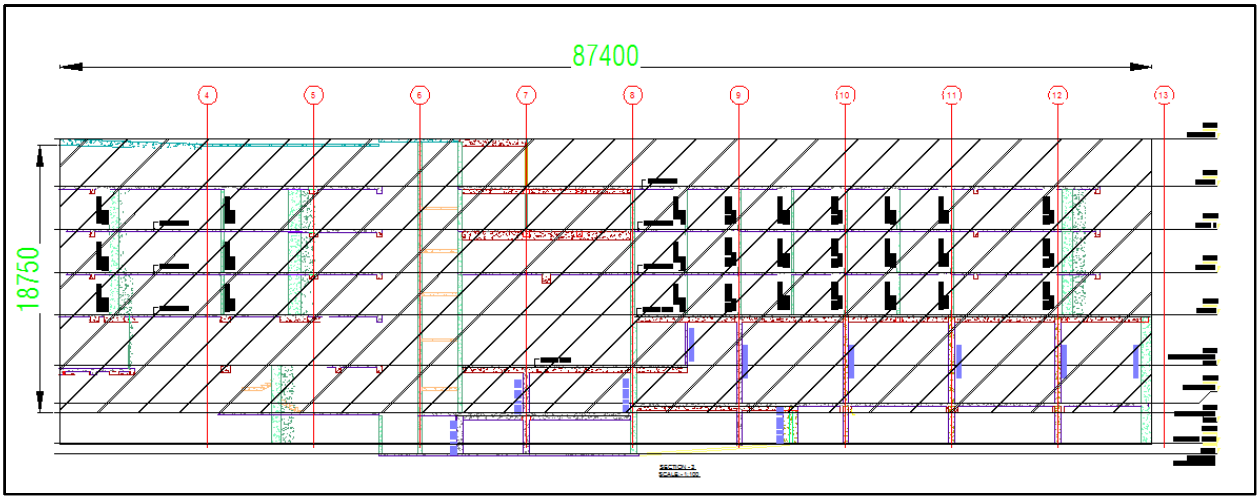
Cladding Wall Coefficients (Across)

Wind pressure	1.476
Cpi	-0.3
Windward	0.8
Leeward	0.5
Side wall	0.65

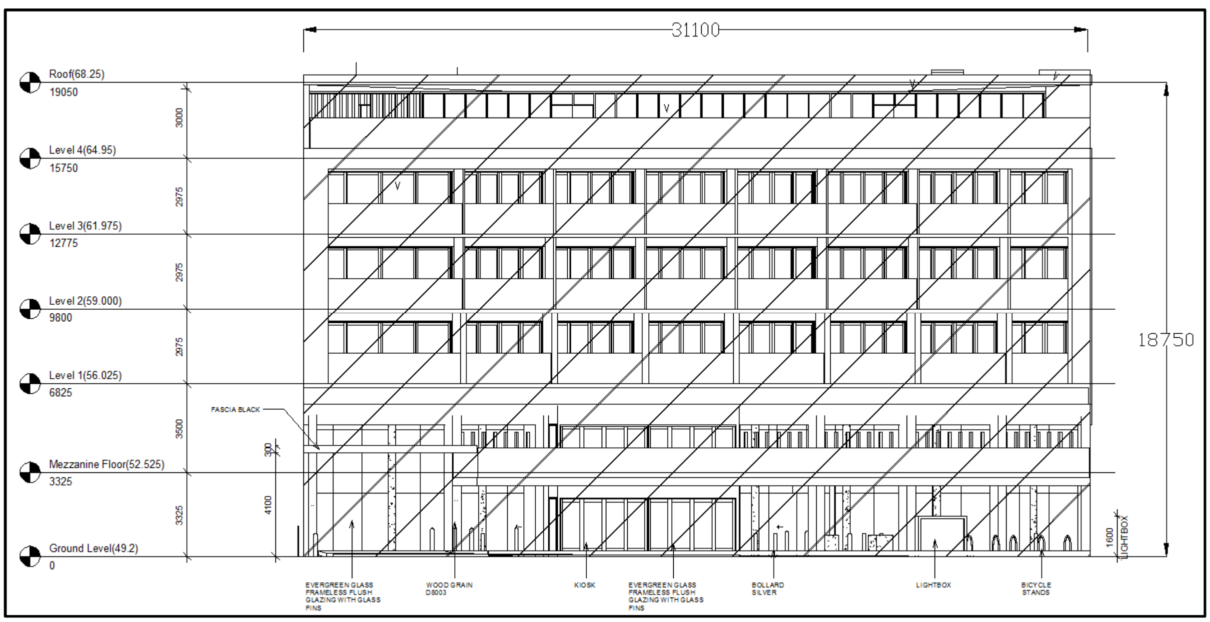


WIND -Z (CPE - CPI)(ACROSS)

Face of building has shown with hatch on which wind load apply as surface.



Wind at +X direction



Wind at +Z direction

As compared to earthquake forces, wind forces are very less and comparison of story forces for wind forces and earthquake forces.

6.3 Soil pressure Load

Appropriate soil pressure has been applied on basement walls on two sides as per actual ground level.

Compare to other loads, horizontal soil loadings are negligible and will not affect anymore in 250mm thick basement RCC walls.

7. Load cases & combinations:-

7.1 Load cases

1:-Dead load

2:- Live load

3:- Earth quake load X direction – response spectrum

4:- Earth quake load Y direction- response spectrum

5:- Wind load X direction

6:- Wind load Y direction

7.2 Load combination

1) 1.35DL
2) 1.2DL + 1.5LL
3) 1.0DL + 0.3LL + 1.0 RX + 0.3 RY
4) 1.0DL + 0.3LL + 1.0 RX - 0.3 RY
5) 1.0DL + 0.3LL - 1.0 RX + 0.3 RY
6) 1.0DL + 0.3LL - 1.0 RX - 0.3 RY
7) 1.0DL + 0.3LL + 1.0 RY + 0.3 RX
8) 1.0DL + 0.3LL + 1.0 RY - 0.3 RX
9) 1.0DL + 0.3LL - 1.0 RY + 0.3 RX
10) 1.0DL + 0.3LL - 1.0 RY - 0.3 RX
11) 1.2DL + 0.4LL + 1.0 W+X(cpe+cpi)
12) 1.2DL + 0.4LL + 1.0 W+X(cpe-cpi)
13) 1.2DL + 0.4LL + 1.0 W-X(cpe+cpi)
14) 1.2DL + 0.4LL + 1.0 W-X(cpe-cpi)
15) 1.2DL + 0.4LL + 1.0 W+Y(cpe+cpi)
16) 1.2DL + 0.4LL + 1.0 W+Y(cpe-cpi)
17) 1.2DL + 0.4LL + 1.0 W-Y(cpe+cpi)

18) 1.2DL + 0.4LL + 1.0 W-Y(cpe-cpi)
19) 0.9DL + 1.0 W+X(cpe+cpi)
20) 0.9DL + 1.0 W+X(cpe-cpi)
21) 0.9DL + 1.0 W-X(cpe+cpi)
22) 0.9DL + 1.0 W-X(cpe-cpi)
23) 0.9DL + 1.0 W+Y(cpe+cpi)
24) 0.9DL + 1.0 W+Y(cpe-cpi)
25) 0.9DL + 1.0 W-Y(cpe+cpi)
26) 0.9DL + 1.0 W-Y(cpe-cpi)
27) 1.2DL + 1.0 W+X(cpe+cpi)
28) 1.2DL + 1.0 W+X(cpe-cpi)
29) 1.2DL + 1.0 W-X(cpe+cpi)
30) 1.2DL + 1.0 W-X(cpe-cpi)
31) 1.2DL + 1.0 W+Y(cpe+cpi)
32) 1.2DL + 1.0 W+Y(cpe-cpi)
33) 1.2DL + 1.0 W-Y(cpe+cpi)
34) 1.2DL + 1.0 W-Y(cpe-cpi)

Foundation Design load combinations:

1) 1.35DL
2) 1.2DL + 1.5LL
3) 1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE +Y
4) 1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE +Y
5) 1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE -Y
6) 1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE -Y
7) 1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE +X
8) 1.0DL +0.3LL + 1.0 EARTHQUAKE - Y + 0.3 EARTHQUAKE +X
9) 1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE -X
10) 1.0DL +0.3LL + 1.0 EARTHQUAKE – Y + 0.3 EARTHQUAKE –X

Serviceability load combinations

1) 1.0DL + 1.0LL
2) 1.0DL + 1.0EQX
3) 1.0DL - 1.0EQX
4) 1.0DL + 1.0EQY
5) 1.0DL - 1.0EQY

8. Fire Resistance Criteria

As per received Fire Engineering brief, Fire resistance rating to be achieved as below.

As per FIRE REPORT, whole building area shall achieve FRR of (30)/30/30 or (60)/60/60. Only Stair-3 & access area up to level-1 shall achieve FRR of (90/90/90).

According to NZS 3101:2006 4.3.1.4, the Fire Resistance Rating (FRR) of concrete may be assessed using the tabulated date given in Table 4.4 to 4.7.

For Beams:

Table 4.1 – Fire resistance criteria for structural adequacy for simply-supported beams

Fire resistance rating (minutes)		Minimum dimensions (mm)				
		Possible combinations of *a** and *b**				Web thickness b_w* (mm)
30	*b* *a*#	80 25	120 20	160 15	200 15	80
60	*b* *a*#	120 45	160 35	200 30	300 25	100
90	*b* *a*#	150 55	200 45	300 40	400 35	100

Table 4.2 – Fire resistance criteria for structural adequacy for continuous beams

Fire resistance rating (minutes)		Minimum dimensions (mm)			
		Possible combinations of *a** and *b**			Web thickness b_w* (mm)
30	*b* *a*#	80 15	160 12	200 12	80
60	*b* *a*#	120 25	200 12	300 12	100
90	*b* *a*#	150 35	250 25	400 25	100

In Hotel HOLIDAY INN structure, RCC beams has been provided with min 300mm width (b) and with min effective cover(a) to single layer Rebar as 50mm (30+10+20/2) which satisfies fire resistance criteria for 90 minutes FRR.

For Slabs:

Table 4.3 – Fire resistance criteria for insulation for slabs

FRR for insulation (minutes)	Effective thickness (mm)
30	60
60	75
90	95

In Hotel HOLIDAY INN, RCC slabs have been provided with min 135mm thickness, hence Fire resistance criterion for 90 minutes FRR has been satisfied.

For Columns:

Table 4.7 – Fire resistance criteria for structural adequacy for columns

Fire resistance rating (minutes)		Minimum dimensions (mm)			
		Column exposed on more than one side			Column exposed on one side
		η_{fi} = 0.2	η_{fi} = 0.5	η_{fi} = 0.7	η_{fi} = 0.7
30	b	200	200	200	155
	a	25	25	30	25
60	b	200	200	250	155
	a	25	35	45	25
90	b	200	300	350	155
	a	30	45	50	25

In Hotel HOLIDAY INN, RCC columns have been provided with min 300mm width (b) and with min effective cover (a) of 60mm (40+10+20/2), which satisfies fire resistance criteria for 90 minutes FRR.

For Walls:

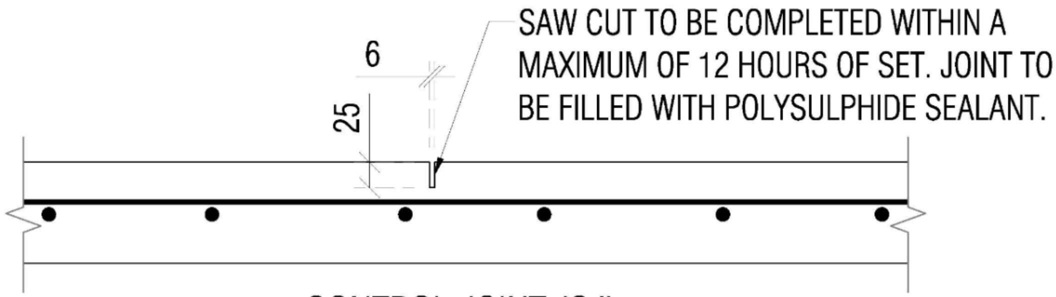
Table 4.8 – Minimum effective thickness for insulation

Fire resistance rating (minutes)	Effective thickness (mm)
30	60
60	75
90	95

In Hotel HOLIDAY INN, RCC walls have been provided with min 100/200mm thickness which satisfies fire resistance criteria for 90 minutes FRR..

9. Shrinkage Calculation

Control joints to control shrinkage effects in a concrete building during construction and in-service will be provided at a maximum distance of 25m in slab on grades and suspended slabs. Reinforcement will be fully continuous in diaphragms at construction joint locations. Construction joint detail attached herewith.



CONTROL JOINT (CJ)
SCALE 1:10

As per NZS 3101:Part 1:2006 clause no. 8.8, requirement for shrinkage reinforcement in floor slab has been checked with reference to provided reinforcement as shown in below table.

Slab Thickness	**Required reinforcement** (0.7/Fy = 0.0014%)	**Provided reinforcement in secondary direction**	**Remark**
150mm	210 mm2	10T @ 200 c/c = 392mm2	Extra reinforcement not required.
175mm	245 mm2	10T @ 200 c/c = 392mm2	Extra reinforcement not required.
200mm	280 mm2	10T @ 200 c/c = 392mm2	Extra reinforcement not required.
250mm	350 mm2	10T @ 200 c/c = 392mm2	Extra reinforcement not required.

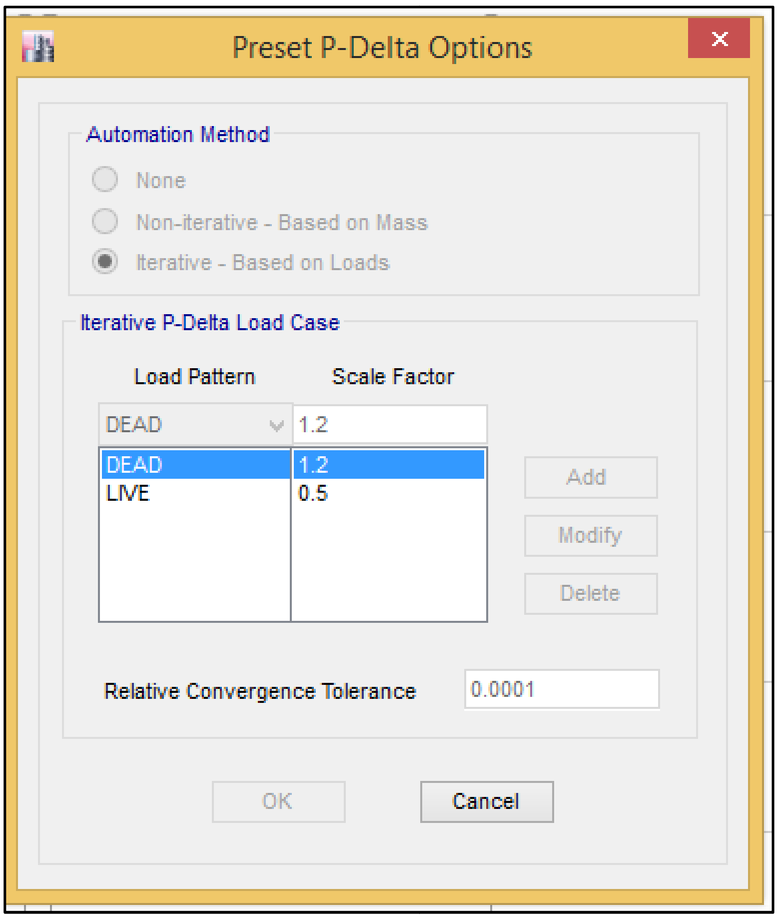
10. Construction loadings:

Structure has been checked for Construction loading for floor wise construction sequence. Separate ETABS models have been prepared and submitted for each floor construction stage loading.

11. P-Delta Effects

P-Delta analysis has been incorporated in ETABS model to take care of column second order effects.

Iterative P-Delta load cases considered as 1.2DL + 0.5LL as shown below.



12. Soil Bearing Capacity:-

- Detail Geotechnical Investigation was done by "Soil & Rock Consultants" on 26-04-2019. It is recommended by consultant that the site is geotechnical suitable for the construction of the proposed hotel development.
- Topsoil and Fill were encountered from the ground surface to a depth of between 0.4m and 0.6m at theborehole locations.
- Volcanic Tuff Deposits were encountered underlying the topsoil / fill to between 0.9m and 1.5m within boreholes MB01 and MB02 respectively. The tuff is described as a clayey silt with various amounts of sand alsopresent. Within MB02 two discrete basalt boulders (0.1m to 0.15m diameter) were encountered within the tuff materials.
- Basalt rock was encountered from 0.9m and 1.5m within boreholes MB01 and MB02 respectively. Refer toindividual borehole logs for descriptions of the weathering profile, and vesicle and fracture characteristics.
- Puketoka Formation deposits underlie the basalt at the MB02 location from 6.35m depth to the terminationdepth of the drillhole.
- Waitemata Group deposits were encountered beneath the Puketoka Formation deposits in MB02 from 10.6mbpgl.
- The soils at the site have been assessed for Site Subsoil Class in accordance with NZS 1170.5:2004. As per consultants opinion the site soils lie within Site Class C – Shallow Soil Site.
- Based on consultants assessment of the available design bearing capacity for the site concrete slab-on-grade foundation type is suitable for theproposed hotel development and estimated total and differential settlements will be within tolerable limits.
- GeneralizedHoek-Brown failure criterion parameters adopted within the analyses and the analysis results are presented in Table 4 as shown below.

	Ultimate Bearing Capacity and Estimated Settlement								
Footing Mark	Ultimate Bearing Capacity, UBC (kPa)		Estimated Max. Ult. Settlement (mm)	Estimated Max. ULS (static & Seismic) Settlement (mm)	Estimated Max. SLS (static) Settlement (mm)	Estimated Max. SLS Foundation Rotation (°)	Estimated SLS (static) Subgrade Reaction (kPa/mm)	Estimated large strain (ultimate, static) Subgrade Reaction (kPa/mm)	Estimated Differential SLS Settlement Gradient
CF1	1022	transverse	220	75	52	0.15	9.8	3.0	1 in 382
		longitudinal	106	43	34	0.06	15.0	7.1	1 in 955
CF2	1564	transverse	225	72	52	0.16	15.0	4.5	1 in 358
		longitudinal	225	72	52	0.16	15.0	4.5	1 in 358
CF3	979	transverse	80	40	28	0.05	17.5	9.4	1 in 1146
		longitudinal	60	51	25	0.085	19.6	14.0	1 in 675
CF4	1657	transverse (grds 7,8,9)	200	70	57	0.24	14.5	5.8	1 in 239
		transverse (grds 15)	90	40	29	0.08	28.6	13.6	1 in 716
		transverse (grd 5d)	170	103	72	0.32	11.5	8.5	1 in 179
		transverse (grds 10, 10a, 11, 1	209	109	85	0.234	9.7	6.7	1 in 245
		longitudinal	541	49	37	0.3	22.4	1.6	1 in 190
CF5	960	transverse (grds 7,8,9)	157	72	59	0.2	8.1	4.9	1 in 286
		transverse (grds 15)	172	60	42	0.123	11.4	3.7	1 in 466
		transverse (grd 5d)	150	110	85	0.33	5.6	7.4	1 in 173
		transverse (grds 10, 10a, 11, 1	116	61	43	0.18	11.2	6.6	1 in 318
		longitudinal	300	136	97	0.21	4.9	2.4	1 in 273
CF5a	1583	transverse	171	55	47	0.019	16.8	6.4	1 in 3016
		longitudinal	300	136	97	0.22	8.2	3.9	1 in 260
CF6	1230	transverse (grd B2)	106	96	67	0.089	11.9	11.0	1 in 644
		transverse (grd C2)	247	164	80	0.27	10.0	2.6	1 in 212
		longitudinal	249	137	130	0.15	6.2	3.6	1 in 382
CF7	1291	transverse	132	72	47	0.046	13.7	7.6	1 in 1246
		longitudinal	148	79	40	0.072	16.1	6.0	1 in 796
CF8	979	transverse	80	60	42	0.07	14.0	10.3	1 in 819
		longitudinal	80	60	42	0.07	14.0	10.3	1 in 819
CF9	979	transverse	172	123	42	0.07	11.7	3.8	1 in 819
		longitudinal	172	123	42	0.07	11.7	3.8	1 in 819
CF9a	979	transverse	172	123	42	0.07	11.7	3.8	1 in 819
		longitudinal	74	49	33	0.136	14.8	11.9	1 in 421

Ultimate Bearing Capacity and Estimated Settlement									
Footing Mark	Ultimate Bearing Capacity, UBC (kPa)		Estimated Max. Ult. Settlement (mm)	Estimated Max. ULS (static & Seismic) Settlement (mm)	Estimated Max. SLS (static) Settlement (mm)	Estimated Max. SLS Foundation Rotation (°)	Estimated SLS (static) Subgrade Reaction (kPa/mm)	Estimated large strain (ultimate, static) Subgrade Reaction (kPa/mm)	Estimated Differential SLS Settlement Gradient
F2.2	1230	transverse	137	95	75	0.087	9.8	7.9	1 in 659
		longitudinal	209	109	85	0.414	8.7	4.0	1 in 1380
F5	1204	transverse	136	91	72	0.16	10.0	7.5	1 in 358
		longitudinal	209	109	85	0.414	8.5	3.9	1 in 138
F1.1		transverse	98	54	39	0.11	21.5	14.2	1 in 521
	1375	longitudinal	153	79	51	0.14	16.5	8.2	1 in 409
F5.1		transverse	85	62	38	0.23	22.1	17.9	1 in 249
		longitudinal	130	70	44	0.06	19.1	9.8	1 in 955
F2	1237	transverse	180	93	73	0.012	8.5	5.8	1 in 4775
		longitudinal	189	93	80	0.239	7.7	5.7	1 in 240
F2.1	1230	transverse	90	80	31	0.017	19.8	10.4	1 in 3370
		longitudinal	189	93	80	0.115	7.7	5.6	1 in 500
F3	1016	transverse	100	97	43	0.17	11.8	8.9	1 in 337
		longitudinal	189	93	80	0.239	6.3	4.7	1 in 240
F3.1		transverse	217	125	67	0.27	10.5	4.7	1 in 212
	1643	longitudinal	217	125	67	0.27	10.5	4.7	1 in 212
F10		transverse	103	93	65	0.085	18.8	17.3	1 in 674
		longitudinal	103	93	65	0.085	18.8	17.3	1 in 674
F3.2		transverse	133	49	40	0.049	17.5	7.5	1 in 1170
		longitudinal	133	49	40	0.049	17.5	7.5	1 in 1170
F6.1		transverse	181	122	51	0.28	13.8	5.4	1 in 205
	1209	longitudinal	169	55	46	0.038	15.3	5.7	1 in 1508
F11		transverse	91	81	57	0.16	10.2	11.4	1 in 358
		longitudinal	132	48	39	0.057	14.9	4.2	1 in 1005
F4	1204	transverse	90	84	34	0.01	17.7	10.8	1 in 5730
		longitudinal	209	109	85	0.414	7.1	4.9	1 in 138
F6	1733	transverse	90	84	33	0.028	26.3	15.2	1 in 2046
		longitudinal	209	109	85	0.414	10.2	7.0	1 in 138
F7	1256	transverse	110	73	54	0.17	14.0	9.0	1 in 337
		longitudinal	209	109	85	0.414	8.9	4.1	1 in 138
F8/ C113	1776	transverse	156	129	80	0.089	13.3	9.3	1 in 644
		longitudinal	189	93	80	0.239	13.3	6.5	1 in 240
F8/ C127	1872	transverse	80	74	34	0.06	27.5	20.3	1 in 955
		longitudinal	189	93	80	0.115	11.7	8.6	1 in 500
F9	1733	transverse	80	74	32	0.07	27.1	18.1	1 in 819
		longitudinal	209	109	85	0.414	10.2	7.0	1 in 138
F9.1	1583	transverse	160	74	52	0.01	15.2	7.3	1 in 5730
		longitudinal	124	69	50	0.042	15.8	10.7	1 in 1364

Note: (1) A strength reduction factor $Ø_{bc}$ = 0.6 is recommended to the Ultimate Bearing Capacity value for the Static Design Bearing Capacity

Note: (2) A strength reduction factor $Ø_{bc}$ = 0.8 to the UBC is recommended to determine Seismic Overstrength Design Bearing Capacity

Note: (3) The subgrade reaction at the centre of the footing may be taken as the average value of those along transverse and longitudinal sections

13. Foundation Design and Uplift resistance

For the design of foundation we have considered the individual pad footing or combined foundation as per structural requirement.

The depth of footing considered 1.5 m below natural ground level as suggested in soil report, to place the pad footing on rock.

The portion of building without basement provided with 150 mm thick grade on slab for vehicular traffic and other amenities as per architecture.

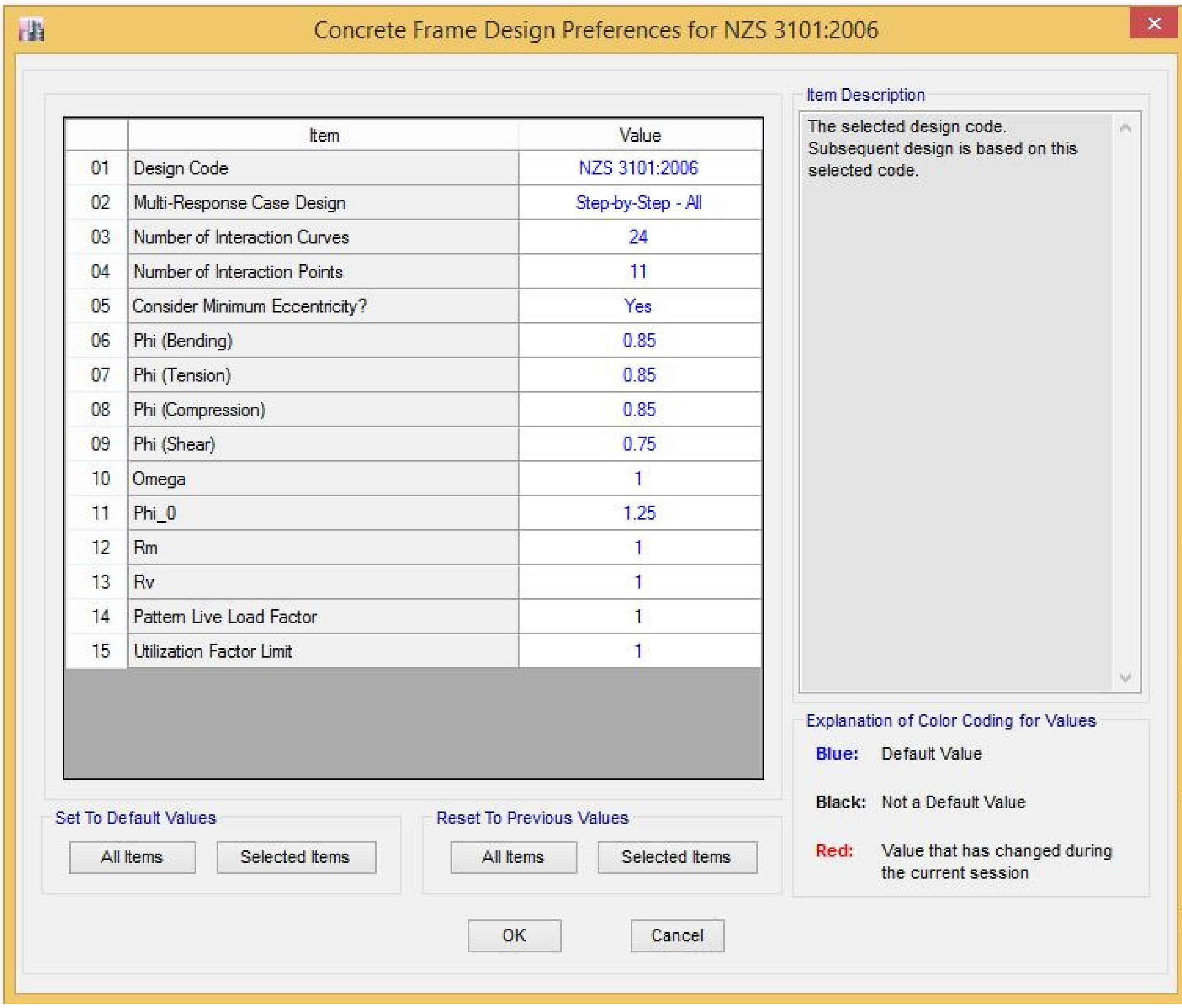
Foundation design for combined foundation has been performed in SAFE software and foundation design for Isolated foundation has been performed in Excel spread sheets.

From Foundation analysis, uplift forces found and 400mm Dia piles in CF3 and 150mm Dia. Micropiles have been provided in remaining foundations as per uplift requirement.

14. DIAPHRAGM DESIGN

Separate model has been generated for diaphragm design and in plane shall stresses has been checked as per NZS1170.5.

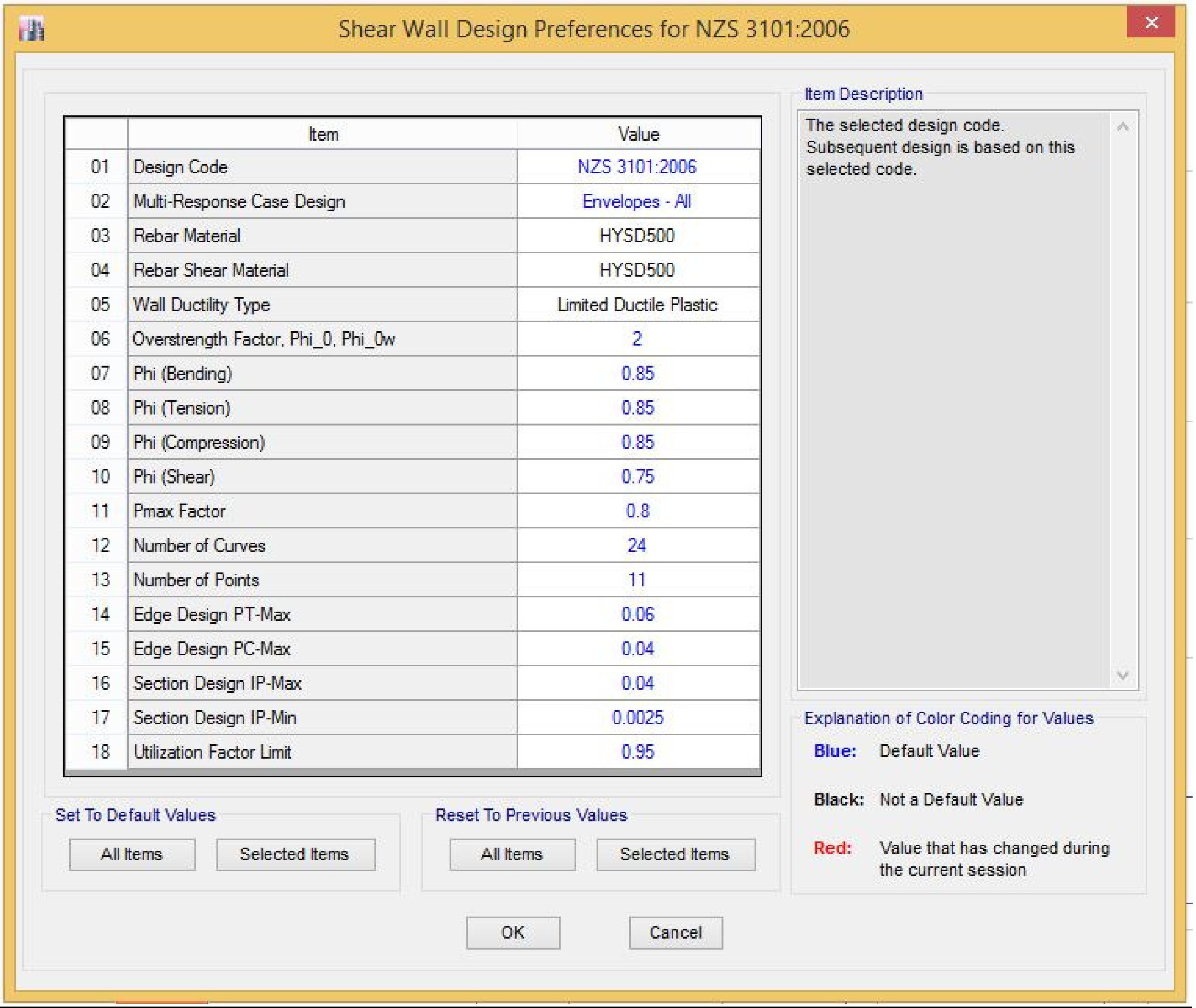
15. CONCRETE FRAMING&SHEAR WALL DESIGN PREFERENCES AND OVERWRITES:



	Item	Value
01	Design Code	NZS 3101:2006
02	Multi-Response Case Design	Step-by-Step - All
03	Number of Interaction Curves	24
04	Number of Interaction Points	11
05	Consider Minimum Eccentricity?	Yes
06	Phi (Bending)	0.85
07	Phi (Tension)	0.85
08	Phi (Compression)	0.85
09	Phi (Shear)	0.75
10	Omega	1
11	Phi_0	1.25
12	Rm	1
13	Rv	1
14	Pattern Live Load Factor	1
15	Utilization Factor Limit	1

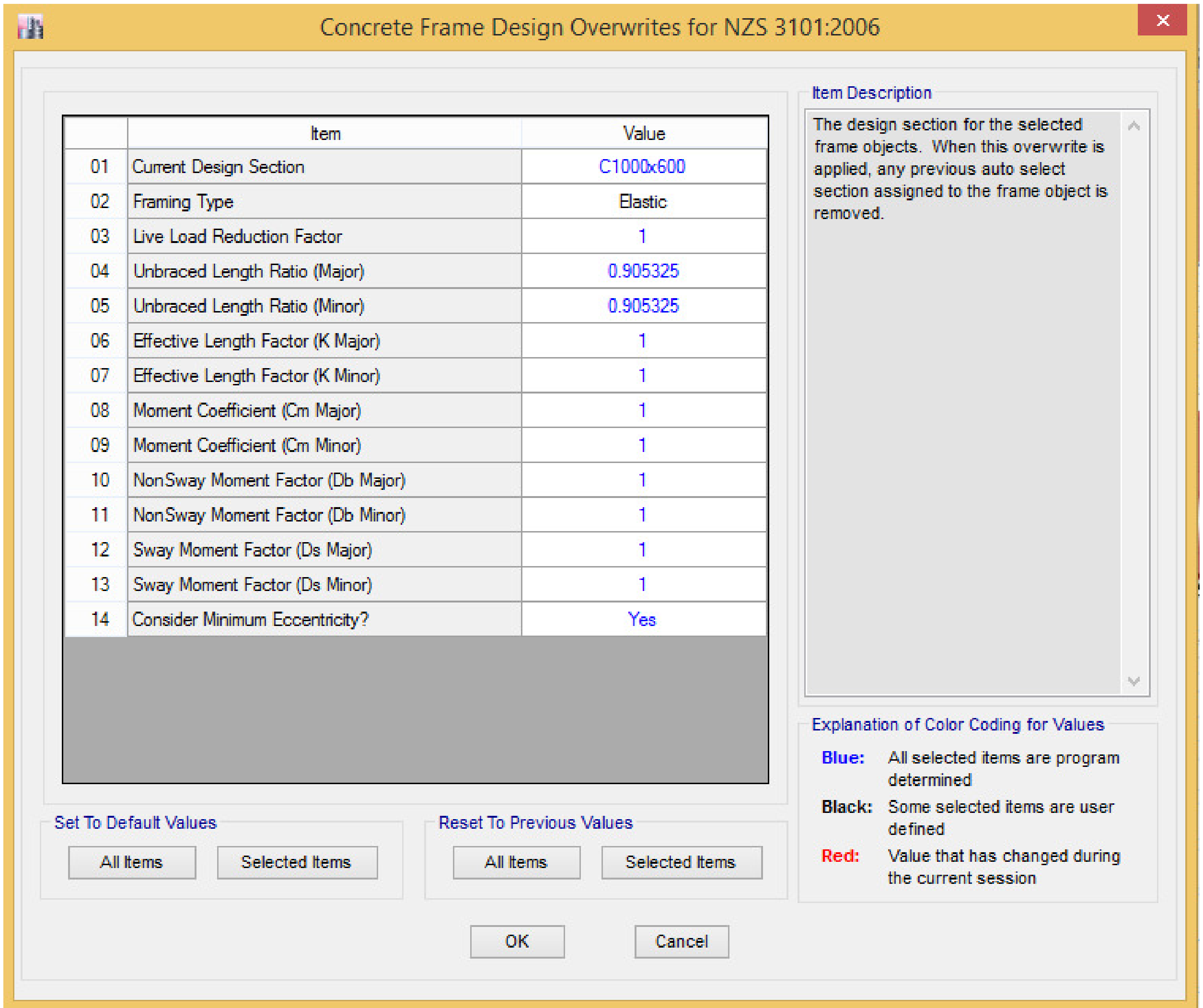
Concrete Frame Design Preferences

SILICON
Engineering Consultants Ltd



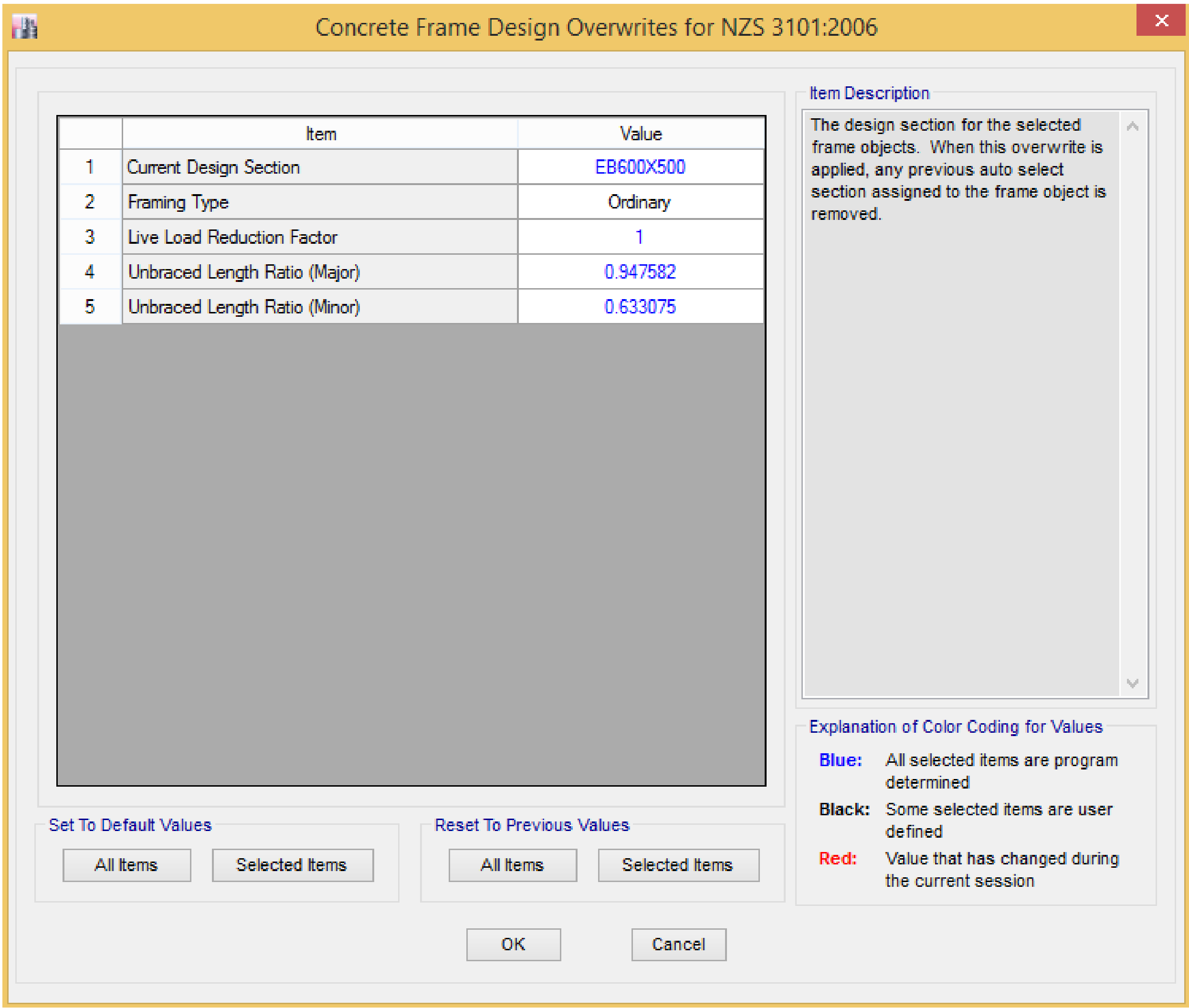
	Item	Value
01	Design Code	NZS 3101:2006
02	Multi-Response Case Design	Envelopes - All
03	Rebar Material	HYSD500
04	Rebar Shear Material	HYSD500
05	Wall Ductility Type	Limited Ductile Plastic
06	Overstrength Factor, Phi_0, Phi_0w	2
07	Phi (Bending)	0.85
08	Phi (Tension)	0.85
09	Phi (Compression)	0.85
10	Phi (Shear)	0.75
11	Pmax Factor	0.8
12	Number of Curves	24
13	Number of Points	11
14	Edge Design PT-Max	0.06
15	Edge Design PC-Max	0.04
16	Section Design IP-Max	0.04
17	Section Design IP-Min	0.0025
18	Utilization Factor Limit	0.95

Shear Wall Design Preferences



	Item	Value
01	Current Design Section	C1000x600
02	Framing Type	Elastic
03	Live Load Reduction Factor	1
04	Unbraced Length Ratio (Major)	0.905325
05	Unbraced Length Ratio (Minor)	0.905325
06	Effective Length Factor (K Major)	1
07	Effective Length Factor (K Minor)	1
08	Moment Coefficient (Cm Major)	1
09	Moment Coefficient (Cm Minor)	1
10	NonSway Moment Factor (Db Major)	1
11	NonSway Moment Factor (Db Minor)	1
12	Sway Moment Factor (Ds Major)	1
13	Sway Moment Factor (Ds Minor)	1
14	Consider Minimum Eccentricity?	Yes

Concrete COLUMN DesignOverwrites



Concrete BEAM DesignOverwrites

R3_Date:18-05-2020

FOUNDATION DESIGN CALCULATION

FOR

HOTEL HOLIDAY INN

AT

180 STODDARD ROAD

Submitted By

SILICON
Engineering Consultants Ltd

188A, Stoddard Road, Mt. Roskill, Auckland

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1 COMBINED FOOTING CF1

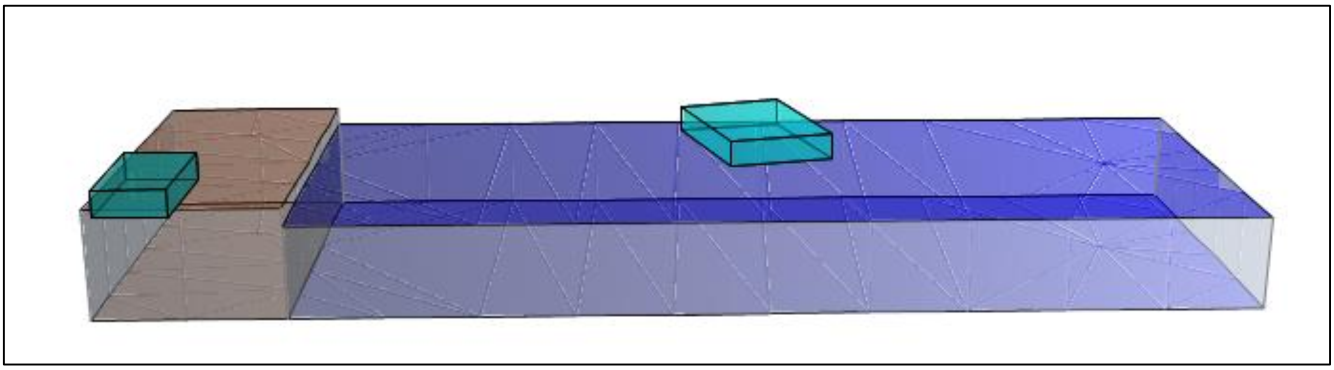
1.1 DESIGN OF CF1

SAFE software is used to design CF1 foundation.

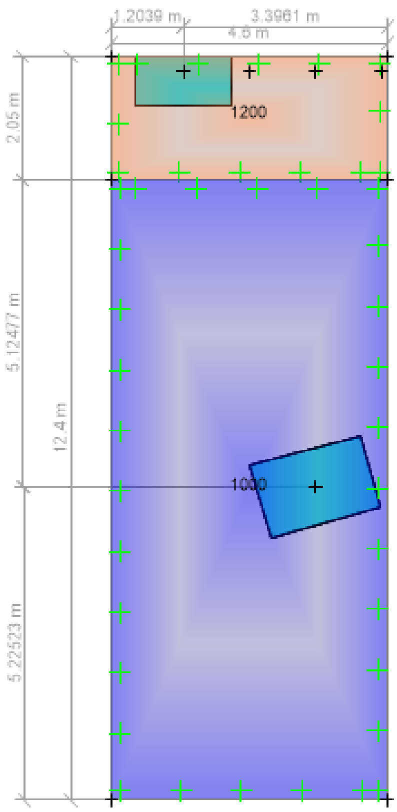
CF1 foundation is modeled in SAFE software as Finite elements. Reactions of wall & column for different load cases are Imported from ETABS as SAFE.F2K file.

Refer below steps showing detailed modeling, analysis and design of CF1 foundation.

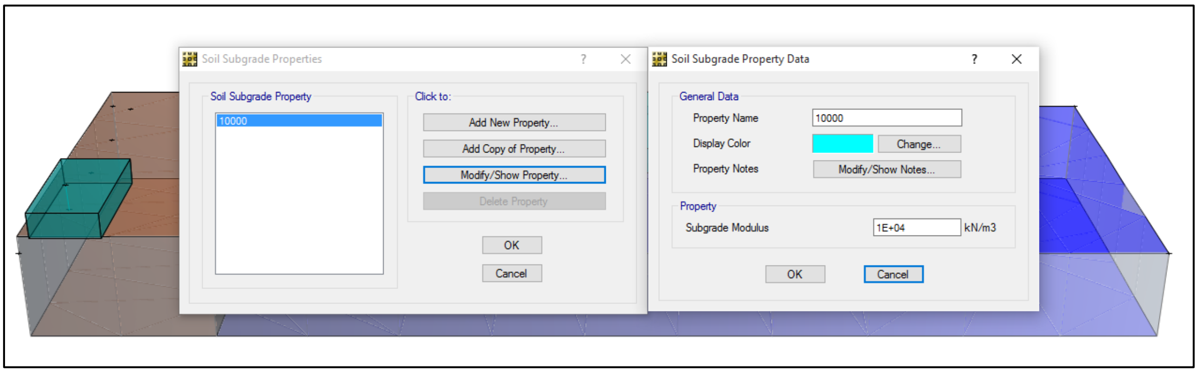
1.2 SAFE MODELING



SAFE modeling of CF1 foundation as finite elements



Properties: 1200 and 1000mm thick slab

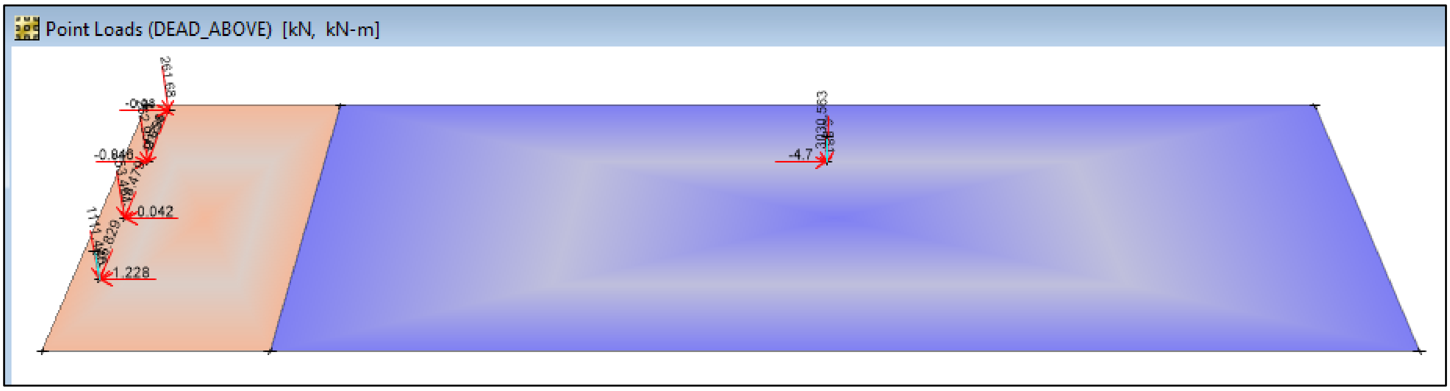


Foundation supports

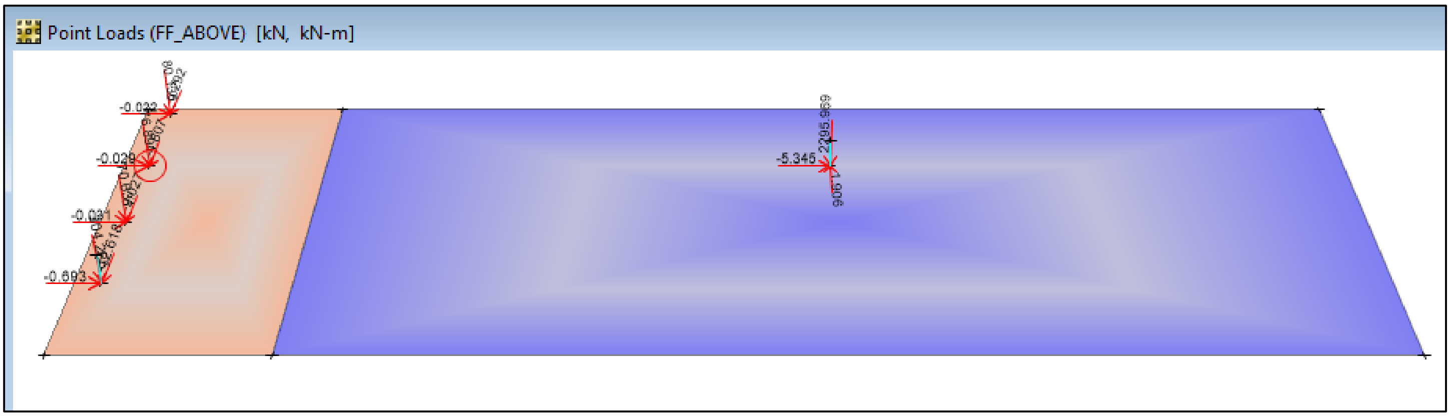
1.3 LOADING

1.3.1 Dead Load

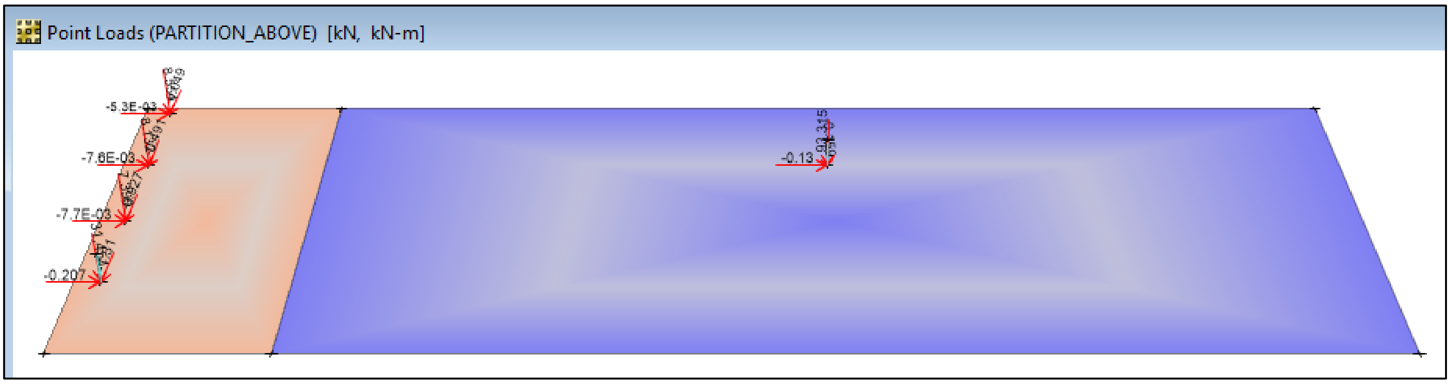
- Dead load obtained from ETABS model
-



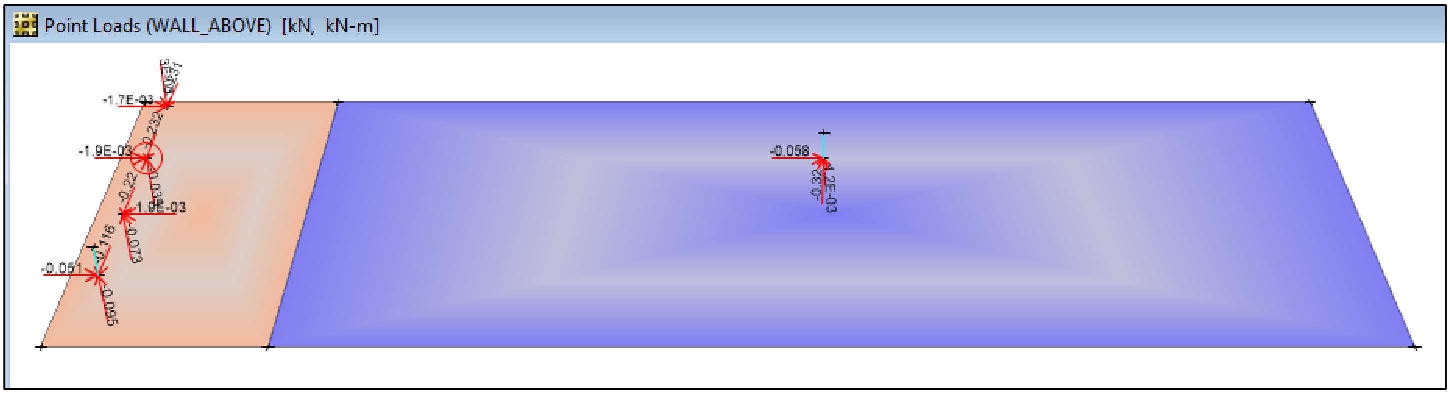
Dead load obtained from ETABS model



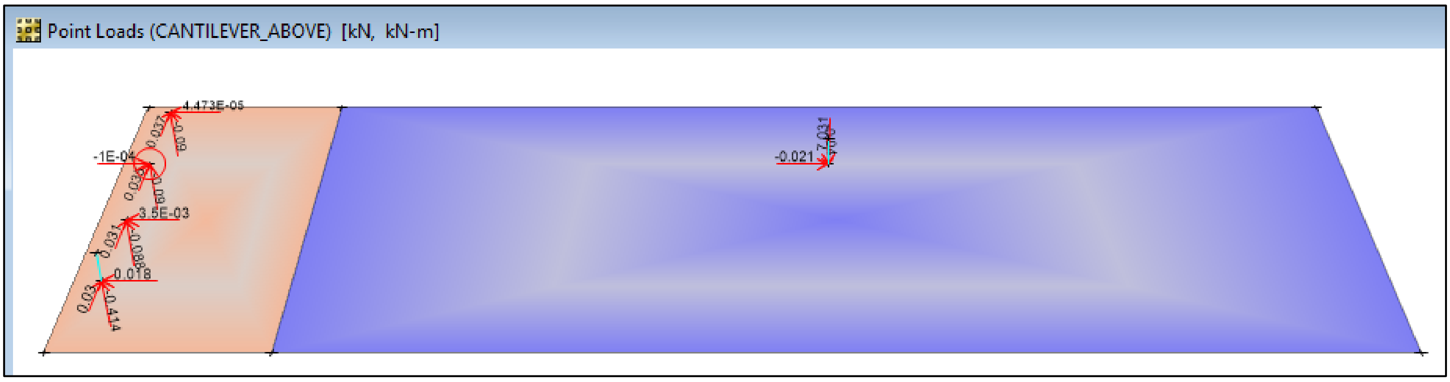
Floor-Finish load obtained from ETABS model



Partition load obtained from ETABS model



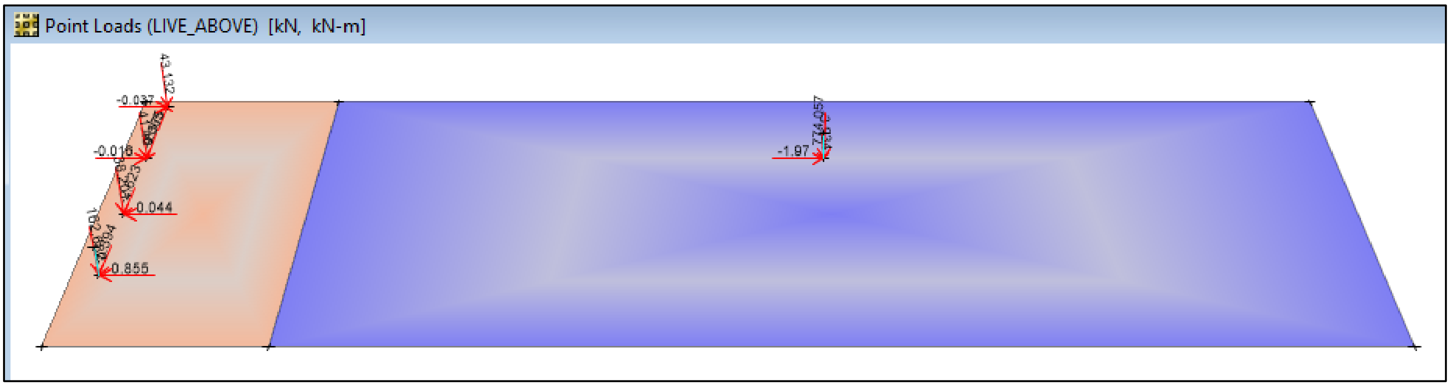
Wall load obtained from ETABS model



Cantilever load obtained from ETABS model

1.3.2 Live Load

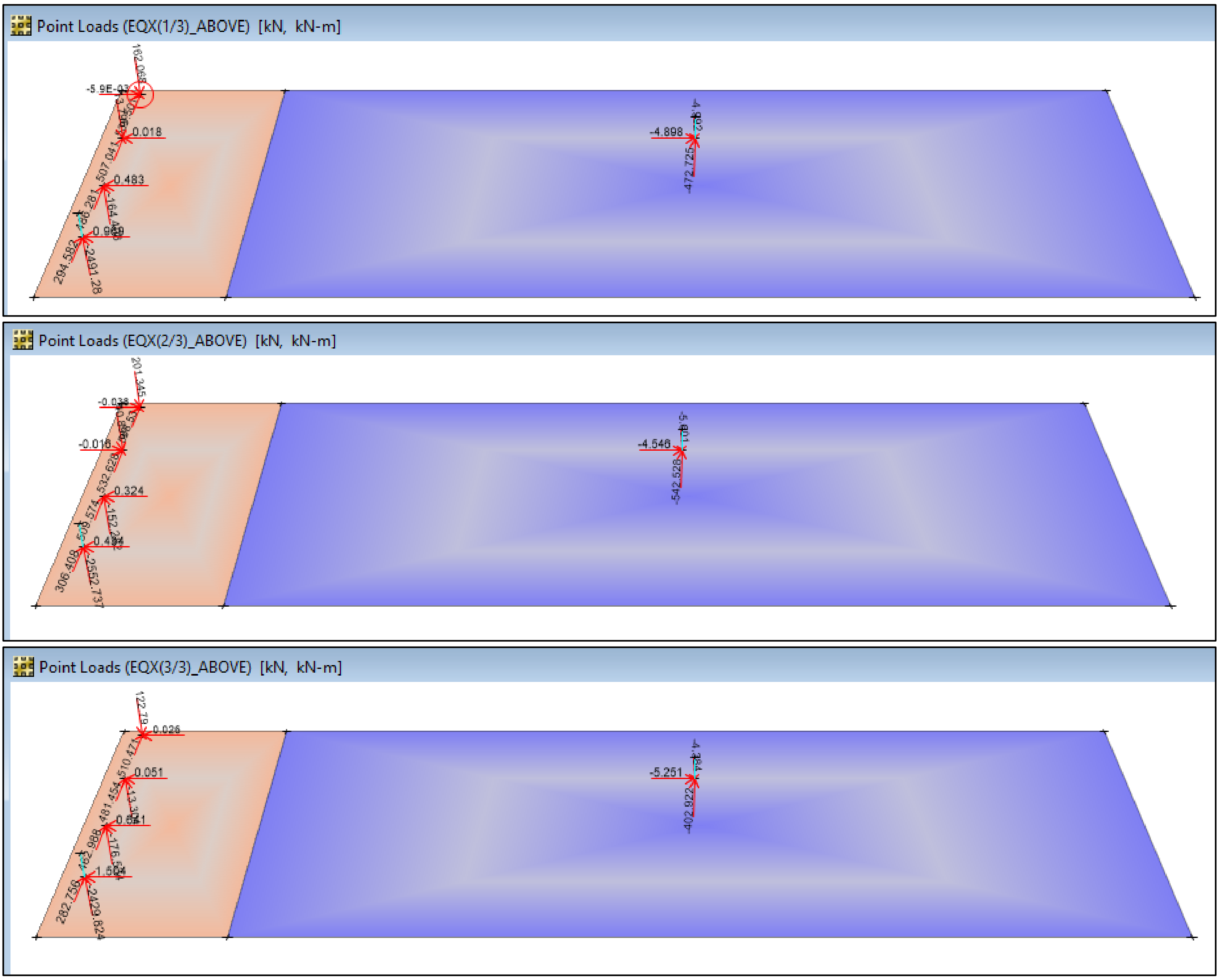
– Live load obtained from ETABS model



Live load obtained from ETABS model

1.3.3 EQX (Seismic Force in X-Direction)

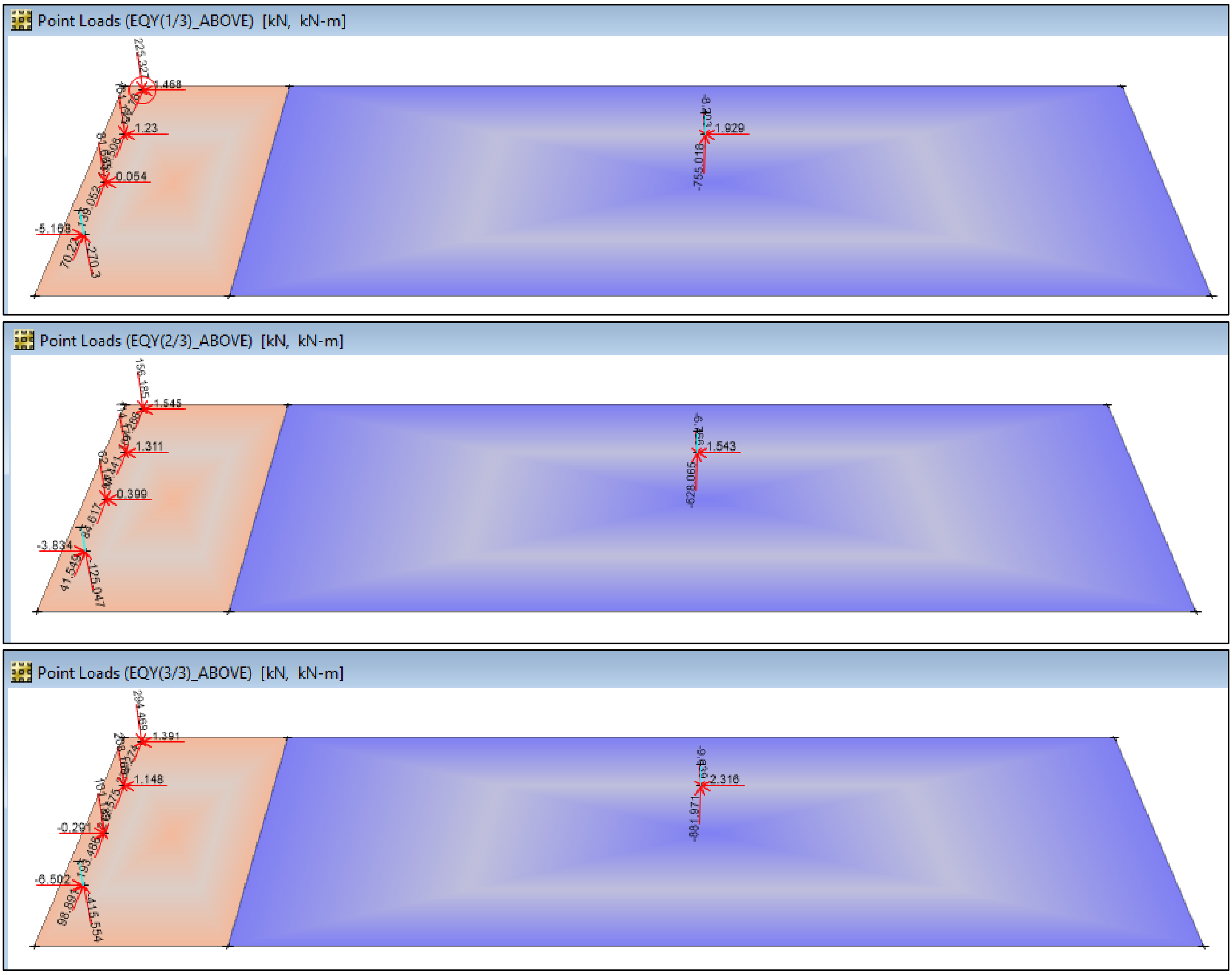
– Seismic loads obtained from reactions of ETABS model



EQX obtained from ETABS model

1.3.4 EQY (Seismic Force in Y-Direction)

– Seismic loads obtained from ETABS model



EQY obtained from ETABS model

1.4 Load Combinations

Design load combinations

1.35DL
1.2DL + 1.5LL
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE - Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE -X
1.0DL +0.3LL + 1.0 EARTHQUAKE – Y + 0.3 EARTHQUAKE –X

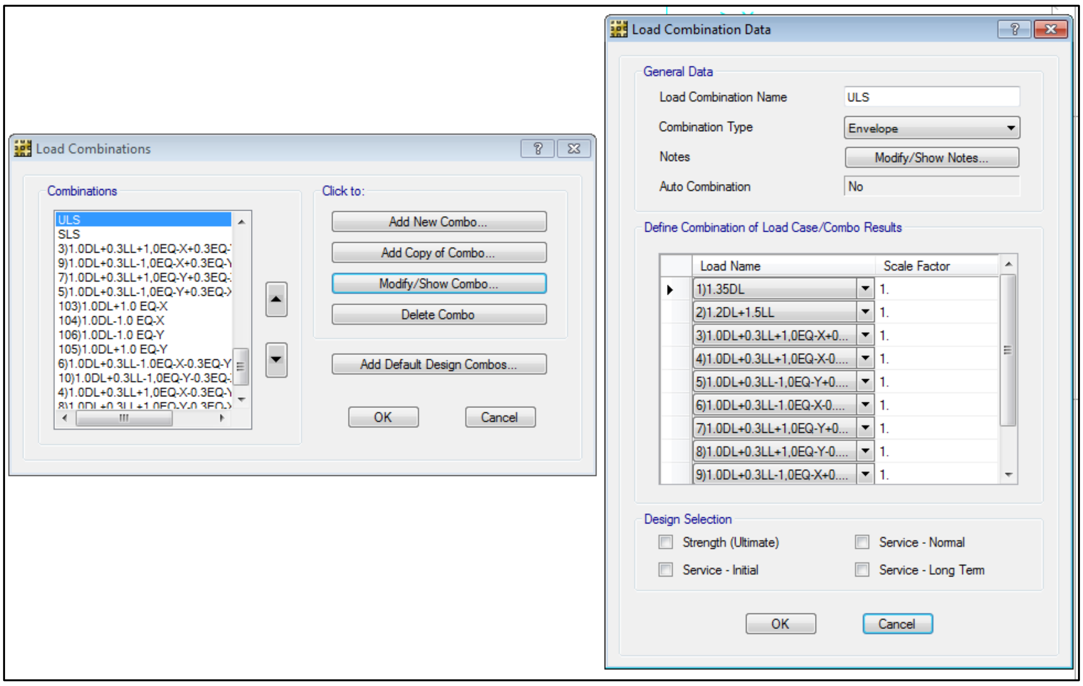
Serviceability load combinations

1.0DL + 1.0LL
1.0DL + 1.0EQX
1.0DL - 1.0EQX
1.0DL + 1.0EQY
1.0DL - 1.0EQY

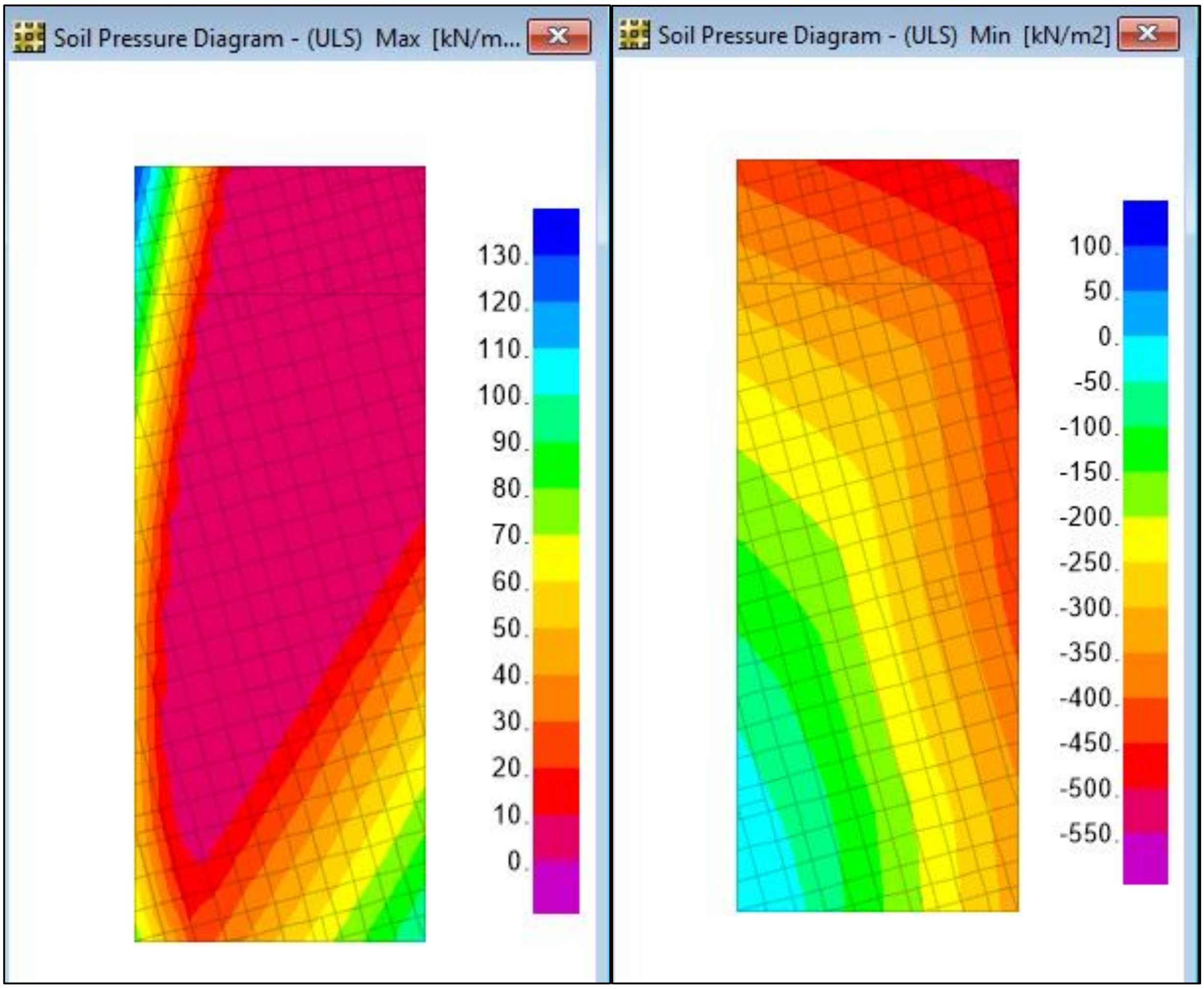
1.5 Base Pressure Check

1.5.1 Check of maximum base pressure for design load combinations:

Refer below image showing soil pressure diagram of base pressure for design load combinations:



Design load combination envelope



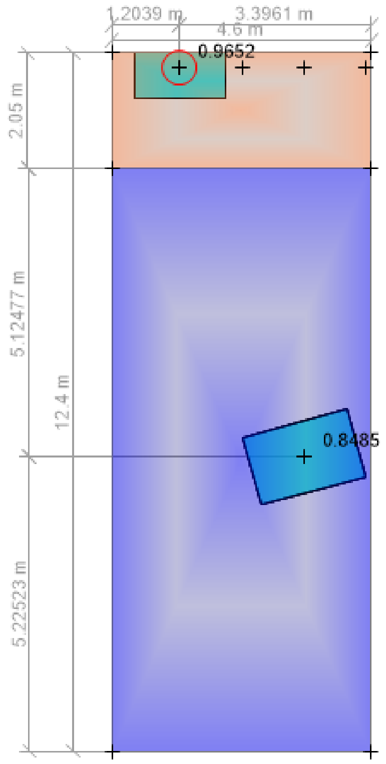
Soil pressure diagram for Seismic Ultimate load combination (Max & Min)

Permissible SBC for design load combinations = 575 kN/m^2

Maximum base pressure (Downward) = 531 kN/m^2<575 kN/m^2 (Hence, OK)

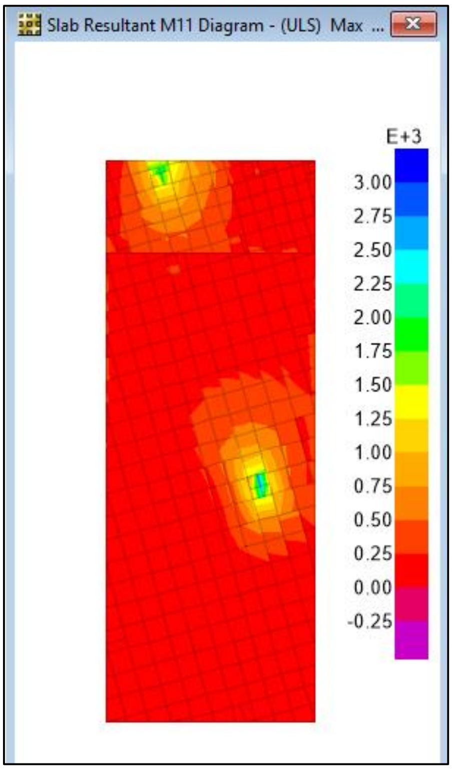
Maximum base pressure (Upward) = 130 kN/m^2

1.6 Punching Shear Check

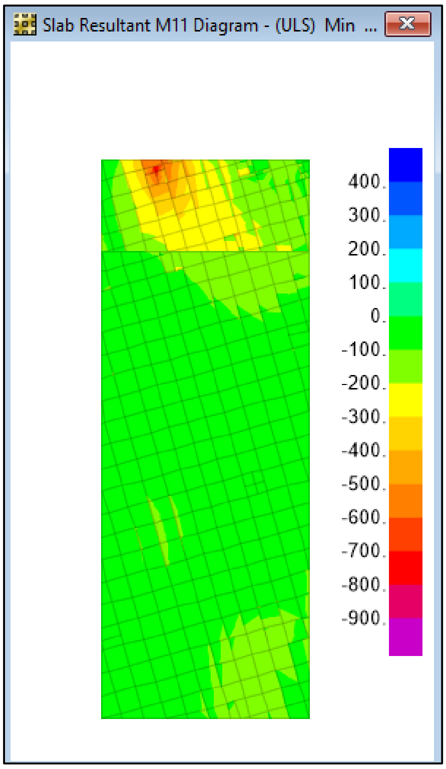


Check for Punching Shear

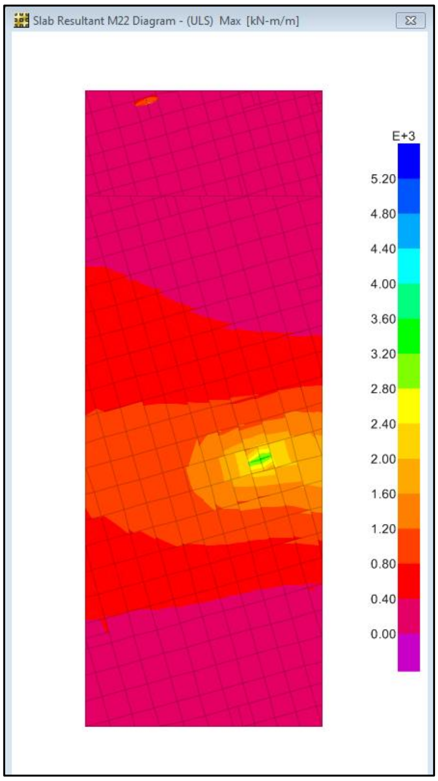
1.7 Moment Diagram:



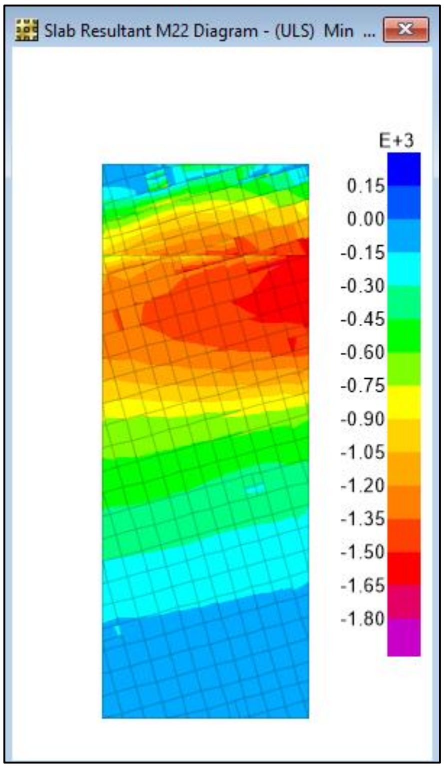
Moment diagram in X-dir for Design load combination (Max)



Moment diagram in X-dirfor Design load combination (Min)

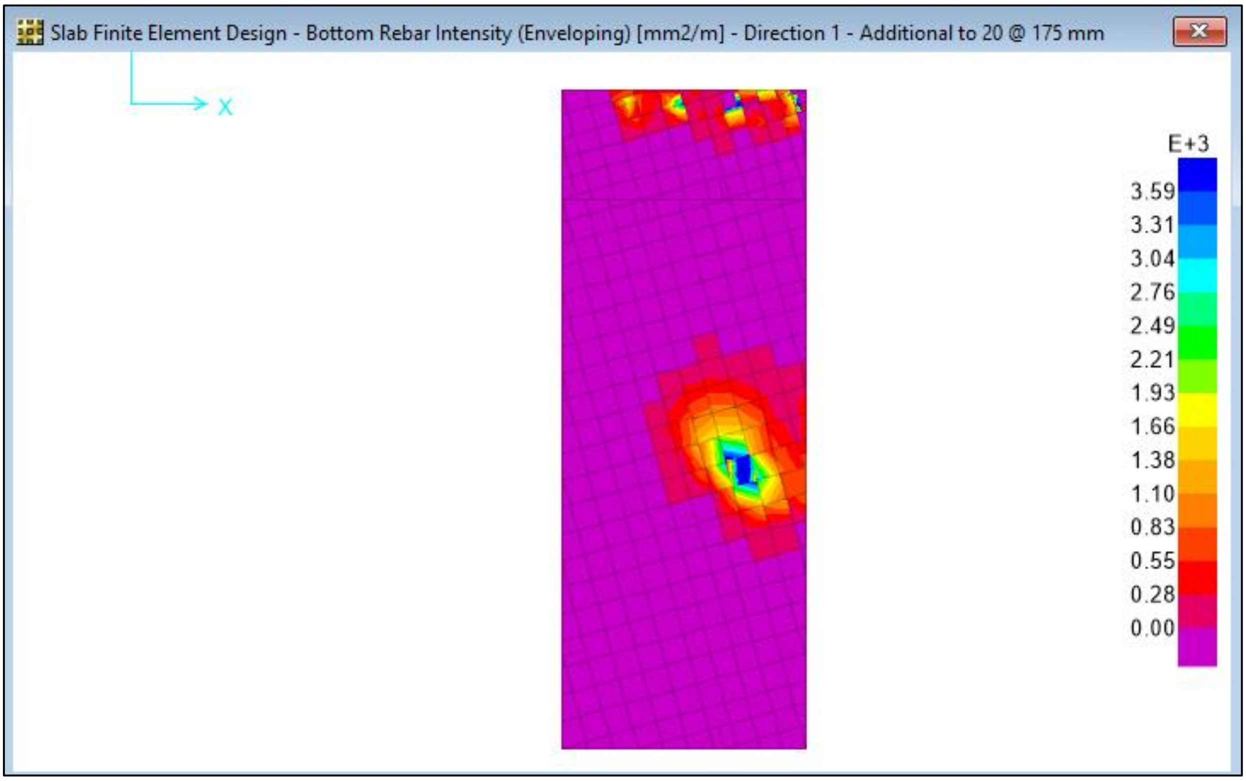


Moment diagram in Y-dir for Design load combination (Max)

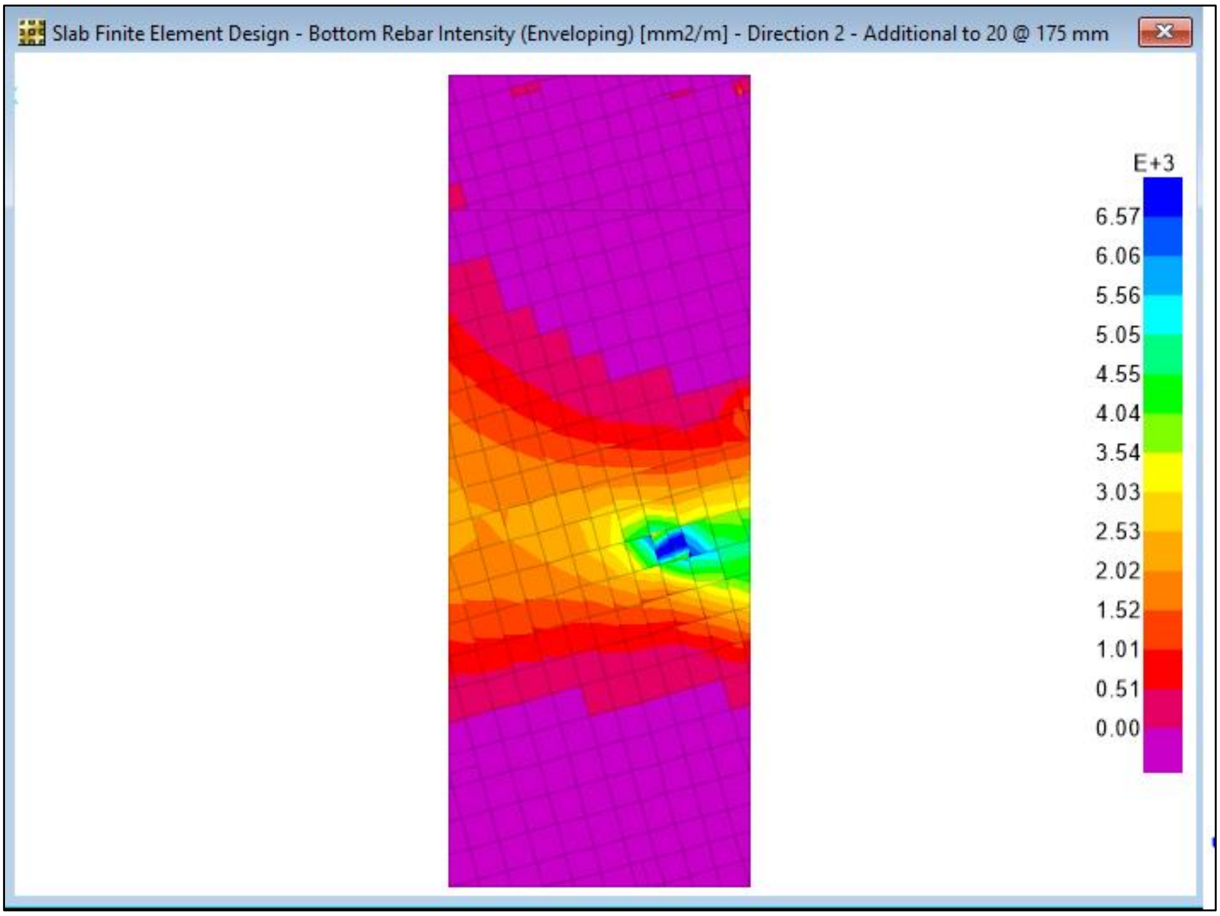


Moment diagram in Y-dir for Design load combination (Min)

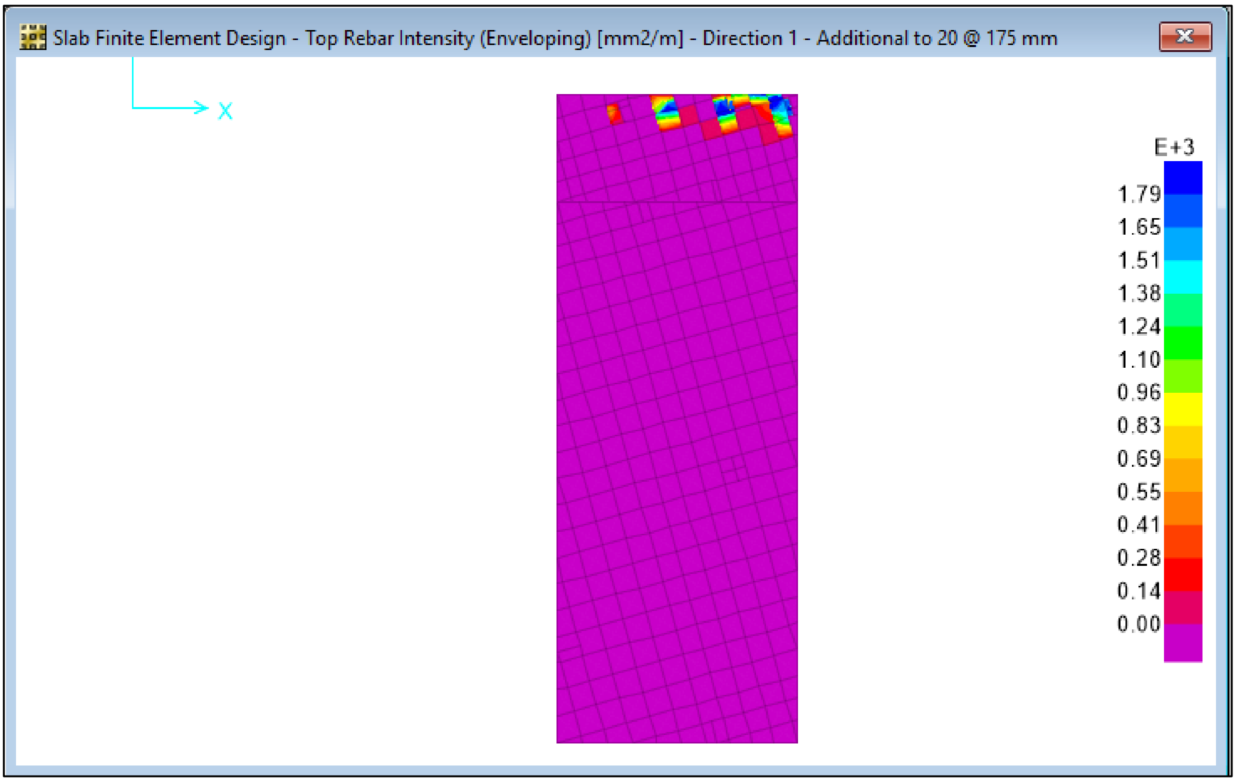
1.8 Design of combined footing:



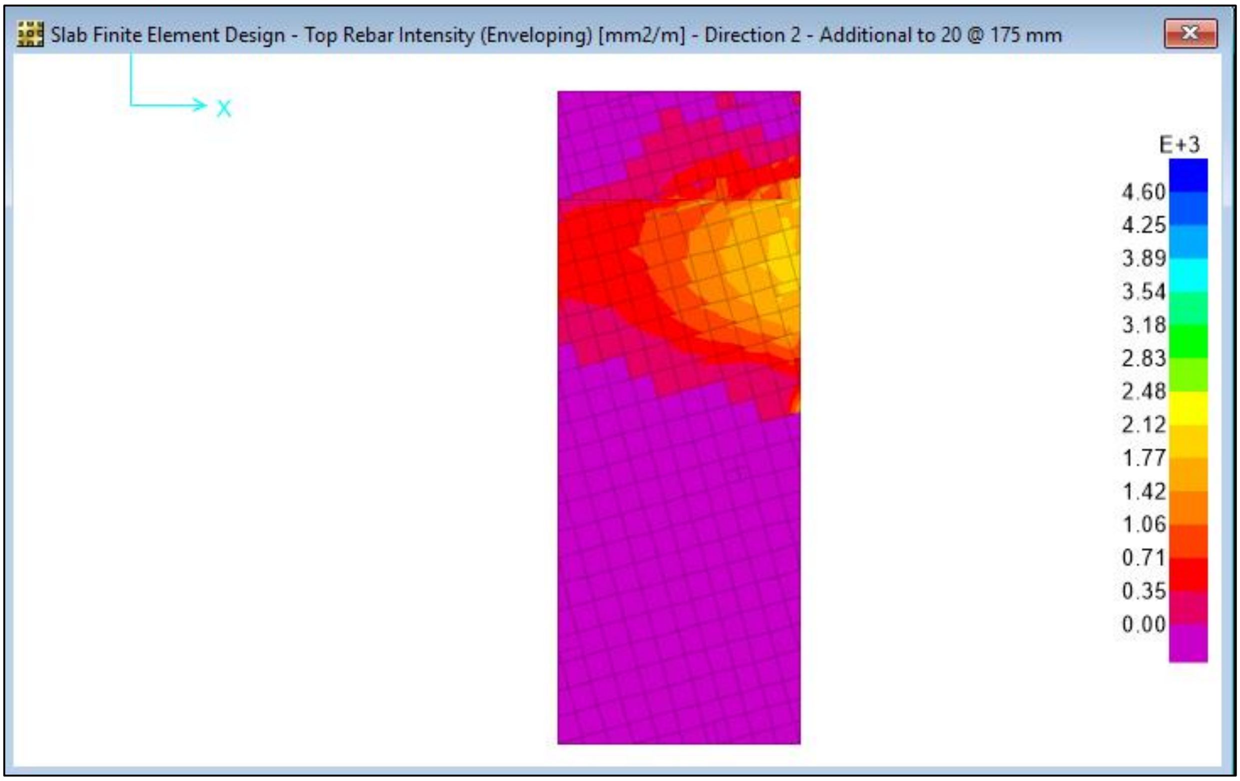
Bottom Reinforcement diagram in X-dir



Bottom Reinforcement diagram in Y-dir



Top Reinforcement diagram in X-dir



Top Reinforcement diagram in Y-dir

2 COMBINED FOOTING CF2

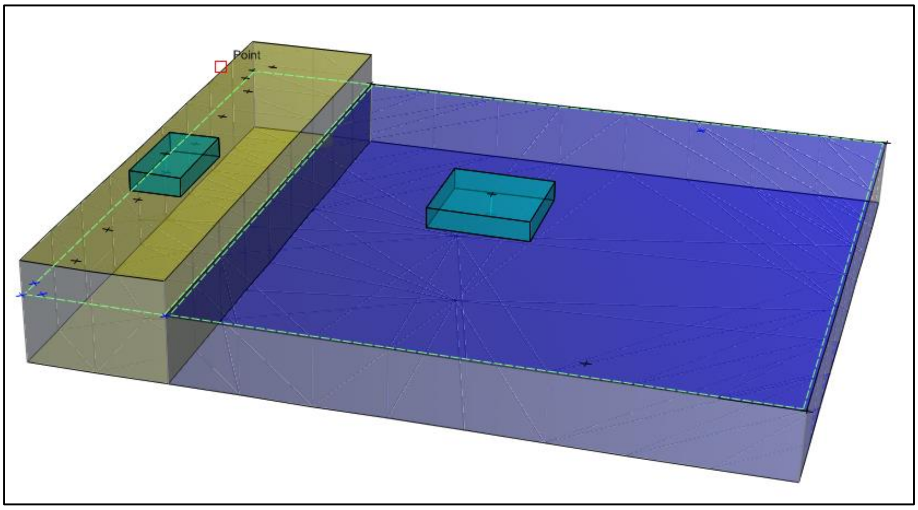
2.1 DESIGN OF CF2

SAFE software is used to design CF2 foundation.

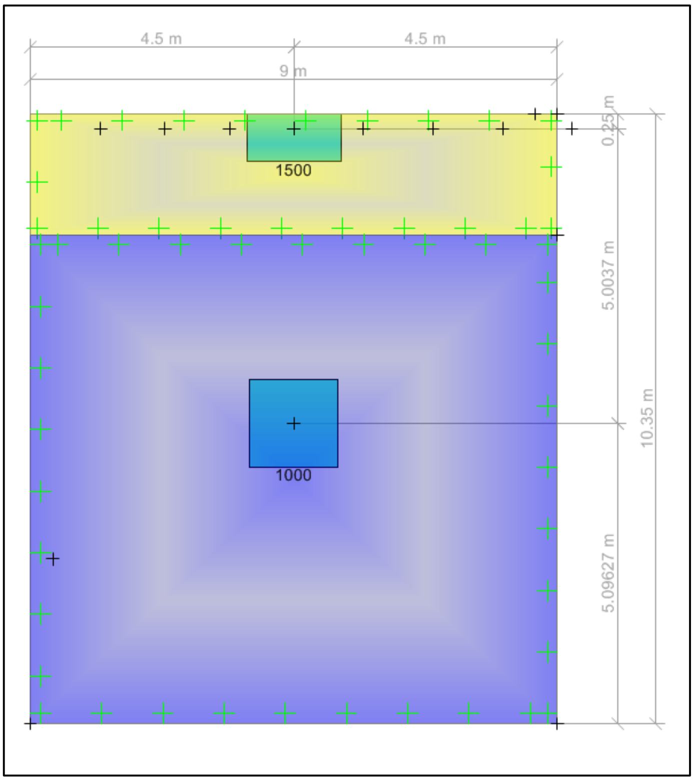
CF2 foundation is modeled in SAFE software as Finite elements. Reactions of wall & column for different load cases are Imported from ETABS as SAFE.F2K file.

Refer below steps showing detailed modeling, analysis and design of CF2 foundation.

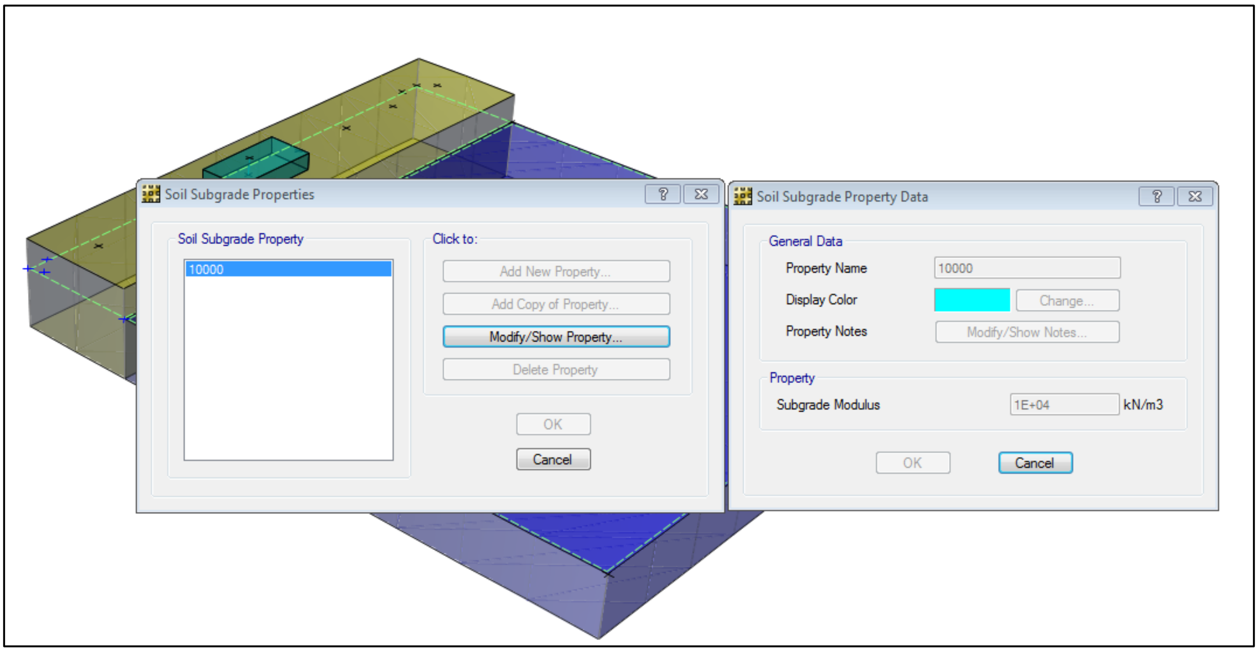
2.2 SAFE MODELING



SAFE modeling of CF2 foundation as finite elements



Properties: 1500 and 1000mm thick slab

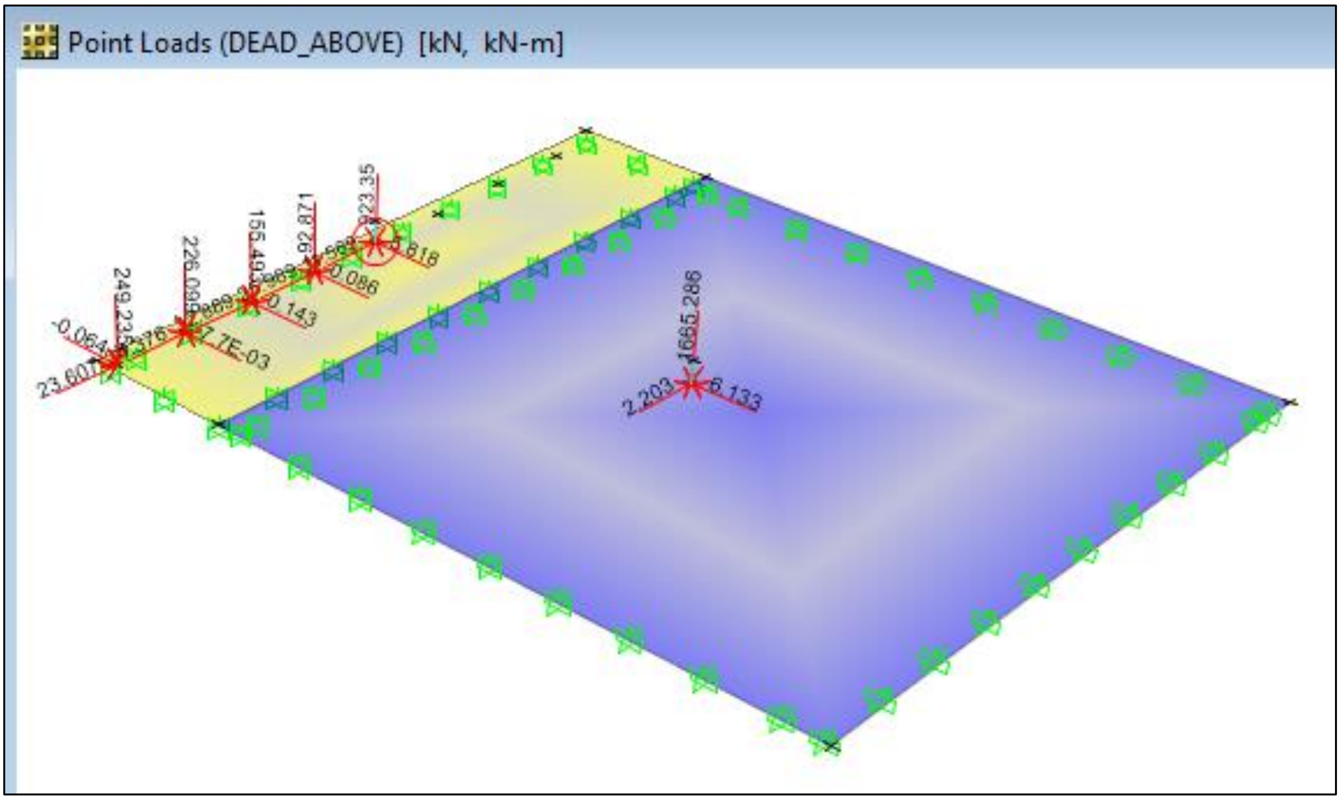


Foundation supports

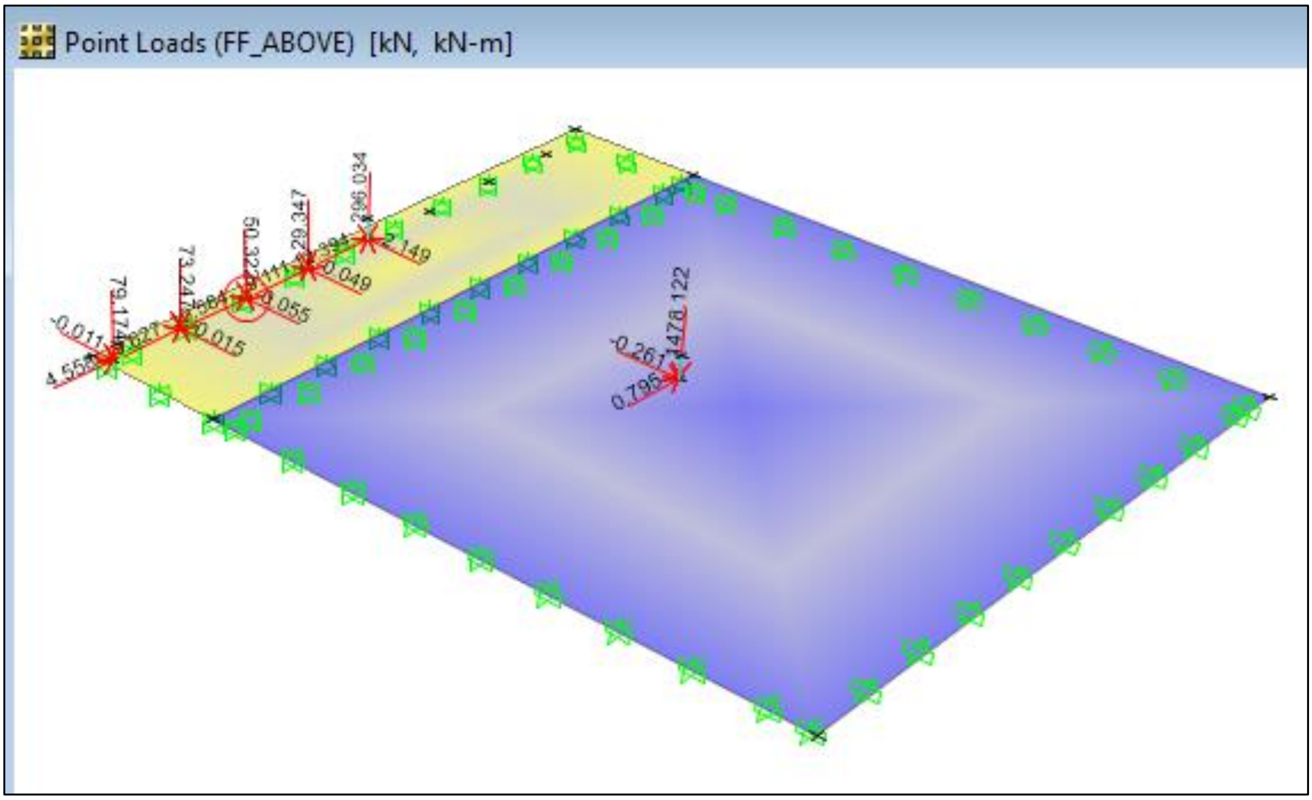
2.3 LOADING

2.3.1 Dead Load

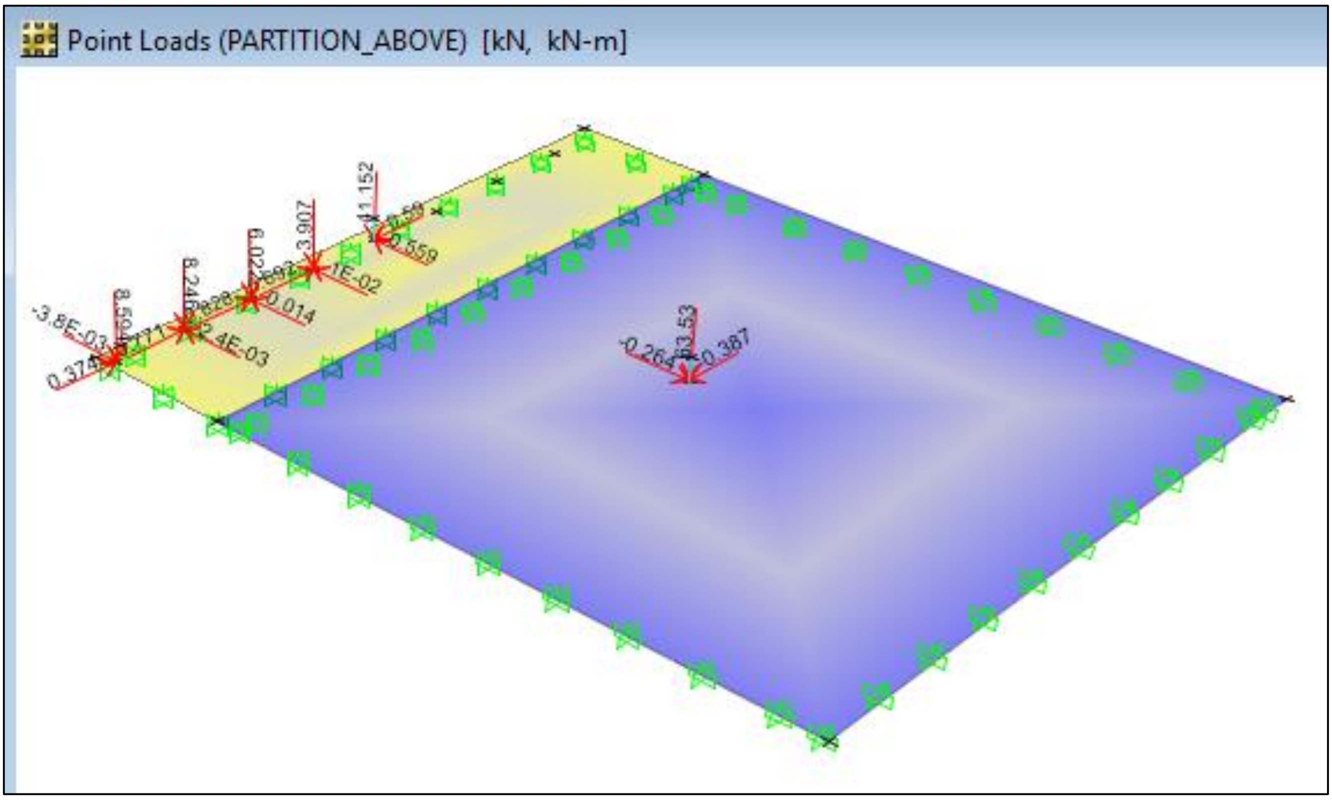
- Dead load obtained from ETABS model



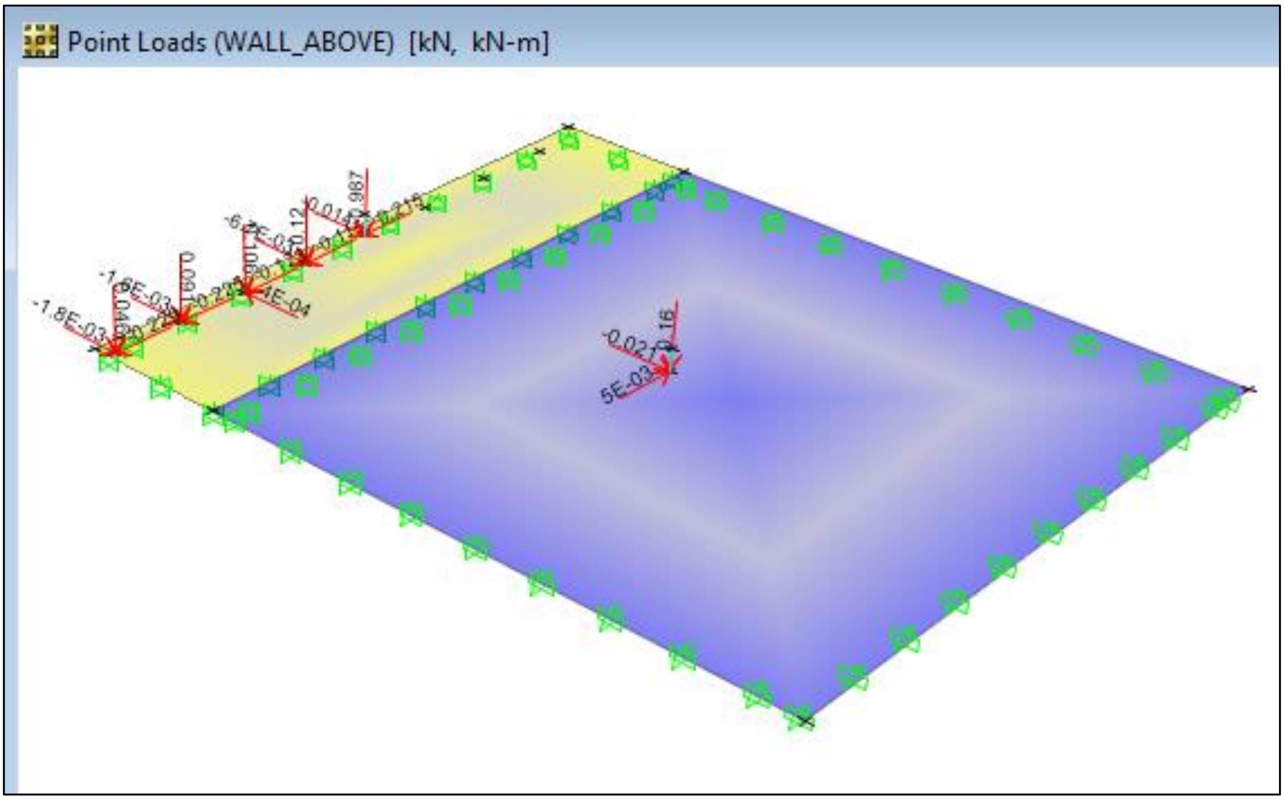
Dead load obtained from ETABS model



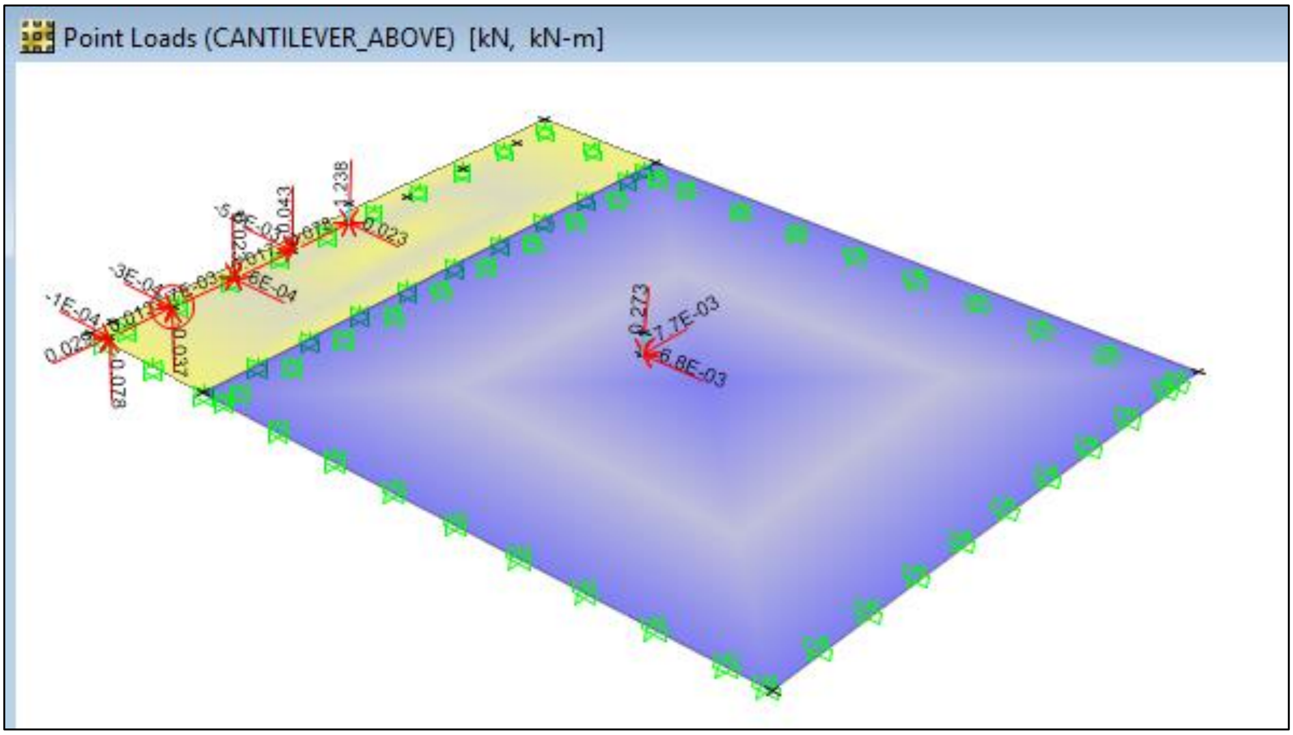
Floor-Finish load obtained from ETABS model



Partition load obtained from ETABS model



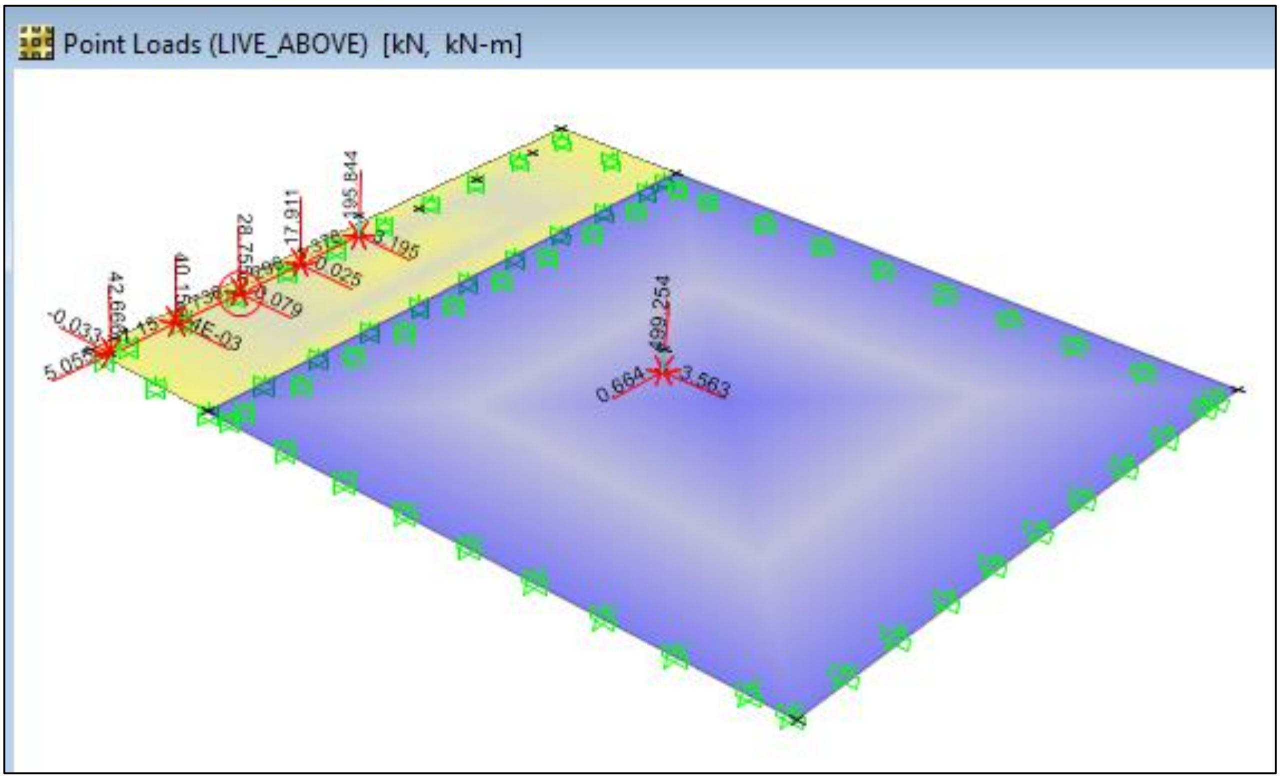
Wall load obtained from ETABS model



Cantilever load obtained from ETABS model

2.3.2 Live Load

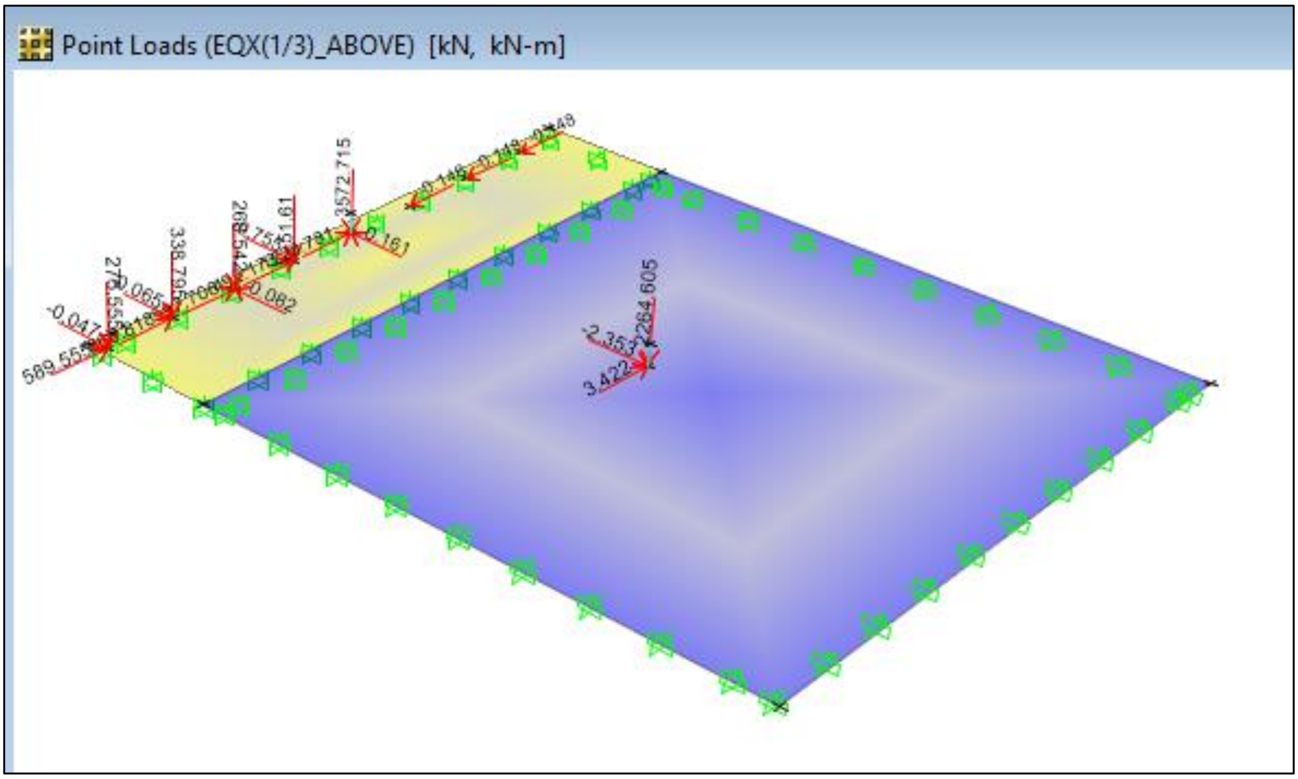
– Live load obtained from ETABS model

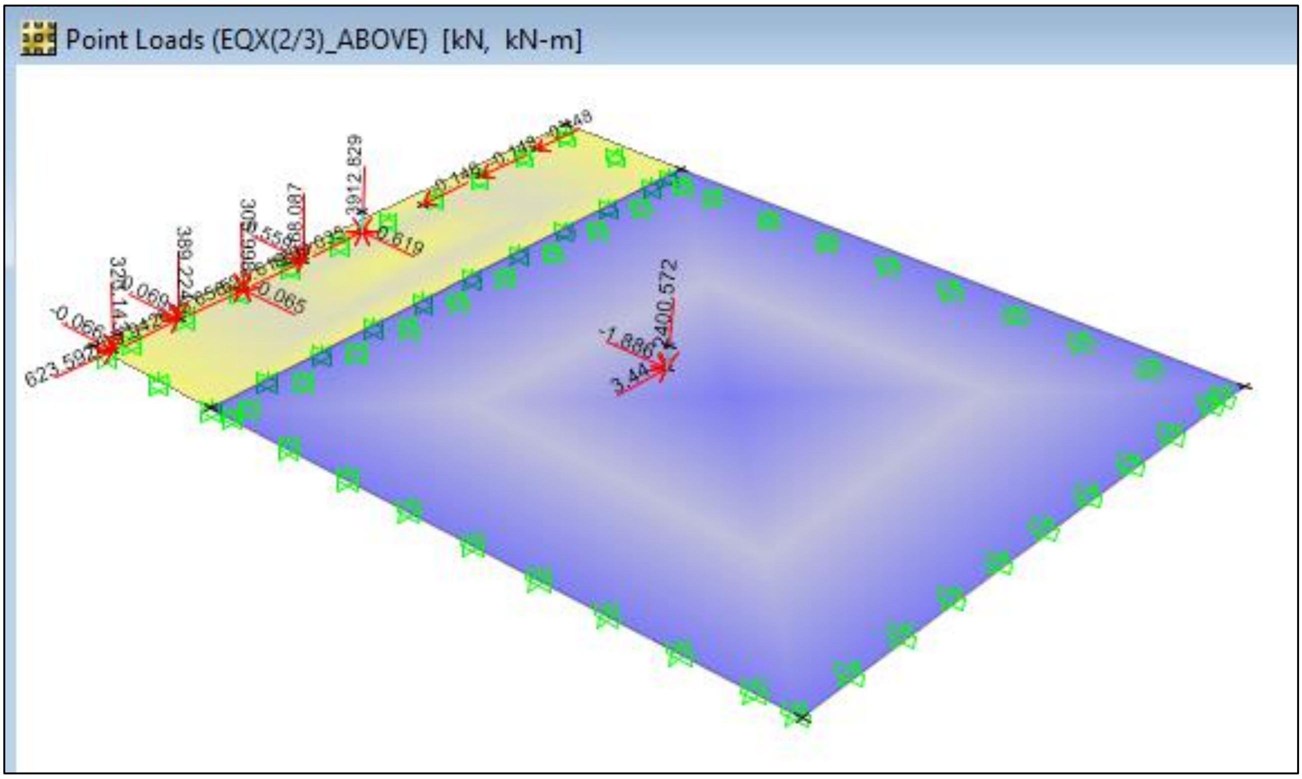


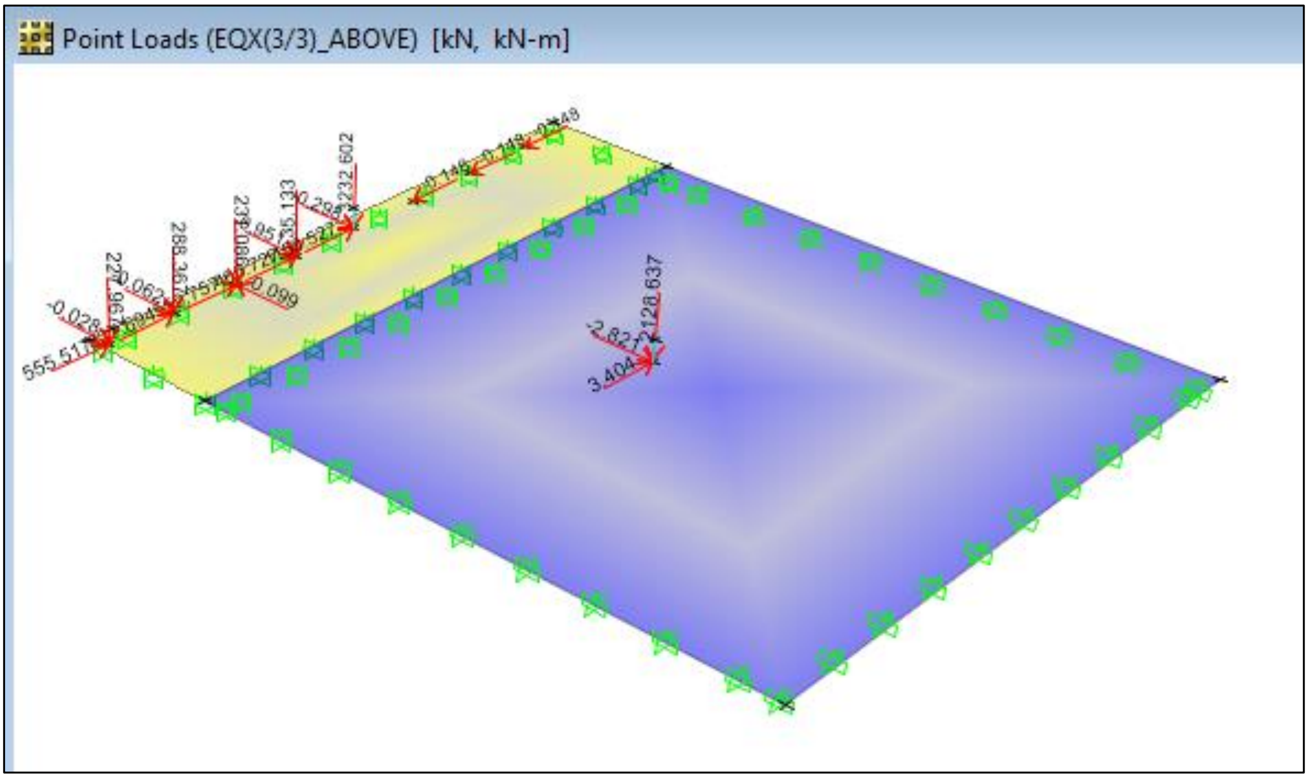
Live load obtained from ETABS model

2.3.3 EQX (Seismic Force in X-Direction)

– Seismic loads obtained from reactions of ETABS model



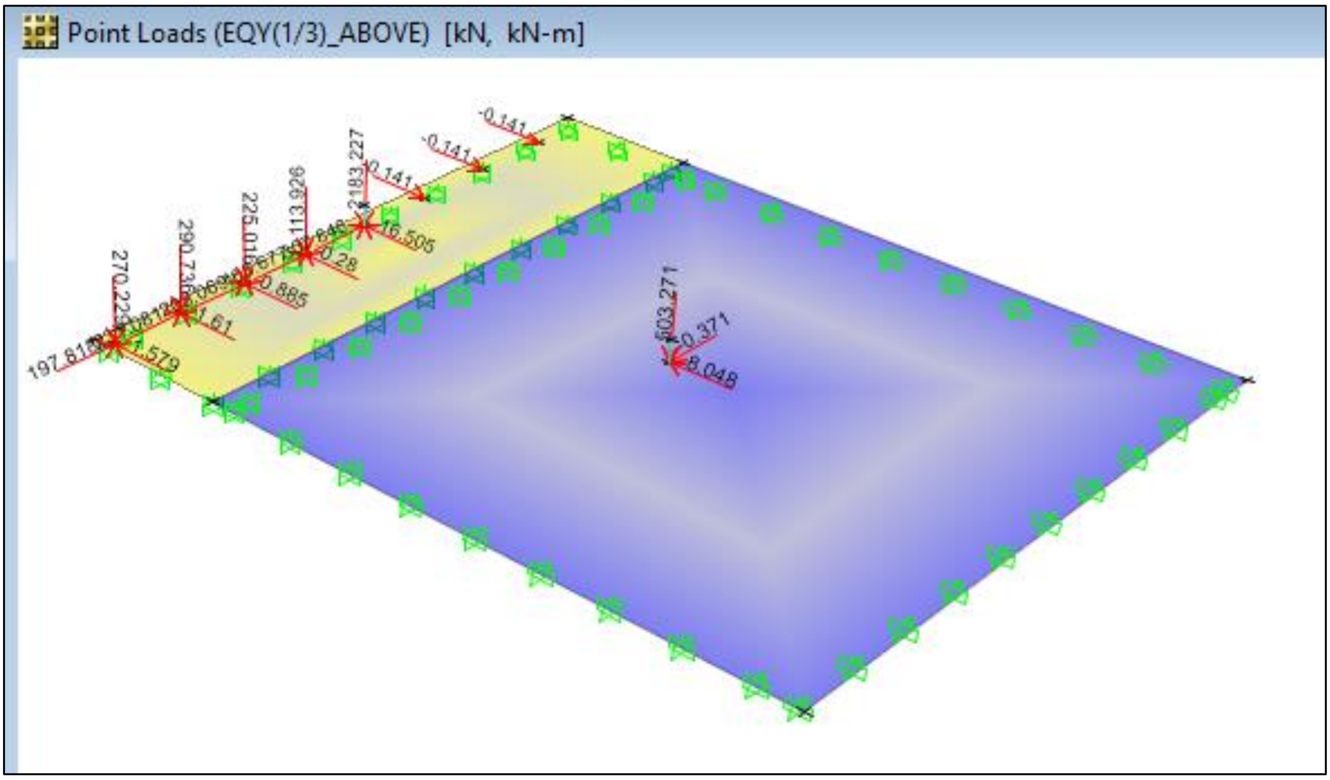


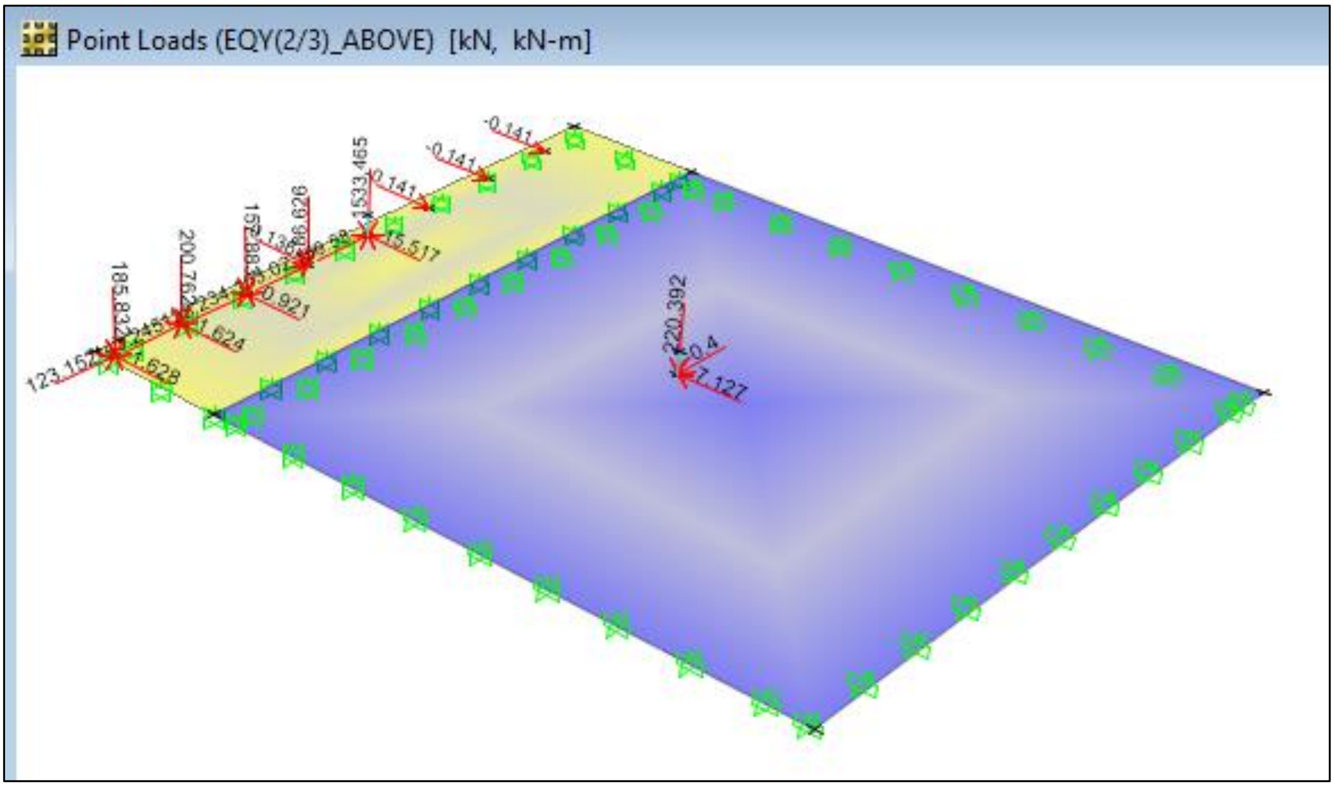


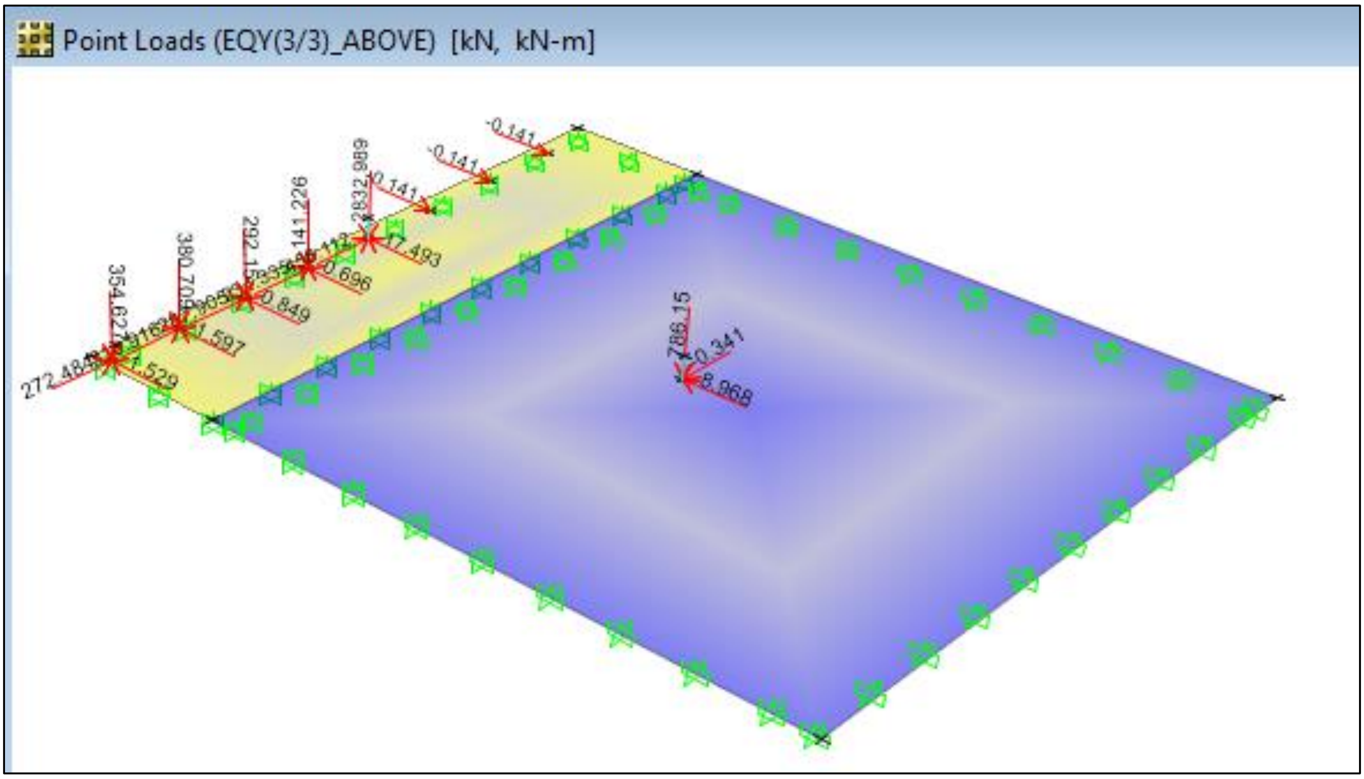
EQX obtained from ETABS model

2.3.4 EQY (Seismic Force in Y-Direction)

– Seismic loads obtained from ETABS model







EQY obtained from ETABS model

2.4 Load Combinations

Design load combinations

1.35DL
1.2DL + 1.5LL
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE - Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE -X
1.0DL +0.3LL + 1.0 EARTHQUAKE – Y + 0.3 EARTHQUAKE –X

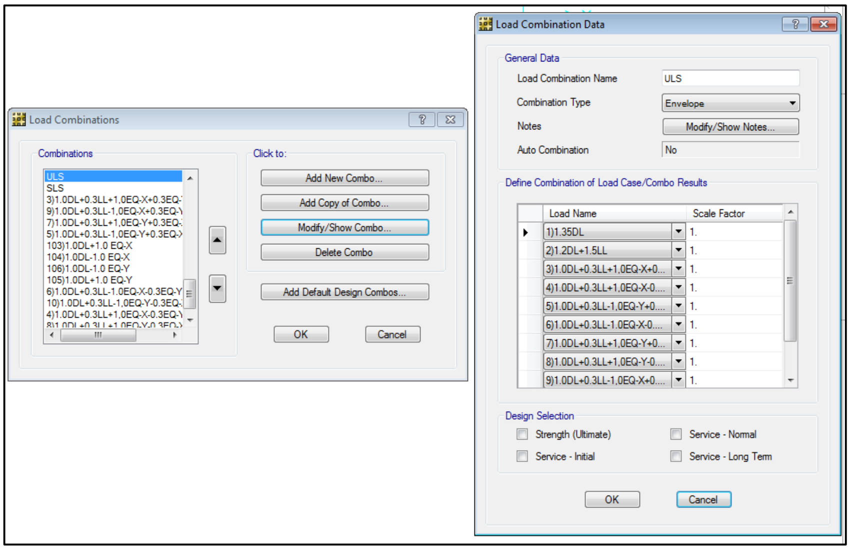
Serviceability load combinations

1.0DL + 1.0LL
1.0DL + 1.0EQX
1.0DL - 1.0EQX
1.0DL + 1.0EQY
1.0DL - 1.0EQY

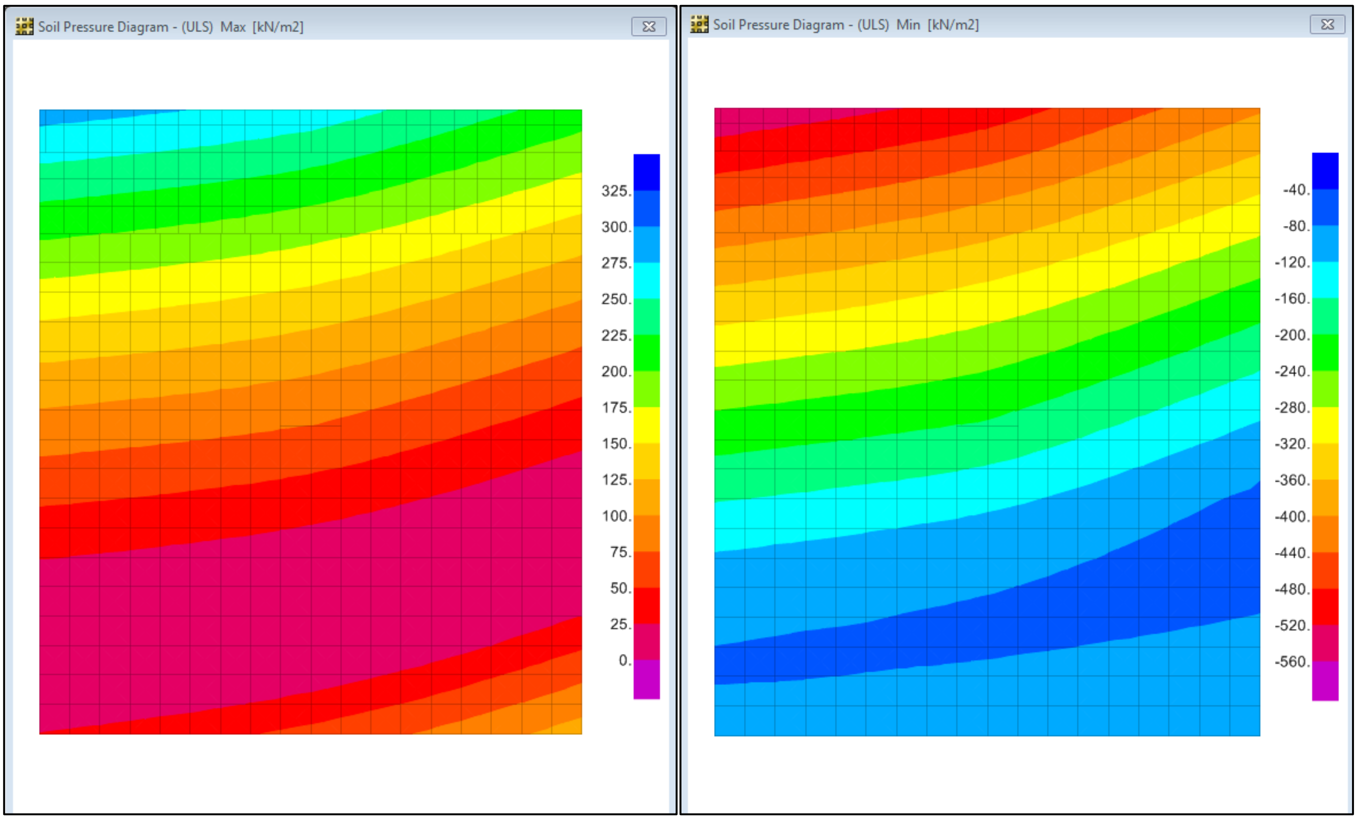
2.5 Base Pressure Check

2.5.1 Check of maximum base pressure for design load combinations:

Refer below image showing soil pressure diagram of base pressure for design load combinations:



Design load combination envelope



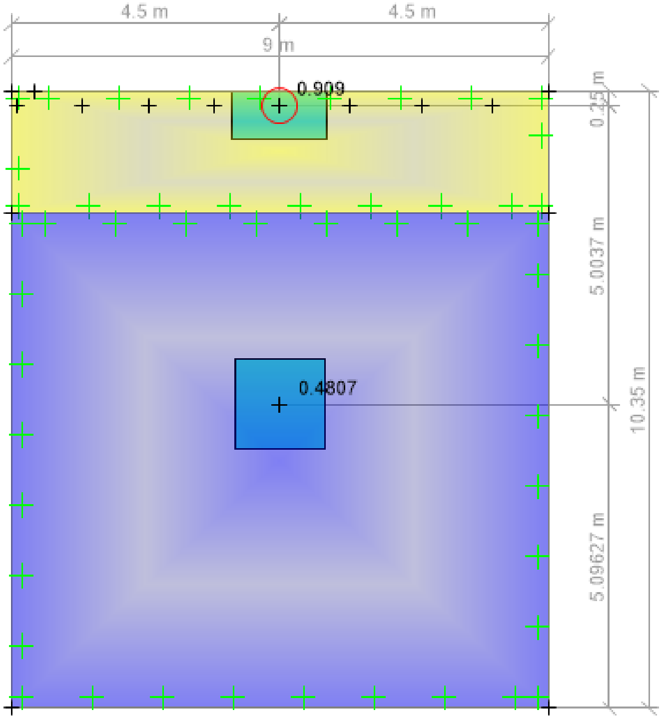
Soil pressure diagram for Seismic ultimate load combination (Max & Min)

Permissible SBC for design load combinations = 575 kN/m^2

Maximum base pressure (Downward) = 540 kN/m^2< 575 kN/m^2 (Hence, OK)

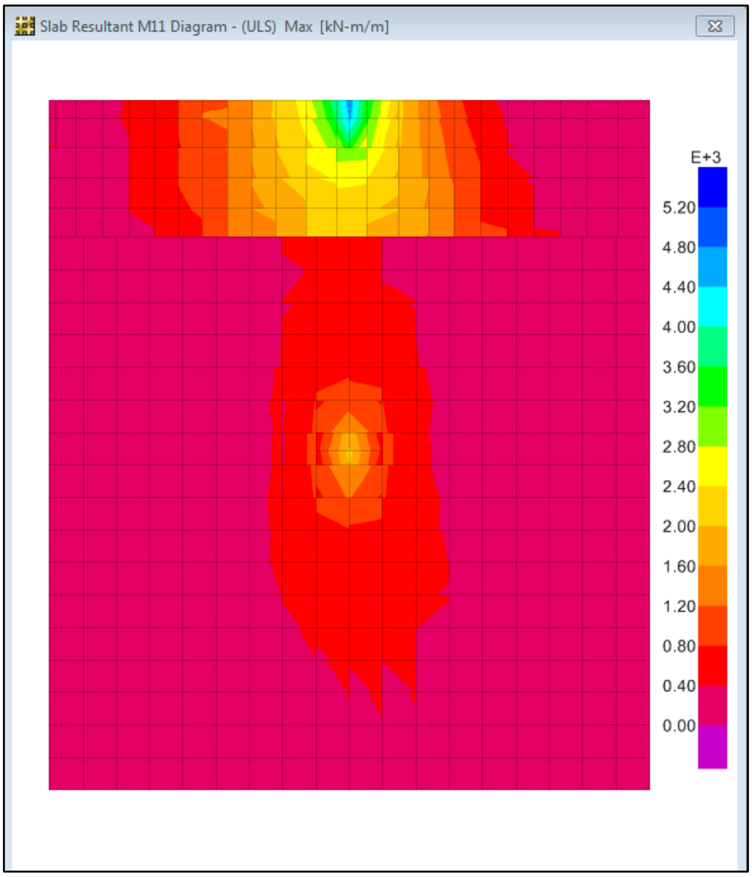
Maximum base pressure (Upward) = 268 kN/m^2

2.6 Punching Shear Check

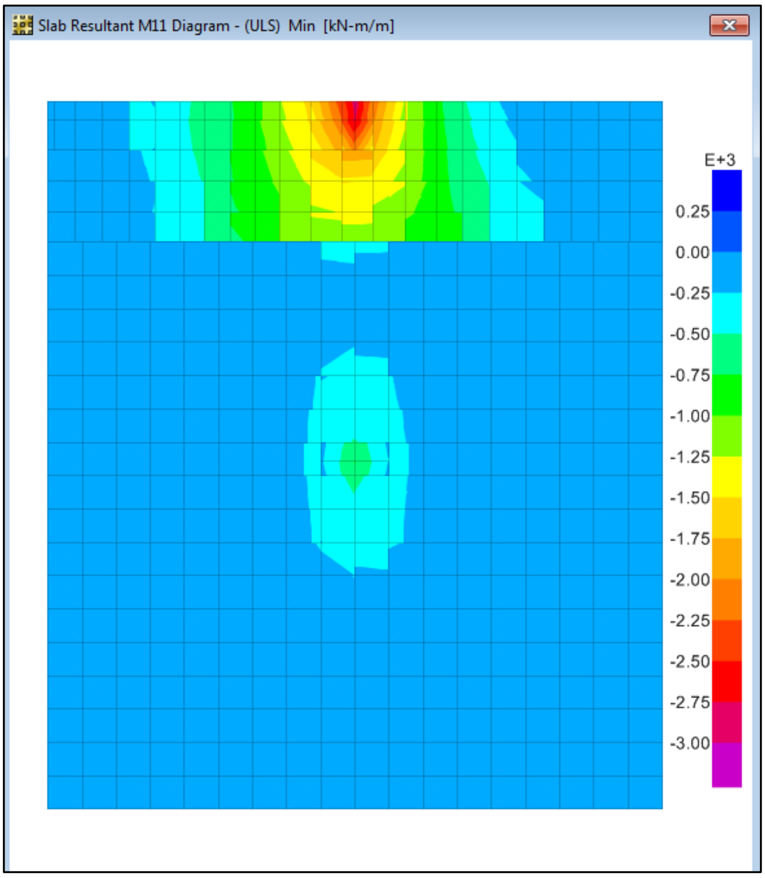


Check for Punching Shear

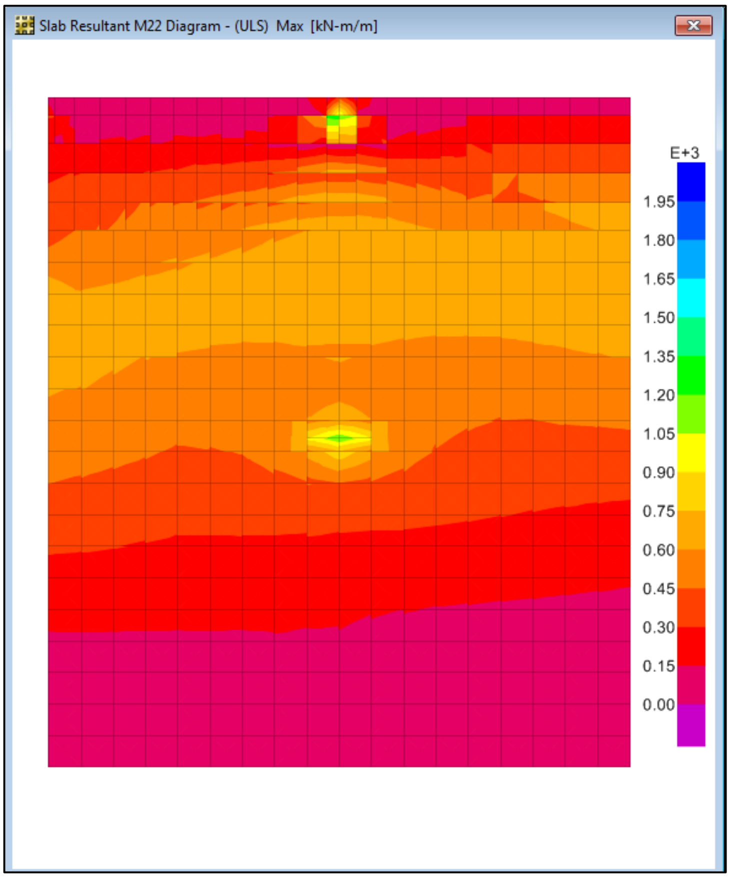
2.7 Moment Diagram:



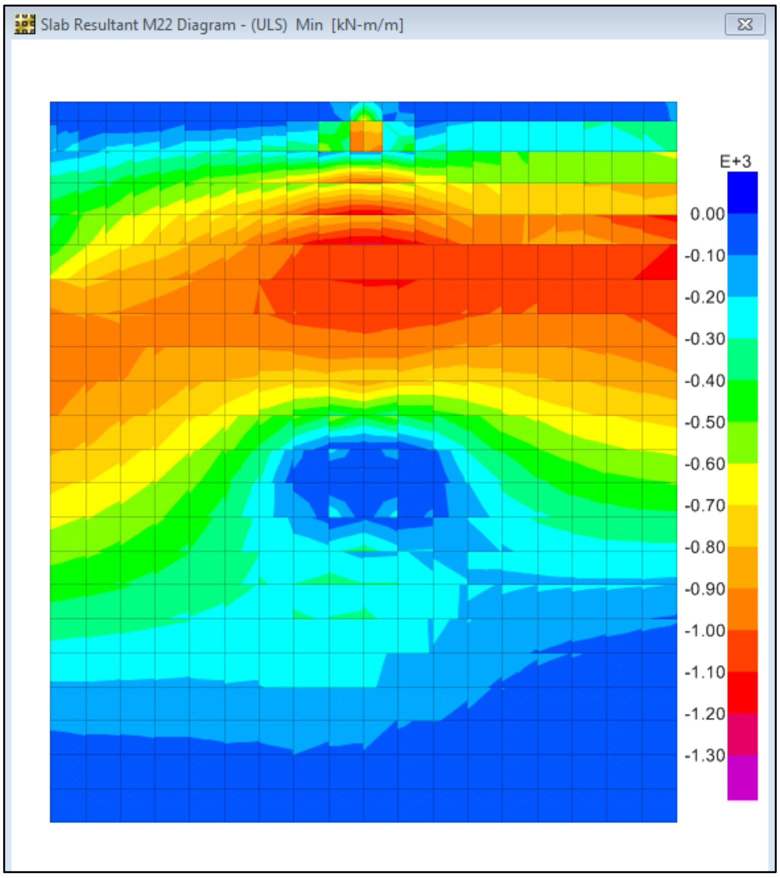
Moment diagram in X-dir for Design load combination (Max)



Moment diagram in X-dir for Design load combination (Min)

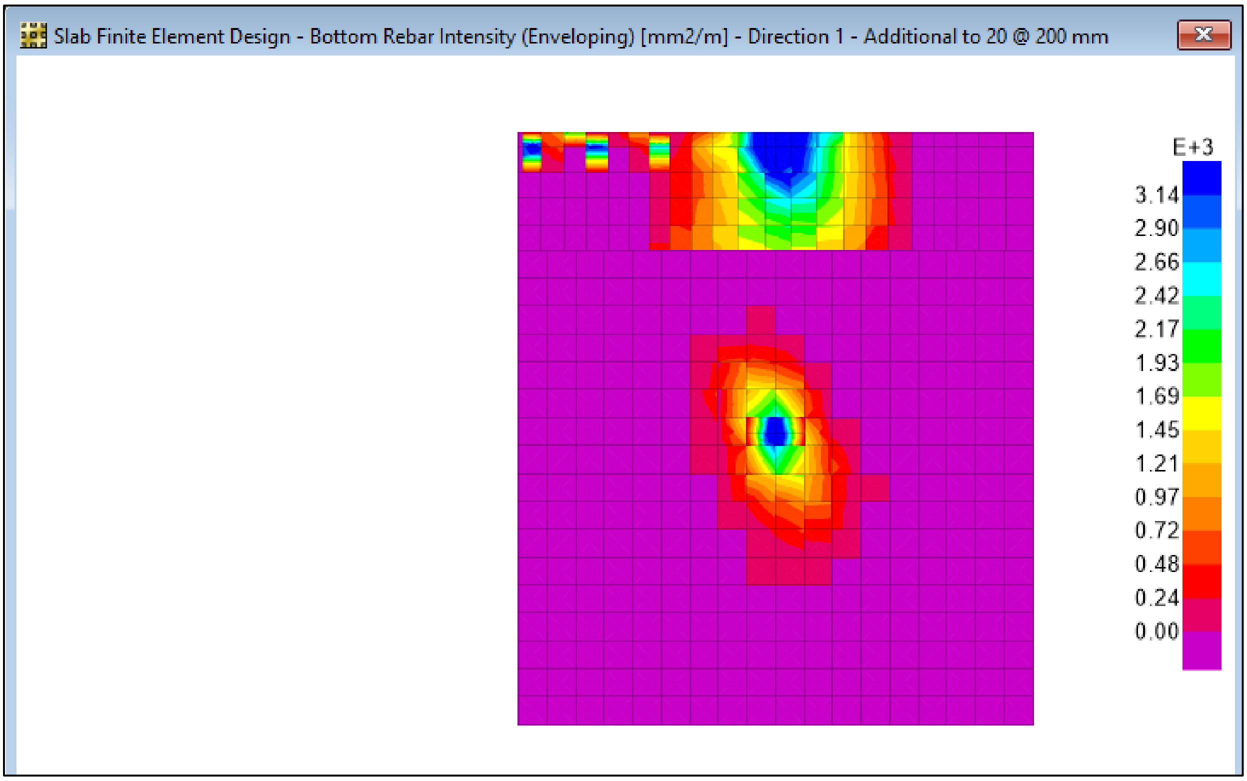


Moment diagram in Y-dir for Design load combination (Max)

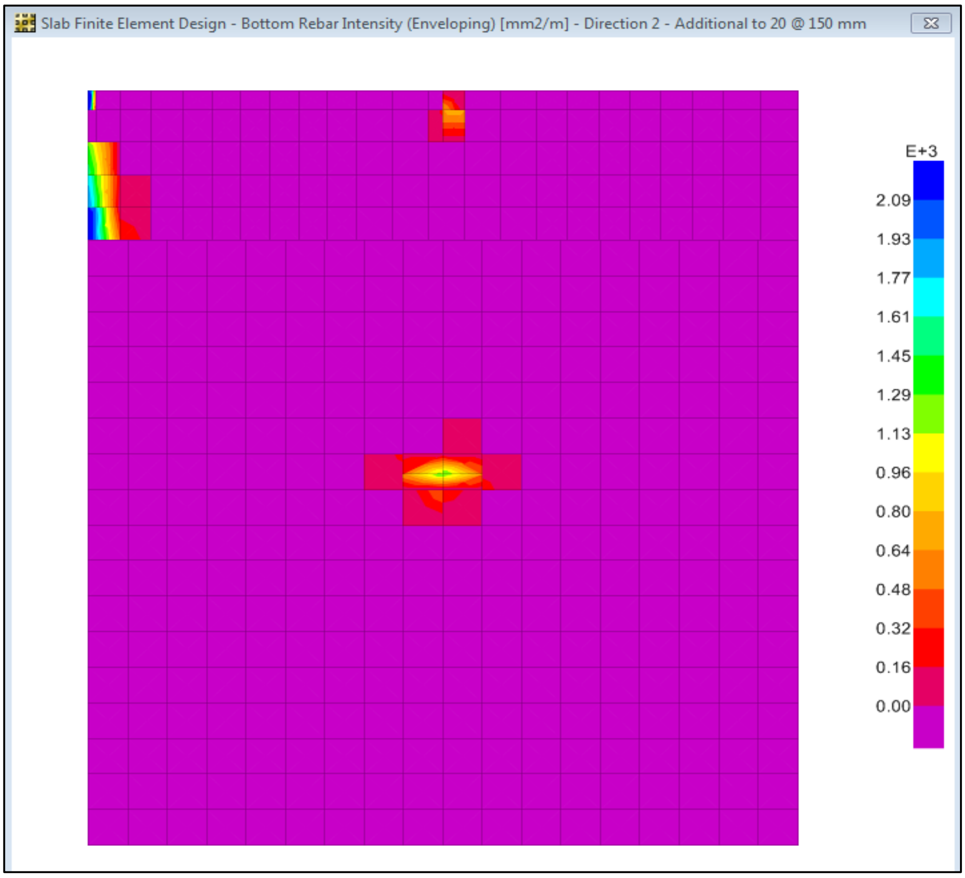


Moment diagram in Y-dir for Design load combination (Min)

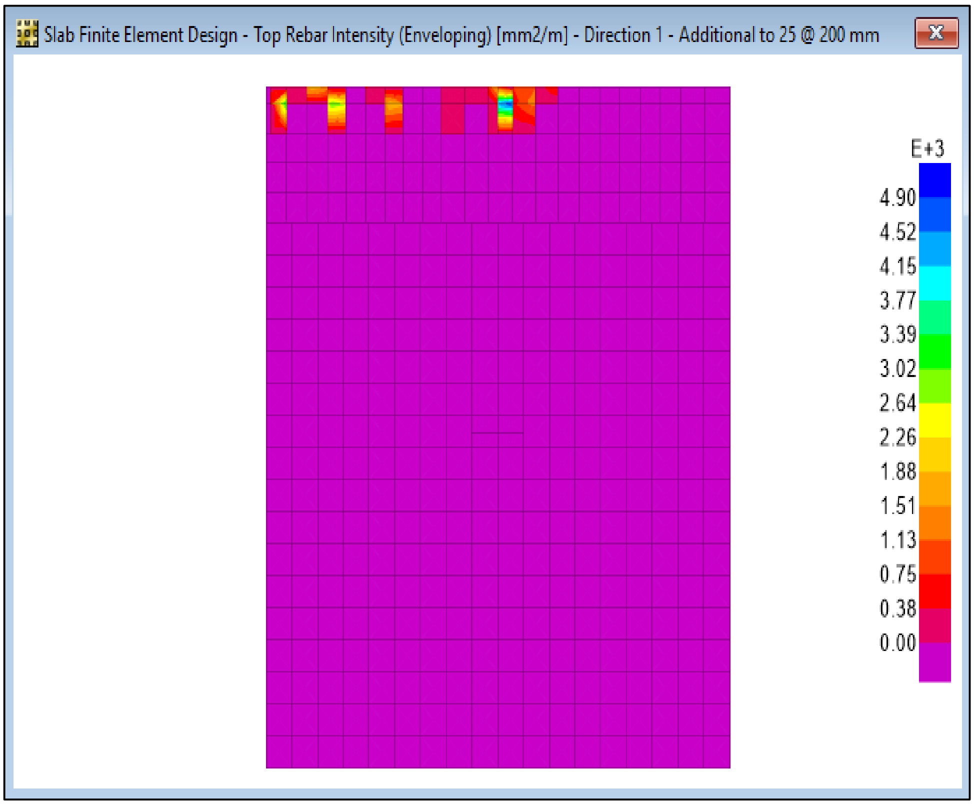
2.8 Design of combined footing:



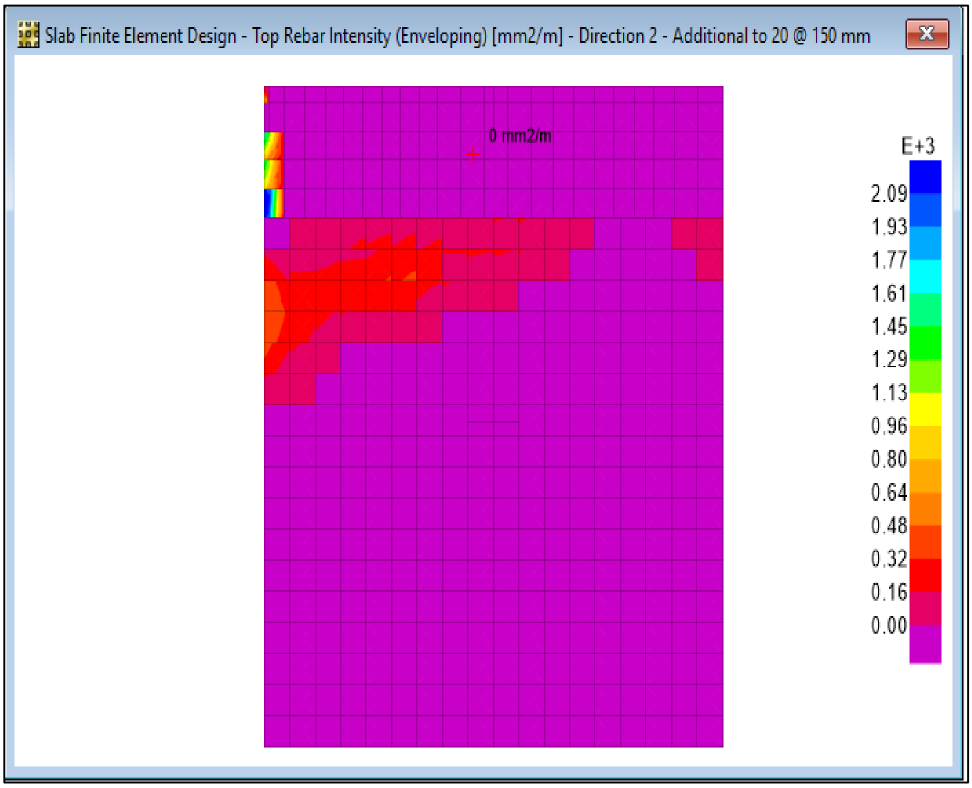
Bottom Reinforcement diagram in X-dir



Bottom Reinforcement diagram in Y-dir



Top Reinforcement diagram in X-dir



Top Reinforcement diagram in Y-dir

3 COMBINED FOOTING CF6

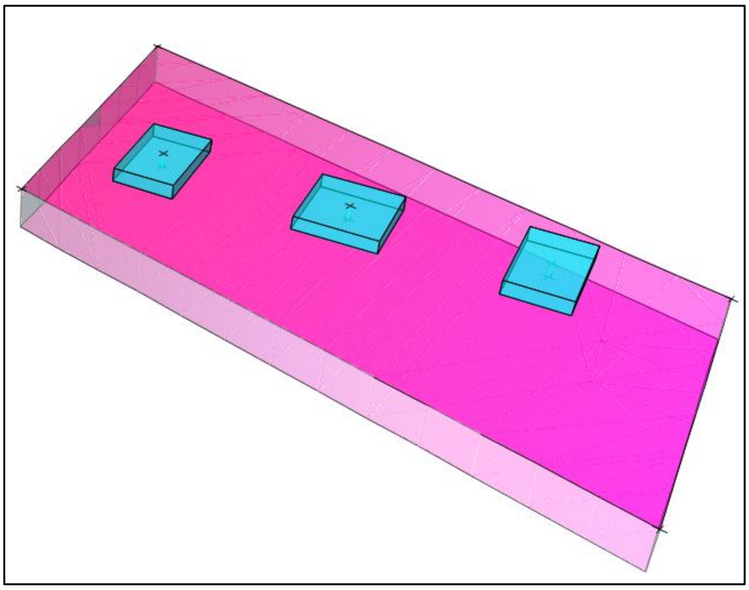
3.1 DESIGN OF CF6

SAFE software is used to design CF6 foundation.

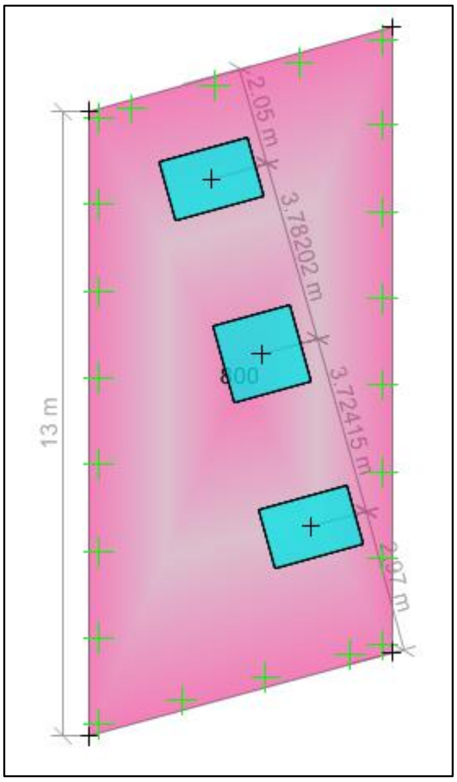
CF6 foundation is modeled in SAFE software as Finite elements. Reactions of wall & column for different load cases are Imported from ETABS as SAFE.F2K file.

Refer below steps showing detailed modeling, analysis and design of CF6 foundation.

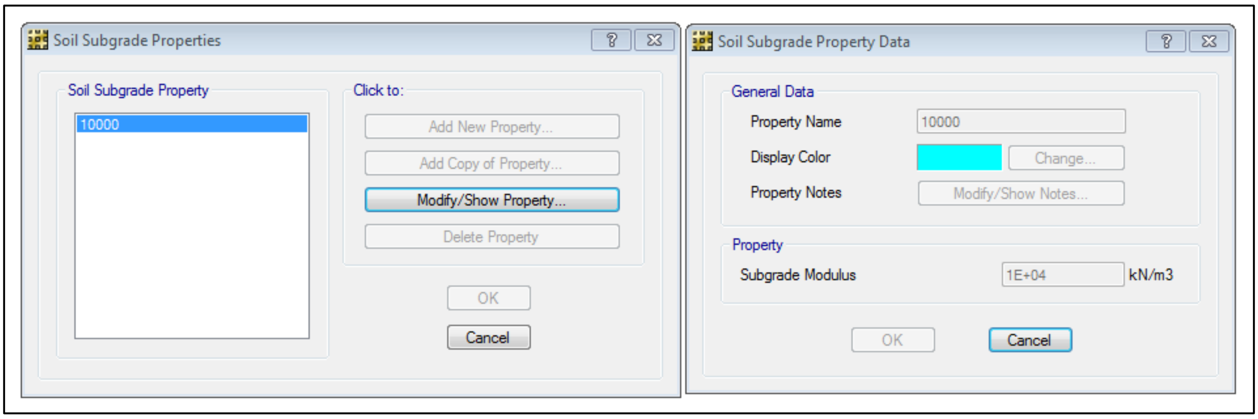
3.2 SAFE MODELING



SAFE modeling of CF6 foundation as finite elements



Properties: 800mm thick slab

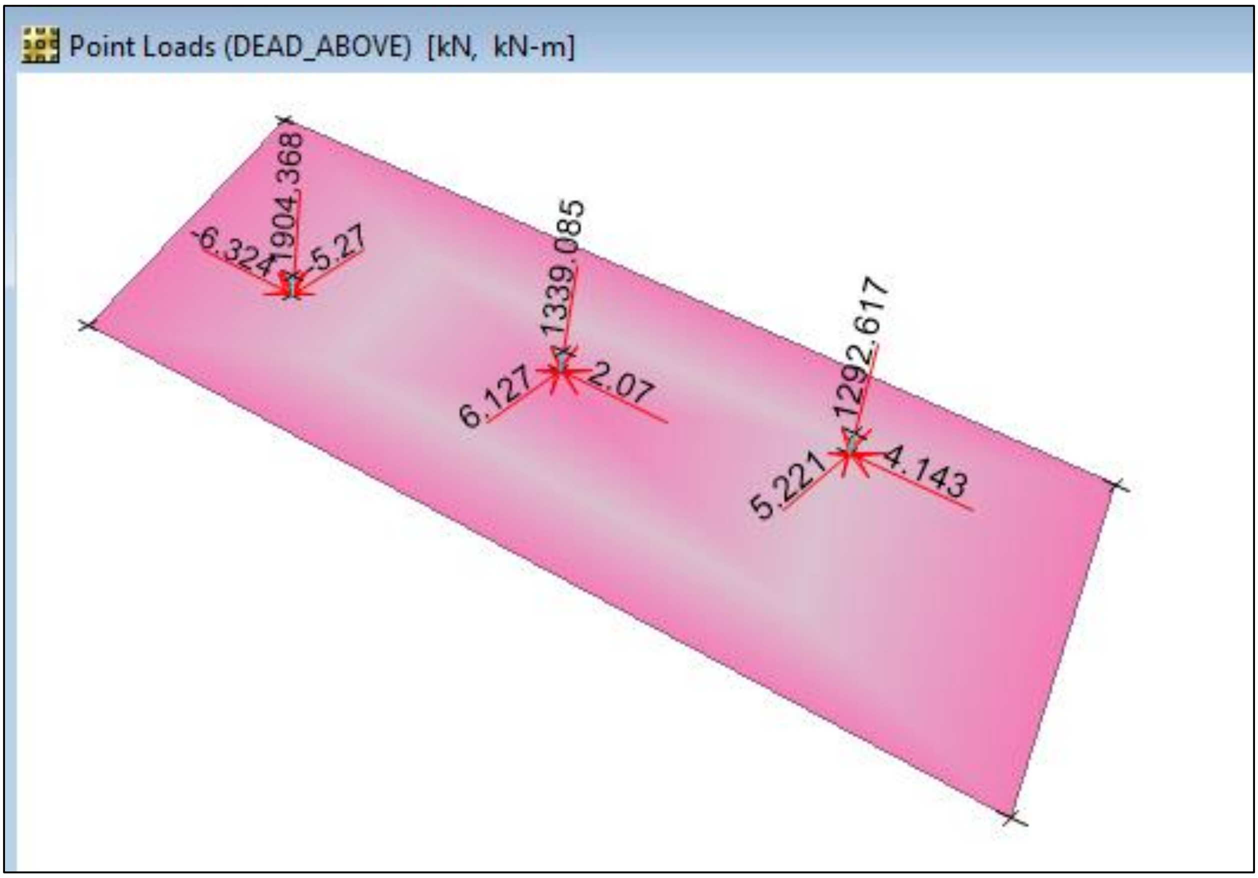


Foundation supports

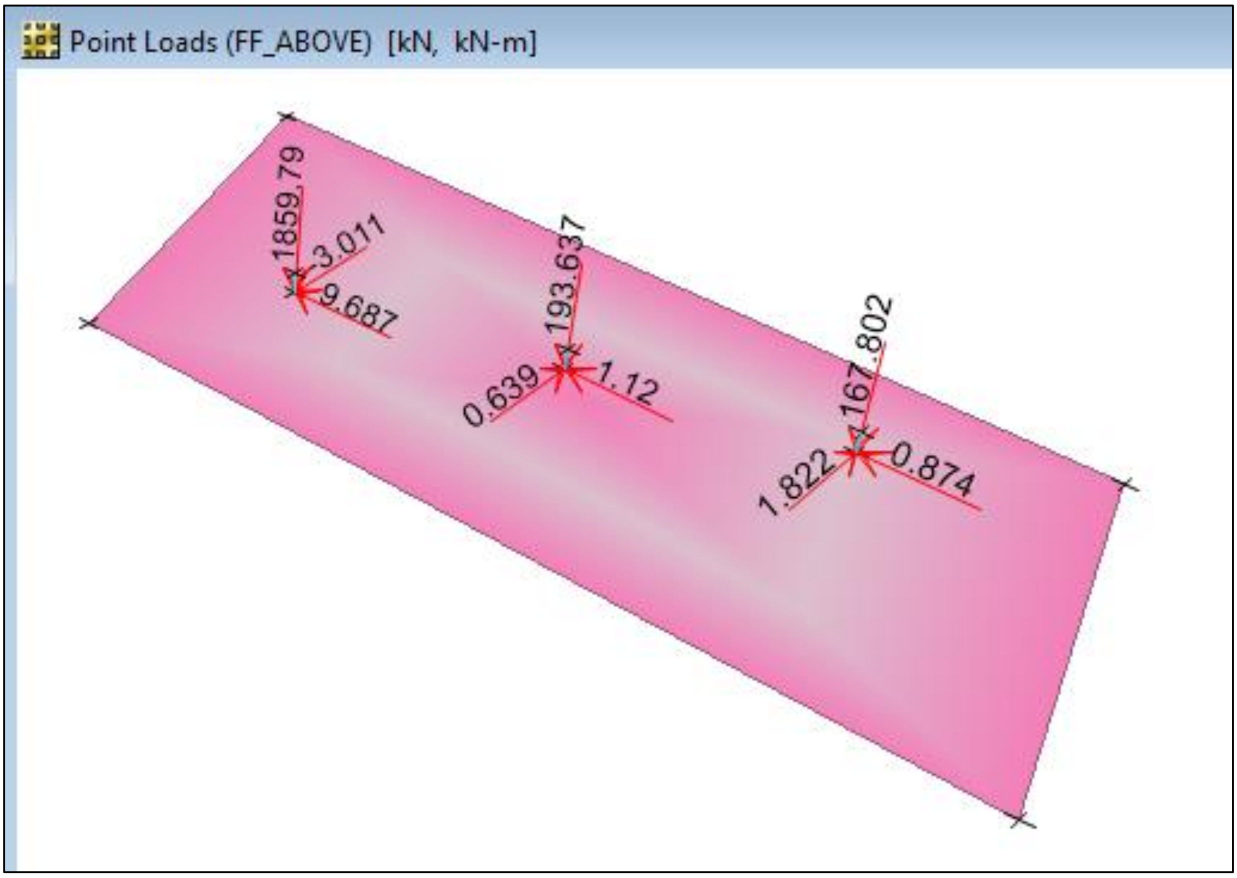
3.3 LOADING

3.3.1 Dead Load

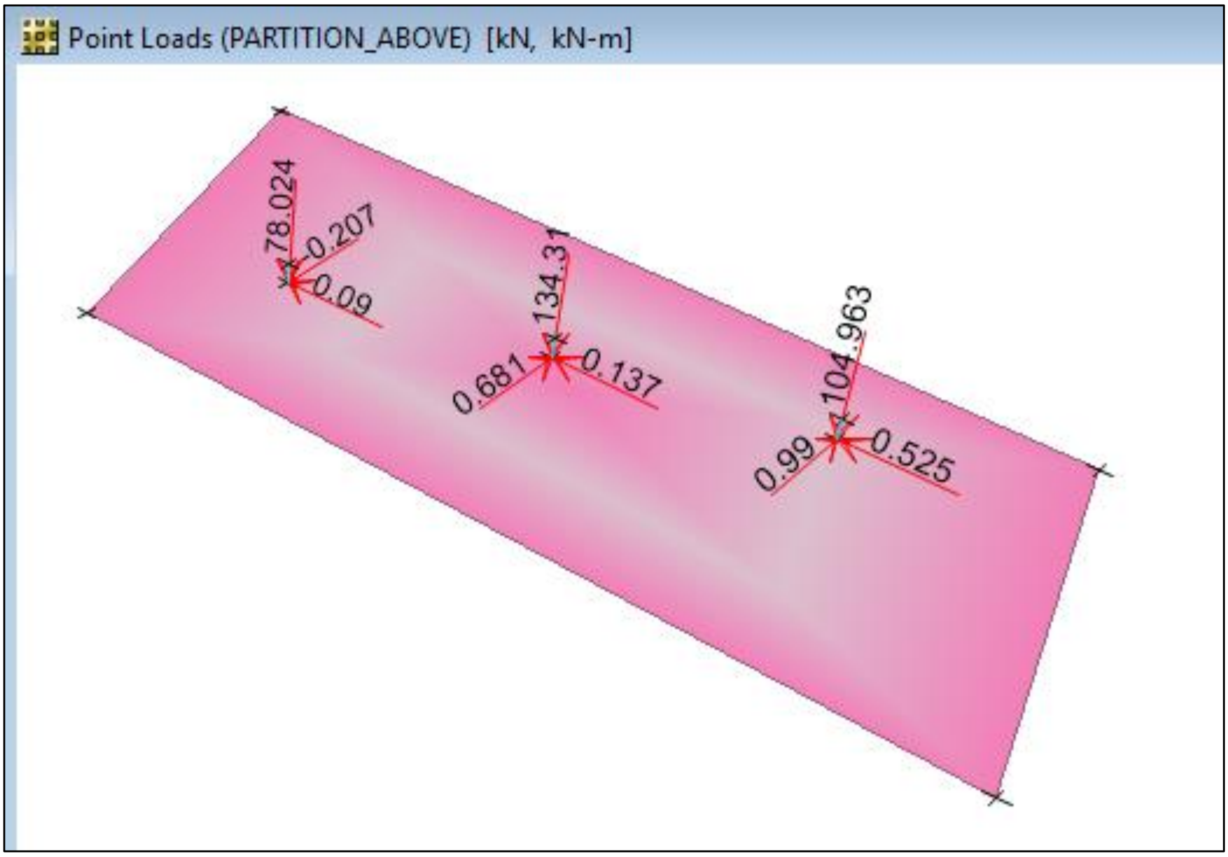
– Dead load obtained from ETABS model



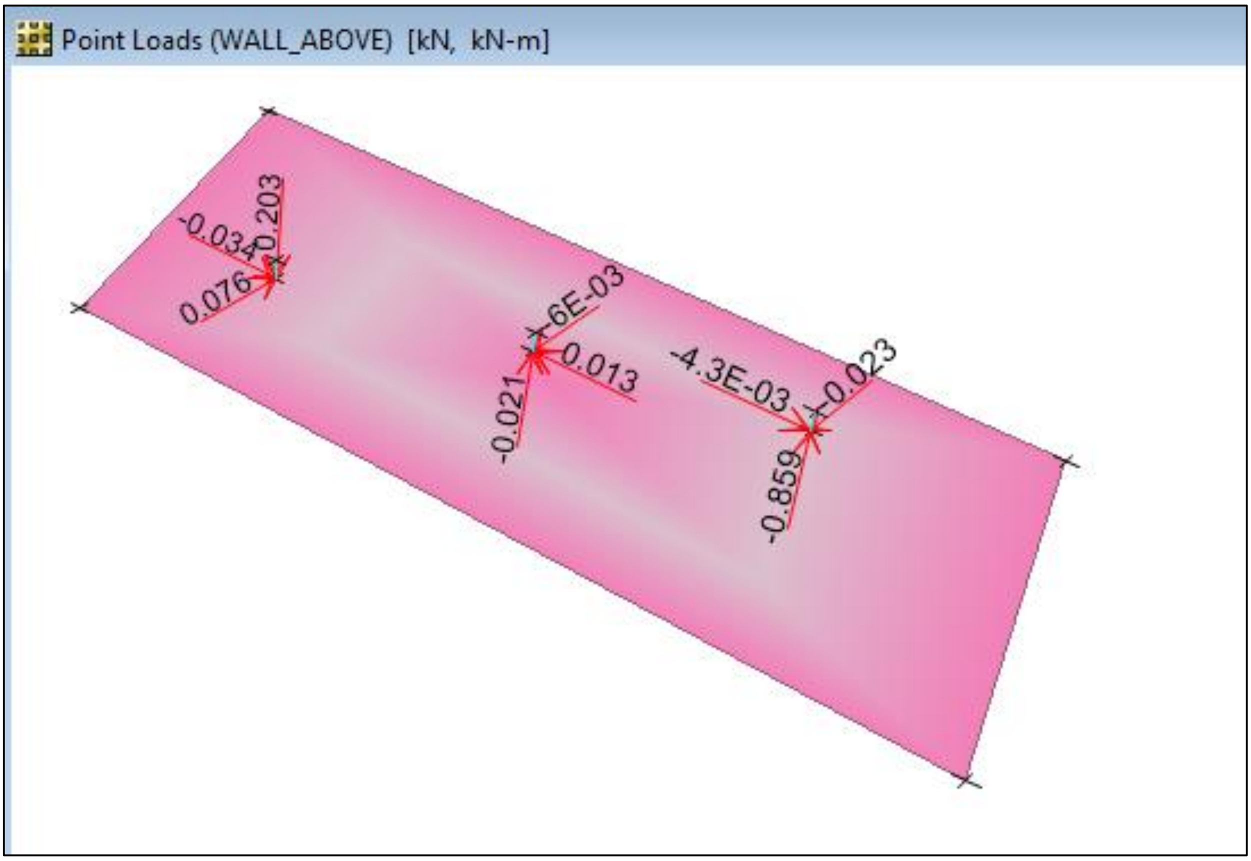
Dead load obtained from ETABS model



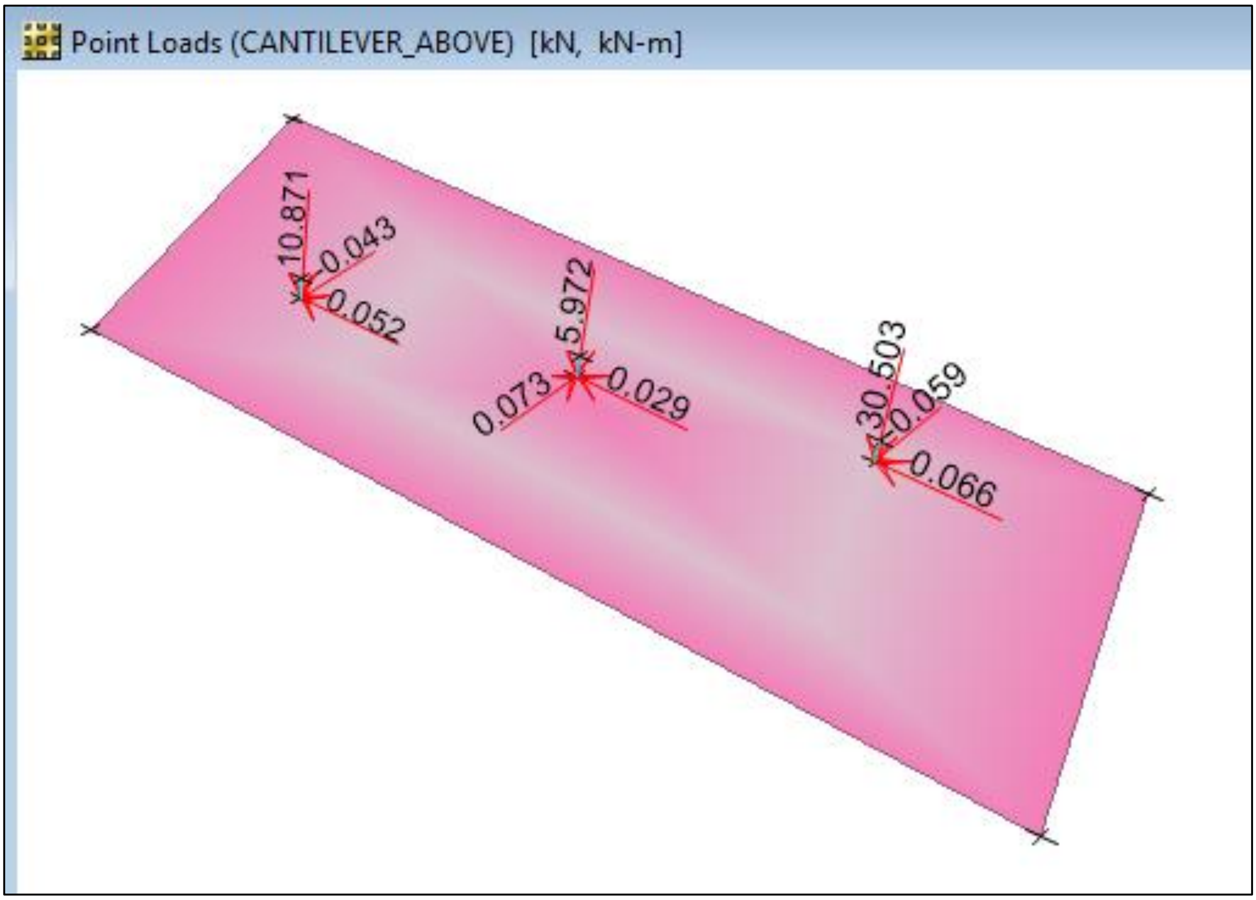
Floor-Finish load obtained from ETABS model



Partition load obtained from ETABS model



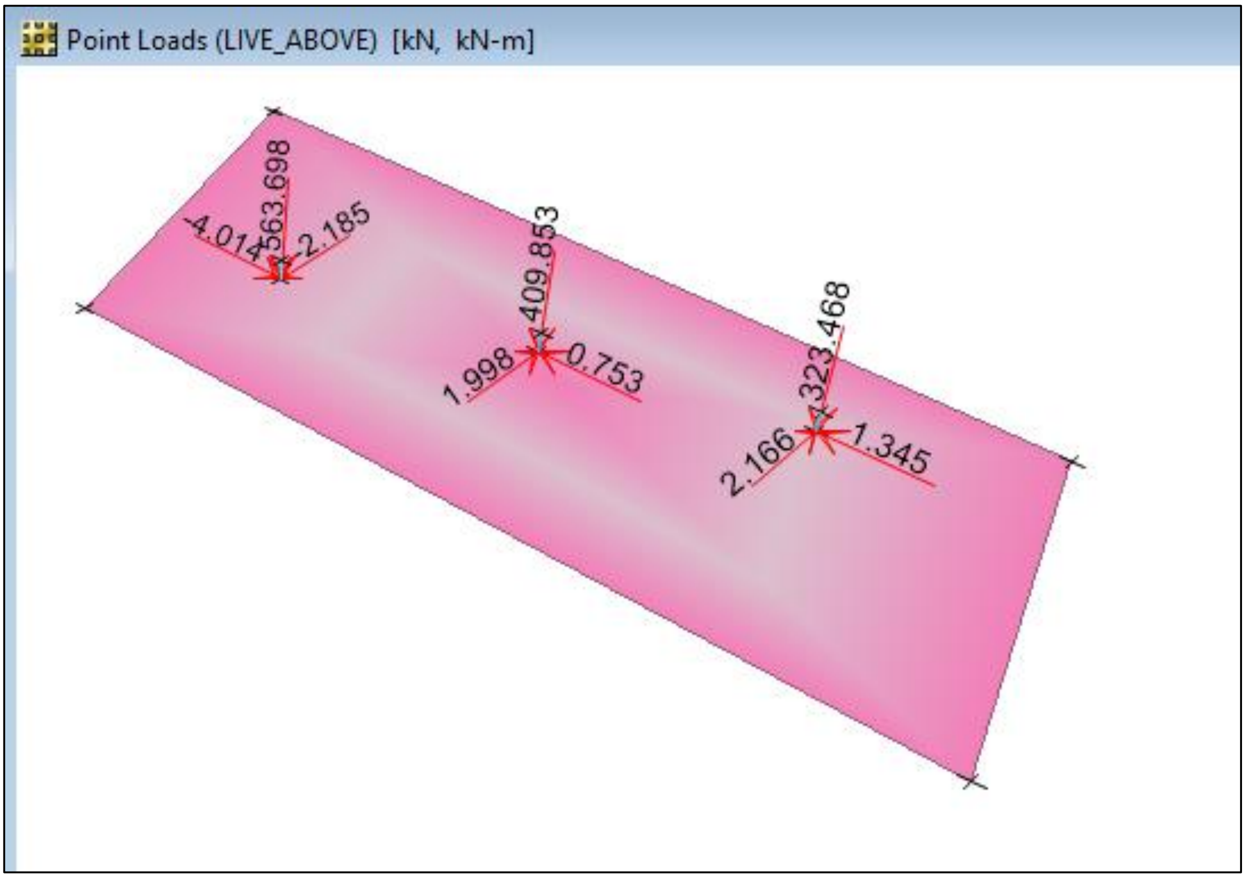
Wall load obtained from ETABS model



Cantilever load obtained from ETABS model

3.3.2 Live Load

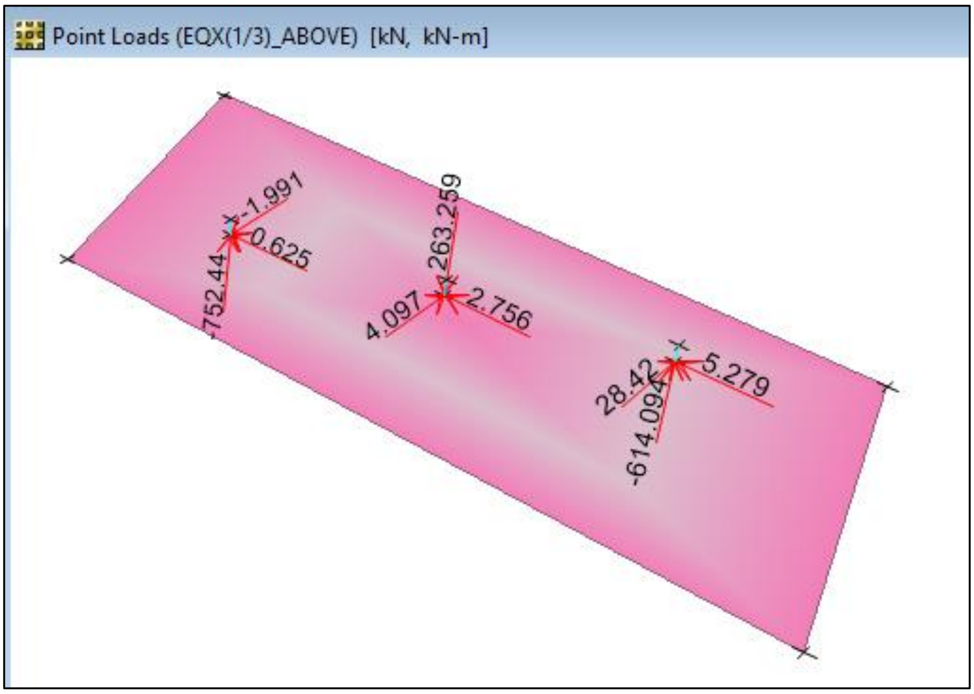
– Live load obtained from ETABS model

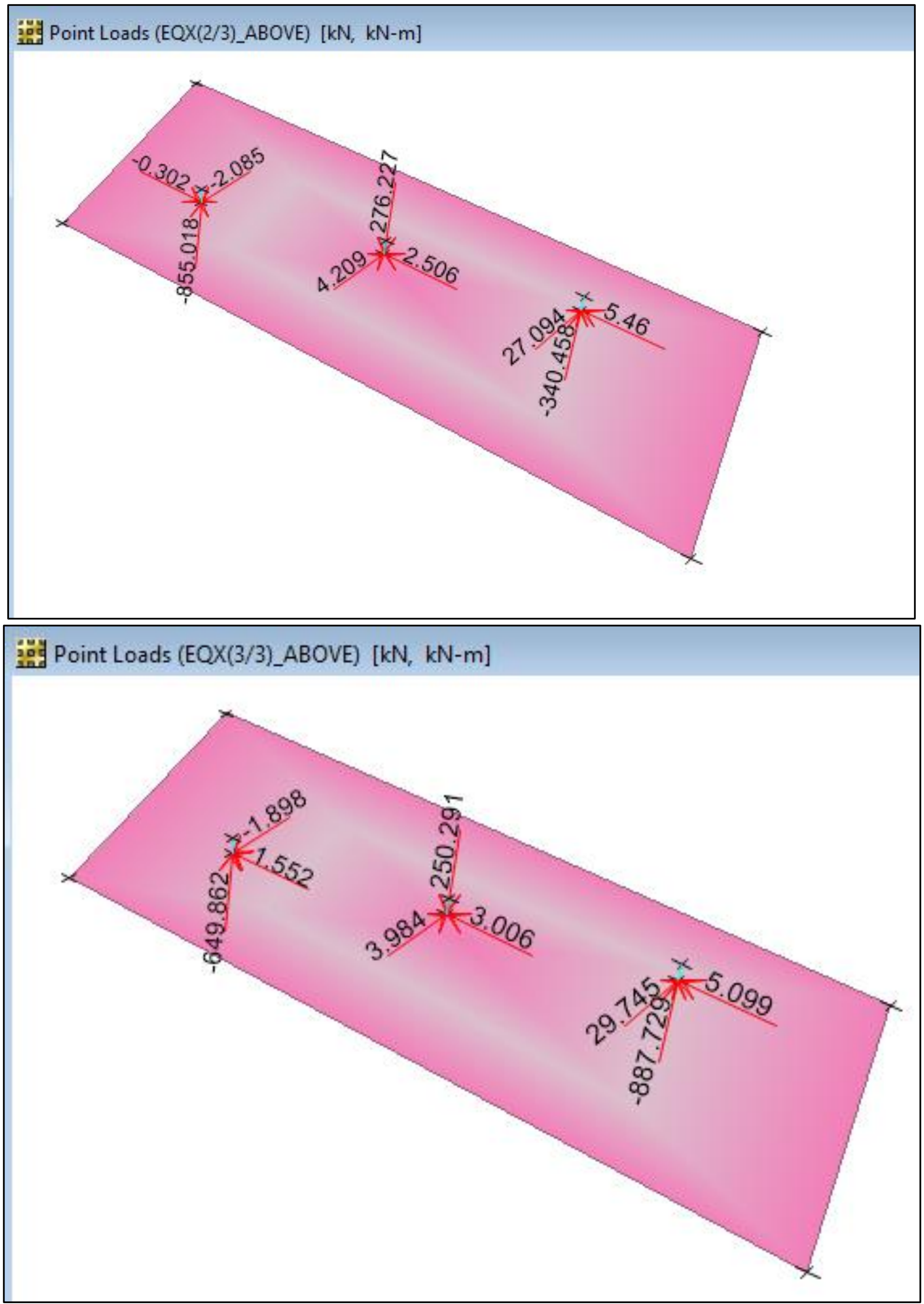


Live load obtained from ETABS model

3.3.3 EQX (Seismic Force in X-Direction)

– Seismic loads obtained from reactions of ETABS model

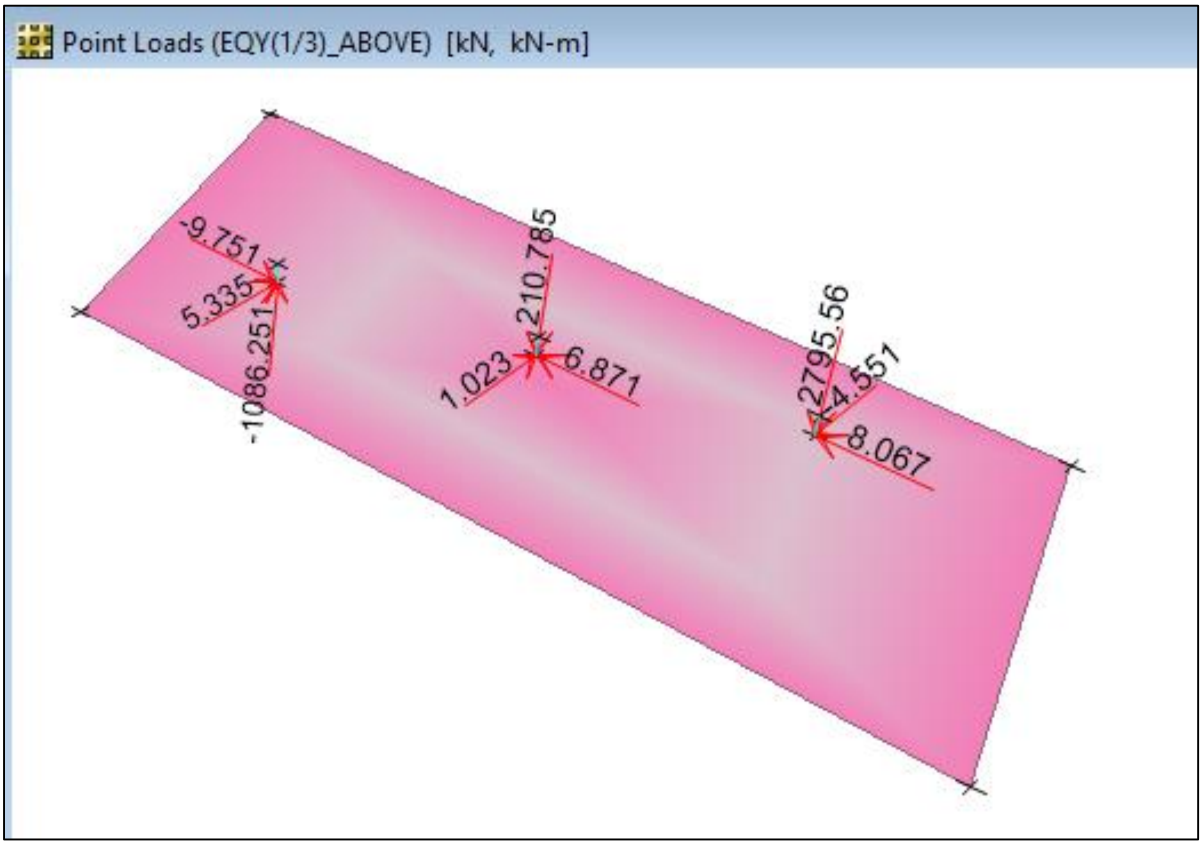


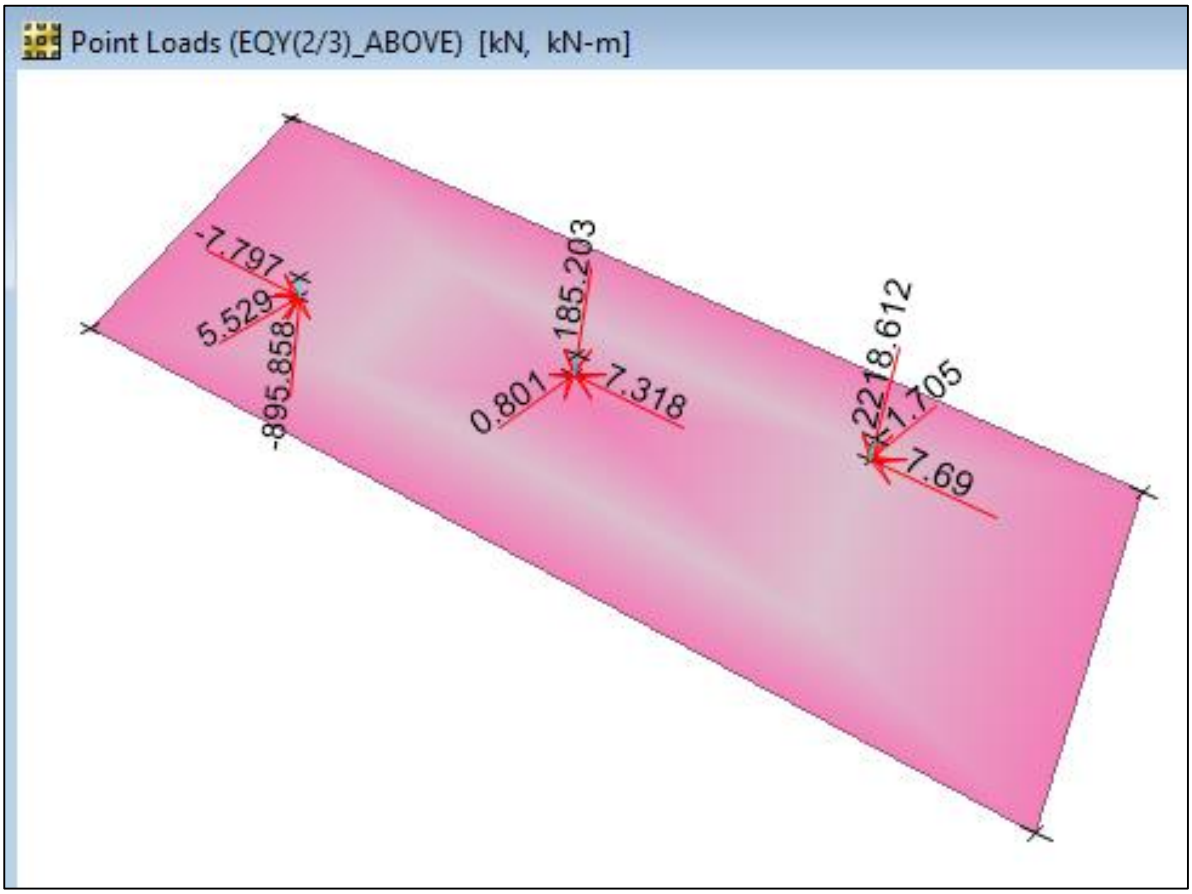


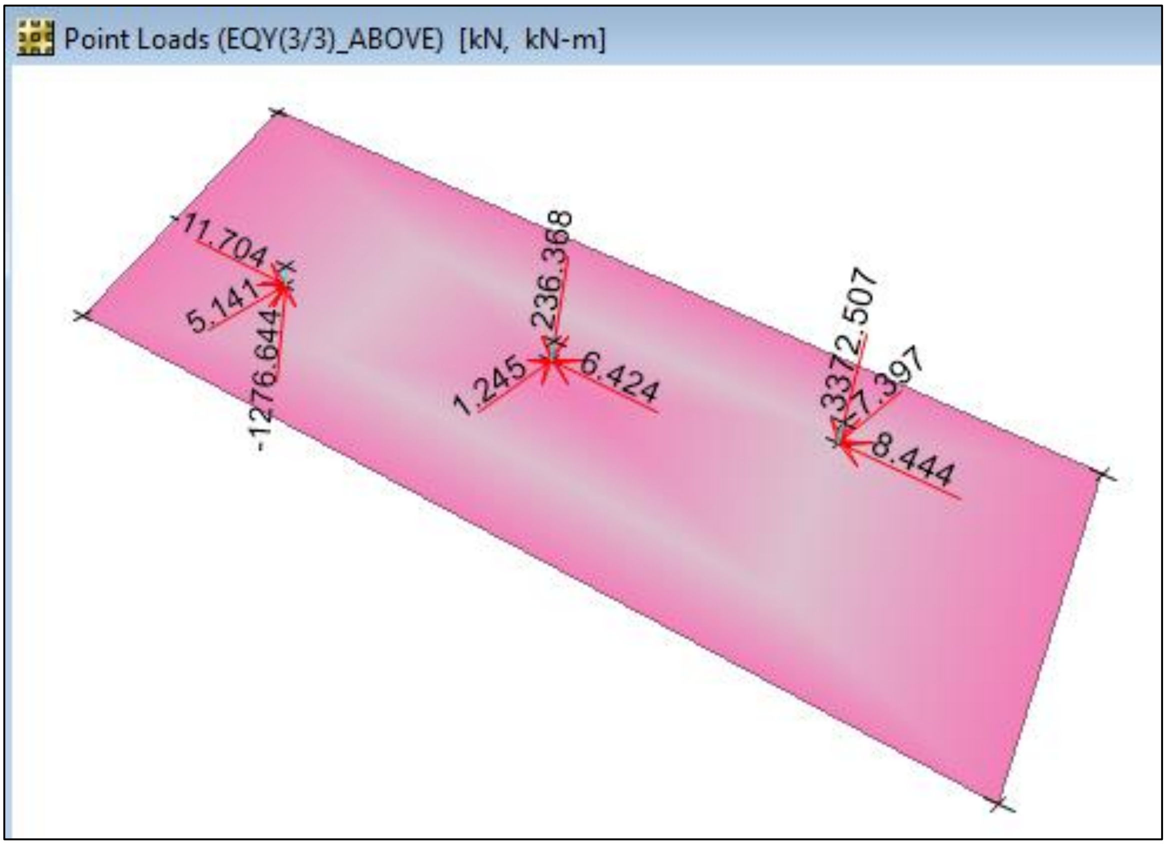
EQX obtained from ETABS model

3.3.4 EQY (Seismic Force in Y-Direction)

- Seismic loads obtained from ETABS model







EQY obtained from ETABS model

3.4 Load Combinations

Design load combinations

1.35DL
1.2DL + 1.5LL
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE - Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE -X
1.0DL +0.3LL + 1.0 EARTHQUAKE – Y + 0.3 EARTHQUAKE –X

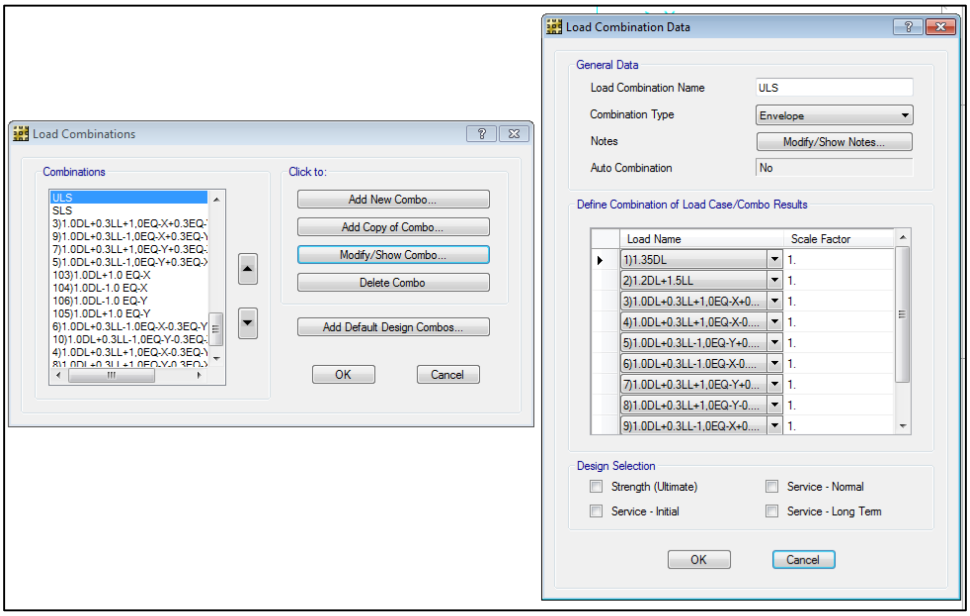
Serviceability load combinations

1.0DL + 1.0LL
1.0DL + 1.0EQX
1.0DL - 1.0EQX
1.0DL + 1.0EQY
1.0DL - 1.0EQY

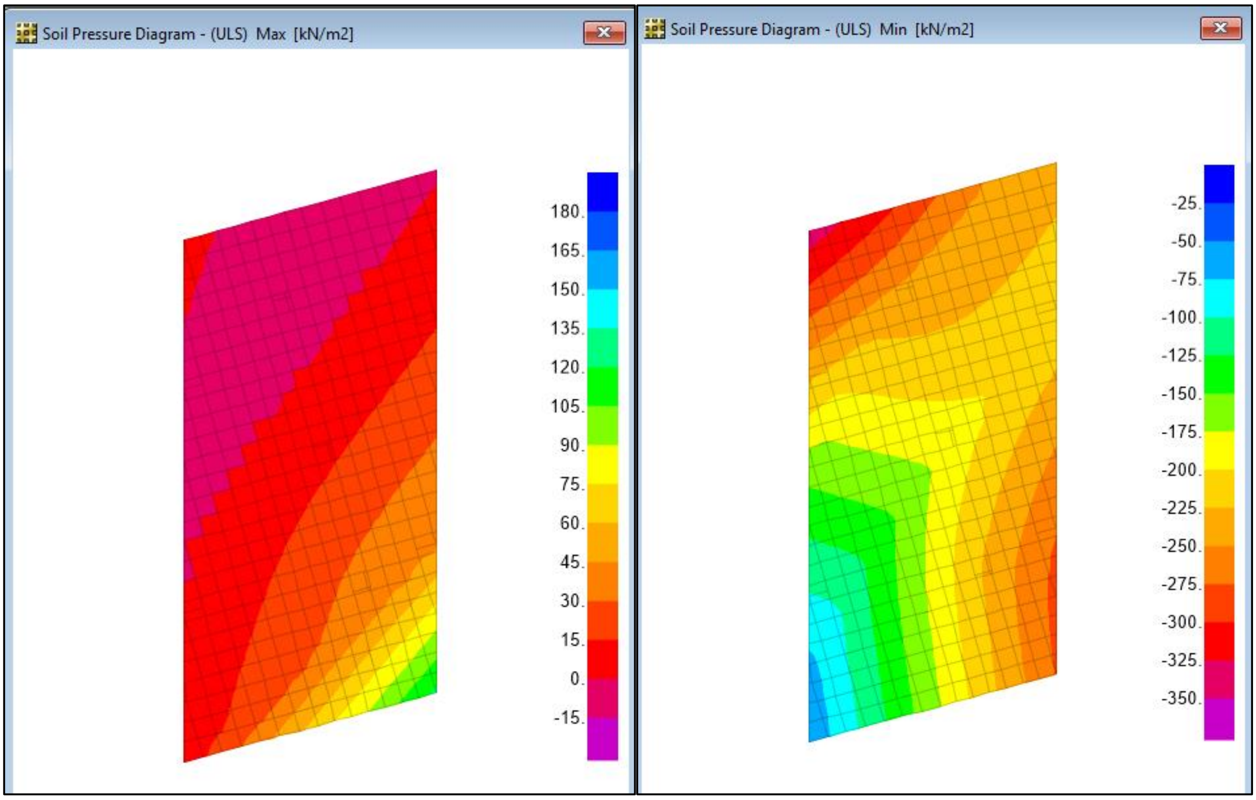
3.5 Base Pressure Check

3.5.1 Check of maximum base pressure for design load combinations:

Refer below image showing soil pressure diagram of base pressure for design load combinations:



Design load combination envelope



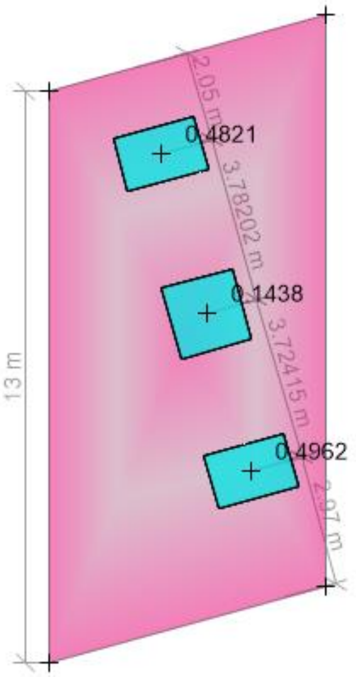
Soil pressure diagram for Seismic ultimate load combination (Max & Min)

Permissible SBC for design load combinations = 575 kN/m^2

Maximum base pressure (Downward) = 339 kN/m^2< 575 kN/m^2 (Hence, OK)

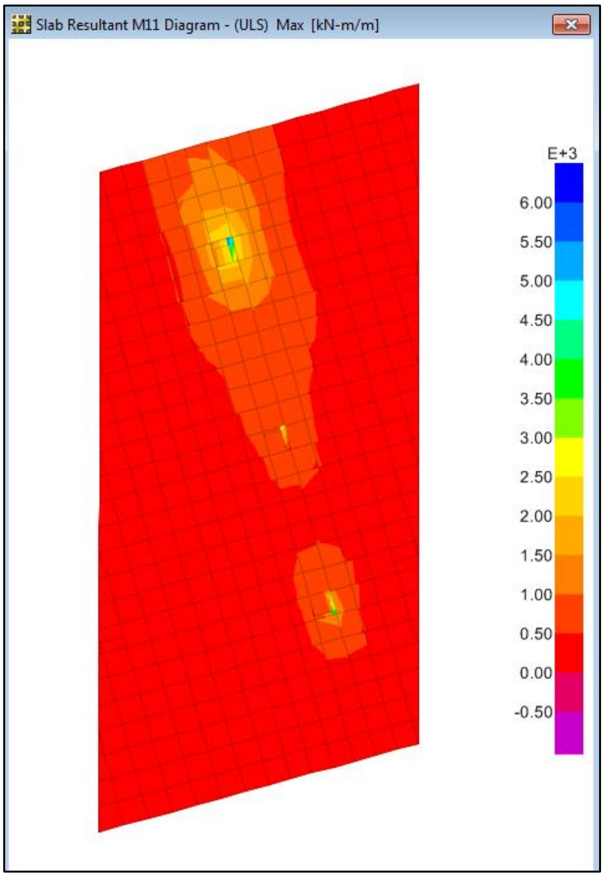
Maximum base pressure (Upward) = 122 kN/m^2

3.6 Punching Shear Check

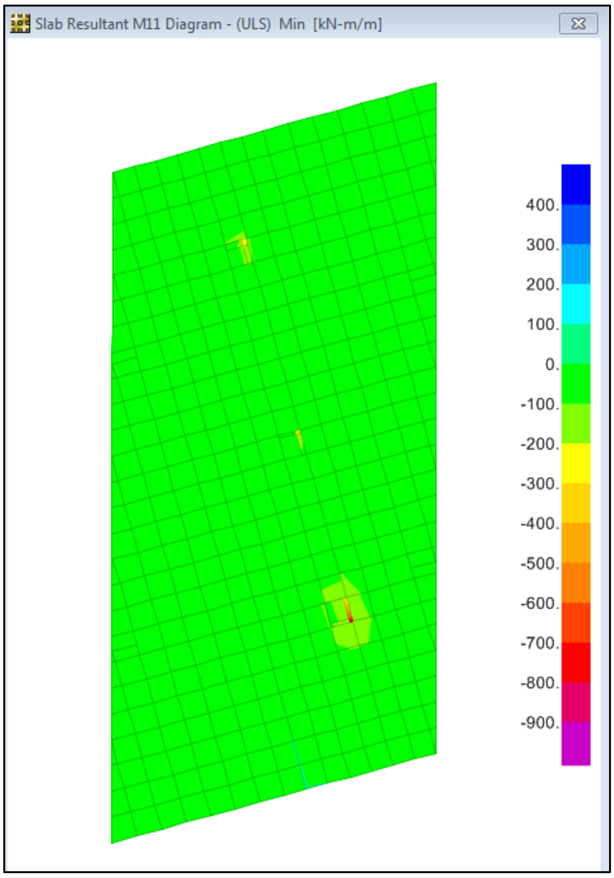


Check for Punching Shear

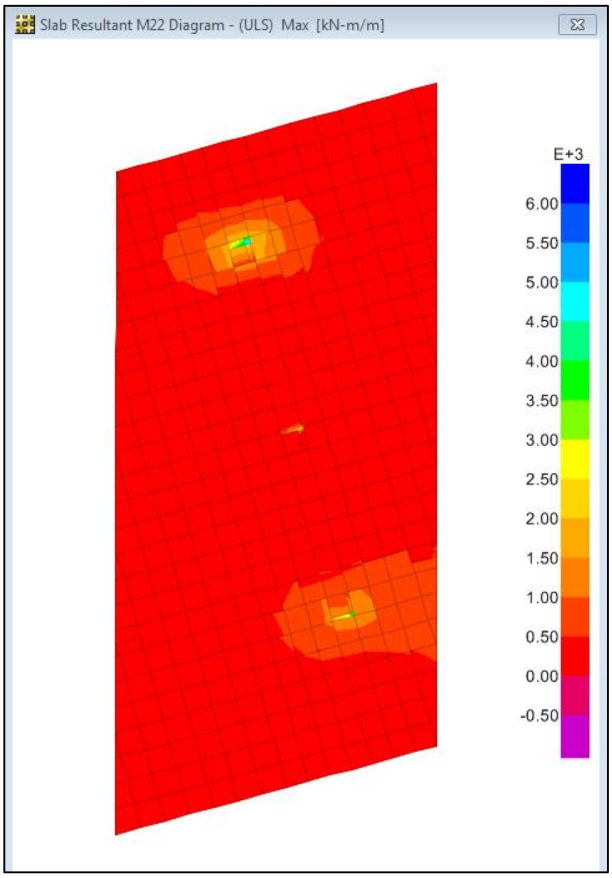
3.7 Moment Diagram:



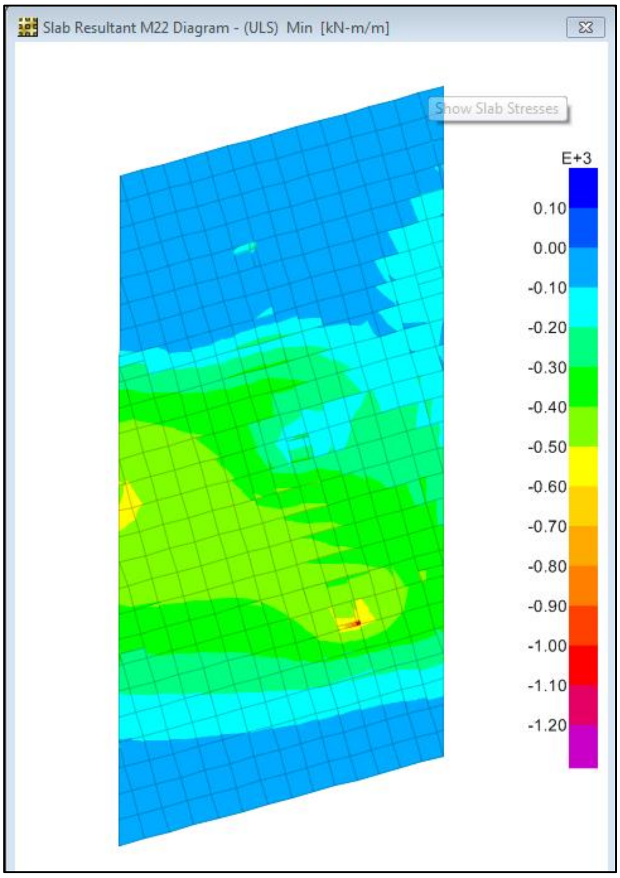
Moment diagram in X-dir for Design load combination (Max)



Moment diagram in X-dir for Design load combination (Min)

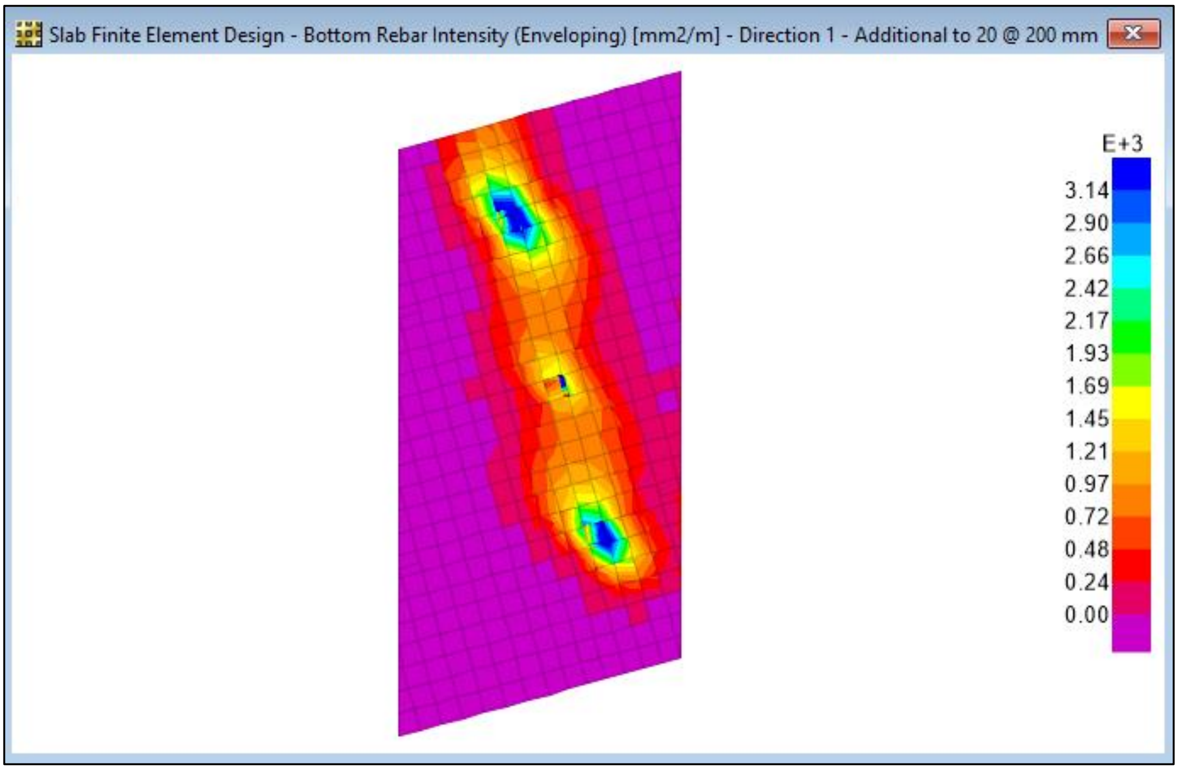


Moment diagram in Y-dir for Design load combination (Max)

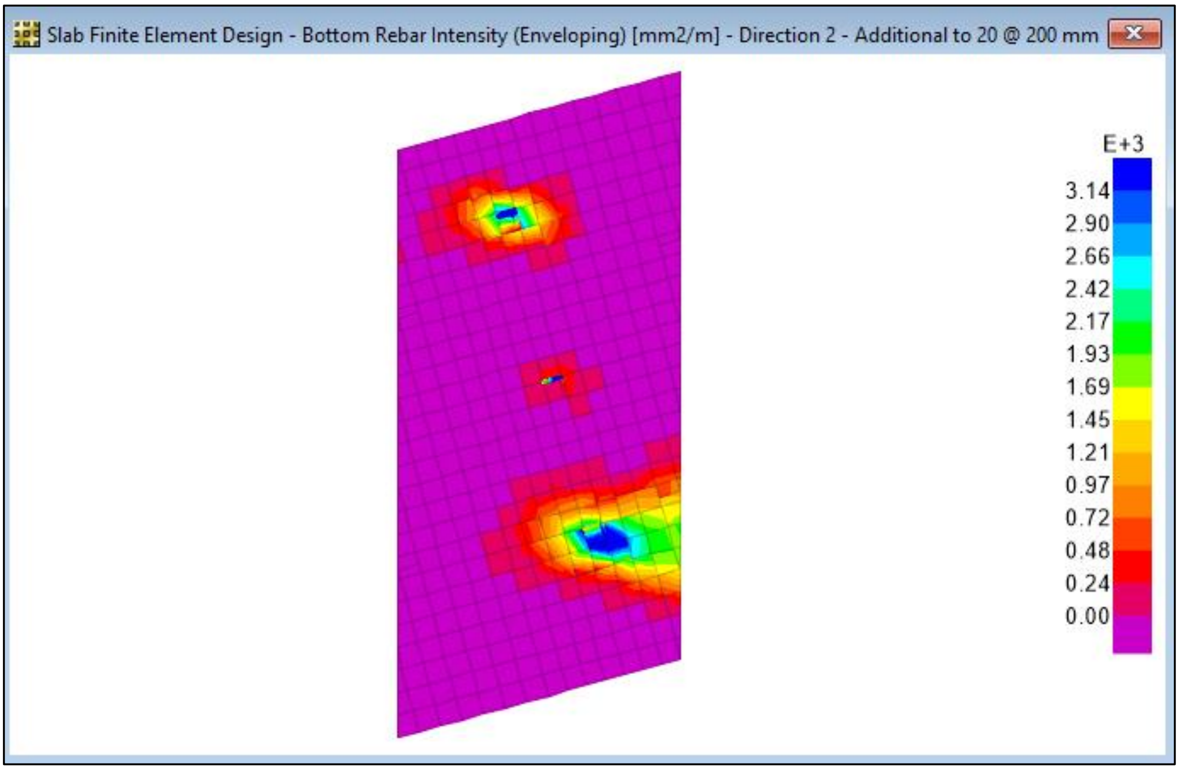


Moment diagram in Y-dir for Design load combination (Min)

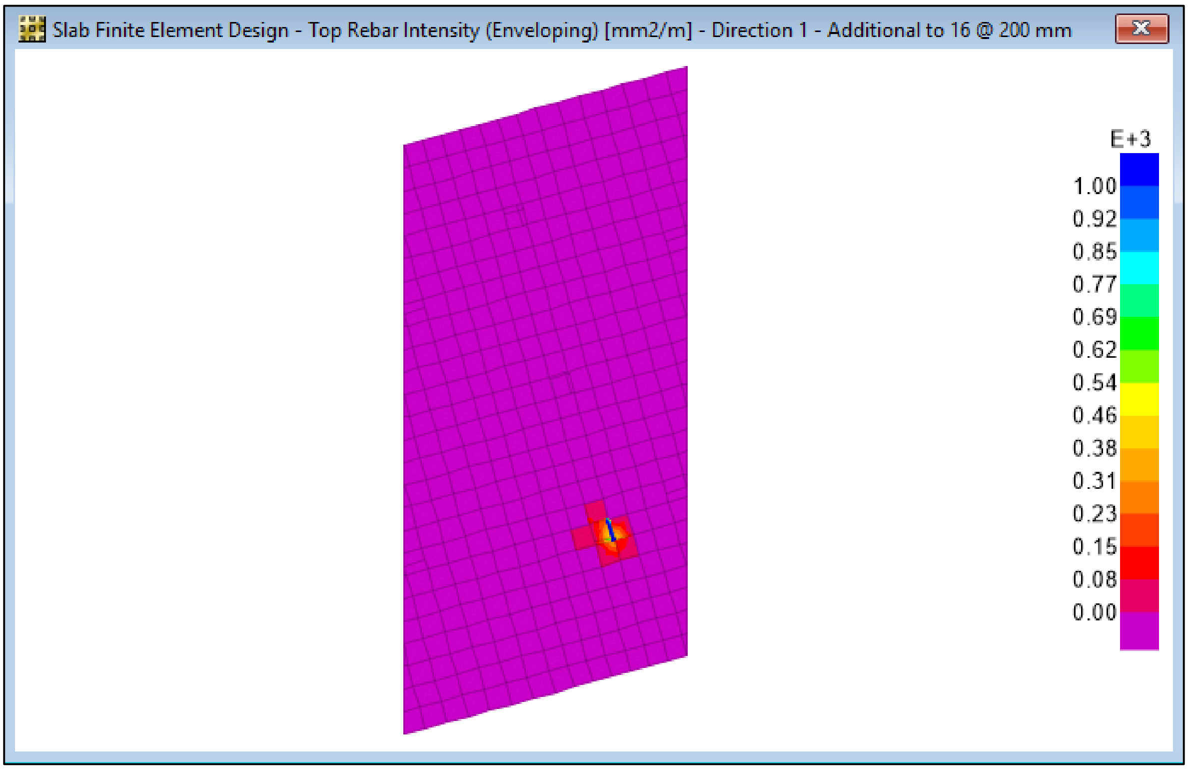
3.8 Design of combined footing:



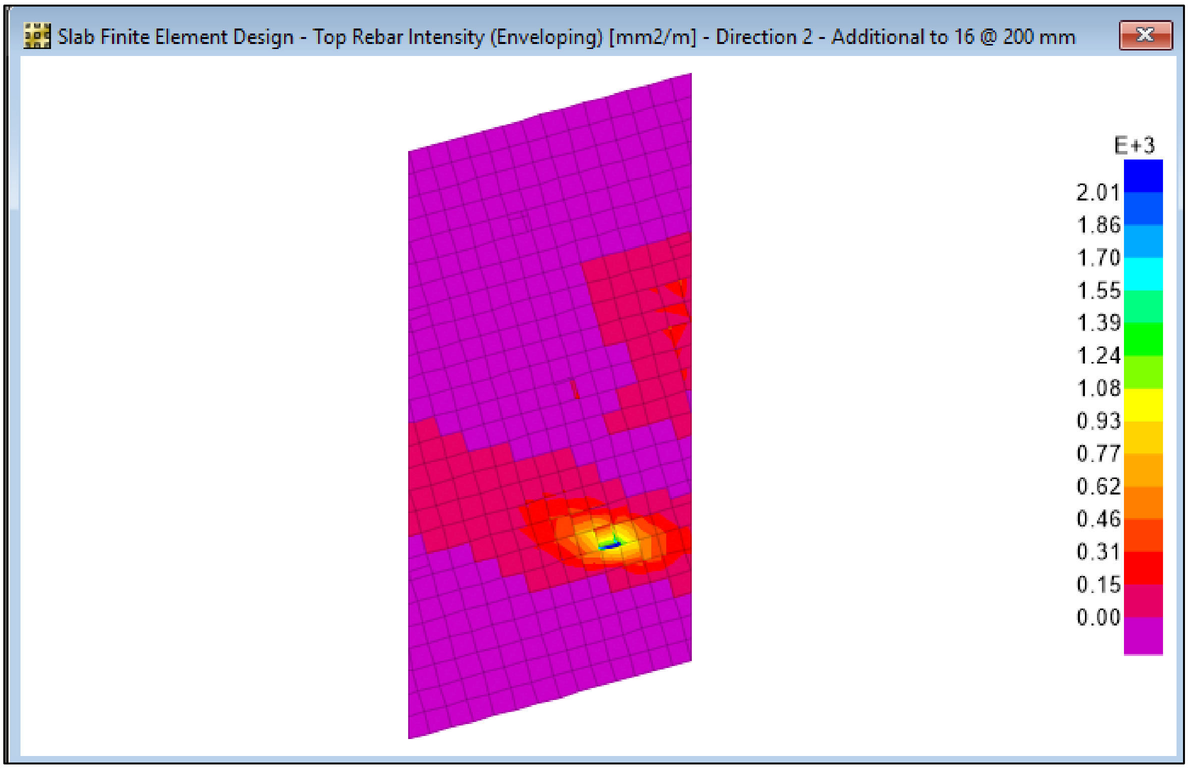
Bottom Reinforcement diagram in X-dir



Bottom Reinforcement diagram in Y-dir



Top Reinforcement diagram in X-dir



Top Reinforcement diagram in Y-dir

4 COMBINED FOOTING CF3 & CF4

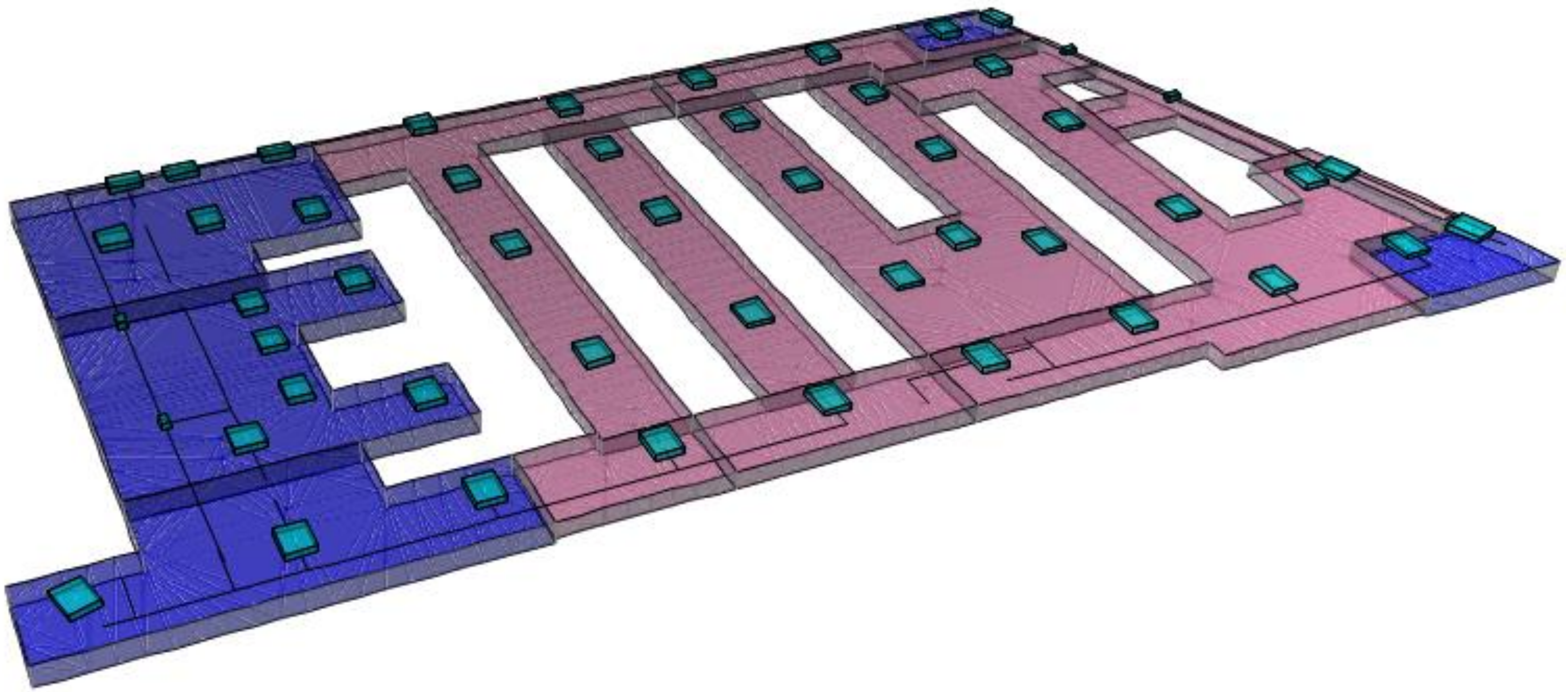
4.1 DESIGN OF CF3 & CF4

SAFE software is used to design CF3-CF4 foundation.

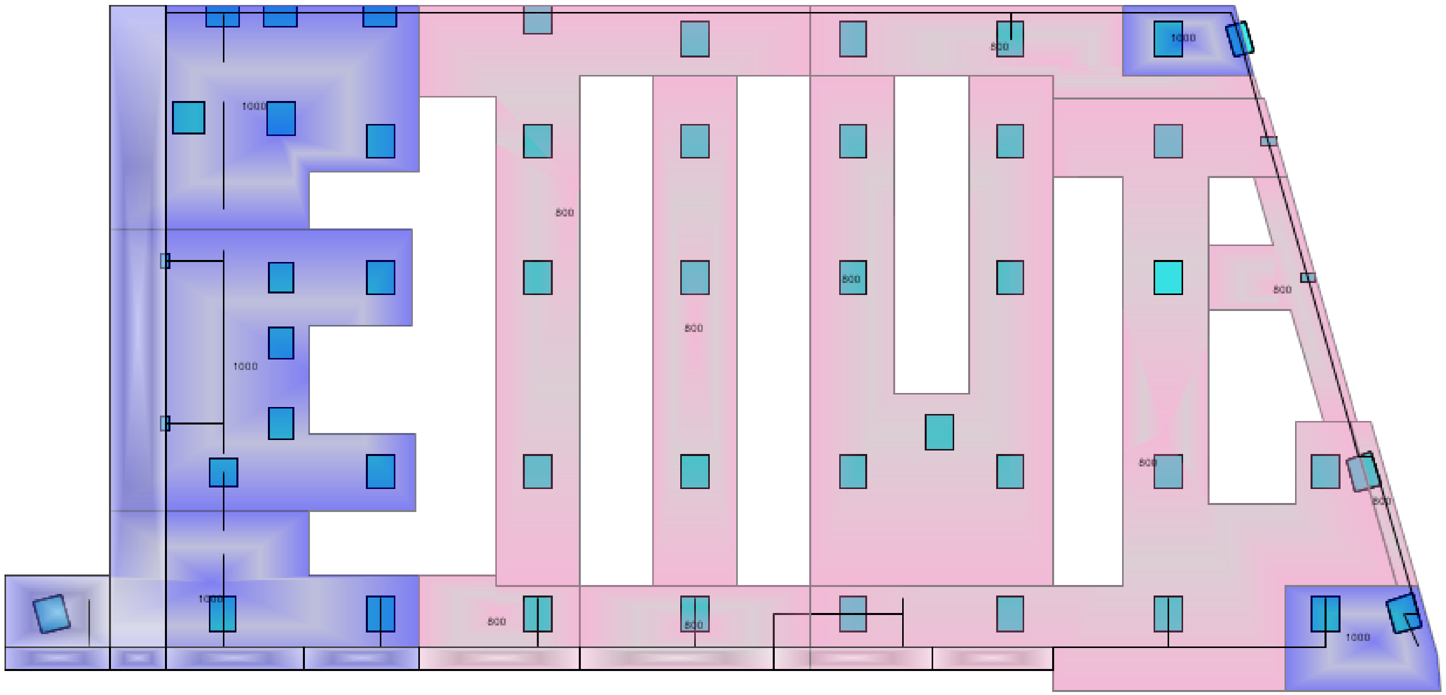
CF3-CF4 foundation is modeled in SAFE software as Finite elements. Reactions of wall & column for different load cases are Imported from ETABS as SAFE.F2K file.

Refer below steps showing detailed modeling, analysis and design of CF3-CF4 foundation.

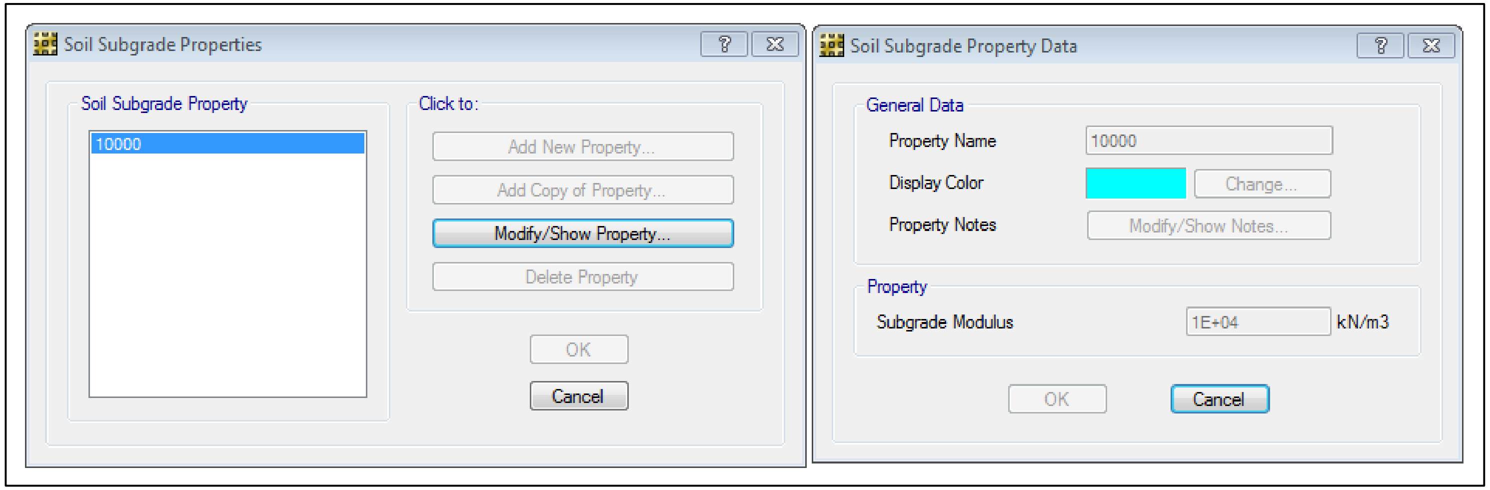
4.2 SAFE MODELING



SAFE modeling of CF4 foundation as finite elements



Properties: 800mm thick and 1000mm thick slab

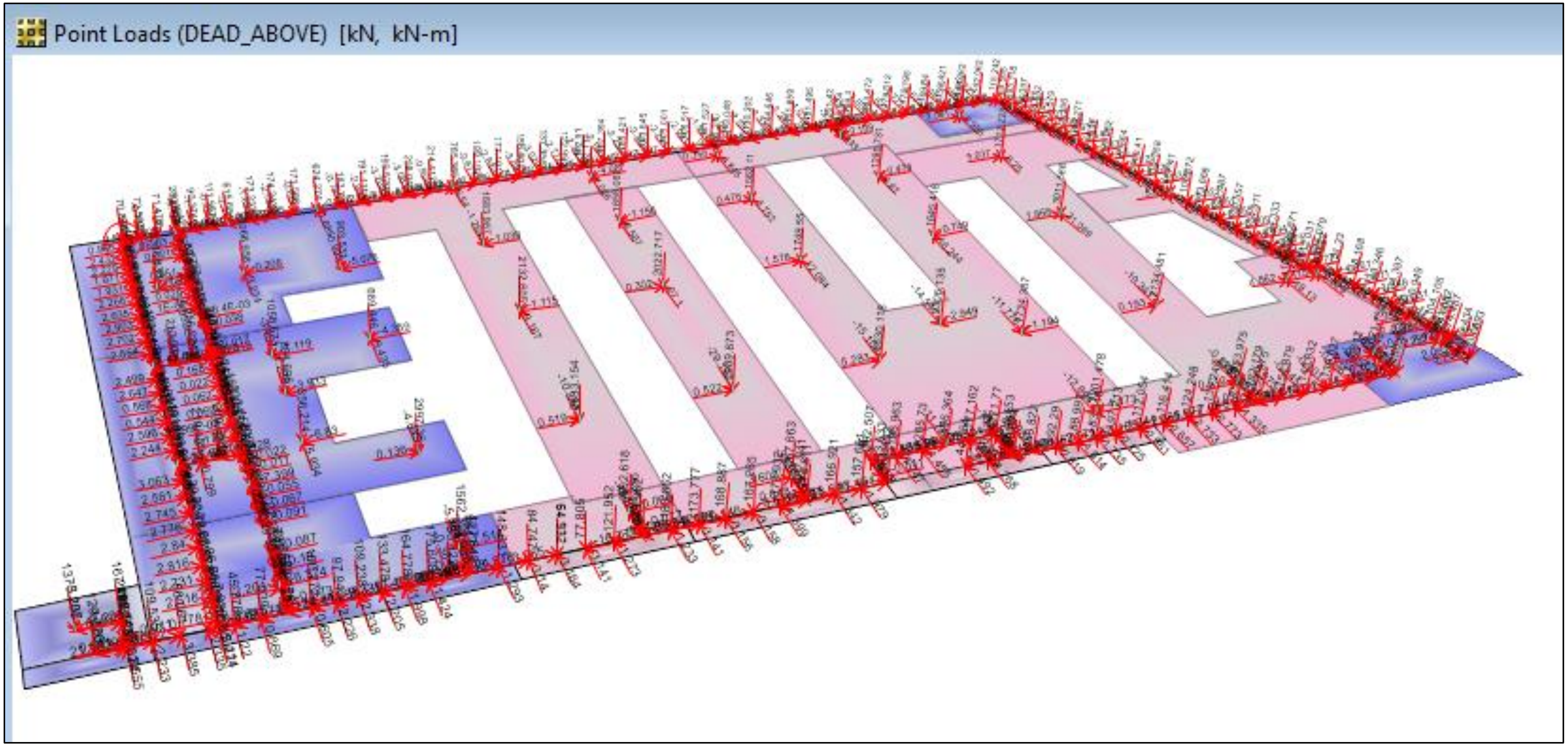


Foundation supports

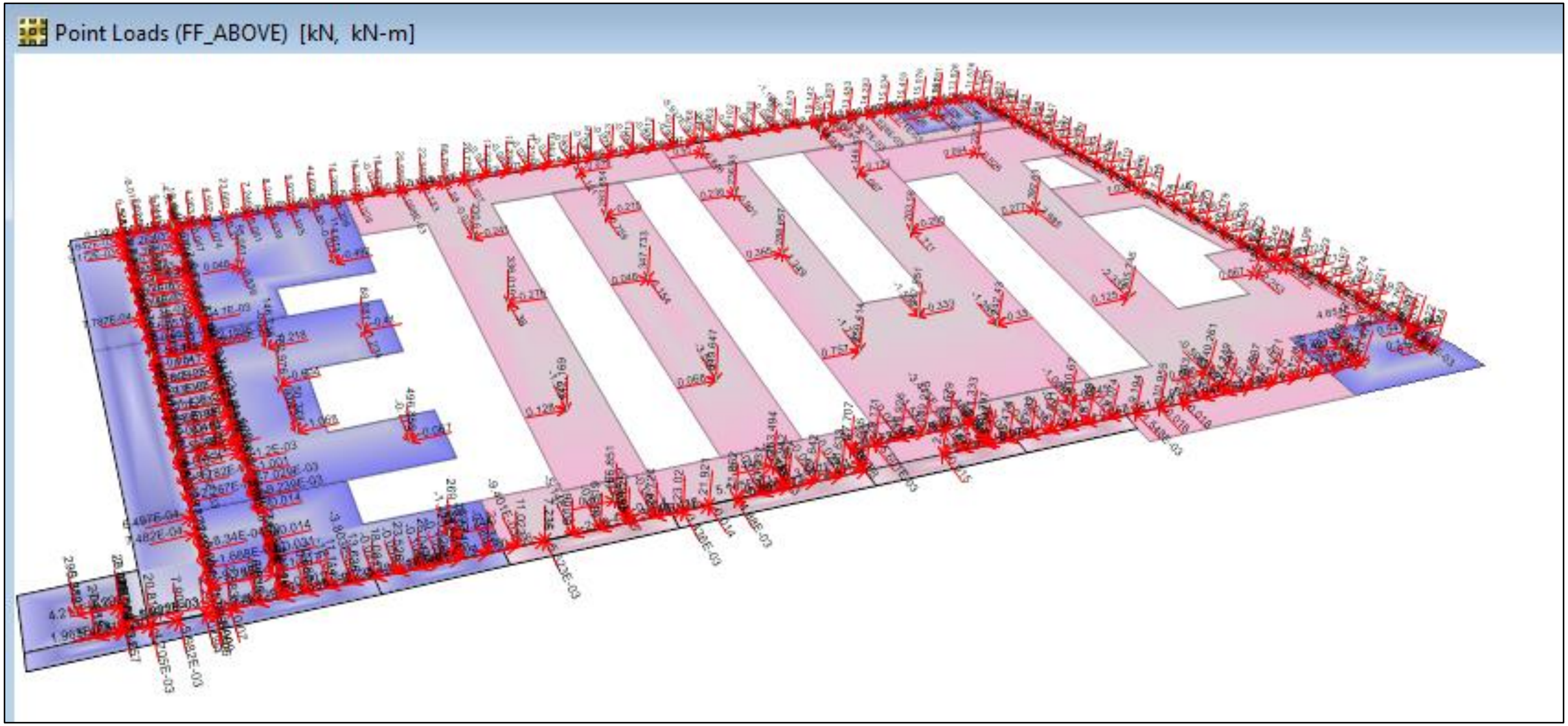
4.3 LOADING

4.3.1 Dead Load

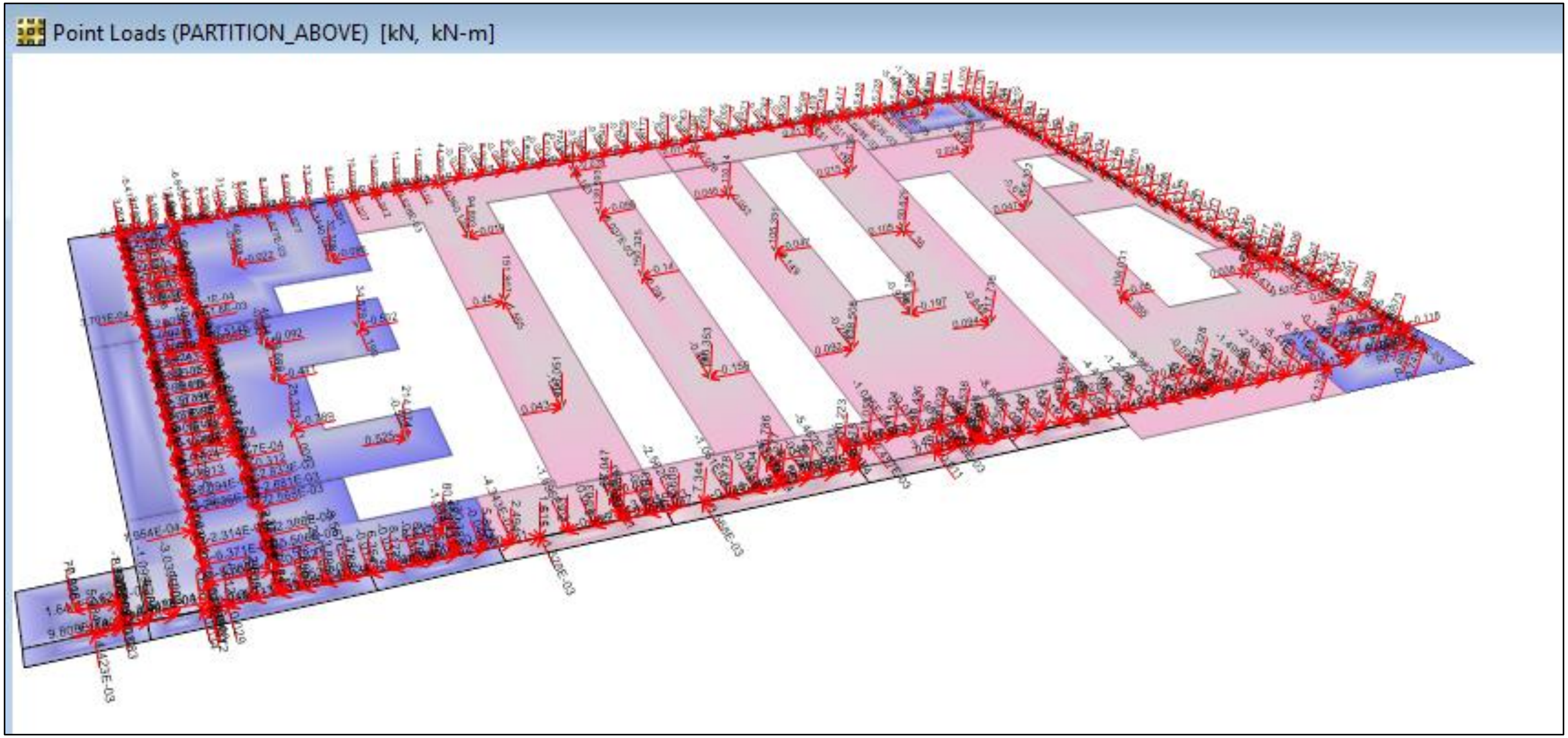
- Dead load obtained from ETABS model



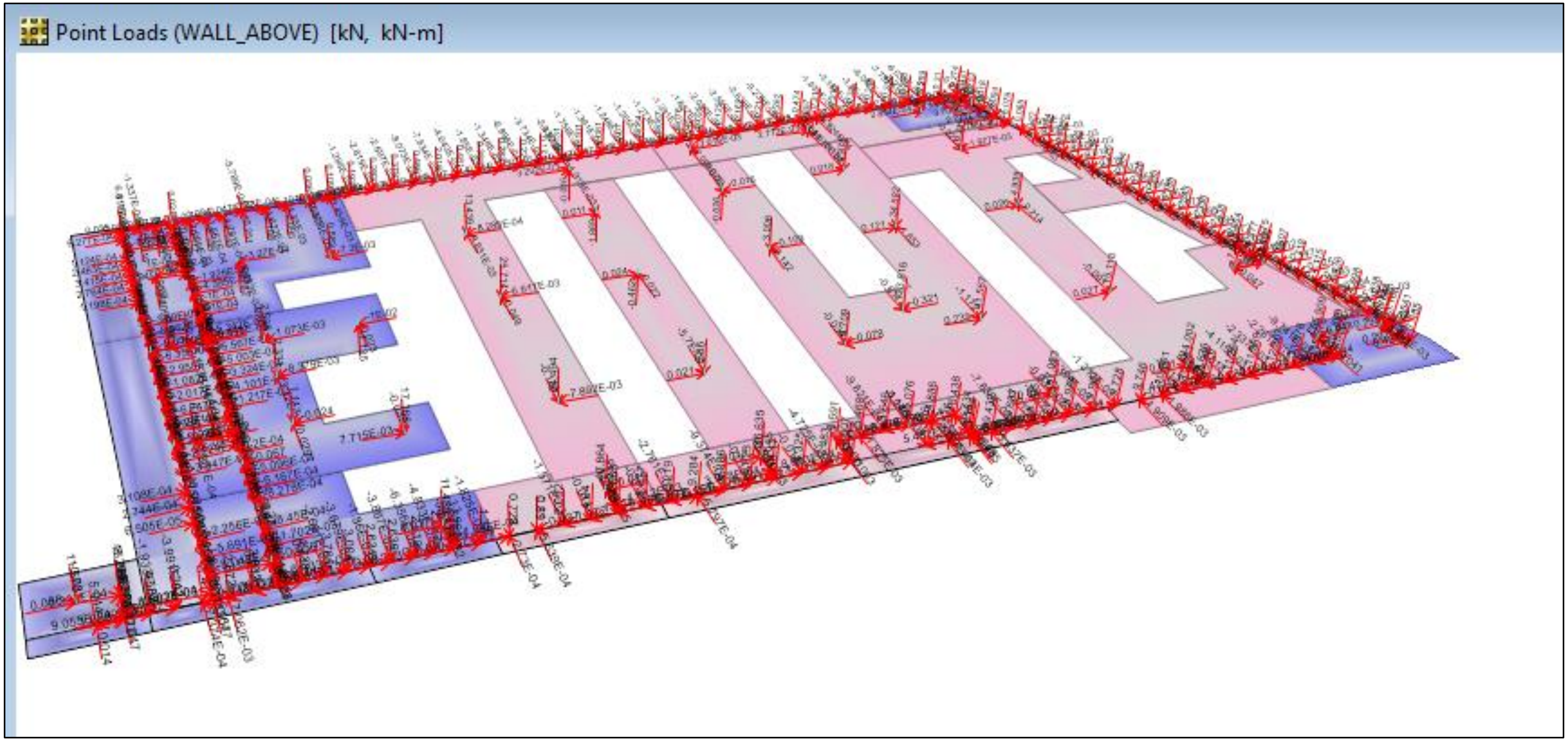
Dead load obtained from ETABS model



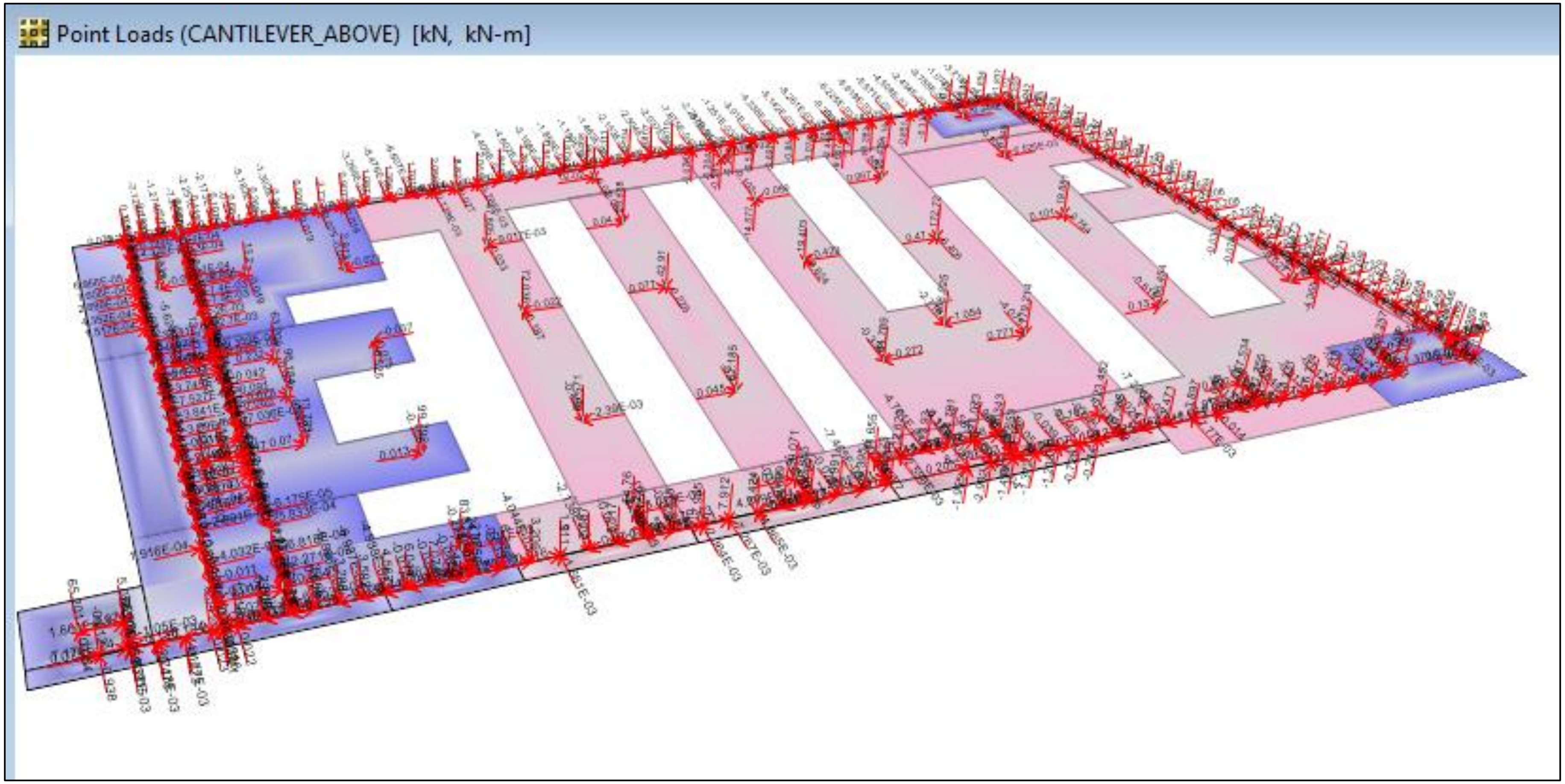
Floor-Finish load obtained from ETABS model



Partition load obtained from ETABS model



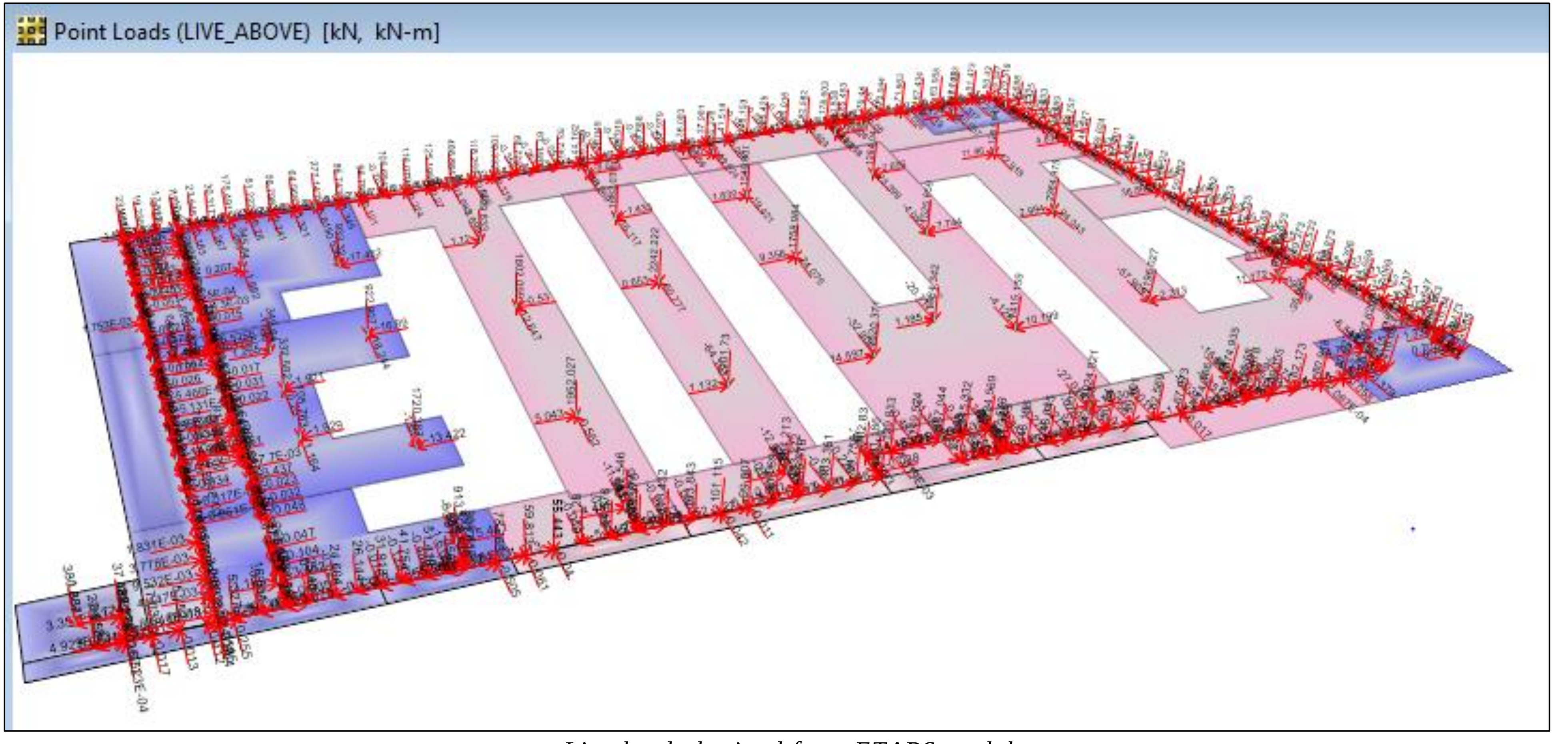
Wall load obtained from ETABS model



Cantilever load obtained from ETABS model

4.3.2 Live Load

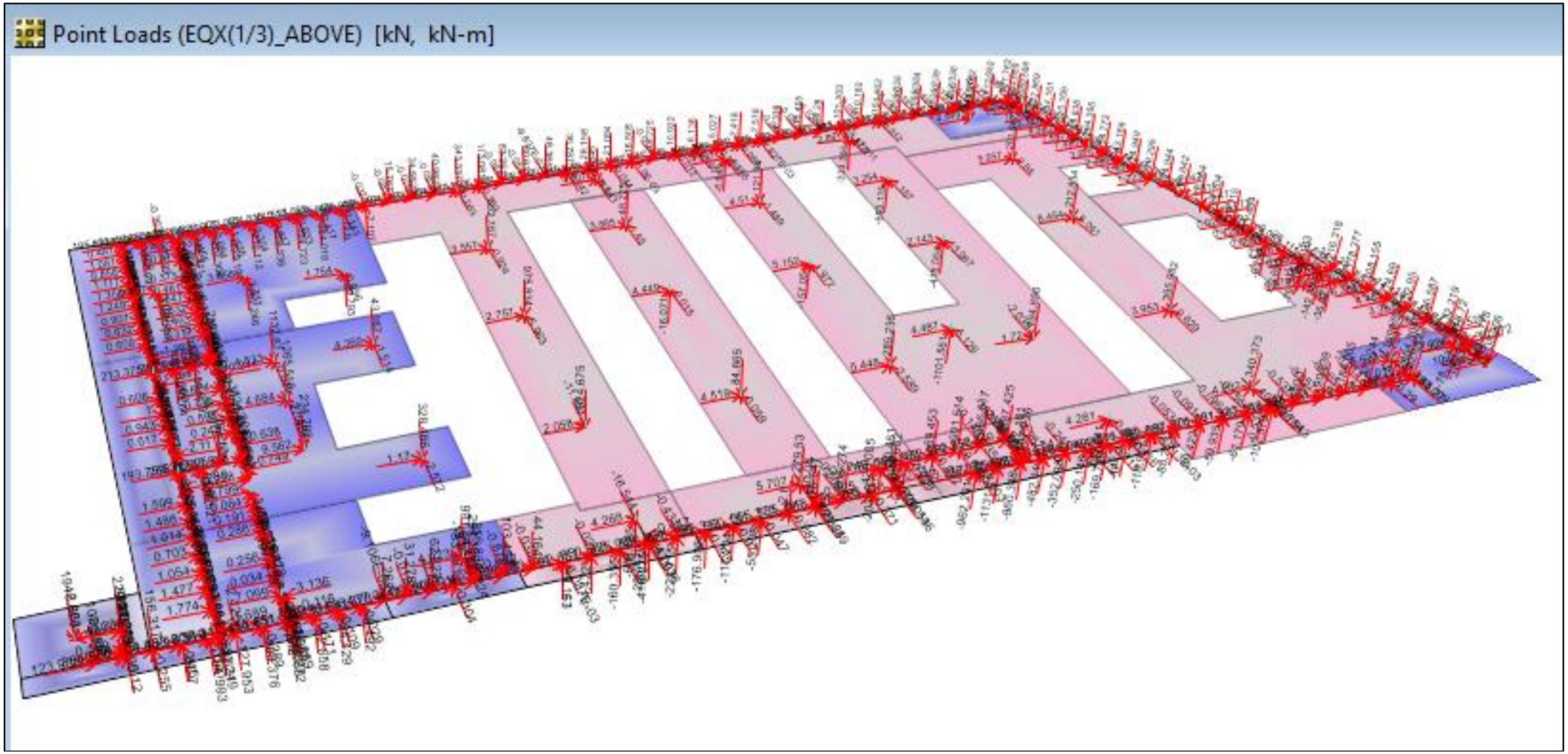
- Live load obtained from ETABS model

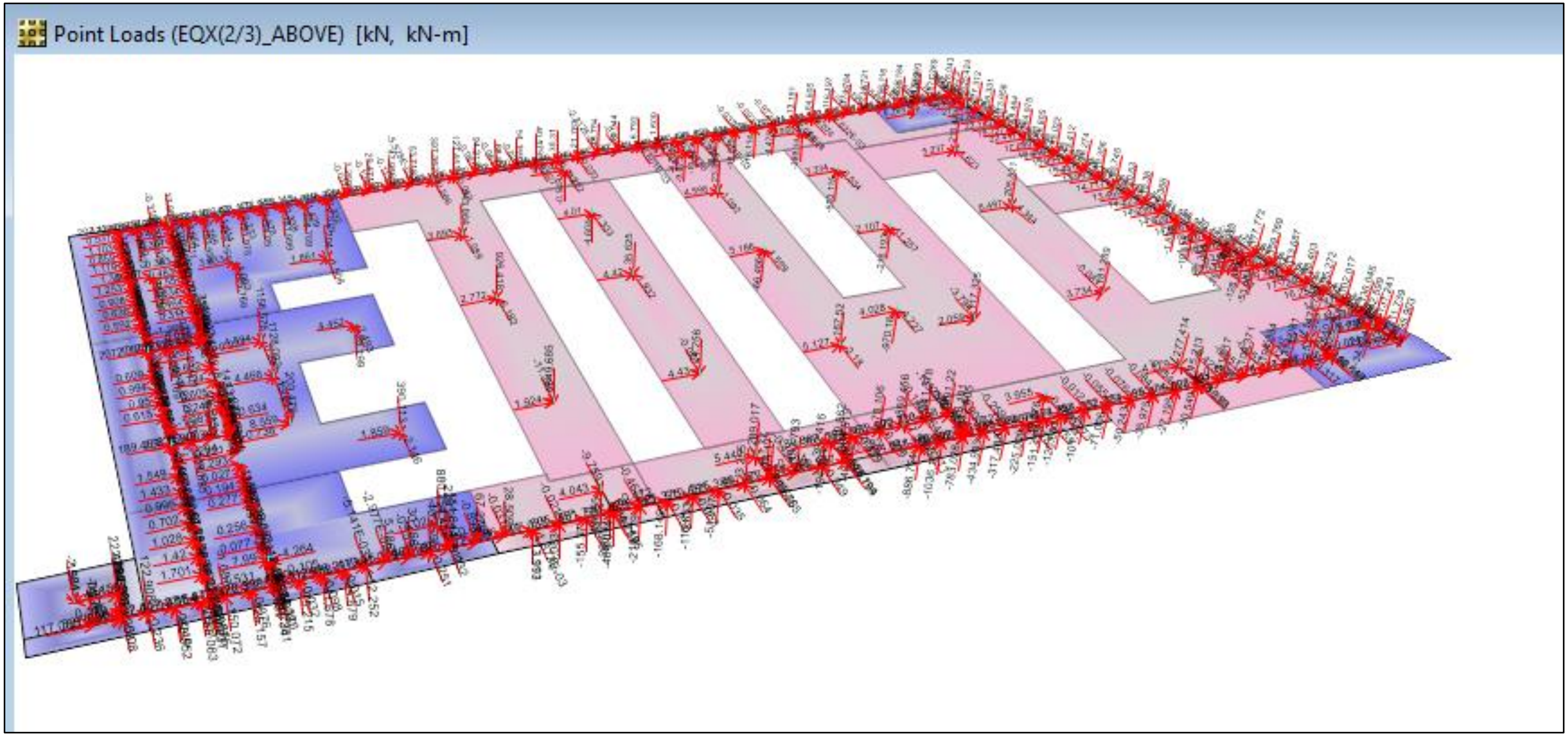


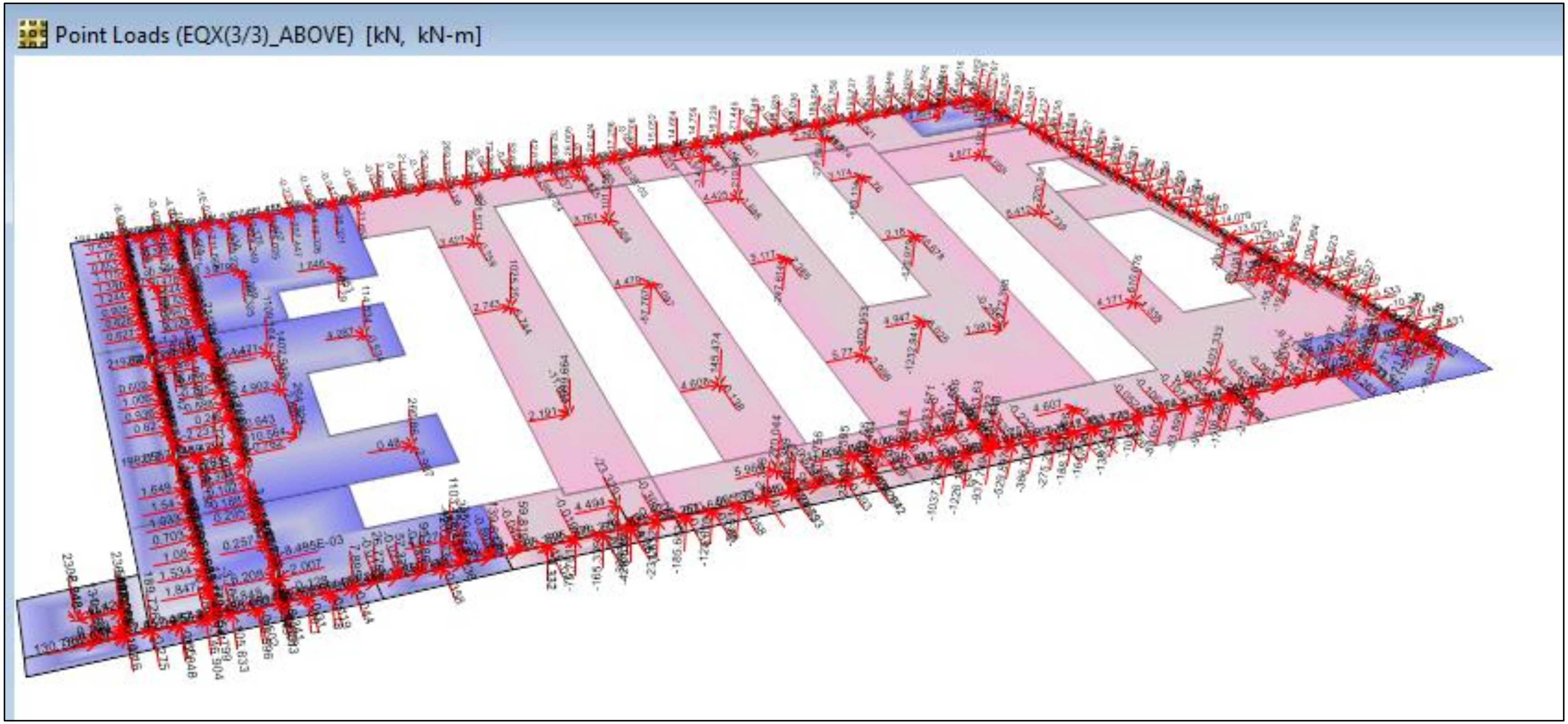
Live load obtained from ETABS model

EQX (Seismic Force in X-Direction)

- Seismic loads obtained from reactions of ETABS model


Point Loads (EQX(1/3)_ABOVE) [kN, kN-m]

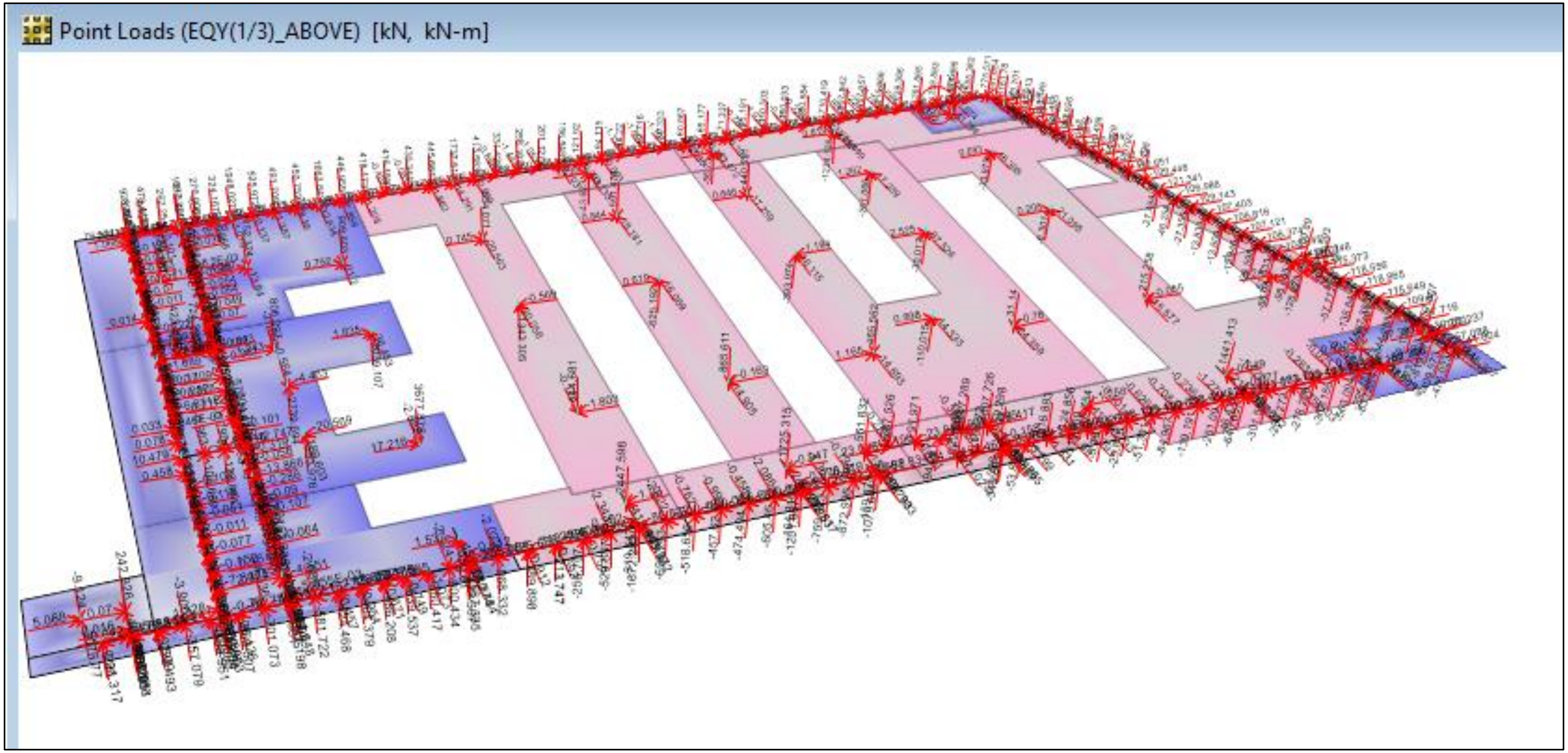

Point Loads (EQX(2/3)_ABOVE) [kN, kN-m]

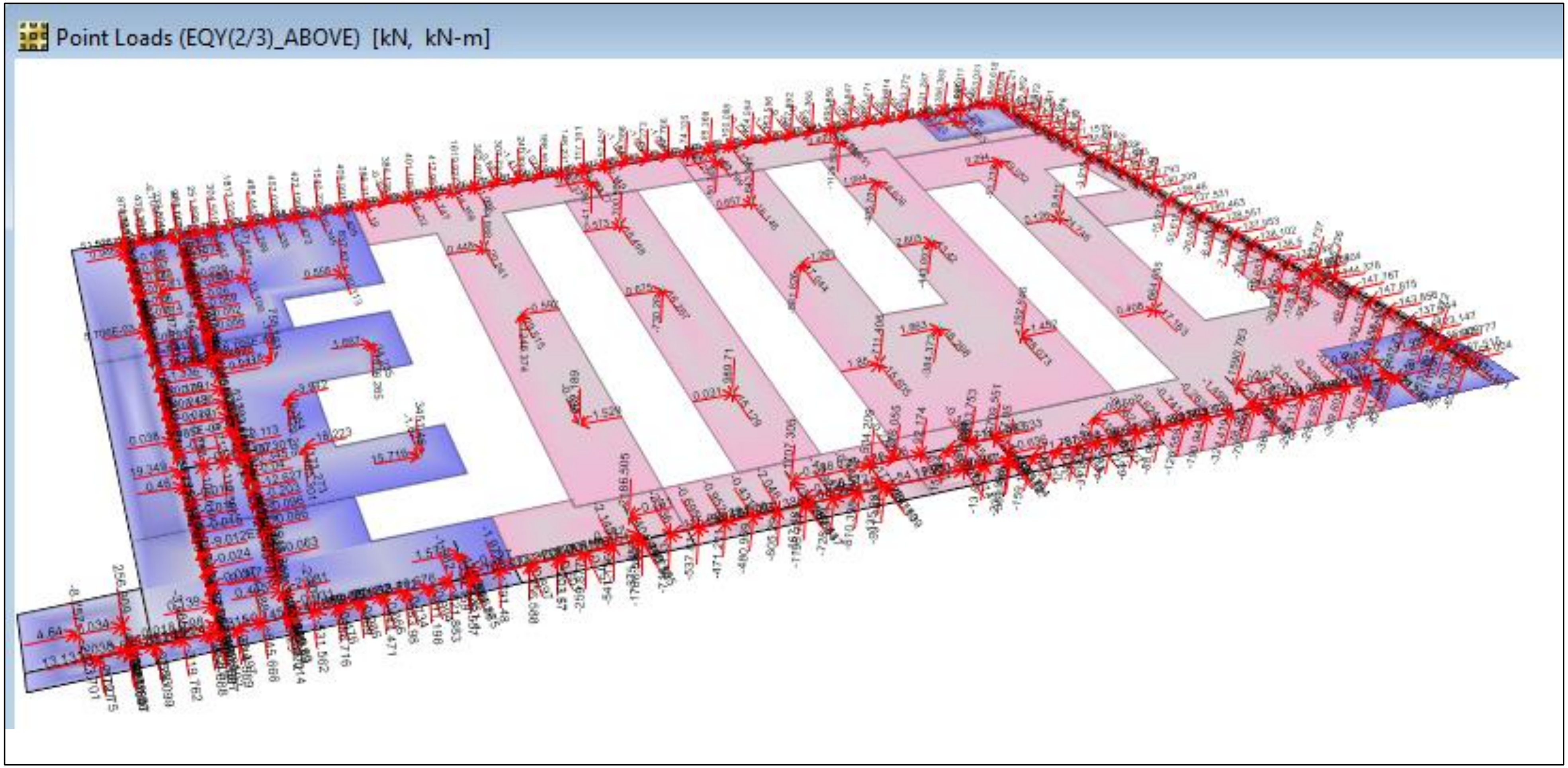


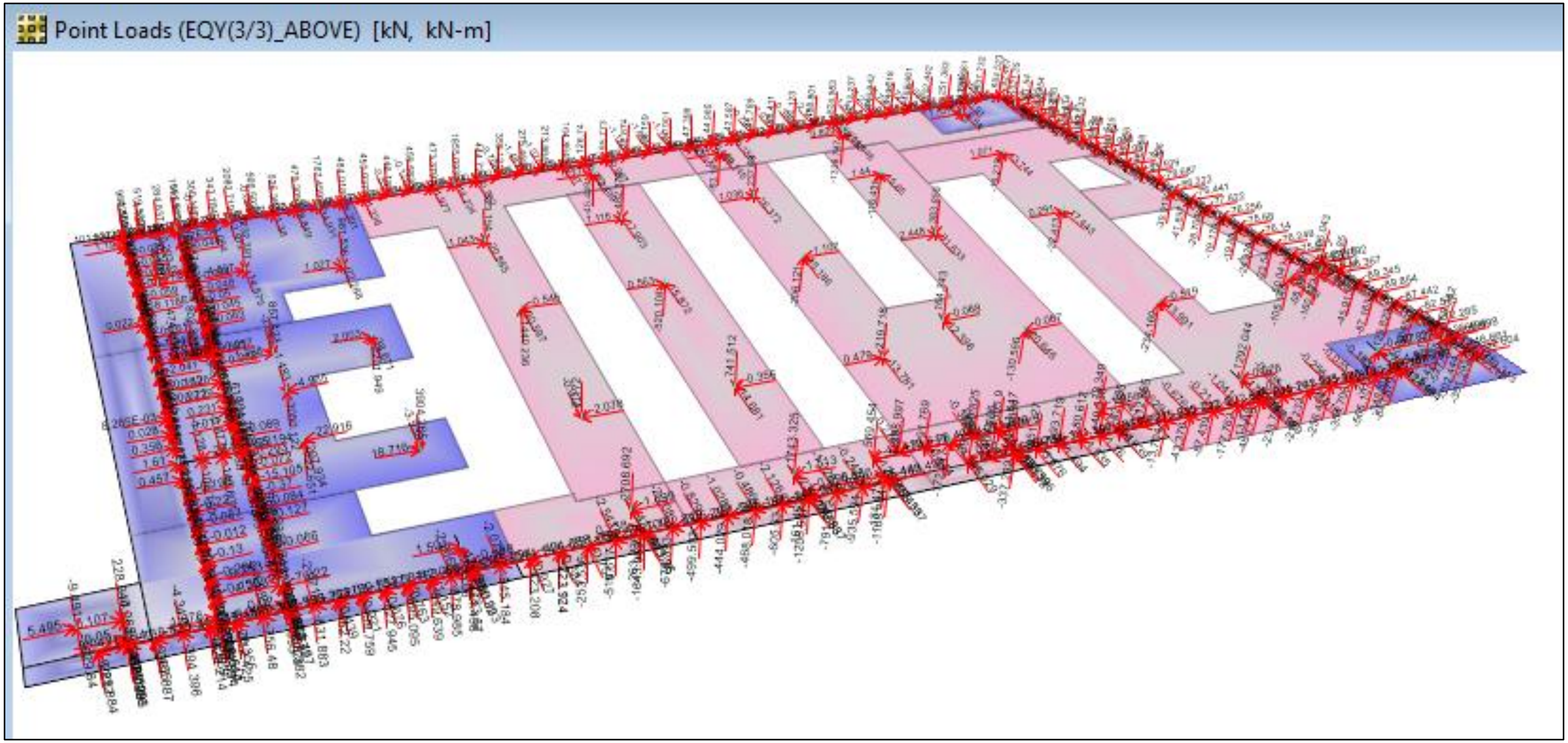
EQX obtained from ETABS model

EQY (Seismic Force in Y-Direction)

– Seismic loads obtained from ETABS model




Point Loads (EQY(2/3)_ABOVE) [kN, kN-m]



EQY obtained from ETABS model

4.4 Load Combinations

Design load combinations

1.35DL
1.2DL + 1.5LL
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE - Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE -X
1.0DL +0.3LL + 1.0 EARTHQUAKE – Y + 0.3 EARTHQUAKE –X

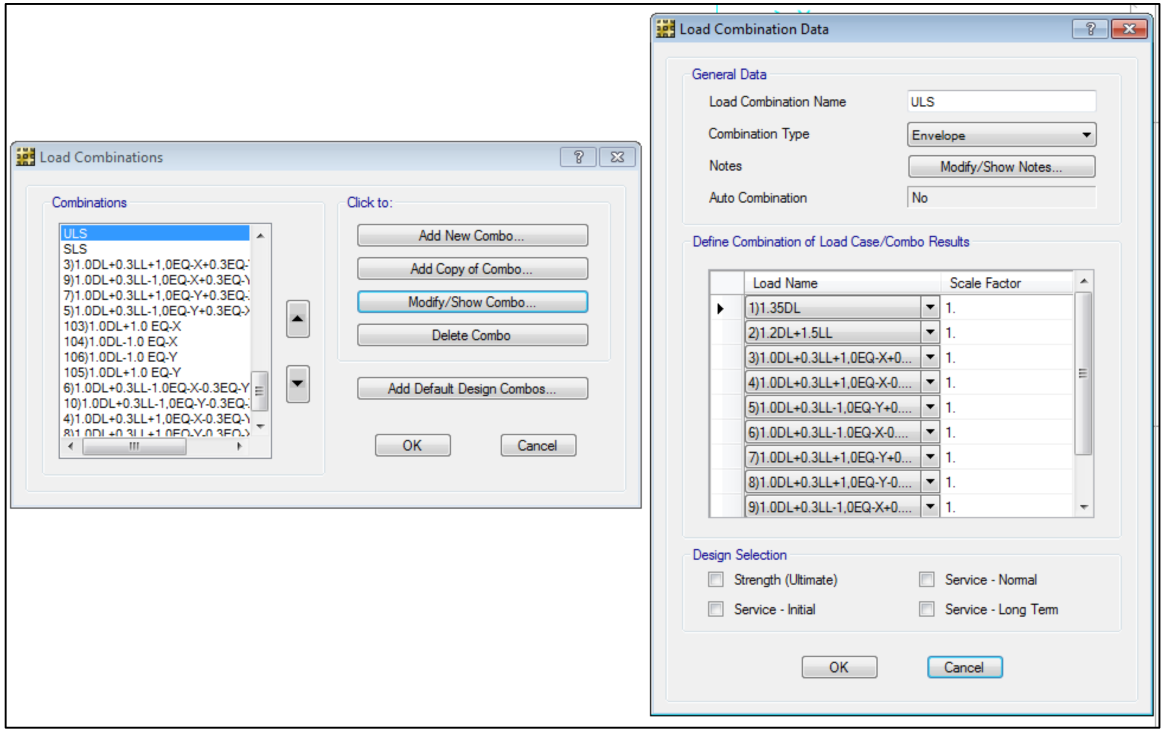
Serviceability load combinations

1.0DL + 1.0LL
1.0DL + 1.0EQX
1.0DL - 1.0EQX
1.0DL + 1.0EQY
1.0DL - 1.0EQY

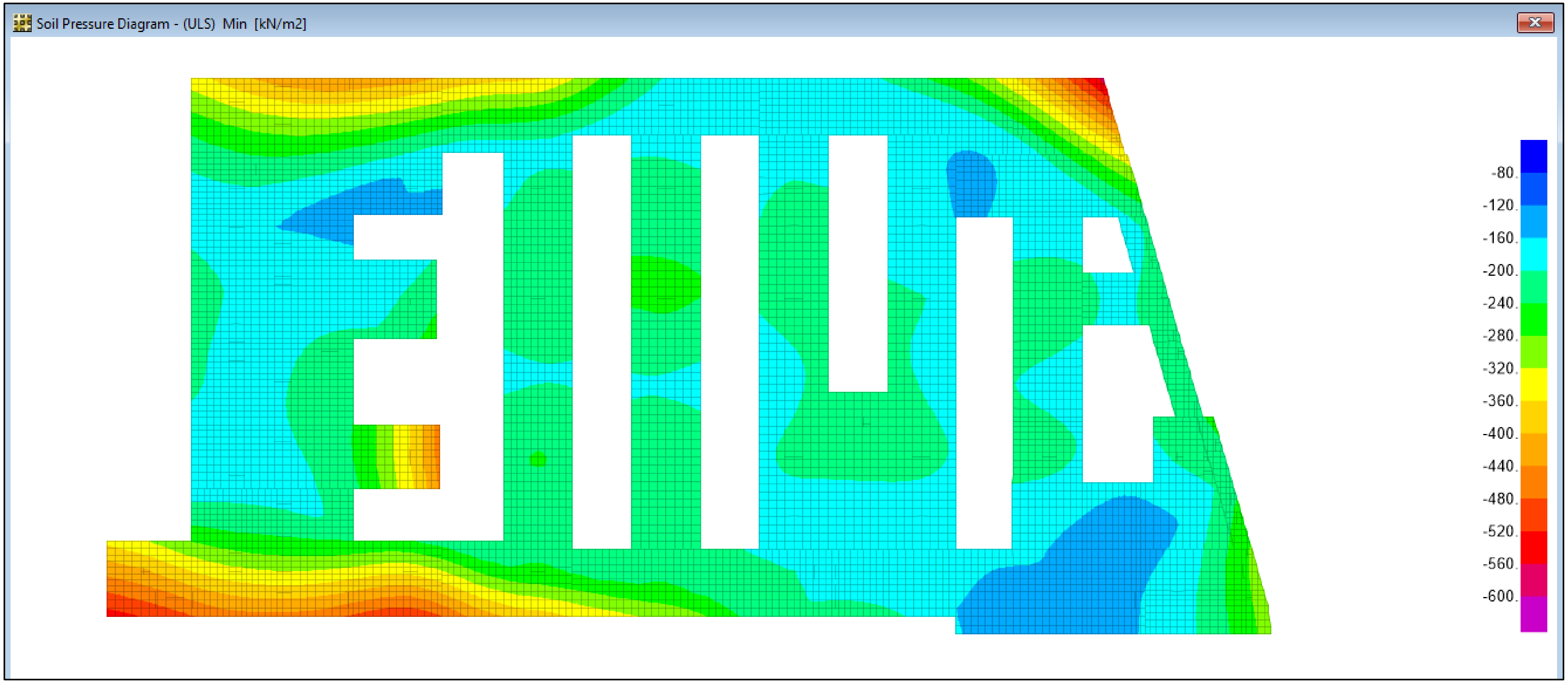
4.5 Base Pressure Check

4.5.1 Check of maximum base pressure for design load combinations:

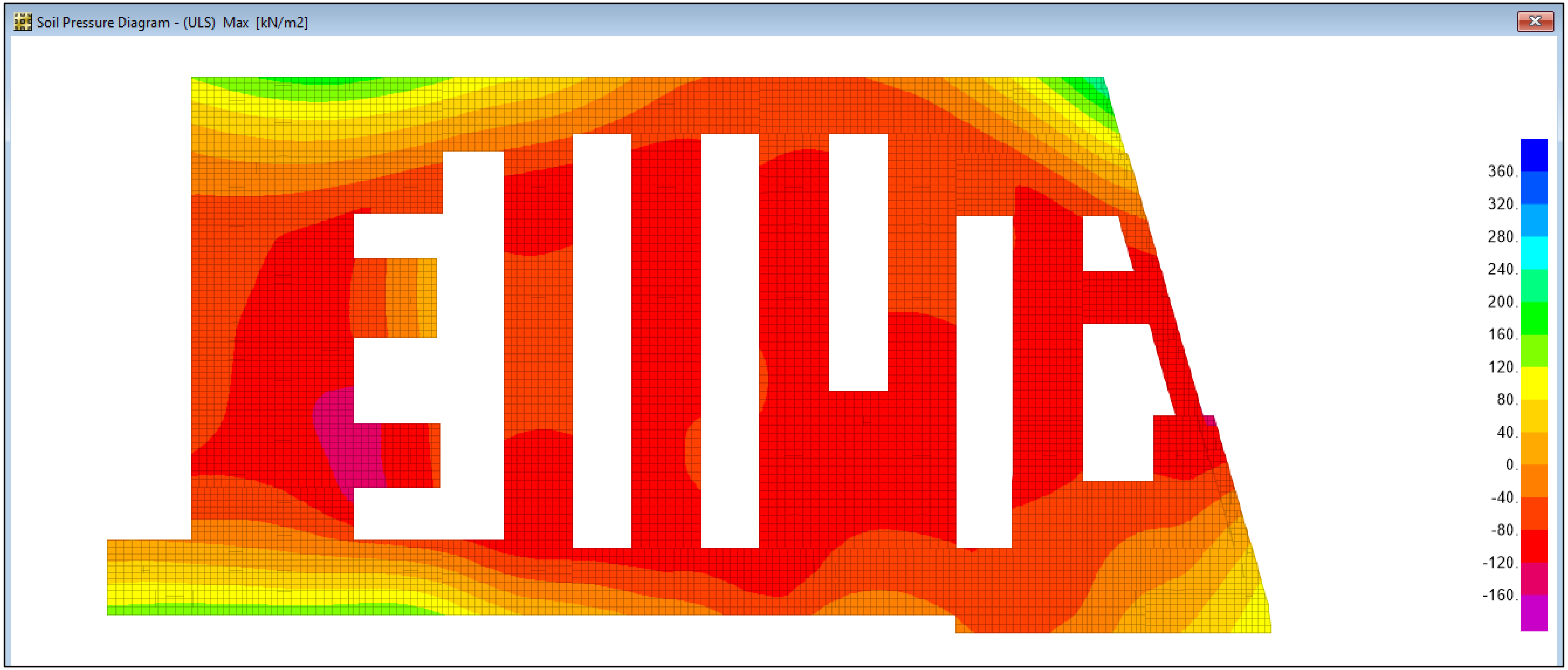
Refer below image showing soil pressure diagram of base pressure for design load combinations:



Design load combination envelope



Soil pressure diagram for Seismic ultimate load combination (Min)



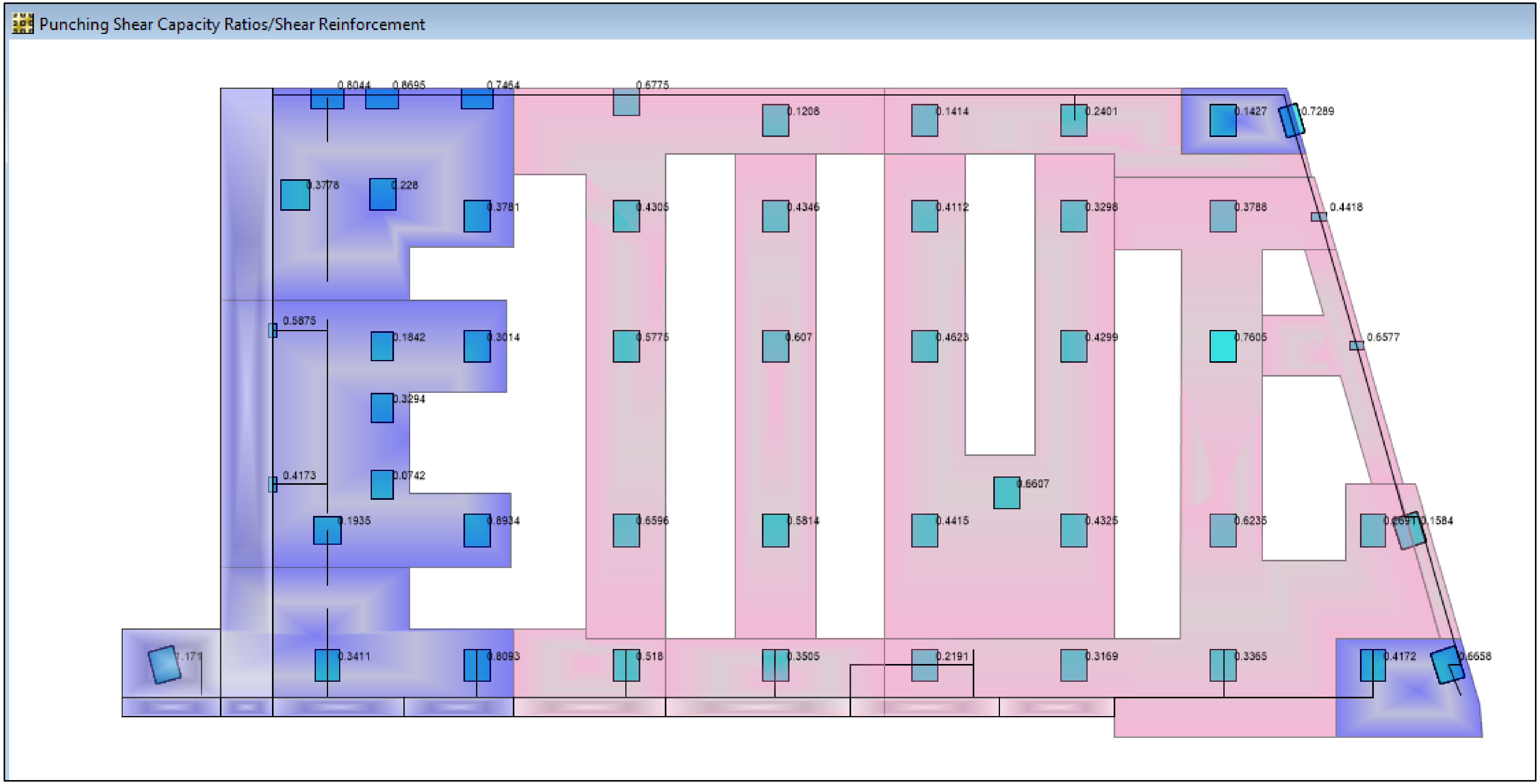
Soil pressure diagram for Seismic ultimate load combination (Max)

Permissible SBC for design load combinations = 575 kN/m^2

Maximum base pressure (downward) = 549 kN/m^2< 575 kN/m^2 (Hence, OK)

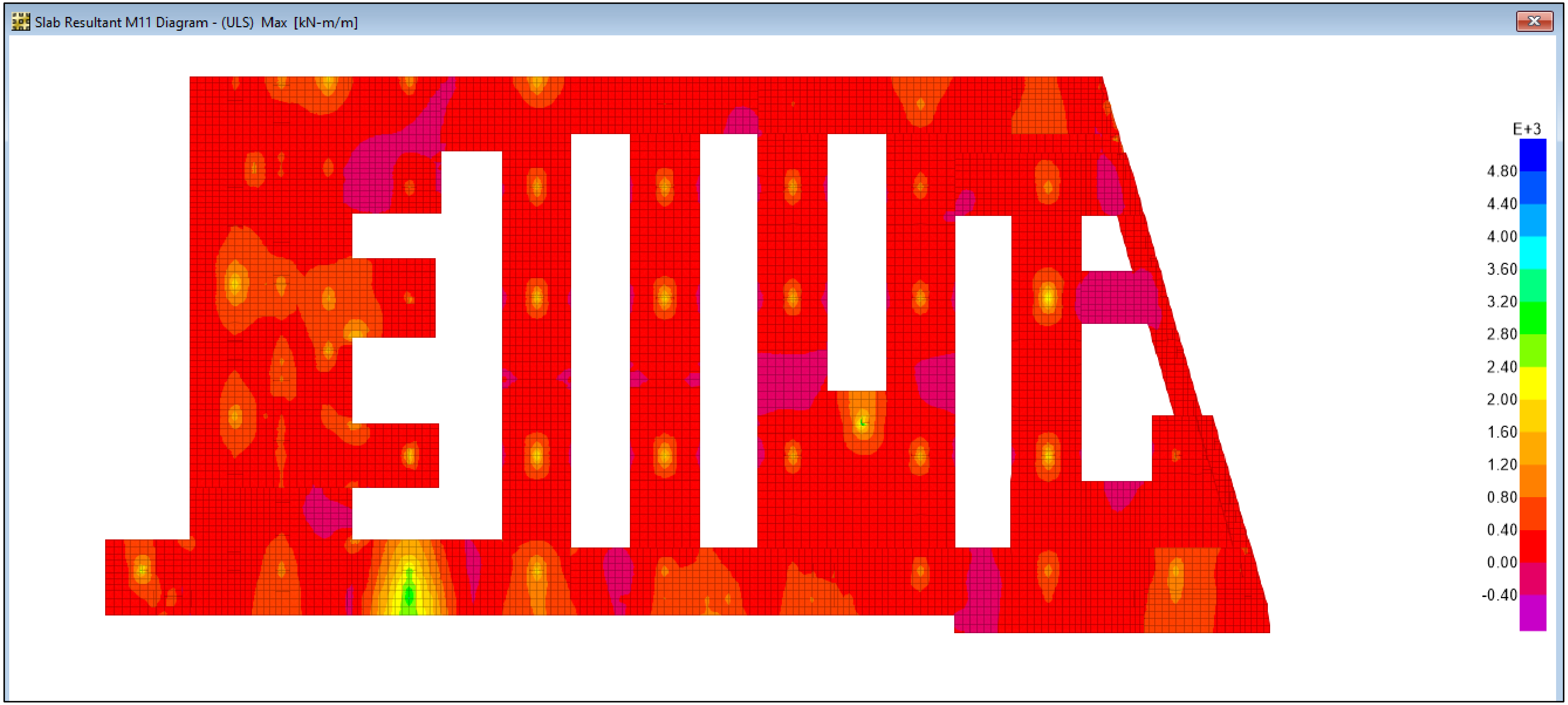
Maximum base pressure (Upward) = 223 kN/m^2

Punching Shear Check

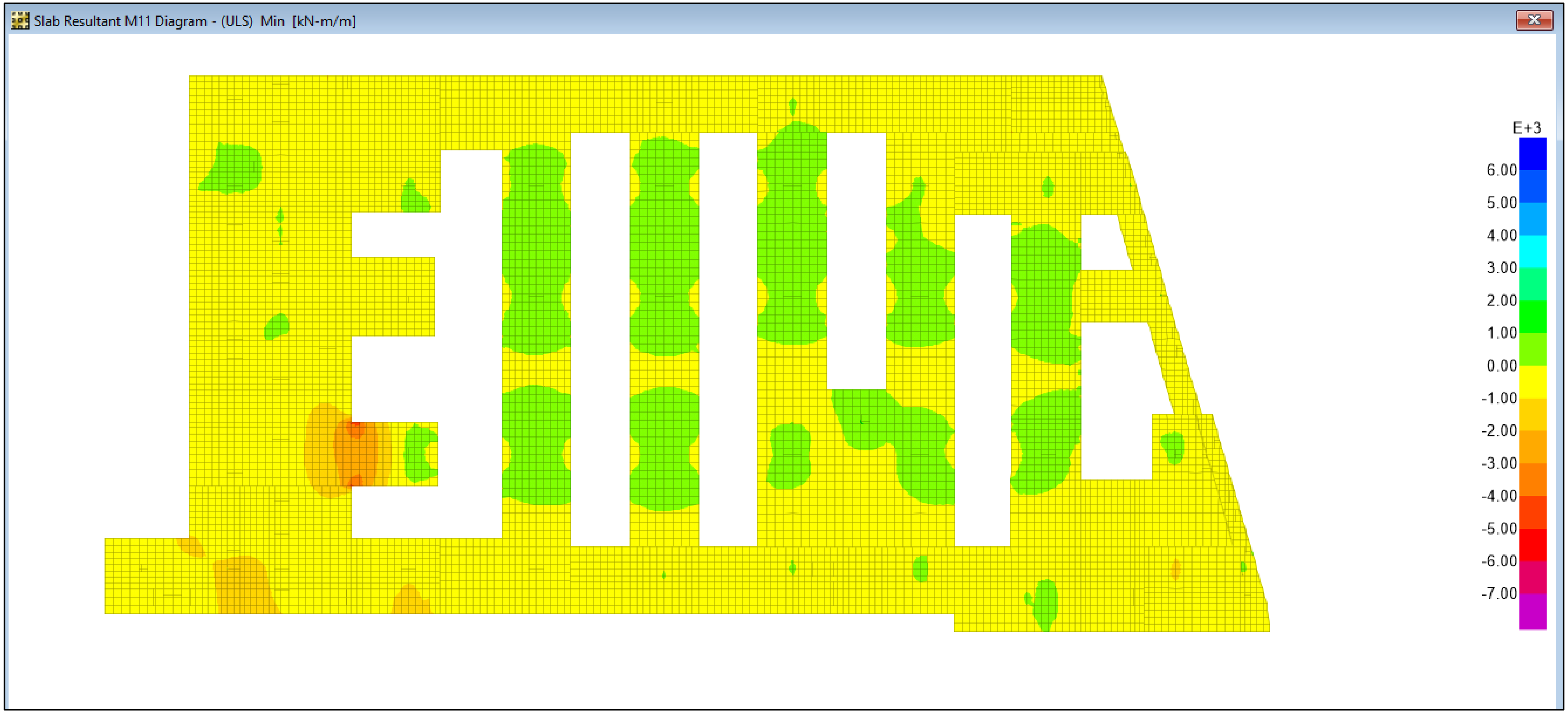


__Check for Punching Shear__

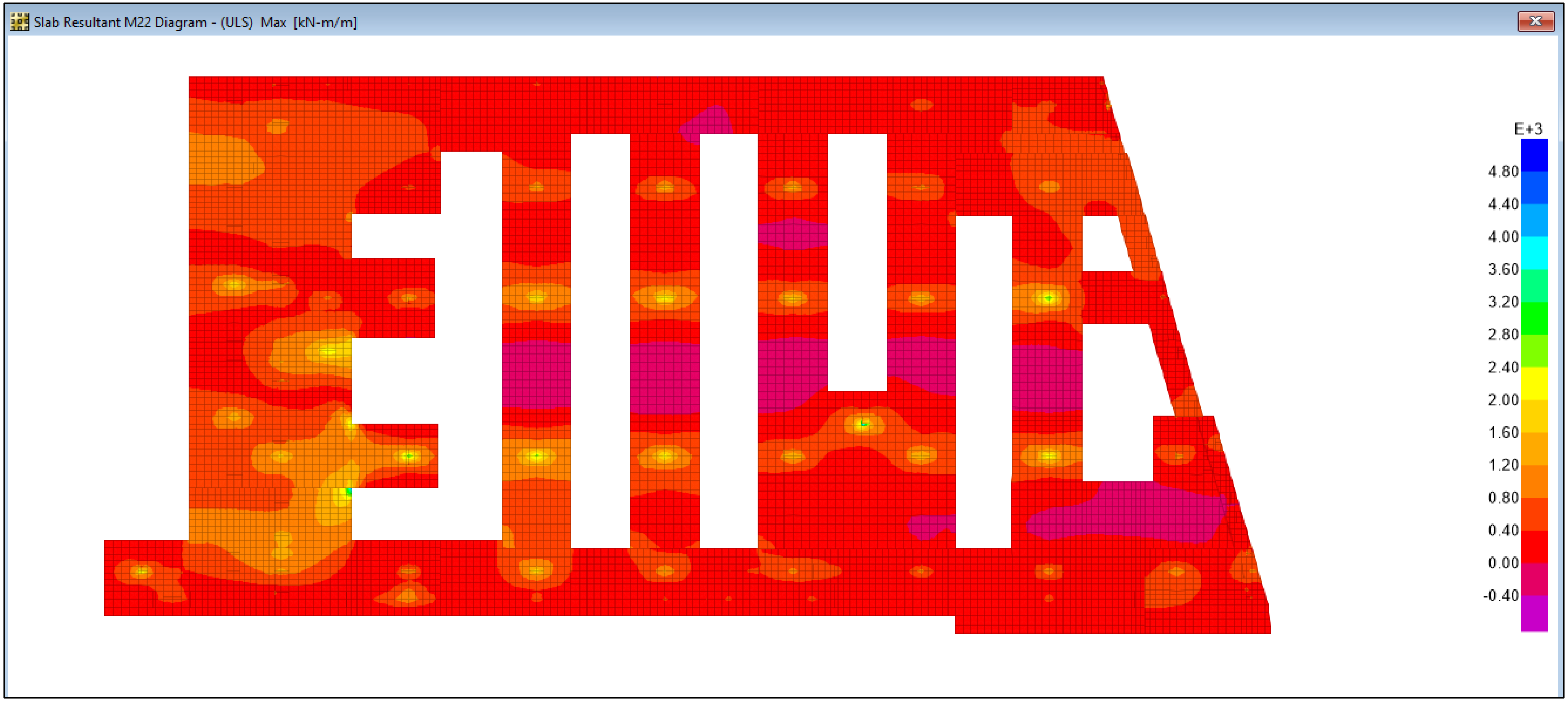
4.6 Design of combined footing:



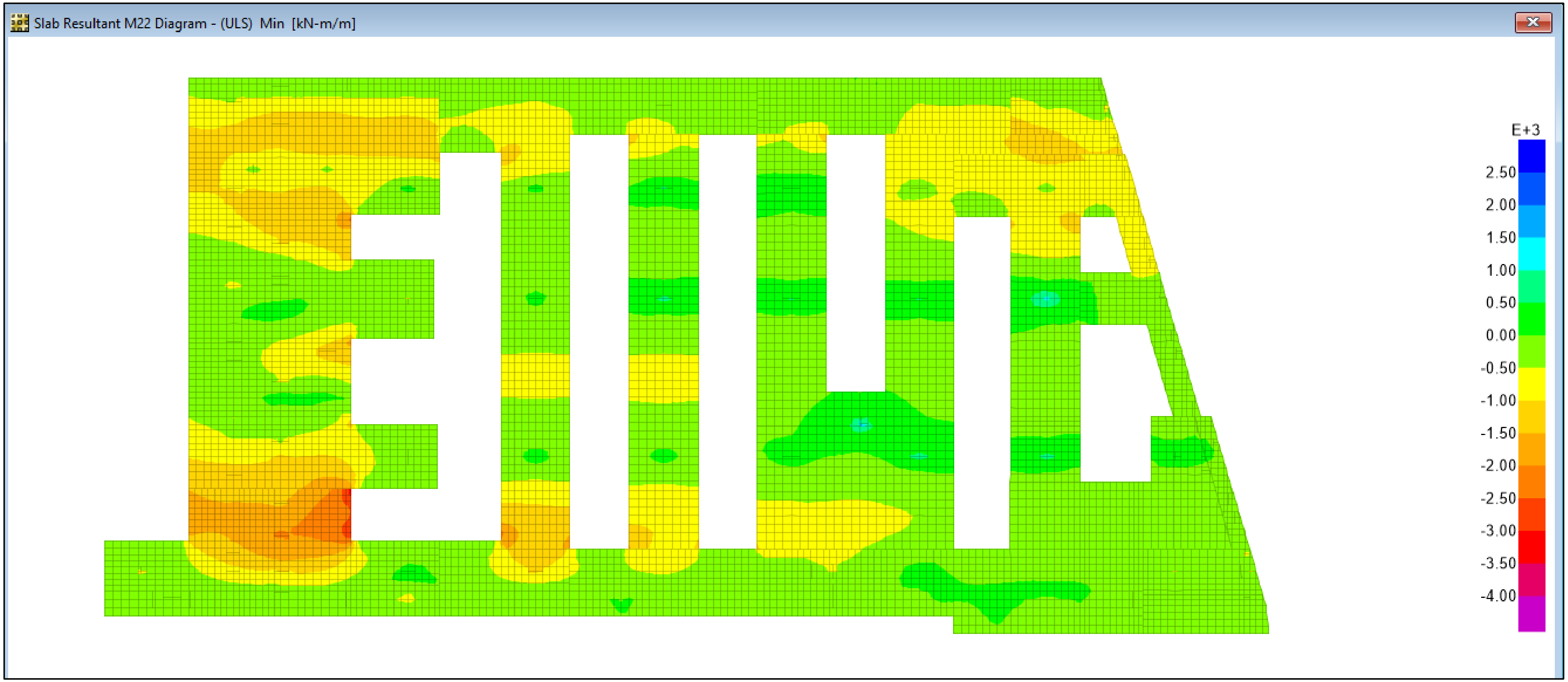
Moment diagram in X-dir for Design load combination (Max)



Moment diagram in X-dir for Design load combination (Min)

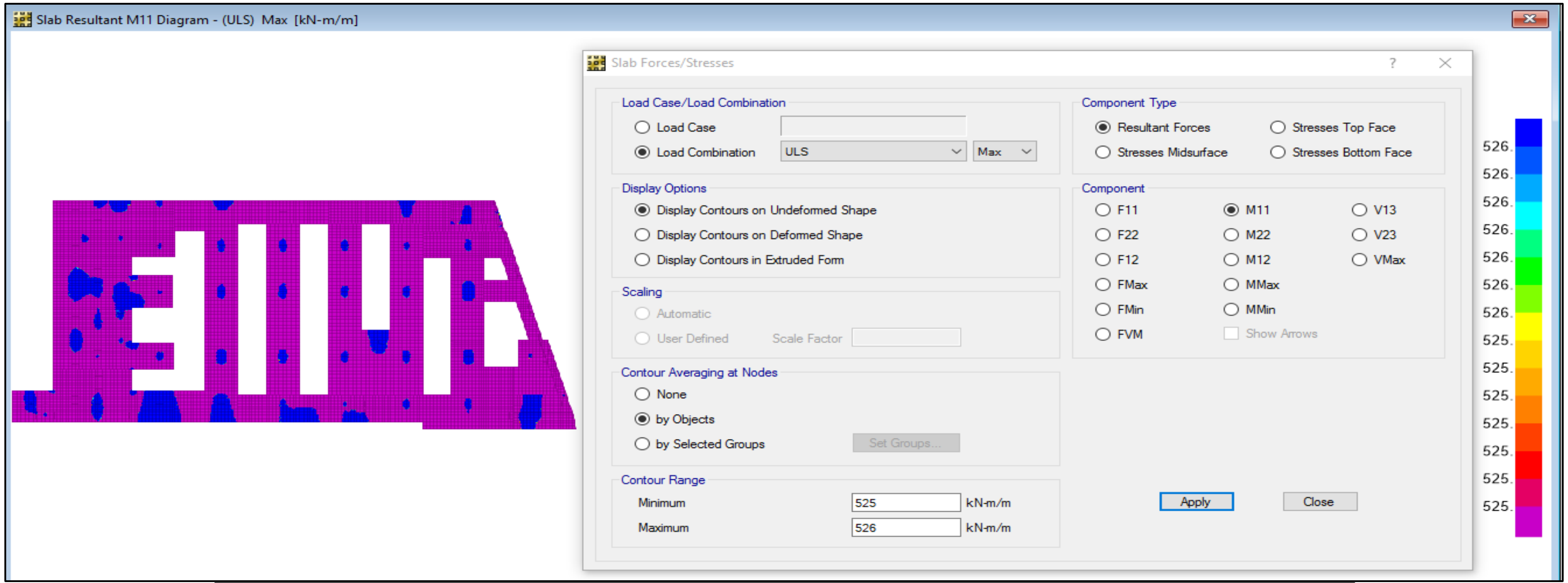


Moment diagram in Y-dir for Design load combination (Max)



Moment diagram in Y-dir for Design load combination (Min)

4.7 Design of Foundation – 800mm thick (Bottom reinforcement)



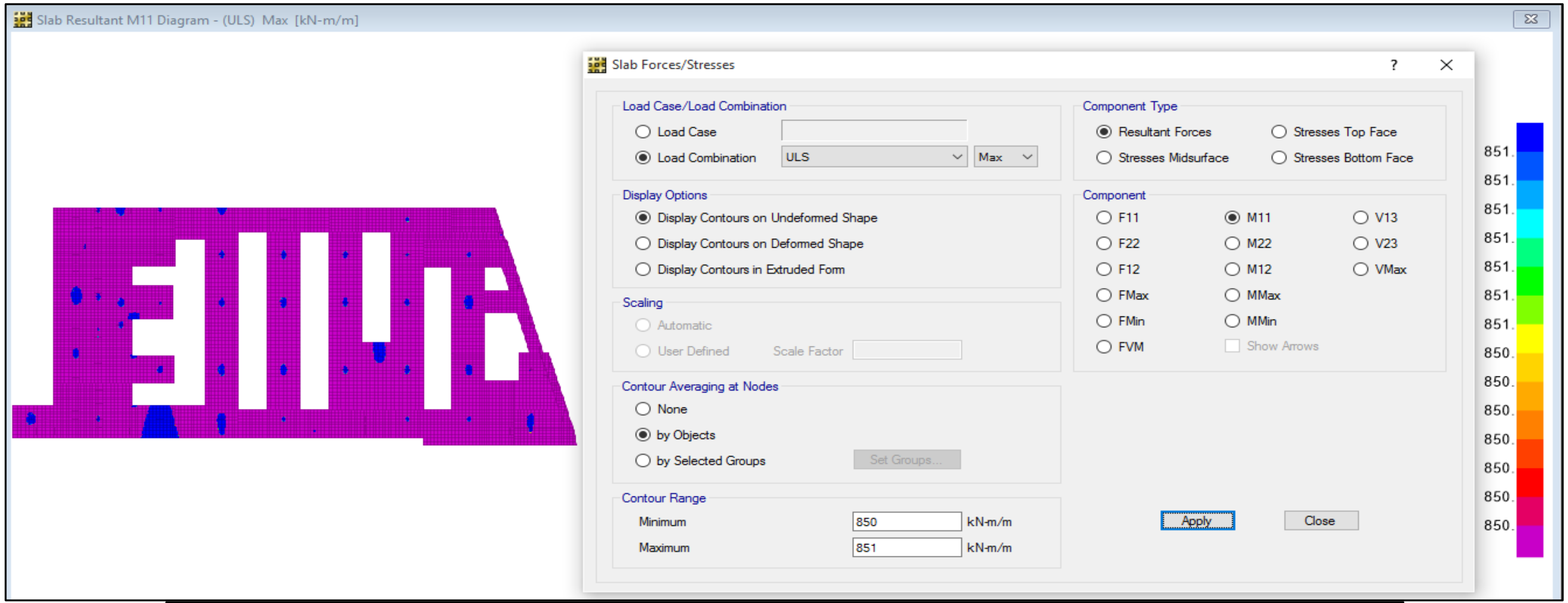
Flexure design:

Maximum Moment +M		=	525.00 kN.m/m					
Bending moment in kN-m per Meter				Concrete	fck	=	35	Mpa
				Reinforcement	fy	=	500	Mpa
b	1000 mm							
				Clear cover In Raft	C	=	75	mm
				Slab Thickness, T		=	800	mm
				Effective thickness, t		=	715	mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

Asr	=	(0.85 x500x715- ((0.85x500x715)^2 - (2.36 x525x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))					
	=	1764.39 mm2					
Minimum Pt	=	0.140	%				
Minimum Ast	=	1120					
Provided Pt	=	0.251					
Provided Ast	=	1795	mm²				
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)	
	+	0	Dia @	175	mm c/c	(Extra)	
				O.K.			

HD20@175CRS through Bottom - X Direction



Flexure design:

Maximum Moment +M = 850.00 kN.m/m

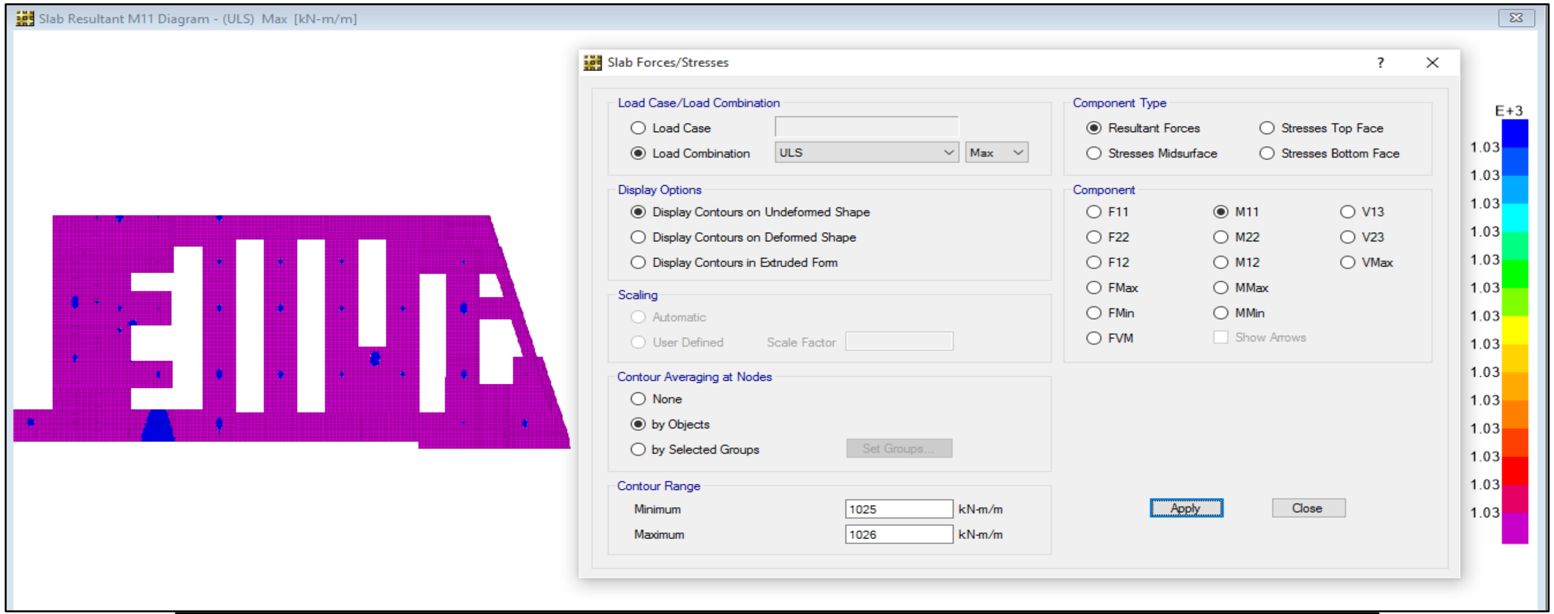
Bending moment in kN-m per Meter		Concrete	fck	=	35	Mpa
		Reinforcement	fy	=	500	Mpa
b	1000 mm					
		Clear cover In Raft	C	=	75	mm
		Slab Thickness, T		=	800	mm
		Effective thickness, t		=	715	mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

Asr = (0.85 x500x715- ((0.85x500x715)^2 - (2.36 x850x10^6x0.85x500^2)/(35x1000)))^0.5) x ((35x1000)/(1.18x0.85x500^2))
= 2896.08 mm2

Minimum Pt	=	0.140	%				
Minimum Ast	=	1120					
Provided Pt	=	0.412					
Provided Ast	=	2944	mm^2				
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)	
	+	16	Dia @	175	mm c/c	(Extra)	
				O.K.			

HD20@175CRS Through + HD16@175CRS Extra Bottom X Direction



Flexure design:

Maximum Moment +M = 1025.00 kN.m/m

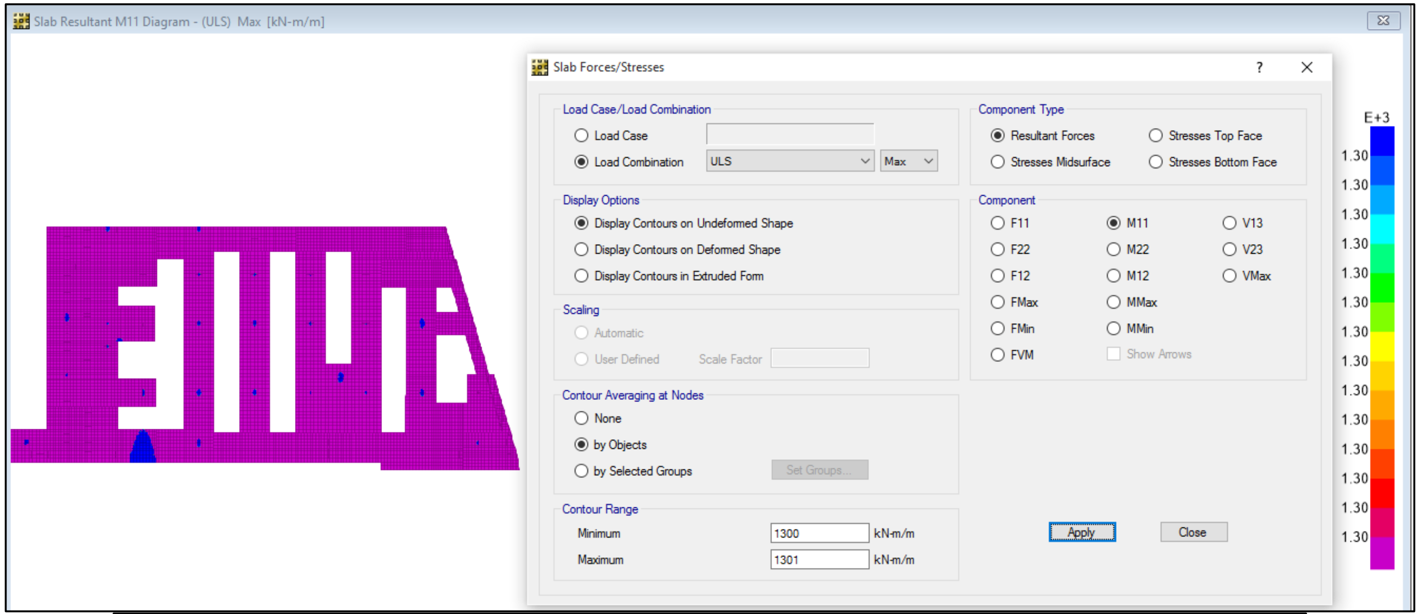
Bending moment in kN-m per Meter			Concrete	fck	=	35	Mpa
			Reinforcement	fy	=	500	Mpa
b	1000 mm						
			Clear cover In Raft	C	=	75	mm
			Slab Thickness, T		=	800	mm
			Effective thickness, t		=	715	mm

$$A_{st} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^{\,2}}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^{\,2}}$$

Asr = (0.85 x500x715- ((0.85x500x715)^2 - (2.36 x1025x10^6x0.85x500^2)/(35x1000)))^0.5) x ((35x1000)/(1.18x0.85x500^2))
= 3519.09 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1120				
Provided Pt	=	0.502				
Provided Ast	=	3590	mm^2			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	20	Dia @	175	mm c/c	(Extra)
			O.K.			

HD20@175CRS Through + HD20@175CRS Extra Bottom X Direction



Flexure design:

Maximum Moment +M = 1300.00 kN.m/m

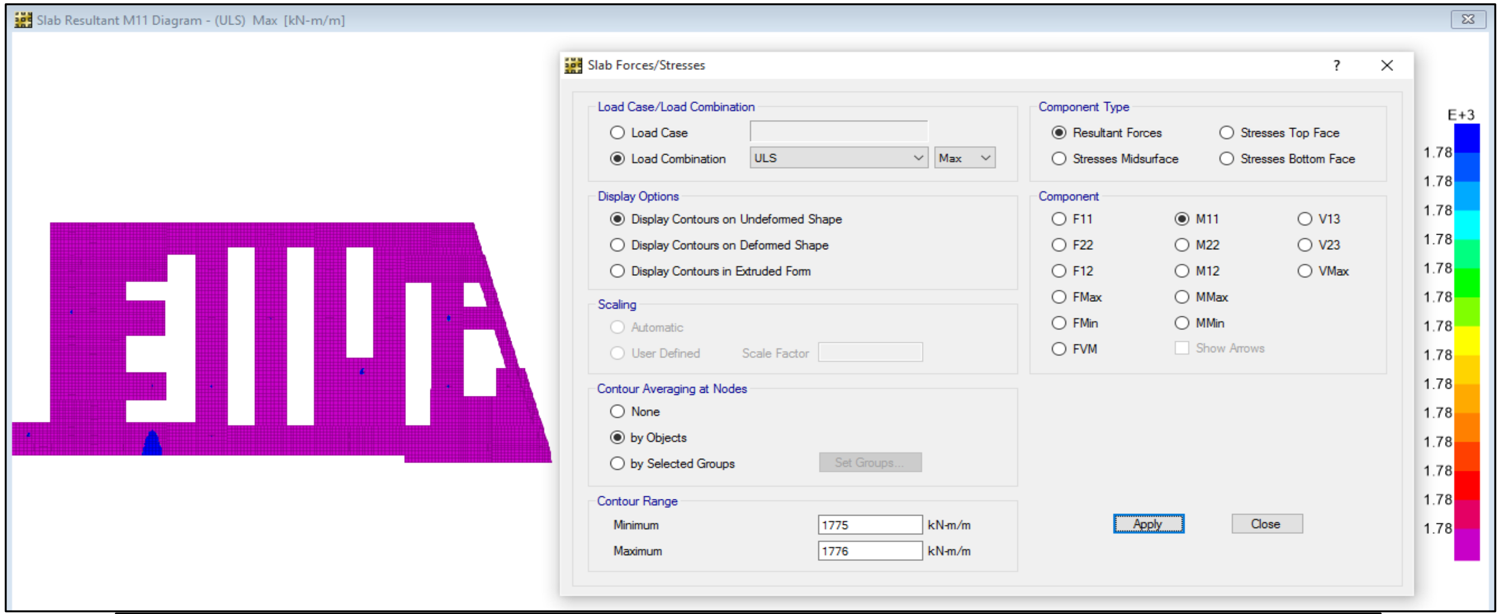
Bending moment in kN-m per Meter		Concrete	fck	=	35	Mpa
		Reinforcement	fy	=	500	Mpa
b	1000 mm					
		Clear cover In Raft	C	=	75	mm
		Slab Thickness, T		=	800	mm
		Effective thickness, t		=	715	mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

Asr = (0.85 x500x715- ((0.85x500x715)^2 - (2.36 x1300x10^6x0.85x500^2)/(35x1000)))^0.5) x ((35x1000)/(1.18x0.85x500^2))
= 4518.79 mm2

Minimum Pt	=	0.140	%				
Minimum Ast	=	1120					
Provided Pt	=	0.643					
Provided Ast	=	4600	mm^2				
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)	
	+	25	Dia @	175	mm c/c	(Extra)	
			O.K.				

HD20@175CRS Through + HD25@175CRS Extra Bottom X Direction



Flexure design:

Maximum Moment +M = 1775.00 kN.m/m

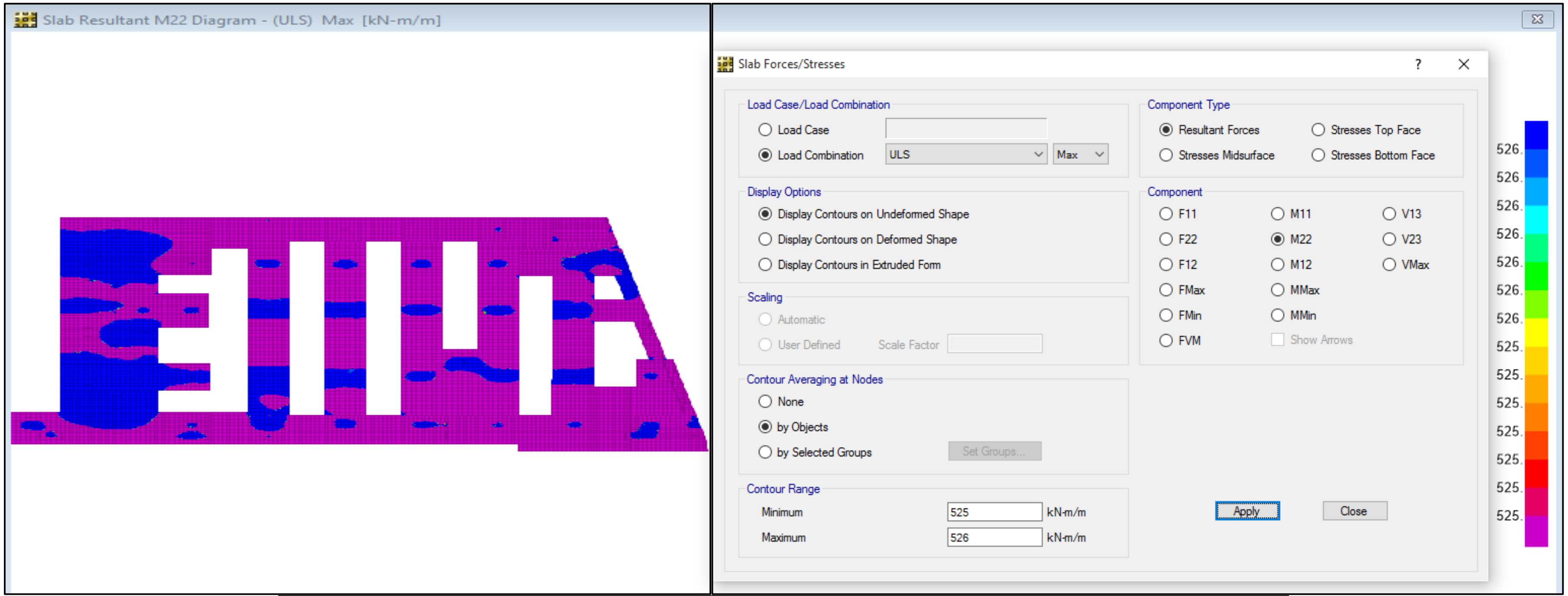
Bending moment in kN-m per Meter		Concrete	fck	=	35	Mpa
		Reinforcement	fy	=	500	Mpa
b	1000 mm					
		Clear cover In Raft	C	=	75	mm
		Slab Thickness, T		=	800	mm
		Effective thickness, t		=	715	mm

$$A_{st} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^{\,2}}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^{\,2}}$$

Asr = (0.85 x500x715- ((0.85x500x715)^2 - (2.36 x1775x10^6x0.85x500^2)/(35x1000)))^0.5) x ((35x1000)/(1.18x0.85x500^2))
= 6310.68 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1120				
Provided Pt	=	0.894				
Provided Ast	=	6391	mm²			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	32	Dia @	175	mm c/c	(Extra)
			O.K.			

HD20@175CRS Through + HD32@175CRS Extra Bottom X Direction



Flexure design:

Maximum Moment +M = 525.00 kN.m/m

Bending moment in kN-m per Meter

Concrete	fck	=	35	Mpa
Reinforcement	fy	=	500	Mpa
Clear cover In Raft	C	=	75	mm
Slab Thickness, T		=	800	mm
Effective thickness, t		=	715	mm

b 1000 mm

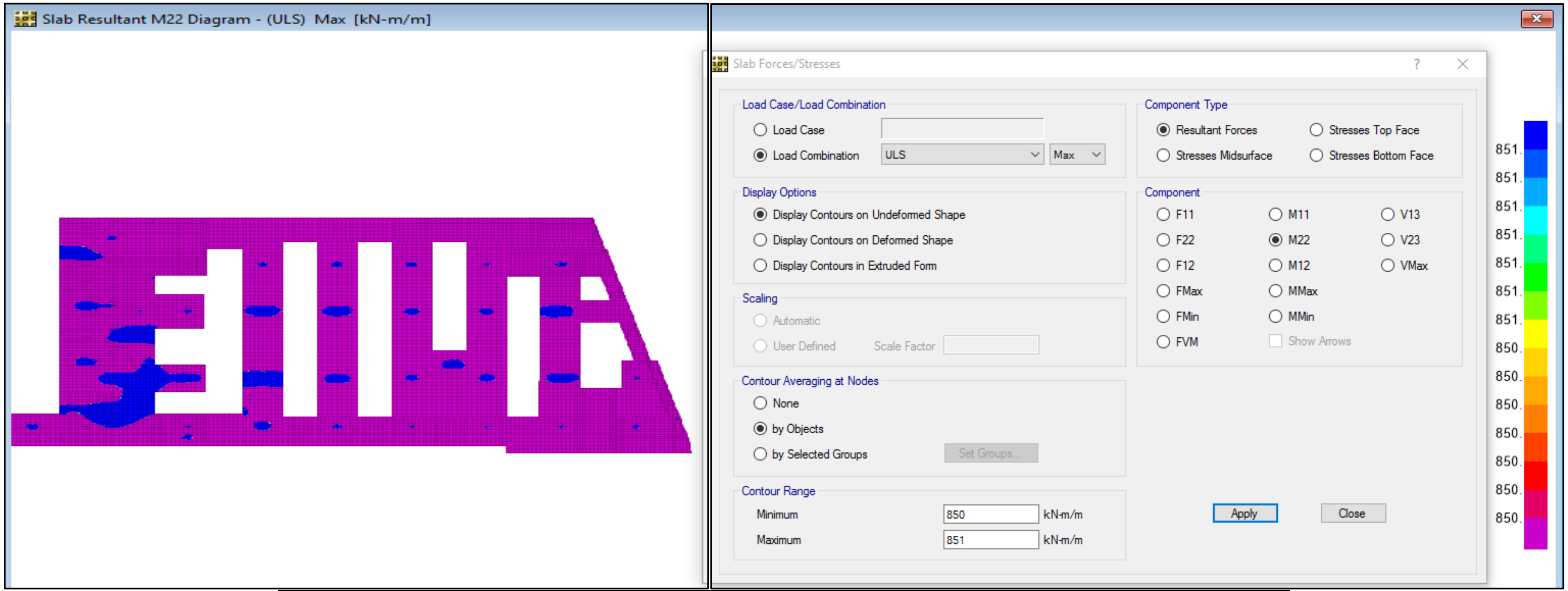
$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

Asr = (0.85 x500x715- ((0.85x500x715)^2 - (2.36 x525x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 1764.39 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1120				
Provided Pt	=	0.251				
Provided Ast	=	1795	mm^2			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	0	Dia @	175	mm c/c	(Extra)
			O.K.			

HD20@175CRS through Bottom Y Direction



Flexure design:

Maximum Moment +M		=	850.00 kN.m/m				
Bending moment in kN-m per Meter				Concrete	fck	=	35 Mpa
				Reinforcement	fy	=	500 Mpa
b	1000 mm						
				Clear cover In Raft	C	=	75 mm
				Slab Thickness, T		=	800 mm
				Effective thickness, t		=	715 mm

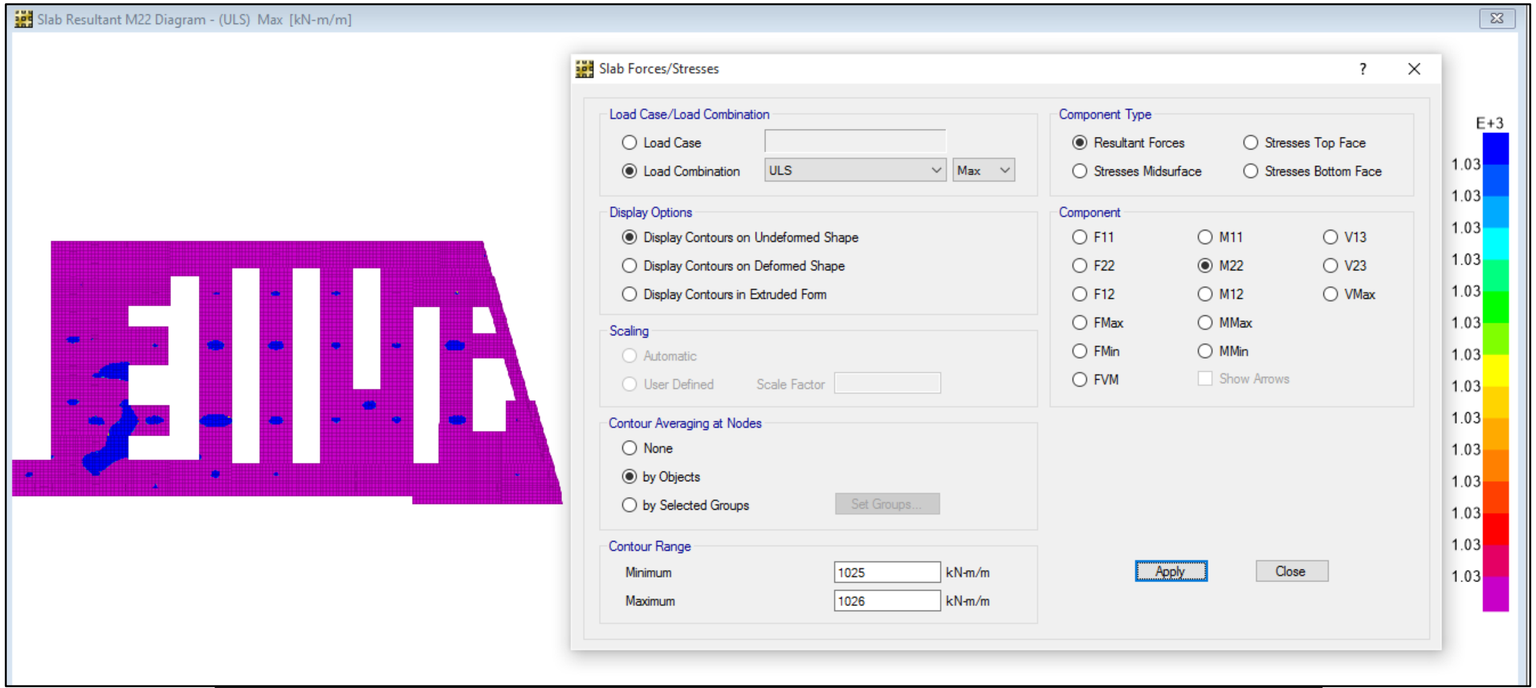
$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

Asr = (0.85 x500x715- ((0.85x500x715)^2 - (2.36 x850x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 2896.08 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1120				
Provided Pt	=	0.412				
Provided Ast	=	2944	mm^2			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	16	Dia @	175	mm c/c	(Extra)
				O.K.		

HD20@175CRS Through + HD16@175CRS Extra Bottom Y Direction



Flexure design:

Maximum Moment +M = 1025.00 kN.m/m

Bending moment in kN-m per Meter		Concrete	fck	=	35 Mpa
		Reinforcement	fy	=	500 Mpa
b	1000 mm				
		Clear cover In Raft	C	=	75 mm
		Slab Thickness, T		=	800 mm
		Effective thickness, t		=	715 mm

$$A_{st} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

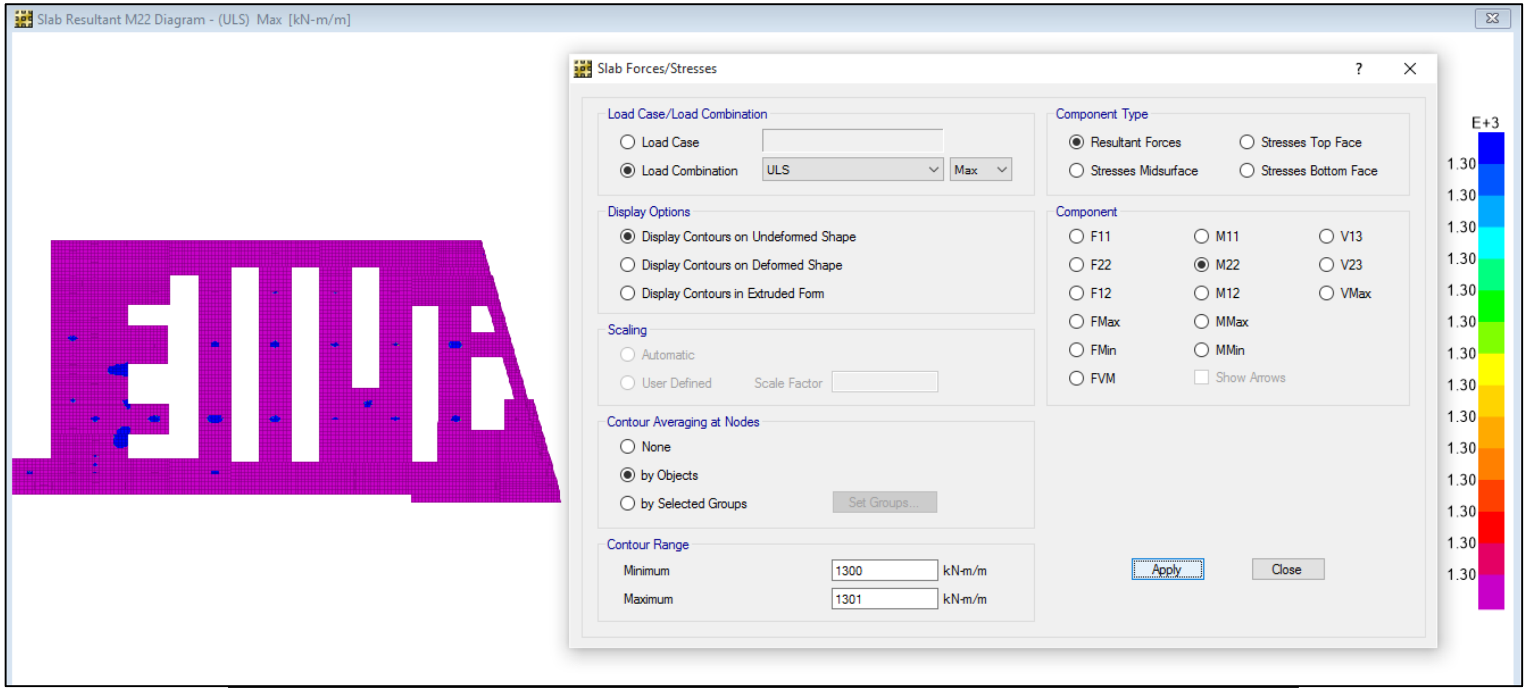
Asr = (0.85 x500x715- ((0.85x500x715)^2 - (2.36 x1025x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 3519.09 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1120				
Provided Pt	=	0.502				
Provided Ast	=	3590	mm^2			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	20	Dia @	175	mm c/c	(Extra)

O.K.

HD20@175CRS Through + HD20@175CRS Extra Bottom Y Direction



Flexure design:

Maximum Moment +M = 1300.00 kN.m/m

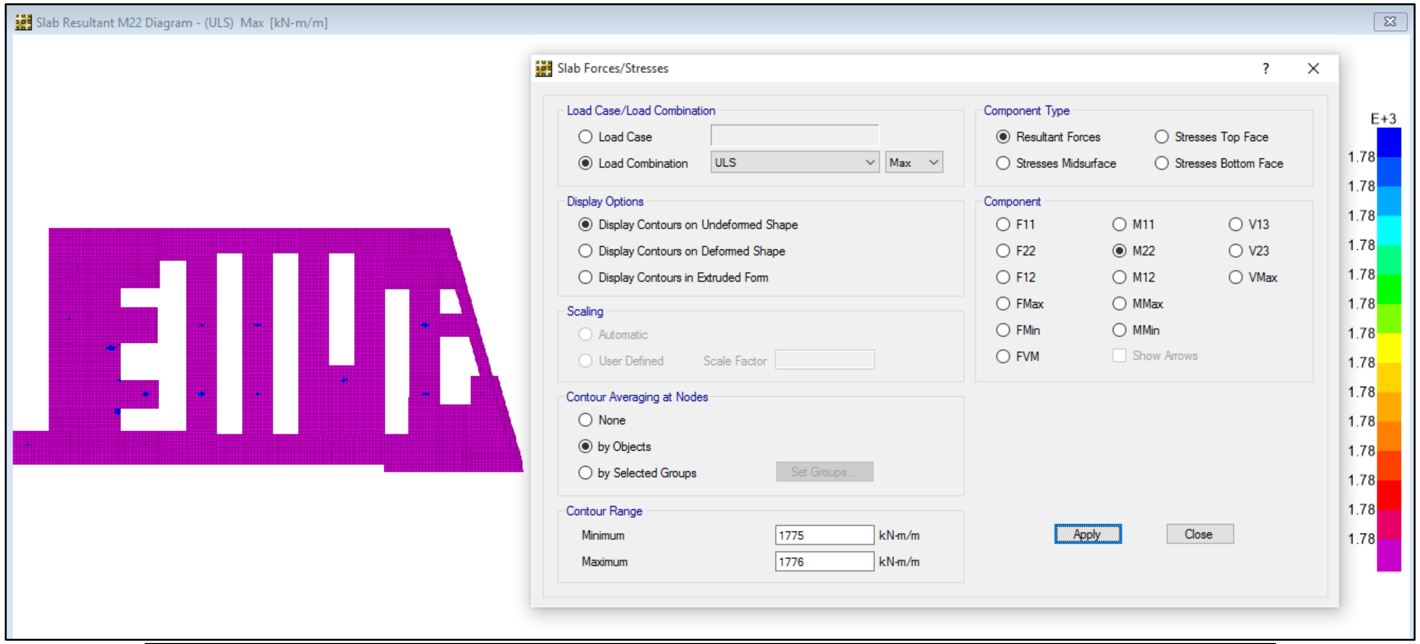
Bending moment in kN-m per Meter	Concrete	fck	=	35	Mpa
	Reinforcement	fy	=	500	Mpa
b 1000 mm					
	Clear cover In Raft	C	=	75	mm
	Slab Thickness, T		=	800	mm
	Effective thickness, t		=	715	mm

$$A_{st} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f'_c \cdot b}}\right] \cdot \frac{f'_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

Asr = (0.85 x500x715- ((0.85x500x715)^2 - (2.36 x1300x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))
= 4518.79 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1120				
Provided Pt	=	0.643				
Provided Ast	=	4600	mm^2			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	25	Dia @	175	mm c/c	(Extra)
			O.K.			
		1300				
		800				

HD20@175CRS Through + HD25@175CRS Extra Bottom Y Direction



Flexure design:

Maximum Moment +M = 1775.00 kN.m/m

Bending moment in kN-m per Meter		Concrete	fck	=	35	Mpa
		Reinforcement	fy	=	500	Mpa
b	1000 mm					
		Clear cover In Raft	C	=	75	mm
		Slab Thickness, T		=	800	mm
		Effective thickness, t		=	715	mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

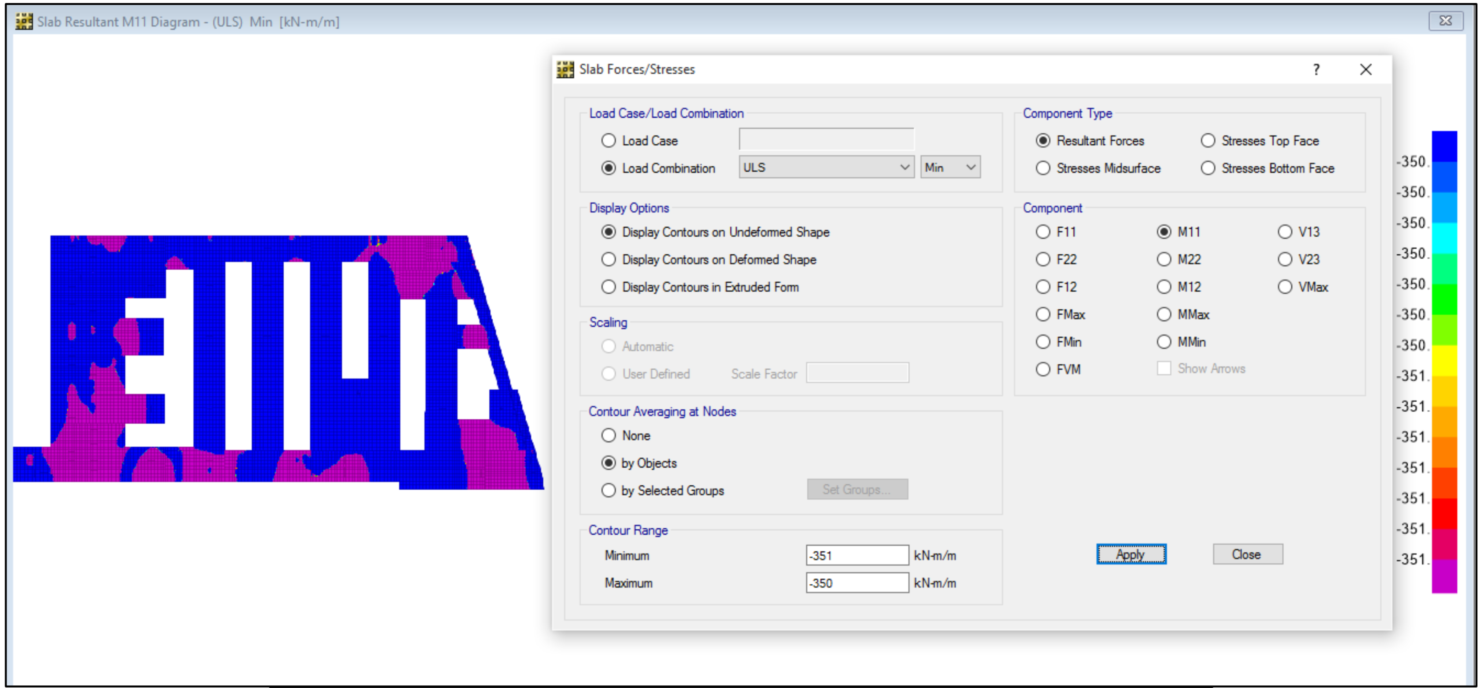
Asr = (0.85 x500x715- ((0.85x500x715)^2 - (2.36 x1775x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 6310.68 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1120				
Provided Pt	=	0.894				
Provided Ast	=	6391	mm²			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	32	Dia @	175	mm c/c	(Extra)
			O.K.			

HD20@175CRS Through + HD32@175CRS Extra Bottom Y Direction

4.8 Design of Foundation – 800mm thick (Top reinforcement)



Flexure design:

Maximum Moment +M = 350.00 kN.m/m

Bending moment in kN-m per Meter

b 1000 mm

Concrete	fck	=	35 Mpa
Reinforcement	fy	=	500 Mpa
Clear cover In Raft	C	=	50 mm
Slab Thickness, T		=	800 mm
Effective thickness, t		=	740 mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

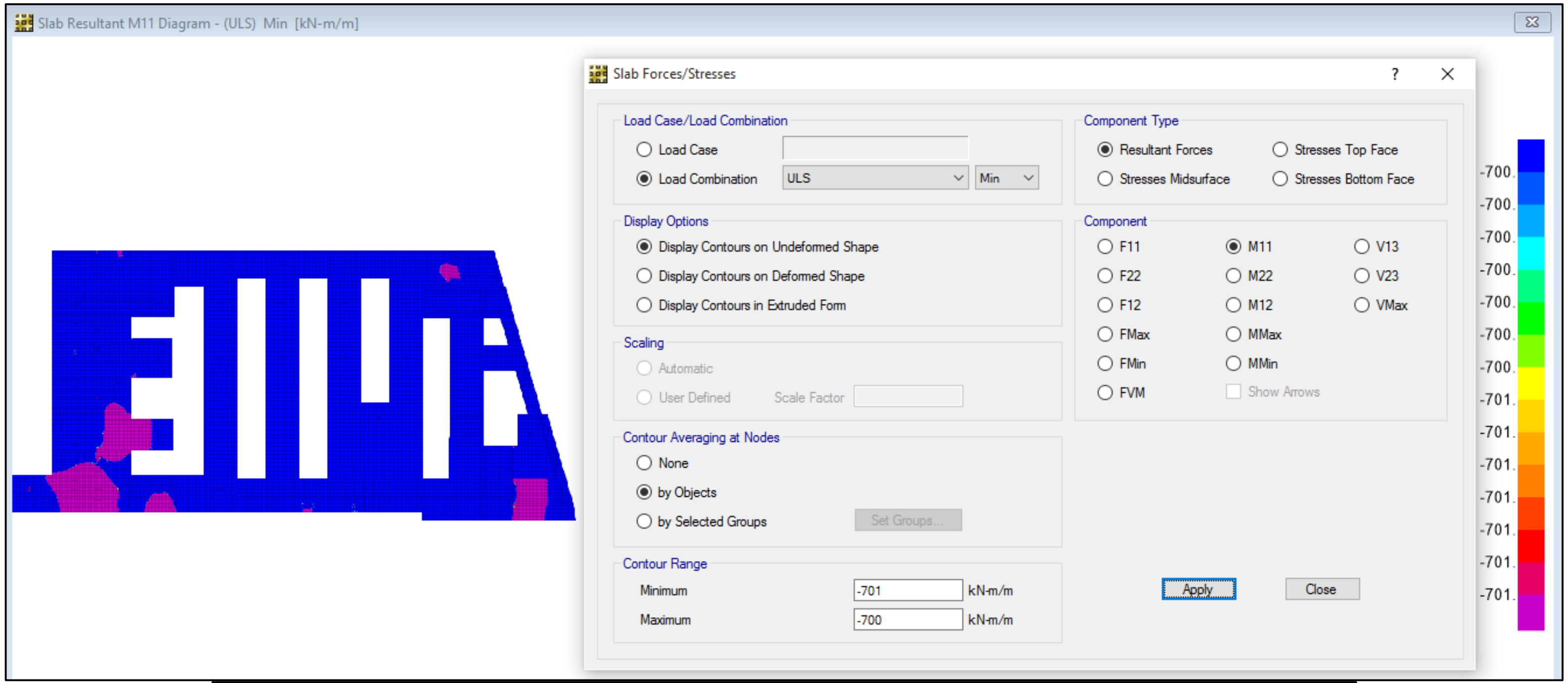
Asr = (0.85 x500x740- ((0.85x500x740)^2 - (2.36 x350x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 1127.36 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1120				
Provided Pt	=	0.155				
Provided Ast	=	1149	mm²			
Dia of Reinforcement	=	16	Dia @	175	mm c/c	(Through)
	+	0	Dia @	175	mm c/c	(Extra)

O.K.

HD16@175CRS through Top - X Direction



Flexure design:

Maximum Moment +M = 700.00 kN.m/m

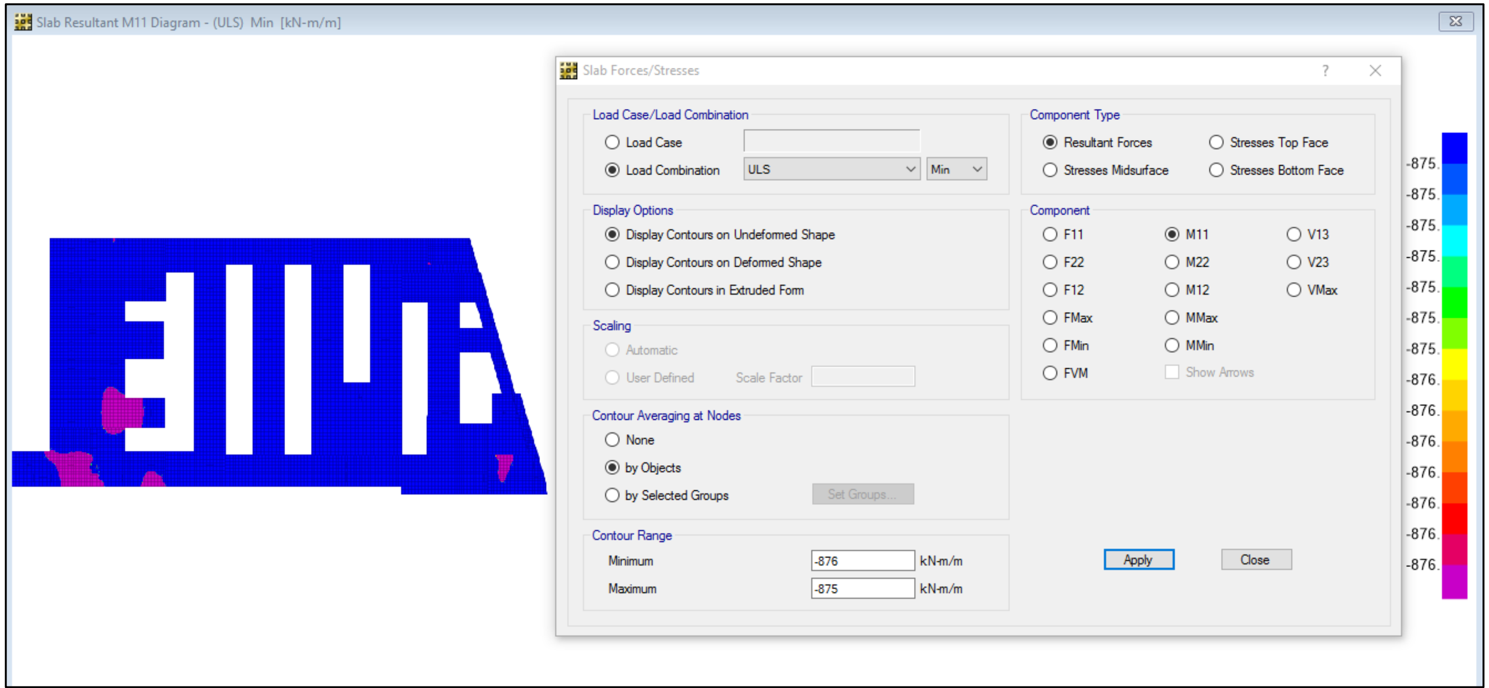
Bending moment in kN-m per Meter		Concrete	fck	=	35	Mpa
		Reinforcement	fy	=	500	Mpa
b	1000 mm					
		Clear cover In Raft	C	=	50	mm
		Slab Thickness, T		=	800	mm
		Effective thickness, t		=	740	mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^{\ 2}}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^{\ 2}}$$

Asr = (0.85 x500x740- ((0.85x500x740)^2 - (2.36 x700x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))
= 2285.24 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1120				
Provided Pt	=	0.311				
Provided Ast	=	2298	mm^2			
Dia of Reinforcement	=	16	Dia @	175	mm c/c	(Through)
	+	16	Dia @	175	mm c/c	(Extra)
				O.K.		

HD16@175CRS Through + HD16@175CRS Extra Top X Direction



Flexure design:

Maximum Moment +M	=	875.00 kN.m/m	

Bending moment in kN-m per Meter

b 1000 mm

Concrete	fck	=	35	Mpa
Reinforcement	fy	=	500	Mpa
Clear cover In Raft	C	=	50	mm
Slab Thickness, T		=	800	mm
Effective thickness, t		=	740	mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

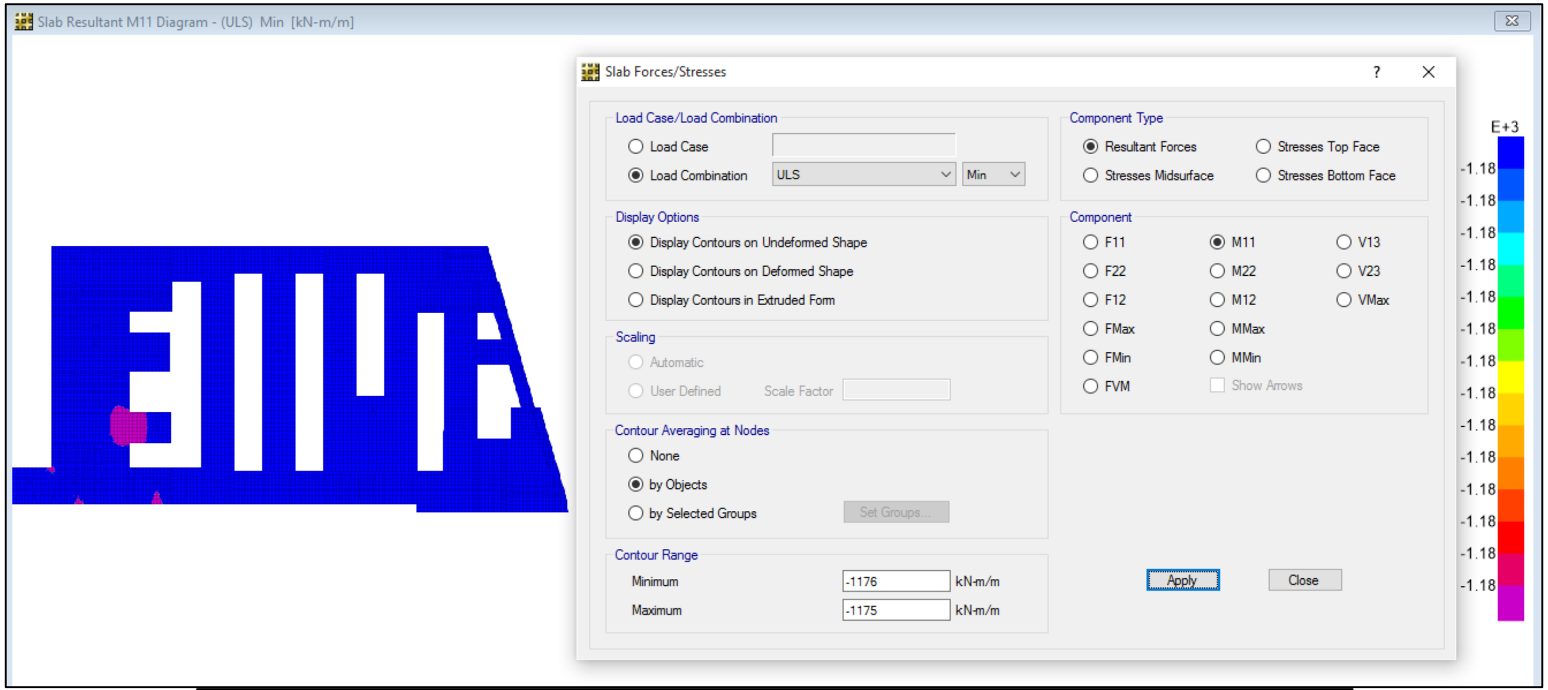
Asr = (0.85 x500x740- ((0.85x500x740)^2 - (2.36 x875x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 2876.44 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1120				
Provided Pt	=	0.398				
Provided Ast	=	2944	mm²			
Dia of Reinforcement	=	16	Dia @	175	mm c/c	(Through)
	+	20	Dia @	175	mm c/c	(Extra)

O.K.

HD16@175CRS Through + HD20@175CRS Extra Top X Direction



Flexure design:

Maximum Moment +M = 1175.00 kN.m/m

Bending moment in kN-m per Meter

b 1000 mm

Concrete	fck	=	35	Mpa
Reinforcement	fy	=	500	Mpa
Clear cover In Raft	C	=	50	mm
Slab Thickness, T		=	800	mm
Effective thickness, t		=	740	mm

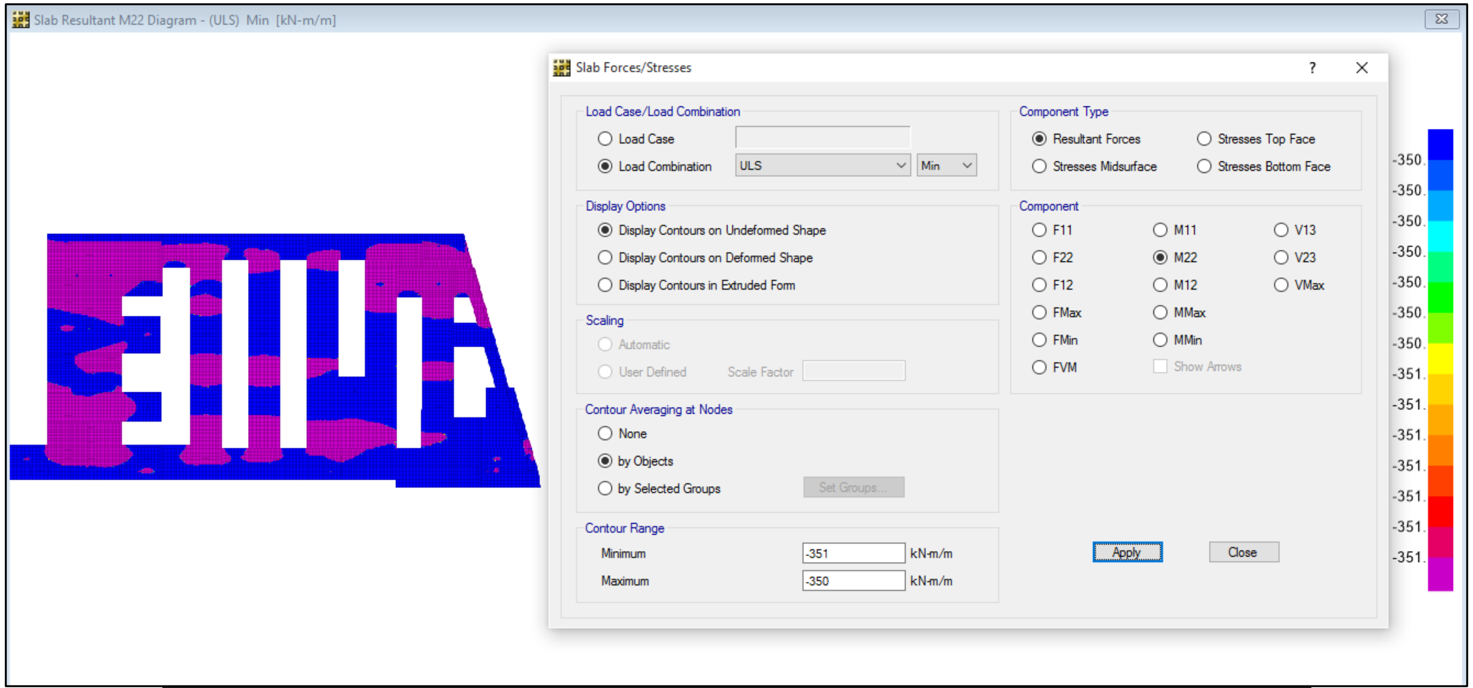
$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

Asr = (0.85 x500x740- ((0.85x500x740)^2 - (2.36 x1175x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))
= 3910.25 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1120				
Provided Pt	=	0.534				
Provided Ast	=	3954	mm²			
Dia of Reinforcement	=	16	Dia @	175	mm c/c	(Through)
	+	25	Dia @	175	mm c/c	(Extra)

O.K.

HD16@175CRS Through + HD25@175CRS Extra Top X Direction



Flexure design:

Maximum Moment +M = 350.00 kN.m/m

Bending moment in kN-m per Meter		Concrete	fck	=	35 Mpa
		Reinforcement	fy	=	500 Mpa
b	1000 mm				
		Clear cover In Raft	C	=	50 mm
		Slab Thickness, T		=	800 mm
		Effective thickness, t		=	740 mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

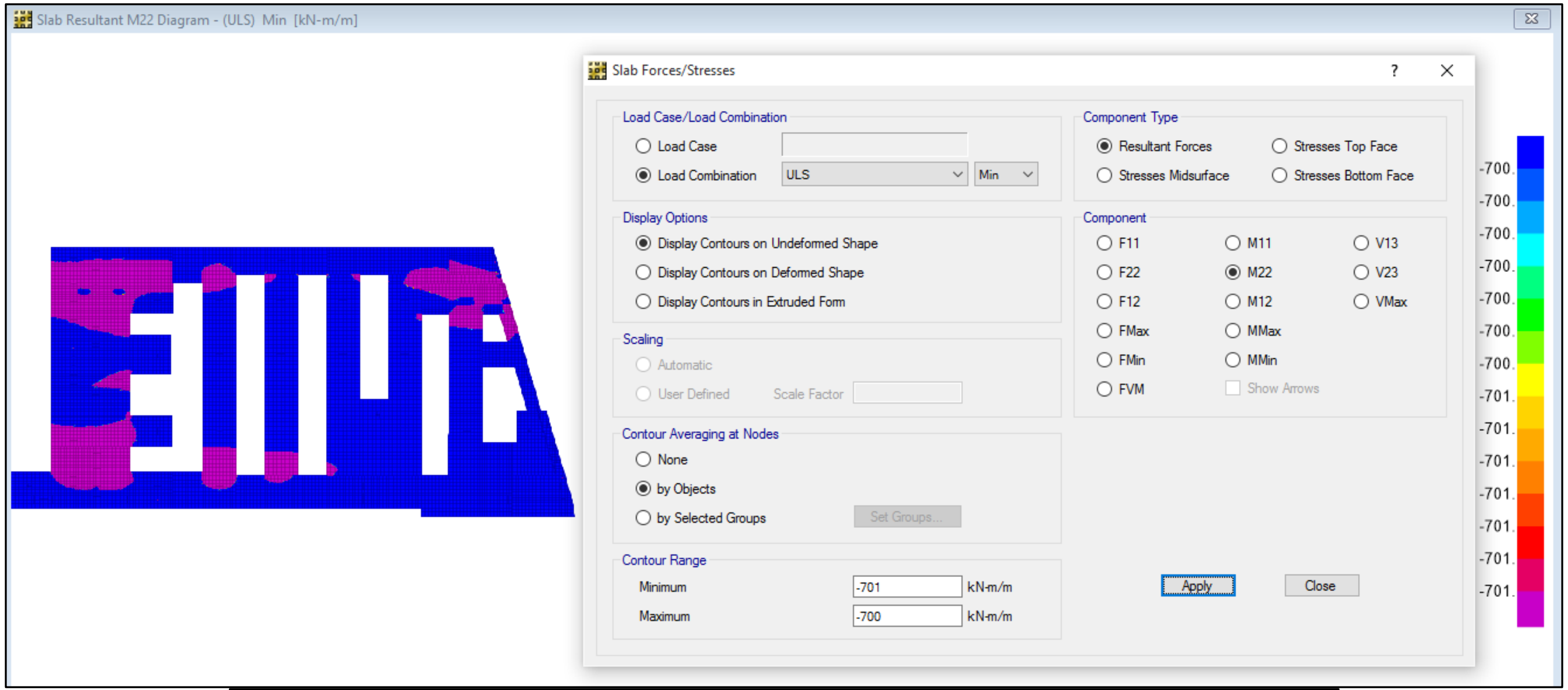
Asr = (0.85 x500x740- ((0.85x500x740)^2 - (2.36 x350x10^6x0.85x500^2)/(35x1000)))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 1127.36 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1120				
Provided Pt	=	0.155				
Provided Ast	=	1149	mm²			
Dia of Reinforcement	=	16	Dia @	175	mm c/c	(Through)
	+	0	Dia @	175	mm c/c	(Extra)

O.K.

HD16@175CRS through Top - Y Direction



Flexure design:

Maximum Moment +M = 700.00 kN.m/m

Bending moment in kN-m per Meter		Concrete	fck	=	35 Mpa
		Reinforcement	fy	=	500 Mpa
b	1000 mm				
		Clear cover In Raft	C	=	50 mm
		Slab Thickness, T		=	800 mm
		Effective thickness, t		=	740 mm

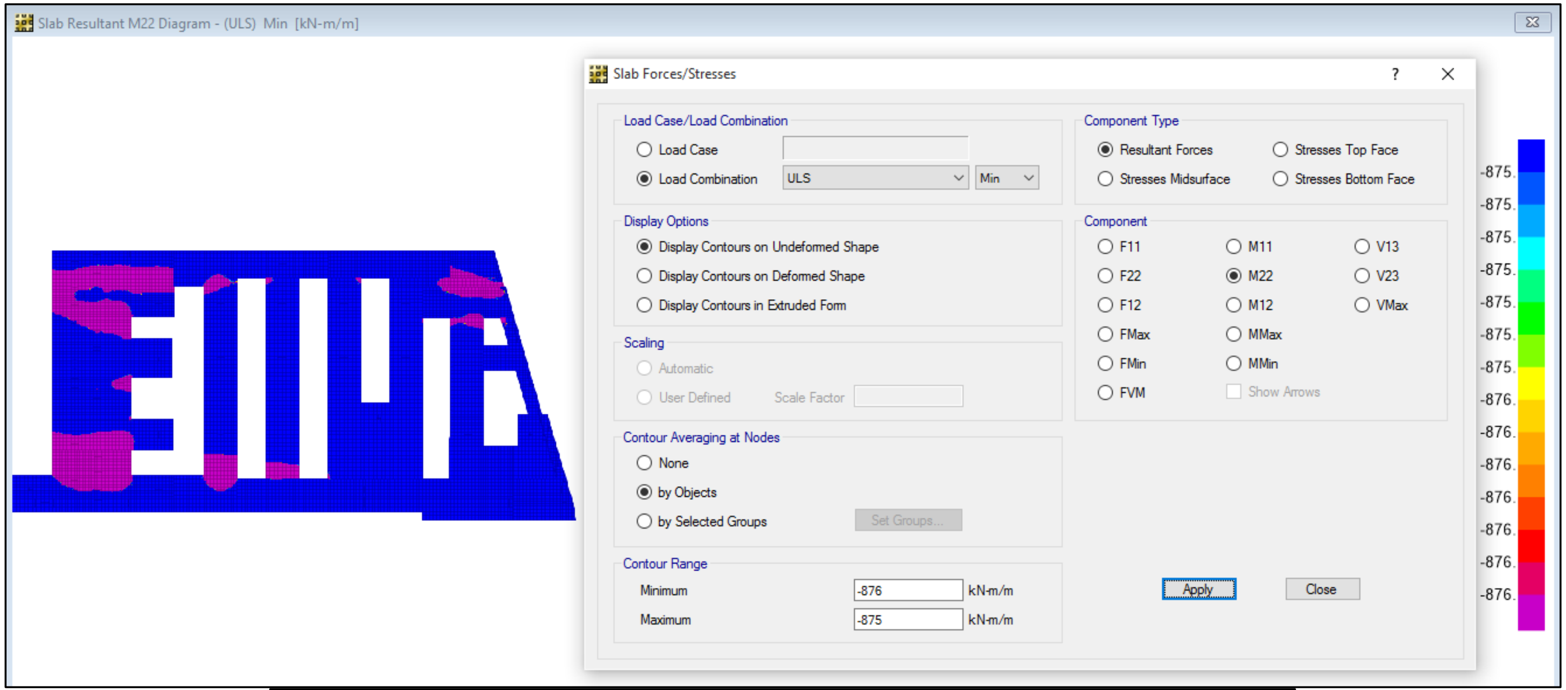
$$A_{sr} := \left[\phi\cdot f_y\cdot d - \sqrt{(\phi\cdot f_y\cdot d)^2 - 2.36\cdot M^{*}\cdot\phi\cdot\frac{f_y^{\,2}}{f_c\cdot b}}\right]\cdot\frac{f_c\cdot b}{1.18\cdot\phi\cdot f_y^{\,2}}$$

Asr = (0.85 x500x740- ((0.85x500x740)^2 - (2.36 x700x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 2285.24 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1120				
Provided Pt	=	0.311				
Provided Ast	=	2298	mm²			
Dia of Reinforcement	=	16	Dia @	175	mm c/c	(Through)
	+	16	Dia @	175	mm c/c	(Extra)
			O.K.			

HD16@175CRS Through + HD16@175CRS Extra Top Y Direction



Flexure design:

Maximum Moment +M	=	875.00 kN.m/m	

Bending moment in kN-m per Meter

b 1000 mm

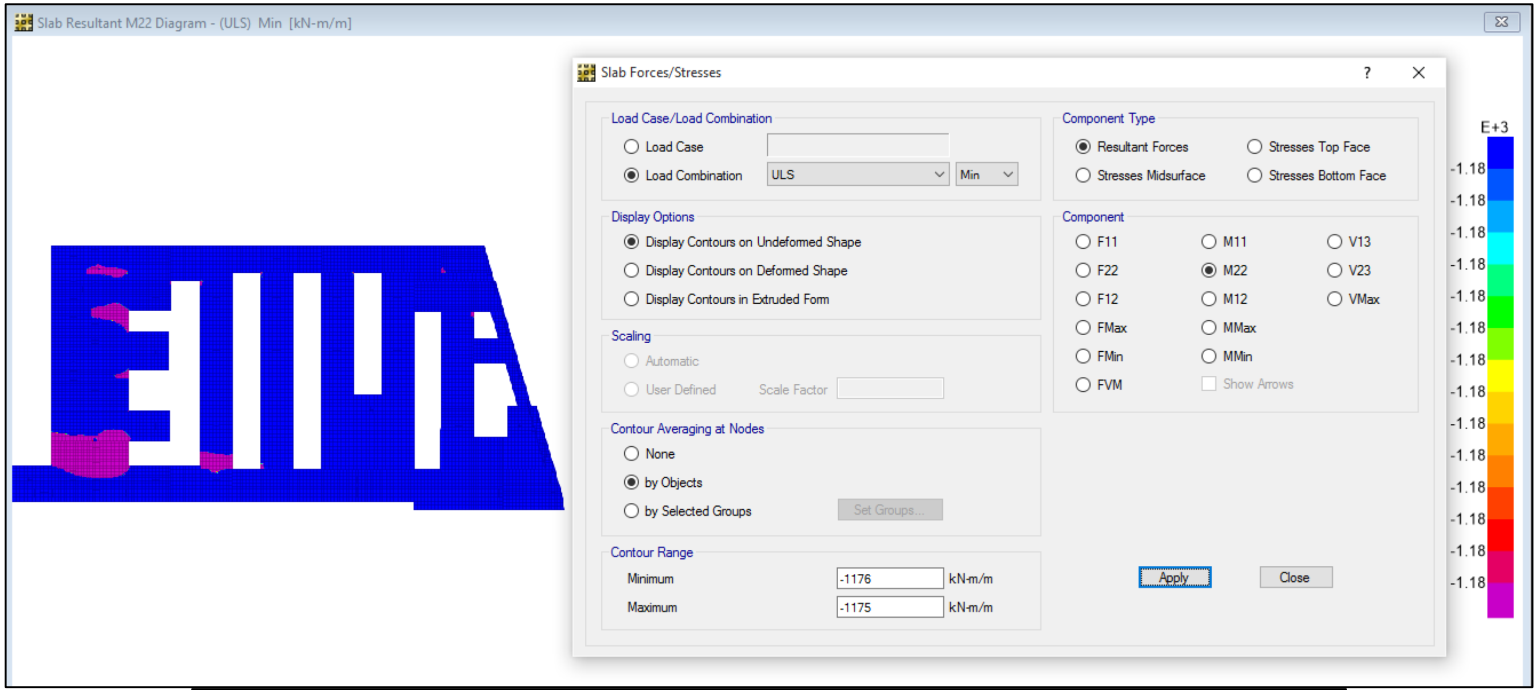
$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^{\,2}}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^{\,2}}$$

Concrete	fck	=	35	Mpa
Reinforcement	fy	=	500	Mpa
Clear cover In Raft	C	=	50	mm
Slab Thickness, T		=	800	mm
Effective thickness, t		=	740	mm

Asr = (0.85 x500x740- ((0.85x500x740)^2 - (2.36 x875x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))
= 2876.44 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1120				
Provided Pt	=	0.398				
Provided Ast	=	2944	mm²			
Dia of Reinforcement	=	16	Dia @	175	mm c/c	(Through)
	+	20	Dia @	175	mm c/c	(Extra)
				O.K.		

HD16@175CRS Through + HD20@175CRS Extra Top Y Direction



Flexure design:

Maximum Moment +M	=	1175.00 kN.m/m	

Bending moment in kN-m per Meter

b 1000 mm

Concrete	fck	=	35	Mpa
Reinforcement	fy	=	500	Mpa
Clear cover In Raft	C	=	50	mm
Slab Thickness, T		=	800	mm
Effective thickness, t		=	740	mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

Asr = (0.85 x500x740- ((0.85x500x740)^2 - (2.36 x1175x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))

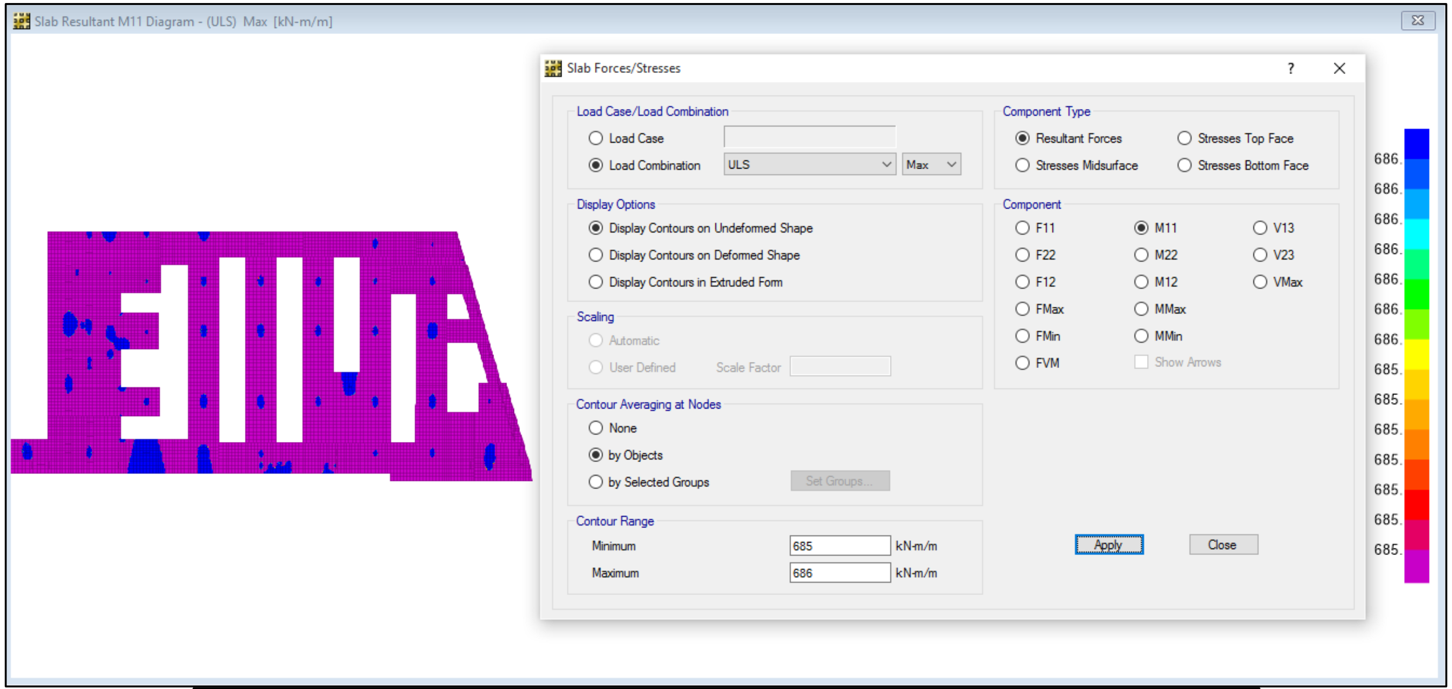
= 3910.25 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1120				
Provided Pt	=	0.534				
Provided Ast	=	3954	mm^2			
Dia of Reinforcement	=	16	Dia @	175	mm c/c	(Through)
	+	25	Dia @	175	mm c/c	(Extra)

O.K.

HD16@175CRS Through + HD25@175CRS Extra Top Y Direction

4.9 Design of Foundation – 1000mm thick (Bottom reinforcement)



Flexure design:

Maximum Moment +Mx = 685.00 kN.m/m

Bending moment in kN-m per Meter

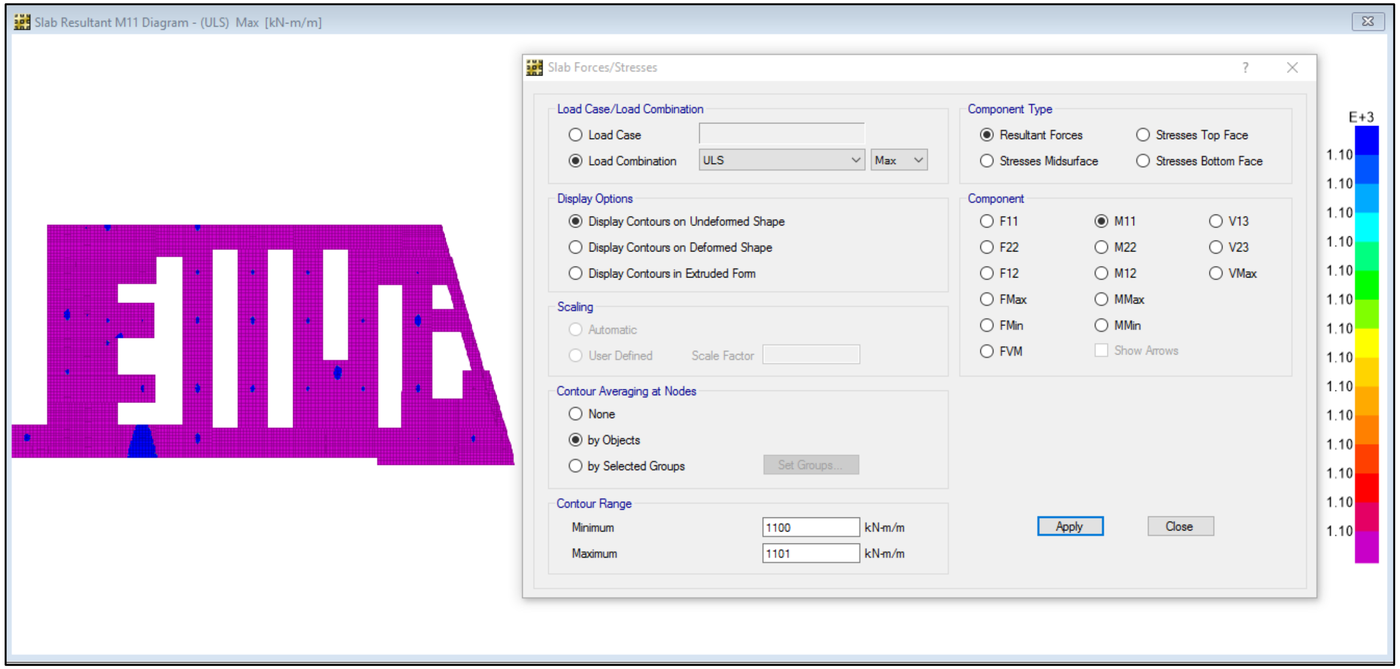
b 1000 mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^{\,2}}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^{\,2}}$$

Asr = (0.85 x500x915- ((0.85x500x915)^2 - (2.36 x685x10^6x0.85x500^2)/(35x1000)))^0.5) x ((35x1000)/(1.18x0.85x500^2))
= 1791.05 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.196				
Provided Ast	=	1795	mm²			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	0	Dia @	200	mm c/c	(Extra)
		685	O.K.			

HD20@175CRS through Bottom X Direction



Flexure design:

Maximum Moment +Mx		=	1100.00 kN.m/m				
Bending moment in kN-m per Meter							
			Concrete	fck	=	35	Mpa
b	1000 mm		Reinforcement	fy	=	500	Mpa
					=		
			Clear cover In Raft	C	=	75	mm
			Slab Thickness, T		=	1000	mm
			Effective thickness, t		=	915	mm

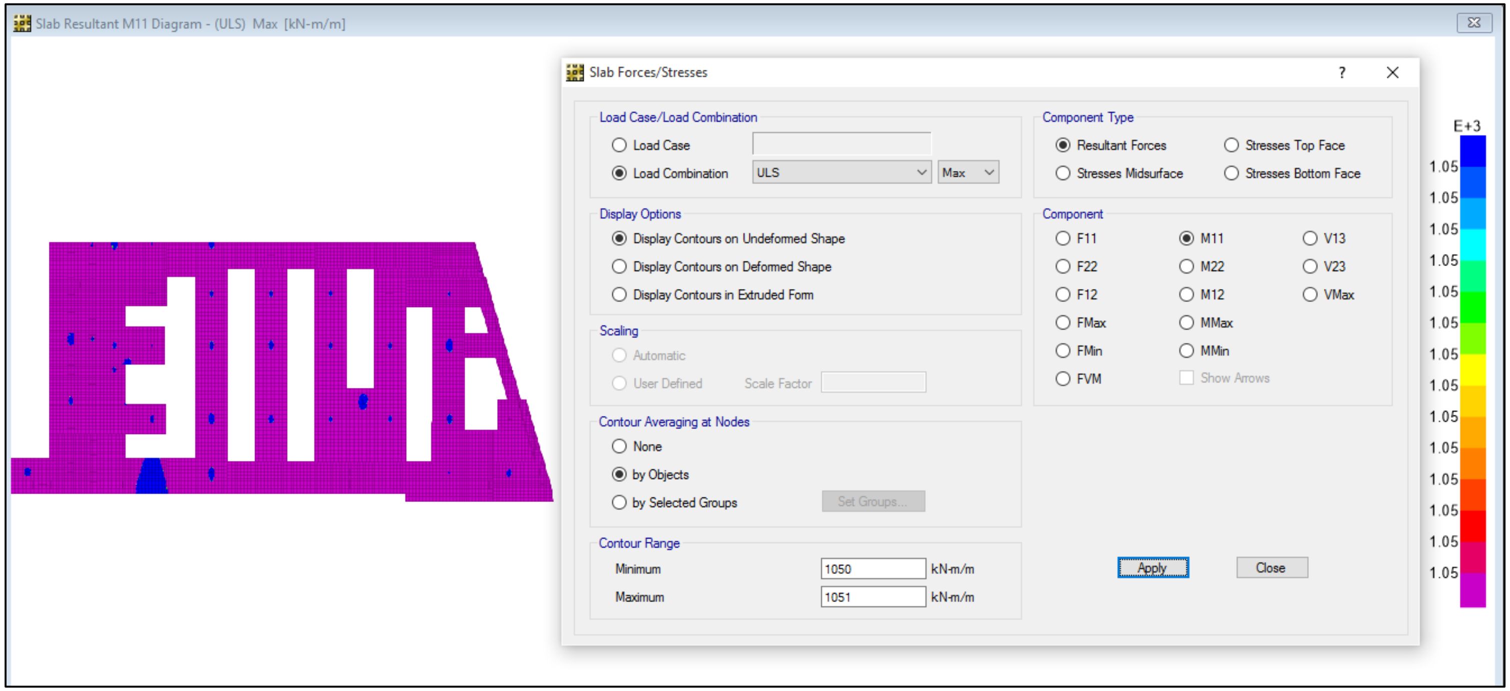
$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^{*} \cdot \phi \cdot \frac{f_y^{\,2}}{f_c \cdot b}}\,\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^{\,2}}$$

Asr = (0.85 x500x915- ((0.85x500x915)^2 - (2.36 x1100x10^6x0.85x500^2)/(35x1000)))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 2906.49 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.322				
Provided Ast	=	2944	mm²			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	16	Dia @	175	mm c/c	(Extra)
			O.K.			

HD20@175CRS Through + HD16@175CRS Extra Bottom X Direction



Flexure design:

Maximum Moment +M = 1050.00 kN.m/m

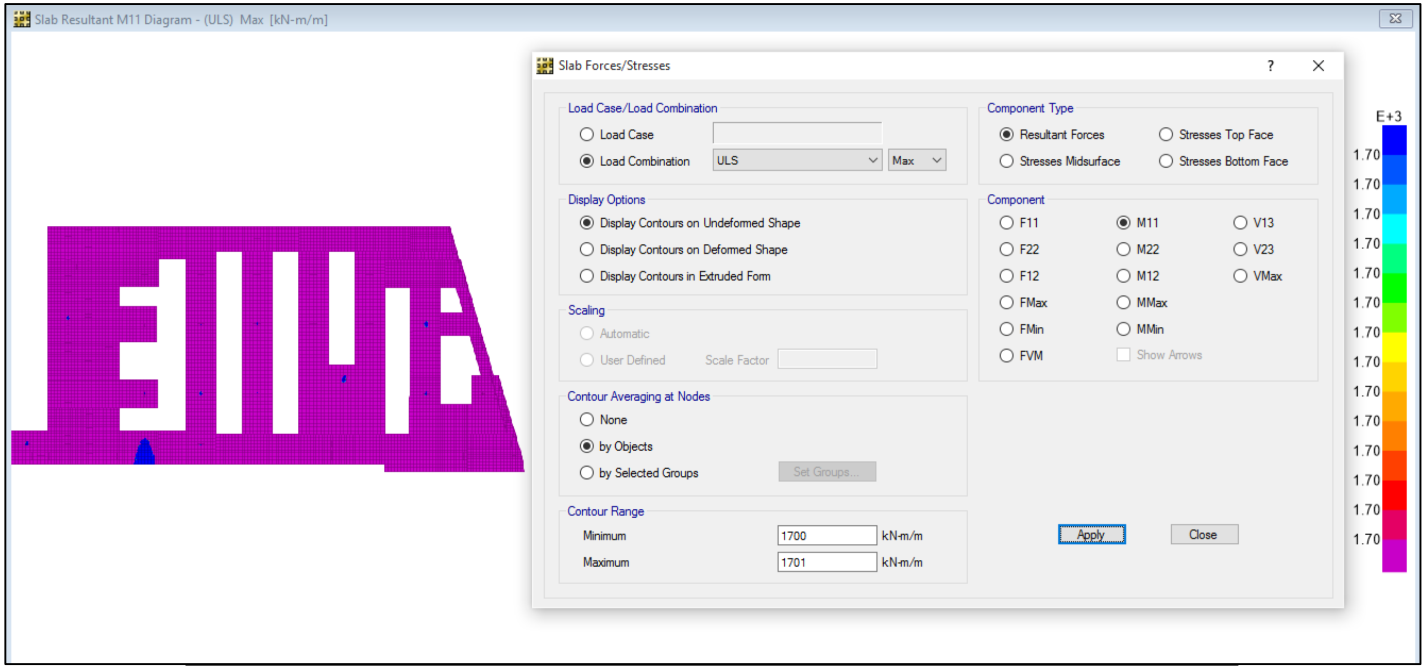
Bending moment in kN-m per Meter		Concrete	fck	=	35	Mpa
		Reinforcement	fy	=	500	Mpa
b	1000 mm					
		Clear cover in Raft	C	=	75	mm
		Slab Thickness, T		=	1000	mm
		Effective thickness, t		=	915	mm

$$A_{st} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

Asr = (0.85 x500x915- ((0.85x500x915)^2 - (2.36 x1050x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))
= 2770.82 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.307				
Provided Ast	=	2805	mm^2			
Dia of Reinforcement	=	25	Dia @	175	mm c/c	(Through)
	+	0	Dia @	175	mm c/c	(Extra)
				O.K.		

HD25@175CRS through Bottom X Direction



Flexure design:

Maximum Moment +M	=	1700.00 kN.m/m					
Bending moment in kN-m per Meter			Concrete	fck	=	35	Mpa
			Reinforcement	fy	=	500	Mpa
b	1000 mm						
			Clear cover In Raft	C	=	75	mm
			Slab Thickness, T		=	1000	mm
			Effective thickness, t		=	915	mm

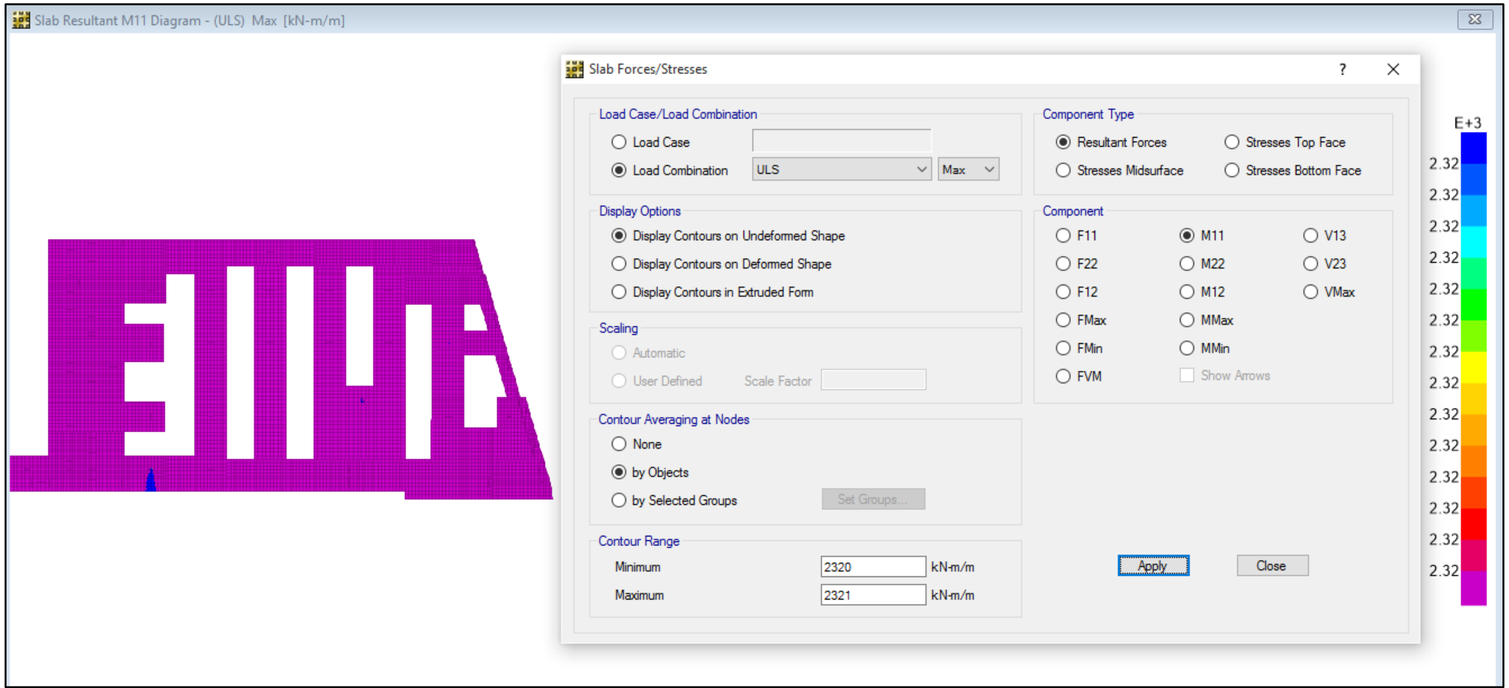
$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^{\,2}}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^{\,2}}$$

Asr = (0.85 x500x915- ((0.85x500x915)^2 - (2.36 x1700x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 4563.42 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.503				
Provided Ast	=	4600	mm²			
Dia of Reinforcement	=	25	Dia @	175	mm c/c	(Through)
	+	20	Dia @	175	mm c/c	(Extra)
				O.K.		

HD20@175CRS Through + HD25@175CRS Extra Bottom X Direction



Flexure design:

Maximum Moment +Mx	=	2320.00 kN.m/m

Bending moment in kN-m per Meter

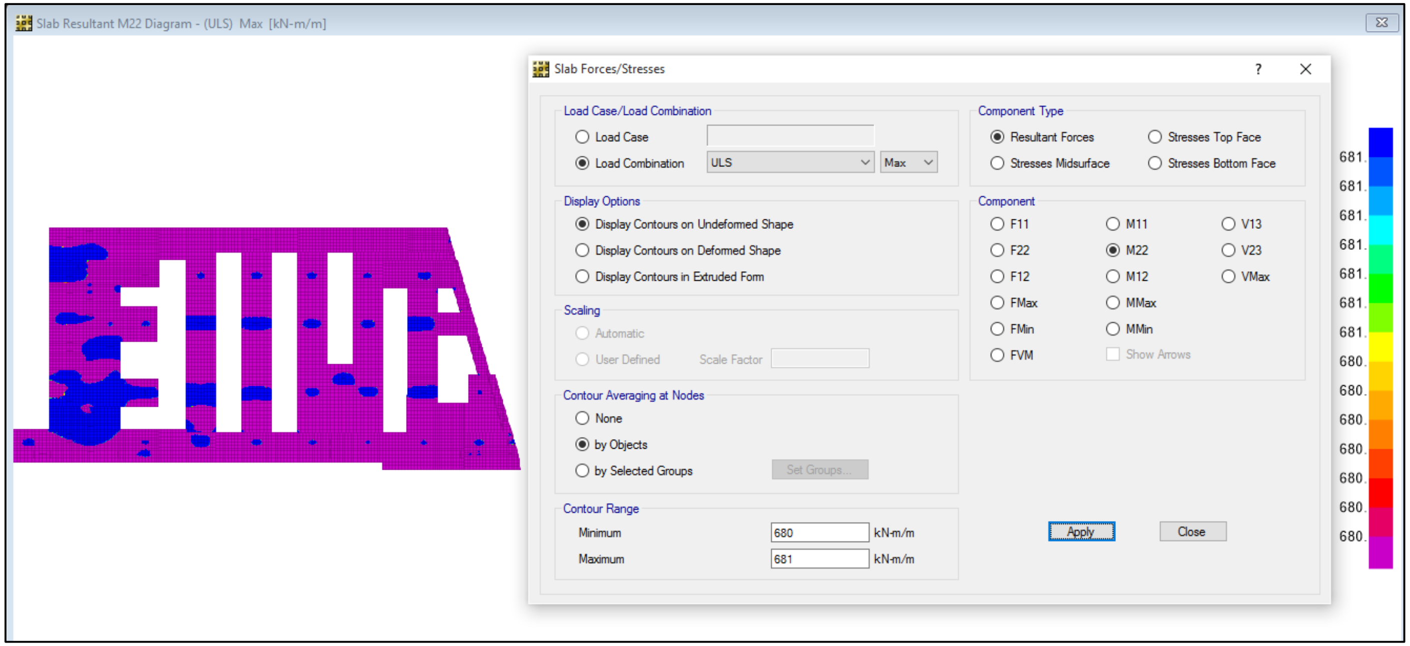
b 1000 mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^{\,2}}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^{\,2}}$$

Asr = (0.85 x500x915- ((0.85x500x915)^2 - (2.36 x2320x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))
= 6335.69 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.698				
Provided Ast	=	6391	mm²			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	32	Dia @	175	mm c/c	(Extra)
			O.K.			

HD20@175CRS Through + HD32@175CRS Extra Bottom X Direction



Flexure design:

Maximum Moment +Mx = 685.00 kN.m/m

Bending moment in kN-m per Meter

b	1000	mm	Concrete	fck	=	35	Mpa
			Reinforcement	fy	=	500	Mpa
					=		
			Clear cover In Raft	C	=	75	mm
			Slab Thickness, T		=	1000	mm
			Effective thickness, t		=	915	mm

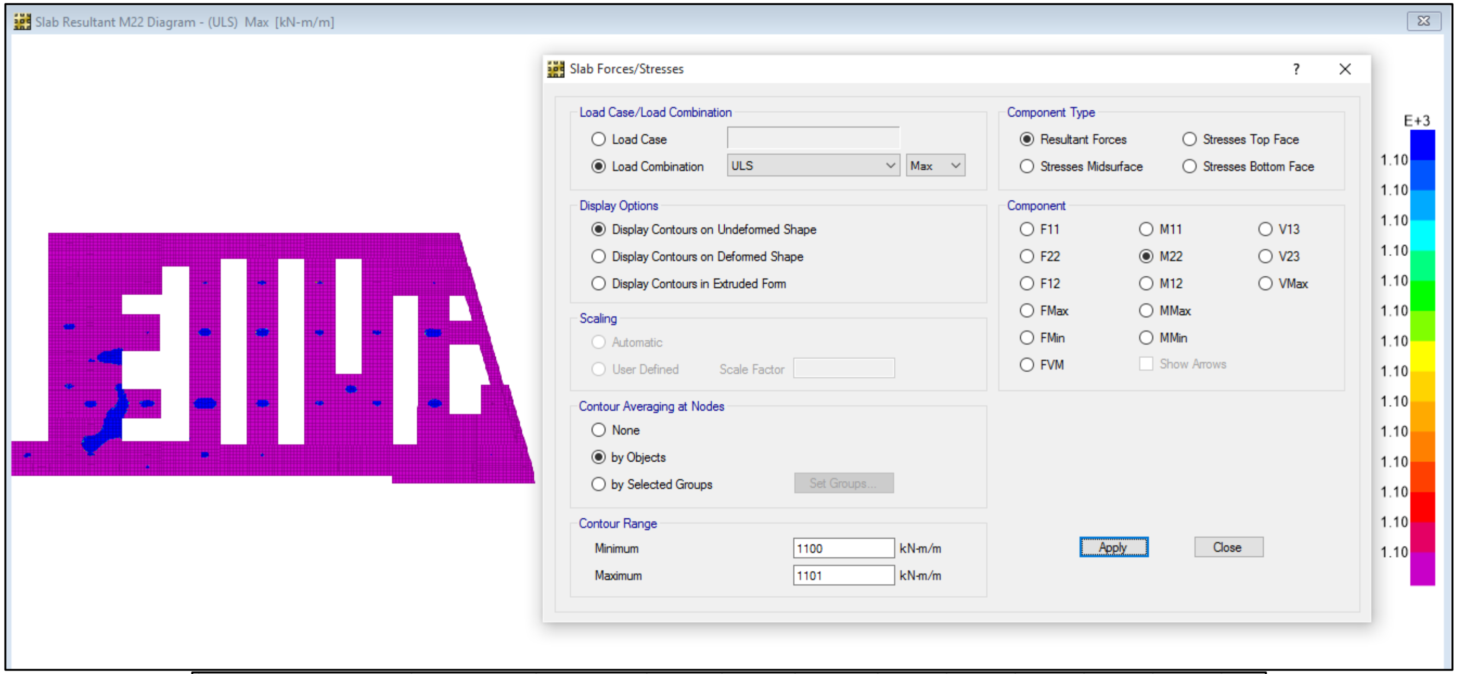
$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

Asr = (0.85 x500x915- ((0.85x500x915)^2 - (2.36 x685x10^6x0.85x500^2)/(35x1000)))^0.5) x ((35x1000)/(1.18x0.85x500^2))
= 1791.05 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.196				
Provided Ast	=	1795	mm²			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	0	Dia @	175	mm c/c	(Extra)

O.K.

HD20@175CRS through Bottom Y Direction



Flexure design:

Maximum Moment +Mx = 1100.00 kN.m/m

Bending moment in kN-m per Meter

Concrete	fck	=	35	Mpa
Reinforcement	fy	=	500	Mpa
		=		
Clear cover In Raft	C	=	75	mm
Slab Thickness, T		=	1000	mm
Effective thickness, t		=	915	mm

b 1000 mm

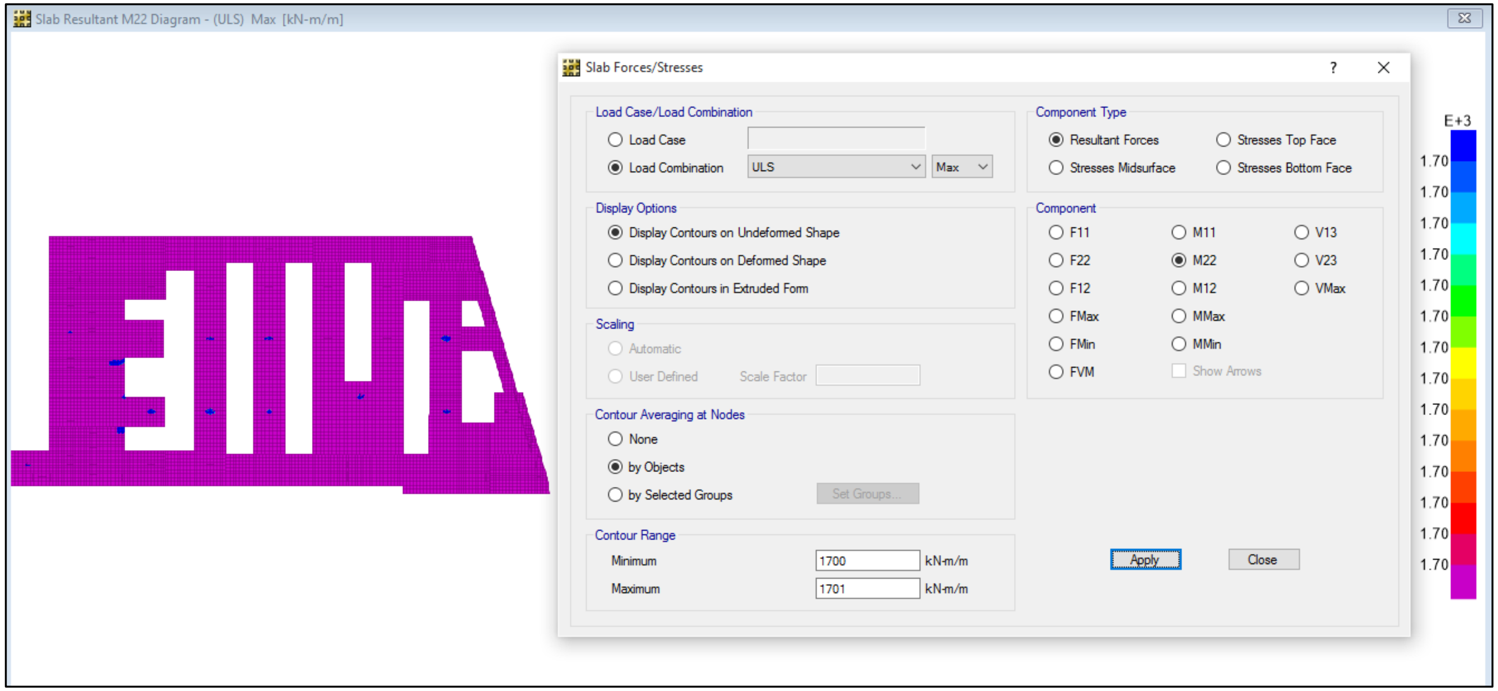
$$A_{st} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^{\,2}}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^{\,2}}$$

Asr = (0.85 x500x915- ((0.85x500x915)^2 - (2.36 x1100x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 2906.49 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.322				
Provided Ast	=	2944	mm²			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	16	Dia @	175	mm c/c	(Extra)
				O.K.		

HD20@175CRS Through + HD16@175CRS Extra Bottom Y Direction



Flexure design:

Maximum Moment +M = 1700.00 kN.m/m

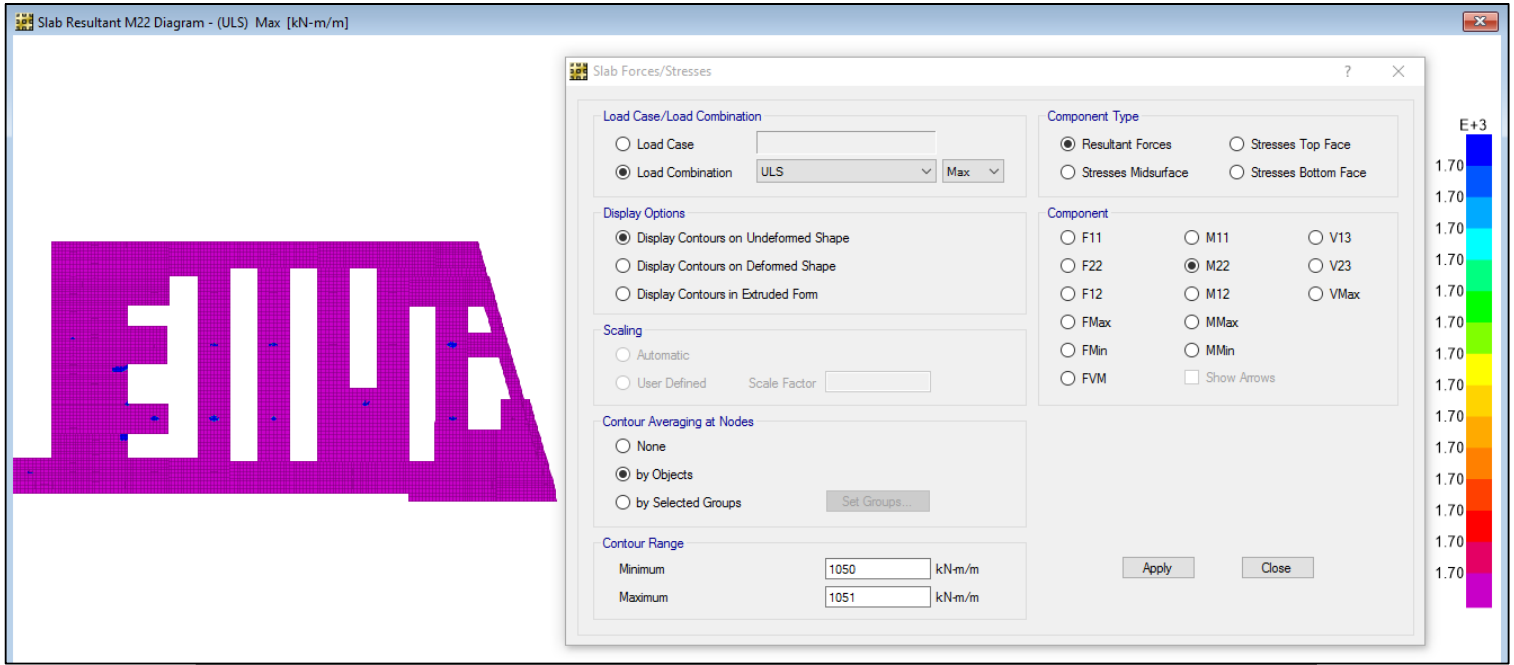
Bending moment in kN-m per Meter		Concrete	fck	=	35	Mpa
		Reinforcement	fy	=	500	Mpa
b	1000 mm					
		Clear cover In Raft	C	=	75	mm
		Slab Thickness, T		=	1000	mm
		Effective thickness, t		=	915	mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

Asr = (0.85 x500x915- ((0.85x500x915)^2 - (2.36 x1700x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))
= 4563.42 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.503				
Provided Ast	=	4600	mm²			
Dia of Reinforcement	=	25	Dia @	175	mm c/c	(Through)
	+	20	Dia @	175	mm c/c	(Extra)
			O.K.			

HD20@175CRS Through + HD25@175CRS Extra Bottom Y Direction



Flexure design:

Maximum Moment +M = 1050.00 kN.m/m

Bending moment in kN-m per Meter	Concrete	fck	=	35	Mpa
	Reinforcement	fy	=	500	Mpa
b 1000 mm					
	Clear cover In Raft	C	=	75	mm
	Slab Thickness, T		=	1000	mm
	Effective thickness, t		=	915	mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

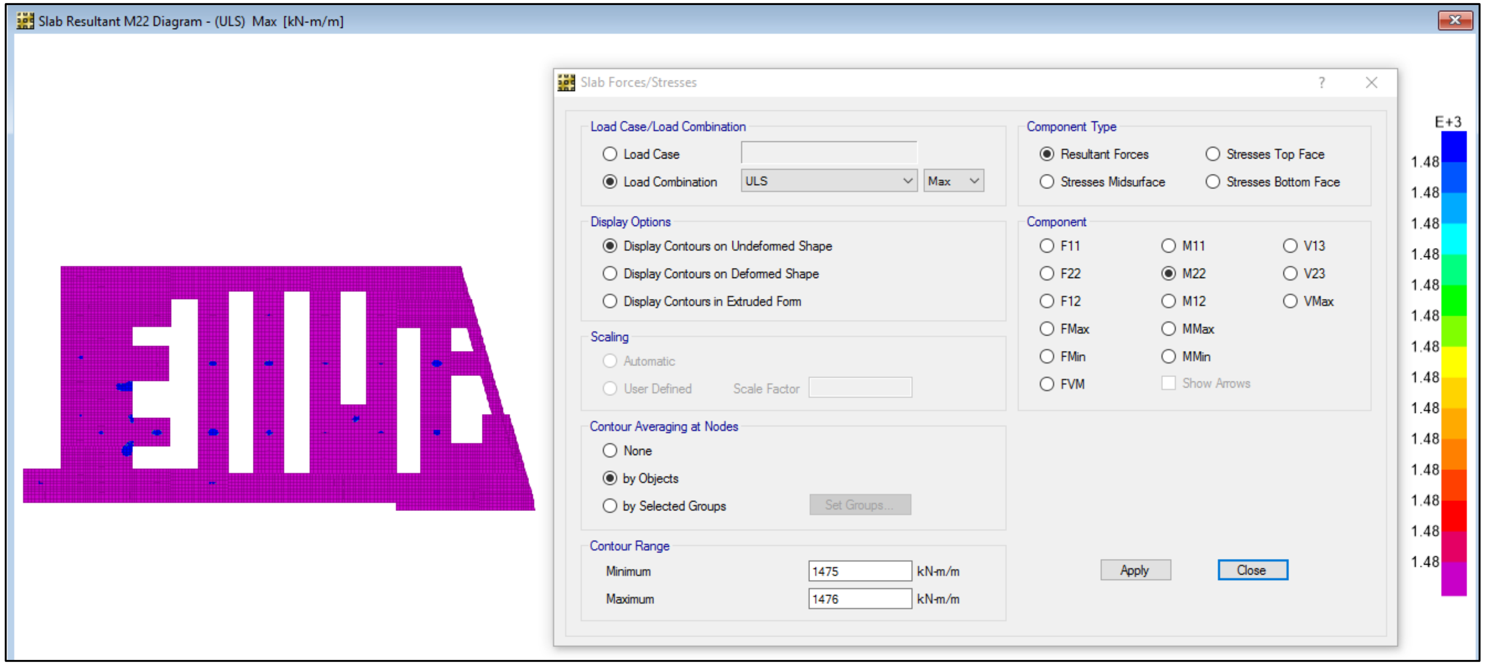
Asr = (0.85 x500x915- ((0.85x500x915)^2 - (2.36 x1050x10^6x0.85x500^2)/(35x1000)))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 2770.82 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.307				
Provided Ast	=	2805	mm²			
Dia of Reinforcement	=	25	Dia @	175	mm c/c	(Through)
	+	0	Dia @	175	mm c/c	(Extra)

O.K.

HD25@175CRS through Bottom Y Direction



Flexure design:

Maximum Moment +Mx = 1475.00 kN.m/m

Bending moment in kN-m per Meter

b	1000 mm	Concrete	fck	=	35	Mpa
		Reinforcement	fy	=	500	Mpa
				=		
		Clear cover In Raft	C	=	75	mm
		Slab Thickness, T		=	1000	mm
		Effective thickness, t		=	915	mm

$$A_{st} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^{*} \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

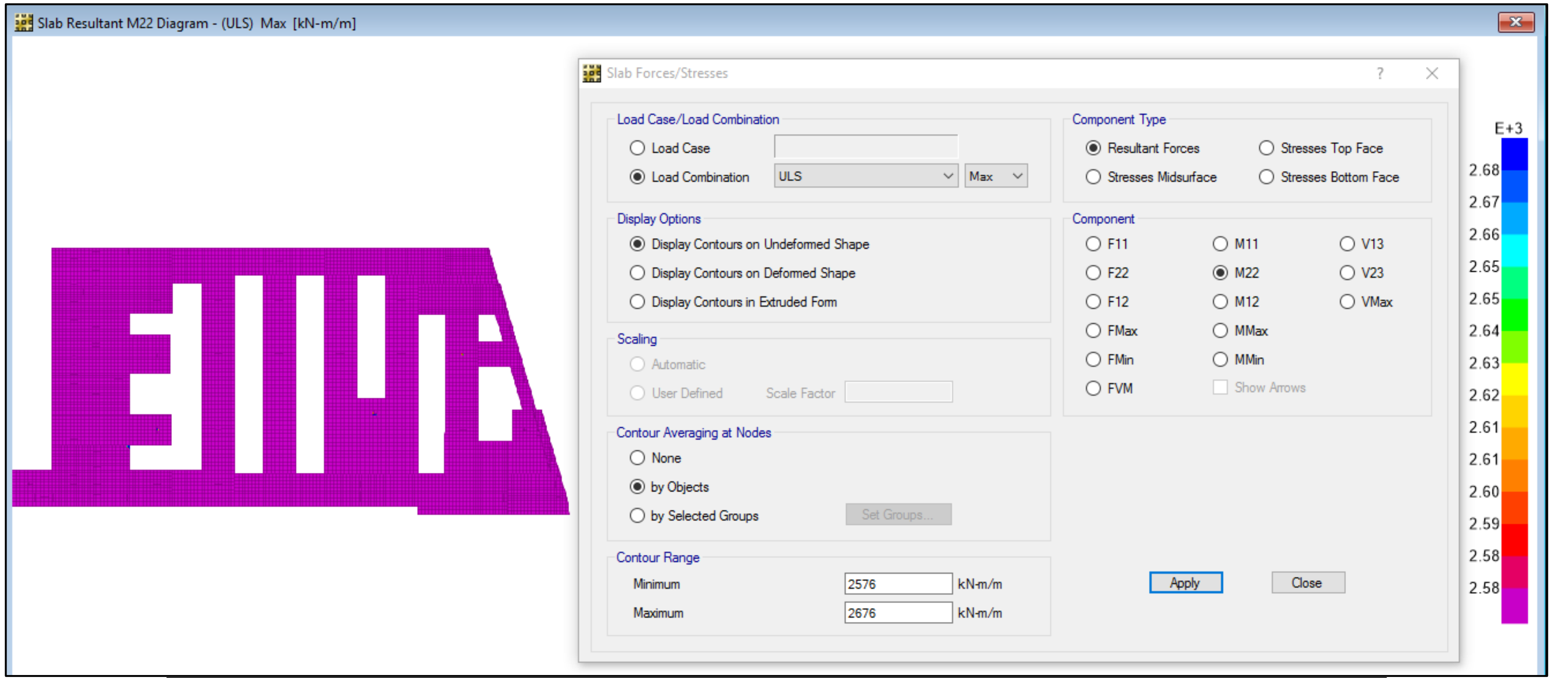
Asr = (0.85 x500x915- ((0.85x500x915)^2 - (2.36 x1475x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 3935.68 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.432				
Provided Ast	=	3954	mm²			
Dia of Reinforcement	=	25	Dia @	175	mm c/c	(Through)
	+	16	Dia @	175	mm c/c	(Extra)

O.K.

HD25@175CRS Through + HD16@175CRS Extra Bottom Y Direction



Flexure design:

Maximum Moment +M = 2675.00 kN.m/m

Bending moment in kN-m per Meter

Concrete	fck	=	35	Mpa
Reinforcement	fy	=	500	Mpa
Clear cover In Raft	C	=	75	mm
Slab Thickness, T		=	1000	mm
Effective thickness, t		=	915	mm

b 1000 mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}} \right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

Asr = (0.85 x500x915- ((0.85x500x915)^2 - (2.36 x2675x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))

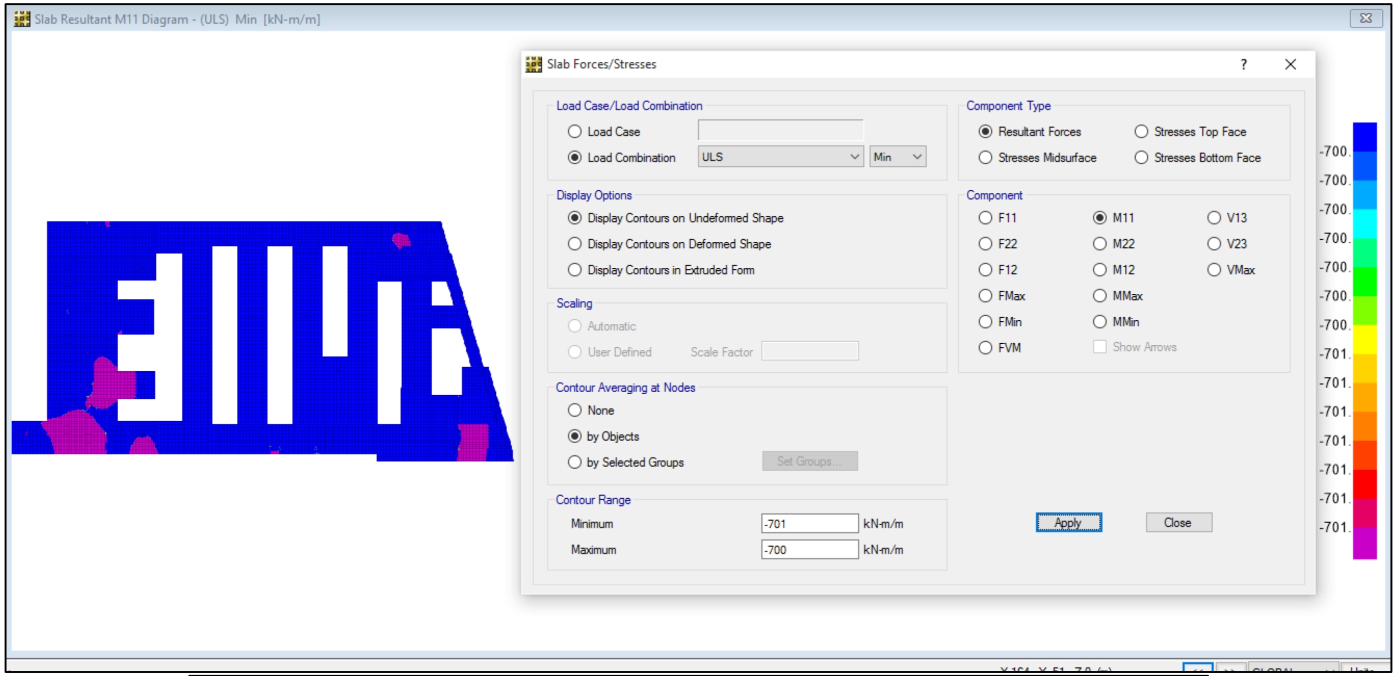
= 7380.61 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.809				
Provided Ast	=	7401	mm²			
Dia of Reinforcement	=	25	Dia @	175	mm c/c	(Through)
	+	32	Dia @	175	mm c/c	(Extra)

O.K.

HD25@175CRS Through + HD32@175CRS Extra Bottom Y Direction

4.10 Design of Foundation – 1000mm thick (Top reinforcement)



Flexure design:

Maximum Moment +M = 700.00 kN.m/m

Bending moment in kN-m per Meter		Concrete	fck	=	35	Mpa
		Reinforcement	fy	=	500	Mpa
b	1000 mm					
		Clear cover In Raft	C	=	50	mm
		Slab Thickness, T		=	1000	mm
		Effective thickness, t		=	940	mm

$$A_{st} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^{\,2}}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^{\,2}}$$

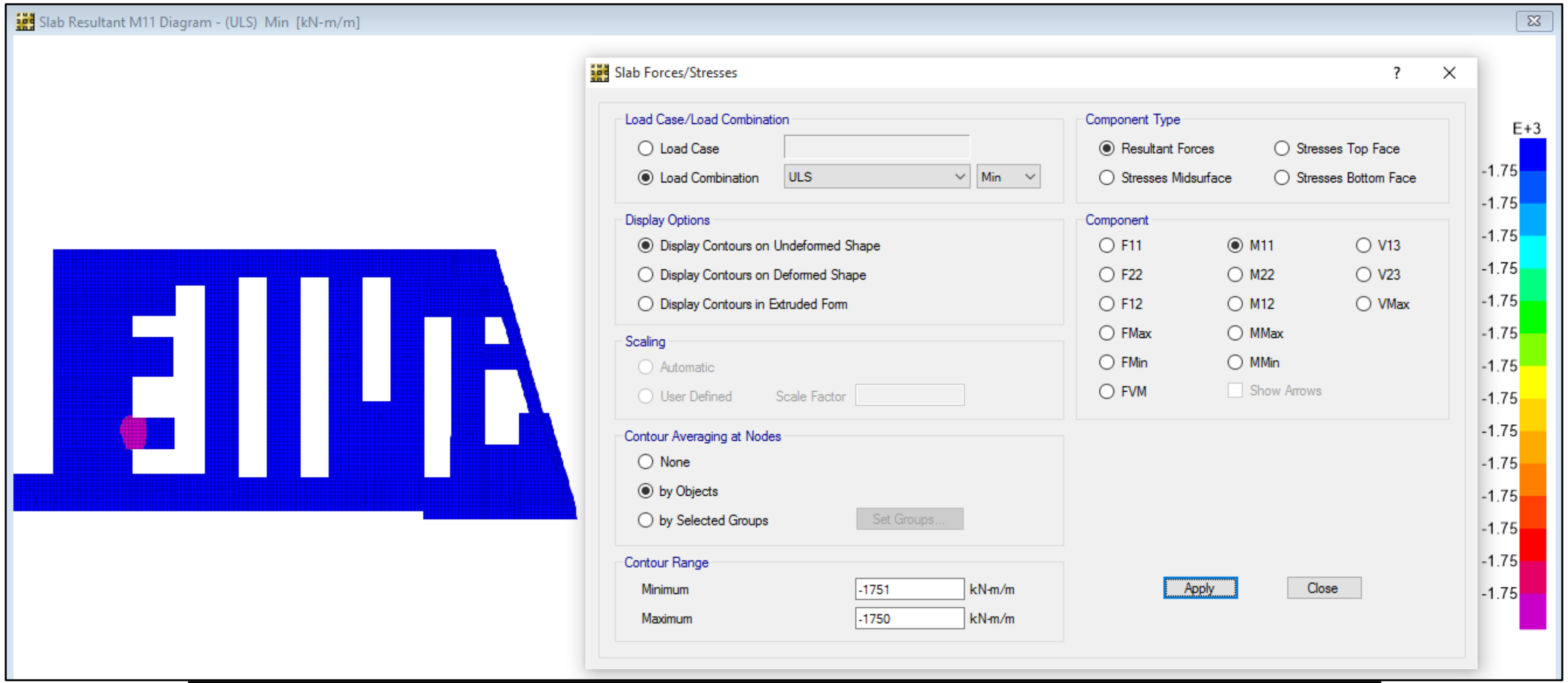
Asr = (0.85 x500x940- ((0.85x500x940)^2 - (2.36 x700x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 1780.62 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.191				
Provided Ast	=	1795	mm²			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	0	Dia @	175	mm c/c	(Extra)

O.K.

HD20@175CRS through Top - X Direction



Flexure design:

Maximum Moment +M = 1750.00 kN.m/m

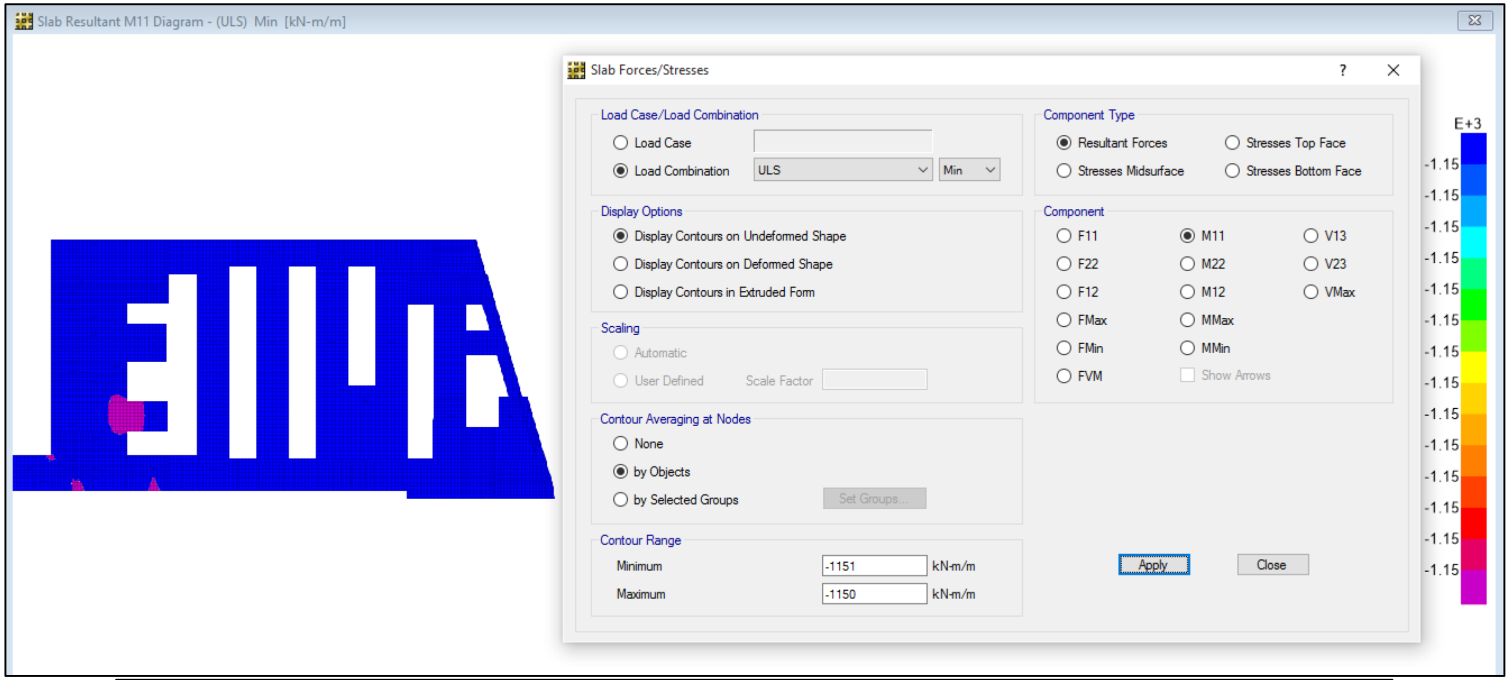
Bending moment in kN-m per Meter		Concrete	fck	= 35	Mpa
		Reinforcement	fy	= 500	Mpa
b	1000 mm				
		Clear cover In Raft	C	= 50	mm
		Slab Thickness, T		= 1000	mm
		Effective thickness, t		= 940	mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^{\,2}}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^{\,2}}$$

Asr = (0.85 x500x940- ((0.85x500x940)^2 - (2.36 x1750x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))
= 4567.54 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.489				
Provided Ast	=	4600	mm^2			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	25	Dia @	175	mm c/c	(Extra)
			O.K.			

HD20@175CRS Through + HD25@175CRS Extra Top X Direction



Maximum Moment +M = 1075.00 kN.m/m

Bending moment in kN-m per Meter				
Concrete	fck	=	35	Mpa
Reinforcement	fy	=	500	Mpa
b	1000 mm			
Clear cover In Raft	C	=	50	mm
Slab Thickness, T		=	1000	mm
Effective thickness, t		=	940	mm

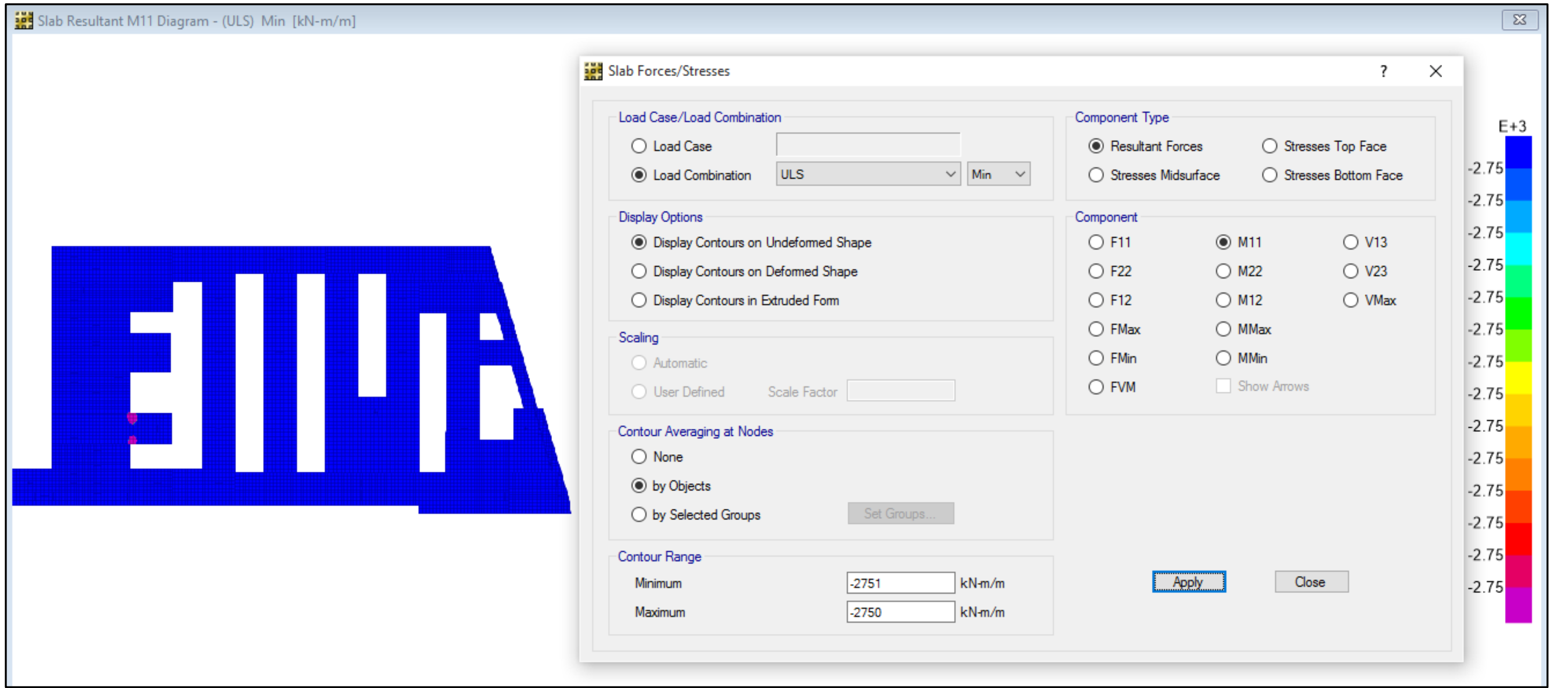
$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^{\,2}}{f_c \cdot b}}\right] \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^{\,2}}$$

Asr = (0.85 x500x940- ((0.85x500x940)^2 - (2.36 x1075x10^6x0.85x500^2)/(35x1000)))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 2759.13 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.298				
Provided Ast	=	2805	mm^2			
Dia of Reinforcement	=	25	Dia @	175	mm c/c	(Through)
	+	0	Dia @	175	mm c/c	(Extra)
			O.K.			

HD25@175CRS through Top - X Direction



DESIGN OF RAFT

MATERIAL GRADES

Flexure design:

Maximum Moment +M = 2750.00 kN.m/m

Bending moment in kN-m per Meter		Concrete	fck	=	35 Mpa
		Reinforcement	fy	=	500 Mpa
b	1000 mm				
		Clear cover In Raft	C	=	50 mm
		Slab Thickness, T		=	1000 mm
		Effective thickness, t		=	940 mm

$$A_{st} := \left[\phi\cdot f_y\cdot d - \sqrt{(\phi\cdot f_y\cdot d)^2 - 2.36\cdot M^*\cdot\phi\cdot\frac{f_y^{\,2}}{f_c\cdot b}}\right]\cdot\frac{f_c\cdot b}{1.18\cdot\phi\cdot f_y^{\,2}}$$

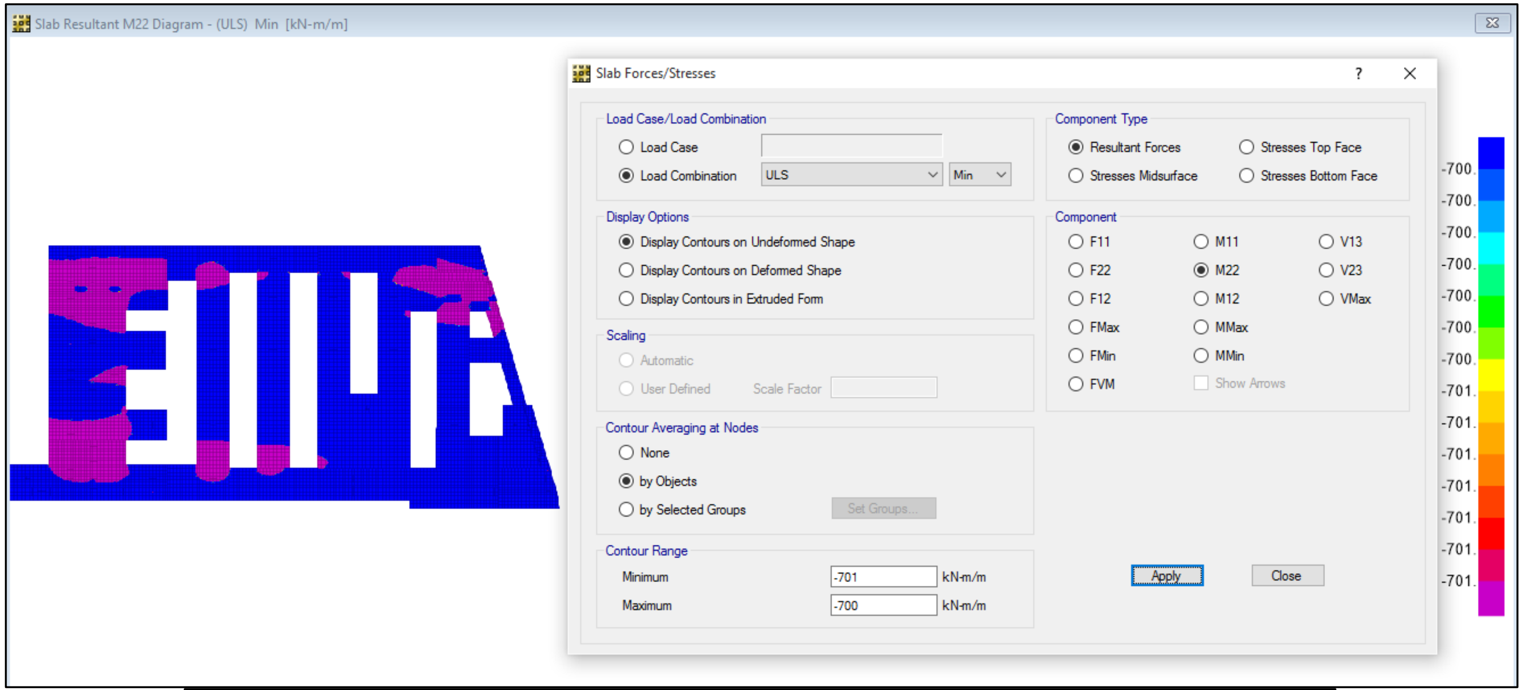
Asr = (0.85 x500x940- ((0.85x500x940)^2 - (2.36 x2750x10^6x0.85x500^2)/(35x1000)))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 7370.74 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.787				
Provided Ast	=	7401	mm^2			
Dia of Reinforcement	=	25	Dia @	175	mm c/c	(Through)
	+	32	Dia @	175	mm c/c	(Extra)

O.K.

HD25@175CRS Through + HD32@175CRS Extra Top X Direction



Flexure design:

Maximum Moment +M = 700.00 kN.m/m

Bending moment in kN-m per Meter				
b	1000 mm			
Concrete	fck	=	35	Mpa
Reinforcement	fy	=	500	Mpa
Clear cover In Raft	C	=	50	mm
Slab Thickness, T		=	1000	mm
Effective thickness, t		=	940	mm

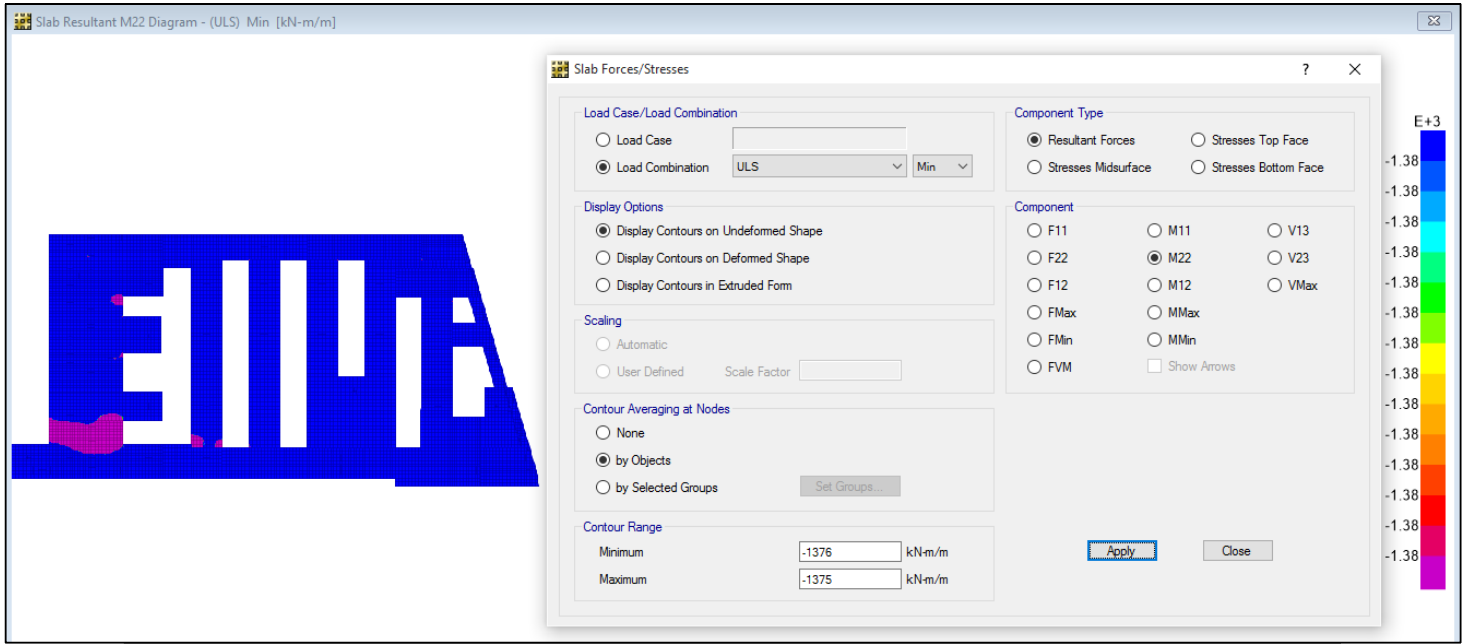
$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

Asr = (0.85 x500x940- ((0.85x500x940)^2 - (2.36 x700x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))
= 1780.62 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.191				
Provided Ast	=	1795	mm^2			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	0	Dia @	175	mm c/c	(Extra)

O.K.

HD20@175CRS through Top - Y Direction



Flexure design:

Maximum Moment +M = 1375.00 kN.m/m

Bending moment in kN-m per Meter

Concrete	fck	=	35	Mpa
Reinforcement	fy	=	500	Mpa
Clear cover In Raft	C	=	50	mm
Slab Thickness, T		=	1000	mm
Effective thickness, t		=	940	mm

b 1000 mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^{\ 2}}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^{\ 2}}$$

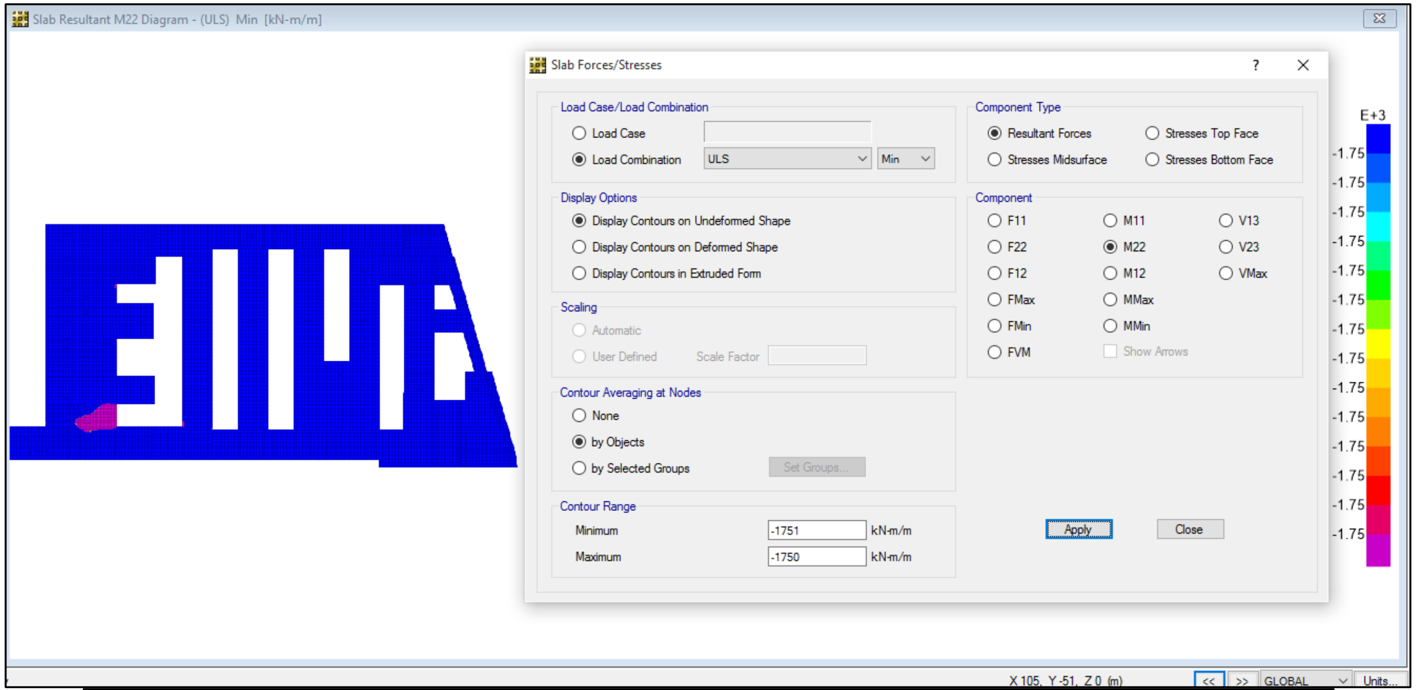
Asr = (0.85 x500x940- ((0.85x500x940)^2 - (2.36 x1375x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 3555.14 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.382				
Provided Ast	=	3590	mm^2			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	20	Dia @	175	mm c/c	(Extra)

O.K.

HD20@175CRS Through + HD20@175CRS Extra Top Y Direction



Flexure design:

Maximum Moment +M = 1750.00 kN.m/m

Bending moment in kN-m per Meter

b 1000 mm

Concrete	fck	=	35	Mpa
Reinforcement	fy	=	500	Mpa
Clear cover In Raft	C	=	50	mm
Slab Thickness, T		=	1000	mm
Effective thickness, t		=	940	mm

$$A_{sr} := \left[\phi \cdot f_y \cdot d - \sqrt{(\phi \cdot f_y \cdot d)^2 - 2.36 \cdot M^* \cdot \phi \cdot \frac{f_y^2}{f_c \cdot b}}\right] \cdot \frac{f_c \cdot b}{1.18 \cdot \phi \cdot f_y^2}$$

Asr = (0.85 x500x940- ((0.85x500x940)^2 - (2.36 x1750x10^6x0.85x500^2)/(35x1000))^0.5) x ((35x1000)/(1.18x0.85x500^2))

= 4567.54 mm2

Minimum Pt	=	0.140	%			
Minimum Ast	=	1400				
Provided Pt	=	0.489				
Provided Ast	=	4600	mm^2			
Dia of Reinforcement	=	20	Dia @	175	mm c/c	(Through)
	+	25	Dia @	175	mm c/c	(Extra)

O.K.

HD20@175CRS Through + HD25@175CRS Extra Top Y Direction

In all Foudnation design, HD20 bars has been replaced by HD16 & HD25 bars as per below mentieond calculation.

We have placed alternate diameter bars of HD16 & HD25 instead of HD20 through bars
Reinforcement required/provided in drawings = HD20 @ 200 CRS = 1570mm2
Reinforcement revised = HD25@400 CRS + HD16@400 CRS = 1225 + 502 = 1727 mm2 > 1570mm@

Extra bars of HD20 has been replaced by HD25.
Reinforcement required/provided in drawings = HD20 @ 200 CRS = 1570mm2
Reinforcement revised = HD25@200 CRS = 2450 mm2 > 1570 mm2

5 COMBINED FOOTING CF8

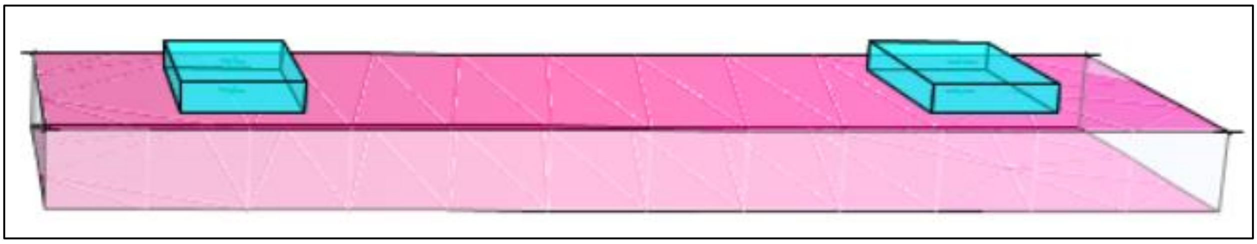
5.1 DESIGN OF CF8

SAFE software is used to design CF8 foundation.

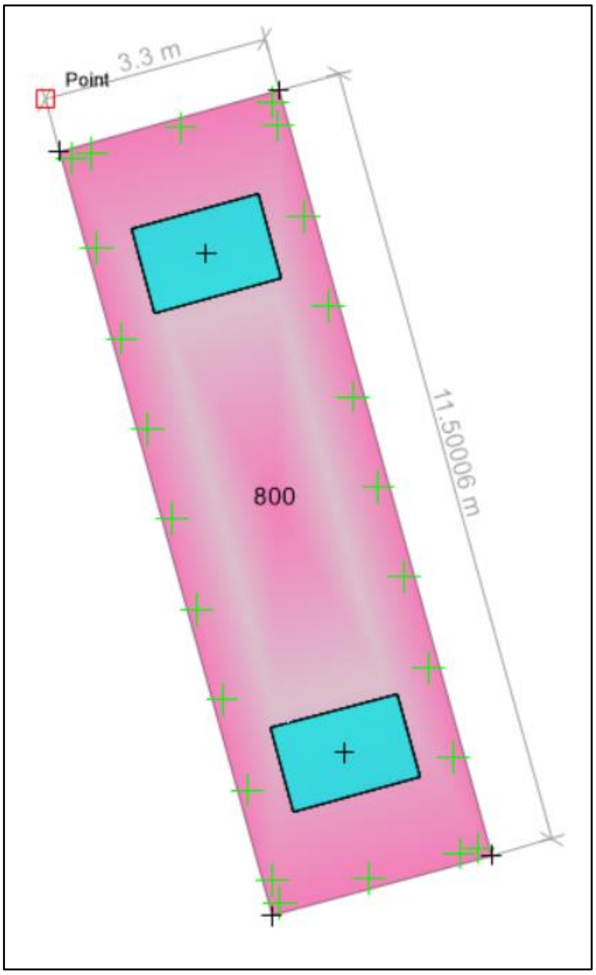
CF8 foundation is modeled in SAFE software as Finite elements. Reactions of wall & column for different load cases are Imported from ETABS as SAFE.F2K file.

Refer below steps showing detailed modeling, analysis and design of CF8 foundation.

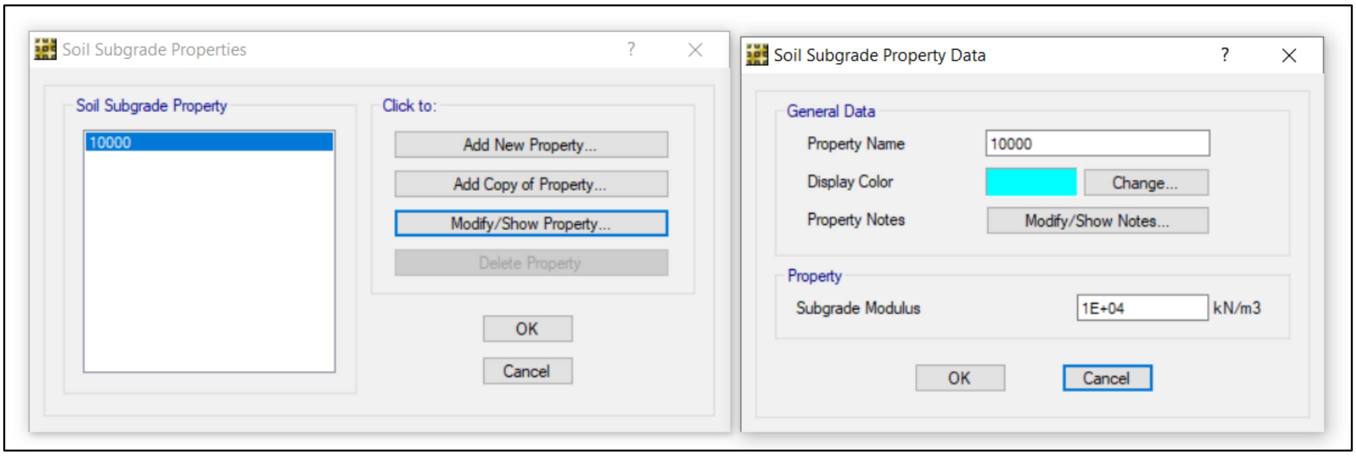
5.2 SAFE MODELING



SAFE modeling of CF8 foundation as finite elements



Properties: 800mm thick slab

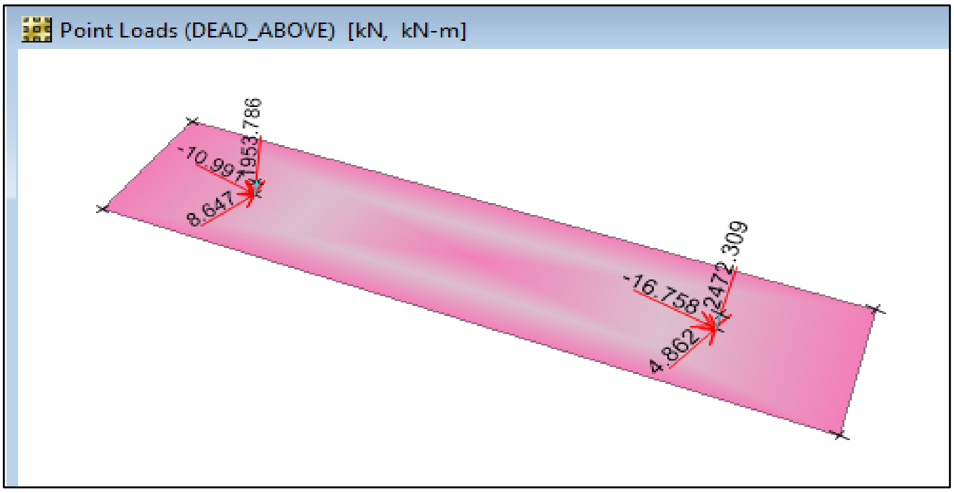


Foundation supports

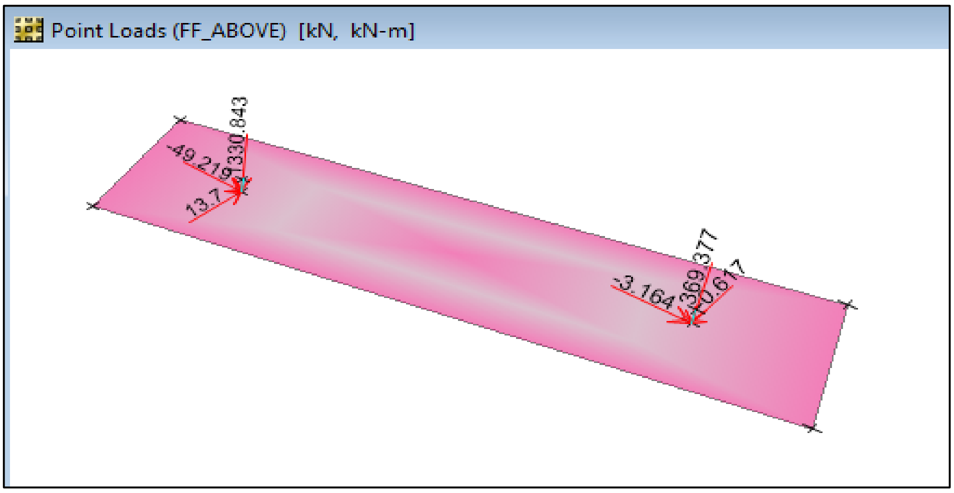
5.3 LOADING

5.3.1 Dead Load

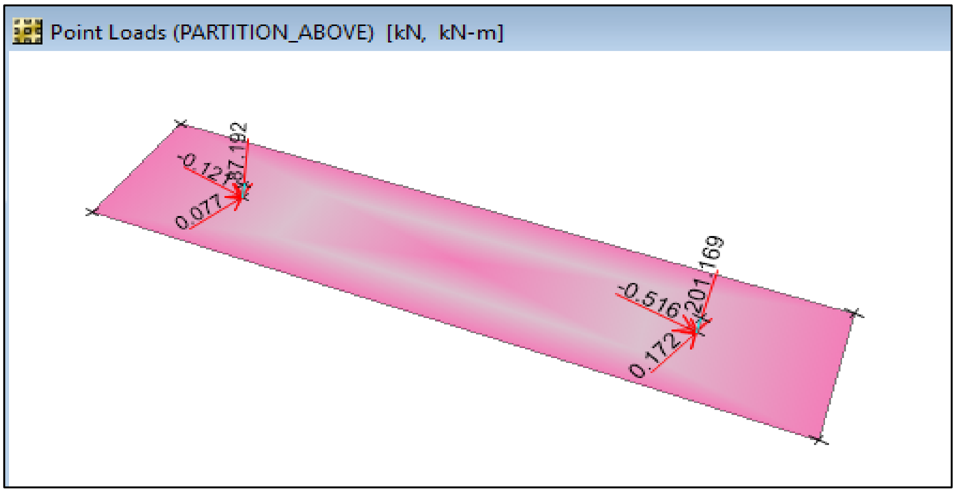
– Dead load obtained from ETABS model



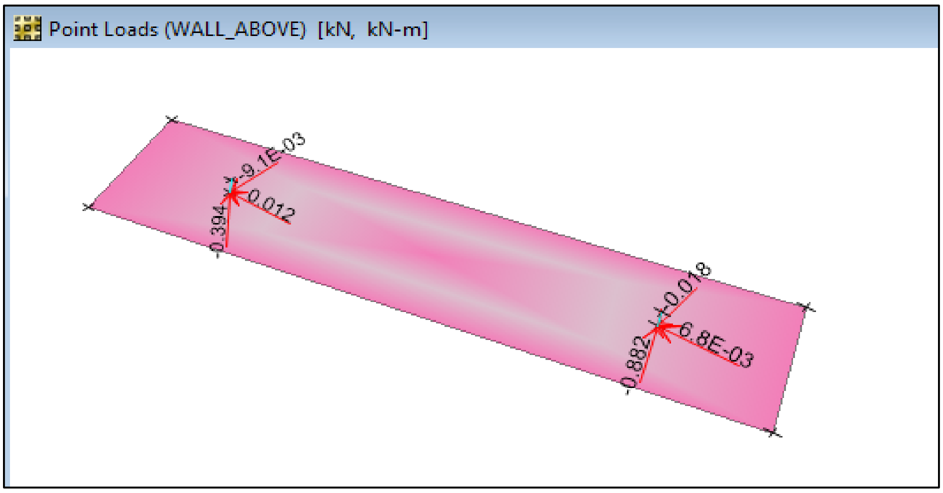
Dead load obtained from ETABS model



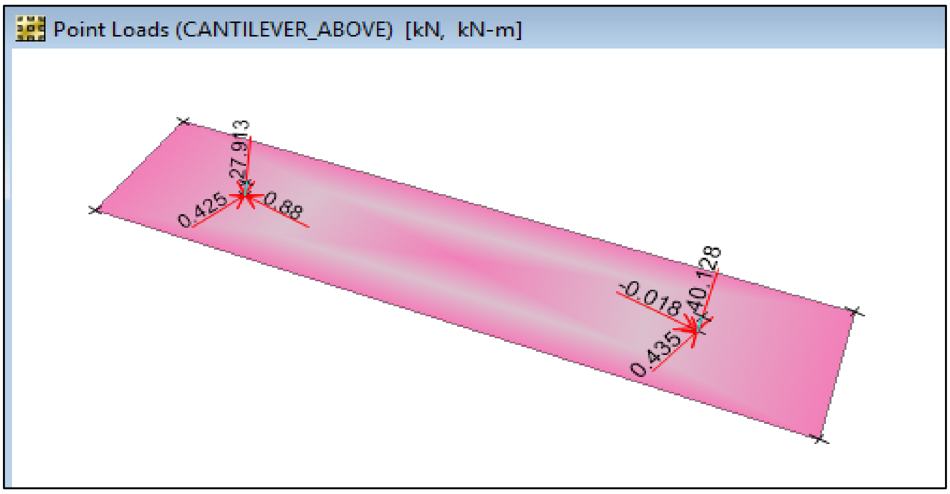
Floor-Finish load obtained from ETABS model



Partition load obtained from ETABS model



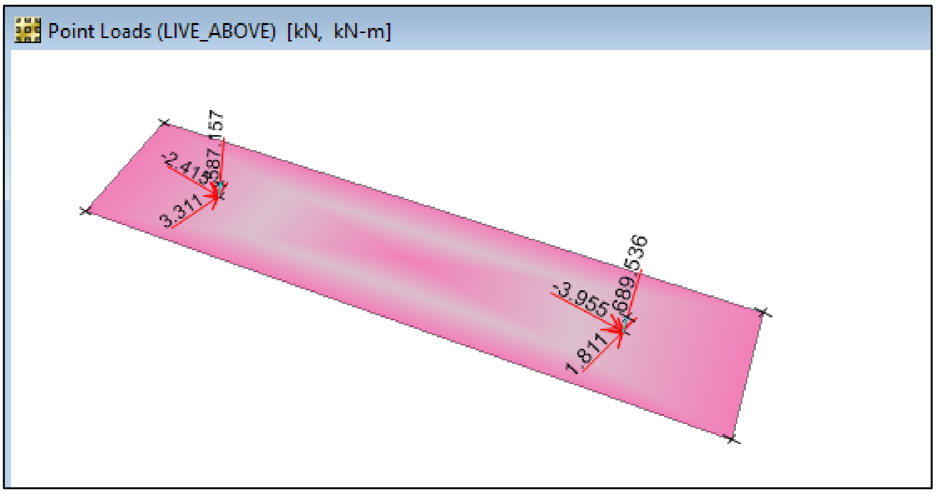
Wall load obtained from ETABS model



Cantilever load obtained from ETABS model

5.3.2 Live Load

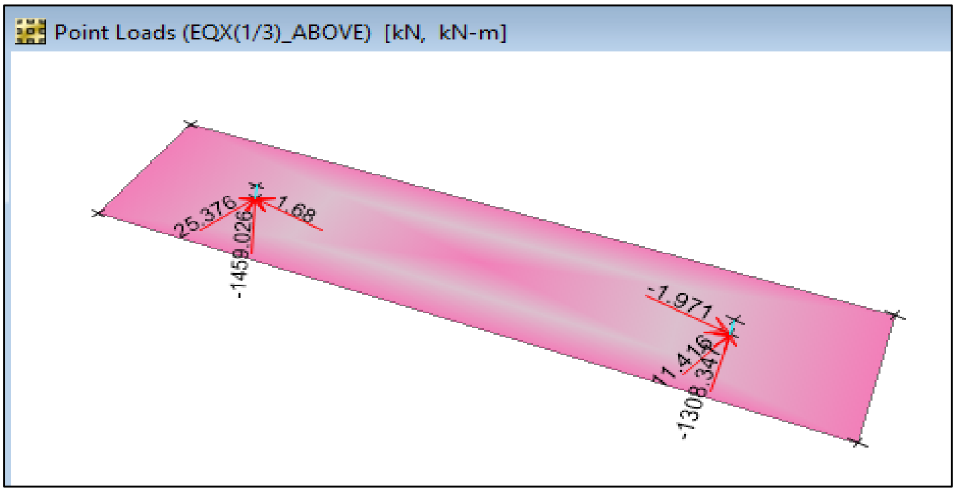
– Live load obtained from ETABS model

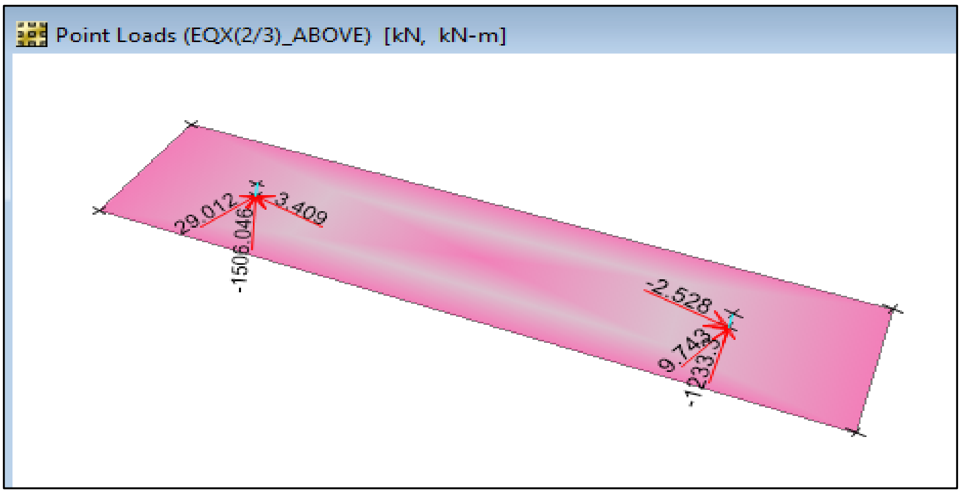


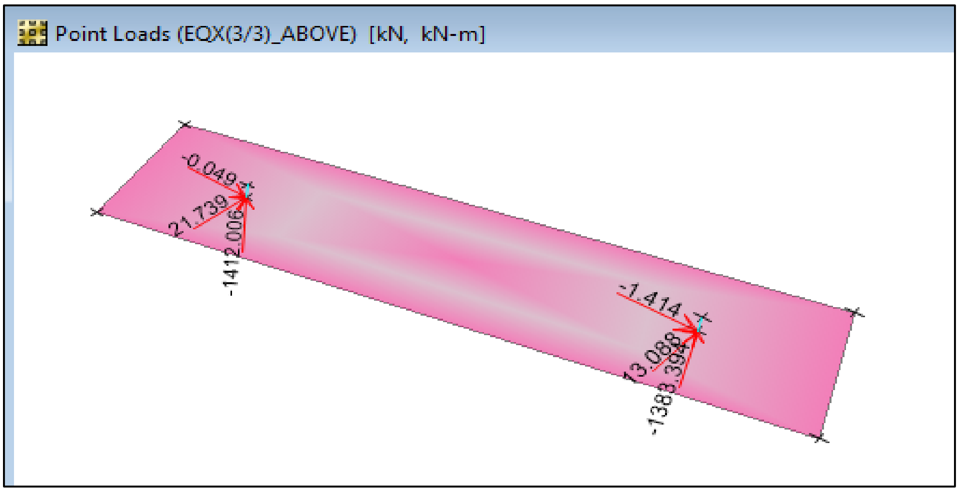
Live load obtained from ETABS model

5.3.3 EQX (Seismic Force in X-Direction)

– Seismic loads obtained from reactions of ETABS model



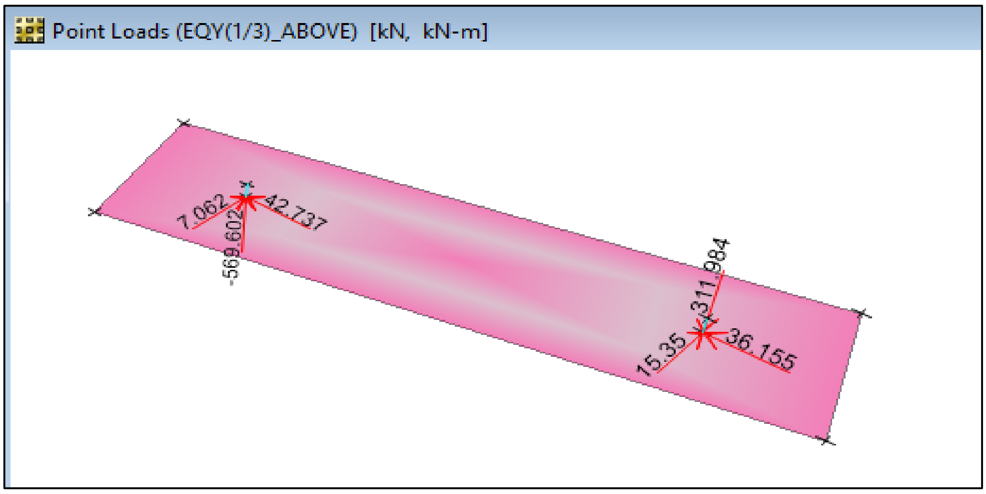


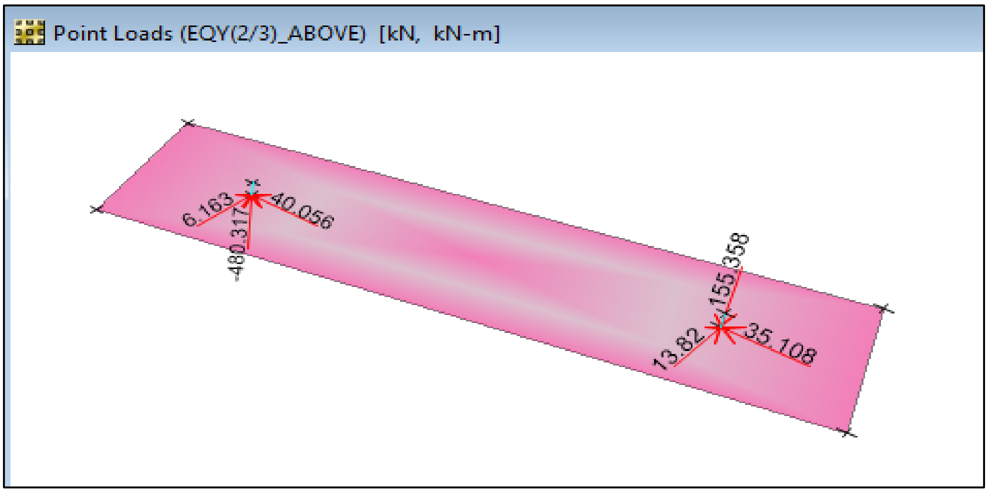


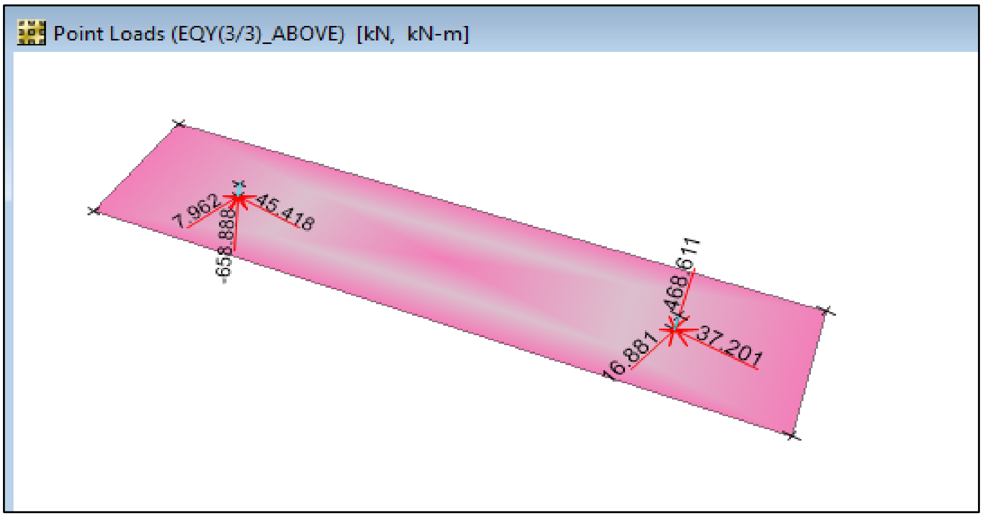
EQX obtained from ETABS model

5.3.4 EQY (Seismic Force in Y-Direction)

– Seismic loads obtained from ETABS model







EQY obtained from ETABS model

5.4 Load Combinations

Design load combinations

1.35DL
1.2DL + 1.5LL
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE - Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE -X
1.0DL +0.3LL + 1.0 EARTHQUAKE – Y + 0.3 EARTHQUAKE –X

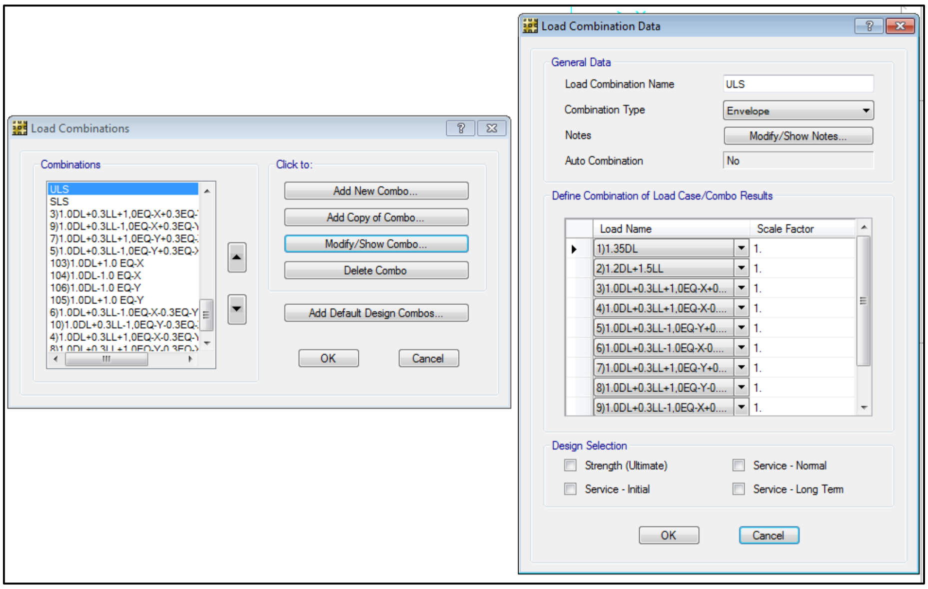
Serviceability load combinations

1.0DL + 1.0LL
1.0DL + 1.0EQX
1.0DL - 1.0EQX
1.0DL + 1.0EQY
1.0DL - 1.0EQY

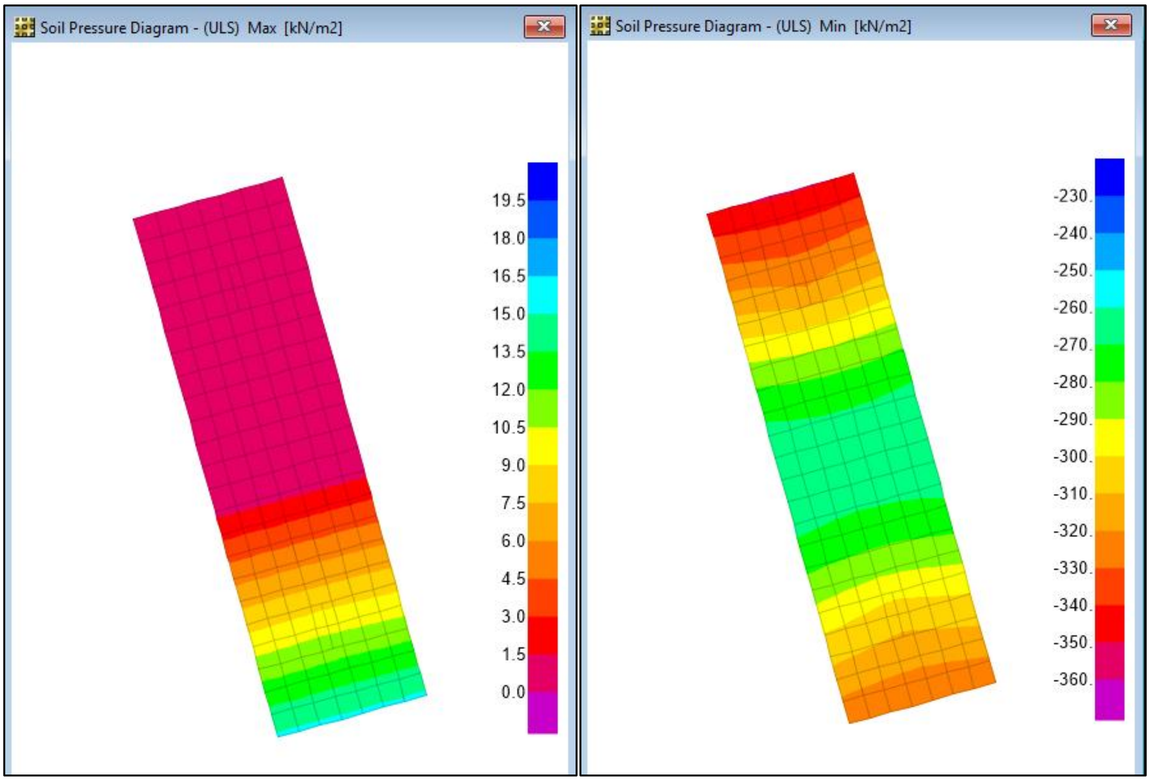
5.5 Base Pressure Check

5.5.1 Check of maximum base pressure for design load combinations:

Refer below image showing soil pressure diagram of base pressure for design load combinations:



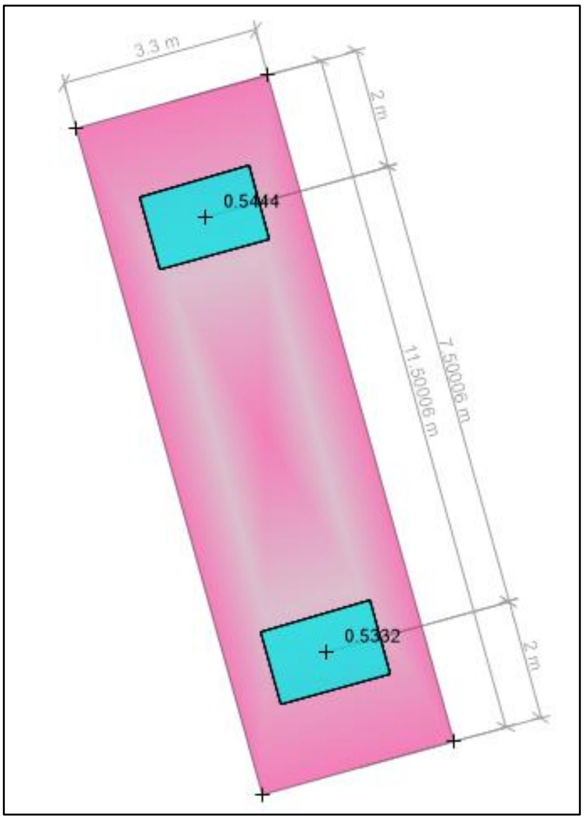
Design load combination envelope



Soil pressure diagram for Seismic ultimate load combination (Max & Min)

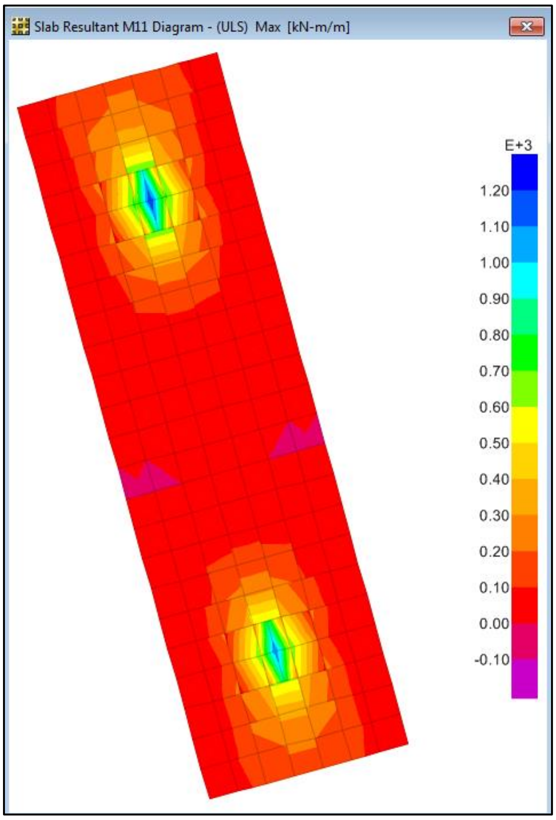
Permissible SBC for design load combinations = 575 kN/m^2
Maximum base pressure (Download) = 350 kN/m^2< 575 kN/m^2 (Hence, OK)
Maximum base pressure (Upward) = 15 kN/m^2

5.6 Punching Shear Check

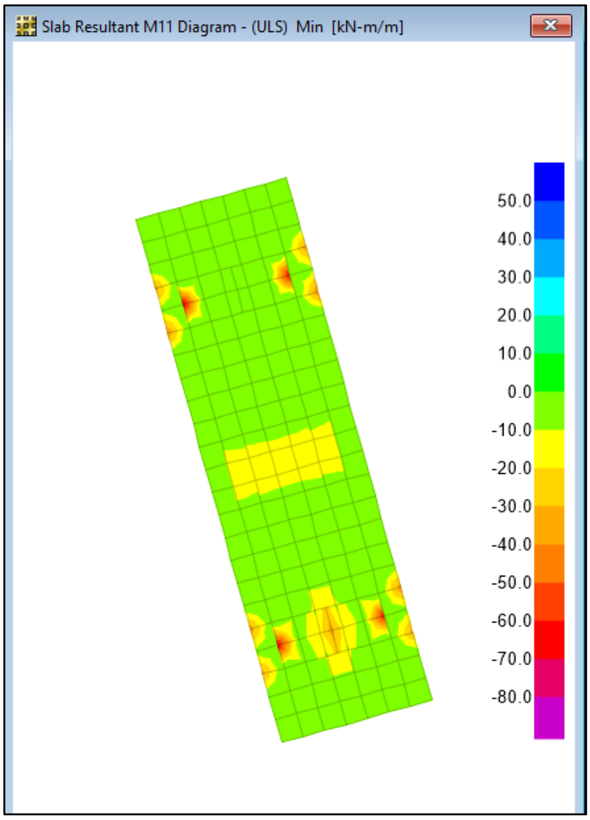


Check for Punching Shear

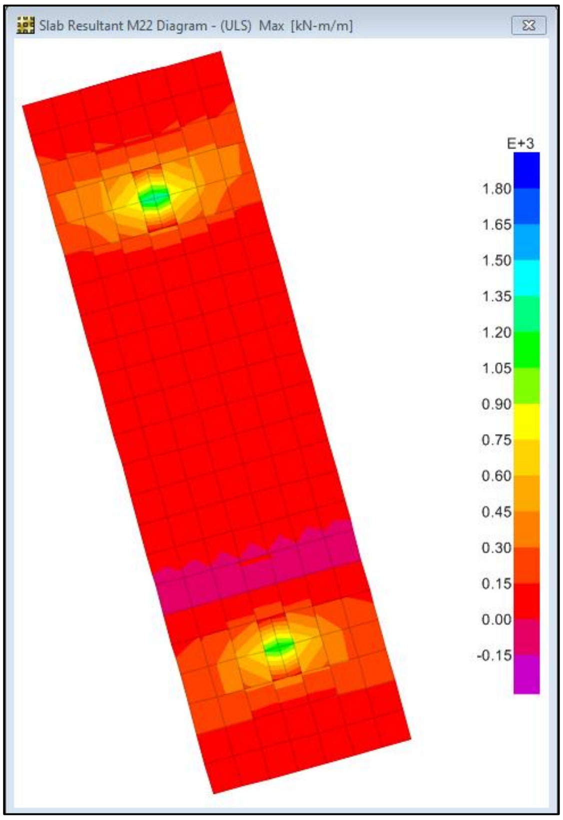
5.7 Moment Diagram:



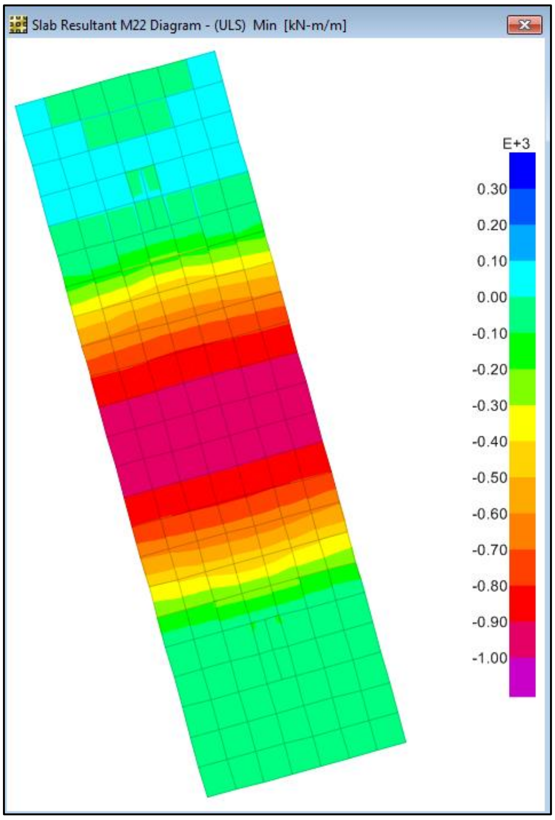
Moment diagram in X-dir. for Design load combination (Max)



Moment diagram in X-dir. for Design load combination (Min)

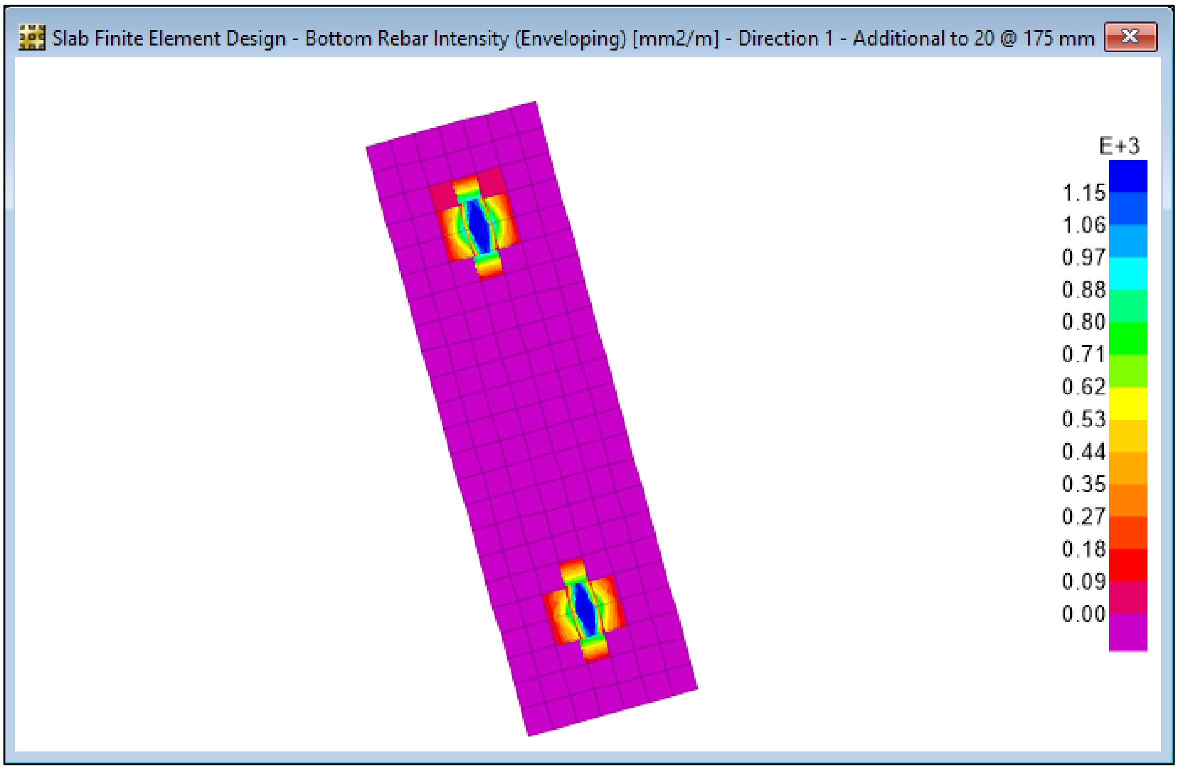


Moment diagram in Y-dir. for Design load combination (Max)

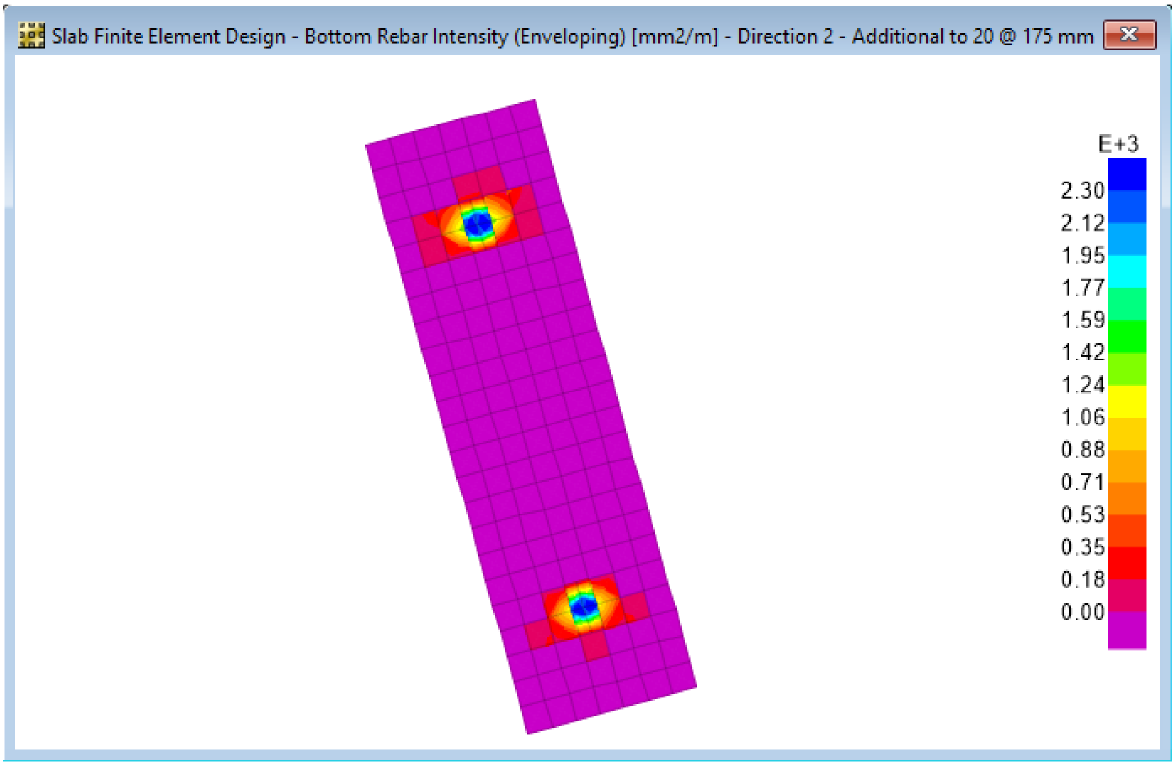


Moment diagram in Y-dir. for Design load combination (Min)

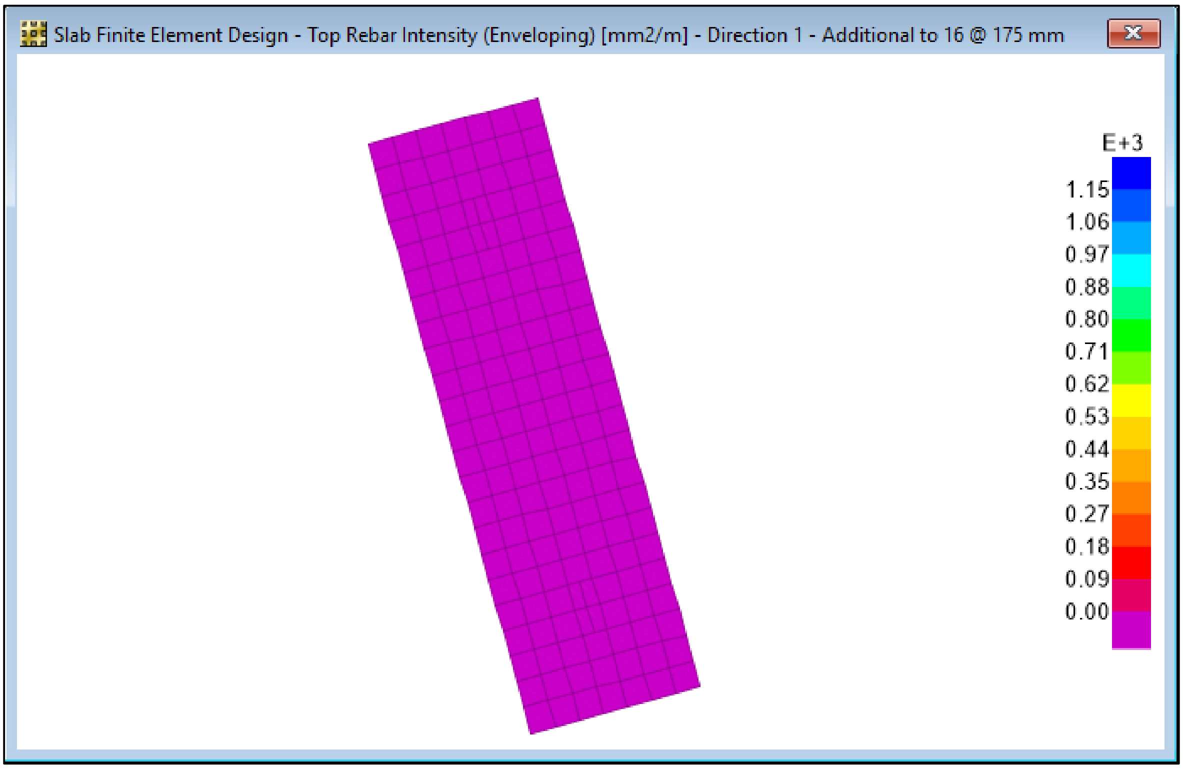
5.8 Design of combined footing



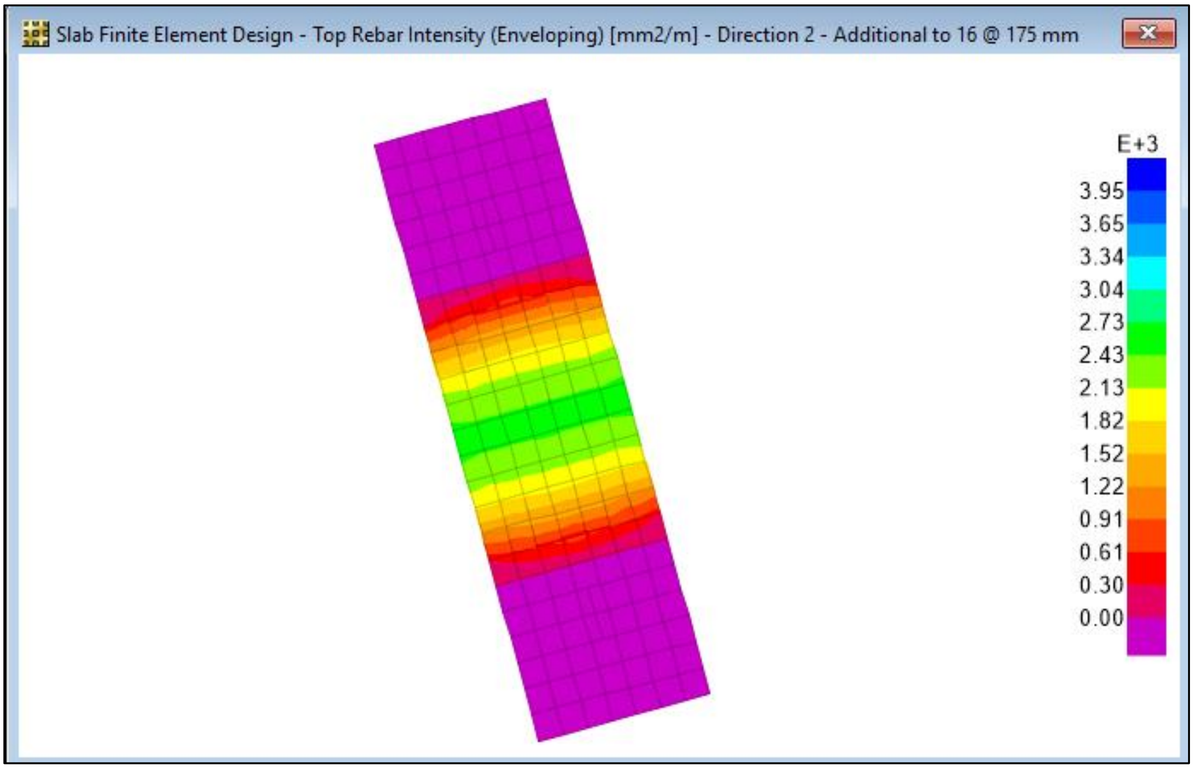
Bottom Reinforcement Día in X direction



Bottom Reinforcement Día in Y direction



Top Reinforcement Día in X direction



Top Reinforcement Día in Y direction

6 COMBINED FOOTING CF7

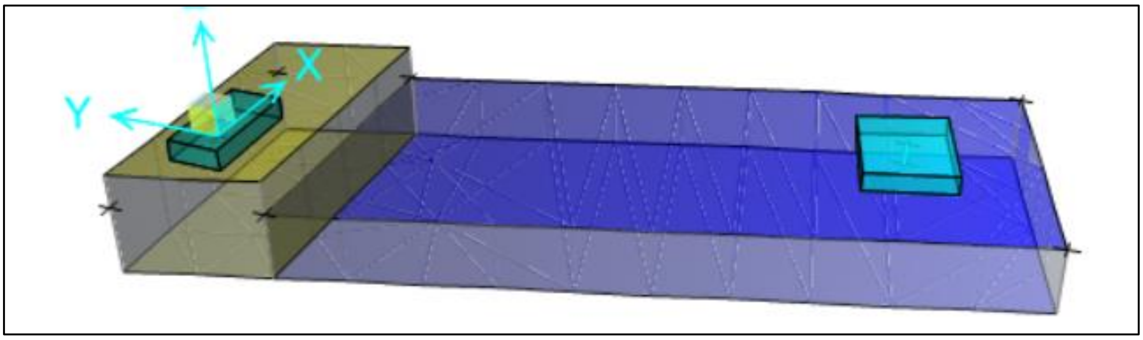
6.1 DESIGN OF CF7

SAFE software is used to design CF7 foundation.

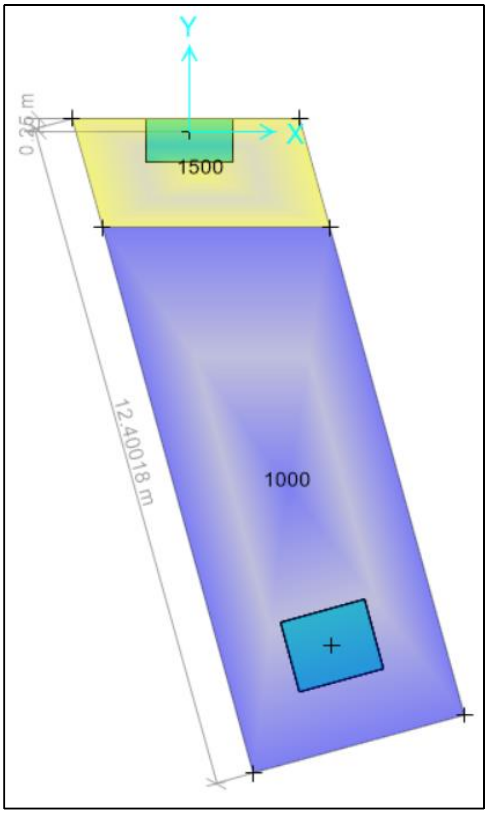
CF7 foundation is modeled in SAFE software as Finite elements. Reactions of wall & column for different load cases are Imported from ETABS as SAFE.F2K file.

Refer below steps showing detailed modeling, analysis and design of CF7 foundation.

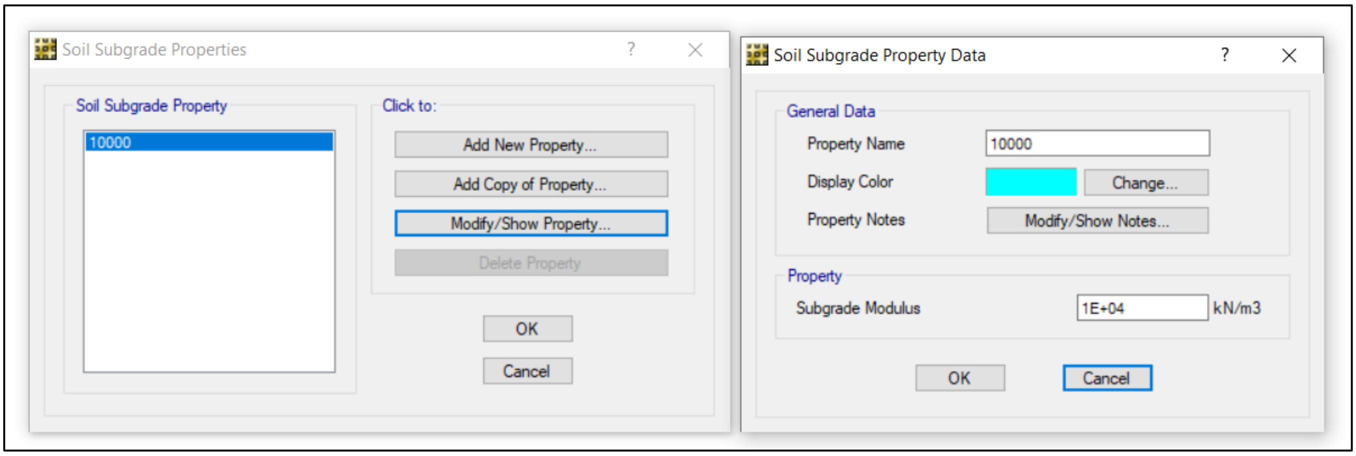
6.2 SAFE MODELING



SAFE modeling of CF7 foundation as finite elements



Properties: 1000mm thick slab

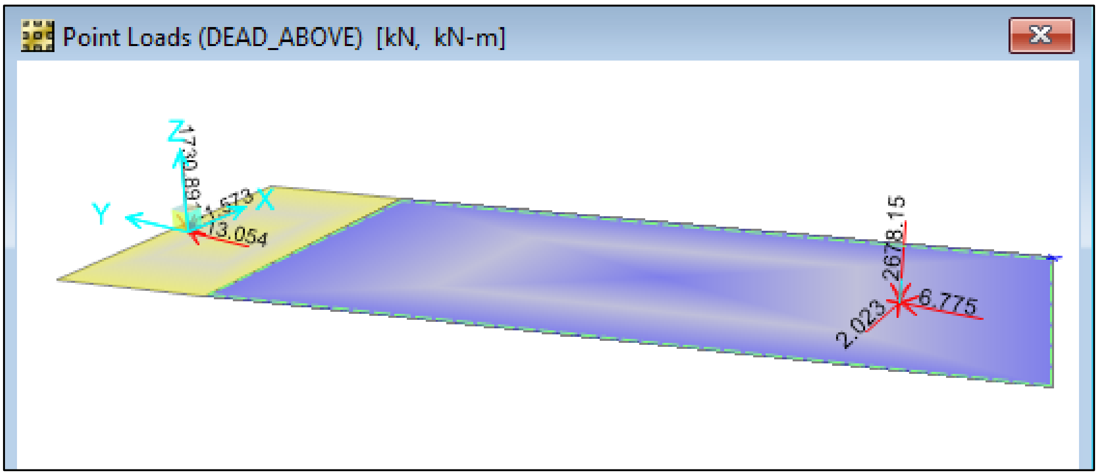


Foundation supports

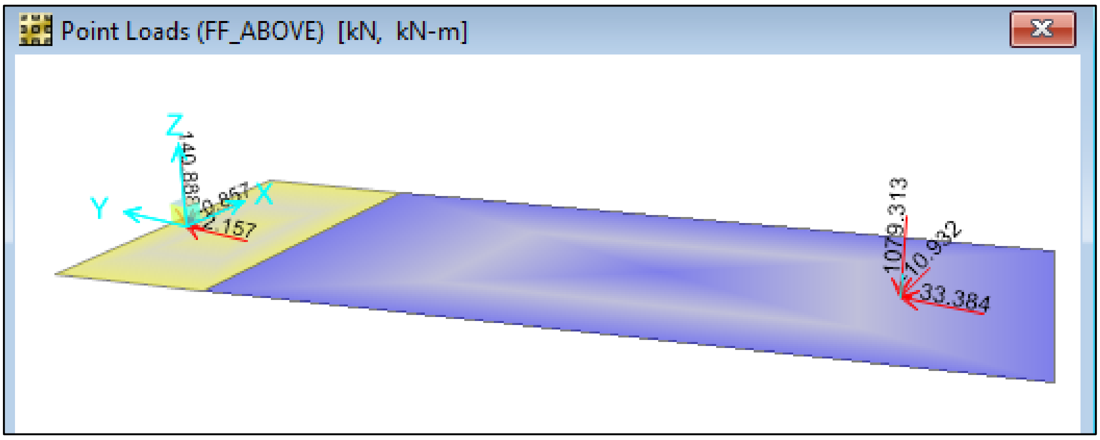
6.3 LOADING

6.3.1 Dead Load

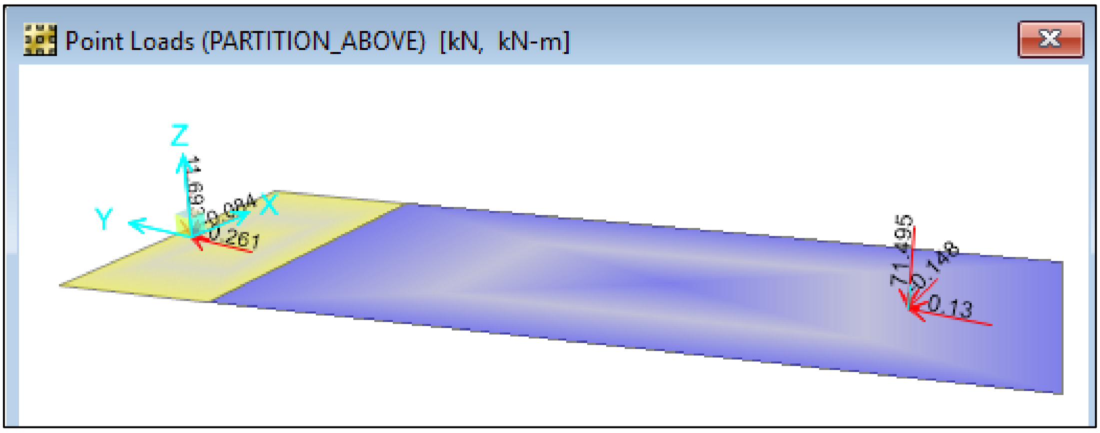
– Dead load obtained from ETABS model



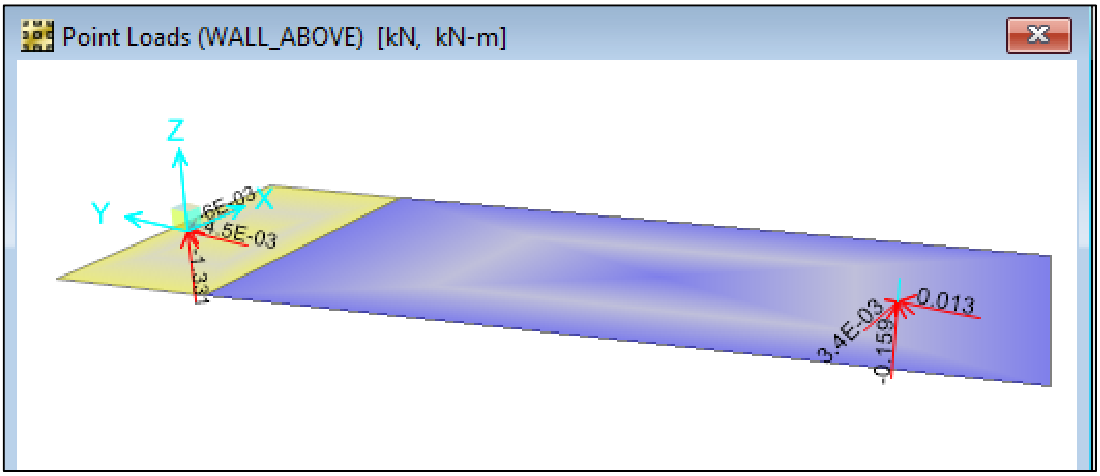
Dead load obtained from ETABS model



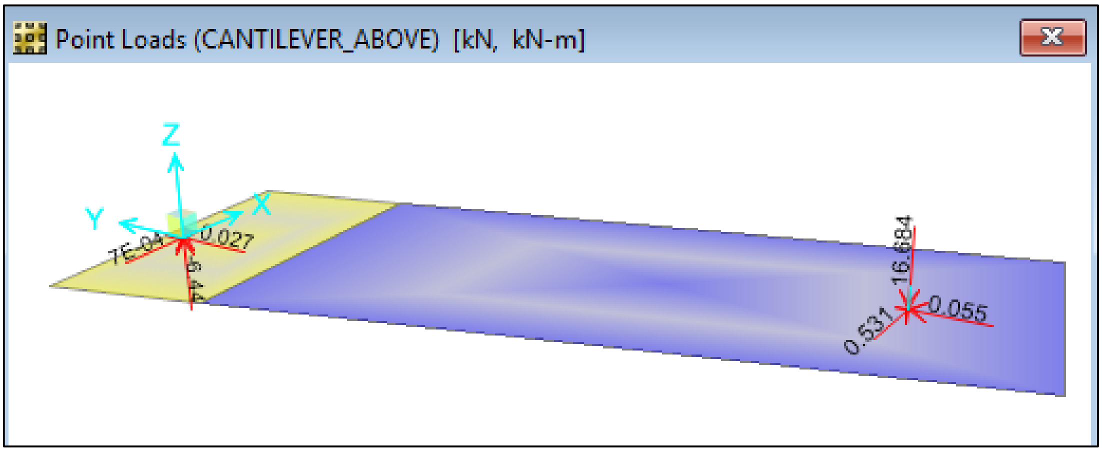
Floor-Finish load obtained from ETABS model



Partition load obtained from ETABS model



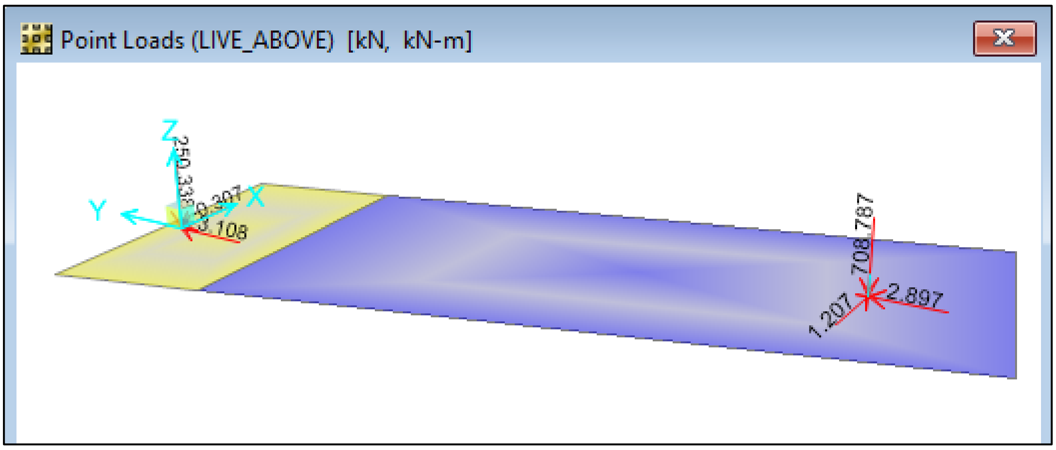
Wall load obtained from ETABS model



Cantilever load obtained from ETABS model

6.3.2 Live Load

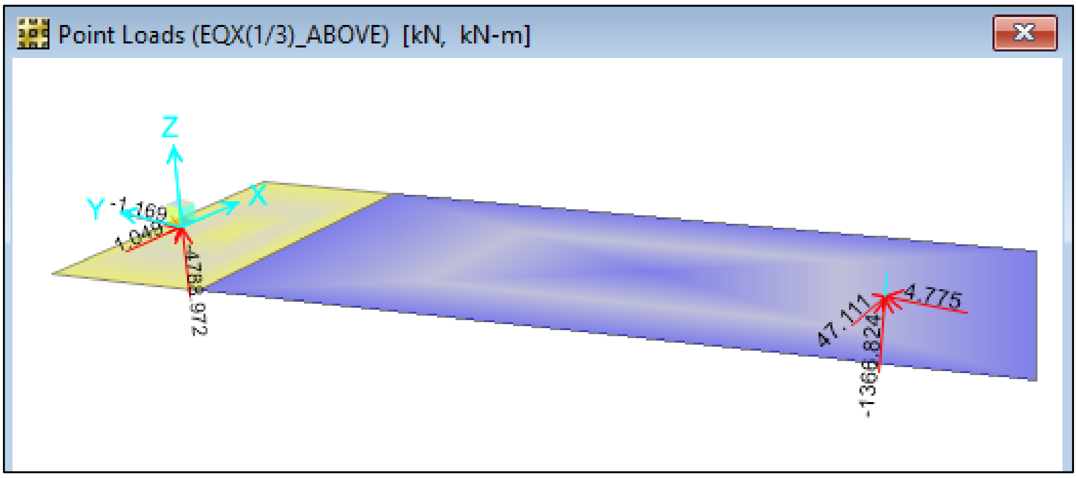
– Live load obtained from ETABS model

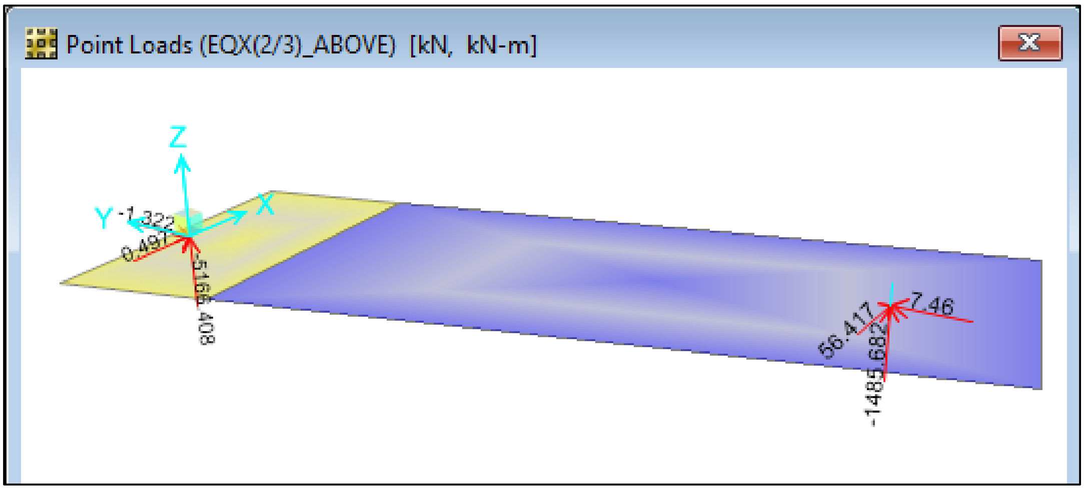


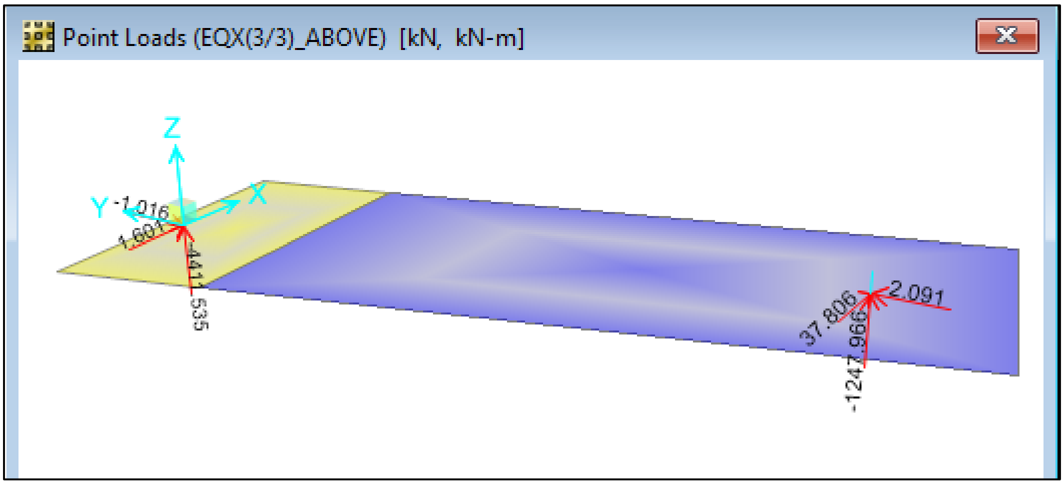
Live load obtained from ETABS model

6.3.3 EQX (Seismic Force in X-Direction)

– Seismic loads obtained from reactions of ETABS model



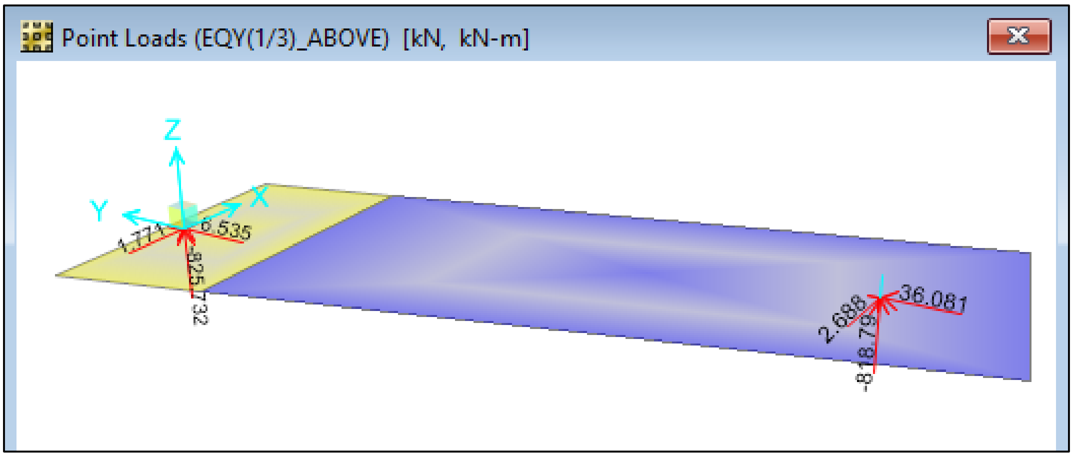


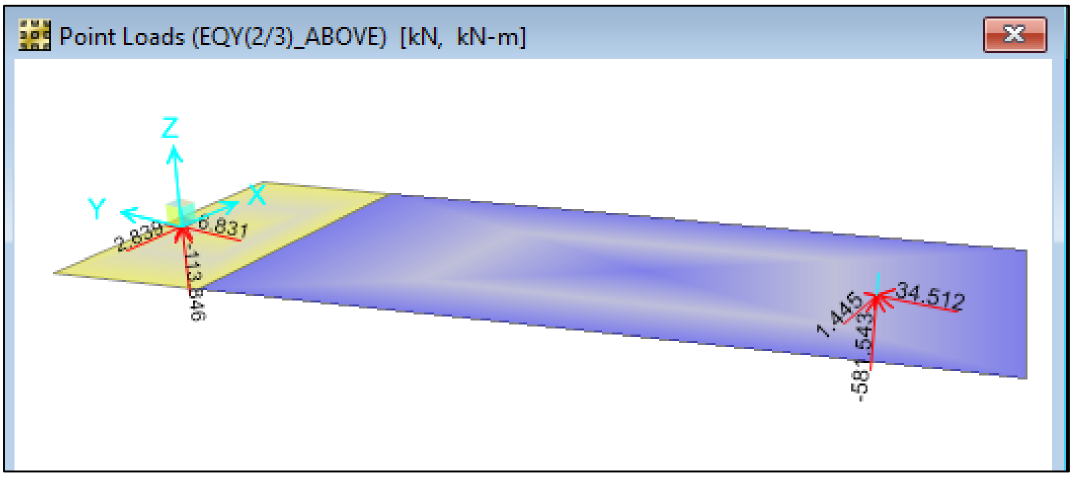


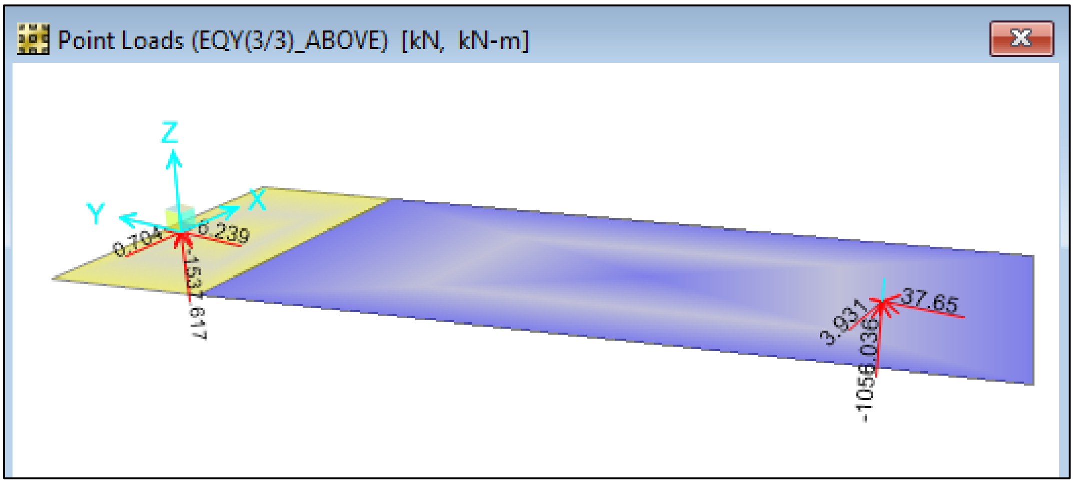
EQX obtained from ETABS model

6.3.4 EQY (Seismic Force in Y-Direction)

– Seismic loads obtained from ETABS model







EQY obtained from ETABS model

6.4 Load Combinations

Design load combinations

1.35DL
1.2DL + 1.5LL
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE - Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE -X
1.0DL +0.3LL + 1.0 EARTHQUAKE – Y + 0.3 EARTHQUAKE –X

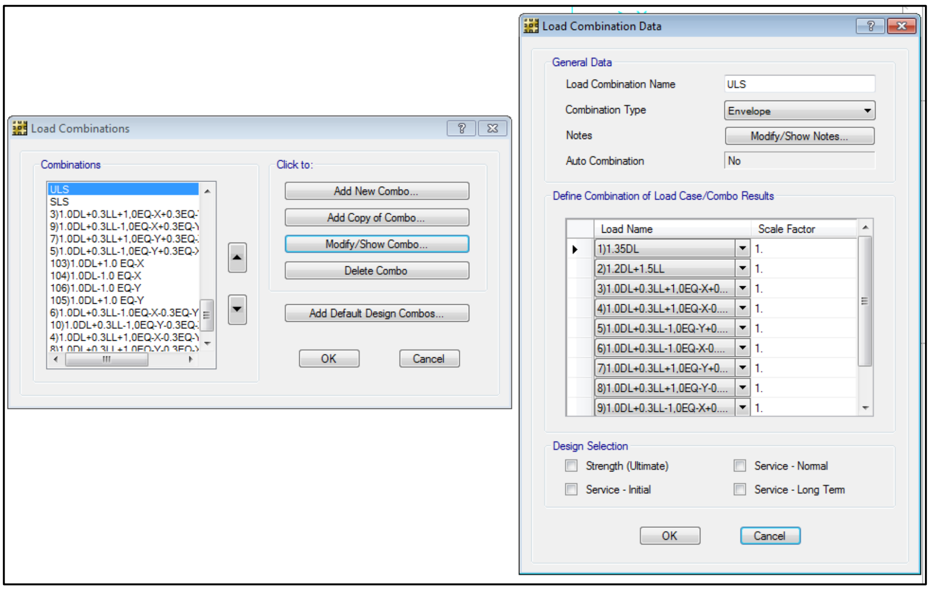
Serviceability load combinations

1.0DL + 1.0LL
1.0DL + 1.0EQX
1.0DL - 1.0EQX
1.0DL + 1.0EQY
1.0DL - 1.0EQY

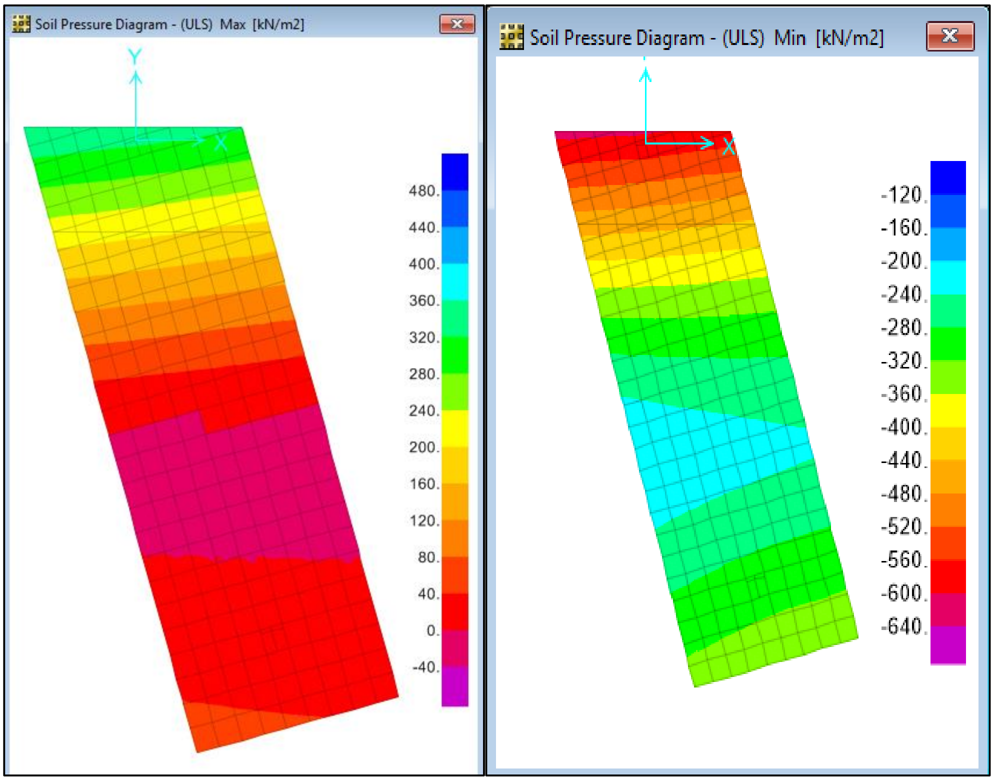
6.5 Base Pressure Check

6.5.1 Check of maximum base pressure for design load combinations:

Refer below image showing soil pressure diagram of base pressure for design load combinations:



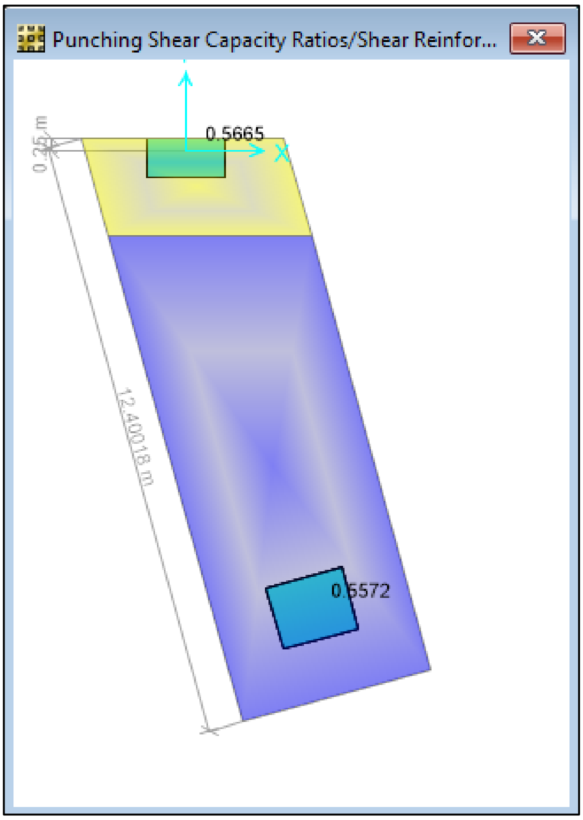
Design load combination envelope



Soil pressure diagram for Seismic ultimate load combination (Max & Min)

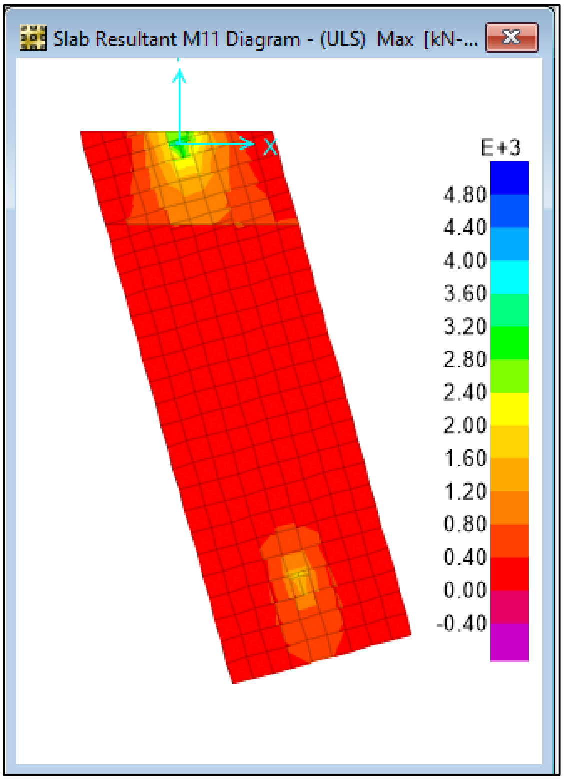
Permissible SBC for design load combinations = 715 kN/m^2 as per SBC report attached herewith. Maximum base pressure (Downward) = 615 kN/m^2< 715 kN/m^2 (Hence, OK) Maximum base pressure (Upward) = 353 kN/m^2

6.6 Punching Shear Check

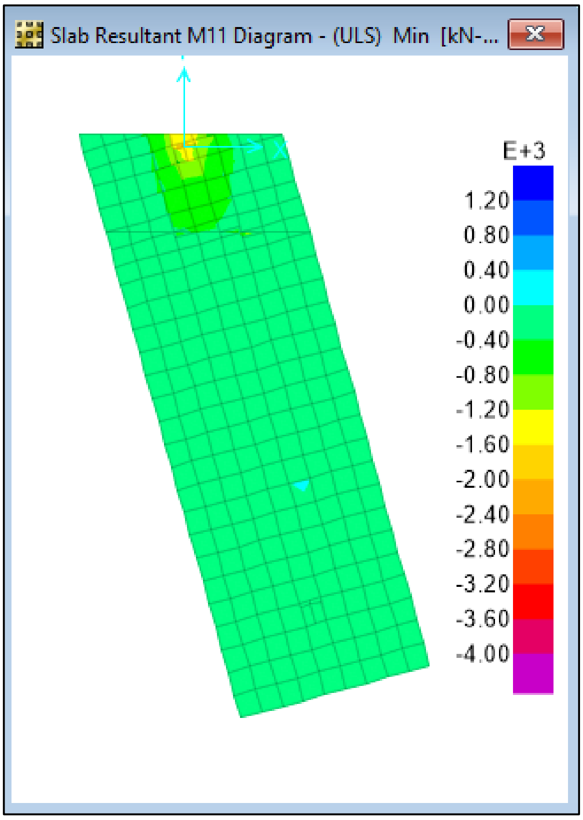


Check for Punching Shear

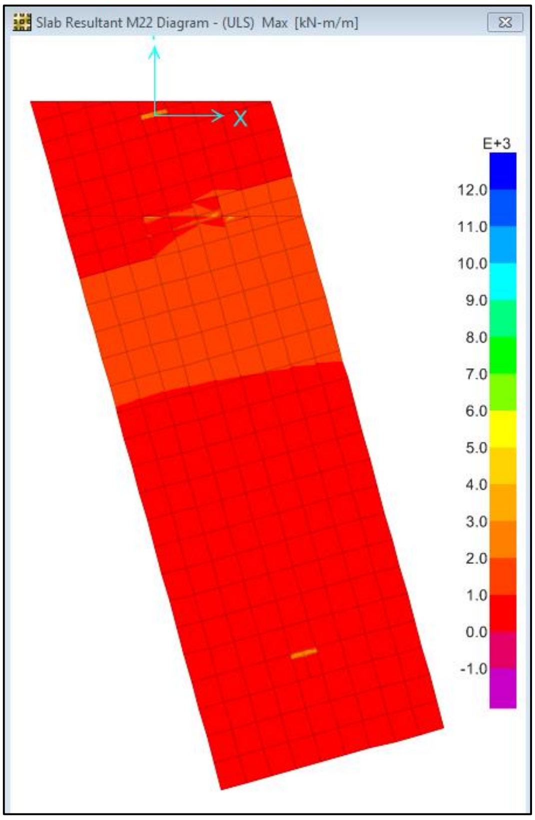
6.7 Moment Diagram:



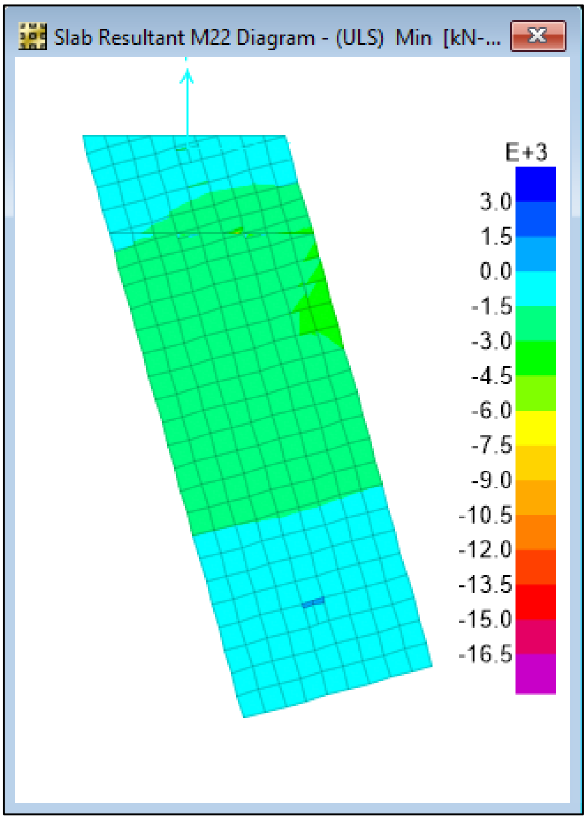
Moment diagram in X-dir. for Design load combination (Max)



Moment diagram in X-dir. for Design load combination (Min)

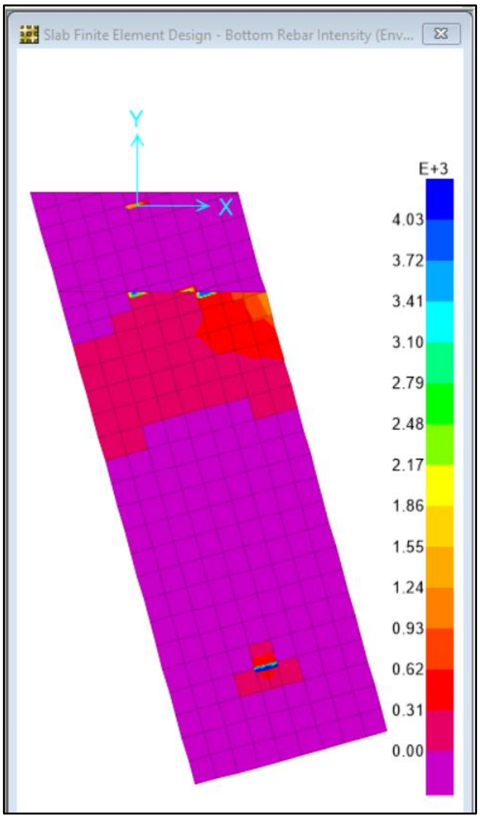


Moment diagram in Y-dir. for Design load combination (Max)

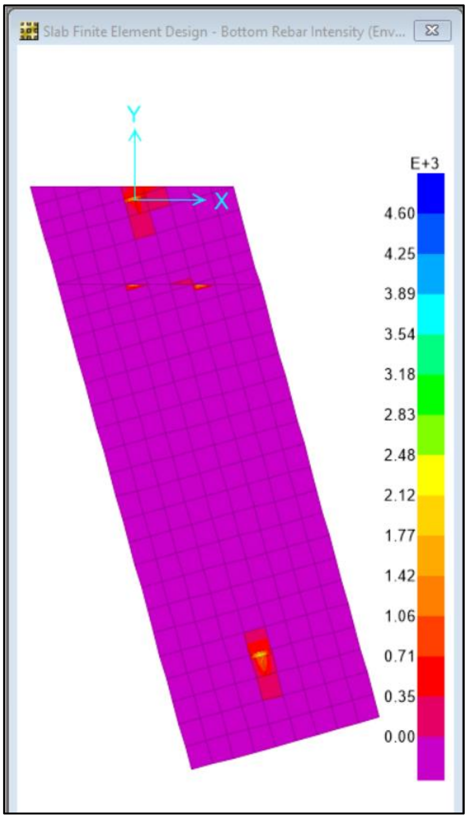


Moment diagram in Y-dir. for Design load combination (Min)

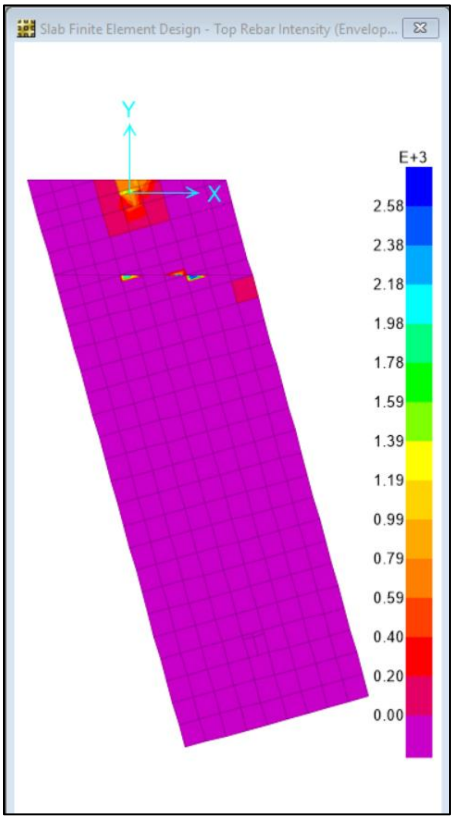
6.8 Design of combined footing:



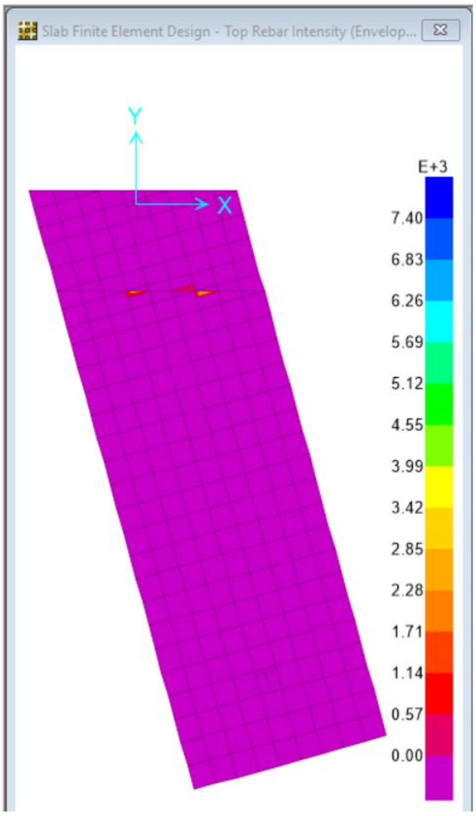
Bottom Reinforcement Día in X direction



Bottom Reinforcement Día in Y direction



Top Reinforcement Día in X direction



Top Reinforcement Día in Y direction

7 COMBINED FOOTING CF5

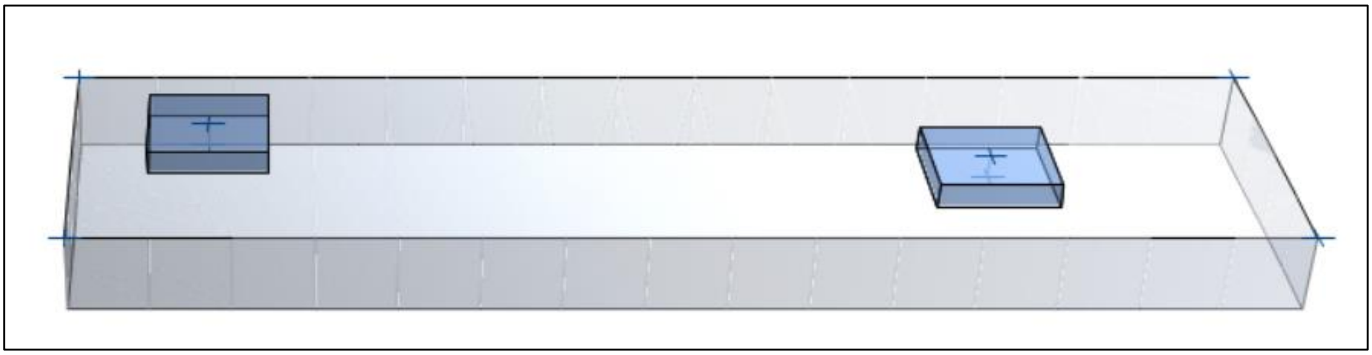
7.1 DESIGN OF CF5

SAFE software is used to design CF5 foundation.

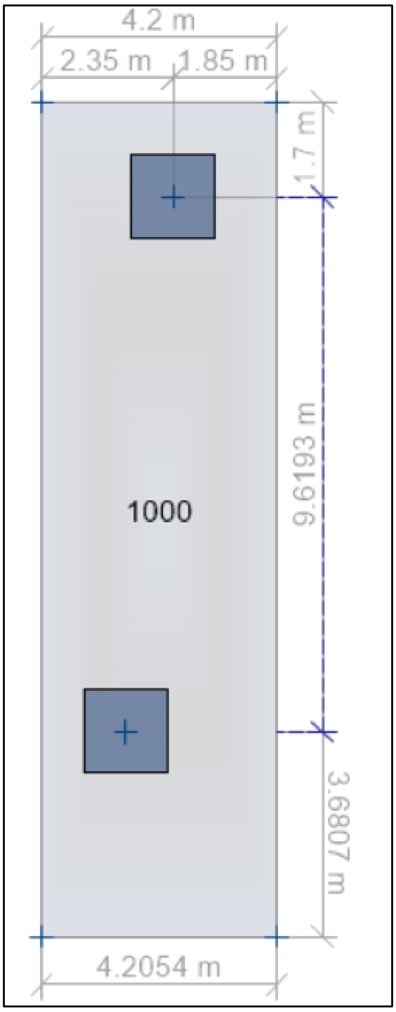
CF5 foundation is modeled in SAFE software as Finite elements. Reactions of wall & column for different load cases are Imported from ETABS as SAFE.F2K file.

Refer below steps showing detailed modeling, analysis and design of CF5 foundation.

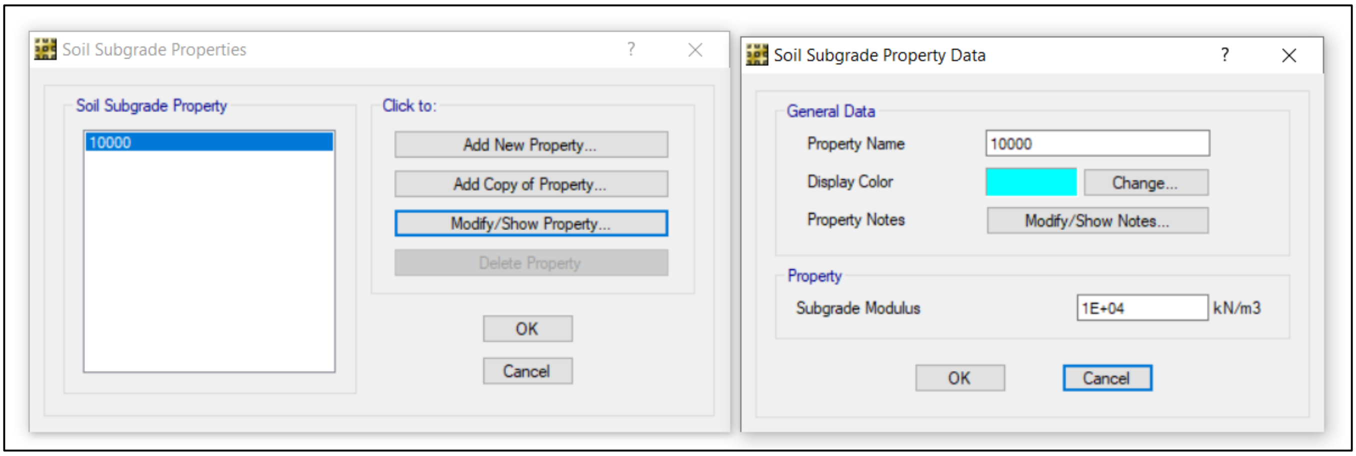
7.2 SAFE MODELING



SAFE modeling of CF5 foundation as finite elements



Properties: 1000mm thick slab

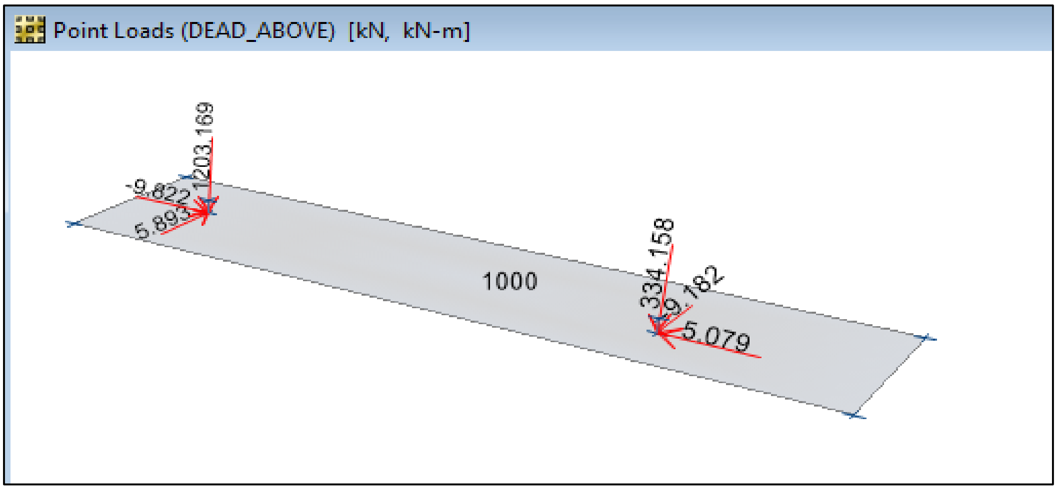


Foundation supports

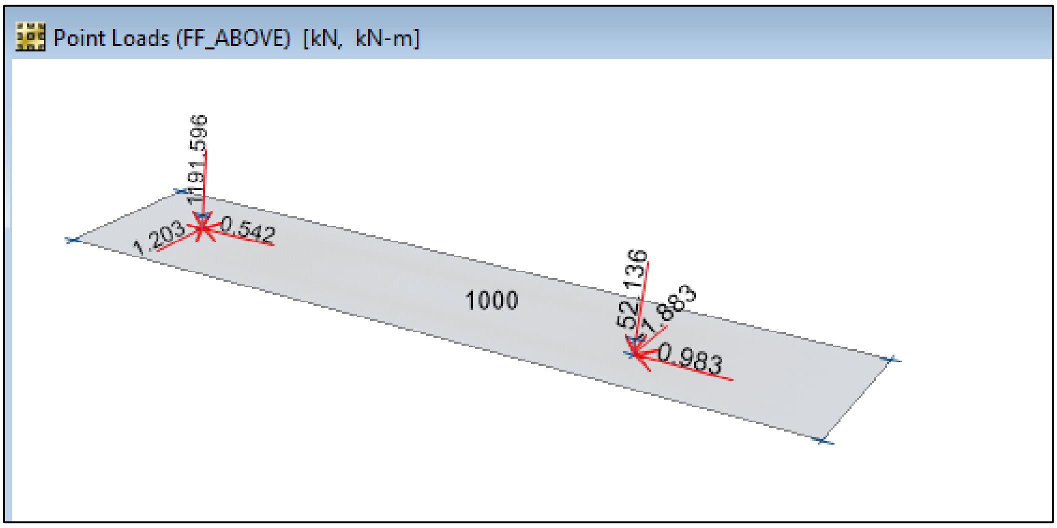
7.3 LOADING

7.3.1 Dead Load

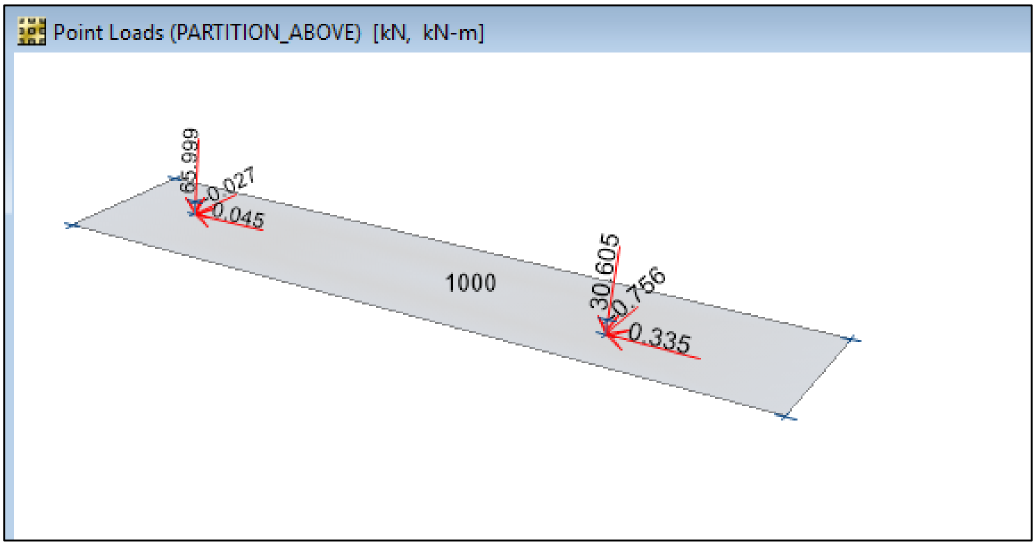
– Dead load obtained from ETABS model



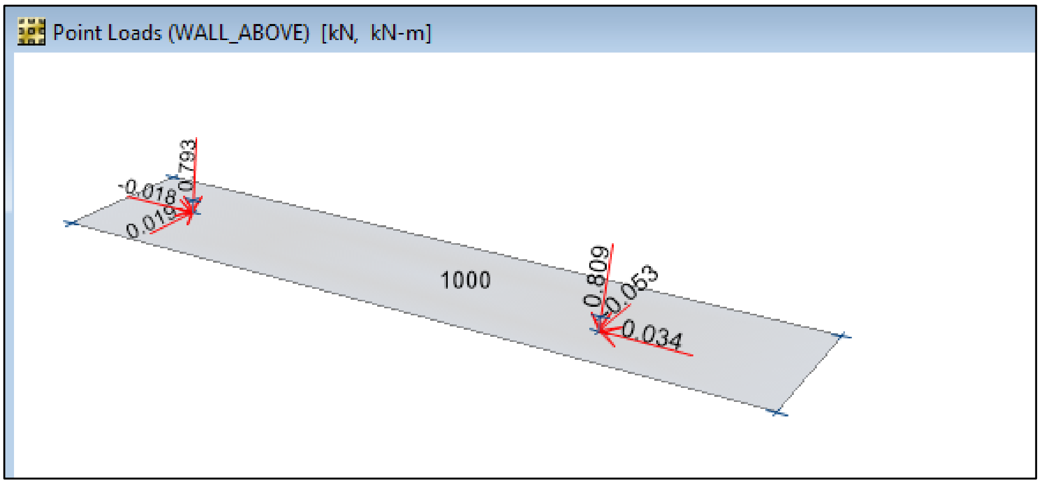
Dead load obtained from ETABS model



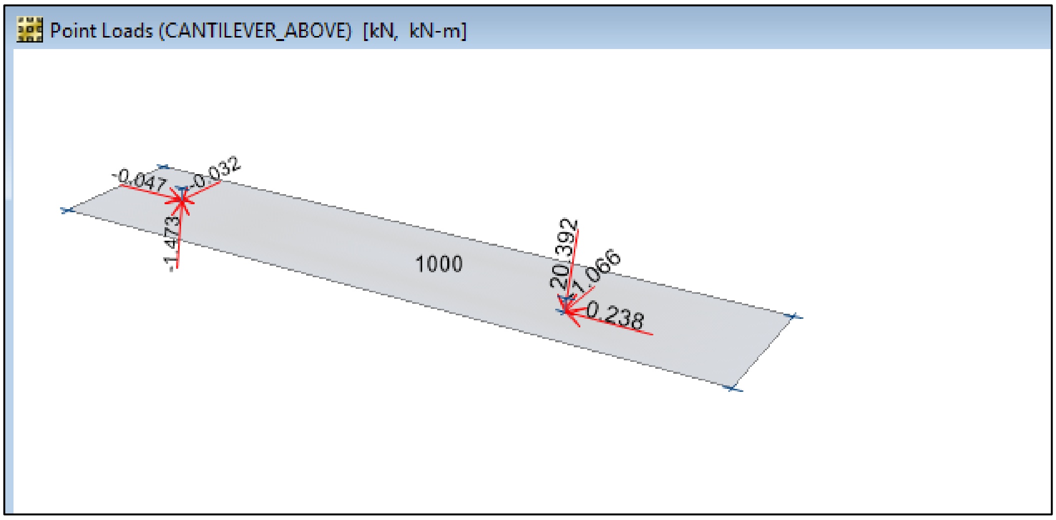
Floor-Finish load obtained from ETABS model



Partition load obtained from ETABS model



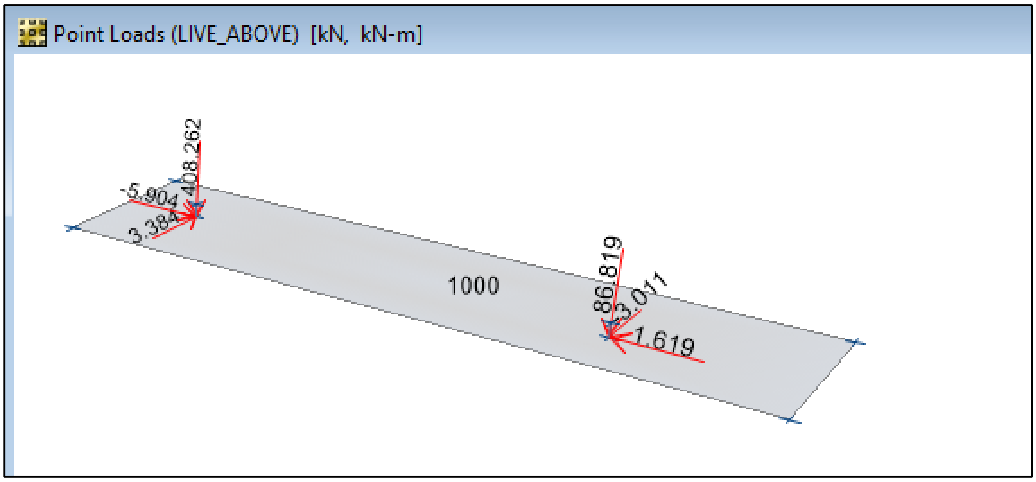
Wall load obtained from ETABS model



Cantilever load obtained from ETABS model

7.3.2 Live Load

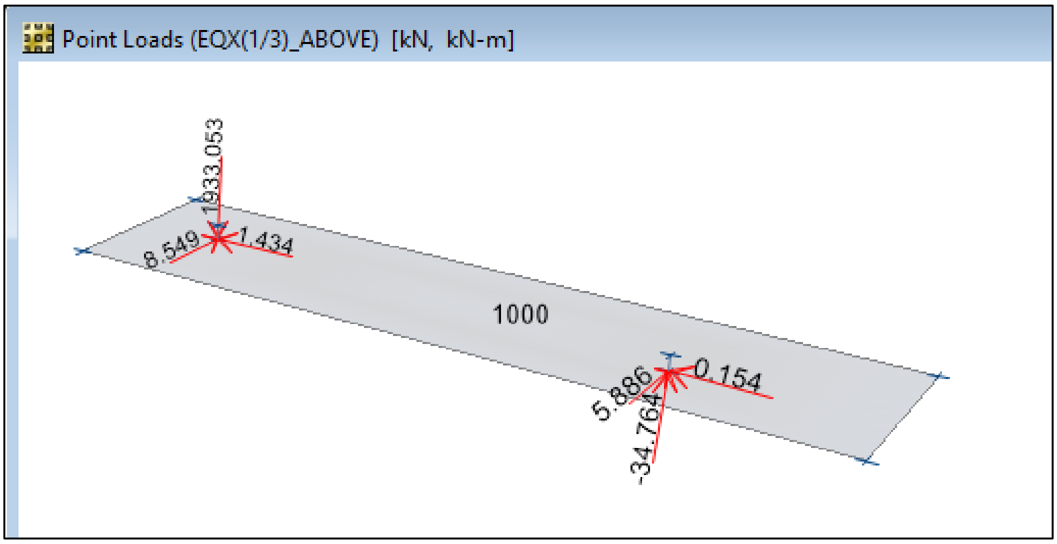
- Live load obtained from ETABS model

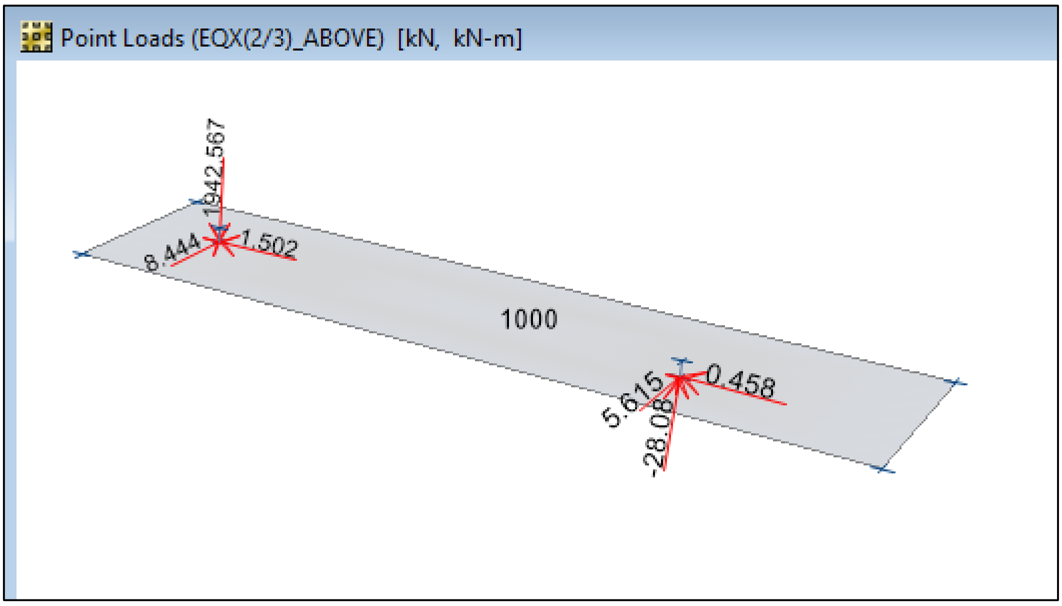


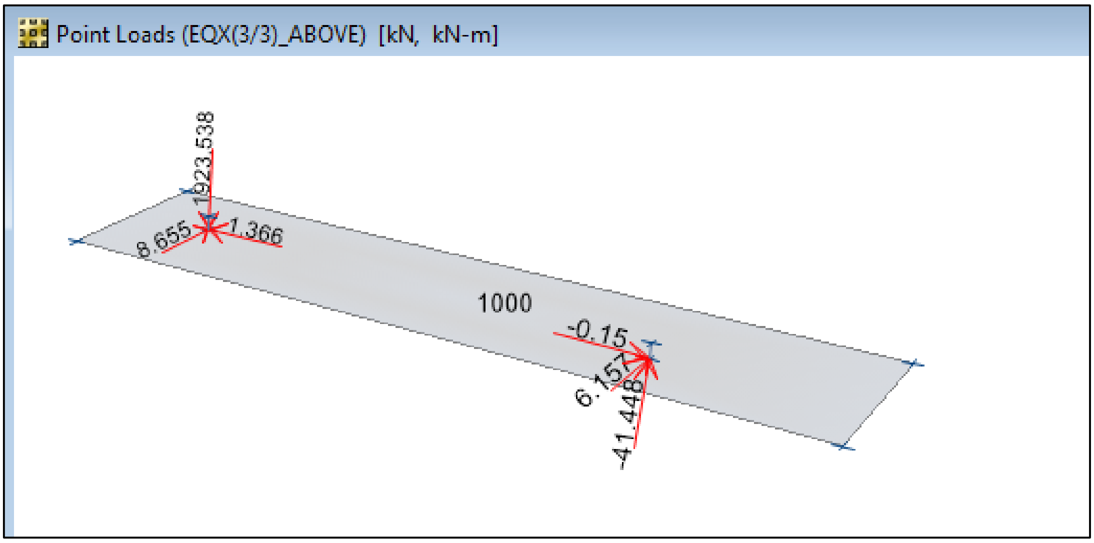
Live load obtained from ETABS model

7.3.3 EQX (Seismic Force in X-Direction)

- Seismic loads obtained from reactions of ETABS model



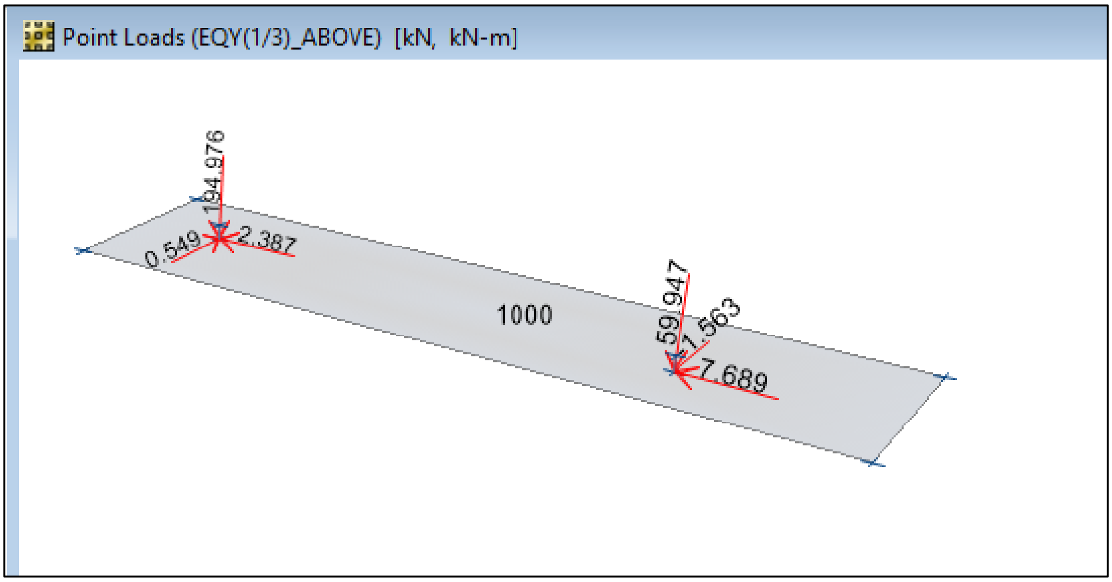


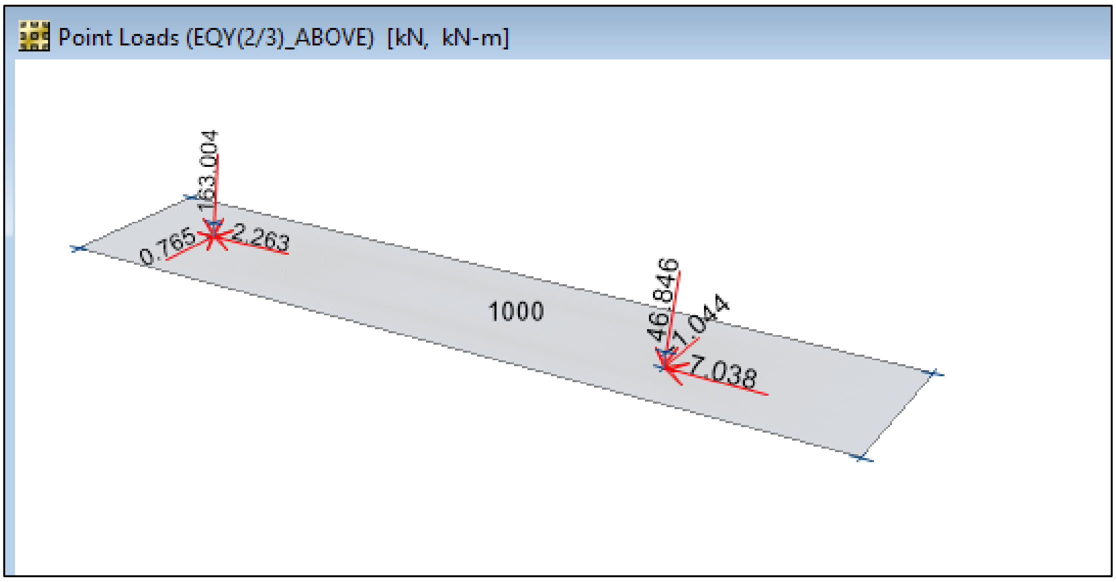


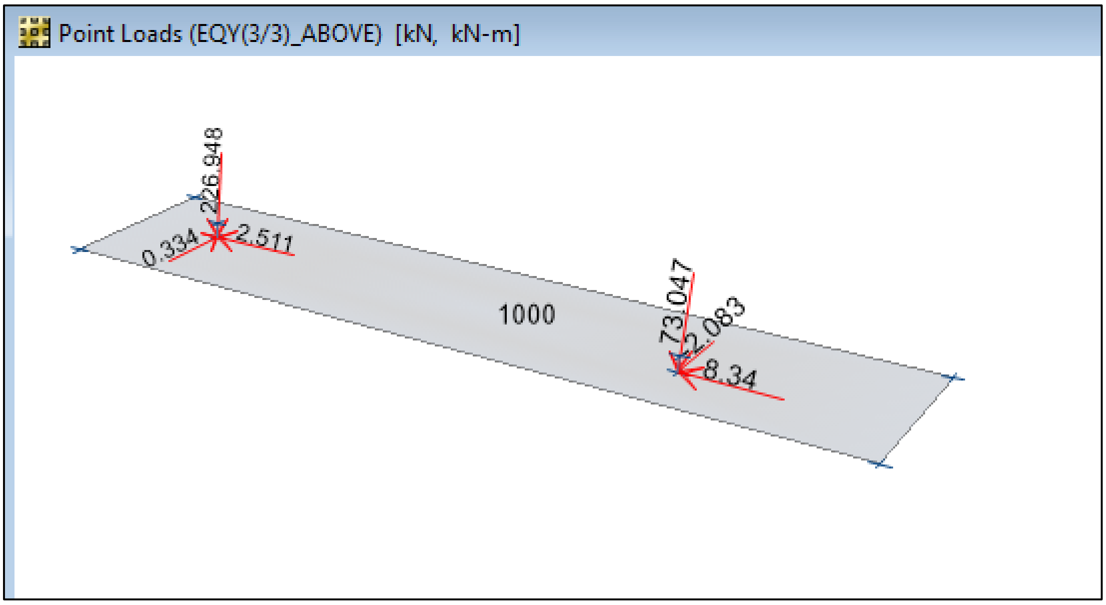
EQX obtained from ETABS model

7.3.4 EQY (Seismic Force in Y-Direction)

- Seismic loads obtained from ETABS model







EQY obtained from ETABS model

7.4 Load Combinations

Design load combinations

1.35DL
1.2DL + 1.5LL
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE - Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE -X
1.0DL +0.3LL + 1.0 EARTHQUAKE – Y + 0.3 EARTHQUAKE –X

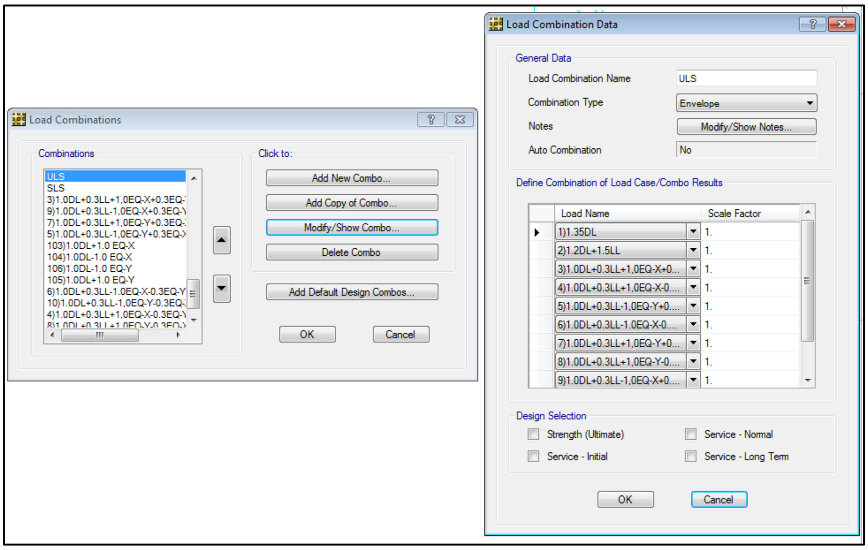
Serviceability load combinations

1.0DL + 1.0LL
1.0DL + 1.0EQX
1.0DL - 1.0EQX
1.0DL + 1.0EQY
1.0DL - 1.0EQY

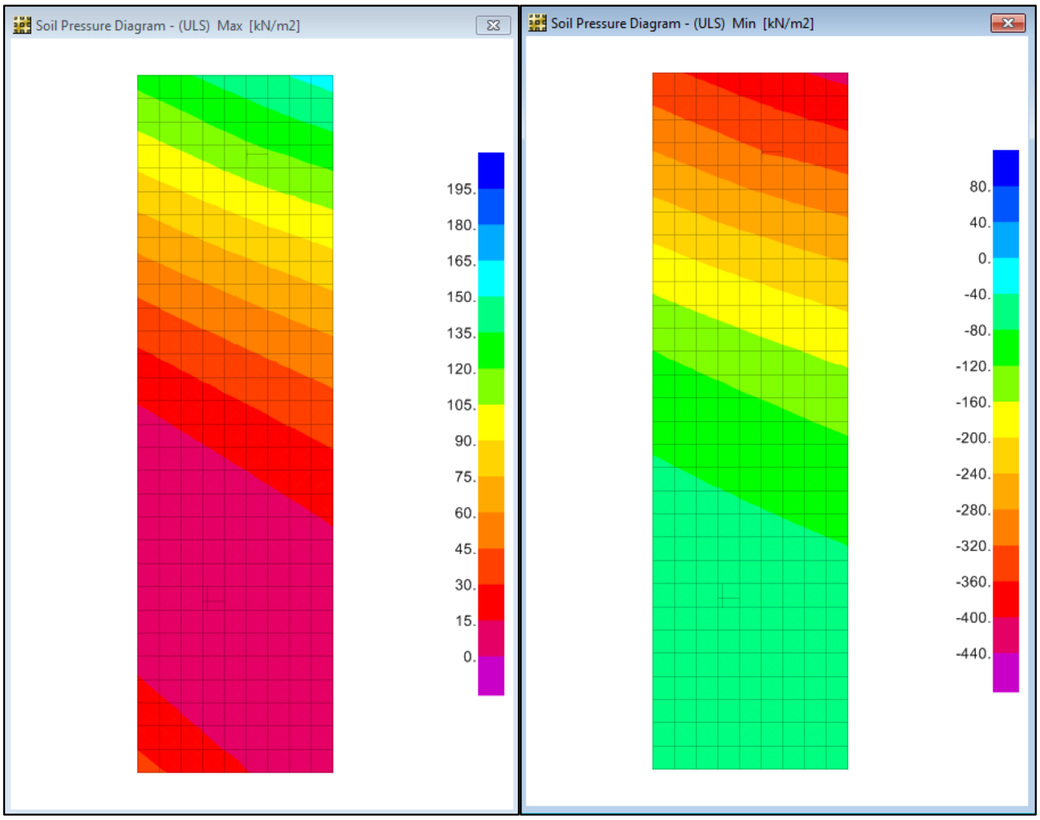
7.5 Base Pressure Check

7.5.1 Check of maximum base pressure for design load combinations:

Refer below image showing soil pressure diagram of base pressure for design load combinations:



Design load combination envelope



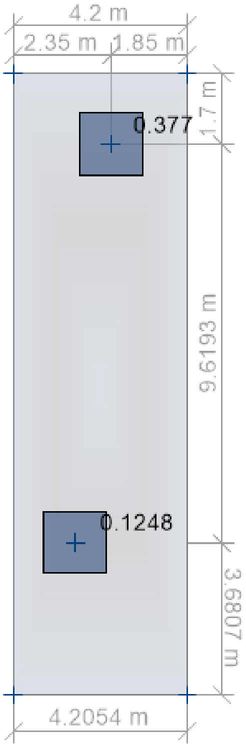
Soil pressure diagram for Seismic ultimate load combination (Max & Min)

Permissible SBC for design load combinations = 575 kN/m^2

Maximum base pressure (Downward) = 341 kN/m^2< 575 kN/m^2 (Hence, OK)

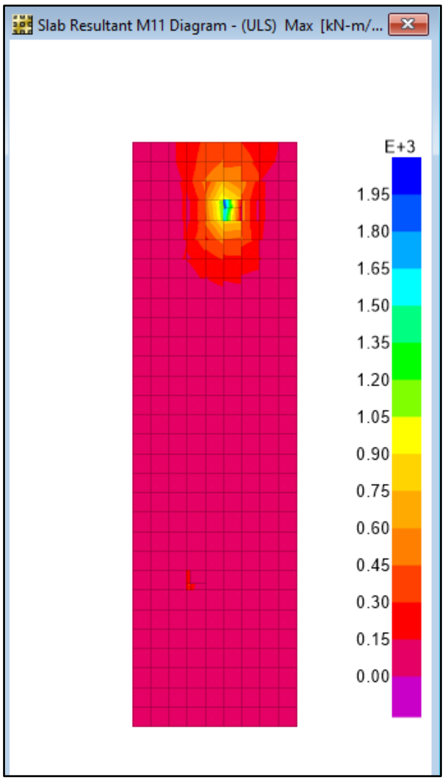
Maximum base pressure (Upward) = 132 kN/m^2

7.6 Punching Shear Check

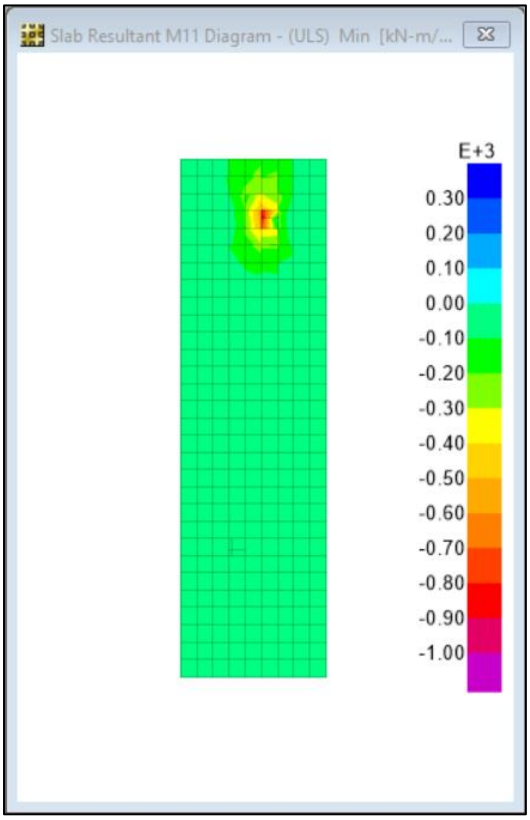


Check for Punching Shear

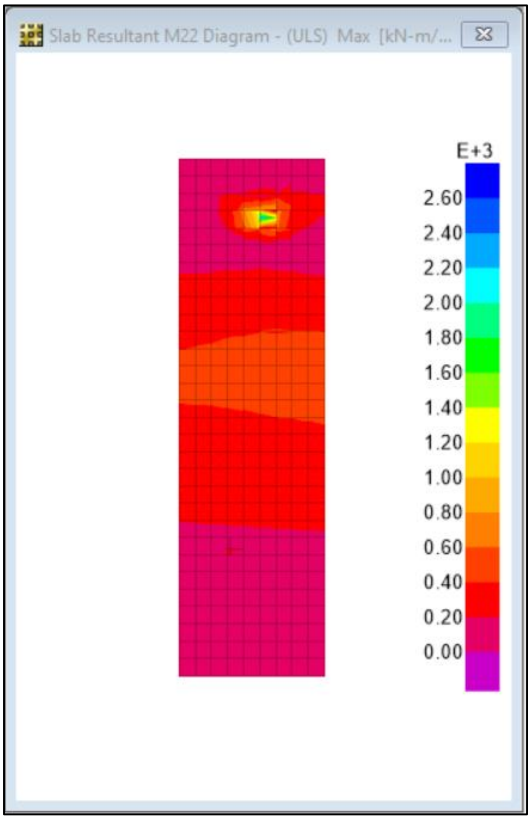
7.7 Moment Diagram:



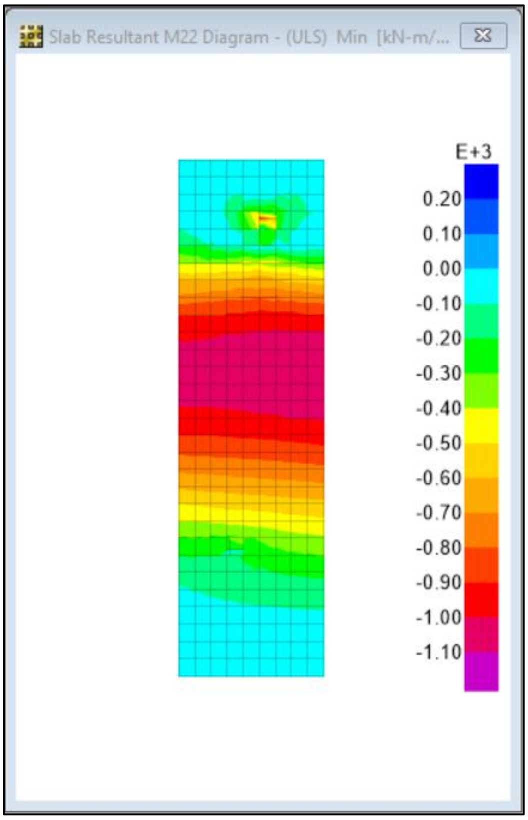
Moment diagram in X-dir. for Design load combination (Max)



Moment diagram in X-dir. for Design load combination (Min)

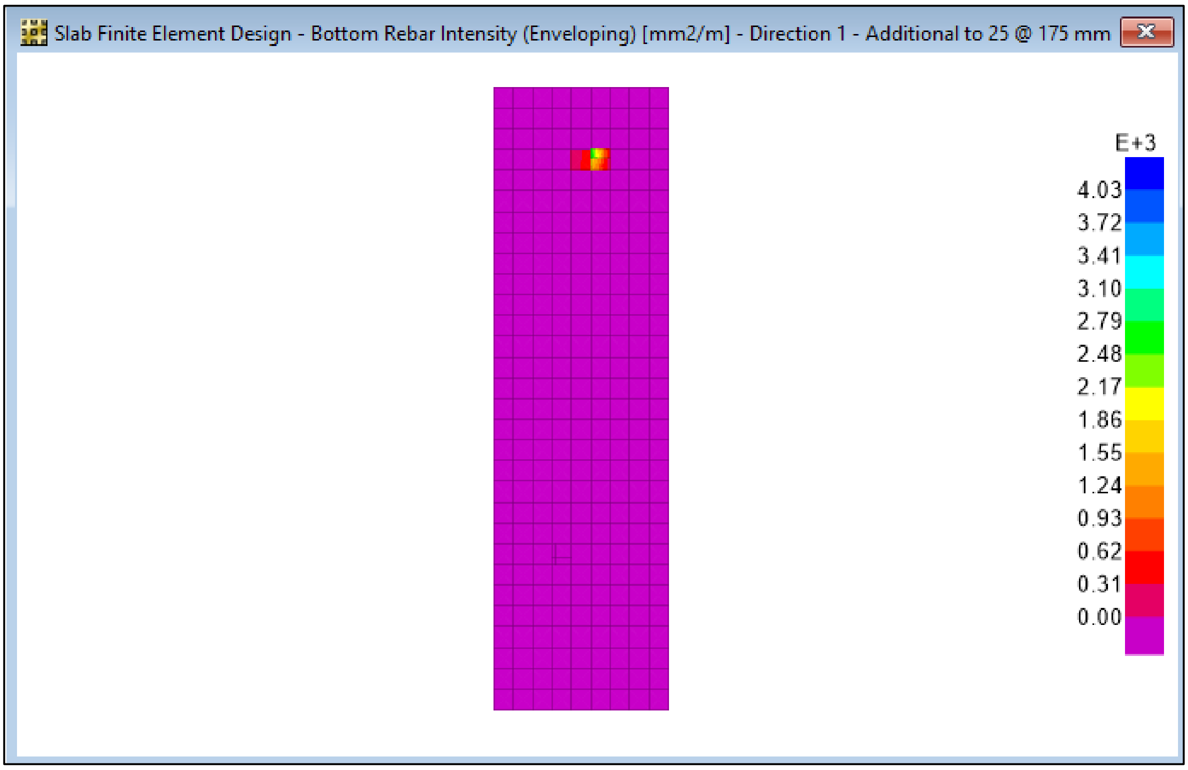


Moment diagram in Y-dir. for Design load combination (Max)

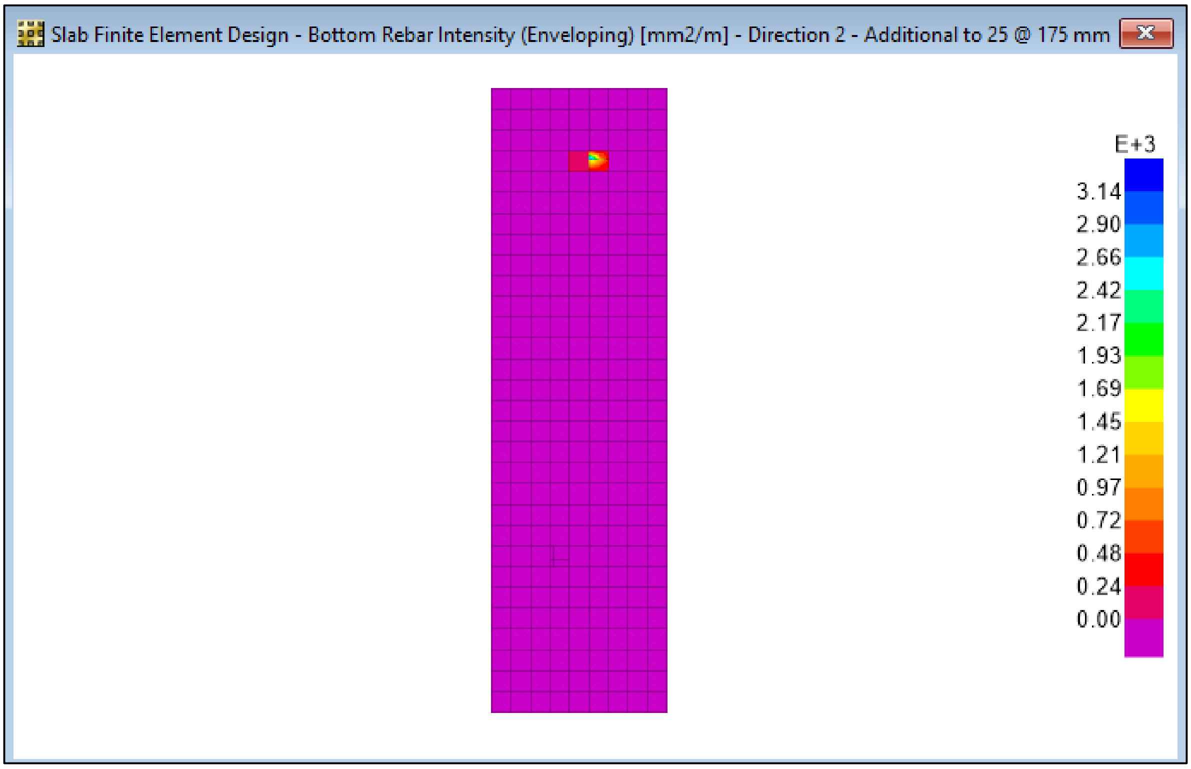


Moment diagram in Y-dir. for Design load combination (Min)

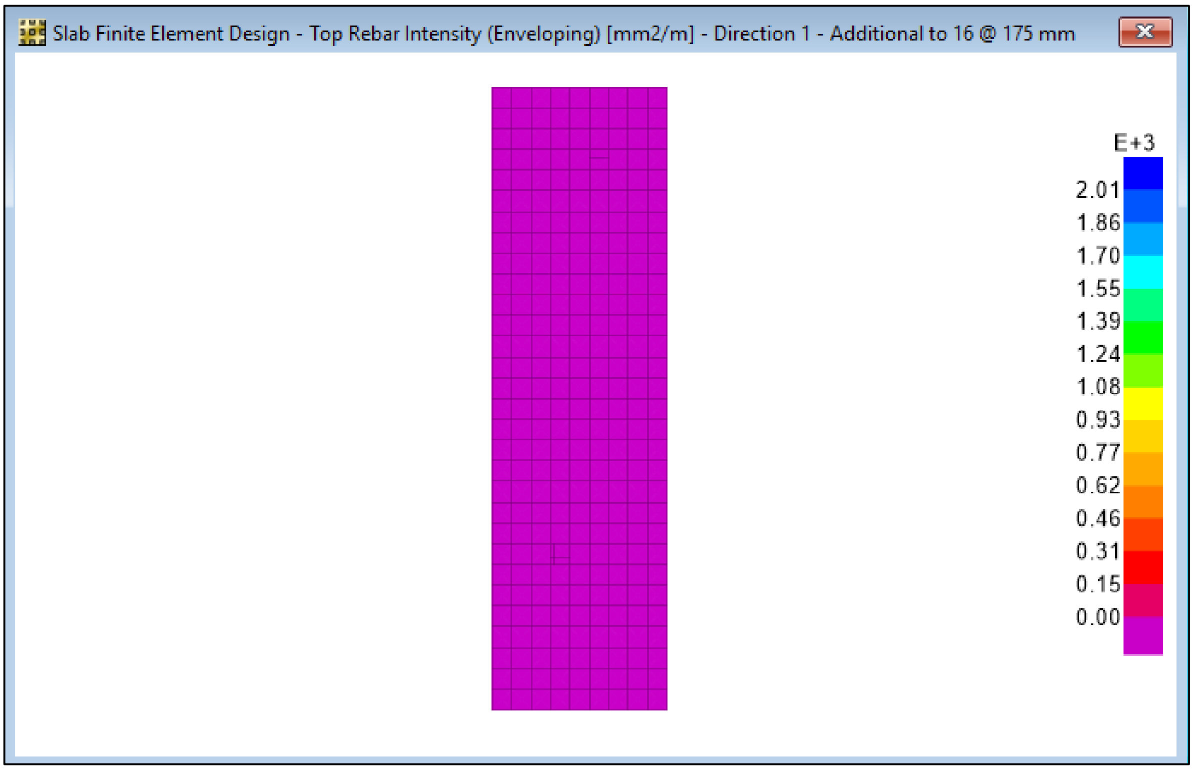
7.8 Design of combined footing:



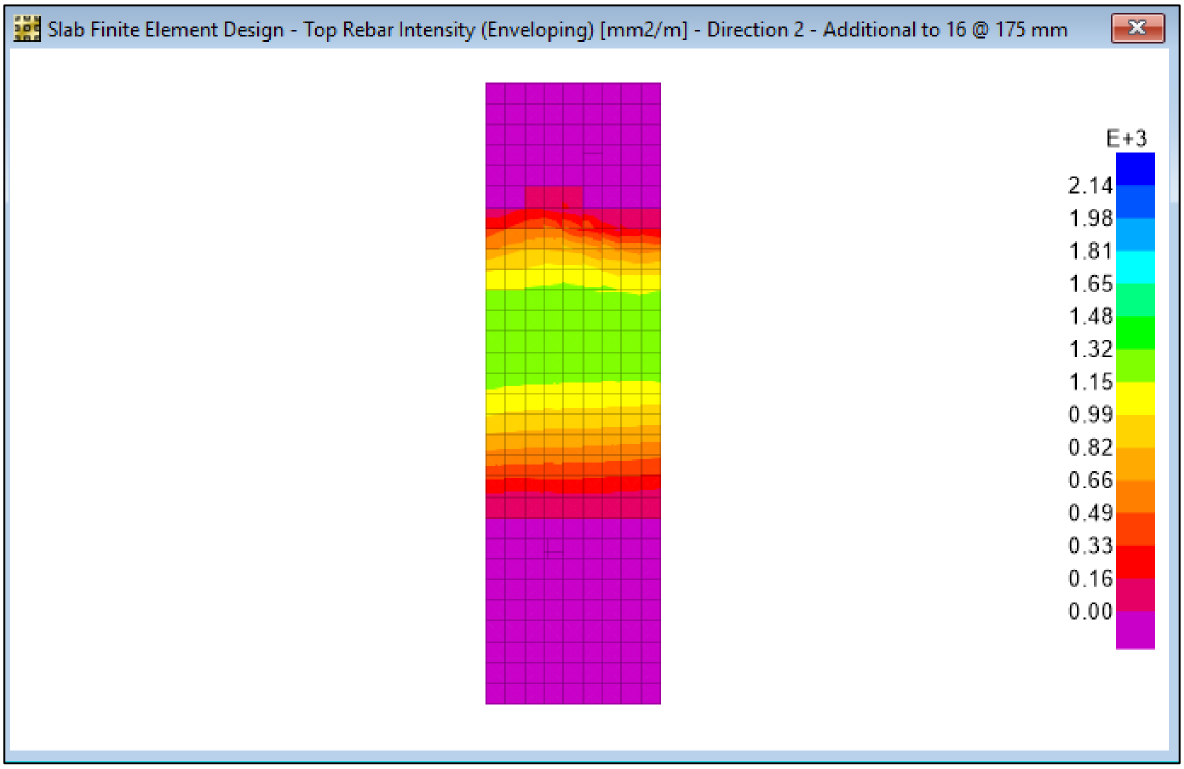
Bottom Reinforcement Día in X direction



Bottom Reinforcement Día in Y direction



Top Reinforcement Día in X direction



Top Reinforcement Día in Y direction

8 FOOTING F1

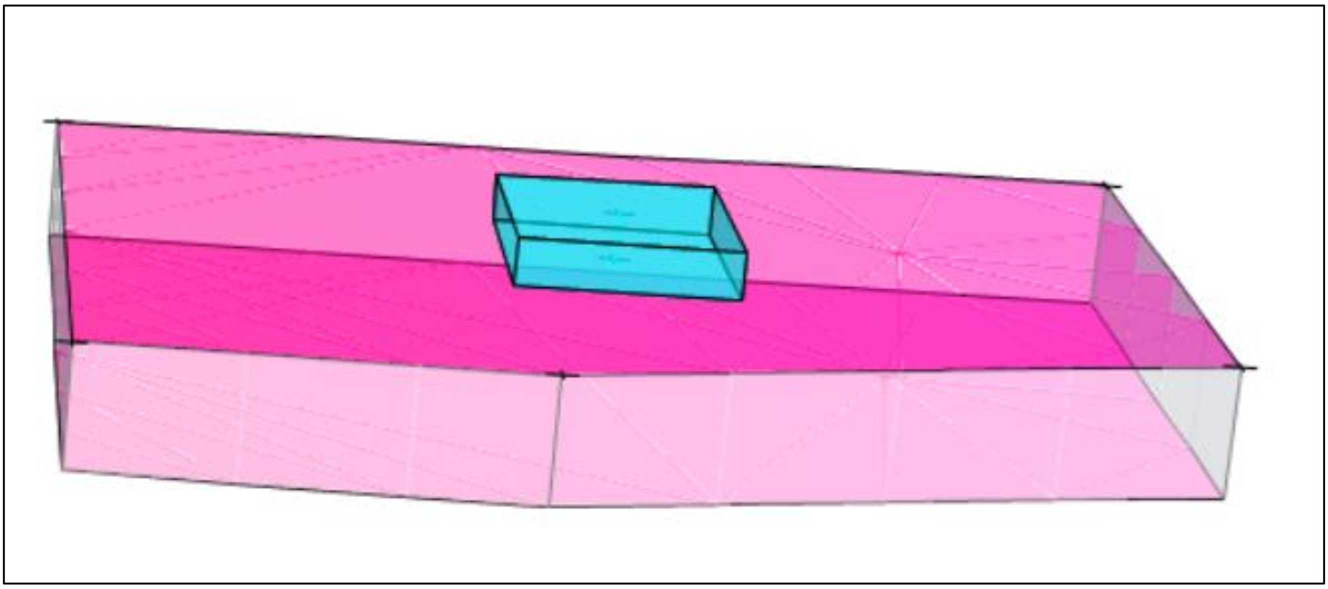
8.1 DESIGN OF F1

SAFE software is used to design F1 foundation.

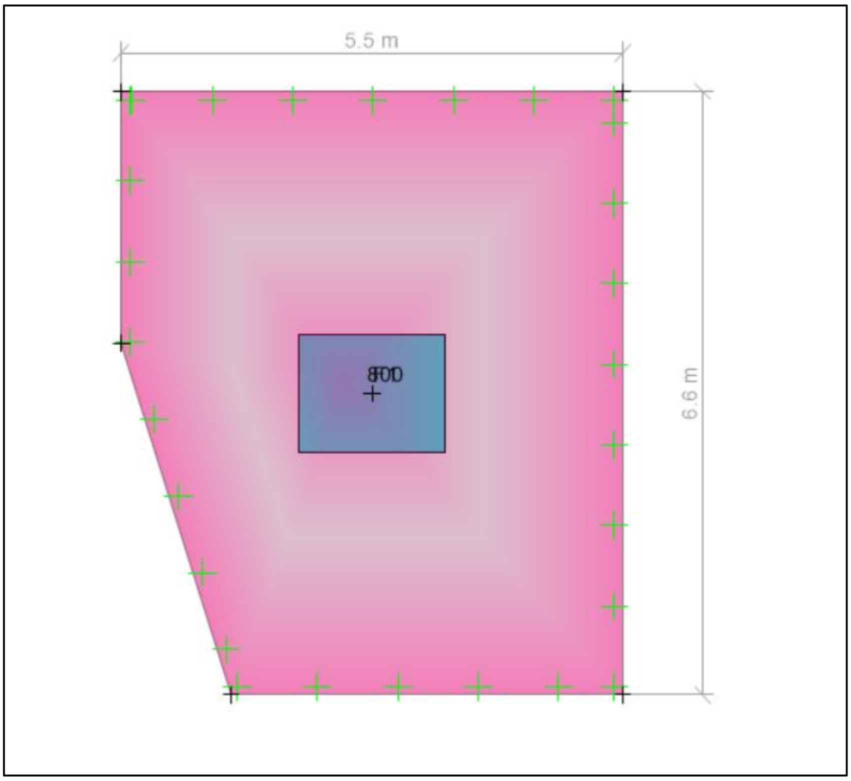
F1 foundation is modeled in SAFE software as Finite elements. Reactions of wall & column for different load cases are Imported from ETABS as SAFE.F2K file.

Refer below steps showing detailed modeling, analysis and design of F1 foundation.

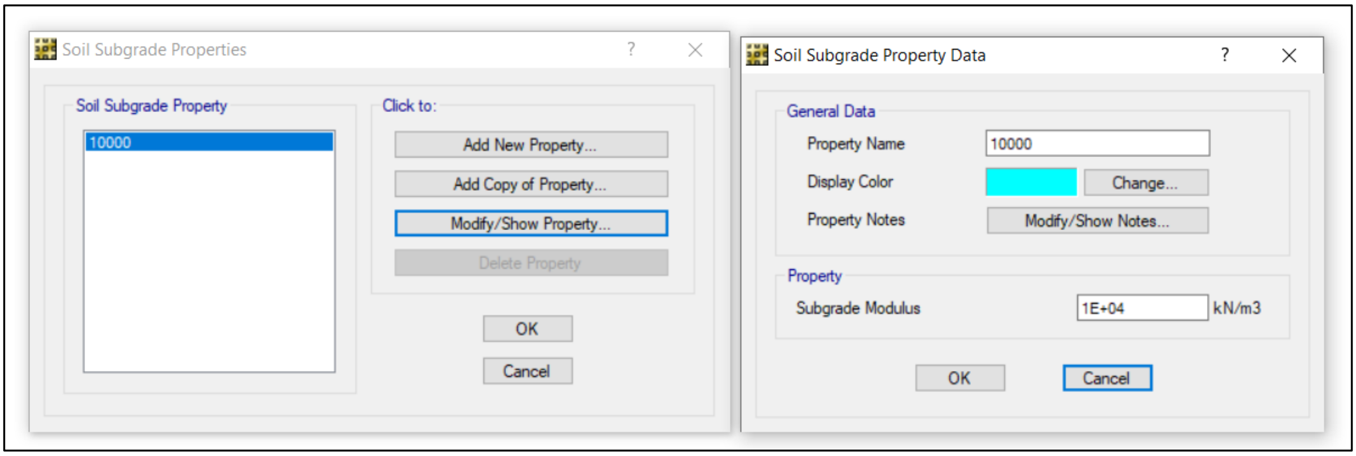
8.2 SAFE MODELING



SAFE modeling of F1 foundation as finite elements



Properties: 1000mm thick slab

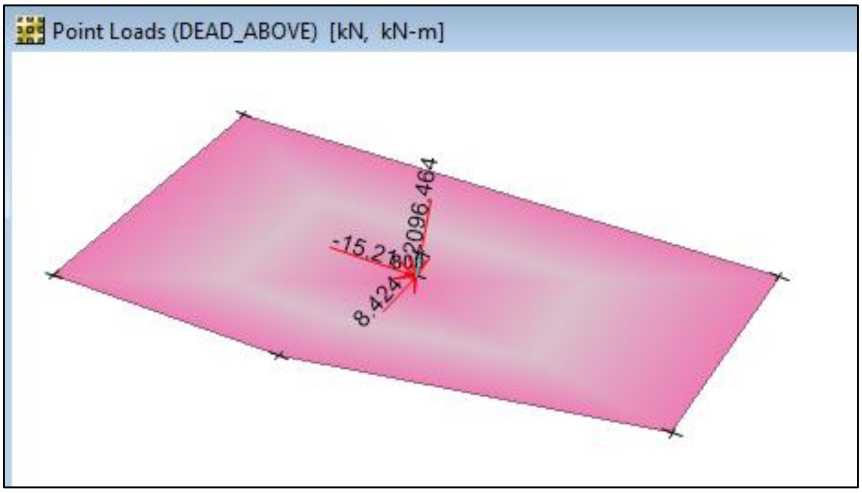


Foundation supports

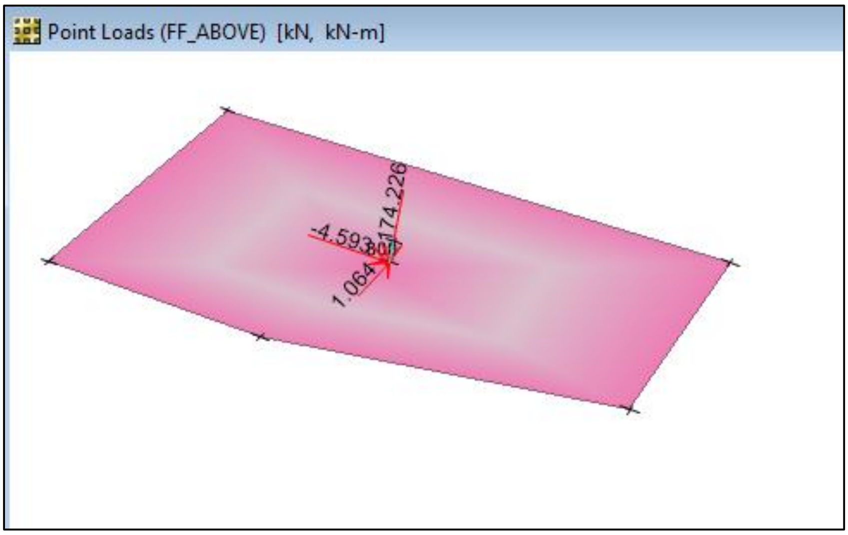
8.3 LOADING

8.3.1 Dead Load

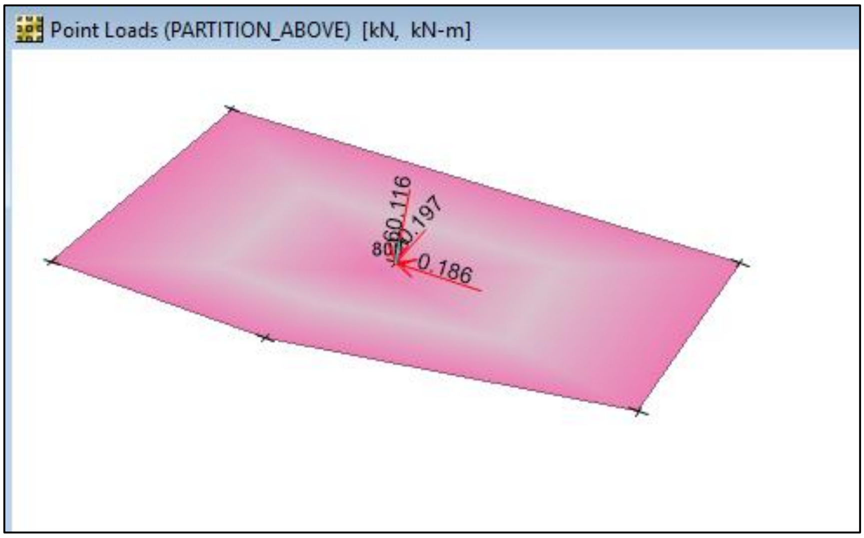
– Dead load obtained from ETABS model



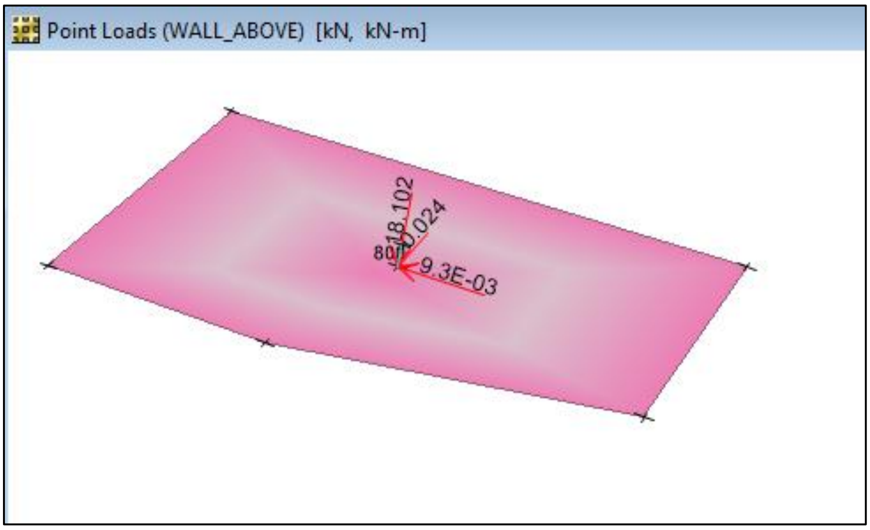
Dead load obtained from ETABS model



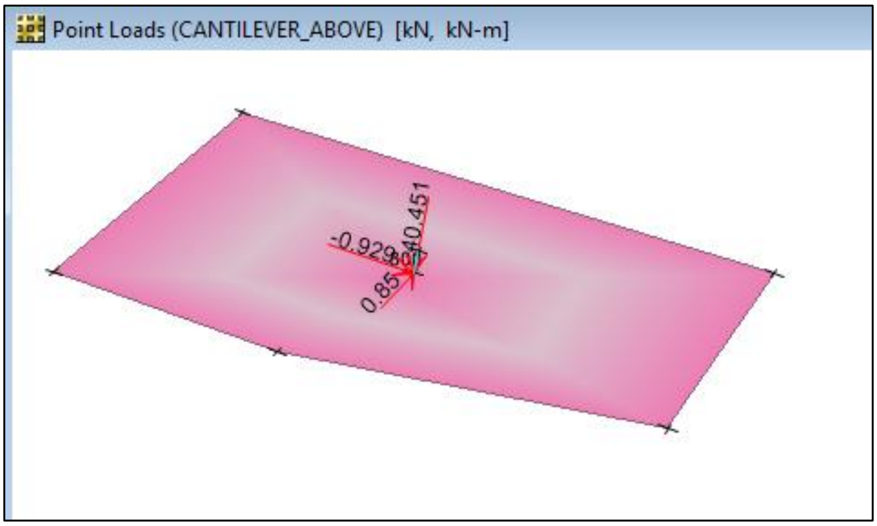
Floor-Finish load obtained from ETABS model



Partition load obtained from ETABS model



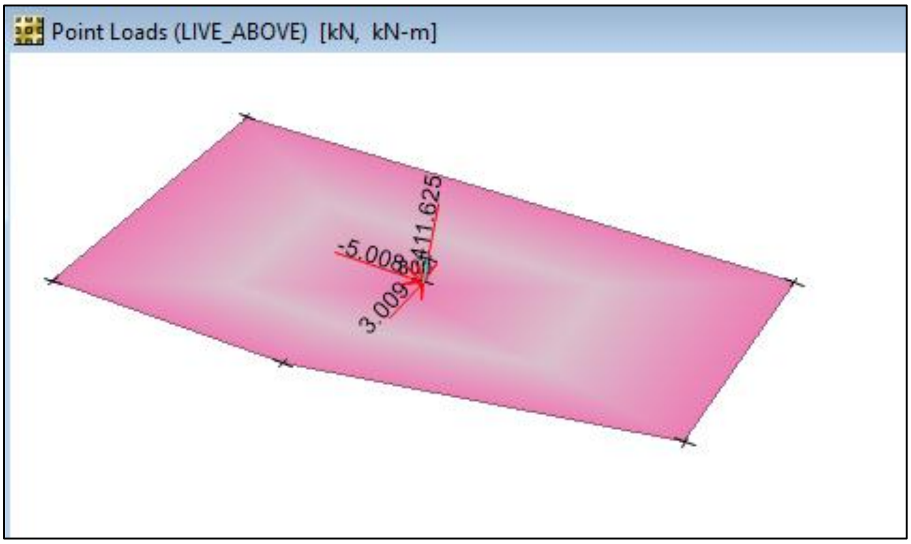
Wall load obtained from ETABS model



Cantilever load obtained from ETABS model

8.3.2 Live Load

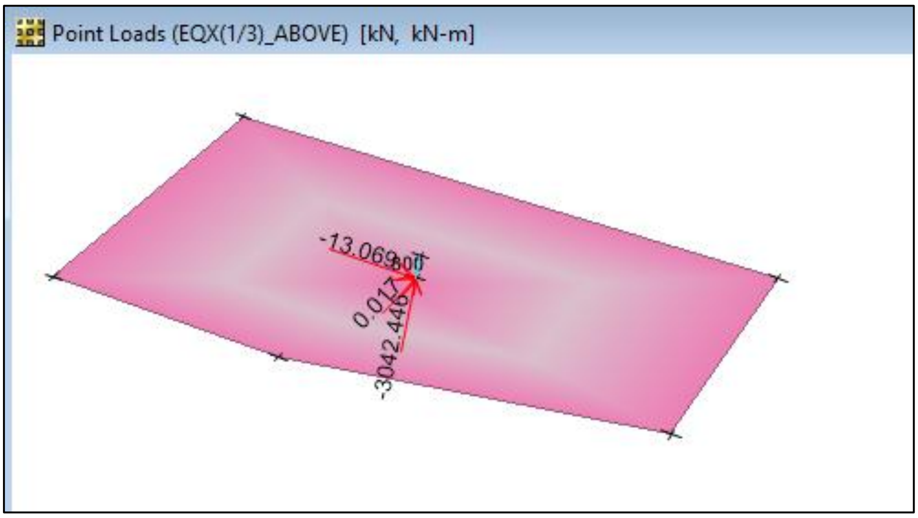
- Live load obtained from ETABS model

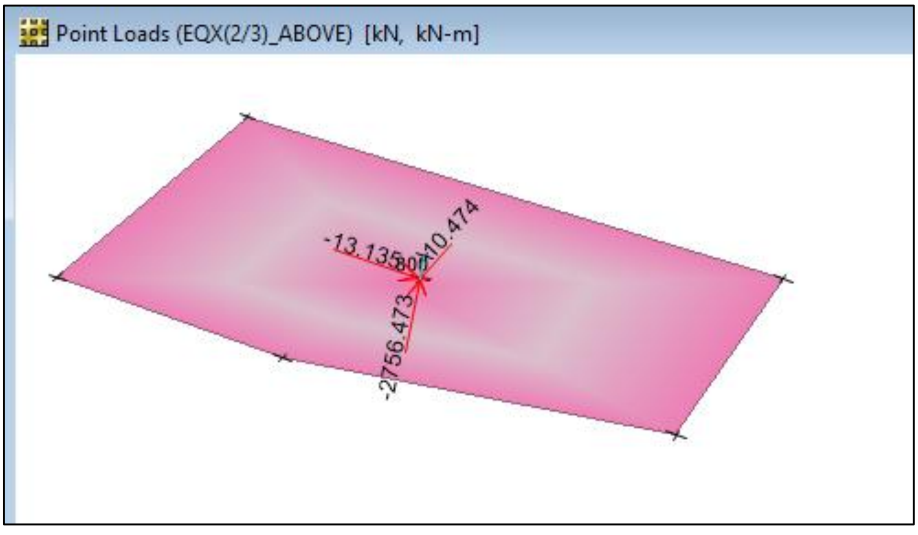


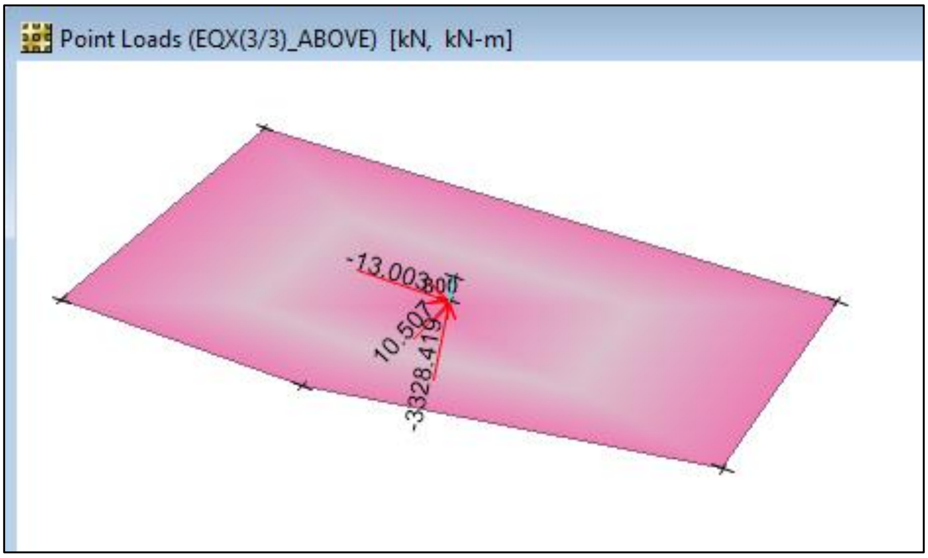
Live load obtained from ETABS model

8.3.3 EQX (Seismic Force in X-Direction)

- Seismic loads obtained from reactions of ETABS model



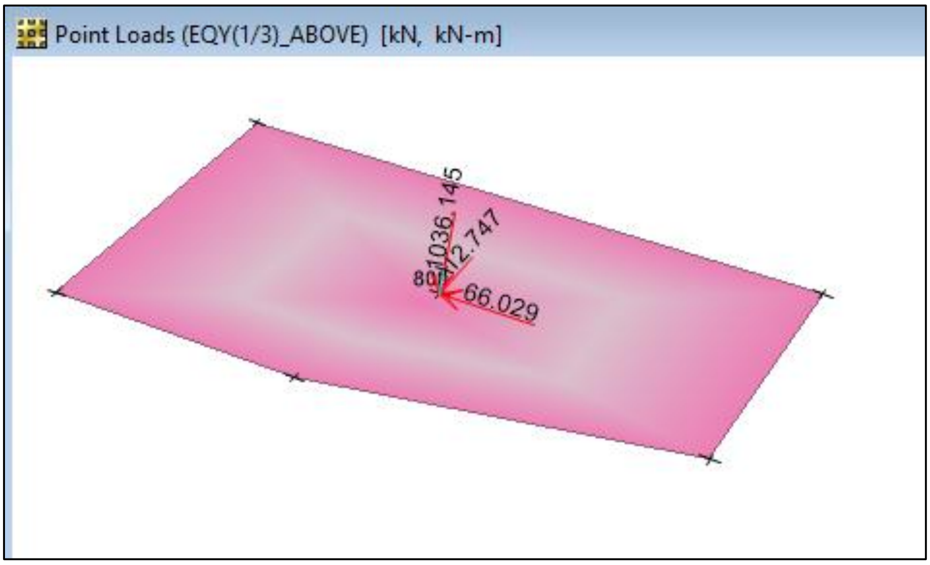


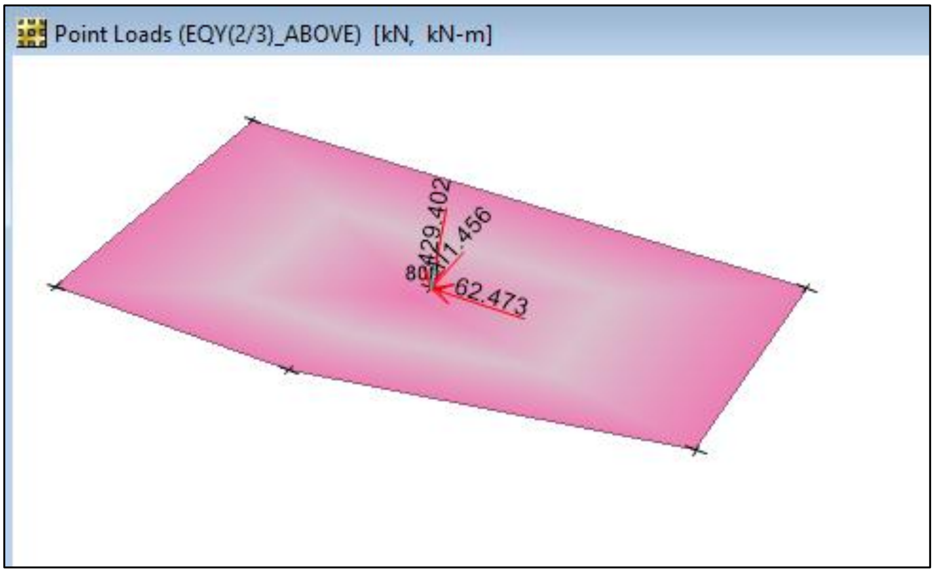


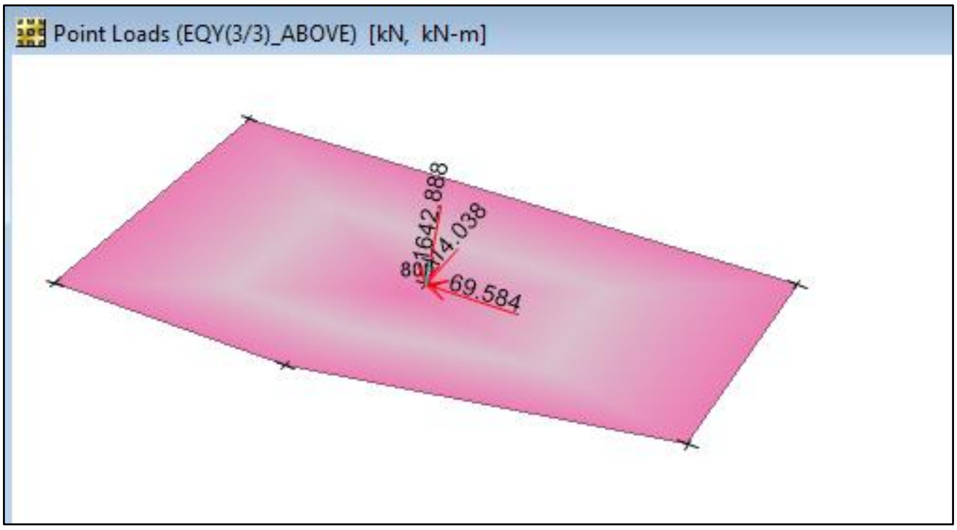
EQX obtained from ETABS model

8.3.4 EQY (Seismic Force in Y-Direction)

- Seismic loads obtained from ETABS model







EQY obtained from ETABS model

8.4 Load Combinations

Design load combinations

1.35DL
1.2DL + 1.5LL
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE +Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE - X + 0.3 EARTHQUAKE -Y
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE - Y + 0.3 EARTHQUAKE +X
1.0DL +0.3LL + 1.0 EARTHQUAKE + Y + 0.3 EARTHQUAKE -X
1.0DL +0.3LL + 1.0 EARTHQUAKE – Y + 0.3 EARTHQUAKE –X

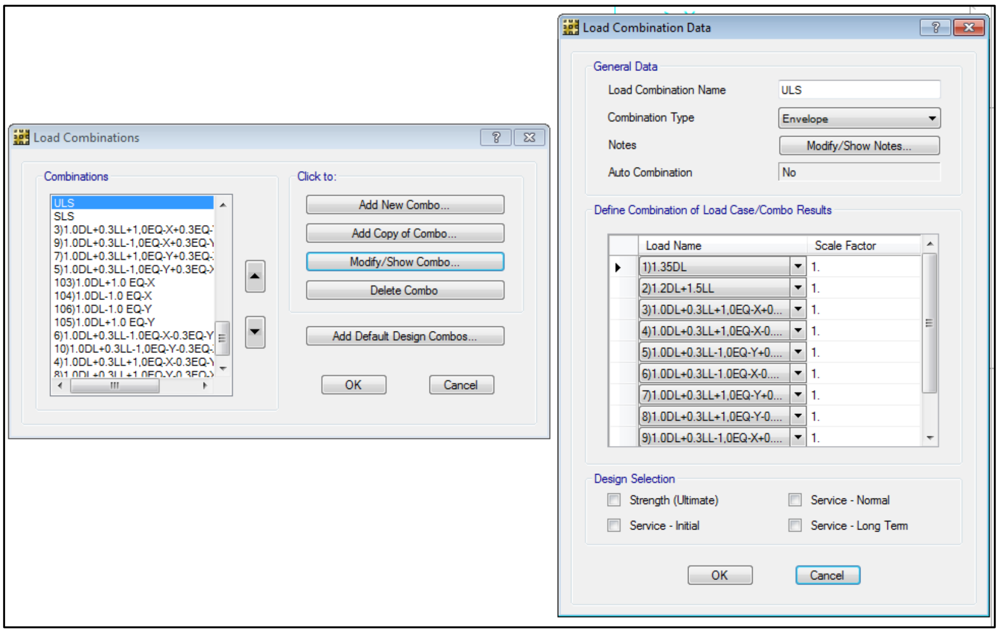
Serviceability load combinations

1.0DL + 1.0LL
1.0DL + 1.0EQX
1.0DL - 1.0EQX
1.0DL + 1.0EQY
1.0DL - 1.0EQY

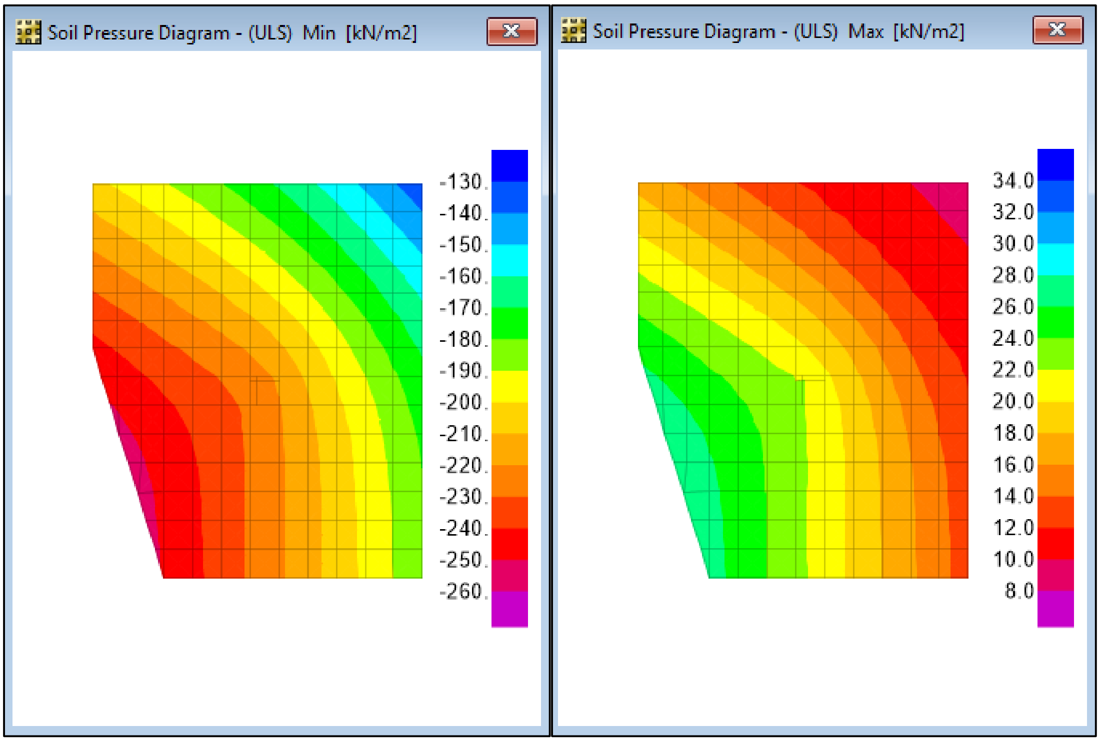
8.5 Base Pressure Check

8.5.1 Check of maximum base pressure for design load combinations:

Refer below image showing soil pressure diagram of base pressure for design load combinations:



Design load combination envelope



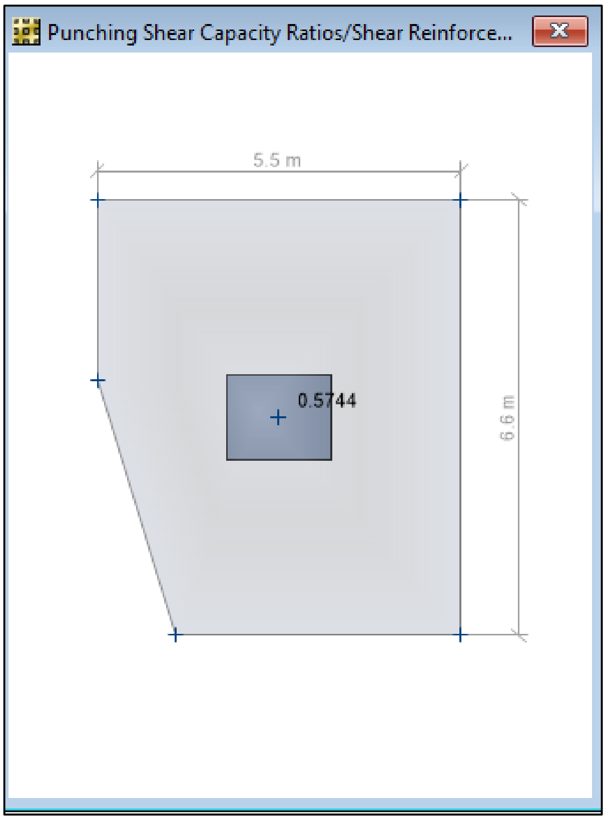
Soil pressure diagram for Seismic ultimate load combination (Max & Min)

Permissible SBC for design load combinations = 575 kN/m^2

Maximum base pressure (Downward) = 142 kN/m^2< 575 kN/m^2 (Hence, OK)

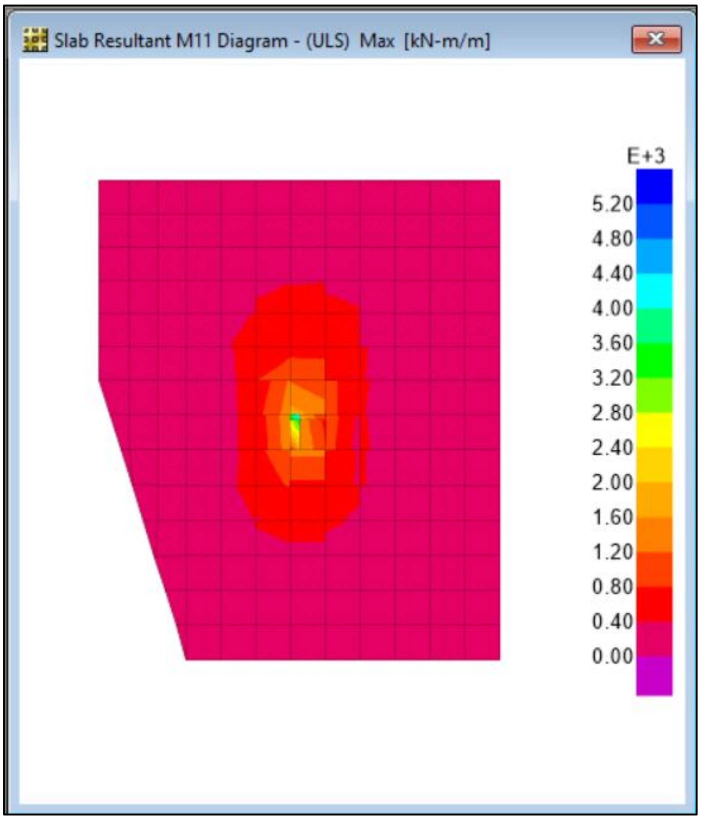
Maximum base pressure (Upward) = 28 kN/m^2

8.6 Punching Shear Check

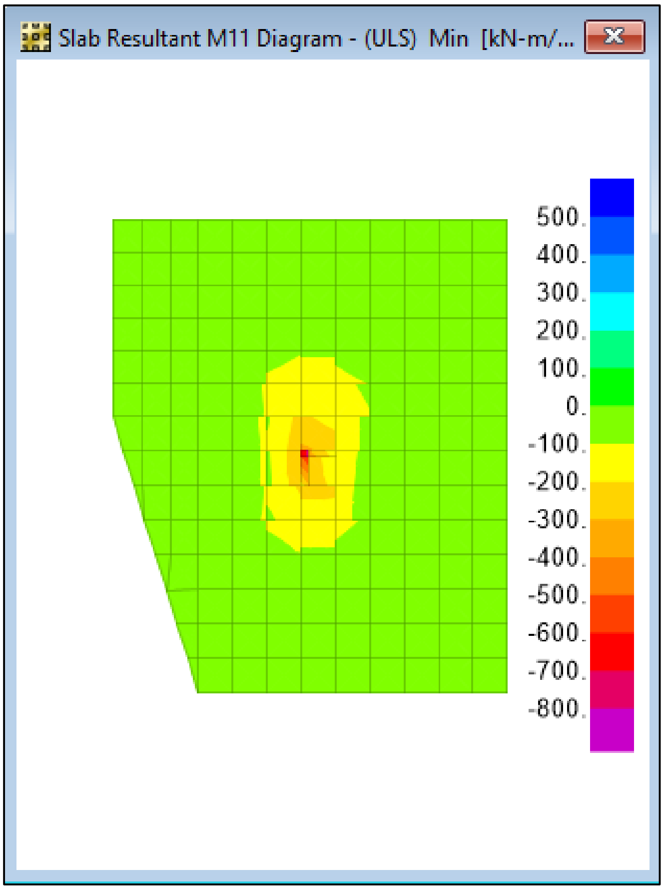


Check for Punching Shear

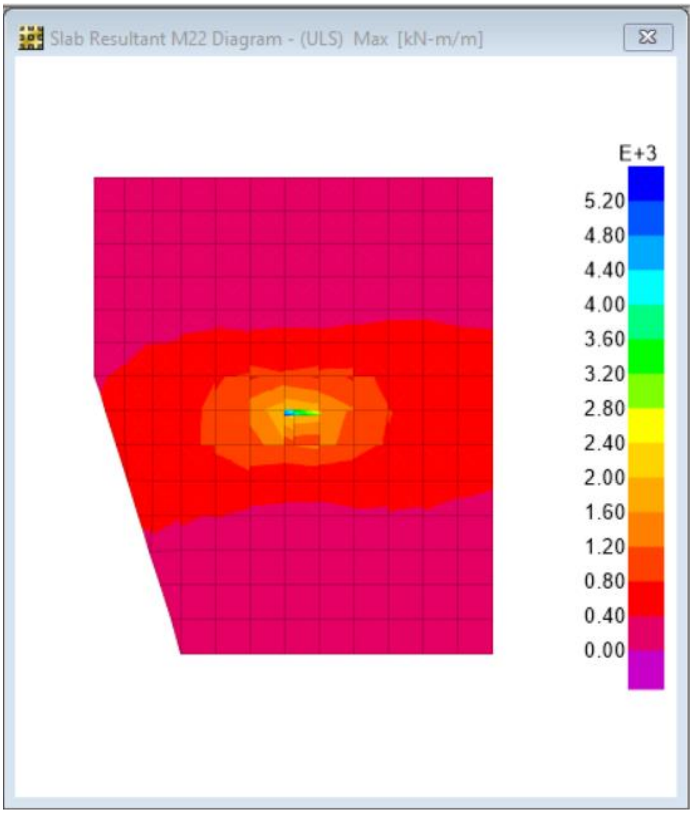
8.7 Moment Diagram:



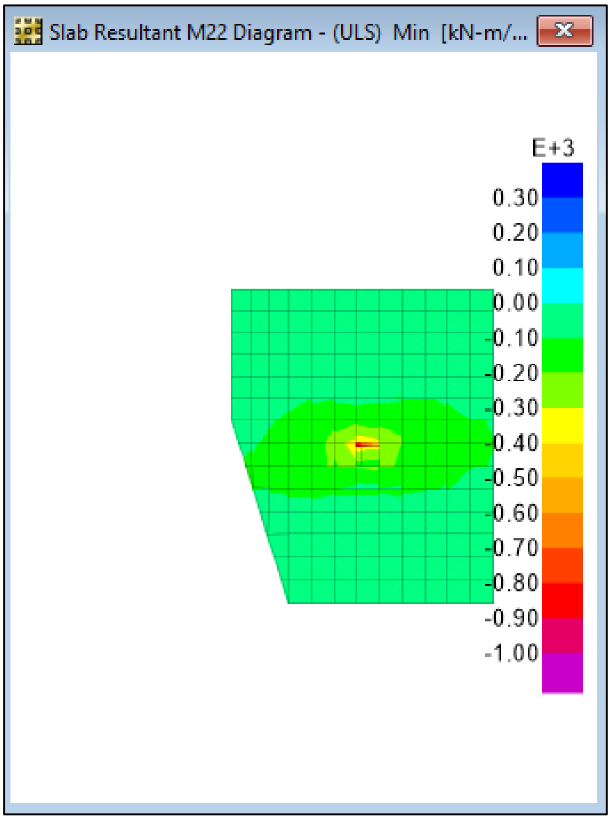
Moment diagram in X-dir. for Design load combination (Max)



Moment diagram in X-dir. for Design load combination (Min)

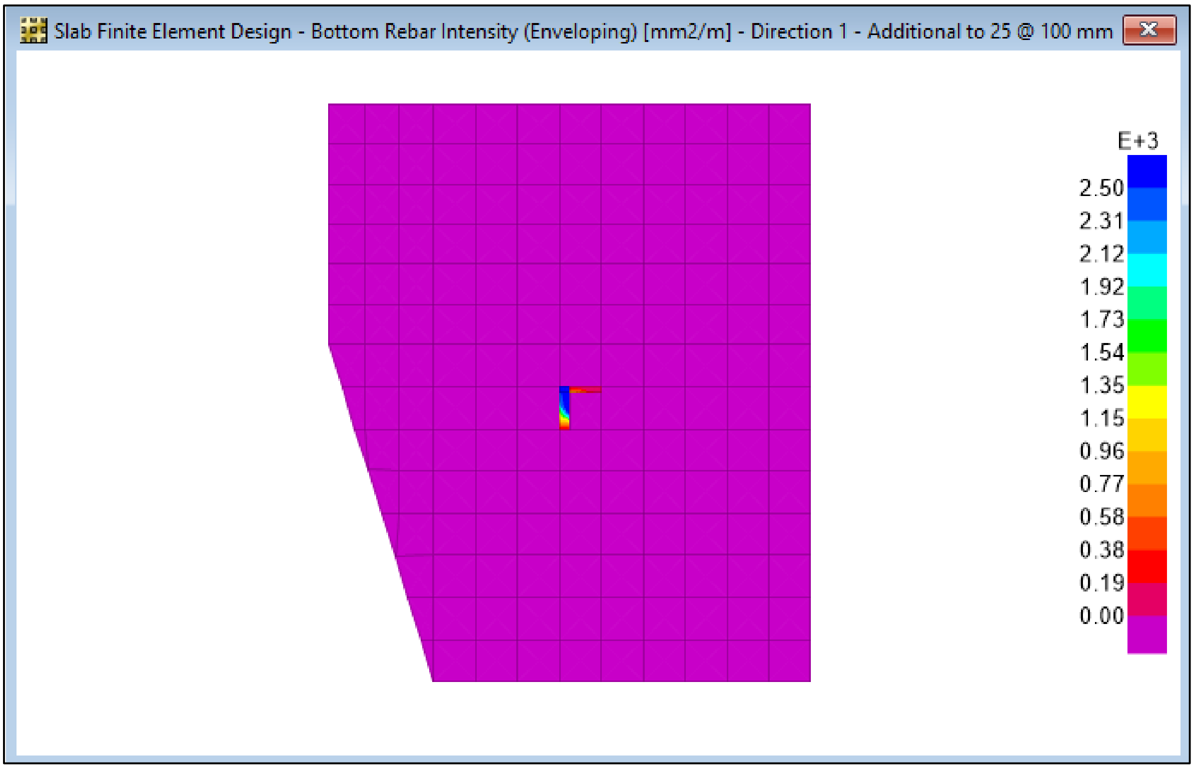


Moment diagram in Y-dir. for Design load combination (Max)

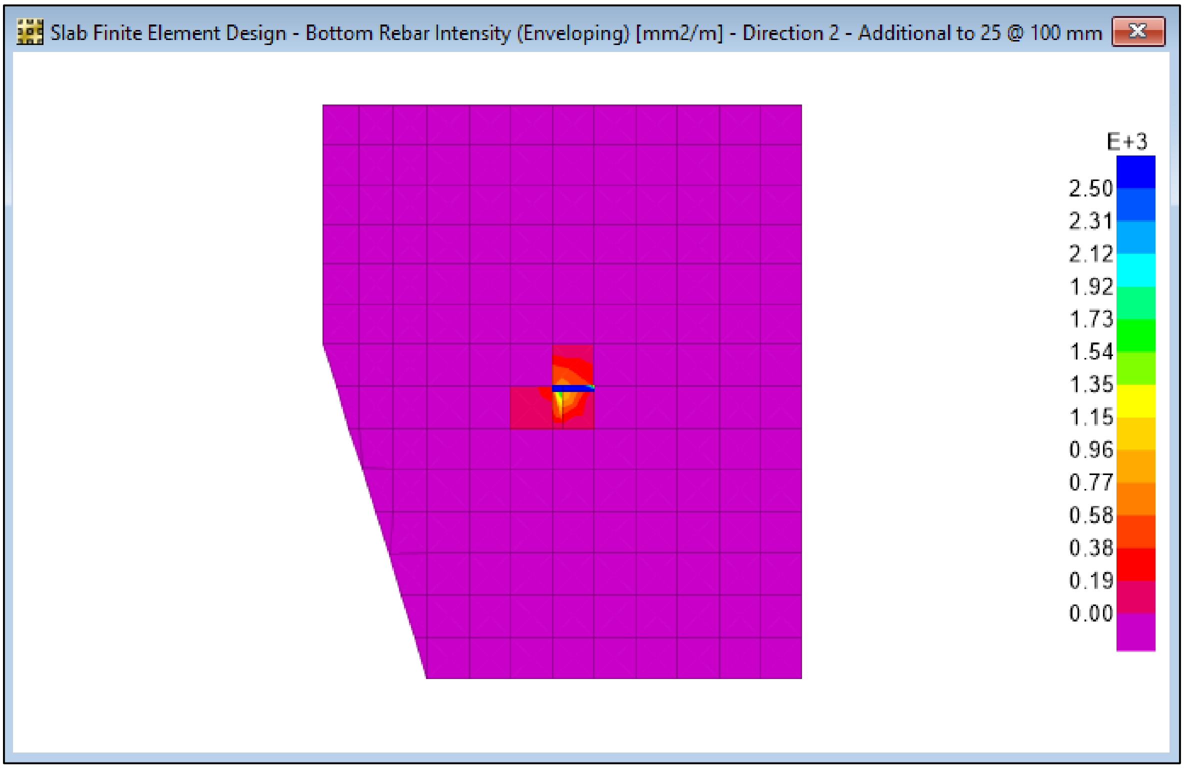


Moment diagram in Y-dir. for Design load combination (Min)

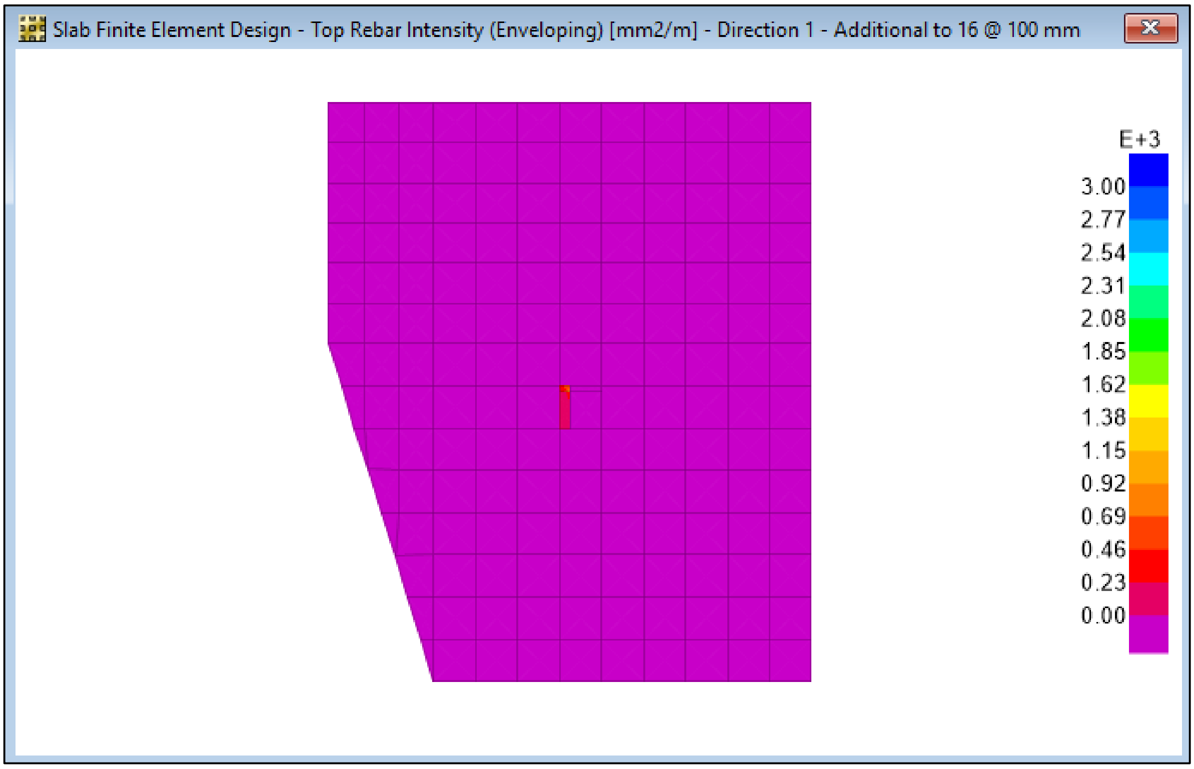
8.8 Design of footing:



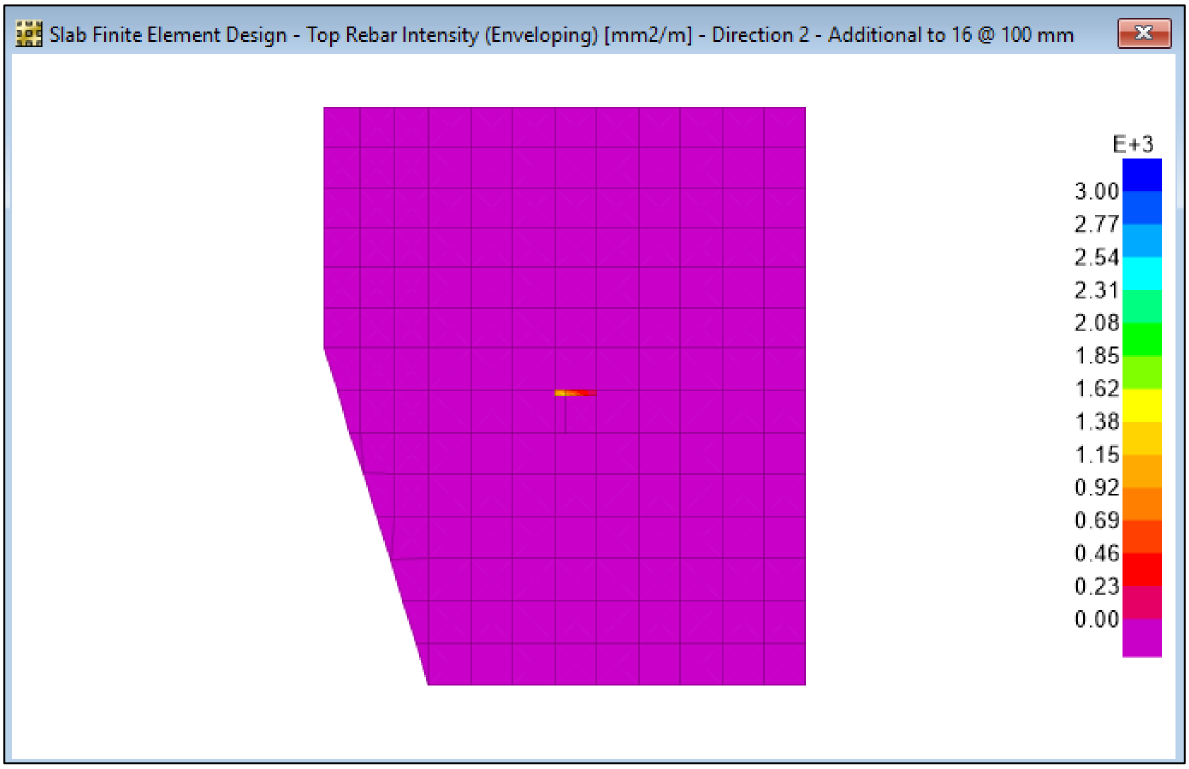
Bottom Reinforcement Día in X direction



Bottom Reinforcement Día in Y direction



Top Reinforcement Día in X direction



Top Reinforcement Día in Y direction

	Ultimate Bearing Capacity and Estimated Settlement								
Footing Mark	Ultimate Bearing Capacity, UBC (kPa)		Estimated Max. Ult. Settlement (mm)	Estimated Max. ULS (static & Seismic) Settlement (mm)	Estimated Max. SLS (static) Settlement (mm)	Estimated Max. SLS Foundation Rotation (°)	Estimated SLS (static) Subgrade Reaction (kPa/mm)	Estimated large strain (ultimate, static) Subgrade Reaction (kPa/mm)	Estimated Differential SLS Settlement Gradient
CF1	1022	transverse	220	75	52	0.15	9.8	3.0	1 in 382
		longitudinal	106	43	34	0.06	15.0	7.1	1 in 955
CF2	1564	transverse	225	72	52	0.16	15.0	4.5	1 in 358
		longitudinal	225	72	52	0.16	15.0	4.5	1 in 358
CF3	979	transverse	80	40	28	0.05	17.5	9.4	1 in 1146
		longitudinal	60	51	25	0.085	19.6	14.0	1 in 675
CF4	1657	transverse (grds 7,8,9)	200	70	57	0.24	14.5	5.8	1 in 239
		transverse (grds 15)	90	40	29	0.08	28.6	13.6	1 in 716
		transverse (grd 5d)	170	103	72	0.32	11.5	8.5	1 in 179
		transverse (grds 10, 10a, 11, 1	209	109	85	0.234	9.7	6.7	1 in 245
		longitudinal	541	49	37	0.3	22.4	1.6	1 in 190
CF5	960	transverse (grds 7,8,9)	157	72	59	0.2	8.1	4.9	1 in 286
		transverse (grds 15)	172	60	42	0.123	11.4	3.7	1 in 466
		transverse (grd 5d)	150	110	85	0.33	5.6	7.4	1 in 173
		transverse (grds 10, 10a, 11, 1	116	61	43	0.18	11.2	6.6	1 in 318
		longitudinal	300	136	97	0.21	4.9	2.4	1 in 273
CF5a	1583	transverse	171	55	47	0.019	16.8	6.4	1 in 3016
		longitudinal	300	136	97	0.22	8.2	3.9	1 in 260
CF6	1230	transverse (grd B2)	106	96	67	0.089	11.9	11.0	1 in 644
		transverse (grd C2)	247	164	80	0.27	10.0	2.6	1 in 212
		longitudinal	249	137	130	0.15	6.2	3.6	1 in 382
CF7	1291	transverse	132	72	47	0.046	13.7	7.6	1 in 1246
		longitudinal	148	79	40	0.072	16.1	6.0	1 in 796
CF8	979	transverse	80	60	42	0.07	14.0	10.3	1 in 819
		longitudinal	80	60	42	0.07	14.0	10.3	1 in 819
CF9	979	transverse	172	123	42	0.07	11.7	3.8	1 in 819
		longitudinal	172	123	42	0.07	11.7	3.8	1 in 819
CF9a	979	transverse	172	123	42	0.07	11.7	3.8	1 in 819
		longitudinal	74	49	33	0.136	14.8	11.9	1 in 421

	Ultimate Bearing Capacity and Estimated Settlement									
Footing Mark	Ultimate Bearing Capacity, UBC (kPa)		Estimated Max. Ult. Settlement (mm)	Estimated Max. ULS (static & Seismic) Settlement (mm)	Estimated Max. SLS (static) Settlement (mm)	Estimated Max. SLS Foundation Rotation (°)	Estimated SLS (static) Subgrade Reaction (kPa/mm)	Estimated large strain (ultimate, static) Subgrade Reaction (kPa/mm)	Estimated Differential SLS Settlement Gradient
F2.2	1230	transverse	137	95	75	0.087	9.8	7.9	1 in 659
		longitudinal	209	109	85	0.414	8.7	4.0	1 in 1380
F5	1204	transverse	136	91	72	0.16	10.0	7.5	1 in 358
		longitudinal	209	109	85	0.414	8.5	3.9	1 in 138
F1.1		transverse	98	54	39	0.11	21.5	14.2	1 in 521
	1375	longitudinal	153	79	51	0.14	16.5	8.2	1 in 409
F5.1		transverse	85	62	38	0.23	22.1	17.9	1 in 249
		longitudinal	130	70	44	0.06	19.1	9.8	1 in 955
F2	1237	transverse	180	93	73	0.012	8.5	5.8	1 in 4775
		longitudinal	189	93	80	0.239	7.7	5.7	1 in 240
F2.1	1230	transverse	90	80	31	0.017	19.8	10.4	1 in 3370
		longitudinal	189	93	80	0.115	7.7	5.6	1 in 500
F3	1016	transverse	100	97	43	0.17	11.8	8.9	1 in 337
		longitudinal	189	93	80	0.239	6.3	4.7	1 in 240
F3.1		transverse	217	125	67	0.27	10.5	4.7	1 in 212
	1643	longitudinal	217	125	67	0.27	10.5	4.7	1 in 212
F10		transverse	103	93	65	0.085	18.8	17.3	1 in 674
		longitudinal	103	93	65	0.085	18.8	17.3	1 in 674
F3.2		transverse	133	49	40	0.049	17.5	7.5	1 in 1170
		longitudinal	133	49	40	0.049	17.5	7.5	1 in 1170
F6.1		transverse	181	122	51	0.28	13.8	5.4	1 in 205
	1209	longitudinal	169	55	46	0.038	15.3	5.7	1 in 1508
F11		transverse	91	81	57	0.16	10.2	11.4	1 in 358
		longitudinal	132	48	39	0.057	14.9	4.2	1 in 1005
F4	1204	transverse	90	84	34	0.01	17.7	10.8	1 in 5730
		longitudinal	209	109	85	0.414	7.1	4.9	1 in 138
F6	1733	transverse	90	84	33	0.028	26.3	15.2	1 in 2046
		longitudinal	209	109	85	0.414	10.2	7.0	1 in 138
F7	1256	transverse	110	73	54	0.17	14.0	9.0	1 in 337
		longitudinal	209	109	85	0.414	8.9	4.1	1 in 138
F8/ C113	1776	transverse	156	129	80	0.089	13.3	9.3	1 in 644
		longitudinal	189	93	80	0.239	13.3	6.5	1 in 240
F8/ C127	1872	transverse	80	74	34	0.06	27.5	20.3	1 in 955
		longitudinal	189	93	80	0.115	11.7	8.6	1 in 500
F9	1733	transverse	80	74	32	0.07	27.1	18.1	1 in 819
		longitudinal	209	109	85	0.414	10.2	7.0	1 in 138
F9.1	1583	transverse	160	74	52	0.01	15.2	7.3	1 in 5730
		longitudinal	124	69	50	0.042	15.8	10.7	1 in 1364

Note: (1) A strength reduction factor Ø$_{bc}$ = 0.6 is recommended to the Ultimate Bearing Capacity value for the Static Design Bearing Capacity

Note: (2) A strength reduction factor Ø$_{bc}$ = 0.8 to the UBC is recommended to determine Seismic Overstrength Design Bearing Capacity

Note: (3) The subgrade reaction at the centre of the footing may be taken as the average value of those along transverse and longitudinal sections