REPUBLIC OF RWANDA
WERTERN PROVINCE.
RUBAVU DISTICT
PROJECT: CONSTRUCTION OF COMMERCIAL BUILDING
PROJECT OWNER: HABIBU MUSSA
Plot No: 1063

REINFORCED CONCRETE STRUCTURAL DESIGN

Design code:	BS 8110-1997. Eurocode 2 – 1992
CAD:	PROKON Software.
DESIGNER:	Eng HAVUGIMANA JUVENS REG: A253/EC/IER/2014

January, 2018

REINFORCED CONCRETE STRUCTURAL DESIGN

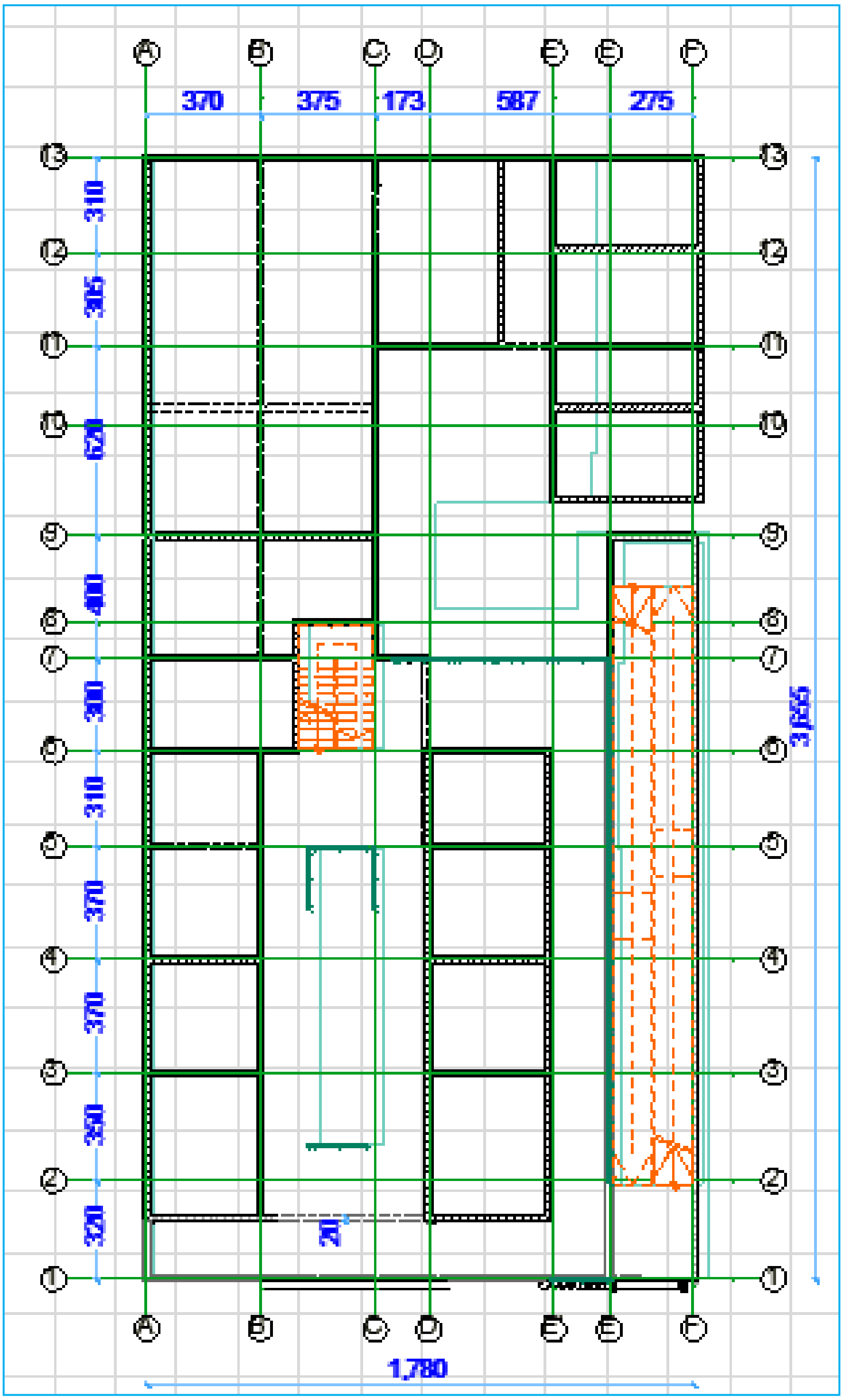
DESIGN INFORMATION

❖BS 8110-1997:The structural use of Concrete 1992 ❖Eurocode 2 - 1992	Relevant Building Regulations and Design Code
COMMERCIAL BUILDING (SUPERMARKET)	Intended use of the building
Roof –Imposed 1.5 kN/m² -Finishes 1.5 kN/m² Floor –Imposed (3)and partitions(1) 5 kN/m² Stairs –Imposed 4 kN/m² - Finishes 1.5 kN/m²	General loading conditions
Severe(external)and Mild (internal)	Exposure conditions
Variable according to the site conditions: Foundation proposed at 80cm deep Average allowable bearing pressure = 500kN/ m²	Subsoil conditions
Reinforced Concrete footing to columns.	Foundation type
Concrete: grade C 25 (with 20mm max. aggregates. Mix ratio 400 kg/ m³ [!] Reinforcement :-Characteristic strength: f_y =450 N/mm for stirrups f_y =250 N/mm²	Material data
Self weight of Reinforced concrete = 25kN/ m³ Self weight of masonry = 18kN/ m³	Other relevant informations
For dead load : 1.4 For live load : 1.6	Partial safety factor

REINFORCED CONCRETE STRUCTURAL DESIGN

Commercial building

TYPICAL STRUCTURAL LAYOUT:



Storey height (MAX) =3.20m
Beam size=50x25cm
Column section: 40x30cm

SLAB DESIGN

Typical slab panel design

Durability and fire resistance

Nominal cover for very moderate conditions of Exposure= 25mm

Nominal cover for 1.5 hours fire resistance= 20mm

Since 25>20, provide nominal cover = 25mm

Typical Slab panel size:

Lx=3.70m

Ly=3.80m

Ly/Lx=380/370=1.10 <2[two way slab]

Thickness determination

Lx=370cm d=370/30------370/40=12.34cm…………..9.25cm

Take d=13cm.

Dead load

Additional dead load:

Floor finish =1.5KN/ m^2

Suspended ceiling: 0.5kN/m^2

Total additional (unfactored) g=2kN/ m^2

Live load Vn

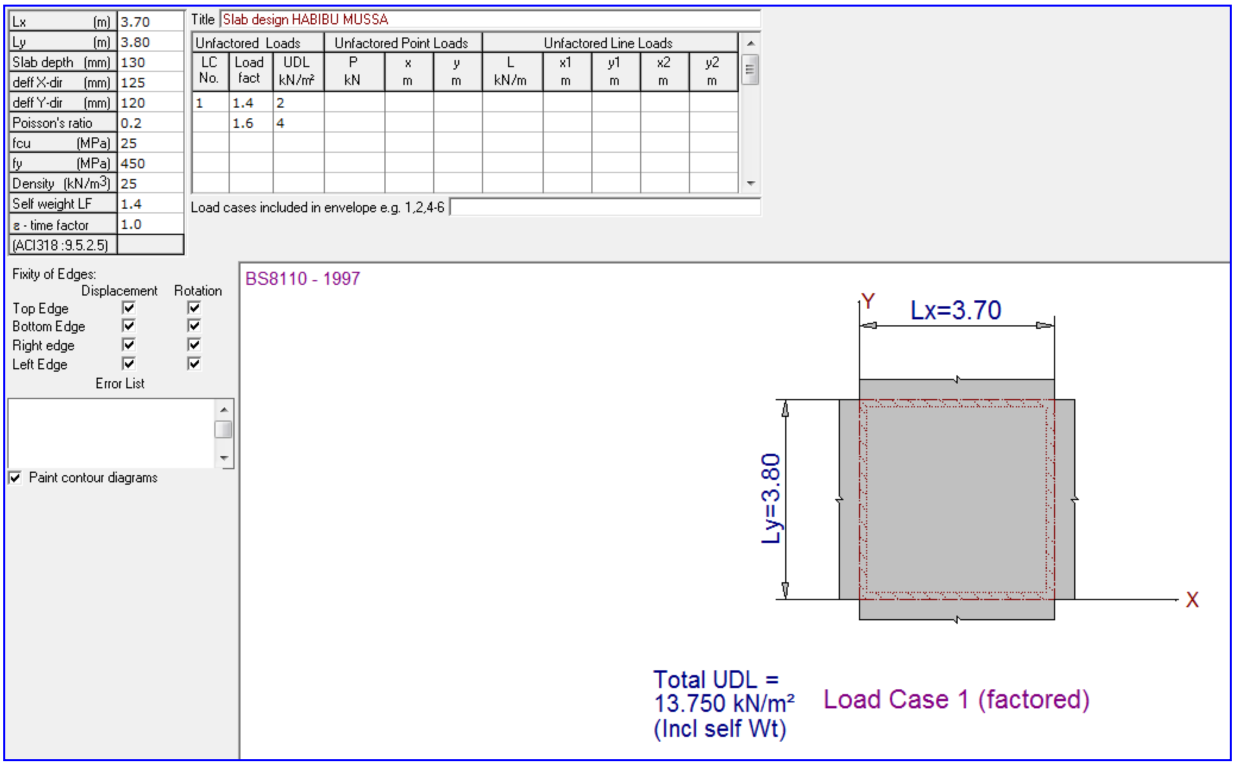
Vn=3kN/ m^2

Partiton load=1kN/m^2

Total (unfactored) Vn=4kN/m^2

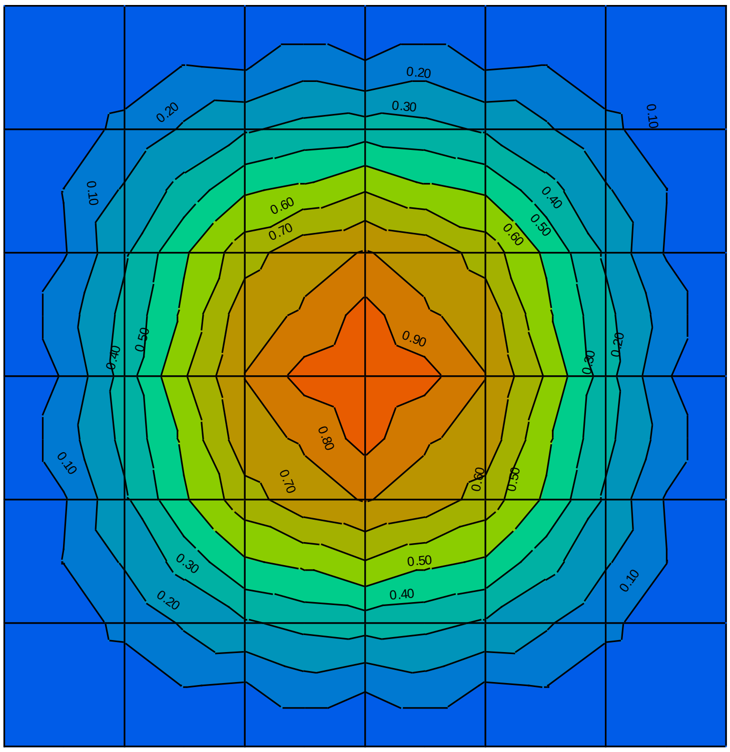
Rectangular slab panel Design to BS 8110-1997

INPUT DATA



Deflection:

Long term deflections: Load case 1 (mm)



NOTE:Long term deflections to ACI318 9.5.2.3

Deflection checking

Ultimate deflection:

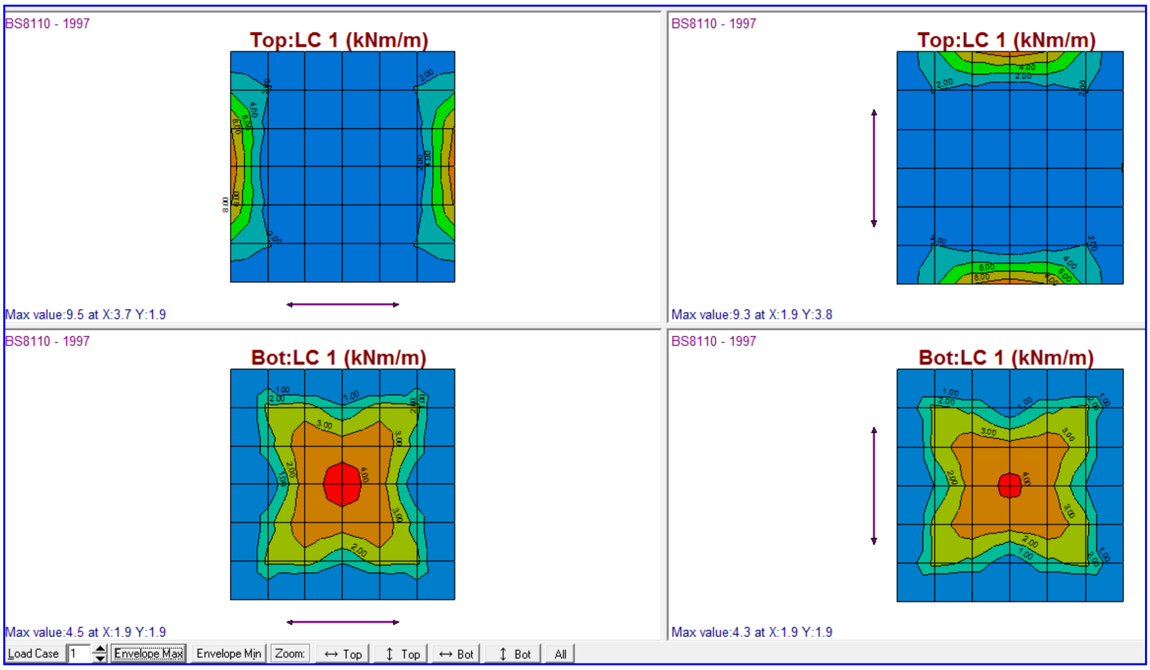
Fu=L/500

fu=3800/500=7.6mm

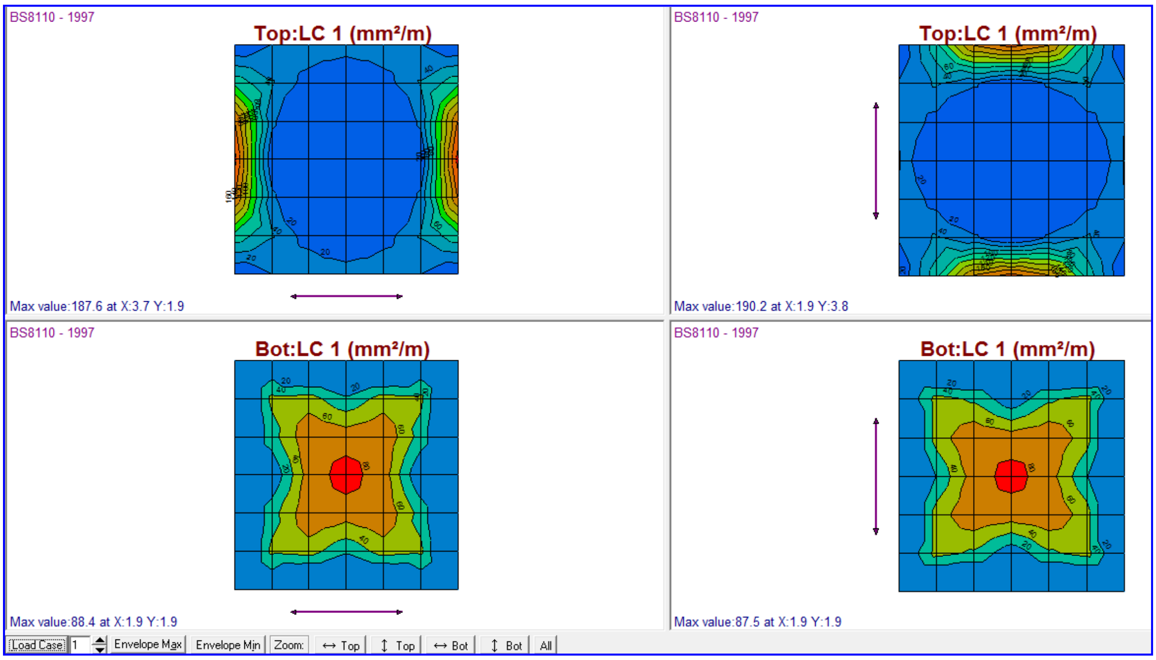
Max long-term deflection=0.9mm<7.6mm…Ok

(Slab thickness =130mm is suitable)

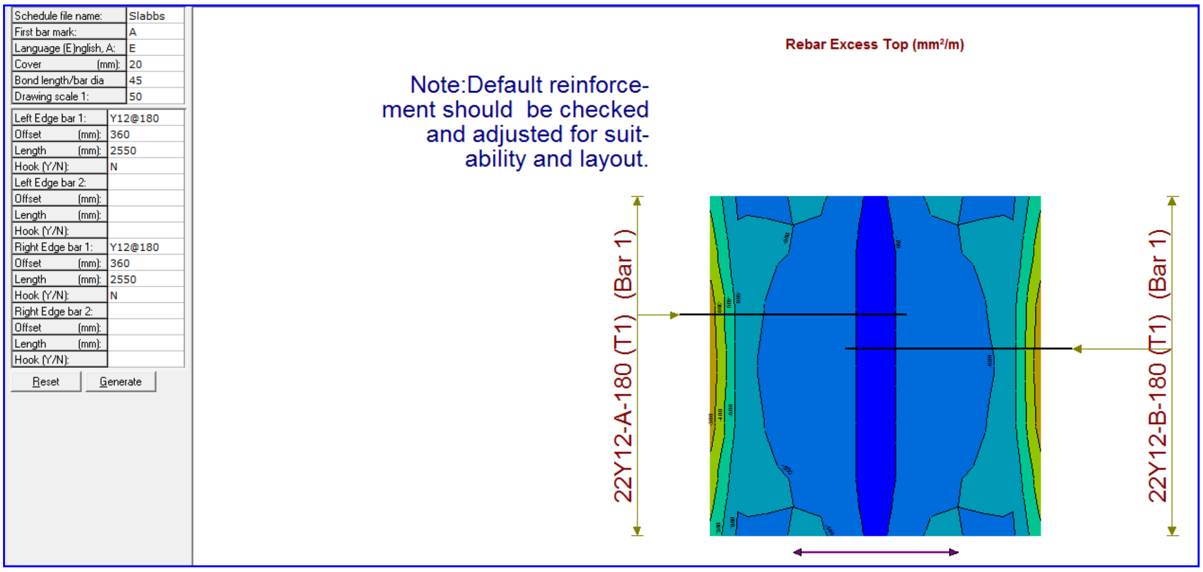
Transformed Bending Moments:

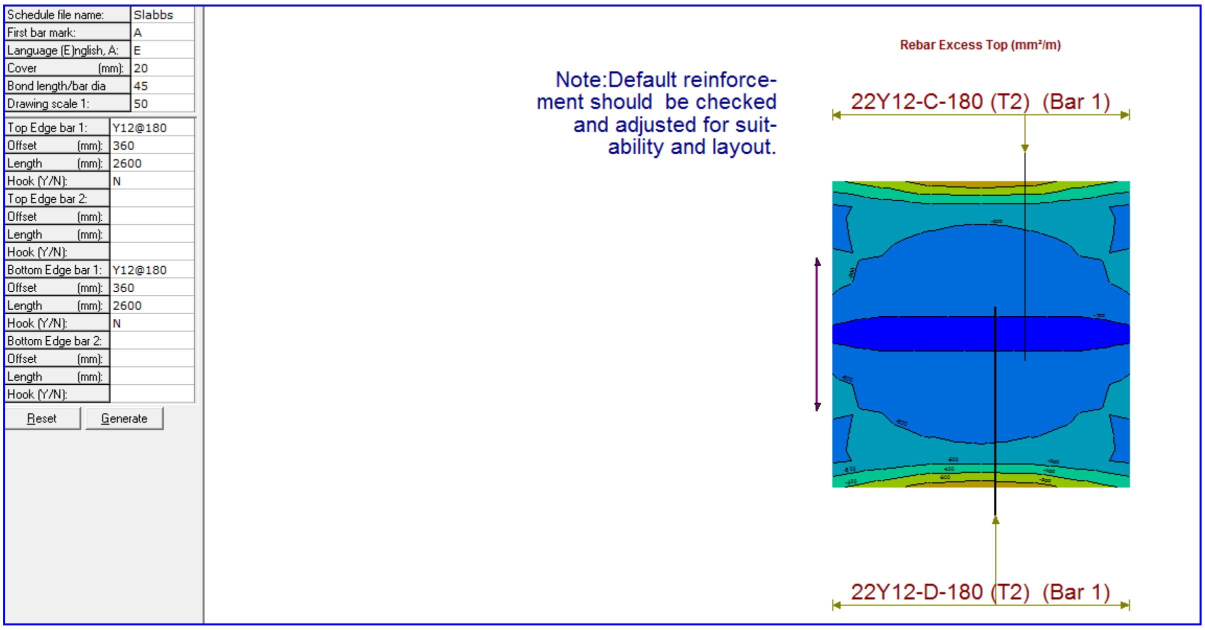


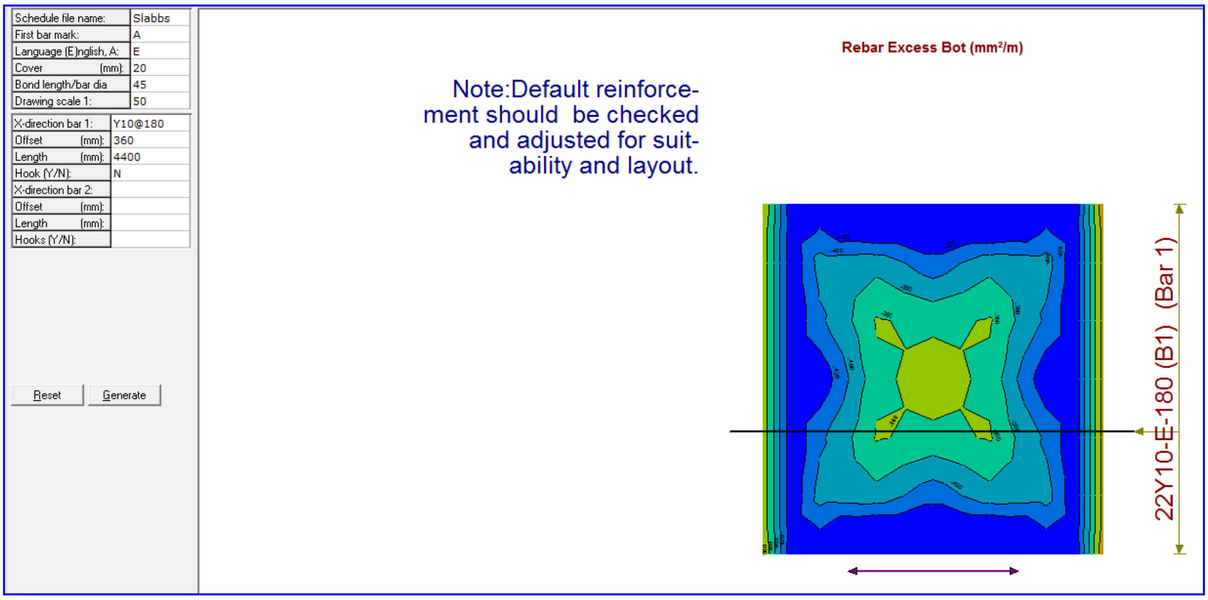
Reinforcement:

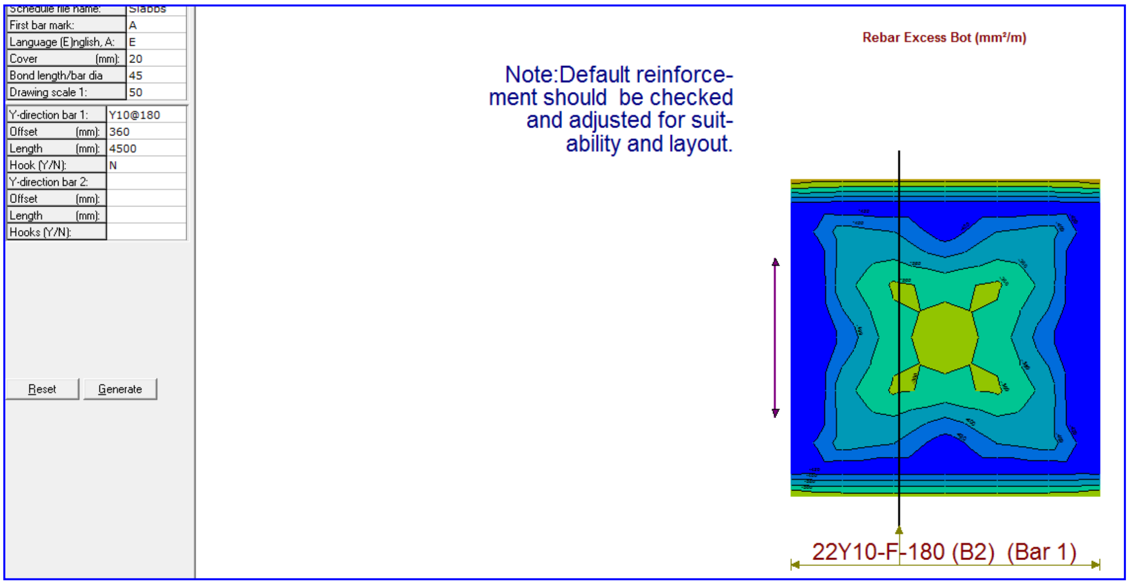


Reinforcement bending schedule



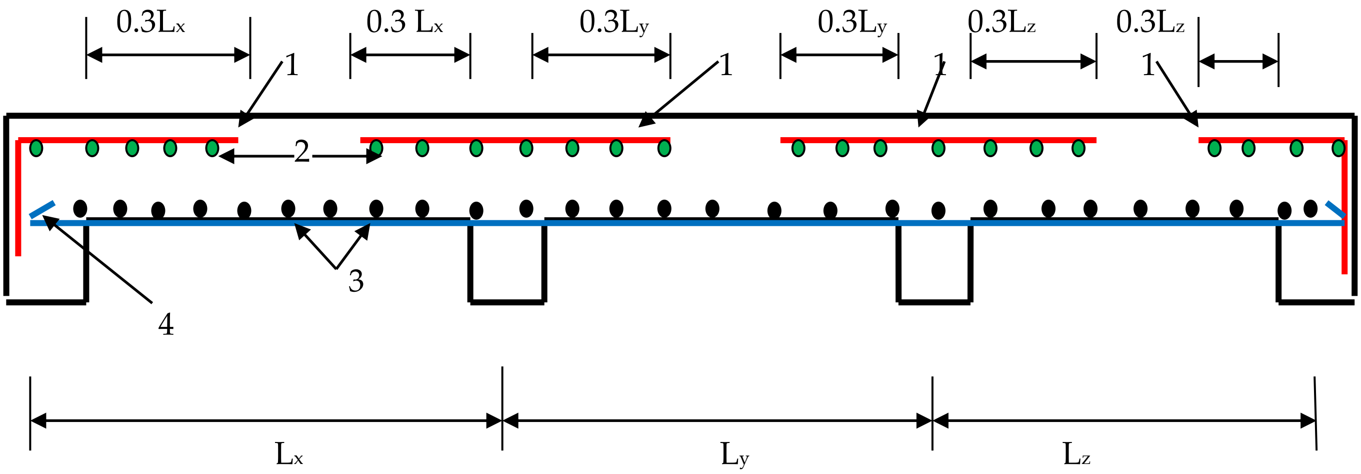






REINFORCEMENT DETAILS

SLAB



1 ⟶ Φ12 @ 18cm
2 ⟶ Φ12 @ 18cm
3 ⟶ Φ10 @18cm
4 ⟶ Φ10 @18cm

Depth of slab: 13cm

RAMP DESIGN:

The ramp is designed as a slab fixed on the inclined beam

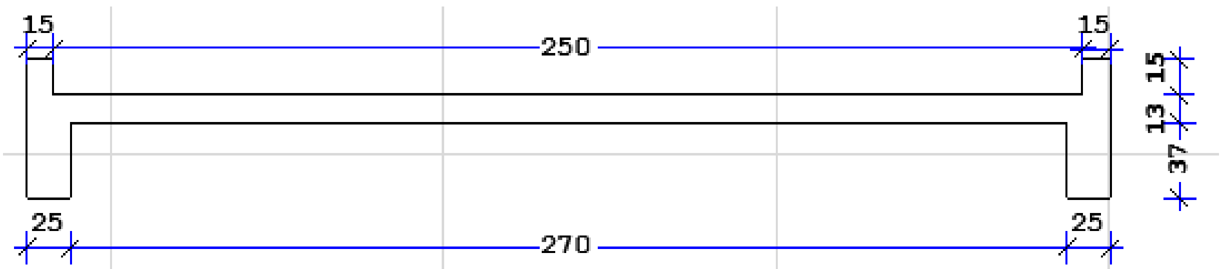
Thickness determination:

d=280/40=7cm take 13cm
Load determination:
Considering the ramp as a slab inclined at an angle of 6.3°

-Live load for commercial building and related roads V= 5KN/ m^2

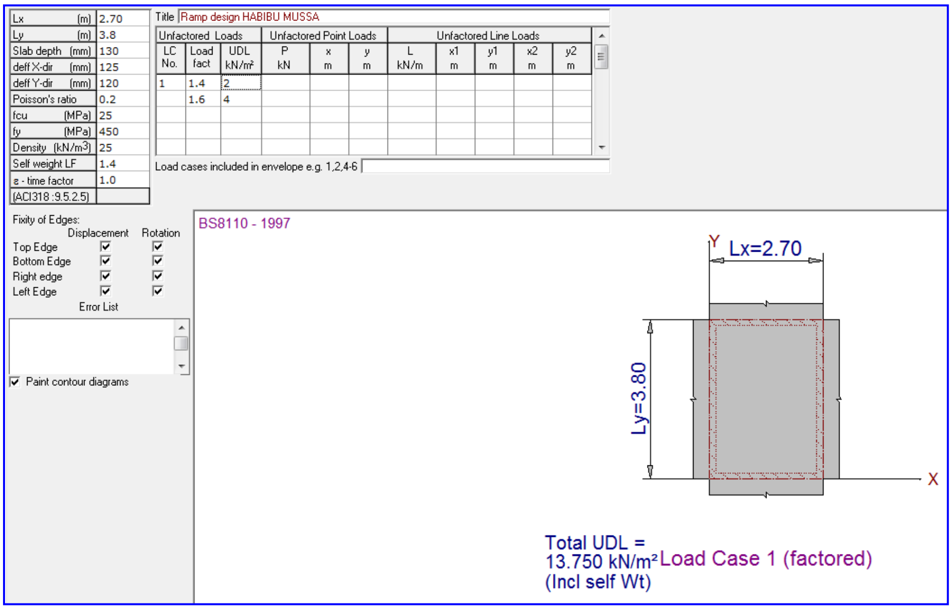
Additional dead load:
-Ramp finish =2KN/ m^2
Total additional dead load = 2 KN/m^2
Equivalent vertical live load=5/cos 6.3° =5.03KN/ m^2
Equivalent vertical dead load=2/cos 6.3° =2.1KN/ m^2
Body guard load :(line load) 1kN/m

Ramp sketch.



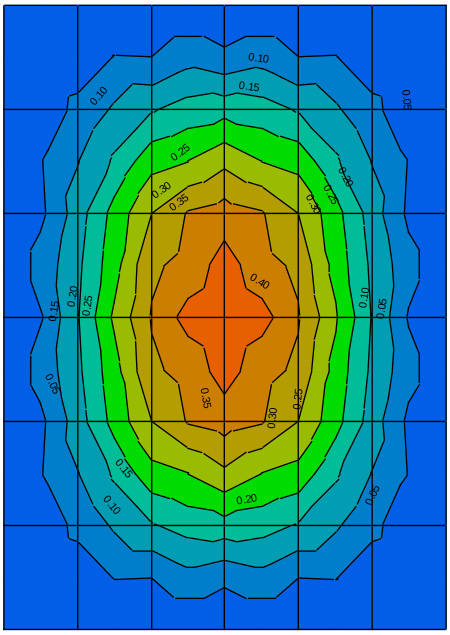
Ramp Design

Design data:



Defflection:

Long term deflections: Load case 1 (mm)



NOTE:Long term deflections to ACI318 9.5.2.3

Deflection checking

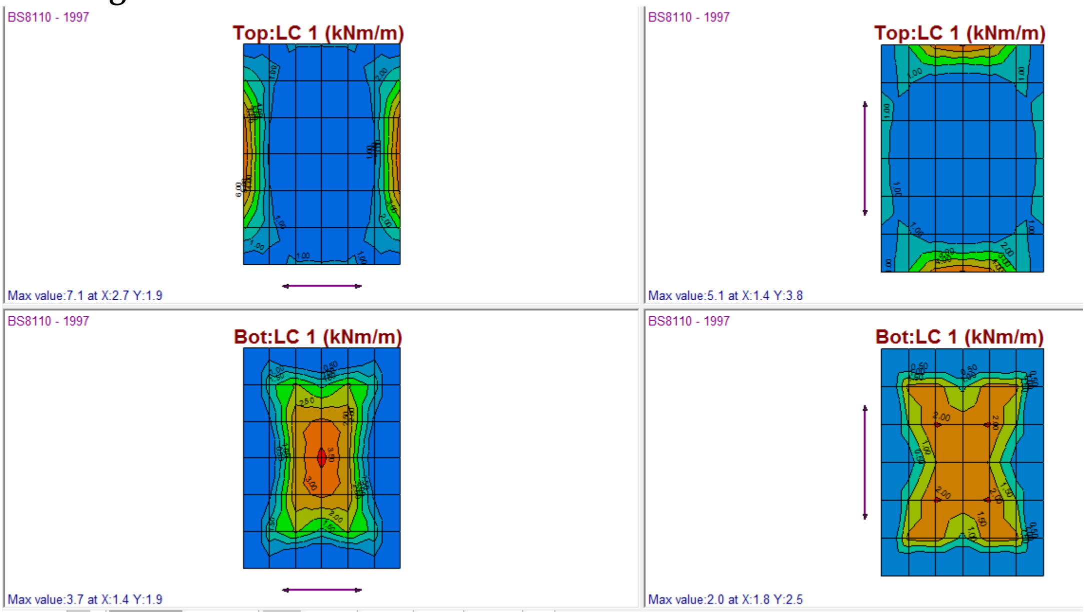
Ultimate deflection:

fu=L/500

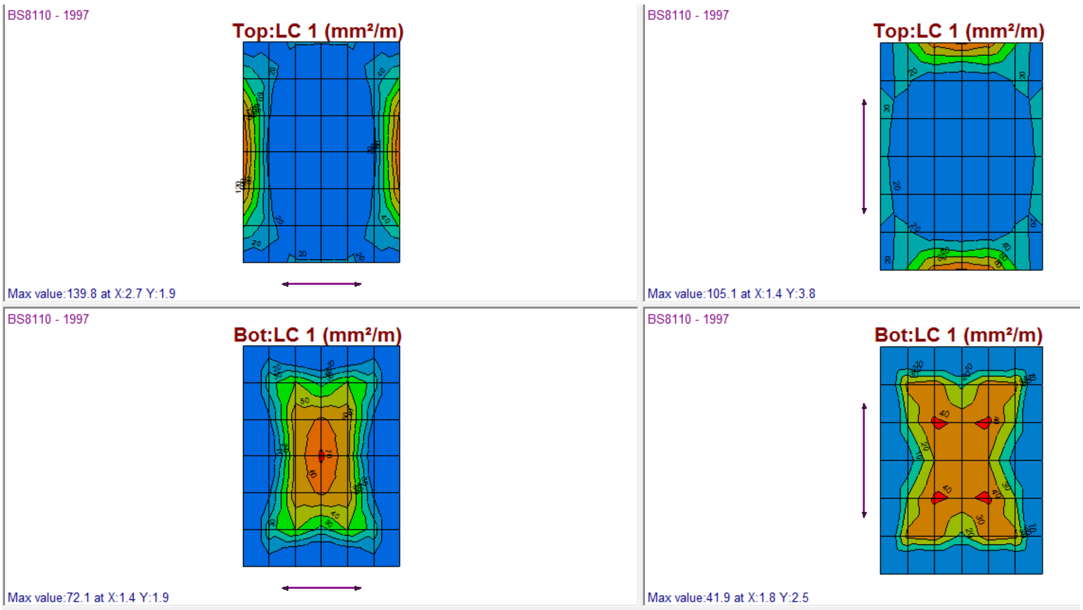
fu=3800/500=7.6mm

Max long-term deflection =0.4 mm < 7.6mm…Ok (Ramp thickness =130mm is OK)

Bending moment:



Reinforcement:

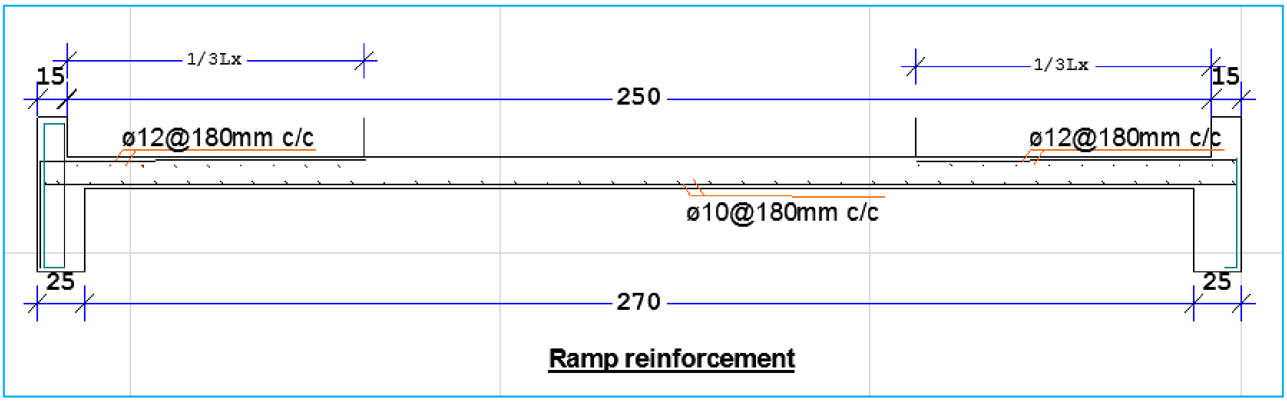


Use the following reinforcement for:

Top1: Ø12@180 mm c/c
Top2: Ø12@180 mm c/c

Bottom 1: Ø10@180 mm c/c
Bottom: Ø10@180 mm c/c

Bending schedule for Ramp's slab:



STAIRCASE DESIGN:

Main stair

The main staircase have landing supported by two inclined beams; these beam has the same reinforcement as other normal beams:

Flight design:

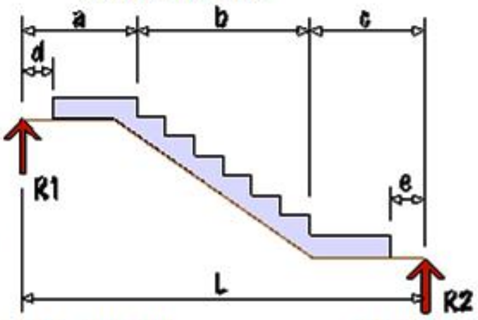
MATERIALS

fcu	25	N/mm²	γm	1.5	concrete	Min bar Ø =	10
fy	450	N/mm²	γm	1.05	steel	Max bar Ø =	14
h agg	25	mm	Density	23.6	kN/m³		
Cover	30	mm	*(Normal weight concrete)*			Nominal top steel ?	Y

DIMENSIONS

a =	600	mm	landing A h =	500
b =	3000	mm	flight waist =	200
c =	1200	mm	landing B h =	200
d =	-600	mm		
e =	-100	mm		
Going =	300	mm	L =	4800
Rise =	165	mm total	10 treads	
Rise =	150	mm each step	Rake = 26.57 °	

Sectional Elevation



LOADING

Imposed	4.00	kN/m²	63.50 kN/m ult	41.68 kN/m ult
Flight finishes	1.60	kN/m²	(31.48 + 12.15)	(18.51 + 9.85)
Landing finishes	1.50	kN/m²		

DESIGN

LANDING A, gk = 11.80 + 1.50 = 13.30 kN/m² n = 1.4 x 13.30 + 1.6 x 4.0 = 25.02 kN/m²

FLIGHT, gk = 7.05 + 1.60 = 8.65 kN/m² n = 1.4 x 8.65 + 1.6 x 4.0 = 18.51 kN/m²

LANDING C, gk = 4.72 + 1.50 = 6.22 kN/m² n = 1.4 x 6.22 + 1.6 x 4.0 = 15.11 kN/m²

Zero shear is at 0.6 + (63.50 - 30.02) /18.51 = 2.409 m from left

M = 63.50 x 2.409 - 30.02 x 2.409 - 18.51 x 1.809²/2 = 50.37 kNm/m

d = 200 - 30 - 7 = 163 mm K = 0.0758 As = 795 mm²/m

PROVIDE Y14 @ 160 B = 962 mm²/m

Enhanced by 17.0 % for deflection Y10 @ 250 T in span

L/d = 4,800 /163 = 29.448 < 23.0 x 1.233 x 1.060 = 30.070 allowed OK

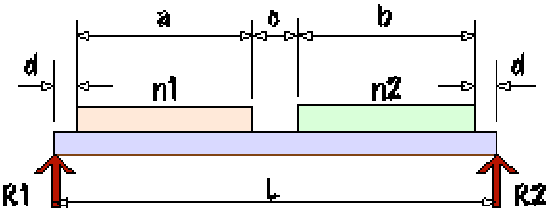
Landing:

MATERIALS

fcu	25	N/mm²	γm	1.5	concrete	Min bar Ø =	10
fy	450	N/mm²	γm	1.05	steel	Max bar Ø =	14
h agg	25	mm	Density	23.6	kN/m³		
Cover	30	mm	*(Normal weight concrete)*			Nominal top steel ?	Y

DIMENSIONS

a =	2000	mm	depth, h =	175	mm
b =	2000	mm	width, w =	1200	mm
c =	250	mm			
d =	175	mm	L =	4500	mm



LOADING

LANDING	Imposed	4.00	kN/m²	154.2 kN ult	133.3 kN ult
	Finishes	1.50	kN/m²	128.5 kN/m ult	111.1 kN/m ult
	Slab	4.13	kN/m²		

n = 1.4 x 5.63 + 1.6 x 4.0 = 14.28 kN/m²

	gk	qk		
Flight a reaction	31.48	12.15	kN/m	n1 = (1.4 x 31.48 + 1.6 x 12.15)/1.20 = 52.92 kN/m
Flight b reaction	18.51	9.85	kN/m	n2 = (1.4 x 18.51 + 1.6 x 9.85)/1.20 = 34.73 kN/m²

DESIGN

Zero shear is at (128.48 - 2.50) /(14.28 + 52.92) + 0.175 = 2.050 m from left

M = 128.48 x 2.050 - 14.28 x 2.050²/2 - 52.92 x 1.875²/2 = 140.34 kNm/m

As: use Y10 @ 275 T in span

Fire Escape:

Flight design:

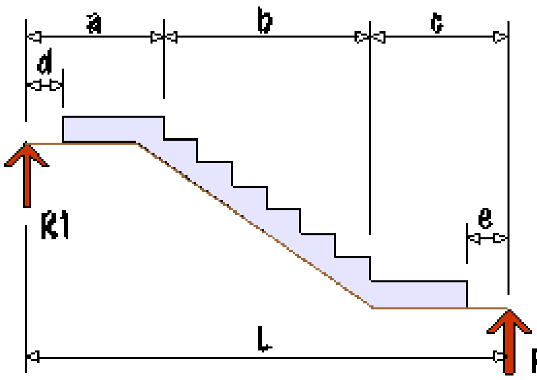
MATERIALS

fcu	25	N/mm²	γm	1.5	concrete	Min bar Ø =	10
fy	450	N/mm²	γm	1.05	steel	Max bar Ø =	14
h agg	25	mm	Density	23.6	kN/m³		
Cover	30	mm	*(Normal weight concrete)*			Nominal top steel ?	Y

DIMENSIONS

a =	1600	mm	landing A h =	500
b =	3000	mm	flight waist =	200
c =	200	mm	landing B h =	200
d =	-600	mm		
e =	-100	mm		
Going =	300	mm	L =	**4800**
Rise =	165	mm total	10 treads	
Rise =	150	mm each step	Rake = 26.57 °	

Sectional Elevation



69.02 kN/m ult (35.42 + 12.15)

46.07 kN/m ult (21.65 + 9.85)

LOADING

Imposed	4.00	kN/m²
Flight finishes	1.60	kN/m²
Landing finishes	1.50	kN/m²

DESIGN

LANDING A,	gk = 11.80 + 1.50 = 13.30 kN/m²	n = 1.4 x 13.30 + 1.6 x 4.0 = 25.02 kN/m²
FLIGHT,	gk = 7.05 + 1.60 = 8.65 kN/m²	n = 1.4 x 8.65 + 1.6 x 4.0 = 18.51 kN/m²
LANDING C,	gk = 4.72 + 1.50 = 6.22 kN/m²	n = 1.4 x 6.22 + 1.6 x 4.0 = 15.11 kN/m²

Zero shear is at 1.6 + (69.02 - 55.04) /18.51 = 2.355 m from left

M = 69.02 x 2.355 - 55.04 x 1.855 - 18.51 x 0.755²/2 = 55.16 kNm/m

d = 200 - 30 - 7 = 163 mm K = 0.0830 As = 880 mm²/m

PROVIDE Y14 @ 140 B = 1100 mm²/m

Enhanced by 23.9 % for deflection Y10 @ 250 T in span

L/d = 4.800 /163 = 29.448 < 23.0 x 1.213 x 1.060 = 29.589 allowed OK

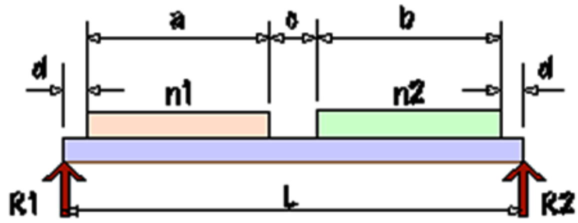
Landing:

MATERIALS

fcu	25	N/mm²	γm 1.5	concrete	Min bar Ø = 10
fy	450	N/mm²	γm 1.05	steel	Max bar Ø = 14
h agg	25	mm	Density 23.6	kN/m³	
Cover	30	mm	(Normal weight concrete)		Nominal top steel ? Y

DIMENSIONS

a =	16000	mm	depth, h =	175	mm
b =	1600	mm	width, w =	1600	mm
c =	250	mm			
d =	175	mm	L =	**4500**	mm



LOADING

LANDING	Imposed	4.00	kN/m²	-834.5 kN ult	2115.3 kN ult
	Finishes	1.50	kN/m²	-521.5 kN/m ult	1322.1 kN/m ult
	Slab	4.13	kN/m²	n = 1.4 x 5.63 + 1.6 x 4.0 = 14.28 kN/m²	
	gk	qk			
Flight a reaction	35.42	12.15	kN/m	n1 = (1.4 x 35.42 + 1.6 x 12.15)/1.60 = 43.14 kN/m²	
Flight b reaction	21.65	9.85	kN/m	n2 = (1.4 x 21.65 + 1.6 x 9.85)/1.60 = 28.80 kN/m²	

DESIGN

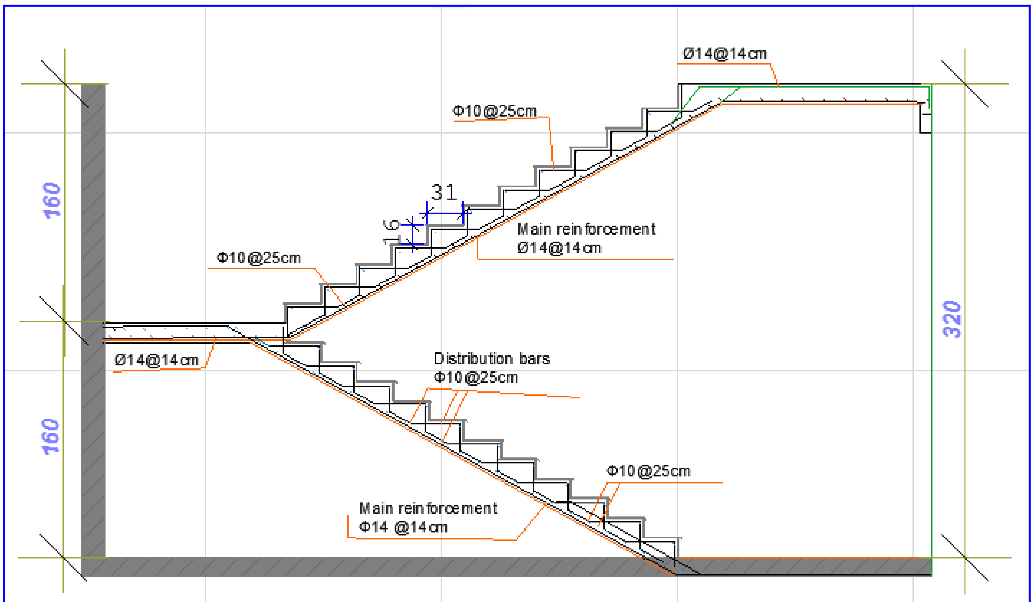
Zero shear is at (1,322.09 - 2.50) /(14.28 + 28.80) + 0.175 = 0.000 m from right

M = 1,322.09 x 0.000 - 14.28 x 0.000²/2 - 28.80 x -0.175²/2 = 0.00 kNm/m

d = K = As

Y10 @ 275 T in span

L/d =



STAIR CASE REINFORCEMENT

DESIGN OF BEAMS, COLUMNS AND FOOTINGS WITH METHOD OF PORTAL FRAME

I. 4 FLOOR BUILDING

LOAD DETERMINATION

LOAD FROM SLAB

Dead load

Additional dead load:

Floor finish =1.5KN/ m^2

Suspended ceiling: 0.5kN/m^2

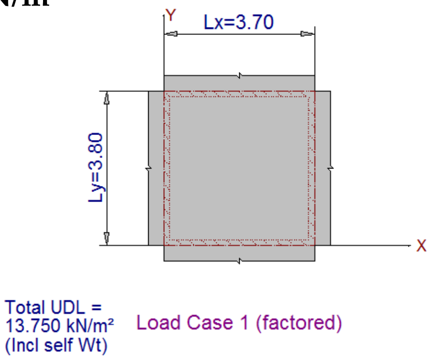
Total additional (unfactored) g=2kN/ m^2

Live load Vn

Vn=4kN/ m^2

Total (unfactored) Vn=4kN/m^2

$\sum$=13, 750 KN/m^2



PORTAL FRAME LOAD

Linear load on beams

Load from slab**:** 3.8x13.75=52.25KN/ml

Wall = 18x0.2x3.2x1.4= 16.13 KN/ml

Wall finishes= 20x0.02x3.2x1.4x2= 3.6 KN/ml

Bottom flange (Nervure): 0, 37x0, 25x25 x1.4=3,3kN/ml

Total = 75.3kN/ml

Column own weight: 1.4x0.3x0.4x3.2x25=13.44KN

Vertical load distribution

100 %
100 %
90%
80%

Live load =3.2x1.6x3.8 = 19.46 KN/ml
Dead load = 75.3– 19.5 = 55.8 KN/ml

4) 75.3 +19.5= 94.8 KN/ml
3) 75.3 +19.5= 94.8KN/ml
2) 75.3 +19.5x0.9= 92.9 KN/ml
1) 75.3 +19.5X0.8= 90.9 KN/ml

FRAME ANALYSIS

Longitudinal Frame of 12 spans

Total length of Frame = 36.55ml
EARTHQUAKE (charge normative)
Storey 4: (95.3/1.6) x36.55=2177.2KN
Axial force: (13.44/1.4) x3.8=36.5KN
Total: 2213.5 KN
1%=22.2KN
Storey 3: 22.2 KN
Storey 2: 92.9/1.6x36.55+36.5=2159KN
→22.0 KN
Storey 1: 90.9/1.6x36.55+36.5=2113.3KN
→21.2KN

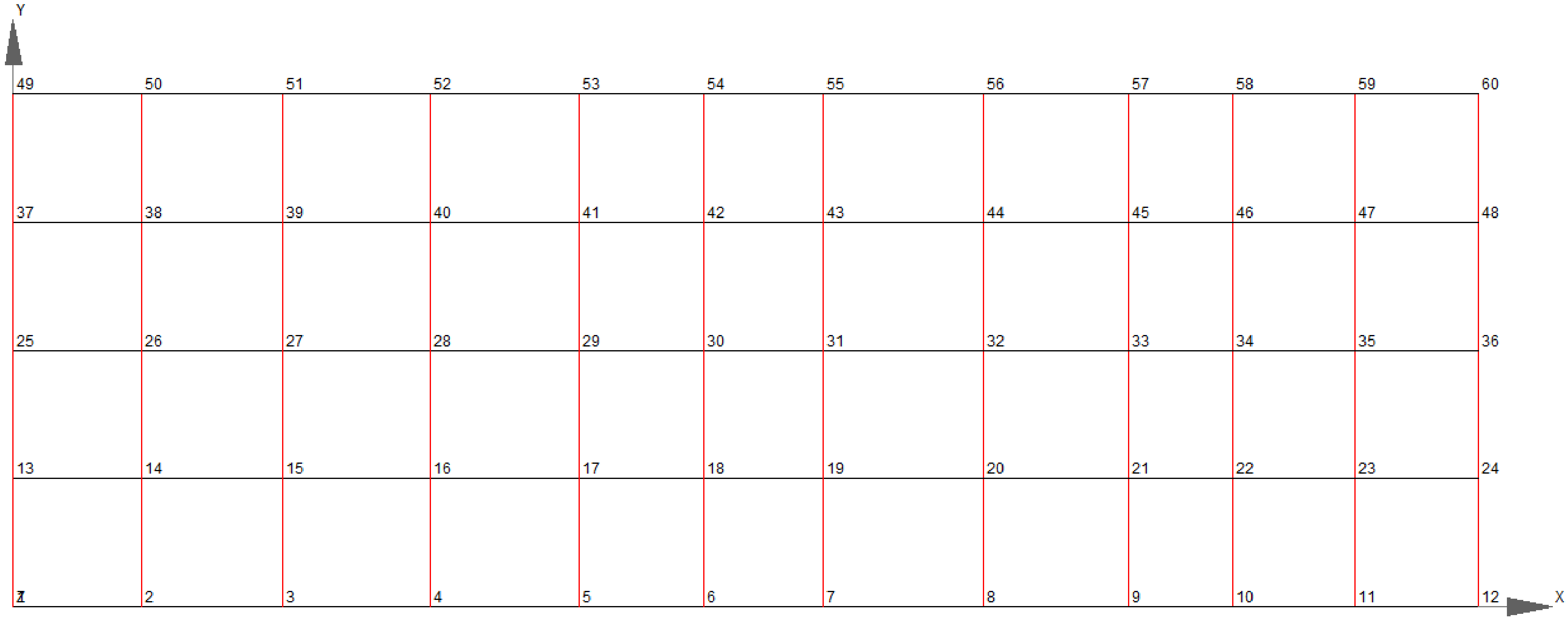
Transversal Frame of 5 spans

Total length of Frame = 17.80ml
EARTHQUAKE (charge normative)
Storey 1: (75.3/1.6) x17.8=937.8KN
Axial force: (13.44/1.4) x3.2=30.8KN
Total: 968.6 KN
1%=9.7KN
Storey 2: 9.7 KN
Storey 3: 92.9/1.6x17.8+36.5=1070KN
→10.7 KN
Storey 4: 90.9/1.6x17.8+36.5=1048KN
→10.5KN

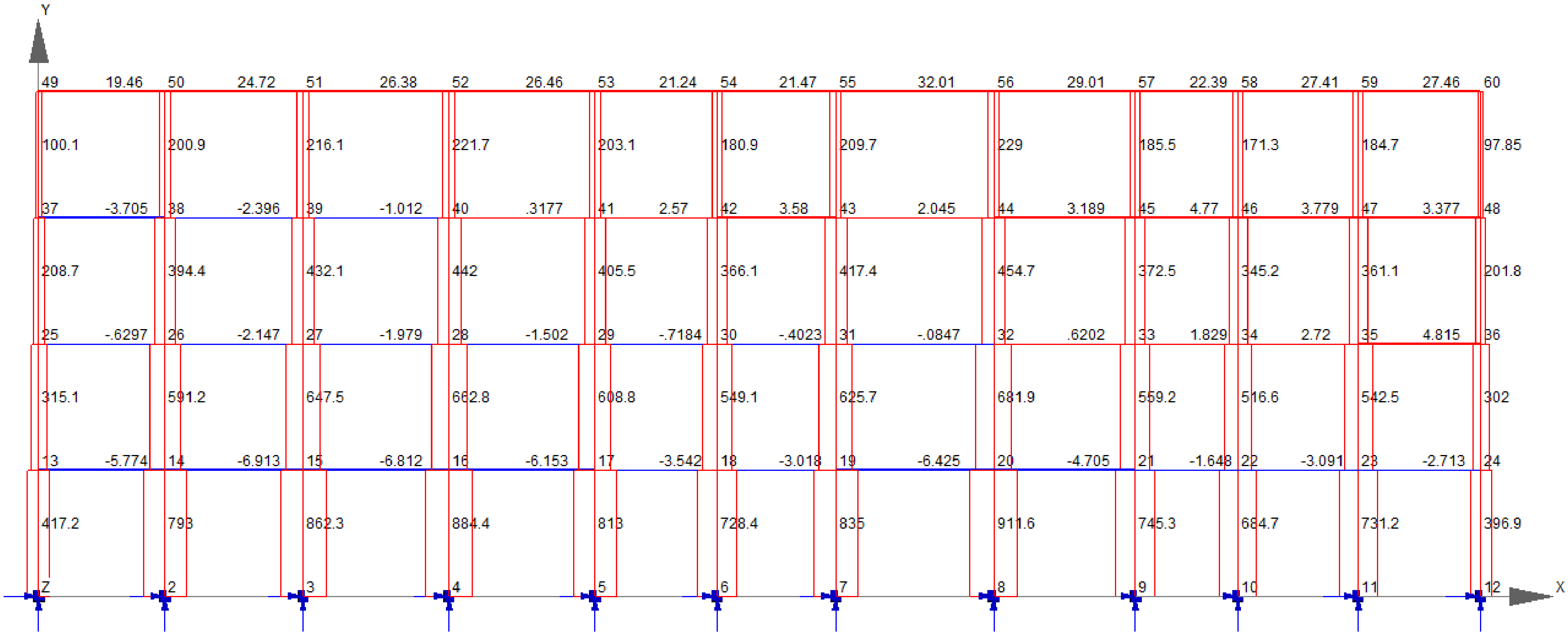
Considered forces:
1. **Axial forces**
2. **Earthquake**
3. **Soil pressur**

1.1 LONGITUDINAL FRAME WITH 11 SPANS

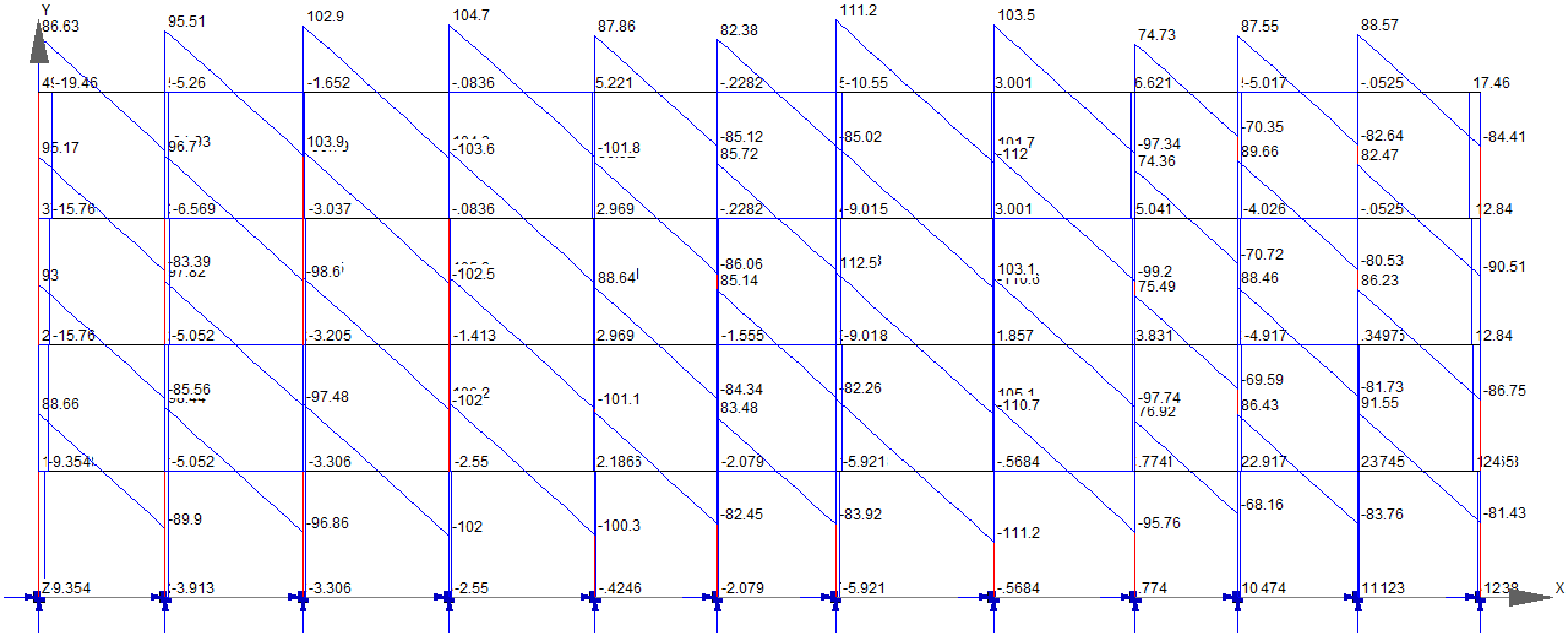
Nodes :

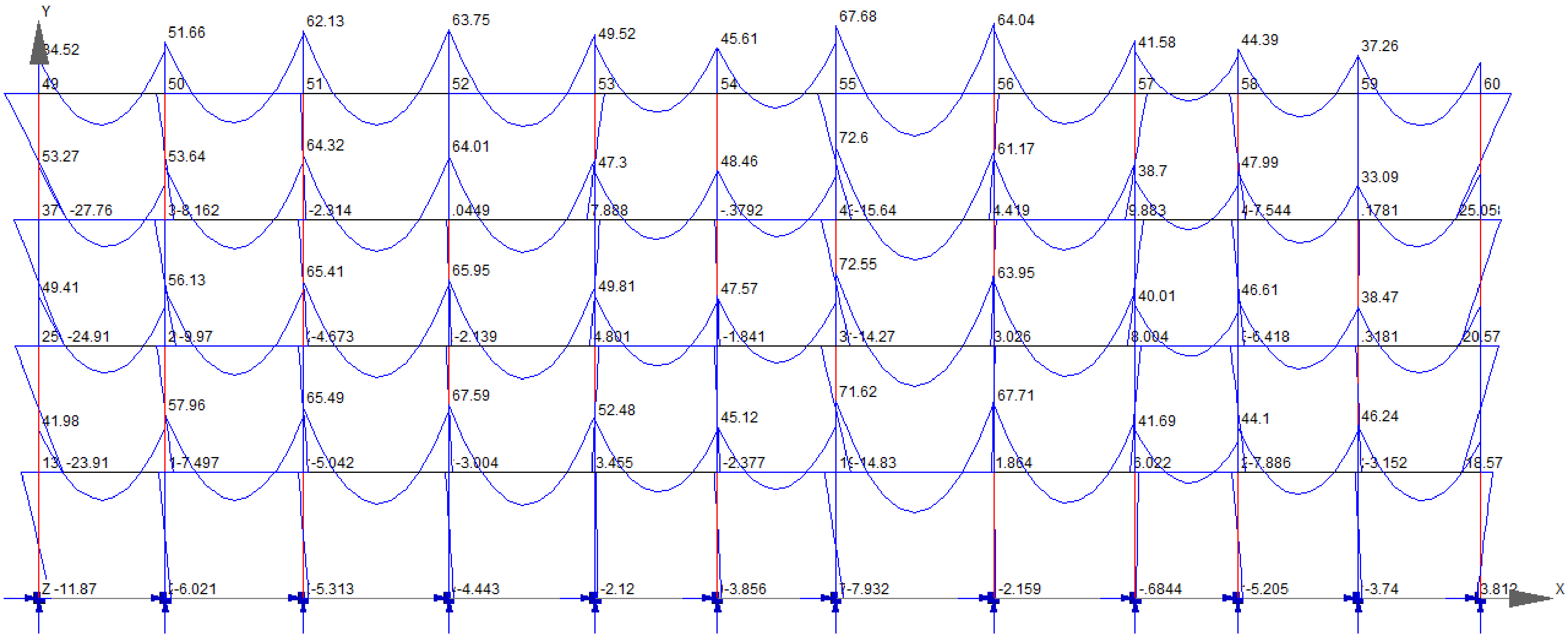


Axial forces :



Shear force and bending moment:




Y
34.52
51.66
62.13
63.75
49.52
45.61
67.68
64.04
41.58
44.39
37.26
49
50
51
52
53
54
55
56
57
58
59
60
53.27
53.64
64.32
64.01
47.3
48.46
72.6
61.17
38.7
47.99
33.09
37
-27.76
-8.162
-2.314
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9.883
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47.57
72.55
63.95
40.01
46.61
38.47
25
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-9.97
-4.673
-2.139
4.801
-1.841
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8.004
-6.418
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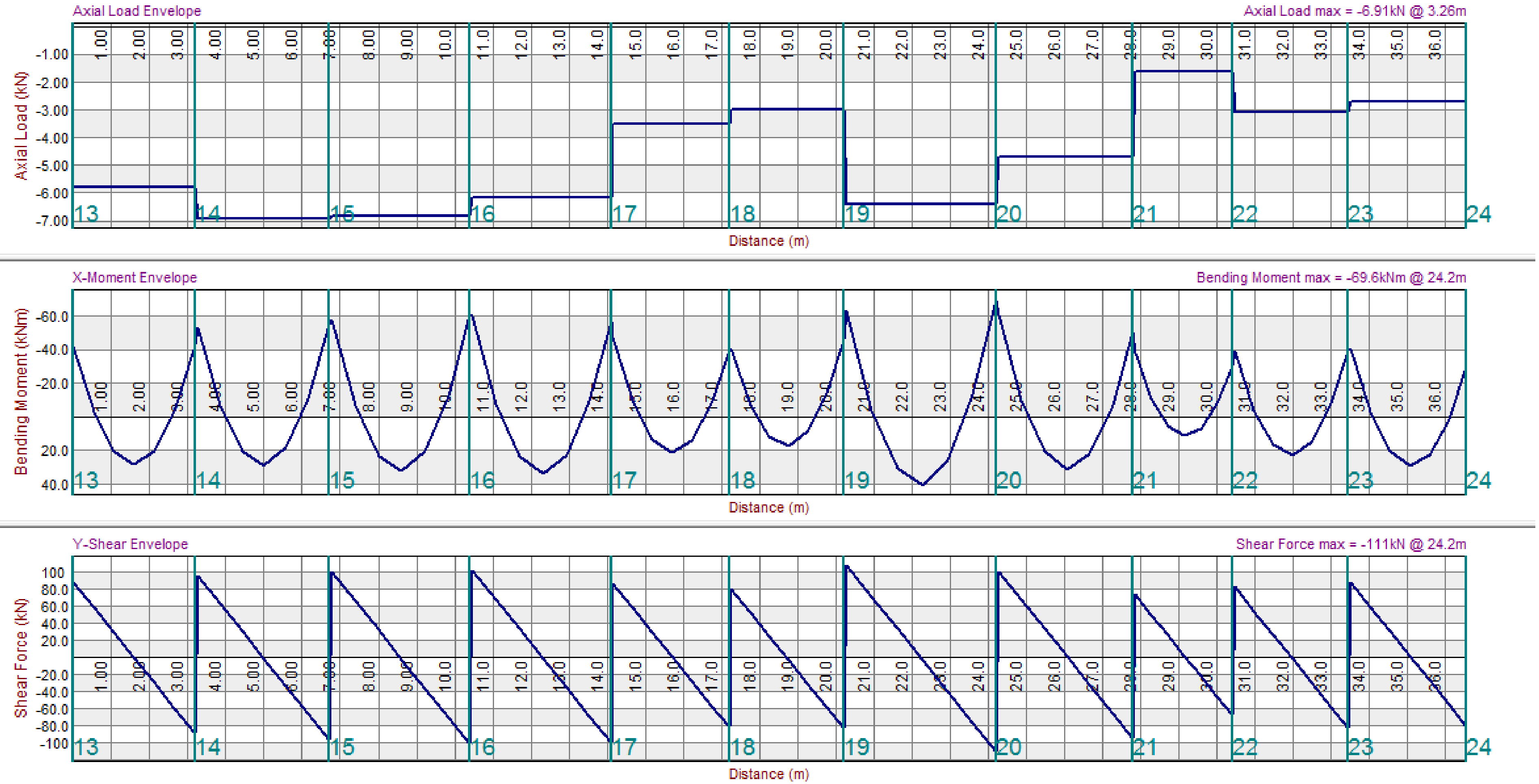
57.96
65.49
67.59
52.48
45.12
71.62
67.71
41.69
44.1
46.24
13
-23.91
-7.497
-5.042
-3.004
3.455
-2.377
-14.83
1.864
6.022
-7.886
-3.152
18.57
Z
-11.87
-6.021
-5.313
-4.443
-2.12
-3.856
-7.932
-2.159
-.6844
-5.205
-3.74
X

ENVELOPE RESULTS FOR CRITICAL LONGITUDINAL BEAM:

Beam nodes 12-13-------24



Max Negative Moment: 69.6KNm

Maximum Positive Moment: 40.5KNm

Shear force: 111 KN

Reinforcements:

Top reinforcement (At supports)

Design Results											
Moment			Shear			Torsion (w eb)			Torsion (flange)		
Muc	314.7	kNm	v	2.50	MPa	v	0.00	MPa	v	0.00	MPa
As	2034	mm²	vc	0.64	MPa	vt	0.34	MPa	vt	0.34	MPa
As'	256	mm²	Asv/Sv	1.1896		Asv/Sv	0.0000		Asv/Sv	0.0000	
Anom	195	mm²	Asv/Sv nom	0.2554		As	0	mm²	As	0	mm²

Asc= 2034 mm²

Use 3Φ25+ 2Φ20 with Asc=2097mm²

Bottom reinforcement (Mid span)

Design Results											
Moment			Shear			Torsion (w eb)			Torsion (flange)		
Muc	314.7	kNm	v	2.50	MPa	v	0.00	MPa	v	0.00	MPa
As	1130	mm²	vc	0.52	MPa	vt	0.34	MPa	vt	0.34	MPa
As'	0	mm²	Asv/Sv	1.2617		Asv/Sv	0.0000		Asv/Sv	0.0000	
Anom	195	mm²	Asv/Sv nom	0.2554		As	0	mm²	As	0	mm²

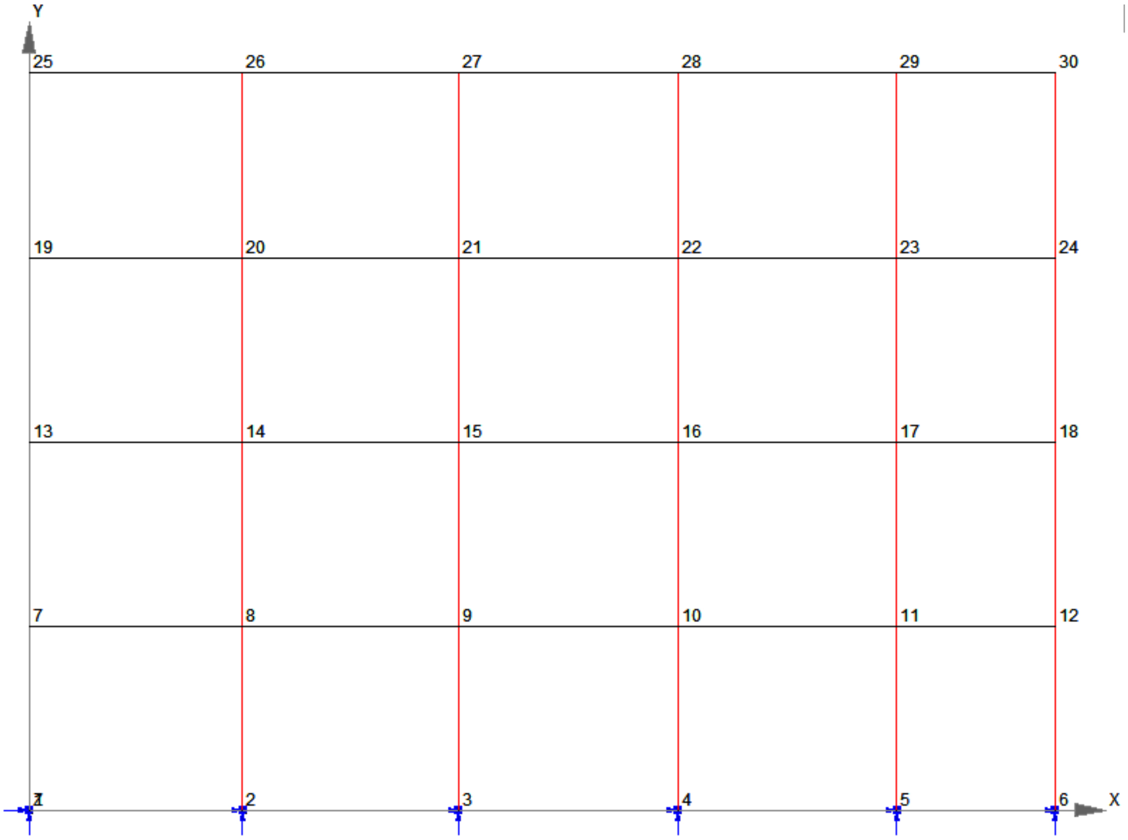
Asc= 1130 mm²

Use 4 Φ20 with Asc=1256mm²

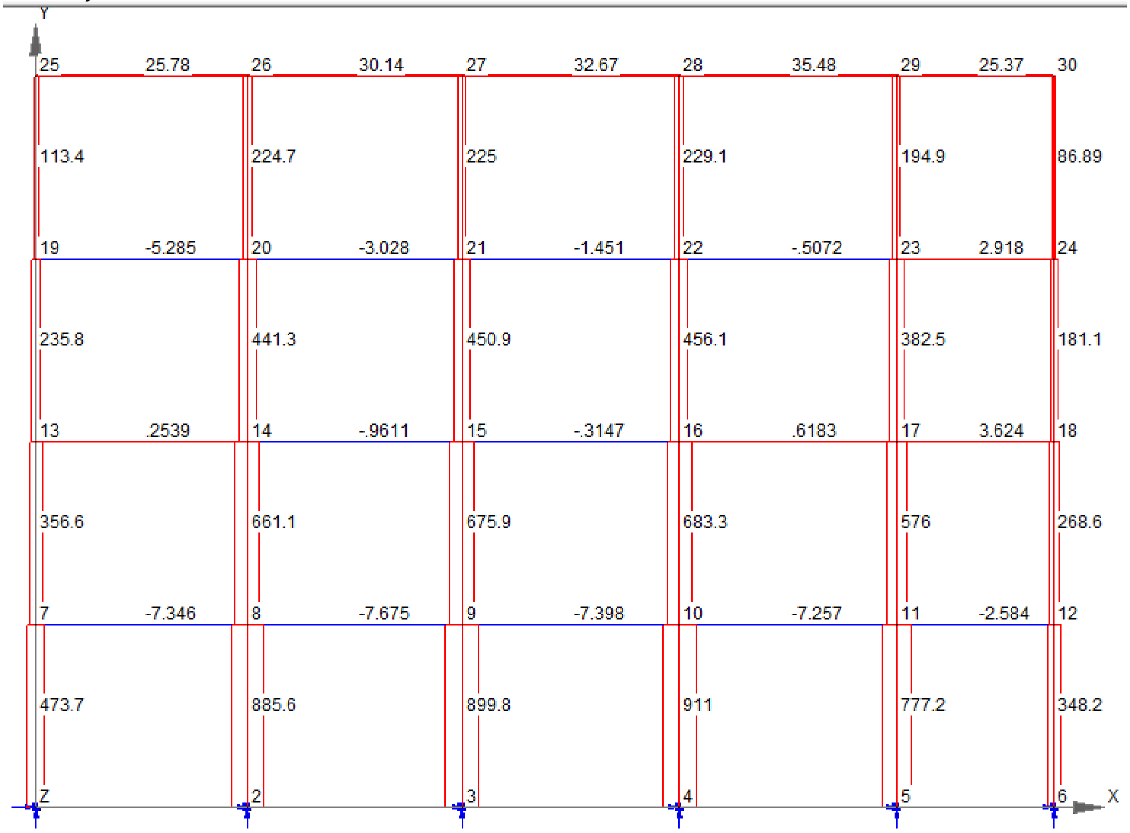
Stirrups: 1,26mm²/mm = 12,6cm²/m, we use Ø8@ 15cm c/c near support and Ø8@ 20cm c/c mid span

1.1 TRANSVERSAL FRAME WITH 5 SPANS

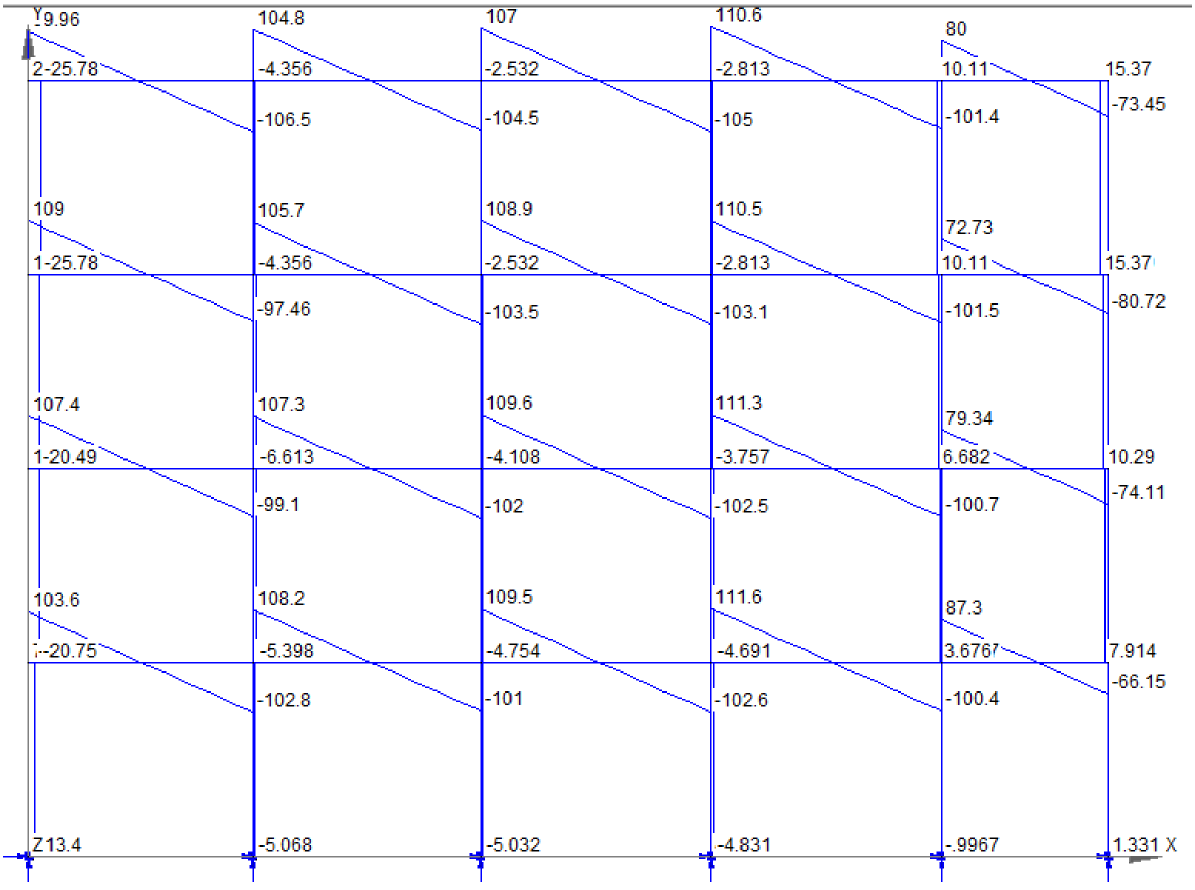
Nodes :

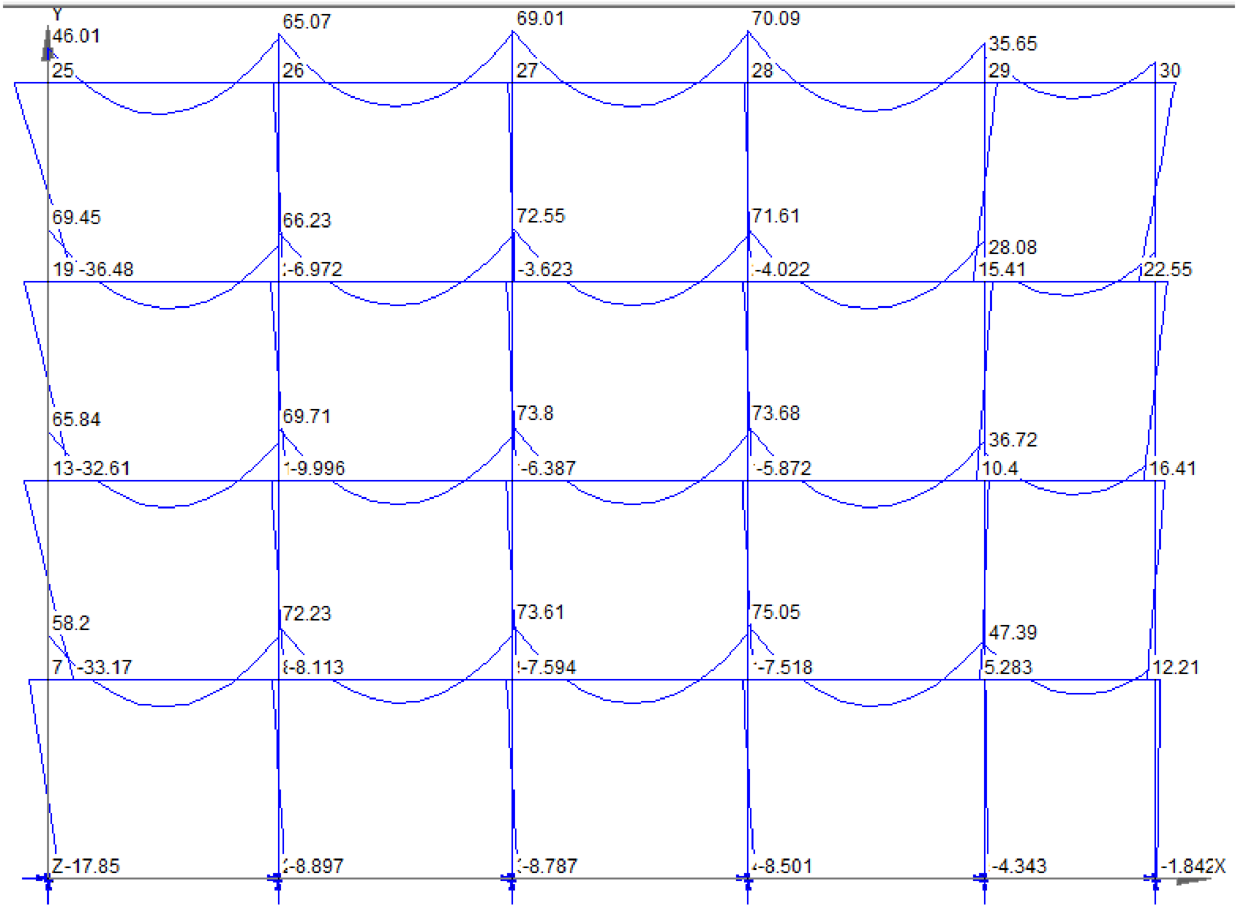


Axial forces :



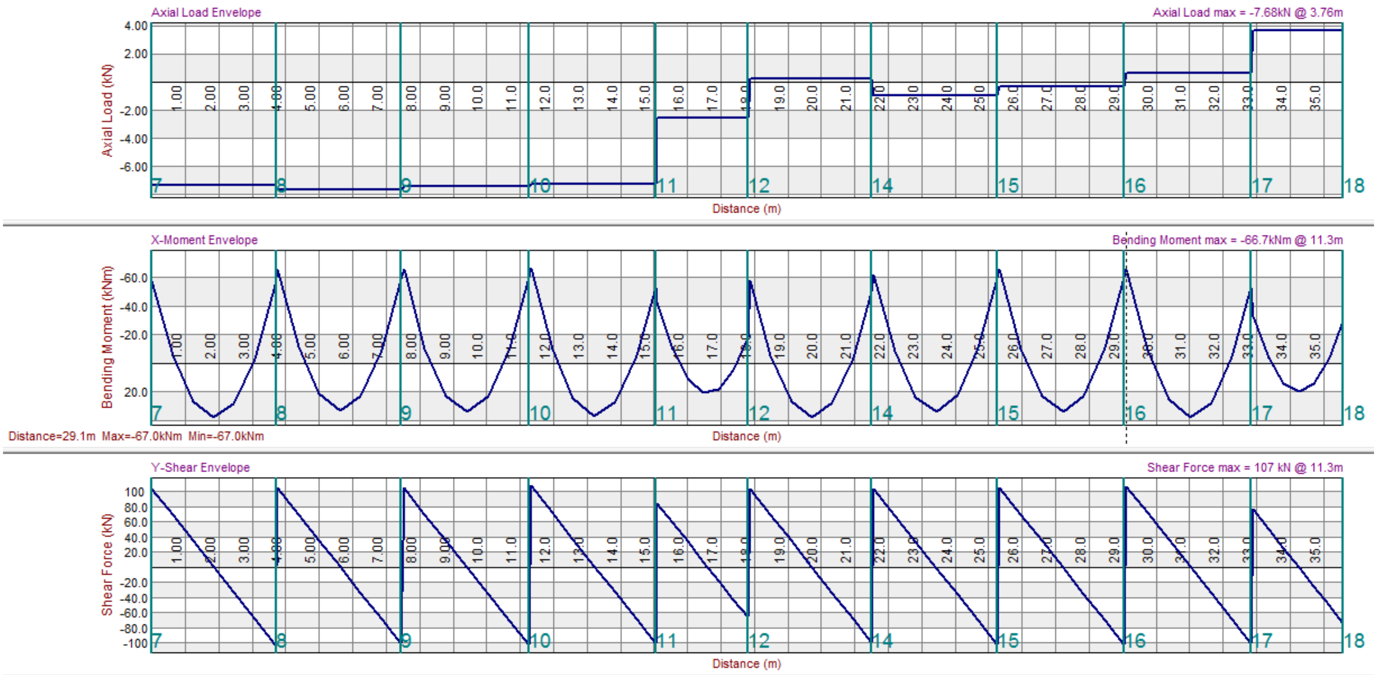
Shear force and bending moment:





ENVELOPE RESULTS FOR CRITICAL TRANSVERSAL BEAM:

Beam nodes   7-8------12



Max Negative Moment : 67.0KNm

Maximum Positive Moment: 75.05KNm

Shear force: 899.78KN

Reinforcements:

Top reinforcement (At supports)

Design Results											
Moment			Shear			Torsion (w eb)			Torsion (flange)		
Muc	377.7	kNm	v	2.53	MPa	v	0.00	MPa	v	0.00	MPa
As	2185	mm²	vc	0.69	MPa	vt	0.37	MPa	vt	0.37	MPa
As'	2	mm²	Asv/Sv	1.1761		Asv/Sv	0.0000		Asv/Sv	0.0000	
Anom	195	mm²	Asv/Sv nom	0.2554		As	0	mm²	As	0	mm²

Asc= 2185 mm²

Use 5Φ25 with Asc=2453mm²

Bottom reinforcement (Mid span)

Design Results											
Moment			Shear			Torsion (w eb)			Torsion (flange)		
Muc	377.7	kNm	v	2.53	MPa	v	0.00	MPa	v	0.00	MPa
As	1096	mm^2	vc	0.55	MPa	vt	0.37	MPa	vt	0.37	MPa
As'	0	mm^2	Asv/Sv	1.2669		Asv/Sv	0.0000		Asv/Sv	0.0000	
Anom	195	mm^2	Asv/Sv nom	0.2554		As	0	mm^2	As	0	mm^2

Asc= 1096 mm^2

Use 4 Φ20 with Asc=1256mm^2

Stirrups: 1,27mm^2/mm = 12.7cm^2/m, we use Ø8@16cm c/c near support and Ø8@20cm c/c mid span

ENVELOPE RESULTS FOR THE CRITICAL COLUMN:

Note: The columns and footings will be designed for the longitudinal and transversal frame's results whichever is greater.

DESIGN OF INTERIOR COLUMN

Interior column (Column 4 – 10--28): (Longitudinal frame has the maximum values)

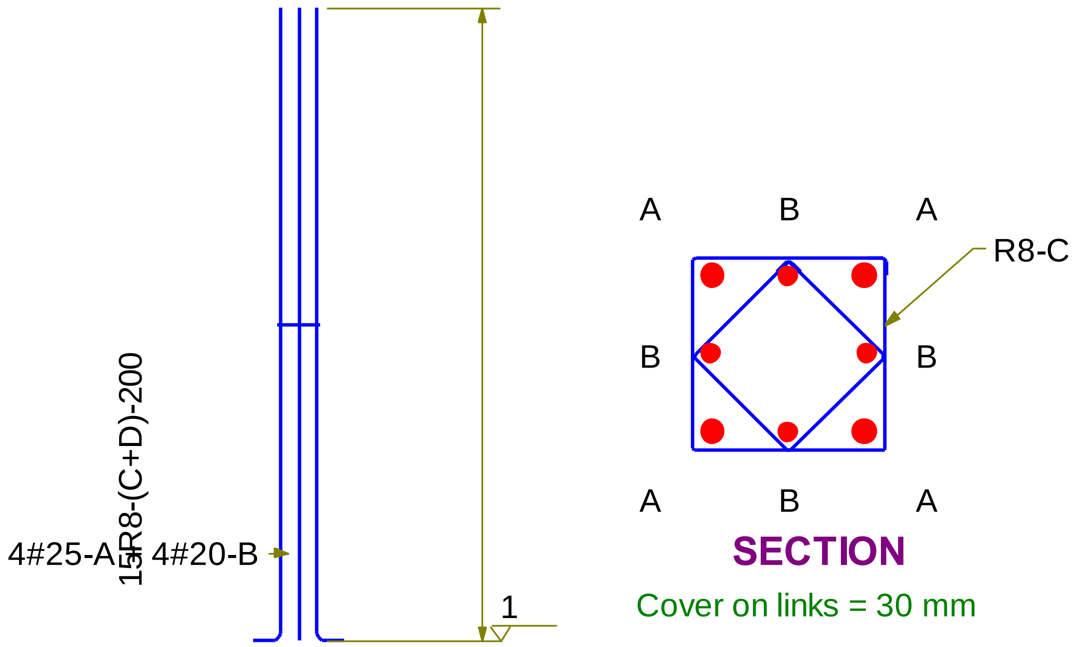
Storey	Node	Axial force (KN)	Moment (KNm)		Shear force (KN)
			Bottom	Top	
0	4-10	911.9	70.1	71.6	18.1
1	10-16	681.9	70.8	28.4	16.8
2	16-22	454.5	27.8	28.6	8.2
3	22-28	229	13.6	20.8	8.67

Column:
Summary of design calculations:
Design results for all load cases:

Load case	Axis	N (kN)	M1 (kNm)	M2 (kNm)	Mi (kNm)	Madd (kNm)	Design	M (kNm)	M' (kNm)	Asc (mm^2)
1	X-X Y-Y	911.6	70.1 0.0	71.6 0.0	28.6 0.0	5.9 0.0	X-X Bottom	74.6 0.0	74.6	2208 (3.5%) 250 (0.4%)

Asc=3.5% = 2208 mm²

Use 4Φ25+4Φ20 with Asc = **2592mm²**



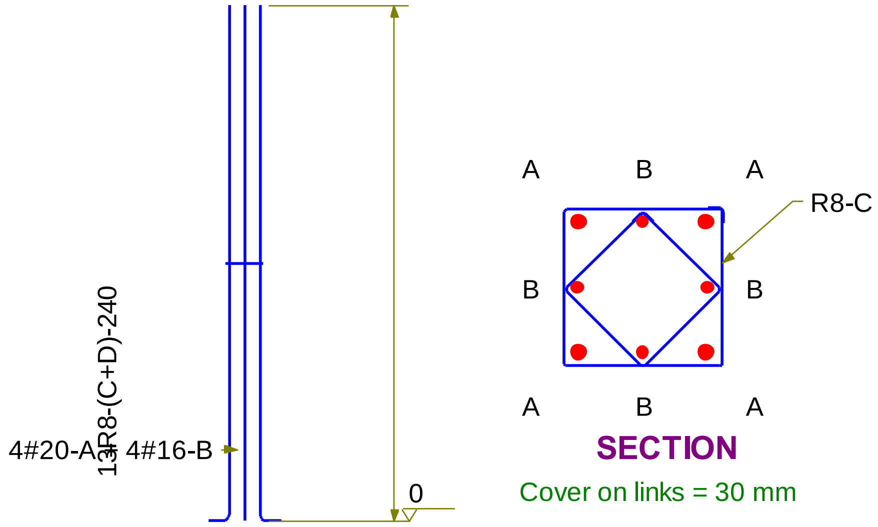
Note : For the same members (internal columns) , the GROUND FLOOR will be evenly reinforced with 4Φ25+4Φ20

Upper storey column reinforcement (1st floor):
Summary of design calculations:
Design results for all load cases:

Load case	Axis	N (kN)	M1 (kNm)	M2 (kNm)	Mi (kNm)	Madd (kNm)	Design	M (kNm)	M' (kNm)	Asc (mm²)
1	X-X Y-Y	683.3	68.4 0.0	70.8 0.0	28.3 0.0	5.3 0.0	X-X Bottom	71.1 0.0	71.1	1642 (2.6%) 250 (0.4%)

Asc=2.6% = 1642mm²

Use 4Φ20+4Φ16 **with Asc = 1659mm²**



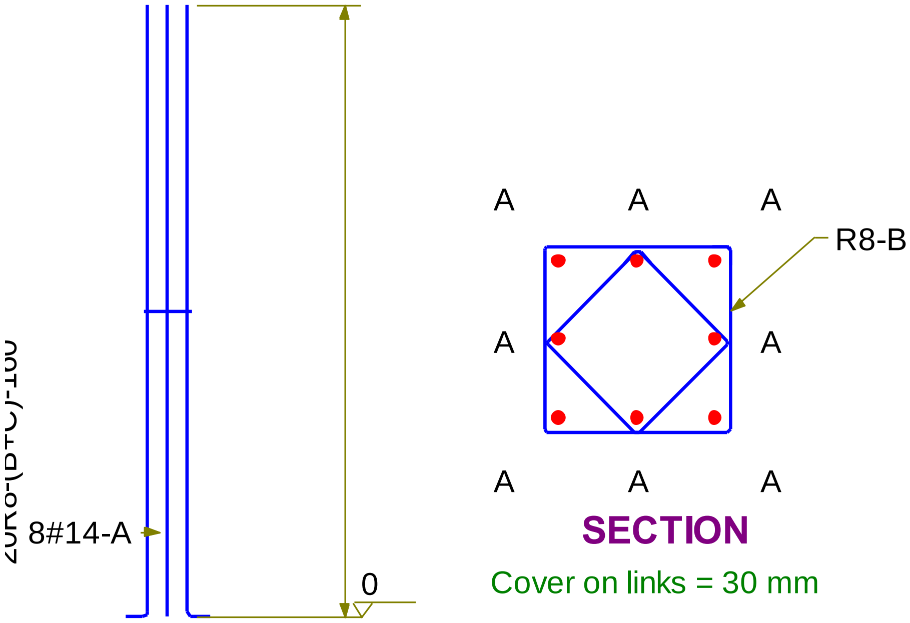
Note : For the same members (internal columns) , the first FLOOR be evenly reinforced with 4Φ20+4Φ16

Upper storey column reinforcement (2nd floor):
Summary of design calculations:
Design results for all load cases:

Load case	Axis	N (kN)	M1 (kNm)	M2 (kNm)	Mi (kNm)	Madd (kNm)	Design	M (kNm)	M' (kNm)	Asc (mm²)
1	X-X Y-Y	454.5	27.8 0.0	28.6 0.0	11.4 0.0	4.3 0.0	X-X Bottom	29.9 0.0	29.9	250 (0.4%) 250 (0.4%)

Asc=0.4% = 250mm² but in practice the minimum allowable Asc is 0.8%
Take Asc = 0.8%x120000 = 960mm²

Use 8Φ14 **with Asc = 924mm²**



Note : For the same members (internal columns) , the second FLOOR and third (last) floor will be evenly reinforced with 8Φ14

DESIGN OF EDGE COLUMNS

Edge column (Column 0 – 7--25): (Transversal frame has the maximum values)

Storey	Node	Axial force (KN)	Moment (KNm)		Shear force (KN)
			Bottom	Top	
0	0-7	473.7	20.75	58.2	103.6
1	7-13	356.6	20.49	165.84	107.4
2	13-19	235.8	25.78	69.45	109
3	19-25	113.4	25.78	46.01	9.96

Column:

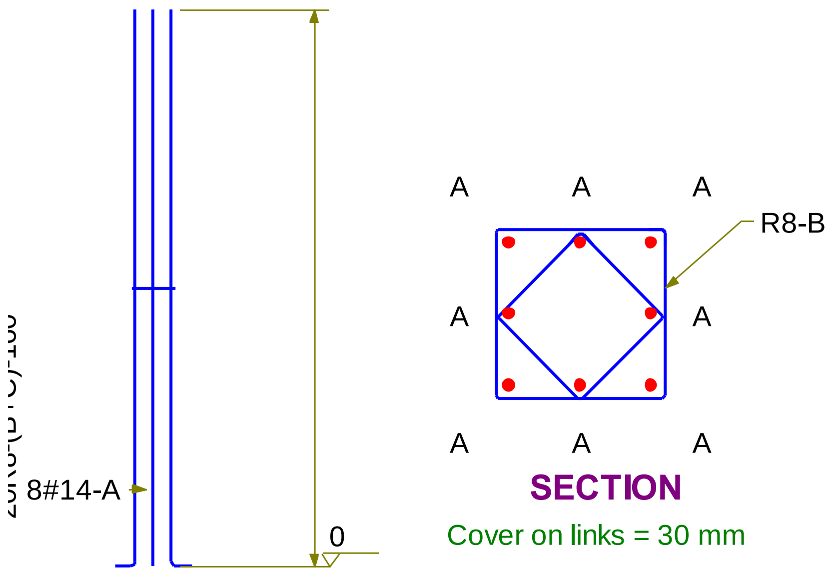
Summary of design calculations:

Design results for all load cases:

Load case	Axis	N (kN)	M1 (kNm)	M2 (kNm)	Mi (kNm)	Madd (kNm)	Design	M (kNm)	M' (kNm)	Asc (mm²)
1	X-X Y-Y	473.7	20.8 0.0	58.2 0.0	58.2 0.0	0.0 0.0	X-X Bottom	58.2 0.0	58.2	480 (0.4%) 480 (0.4%)

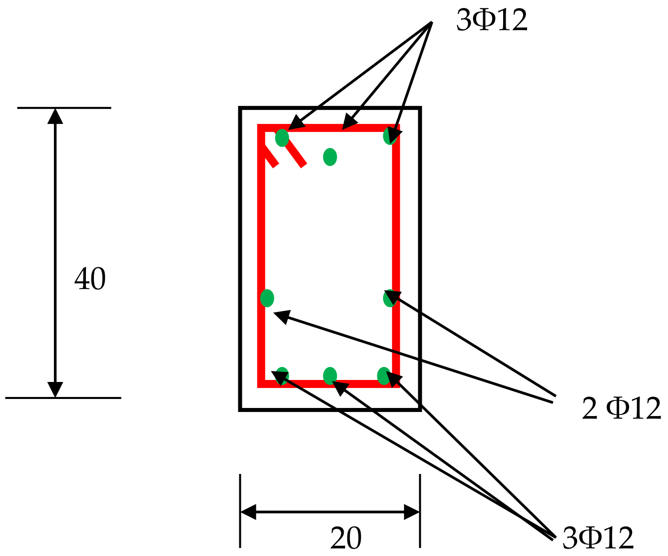
Asc=0.4% = 480mm² but in practice the minimum allowable Asc is 0.8%
Take Asc = 0.8%x120000 = 960mm²

Use 8Φ14 **with Asc = 1231mm²**



Note :
Since we have the minimum allowable reinforcement (0.8%), all the floor's edge columns (Ground, 1st, 2nd and 3rd) will be evenly reinforced with 8 Φ14.

PLINTH BEAM (LONGRINE)

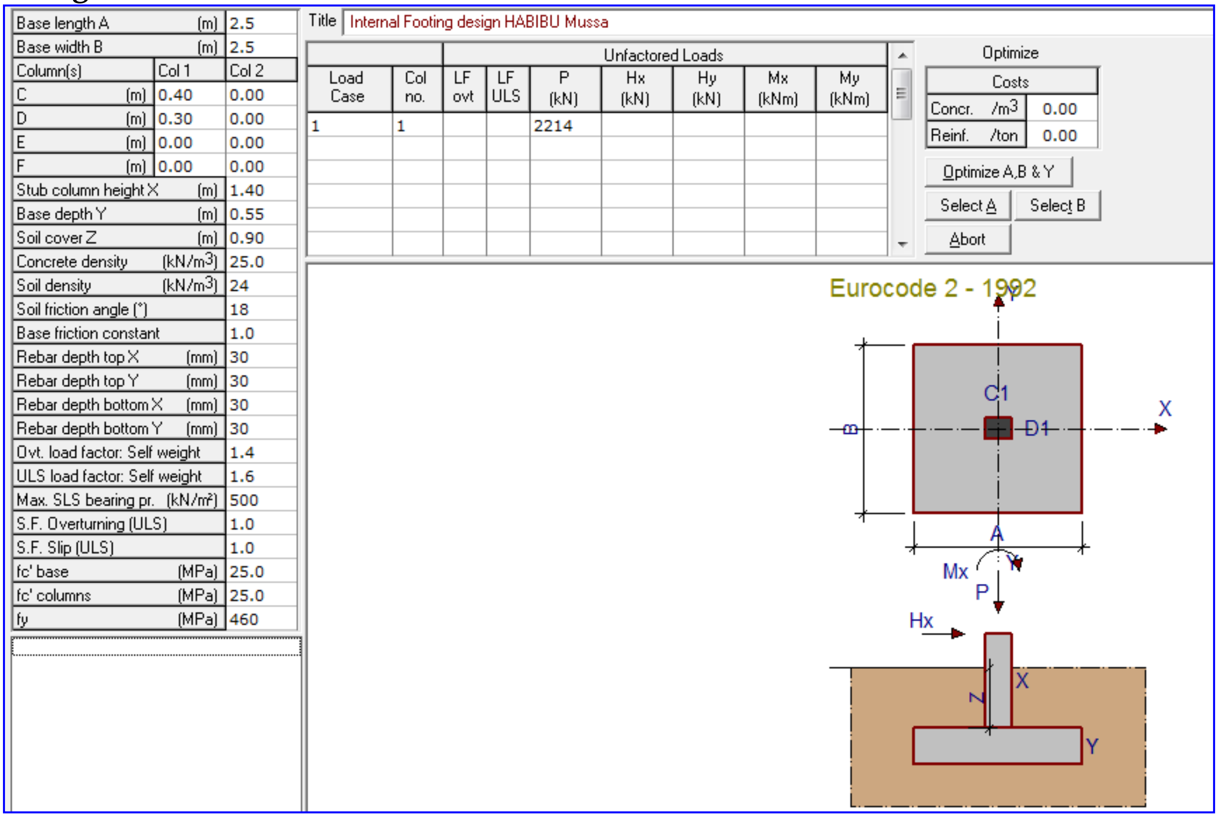


FOOTINGS DESIGN

INTERIOR FOOTING:

Soil bearing capacity: We consider both 4 Points for respectively different 70cm, 60cm, 50cm and 80cm deep.

Design data:



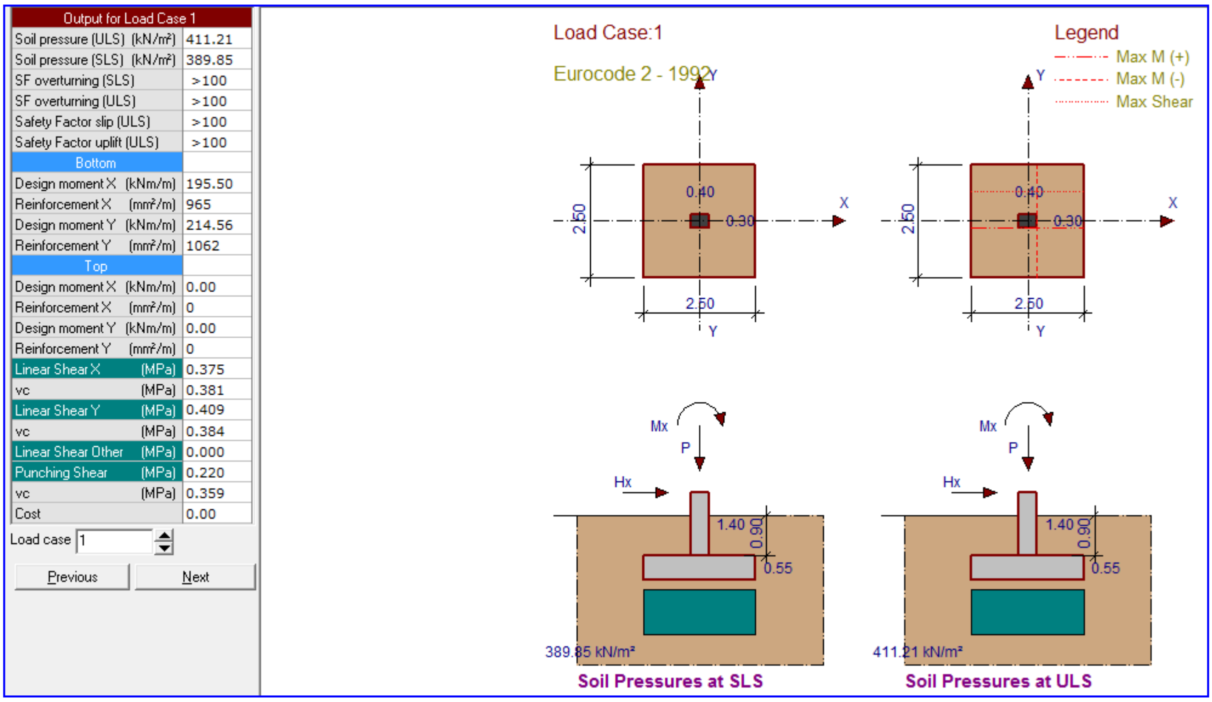
Base length A (m)	2.5	
Base width B (m)	2.5	
Column(s)	Col 1	Col 2
C (m)	0.40	0.00
D (m)	0.30	0.00
E (m)	0.00	0.00
F (m)	0.00	0.00
Stub column height X (m)	1.40	
Base depth Y (m)	0.55	
Soil cover Z (m)	0.90	
Concrete density (kN/m3)	25.0	
Soil density (kN/m3)	24	
Soil friction angle (°)	18	
Base friction constant	1.0	
Rebar depth top X (mm)	30	
Rebar depth top Y (mm)	30	
Rebar depth bottom X (mm)	30	
Rebar depth bottom Y (mm)	30	
Ovt. load factor: Self weight	1.4	
ULS load factor: Self weight	1.6	
Max. SLS bearing pr. (kN/m²)	500	
S.F. Overturning (ULS)	1.0	
S.F. Slip (ULS)	1.0	
fc' base (MPa)	25.0	
fc' columns (MPa)	25.0	
fy (MPa)	460	

Title: Internal Footing design HABIBU Mussa

Load Case	Col no.	LF ovt	LF ULS	Unfactored Loads P (kN)	Hx (kN)	Hy (kN)	Mx (kNm)	My (kNm)
1	1			2214				

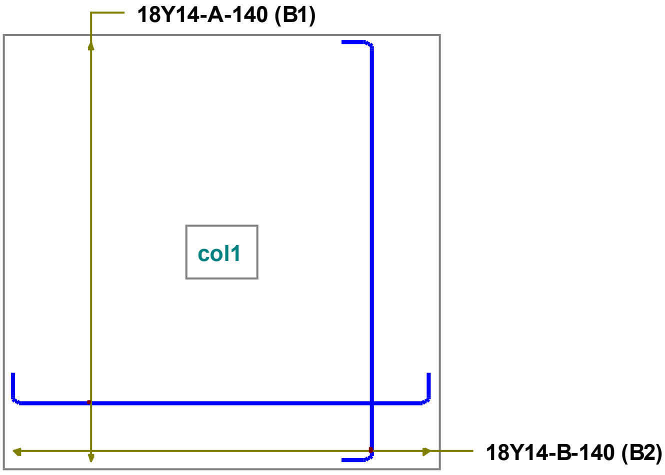
Optimize	
Costs	
Concr. /m3	0.00
Reinf. /ton	0.00

Design results:

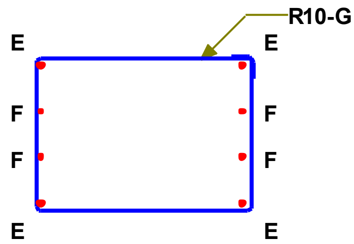


Output for Load Case 1	
Soil pressure (ULS) (kN/m²)	411.21
Soil pressure (SLS) (kN/m²)	389.85
SF overturning (SLS)	>100
SF overturning (ULS)	>100
Safety Factor slip (ULS)	>100
Safety Factor uplift (ULS)	>100
Bottom	
Design moment X (kNm/m)	195.50
Reinforcement X (mm²/m)	965
Design moment Y (kNm/m)	214.56
Reinforcement Y (mm²/m)	1062
Top	
Design moment X (kNm/m)	0.00
Reinforcement X (mm²/m)	0
Design moment Y (kNm/m)	0.00
Reinforcement Y (mm²/m)	0
Linear Shear X (MPa)	0.375
vc (MPa)	0.381
Linear Shear Y (MPa)	0.409
vc (MPa)	0.384
Linear Shear Other (MPa)	0.000
Punching Shear (MPa)	0.220
vc (MPa)	0.359
Cost	0.00

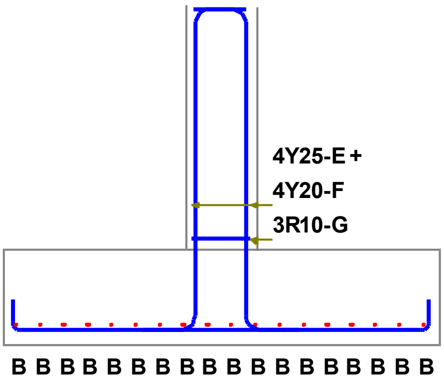
Reinforcement bending schedule:



PLAN



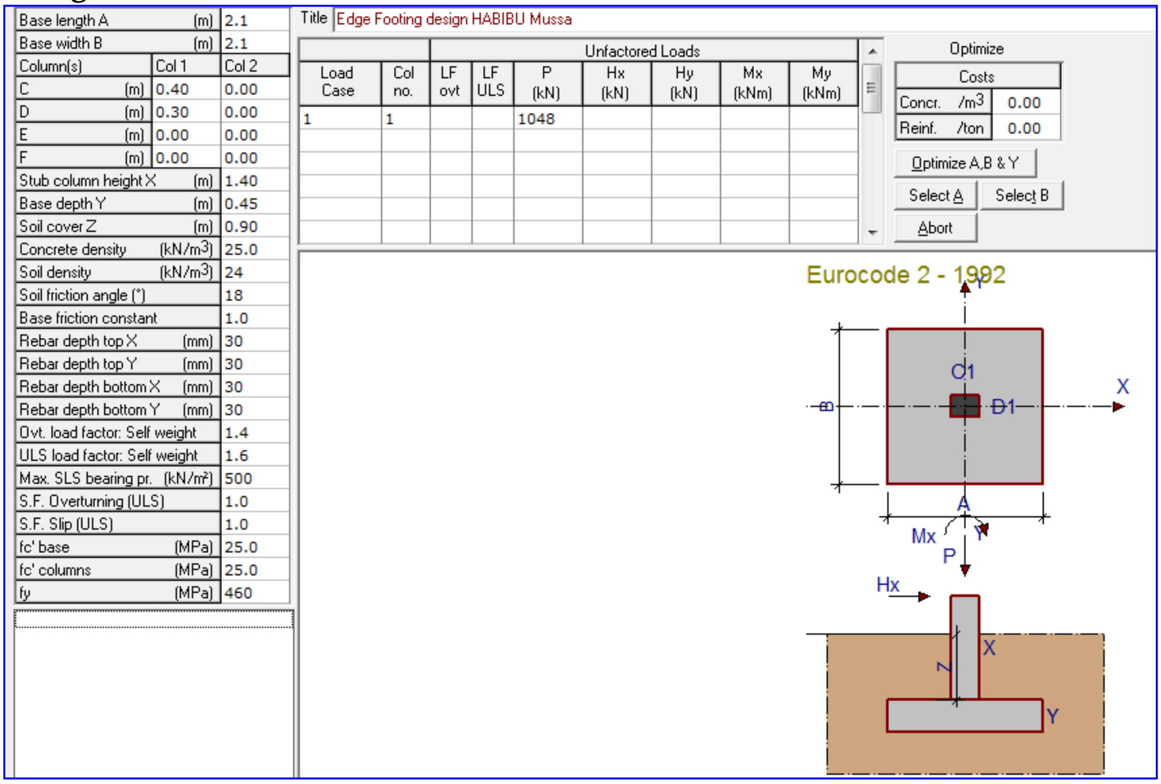
SECTION: col1



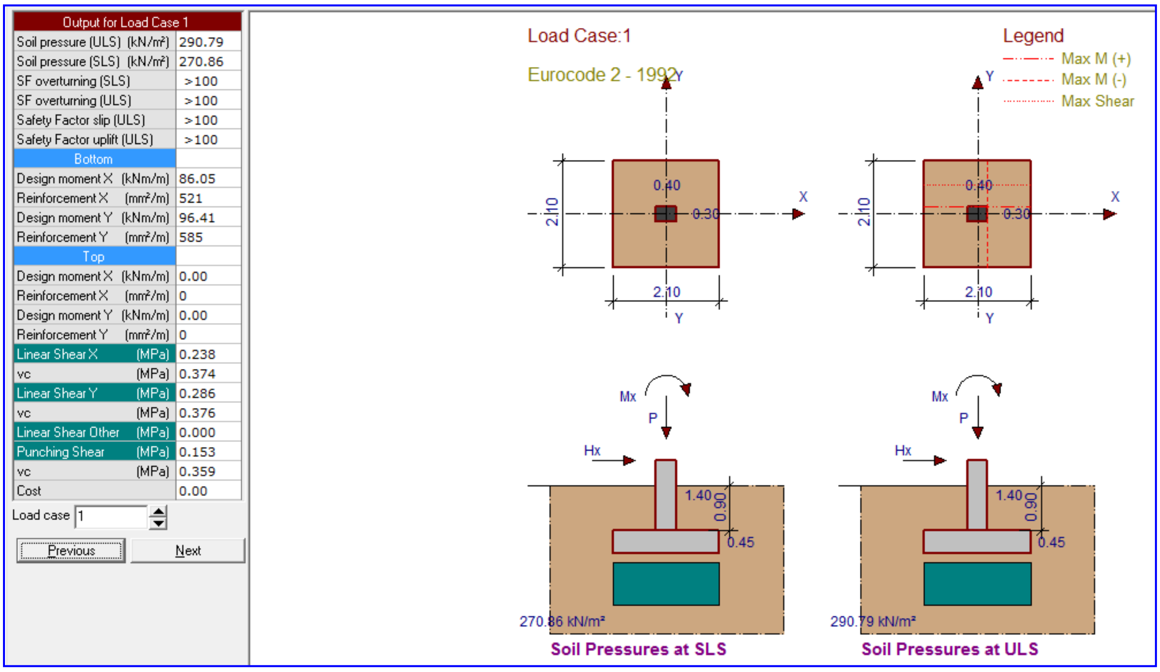
SECTION

EDGE FOOTING:

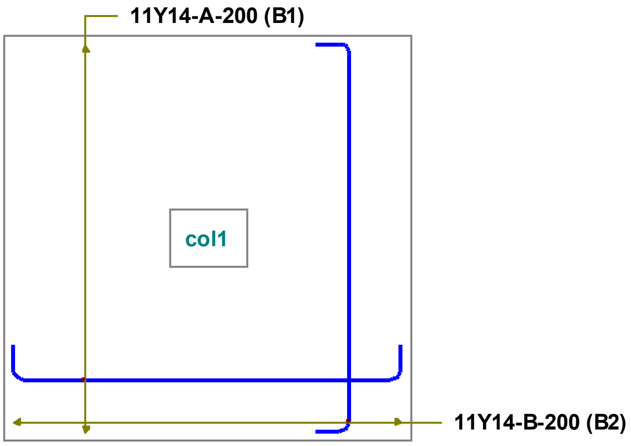
Design data:



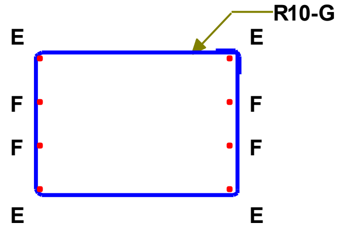
Design results:



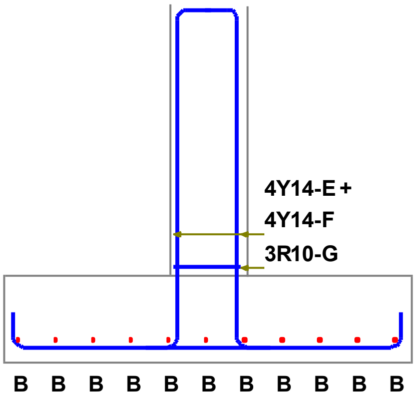
Reinforcement Bending schedule:



PLAN



SECTION: col1



SECTION

II. RECAPTILATION OF THE DESIGN RESULTS

Note: Unless the beams, all the results are related to the transversal frame since it has the maximum values.

5.1.1 COLUMNS SUMMARY

Floor	Internal/Edge	Column dimensions	Column reinforcement	Stirrups
0	Internal	40X30	4Φ25+4Φ20	Φ8@18cm c/c
	Edge	40X30	8Φ14	Φ8@18cm c/c
1	Internal	40X30	4Φ20+4Φ16	Φ8@18cm c/c
	Edge	40X30	8Φ14	Φ8@18cm c/c
2	Internal	40X30	8Φ14	Φ8@18cm c/c
	Edge	40X30	8Φ14	Φ8@18cm c/c
3	Internal	40X30	8Φ14	Φ8@18cm c/c
	Edge	40X30	8Φ14	Φ8@18cm c/c

5.1.2 FOOTINGS SUMMARY

Footing type	Dimensions	Reinforcement in X-direction	Reinforcement in Y-direction	Starter column reinforcement
Type 1 (Internal)	250x250x55	Φ14@14 cm c/c	Φ14@14 cm c/c	4Φ25+4Φ20
Type 2 (Edge)	210x210x45	Φ14@20 cm c/c	Φ14@20 cm c/c	8Φ14

5.1.3 BEAMS SUMMARY

Beam type	Dimensions	Top reinforcement (at support)	Bottom reinforcement (mid-span)	Stirrups near support/Mid span
Longitudinal beams	50x25	3Φ25 + 2Φ20	4Φ20	Φ8@15cm c/c Φ8@20cm c/c
Transversal beams	50x25	5Φ25	4Φ20	Φ8@15cm c/c Φ8@20cm c/c

5.1.4 SLAB SUMMARY

Element	Dimensions	Top x-direction	Top y-direction	Bottom x-direction	Bottom y-direction
Suspended slab	13cm thick	Φ12@18cm c/c	Φ12@18cm c/c	Φ10@18cm c/c	Φ10@18cm c/c

5.1.5 RAMP SUMMARY

Element	Dimensions	Top x-direction	Top y-direction	Bottom x-direction	Bottom y-direction
Suspended slab	13cm thick	Φ12@18cm c/c	Φ12@18cm c/c	Φ10@18cm c/c	Φ10@18cm c/c

Done at Rubavu, January 2018
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BSc.CivilEng