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APPENDIX A

Reinforcement Provided

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Cobiax - Reinforcement Content (mm²/m)

CS - Column strip; MS - Middle strip

Load	Span (m)	Slab Area (m²)	h (mm)	Shear steel (kg/m²)	Minimum (mm²)
7.5m light load	7.5	506	280	0.2	364
7.5m medium load	7.5	506	280	0.4	364
7.5m heavy load	7.5	506	360	0.8	468
9m light load	9	729	300	0.2	390
9m medium load	9	729	340	0.5	442
9m heavy load	9	729	450	0.7	585
10m light load	10	900	340	0.4	442
10m medium load	10	900	400	0.5	520
10m heavy load	10	900	500	0.8	650
11m light load	11	1089	400	0.4	520
11m medium load	11	1089	460	0.5	598
11m heavy load	11	1089	570	0.9	741
12m light load	12	1296	460	0.4	598
12m medium load	12	1296	520	0.7	676
12m heavy load	12	1296	620	1.0	806

Load	Bottom Steel - Edge Span		Bottom Steel - Internal Span		Top Steel - Supports		Total
	CS	MS	CS	MS	CS	MS	kg/m²
7.5m light load	628	524	452	377	1608	377	16.8
7.5m medium load	905	524	452	377	2513	377	22.0
7.5m heavy load	1047	804	524	452	3272	628	29.1
9m light load	1005	670	565	377	2454	524	23.8
9m medium load	1340	754	524	524	3272	524	29.8
9m heavy load	1340	1005	670	565	3272	785	33.0
10m light load	1047	754	524	524	3272	670	28.4
10m medium load	1340	905	670	628	3272	628	31.6
10m heavy load	1608	1137	804	670	3927	1005	39.3
11m light load	1257	905	628	628	3217	628	30.6
11m medium load	1257	1047	804	670	3927	670	35.1
11m heavy load	1636	1340	754	754	5362	754	45.0
12m light load	1257	1257	628	628	3927	628	35.3
12m medium load	1636	1257	754	804	4909	804	42.8
12m heavy load	1963	1340	905	754	6434	754	51.3

Coffer - Reinforcement Content (mm²/m)

CS - Column strip; MS - Middle strip

Load	**Span (m)**	**Slab Area (m²)**	**h (mm)**	**Shear steel (kg/m²)**	Web Width (mm)	Minimum (mm²)		
						Solid Zone	Voided Zone	Provided
7.5m light load	7.5	506	425	0.0	193	553	148	168
7.5m medium load	7.5	506	425	0.2	193	553	148	168
7.5m heavy load	7.5	506	425	0.4	193	553	148	168
9m light load	9	729	425	0.1	193	553	148	168
9m medium load	9	729	425	0.3	193	553	148	168
9m heavy load	9	729	525	0.5	213	683	201	262
10m light load	10	900	425	0.2	193	553	148	168
10m medium load	10	900	525	0.2	213	683	201	262
10m heavy load	10	900	625	0.6	233	813	262	314
11m light load	11	1089	525	0.2	213	683	201	262
11m medium load	11	1089	625	0.3	233	813	262	262
11m heavy load	11	1089	625	0.5	233	813	262	262
12m light load	12	1296	625	0.2	233	813	262	262
12m medium load	12	1296	625	0.4	233	813	262	314

Load	**Bottom Steel - Edge Span**		**Bottom Steel - Internal Span**		**Top Steel - Supports**		**Total**
	CS	MS	CS	MS	CS	MS	kg/m²
7.5m light load	447	349	174	174	1340	262	13.3
7.5m medium load	502	447	174	174	1636	524	16.5
7.5m heavy load	893	698	174	174	3272	524	26.6
9m light load	698	502	174	174	2094	524	19.5
9m medium load	893	698	174	174	2681	670	24.6
9m heavy load	1091	893	349	349	3272	670	31.3
10m light load	893	698	174	174	2681	670	24.5
10m medium load	893	698	349	349	3272	670	28.6
10m heavy load	1091	893	349	349	3927	754	34.6
11m light load	893	698	349	349	3272	670	28.5
11m medium load	1091	893	349	349	3272	754	31.2
11m heavy load	1397	1091	349	349	5362	1047	43.1
12m light load	1091	893	349	349	3272	754	31.1
12m medium load	1397	1091	349	349	3927	754	37.1

Post-tension - Reinforcement Content (m

CS - Column strip; MS - Middle strip

Load	Span (m)	Slab Area (m²)	h (mm)	Shear steel (kg/m²)	Minimum (mm²)
7.5m light load	7.5	506	220	0.0	286
7.5m medium load	7.5	506	230	0.0	299
7.5m heavy load	7.5	506	250	0.1	325
9m light load	9	729	270	0.0	351
9m medium load	9	729	280	0.1	364
9m heavy load	9	729	310	0.3	403
10m light load	10	900	310	0.1	403
10m medium load	10	900	325	0.1	423
10m heavy load	10	900	360	0.3	468
11m light load	11	1089	350	0.1	455
11m medium load	11	1089	370	0.1	481
11m heavy load	11	1089	400	0.5	520
12m light load	12	1296	380	0.1	494
12m medium load	12	1296	410	0.3	533
12m heavy load	12	1296	510	0.6	663

Load	Bottom Steel - Edge Span		Bottom Steel - Internal Span		Top Steel - Supports		Total
	CS	MS	CS	MS	CS	MS	kg/m²
7.5m light load	628	452	314	314	1608	452	15.9
7.5m medium load	785	565	393	393	2454	393	20.9
7.5m heavy load	1608	754	628	377	3927	670	34.1
9m light load	785	565	393	393	2454	565	21.3
9m medium load	1047	754	524	524	3272	670	28.2
9m heavy load	1636	1047	754	524	5362	1047	43.4
10m light load	1047	670	524	524	2681	524	24.9
10m medium load	1340	754	524	524	3272	670	29.8
10m heavy load	2094	1340	670	524	5362	1047	47.4
11m light load	1047	754	1047	754	3272	670	30.2
11m medium load	1608	905	628	628	3927	804	35.7
11m heavy load	2094	1340	754	524	5362	1047	47.6
12m light load	1257	905	628	628	3927	804	33.6
12m medium load	1571	1005	565	565	4021	1005	36.8
12m heavy load	2094	1340	754	524	5362	1047	47.6

APPENDIX B

Cobiax – Reinforcement Required – Strand7

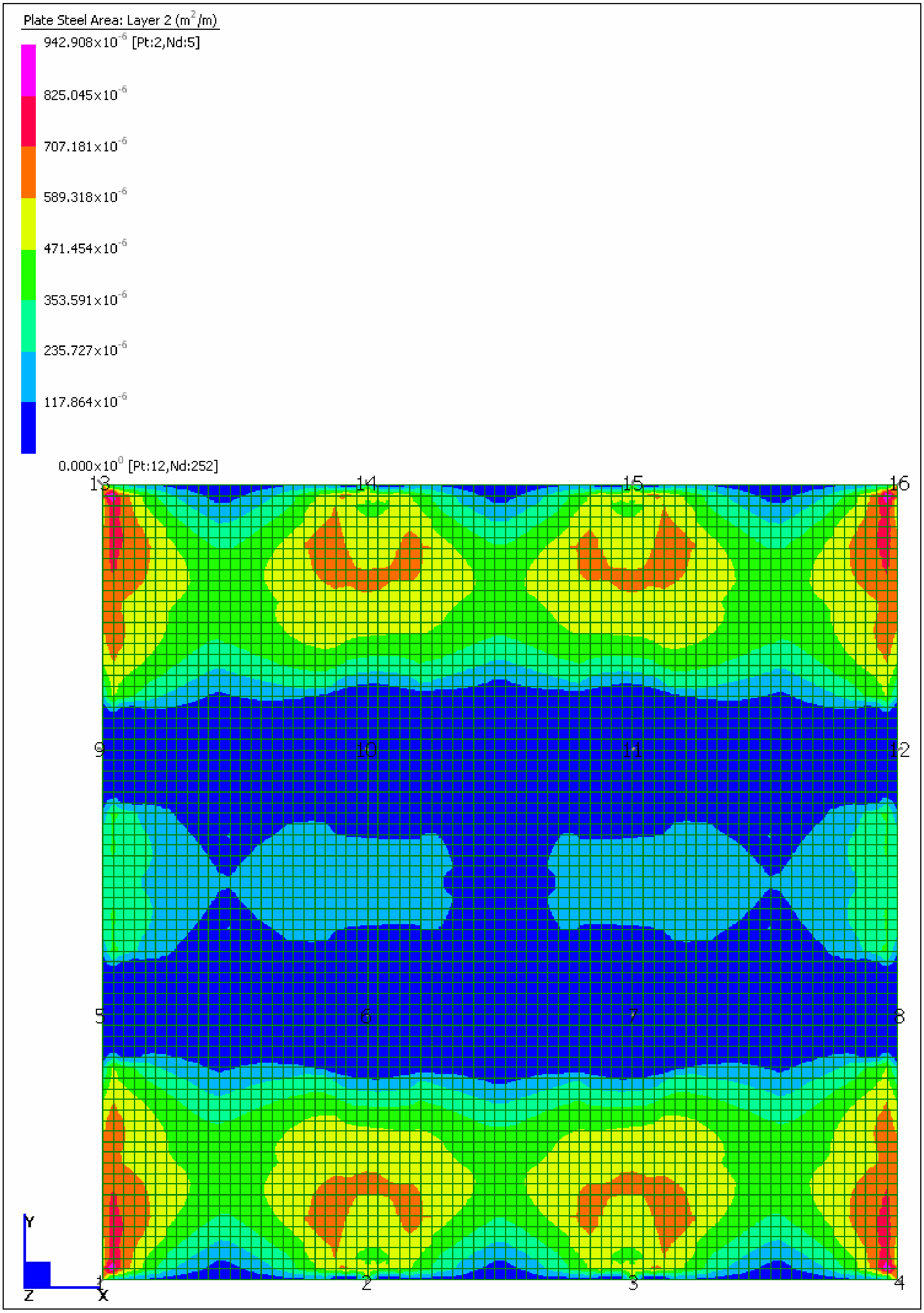
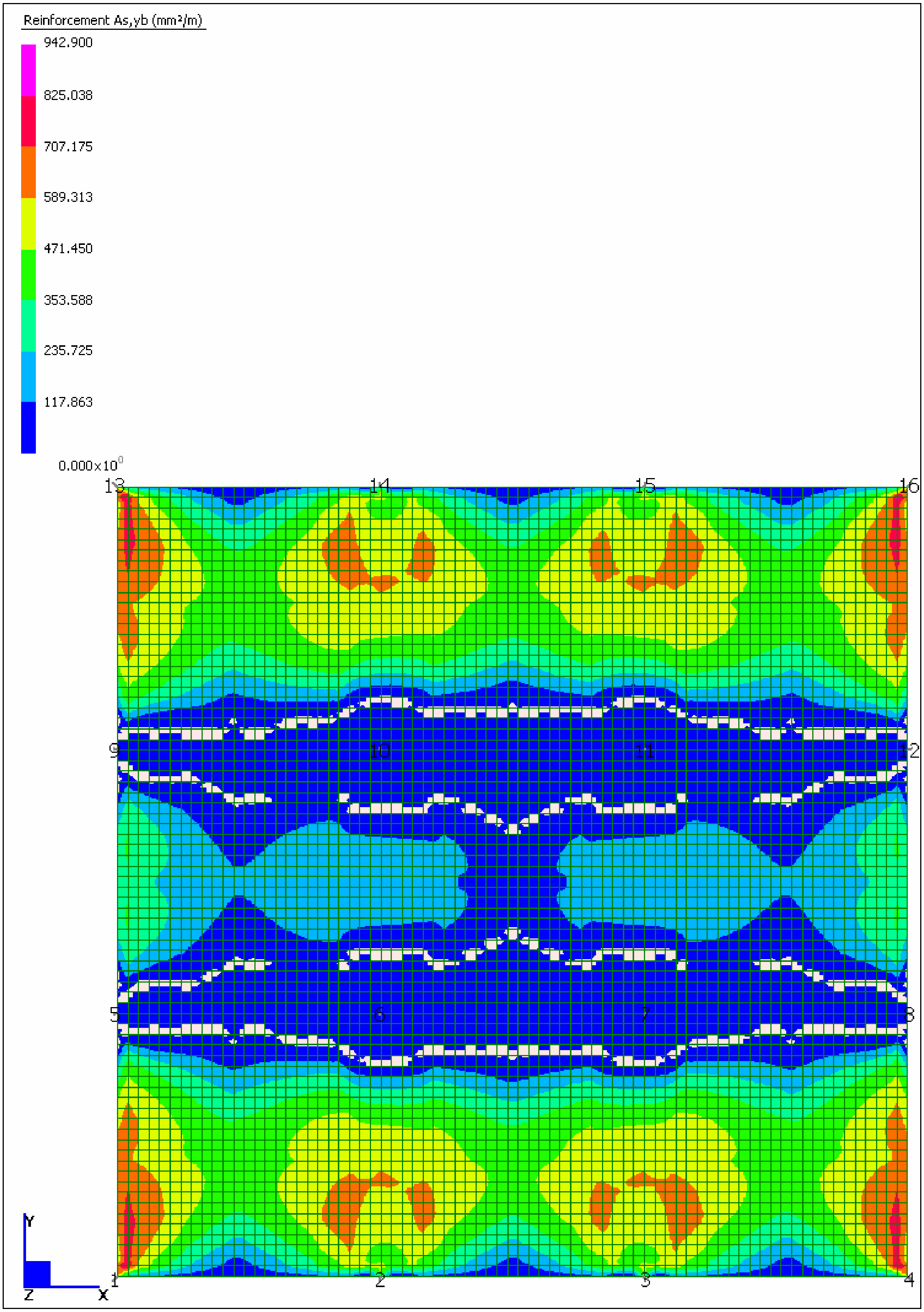


Plate Steel Area: Layer 2 (m^2/m)
942.908x10^-6 [Pt:2,Nd:5]
825.045x10^-6
707.181x10^-6
589.318x10^-6
471.454x10^-6
353.591x10^-6
235.727x10^-6
117.864x10^-6
0.000x10^0 [Pt:12,Nd:252]
13
14
15
16
9
10
11
12
5
6
7
8
1
2
3
4
Y
Z
X
Strand7 Release 2.3.8 [Licenced to:COBIAX]



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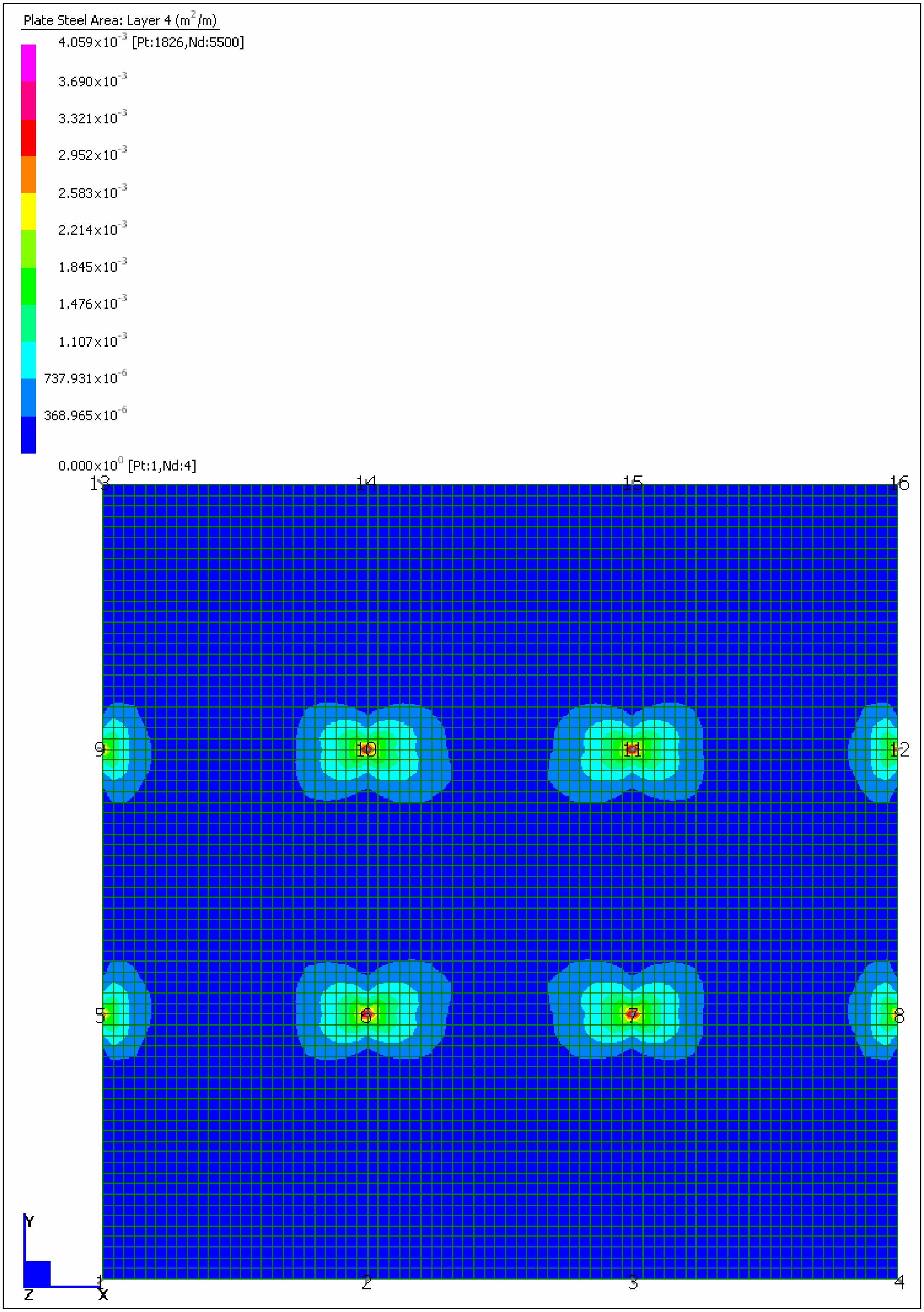

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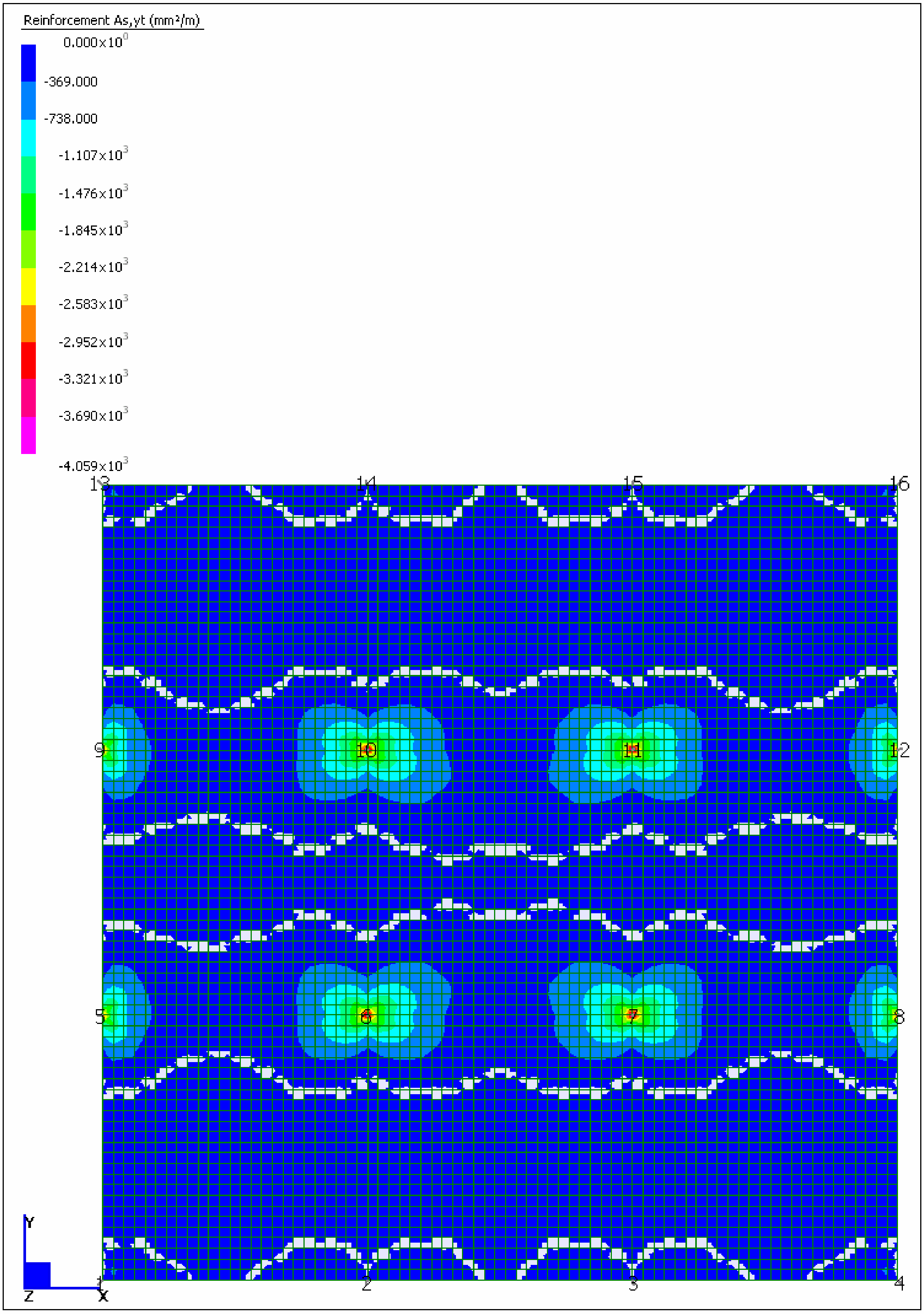
Reinforcement As,yt (mm²/m)
0.000x10^0
-369.000
-738.000
-1.107x10^3
-1.476x10^3
-1.845x10^3
-2.214x10^3
-2.583x10^3
-2.952x10^3
-3.321x10^3
-3.690x10^3
-4.059x10^3
13
14
15
16
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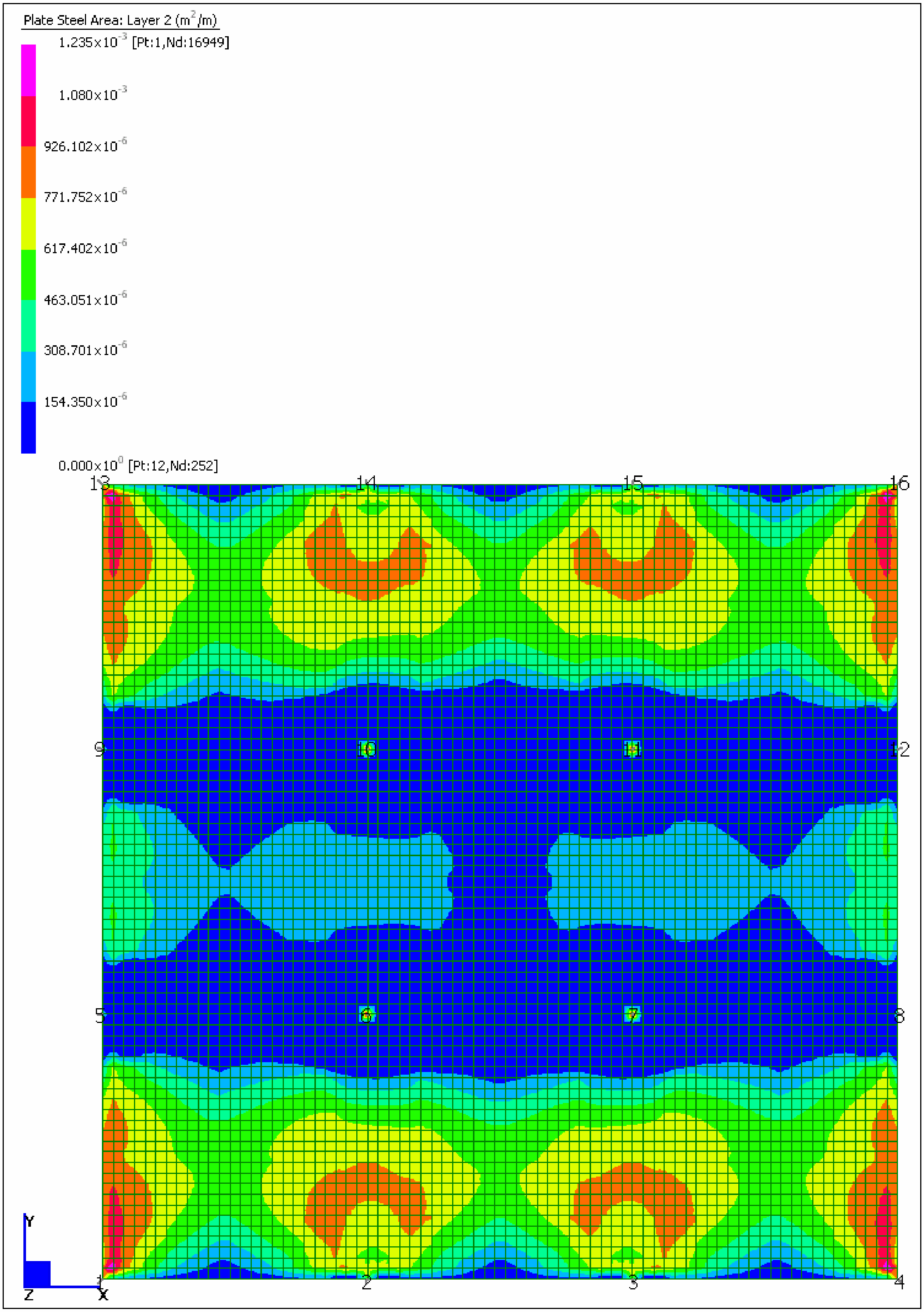
Strand7 Release 2.3.8 [Licenced to:COBIAX]



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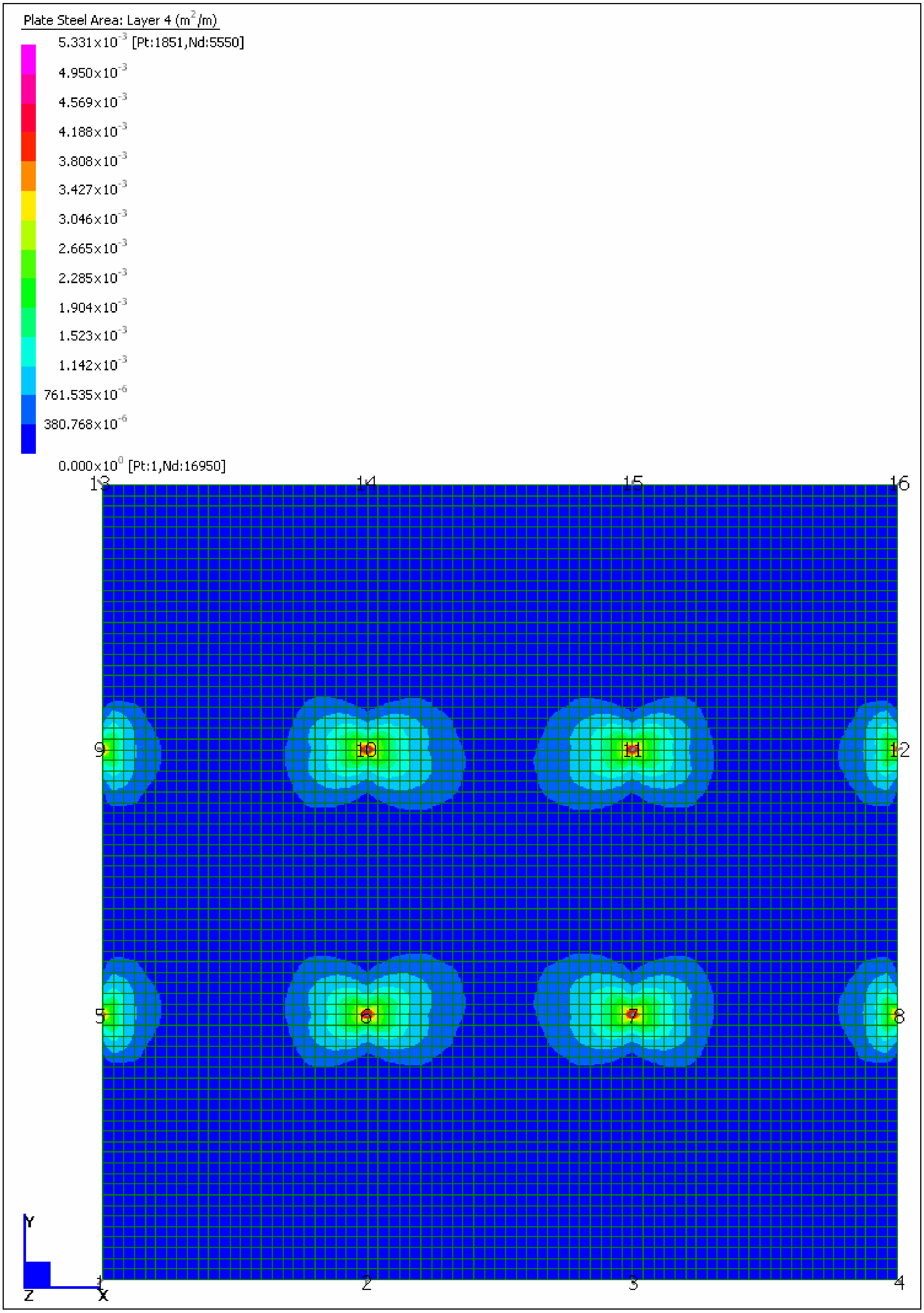
Plate Steel Area: Layer 4 (m²/m)
5.331x10⁻³ [Pt:1851,Nd:5550]
4.950x10⁻³
4.569x10⁻³
4.188x10⁻³
3.808x10⁻³
3.427x10⁻³
3.046x10⁻³
2.665x10⁻³
2.285x10⁻³
1.904x10⁻³
1.523x10⁻³
1.142x10⁻³
761.535x10⁻⁶
380.768x10⁻⁶
0.000x10⁰ [Pt:1,Nd:16950]
13
14
15
16
9
10
11
12
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Y
Z
X
Strand7 Release 2.3.8 [Licenced to:COBIAX]

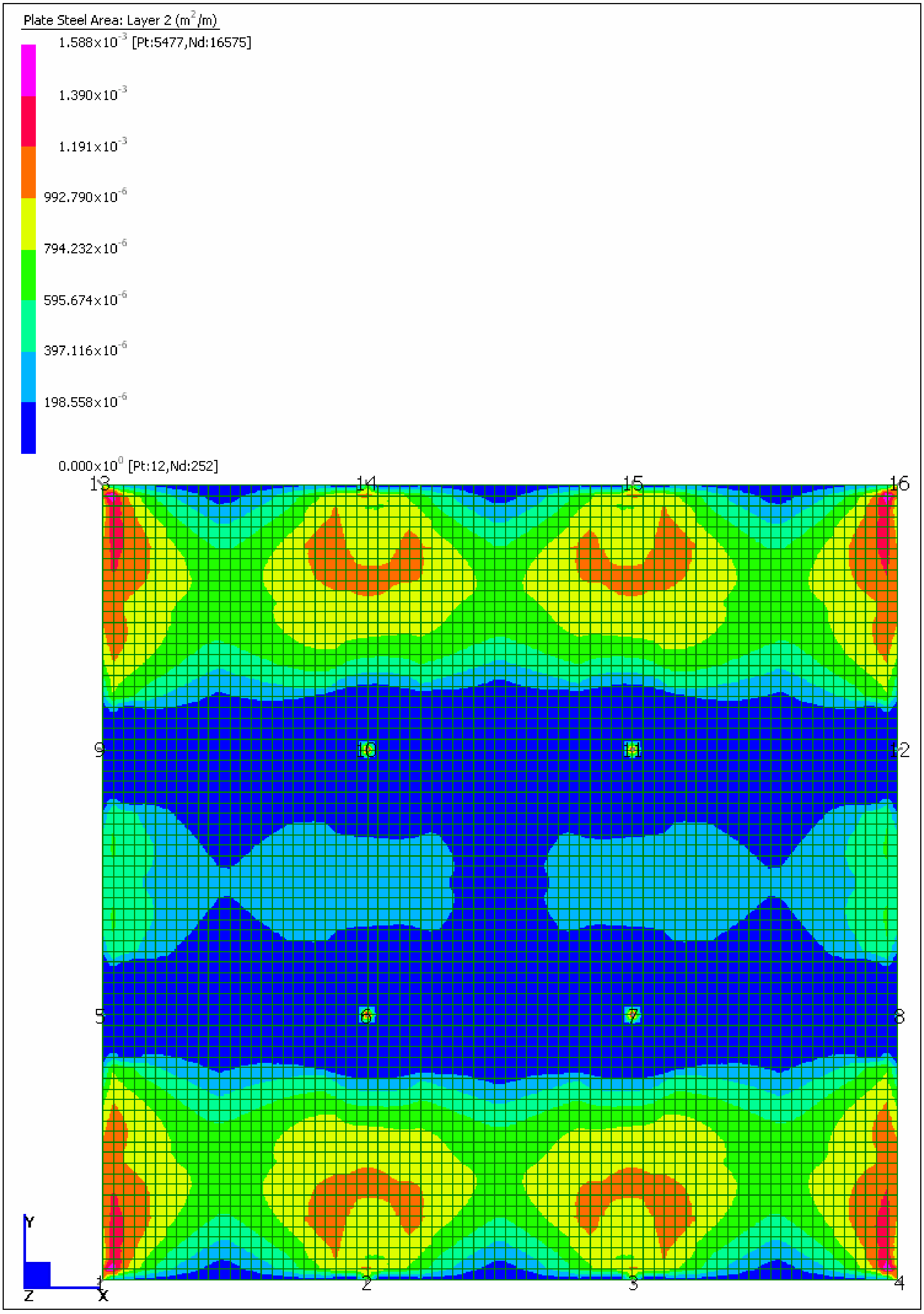
Plate Steel Area: Layer 2 (m²/m)
1.588x10⁻³ [Pt:5477,Nd:16575]
1.390x10⁻³
1.191x10⁻³
992.790x10⁻⁶
794.232x10⁻⁶
595.674x10⁻⁶
397.116x10⁻⁶
198.558x10⁻⁶
0.000x10⁰ [Pt:12,Nd:252]
13
14
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16
9
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Strand7 Release 2.3.8 [Licenced to:COBIAX]

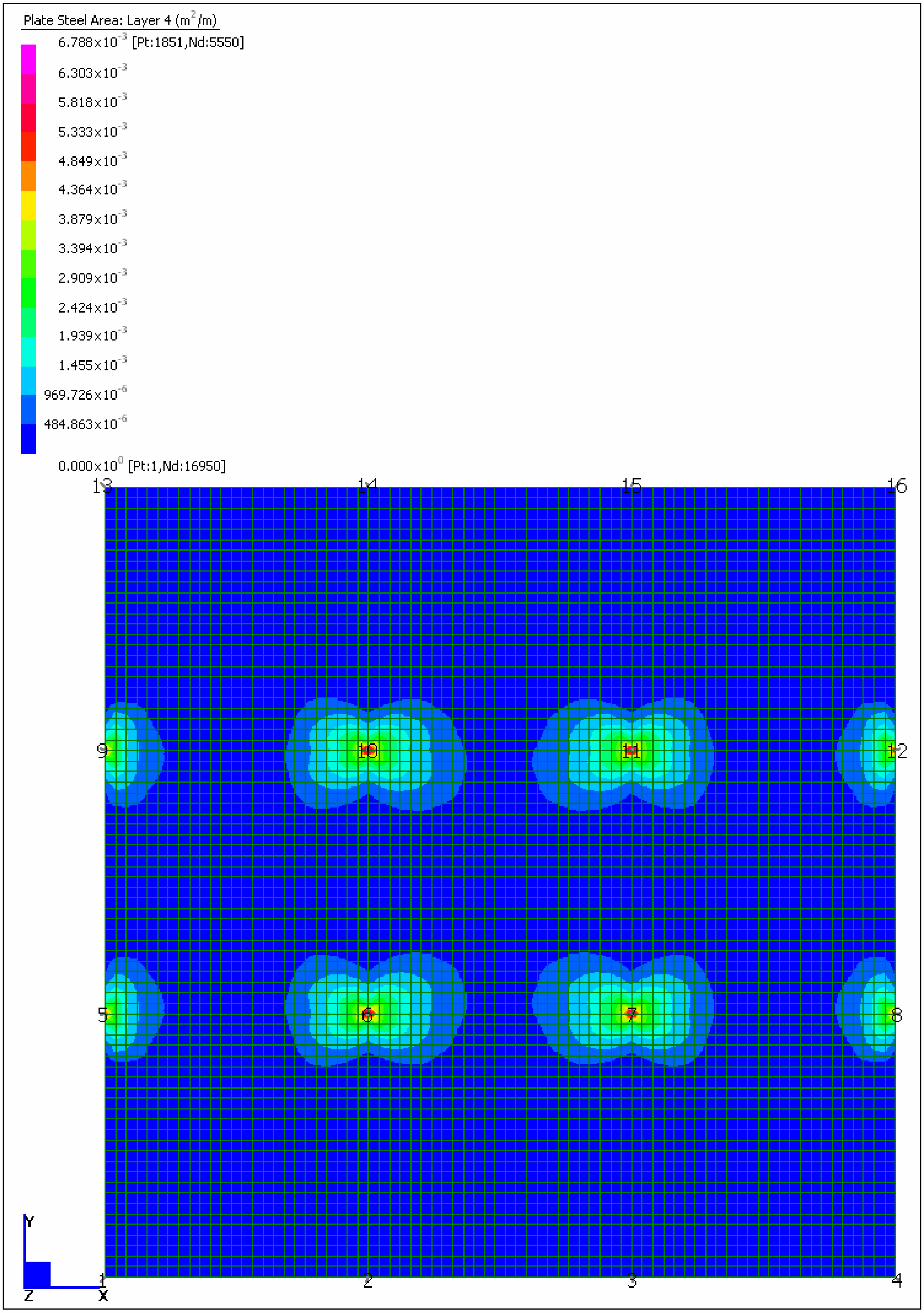
Plate Steel Area: Layer 4 (m²/m)
6.788x10⁻³ [Pt:1851,Nd:5550]
6.303x10⁻³
5.818x10⁻³
5.333x10⁻³
4.849x10⁻³
4.364x10⁻³
3.879x10⁻³
3.394x10⁻³
2.909x10⁻³
2.424x10⁻³
1.939x10⁻³
1.455x10⁻³
969.726x10⁻⁶
484.863x10⁻⁶
0.000x10⁰ [Pt:1,Nd:16950]
13
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APPENDIX C

Coffer –Reinforcement Required

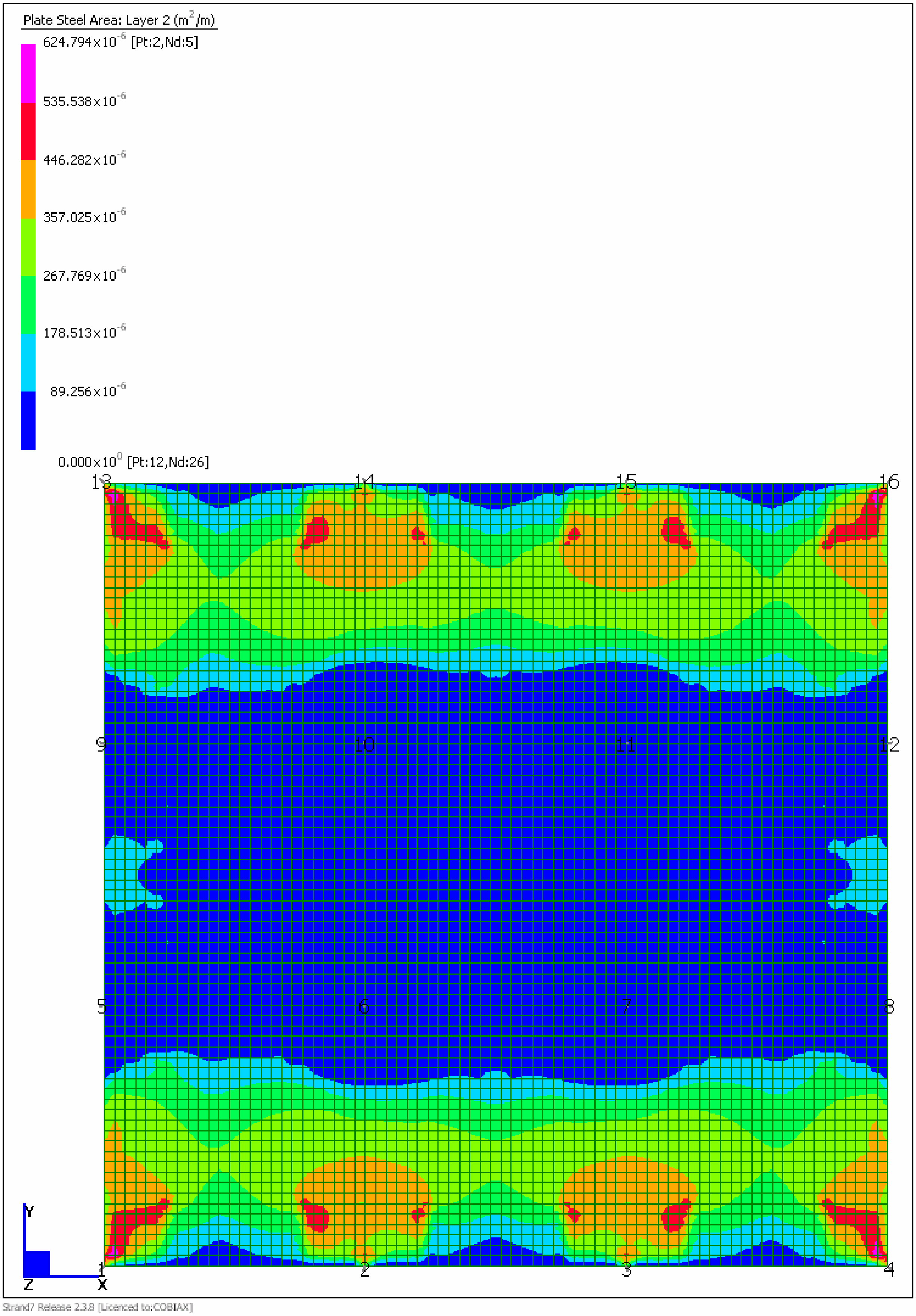
Plate Steel Area: Layer 2 (m^2/m)
624.794x10^-6 [Pt:2,Nd:5]
535.538x10^-6
446.282x10^-6
357.025x10^-6
267.769x10^-6
178.513x10^-6
89.256x10^-6
0.000x10^0 [Pt:12,Nd:26]
13
14
15
16
9
10
11
12
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Y
Z
X
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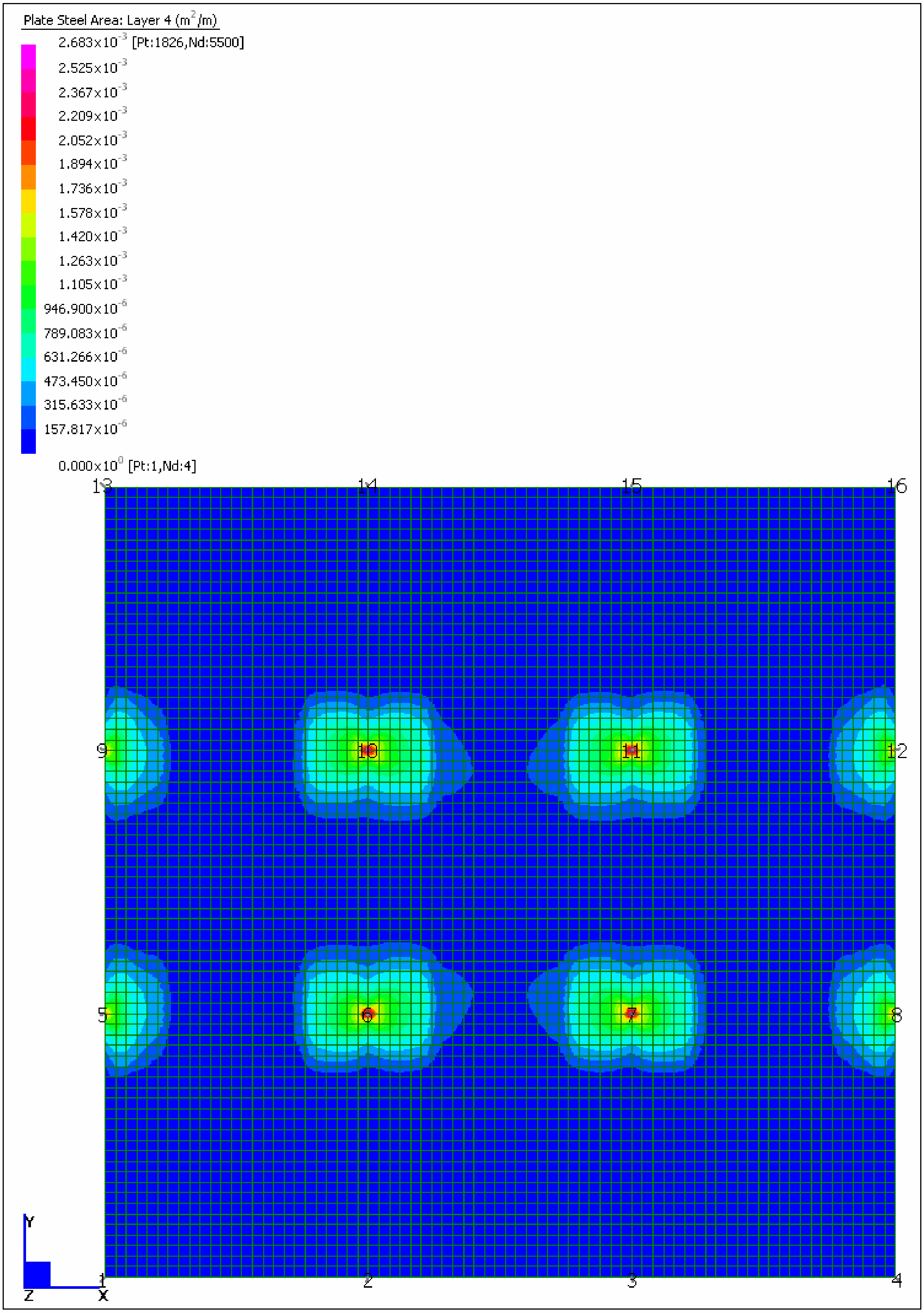
Plate Steel Area: Layer 4 (m2/m)
2.683x10-3 [Pt:1826,Nd:5500]
2.525x10-3
2.367x10-3
2.209x10-3
2.052x10-3
1.894x10-3
1.736x10-3
1.578x10-3
1.420x10-3
1.263x10-3
1.105x10-3
946.900x10-6
789.083x10-6
631.266x10-6
473.450x10-6
315.633x10-6
157.817x10-6
0.000x100 [Pt:1,Nd:4]
13
14
15
16
9
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12
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7
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Y
Z
X
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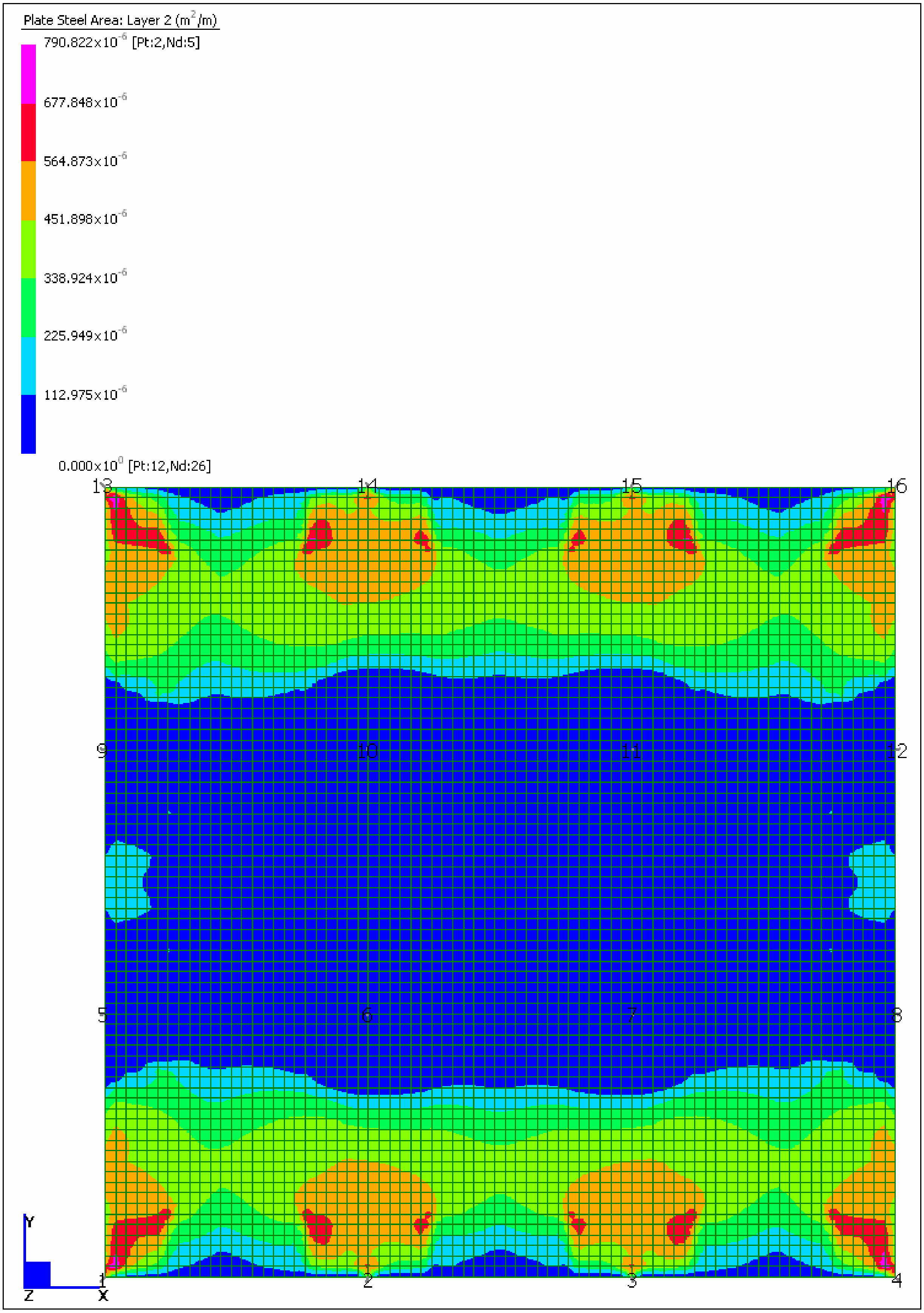
Plate Steel Area: Layer 2 (m²/m)
790.822x10⁻⁶ [Pt:2,Nd:5]
677.848x10⁻⁶
564.873x10⁻⁶
451.898x10⁻⁶
338.924x10⁻⁶
225.949x10⁻⁶
112.975x10⁻⁶
0.000x10⁰ [Pt:12,Nd:26]
13
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16
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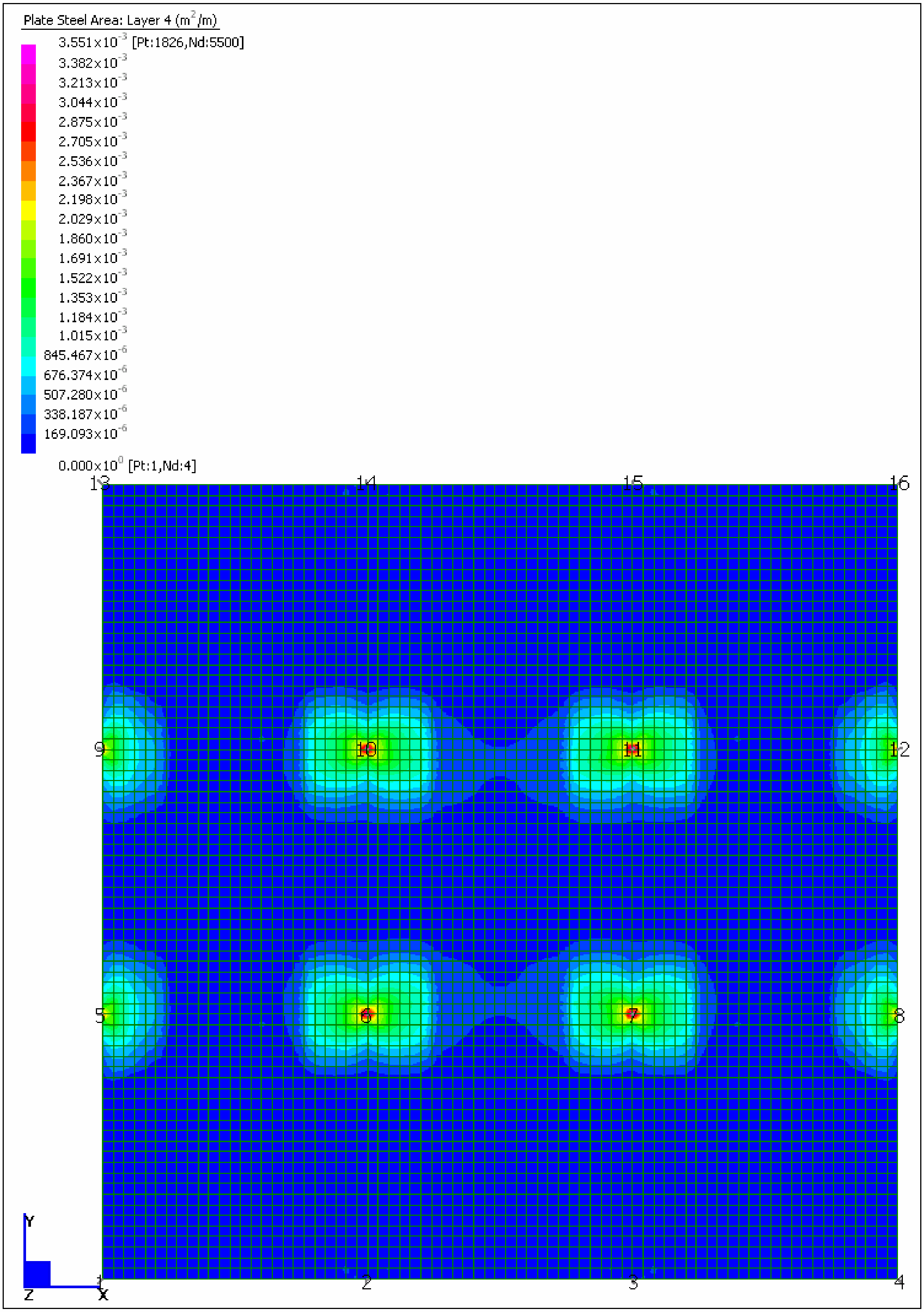

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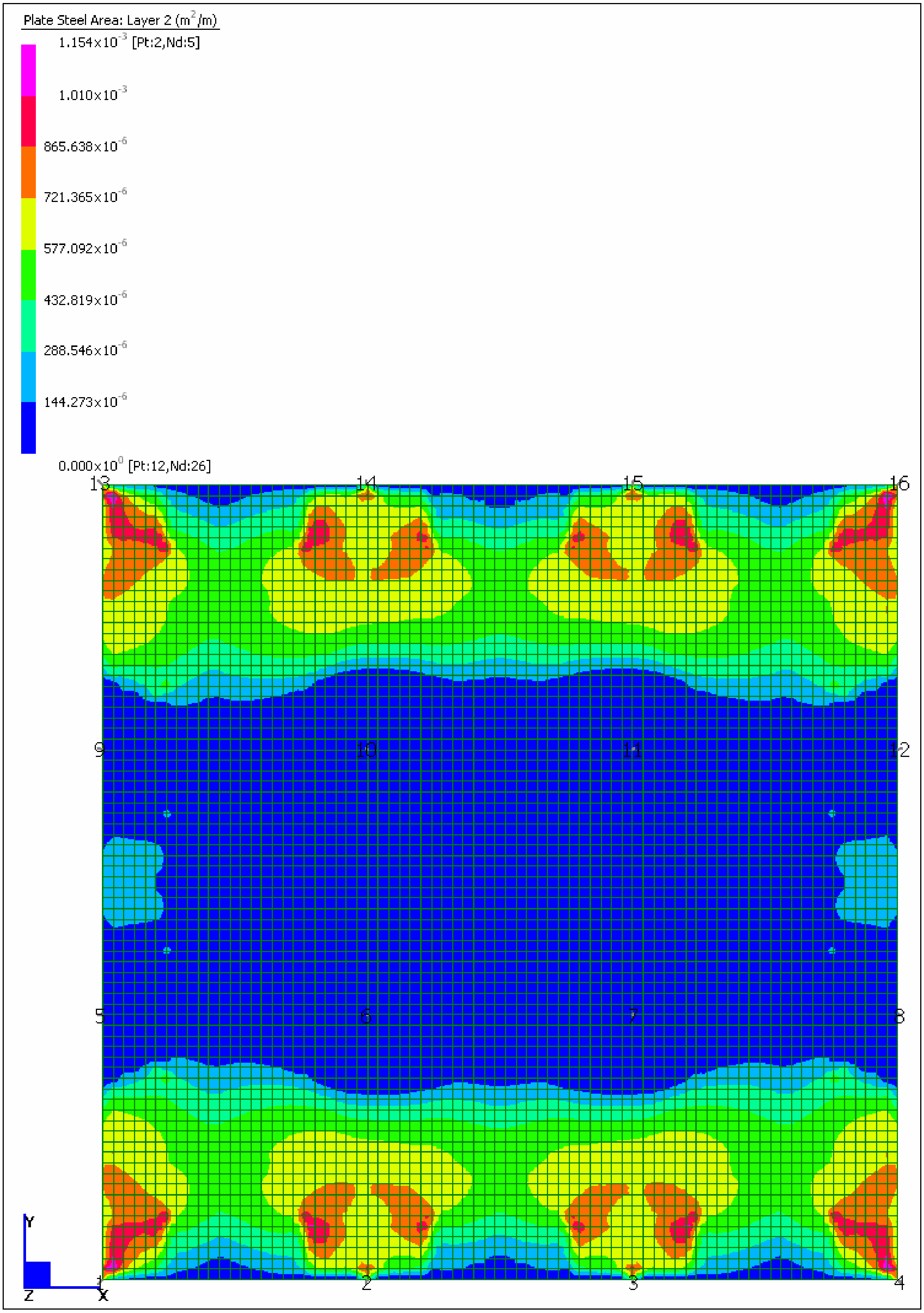
Plate Steel Area: Layer 2 (m^2/m)
1.154x10^-3 [Pt:2,Nd:5]
1.010x10^-3
865.638x10^-6
721.365x10^-6
577.092x10^-6
432.819x10^-6
288.546x10^-6
144.273x10^-6
0.000x10^0 [Pt:12,Nd:26]
13
14
15
16
9
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12
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Y
Z
X
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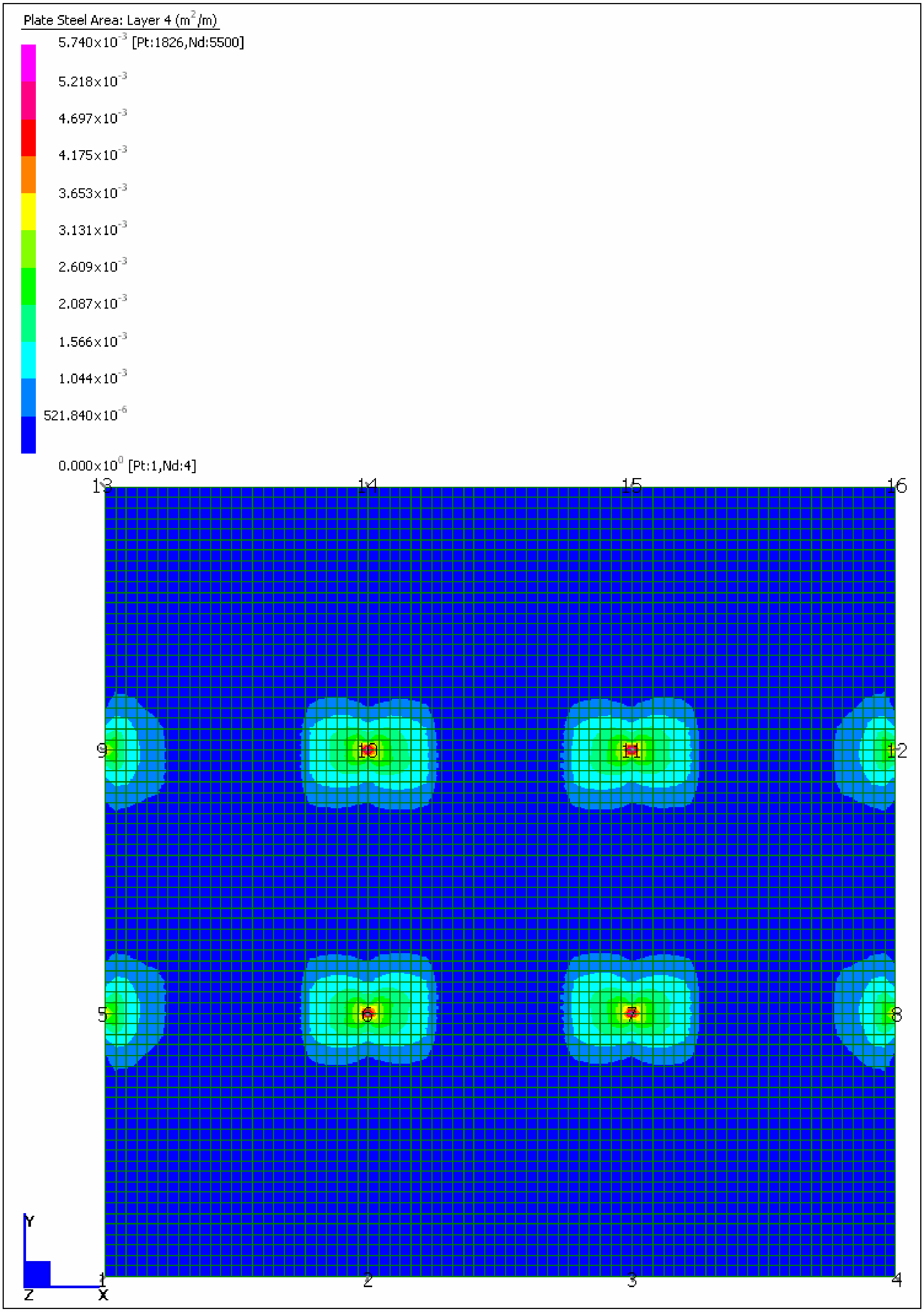

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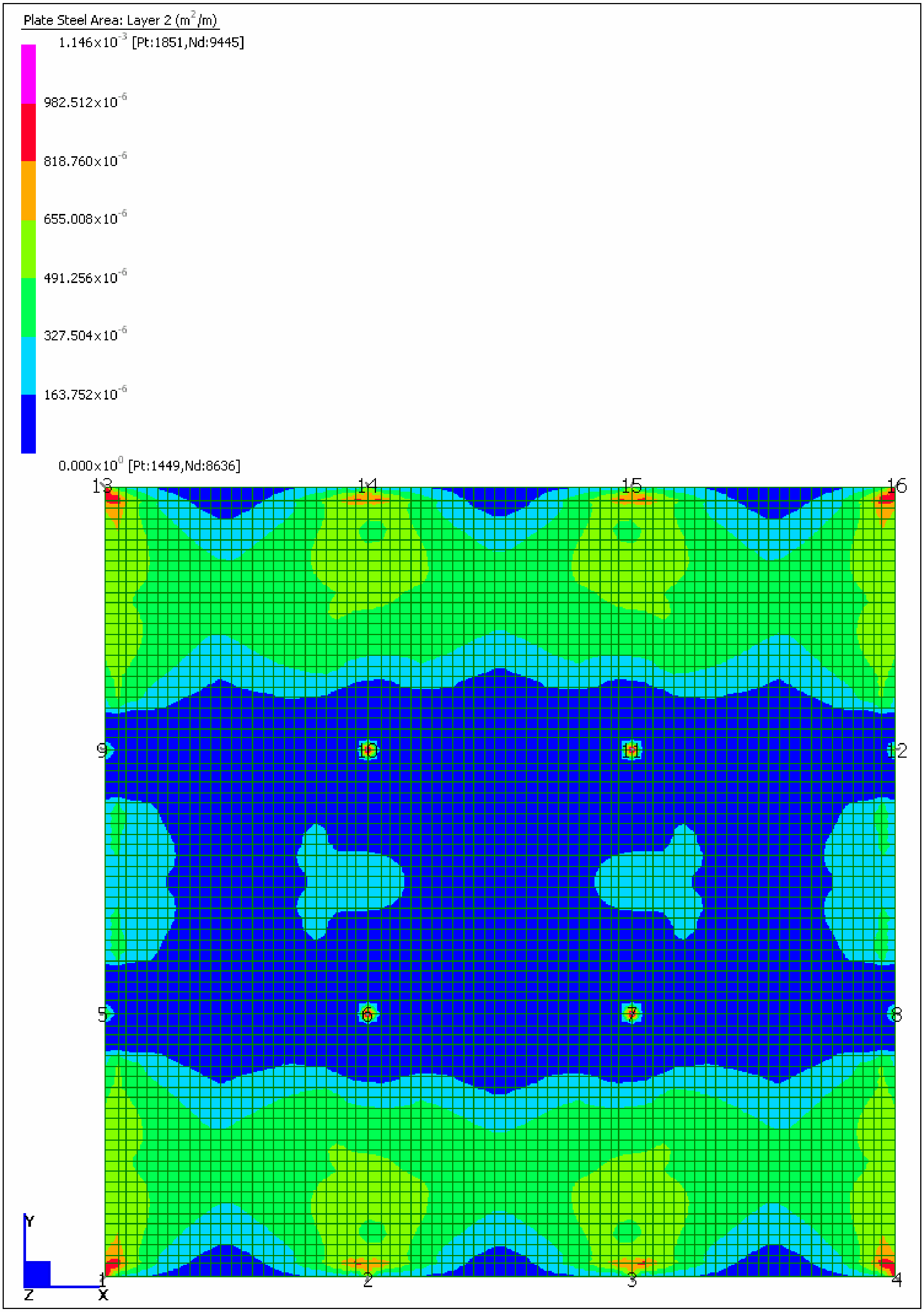
APPENDIX D

Post-tension – Normal Reinforcement Required



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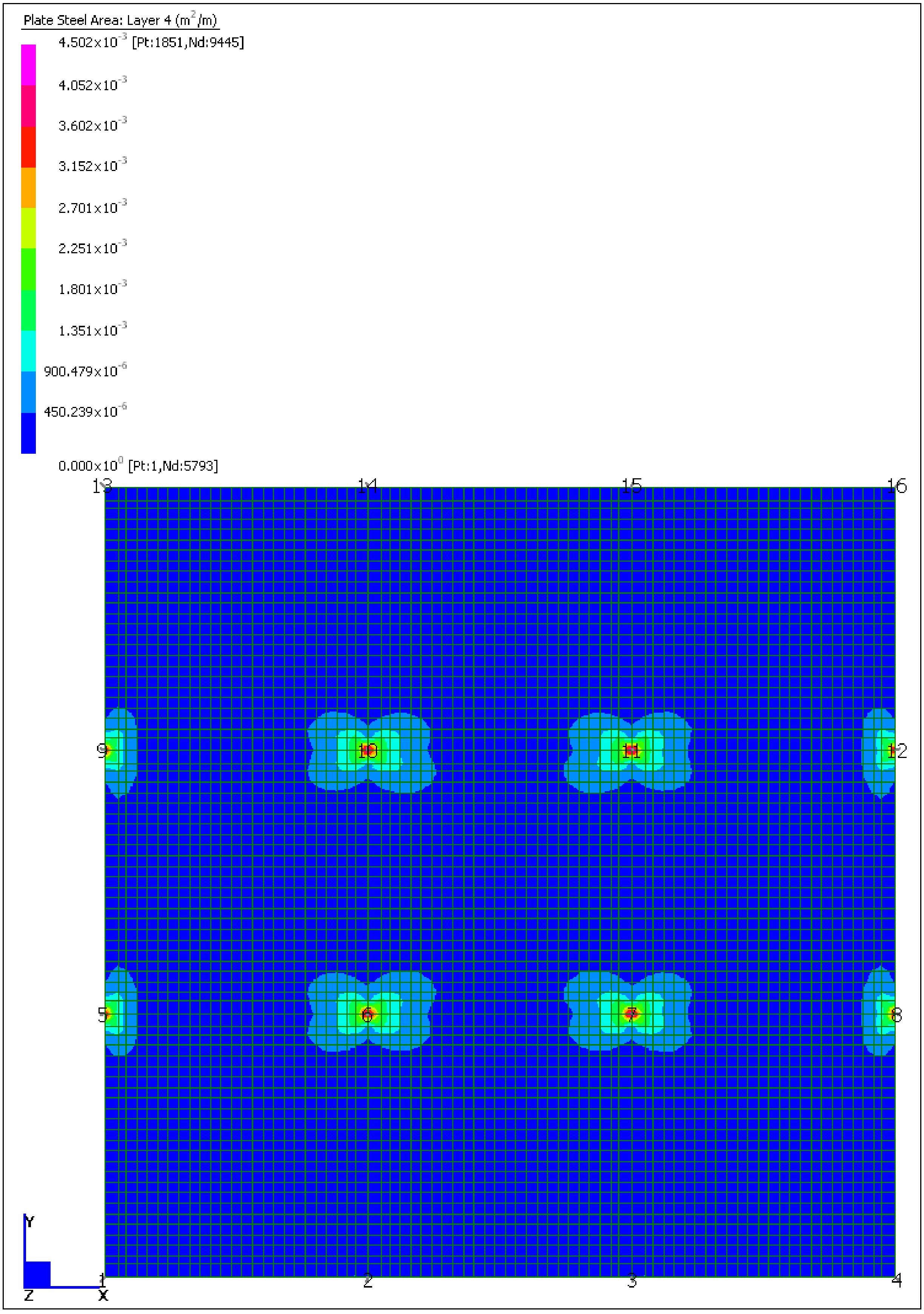
Plate Steel Area: Layer 4 (m2/m)
4.502x10-3 [Pt:1851,Nd:9445]
4.052x10-3
3.602x10-3
3.152x10-3
2.701x10-3
2.251x10-3
1.801x10-3
1.351x10-3
900.479x10-6
450.239x10-6
0.000x100 [Pt:1,Nd:5793]
13
14
15
16
9
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11
12
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Z
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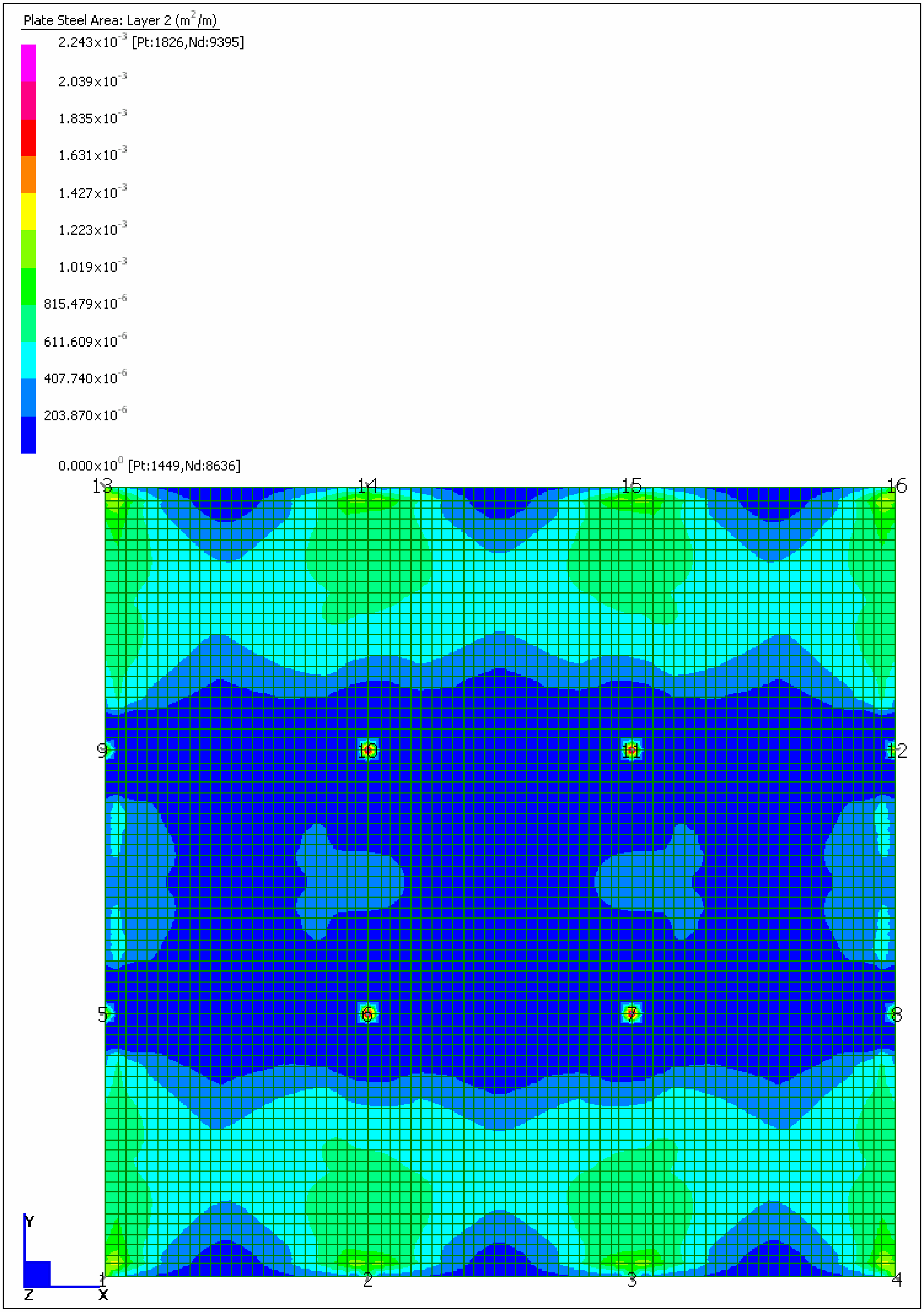

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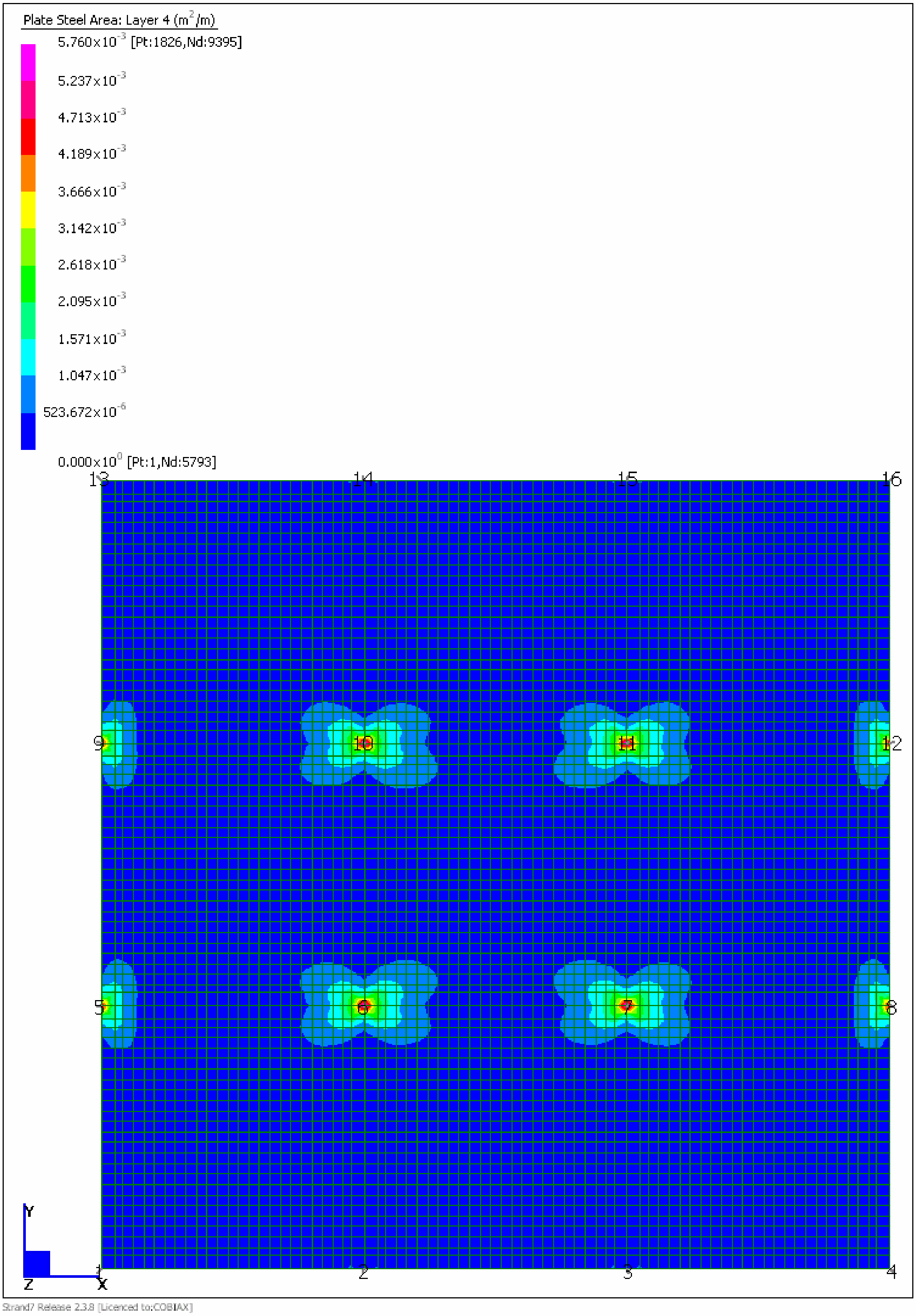
Plate Steel Area: Layer 4 (m2/m)
5.760x10-3 [Pt:1826,Nd:9395]
5.237x10-3
4.713x10-3
4.189x10-3
3.666x10-3
3.142x10-3
2.618x10-3
2.095x10-3
1.571x10-3
1.047x10-3
523.672x10-6
0.000x100 [Pt:1,Nd:5793]
13
14
15
16
9
10
11
12
5
6
7
8
1
2
3
4
Y
Z
X
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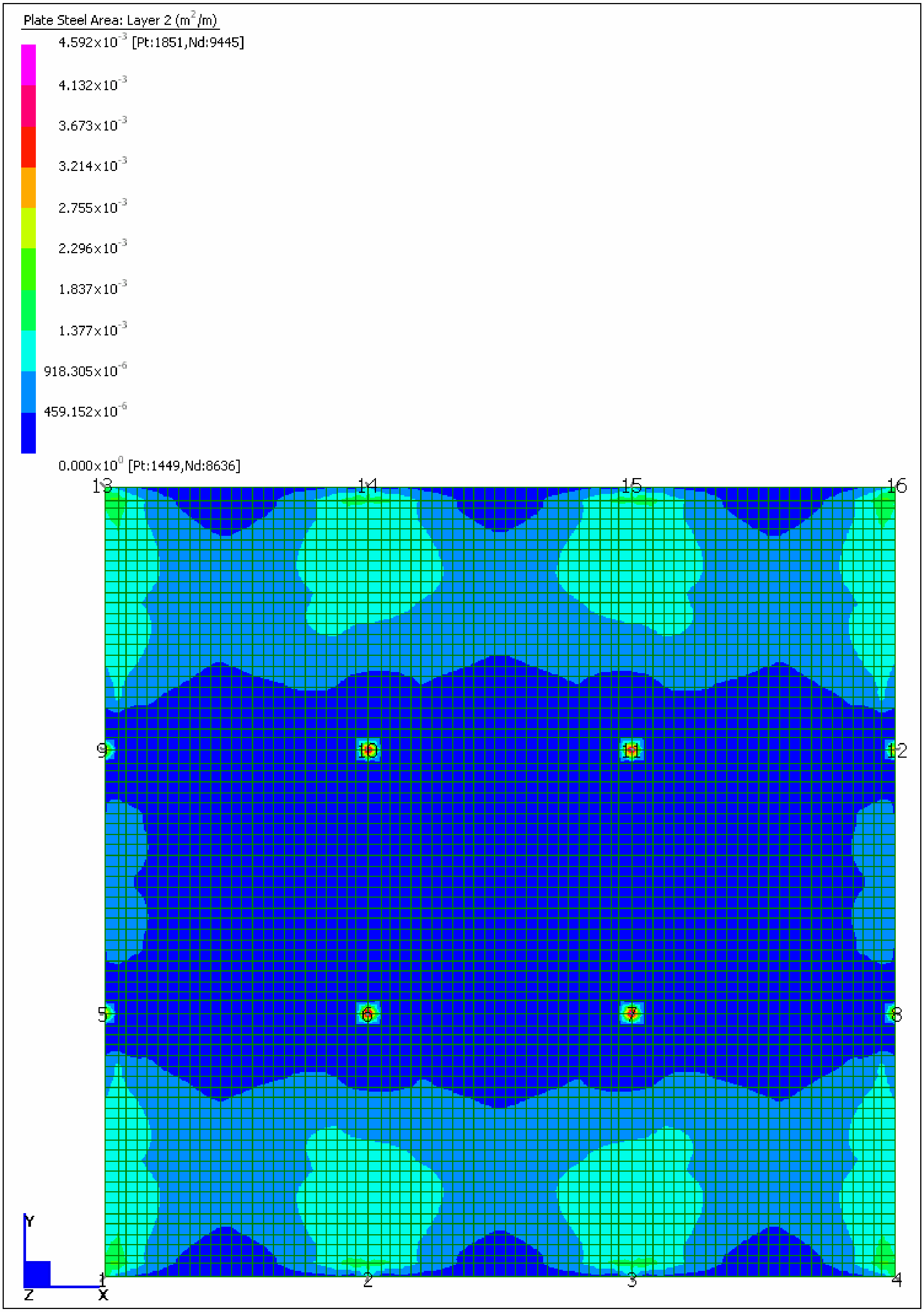
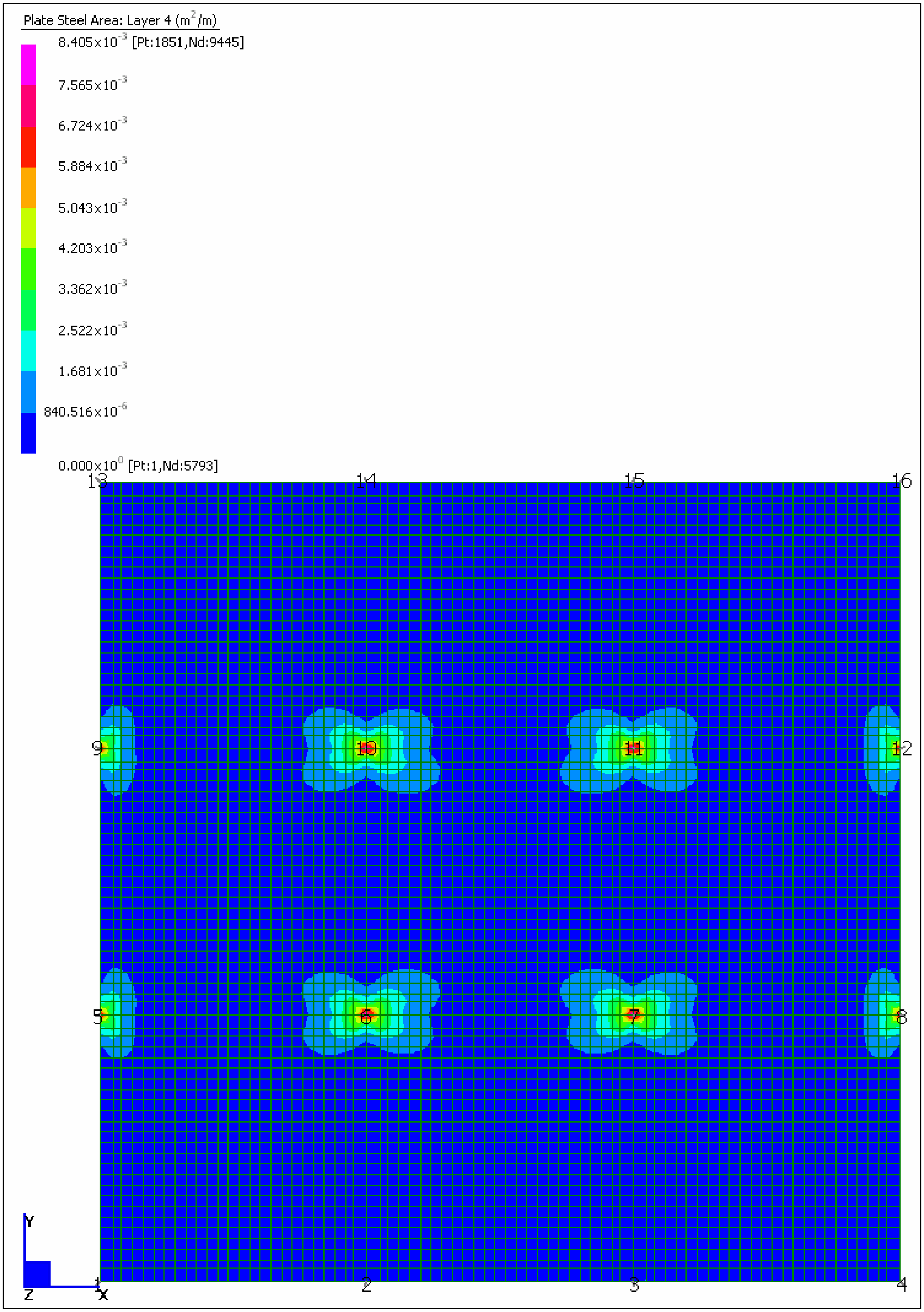


Plate Steel Area: Layer 2 (m^2/m)
4.592x10^{-3} [Pt:1851,Nd:9445]
4.132x10^{-3}
3.673x10^{-3}
3.214x10^{-3}
2.755x10^{-3}
2.296x10^{-3}
1.837x10^{-3}
1.377x10^{-3}
918.305x10^{-6}
459.152x10^{-6}
0.000x10^{0} [Pt:1449,Nd:8636]
13
14
15
16
9
10
11
12
5
6
7
8
1
2
3
4
Y
Z
X



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APPENDIX E

Formwork Cost Analysis

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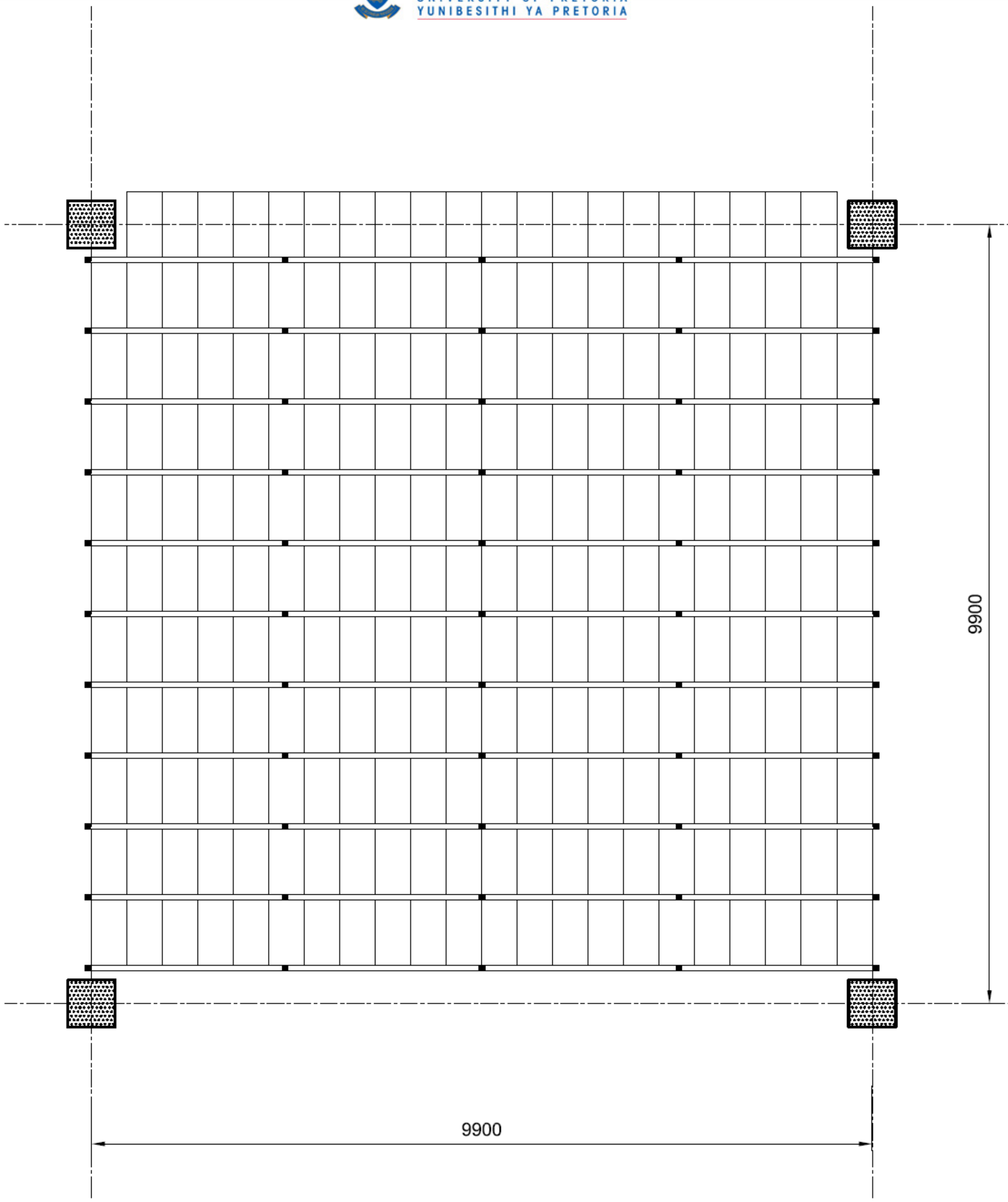

A	FIRST ISSUE	??????????????	Year-Month-Day	
No.	Amendment	By	Auth.	Date

WIEHAHN
4 Setter Road Midrand Industrial Park
Gauteng 1685
Tel : +27(11) 729 2300
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Authorised PERI distributor

Project Description:

COBIAX SLAB LAYOUT

Contactor:

Scale:	Drawn:	Design review:	Date:
Drawing No:			Revision:

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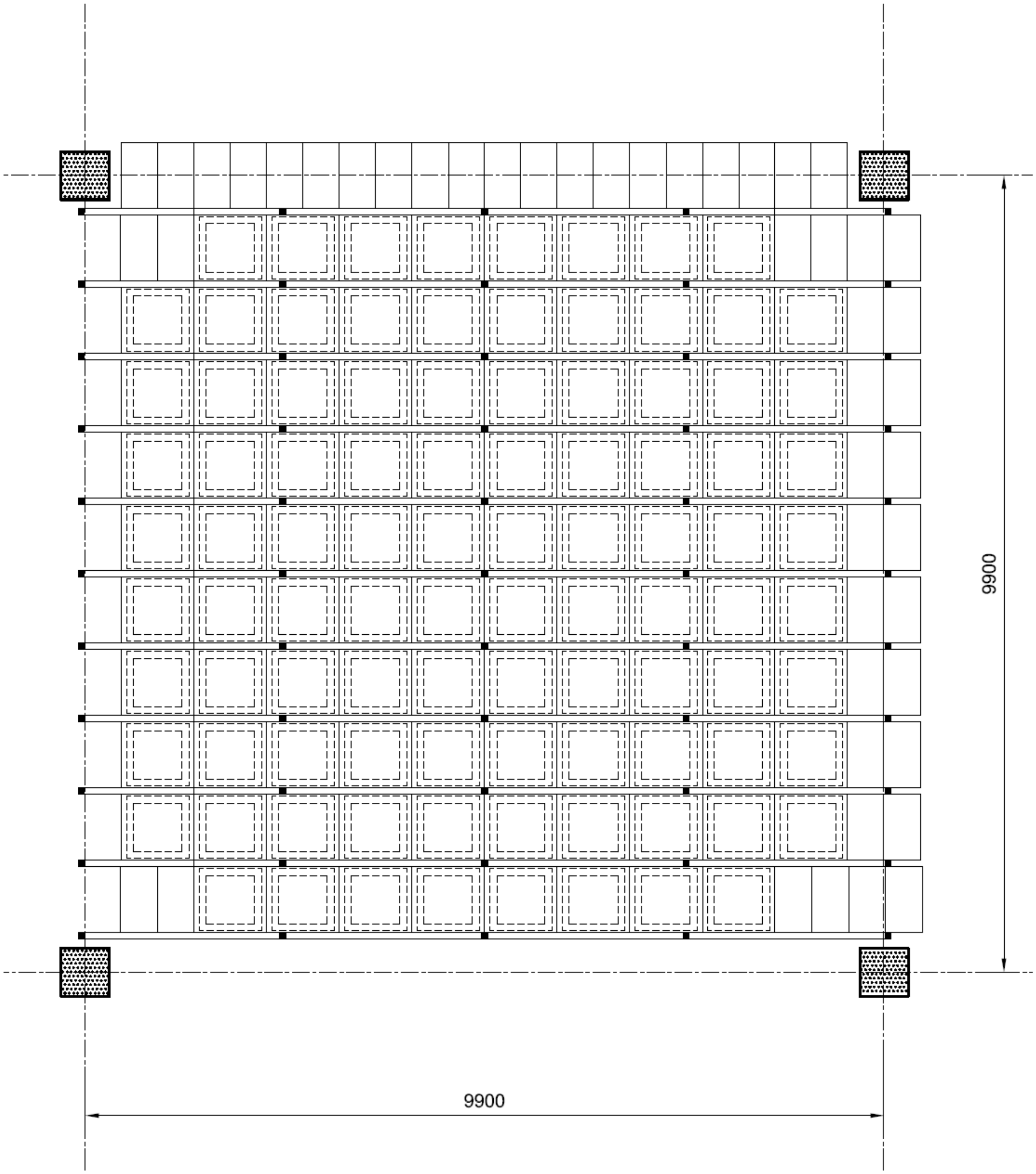
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA



No.	Amendment	By	Auth.	Date

WIEHAHN
4 Setter Road Midrand Industrial Park
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Tel : +27(11) 729 2300
Fax: +27(11) 729 2560
www.periwiehahn.co.za design@wiehahn.co.za
Authorised PERI distributor

Project Description:

COFFERED SLAB LAYOUT

Contactor:

Scale:	Drawn:	Design review:	Date:
Drawing No:			Revision:

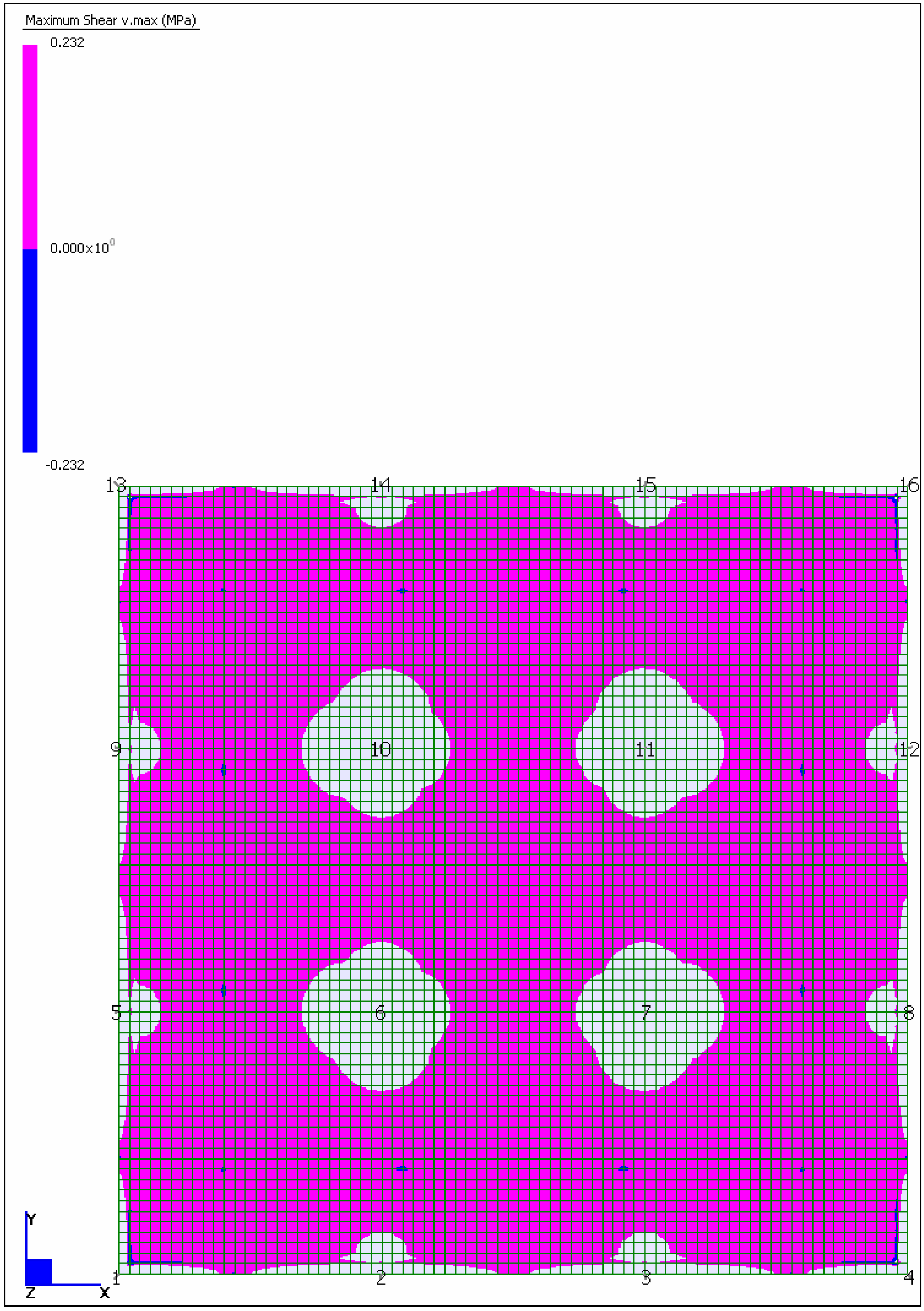
ITEM	OP CODE	D E S C R I P T I O N	UNIT	BILLED QUANTITY	NETT RATE	NETT AMOUNT
A	FW002	315 COBIAX SLAB 9900x9900 GRID	m²	98	14.16	1 387.68
B	FW002L	LABOUR ONLY TO ITEM C ABOVE	m²	98	36.00	3 528.00
C	FW001S	SUPPORT WORK TO A ABOVE (NO RE-PROPPING INCLUDED)	m²	98	13.85	1 357.30
		Page 2 total				6 272.98

ITEM	OP CODE	D E S C R I P T I O N	UNIT	BILLED QUANTITY	NETT RATE	NETT AMOUNT
A	FW001	900x900x425 COFFERED SLAB 9900x9900 GRID	m^2	98	46.69	4 575.62
B	FW001L	LABOUR ONLY TO ITEM A ABOVE	m^2	98	48.00	4 704.00
C	FW001L2	ADDITIONAL LABOUR FOR COFFER PLACEMENT	m^2	98	4.90	480.20
D	FW001S	SUPPORT WORK TO A ABOVE (NO RE-PROPPING INCLUDED)	m^2	98	13.85	1 357.30
		Page 1 total				11 117.12

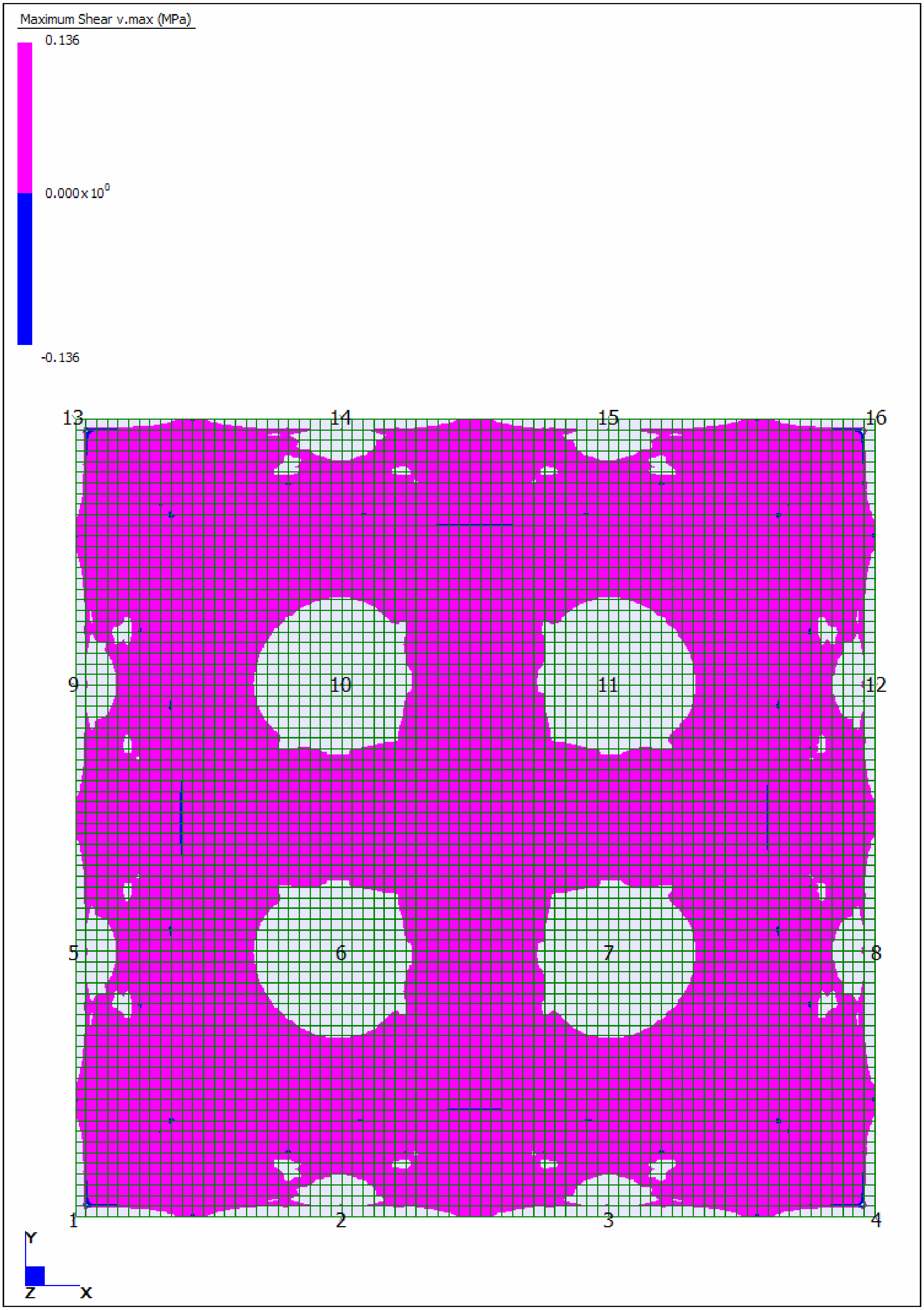
APPENDIX F

Typical Solid Zones for Cobiax and Coffer Slabs – Strand7

Shear Conto ab Solid Zones



Shear Contours In… d Zones – 10m Light



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APPENDIX G

Cobiax – Punching Shear Reinforcement

PROKON Software Consultants (Pty) Ltd Internet: http://www.prokon.com E-Mail : mail@prokon.com	Job Number	UNIVERSITEIT VAN PRETORIA UNIVERSITY OF PRETORIA YUNIBESITHI YA PRETORIA	Sheet
	Job Title	Cobiax 7.5m Light	
	Client		
	Calcs by	Checked by	Date

C23

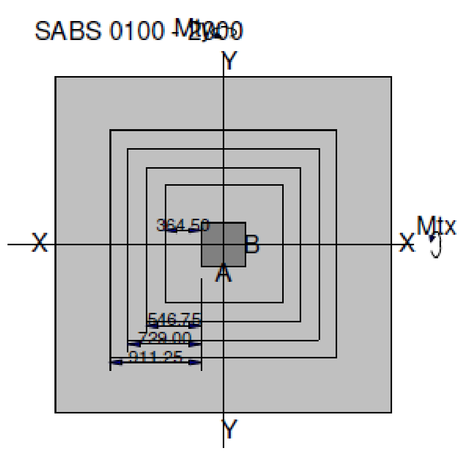
Punching Shear Design :

Input Data

Column width A	(mm)	450
Column breadth B	(mm)	450
Effective slab depth deff	(mm)	243
Nearest edge X-direction	(mm)	7500
Nearest edge Y-direction	(mm)	7500
fcu	(MPa)	30
fy flexural reinforcement	(MPa)	450
fyv shear reinforcement	(MPa)	450
X-reinforcement crossing perimeter		Y10@150
Perimeter 2	(mm²)	Y10@150
Perimeter 3	(mm²)	Y10@150
Perimeter 4	(mm²)	Y10@150
Y-reinforcement crossing perimeter		Y10@150
Perimeter 2	(mm²)	Y10@150
Perimeter 3	(mm²)	Y10@150
Perimeter 4	(mm²)	Y10@150
Shear head present	(Y/[N])	
Max. link/tie size	(mm)	16

Load Cases

Load Case	Description	ULS Shear Vt (kN)	ULS X-moment (kNm)	ULS Y-moment (kNm)
1	1	706		



Output for Load Case 1:1

Critical load case: 1:1	Load Case 1:1			
Perimeter	1	2	3	4
Distance from Column face (mm)	365	547	729	911
Critical length (mm)	4716	6174	7632	9090
Allowable shear stress vc (MPa)	0.39	0.39	0.39	0.39
Shear force capacity Vc (kN)	443	580	717	854
Effective shear force Veff (kN)	812	812	812	812
Total reqd. reinforcement Asv (mm^2)	1600	1533	1895	0
Suggested reinforcement configurations	32Y8	31Y8	25Y10	
	1608 mm^2	1558 mm^2	1963 mm^2	
	21Y10	20Y10	17Y12	
	1649 mm^2	1571 mm^2	1923 mm^2	
	15Y12	14Y12	10Y16	
	1696 mm^2	1583 mm^2	2011 mm^2	
	8Y16	8Y16	7Y20	
	1608 mm^2	1608 mm^2	2199 mm^2	

Shear reinforment should be placed in a band 1.5-d wide inside each critcical perimeter. Maximum spacing 0.75-d.

C23

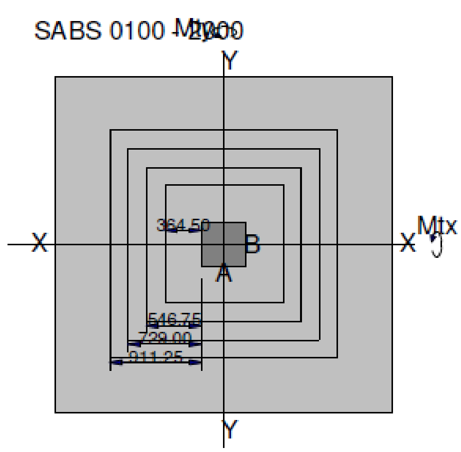
Punching Shear Design :

Input Data

Column width A	(mm)	450
Column breadth B	(mm)	450
Effective slab depth deff	(mm)	243
Nearest edge X-direction	(mm)	7500
Nearest edge Y-direction	(mm)	7500
fcu	(MPa)	30
fy flexural reinforcement	(MPa)	450
fyv shear reinforcement	(MPa)	450
X-reinforcement crossing perimeter (		Y12@125
Perimeter 2	(mm^2)	Y12@125
Perimeter 3	(mm^2)	Y12@125
Perimeter 4	(mm^2)	Y12@125
Y-reinforcement crossing perimeter (		Y12@125
Perimeter 2	(mm^2)	Y12@125
Perimeter 3	(mm^2)	Y12@125
Perimeter 4	(mm^2)	Y12@125
Shear head present	(Y/[N])	
Max. link/tie size	(mm)	16

Load Cases

Load Case	Description	ULS Shear Vt (kN)	ULS X-moment (kNm)	ULS Y-moment (kNm)
1	1	923		



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Job Number		Sheet
Job Title	Cobiax 7.5m Medium	
Client		
Calcs by	Checked by	Date

Output for Load Case 1:1

Critical load case: 1:1	Load Case 1:1			
Perimeter	1	2	3	4
Distance from Column face (mm)	365	547	729	911
Critical length (mm)	4716	6174	7632	9090
Allowable shear stress vc (MPa)	0.46	0.46	0.46	0.46
Shear force capacity Vc (kN)	532	696	860	1025
Effective shear force Veff (kN)	1061	1061	1061	1061
Total reqd. reinforcement Asv (mm^2)	2700	1533	1895	2257
Suggested reinforcement configurations	35Y10	31Y8	25Y10	29Y10
	2749 mm^2	1558 mm^2	1963 mm^2	2278 mm^2
	24Y12	20Y10	17Y12	20Y12
	2714 mm^2	1571 mm^2	1923 mm^2	2262 mm^2
	14Y16	14Y12	10Y16	12Y16
	2815 mm^2	1583 mm^2	2011 mm^2	2413 mm^2
	9Y20	8Y16	7Y20	8Y20
	2827 mm^2	1608 mm^2	2199 mm^2	2513 mm^2
Shear reinforment should be placed in a band 1.5-d wide inside each critcical perimeter. Maximum spacing 0.75-d.				

C23

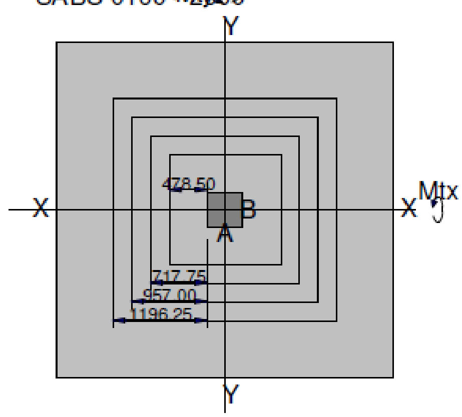
Punching Shear Design :

Input Data

Column width A	(mm)	450
Column breadth B	(mm)	450
Effective slab depth deff	(mm)	319
Nearest edge X-direction	(mm)	7500
Nearest edge Y-direction	(mm)	7500
fcu	(MPa)	30
fy flexural reinforcement	(MPa)	450
fyv shear reinforcement	(MPa)	450
X-reinforcement crossing perimeter		Y16@125
Perimeter 2	(mm²)	Y16@125
Perimeter 3	(mm²)	Y16@125
Perimeter 4	(mm²)	Y16@125
Y-reinforcement crossing perimeter		Y16@125
Perimeter 2	(mm²)	Y16@125
Perimeter 3	(mm²)	Y16@125
Perimeter 4	(mm²)	Y16@125
Shear head present	(Y/[N])	
Max. link/tie size	(mm)	16

Load Cases

Load Case	Description	ULS Shear Vt (kN)	ULS X-moment (kNm)	ULS Y-moment (kNm)
1	1	1532		



Output for Load Case 1:1

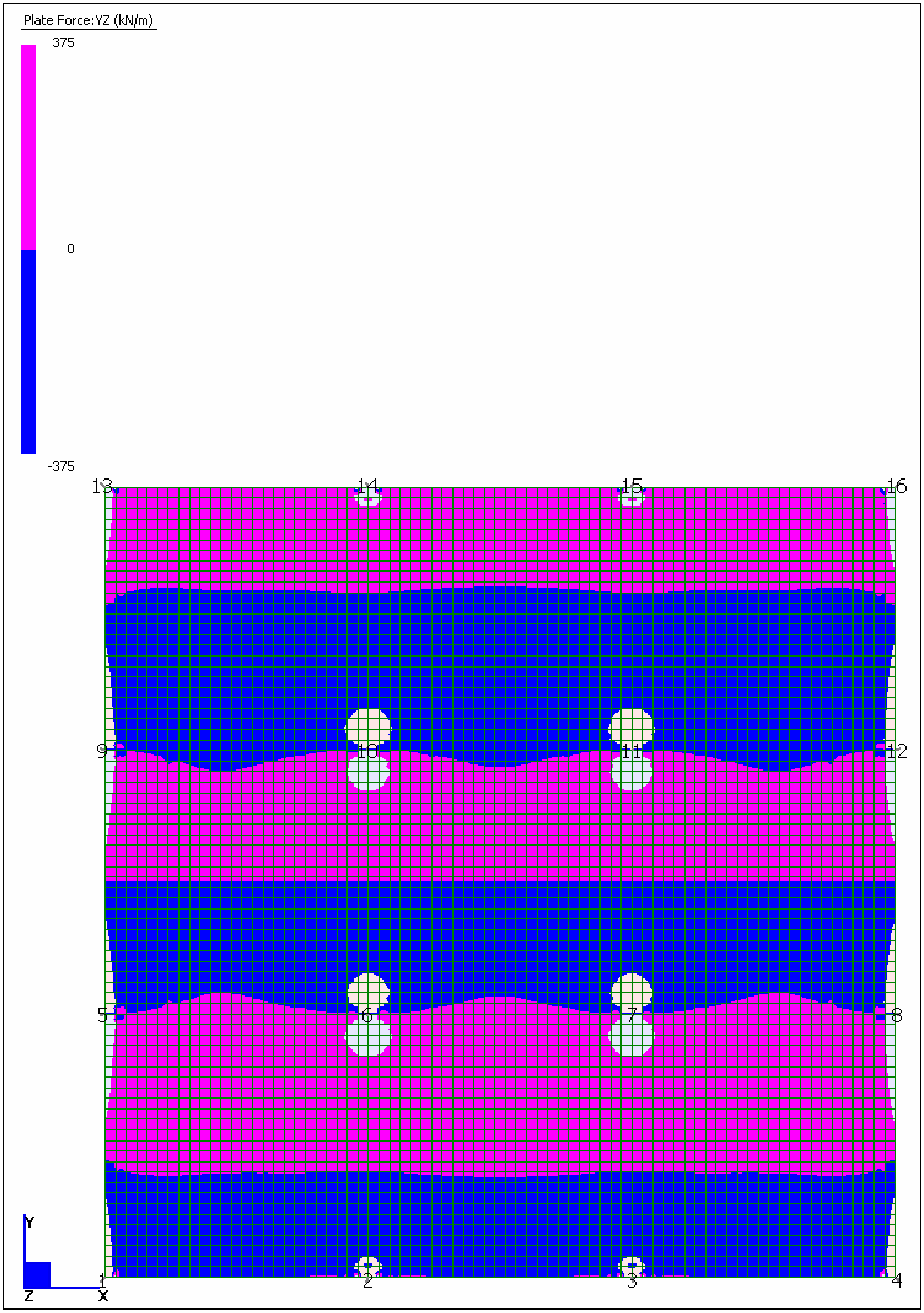
Critical load case: 1:1	Load Case 1:1			
Perimeter	1	2	3	4
Distance from Column face (mm)	479	718	957	1196
Critical length (mm)	5628	7542	9456	11370
Allowable shear stress vc (MPa)	0.48	0.48	0.48	0.48
Shear force capacity Vc (kN)	861	1154	1446	1739
Effective shear force Veff (kN)	1762	1762	1762	1762
Total reqd. reinforcement Asv (mm^2)	4756	2458	3082	3706
Suggested reinforcement configurations	43Y12	32Y10	40Y10	33Y12
	4863 mm^2	2513 mm^2	3142 mm^2	3732 mm^2
	24Y16	22Y12	28Y12	19Y16
	4825 mm^2	2488 mm^2	3167 mm^2	3820 mm^2
	16Y20	13Y16	16Y16	12Y20
	5027 mm^2	2614 mm^2	3217 mm^2	3770 mm^2
	10Y25	8Y20	10Y20	8Y25
	4909 mm^2	2513 mm^2	3142 mm^2	3927 mm^2

Warning: Shear stress v exceeds 2*vc !
justification of the design required

Shear reinforment should be placed in a band 1.5-d wide
inside each critcical perimeter. Maximum spacing 0.75-d.

APPENDIX H

Shear Contours for 620 mm Thick Cobiax Slab – Strand7



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APPENDIX I

Coffer – Punching Shear Reinforcement

C23

Punching Shear Design :

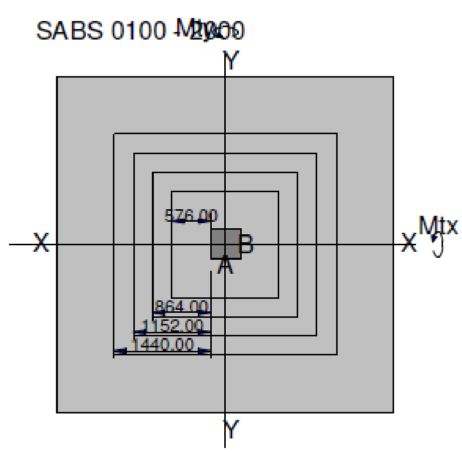
Input Data

Column width A	(mm)	450
Column breadth B	(mm)	450
Effective slab depth deff	(mm)	384
Nearest edge X-direction	(mm)	7500
Nearest edge Y-direction	(mm)	7500
fcu	(MPa)	30
fy flexural reinforcement	(MPa)	450
fyv shear reinforcement	(MPa)	450
X-reinforcement crossing perimeter		Y16@150
Perimeter 2	(mm²)	Y16@150
Perimeter 3	(mm²)	Y16@150
Perimeter 4	(mm²)	Y16@150
Y-reinforcement crossing perimeter		Y16@150
Perimeter 2	(mm²)	Y16@150
Perimeter 3	(mm²)	Y16@150
Perimeter 4	(mm²)	Y16@150
Shear head present	(Y/[N])	
Max. link/tie size	(mm)	16

Load Cases

Load Case	Description	ULS Shear Vt (kN)	ULS X-moment (kNm)	ULS Y-moment (kNm)
1	1	706		

SABS 0100 - 2000



Output for Load Case 1:1

Critical load case: 1:1	Load Case 1:1			
Perimeter	1	2	3	4
Distance from Column face (mm)	576	864	1152	1440
Critical length (mm)	6408	8712	11016	13320
Allowable shear stress vc (MPa)	0.40	0.40	0.40	0.40
Shear force capacity Vc (kN)	996	1355	1713	2071
Effective shear force Veff (kN)	812	812	812	812
Total reqd. reinforcement Asv (mm^2)	0	0	0	0
Suggested reinforcement configurations				
Shear reinforment should be placed in a band 1.5-d wide inside each critcical perimeter. Maximum spacing 0.75-d.				

C23

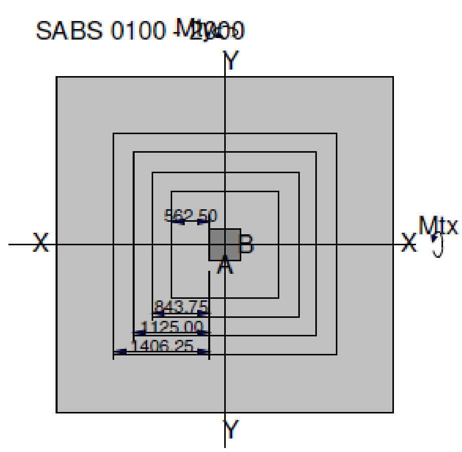
Punching Shear Design :

Input Data

Column width A	(mm)	450
Column breadth B	(mm)	450
Effective slab depth deff	(mm)	375
Nearest edge X-direction	(mm)	7500
Nearest edge Y-direction	(mm)	7500
fcu	(MPa)	30
fy flexural reinforcement	(MPa)	450
fyv shear reinforcement	(MPa)	450
X-reinforcement crossing perimeter		Y25@300
Perimeter 2	(mm²)	Y25@300
Perimeter 3	(mm²)	Y25@300
Perimeter 4	(mm²)	Y25@300
Y-reinforcement crossing perimeter		Y25@300
Perimeter 2	(mm²)	Y25@300
Perimeter 3	(mm²)	Y25@300
Perimeter 4	(mm²)	Y25@300
Shear head present	(Y/[N])	
Max. link/tie size	(mm)	16

Load Cases

Load Case	Description	ULS Shear Vt (kN)	ULS X-moment (kNm)	ULS Y-moment (kNm)
1	1	1057		



Output for Load Case 1:1

Critical load case: 1:1	Load Case 1:1			
Perimeter	1	2	3	4
Distance from Column face (mm)	563	844	1125	1406
Critical length (mm)	6300	8550	10800	13050
Allowable shear stress vc (MPa)	0.44	0.44	0.44	0.44
Shear force capacity Vc (kN)	1037	1407	1777	2147
Effective shear force Veff (kN)	1216	1216	1216	1216
Total reqd. reinforcement Asv (mm^2)	2414	0	0	0
Suggested reinforcement configurations	31Y10			
	2435 mm^2			
	22Y12			
	2488 mm^2			
	13Y16			
	2614 mm^2			
	8Y20			
	2513 mm^2			
Shear reinforment should be placed in a band 1.5-d wide inside each critcical perimeter. Maximum spacing 0.75-d.				

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	Job Title Coffer - 7.5m Heavy			
	Client			
	Calcs by	Checked by	Date	

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YUNIBESITHI YA PRETORIA

C23

Punching Shear Design :

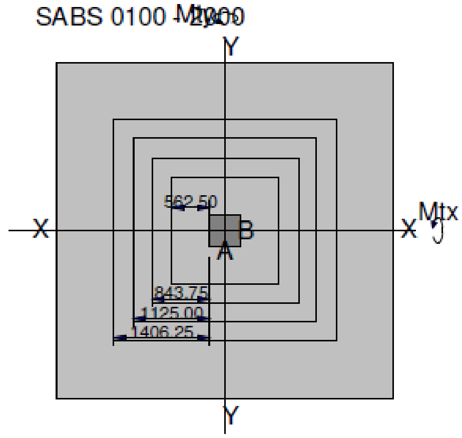
Input Data

Column width A	(mm)	450
Column breadth B	(mm)	450
Effective slab depth deff	(mm)	375
Nearest edge X-direction	(mm)	7500
Nearest edge Y-direction	(mm)	7500
fcu	(MPa)	30
fy flexural reinforcement	(MPa)	450
fyv shear reinforcement	(MPa)	450
X-reinforcement crossing perimeter		Y25@150
Perimeter 2	(mm²)	Y25@150
Perimeter 3	(mm²)	Y25@150
Perimeter 4	(mm²)	Y25@150
Y-reinforcement crossing perimeter		Y25@150
Perimeter 2	(mm²)	Y25@150
Perimeter 3	(mm²)	Y25@150
Perimeter 4	(mm²)	Y25@150
Shear head present	(Y/[N])	
Max. link/tie size	(mm)	16

Load Cases

Load Case	Description	ULS Shear Vt (kN)	ULS X-moment (kNm)	ULS Y-moment (kNm)
1	1	1550		

SABS 0100 - 2000



Output for Load Case 1:1

Critical load case: 1:1	Load Case 1:1			
Perimeter	1	2	3	4
Distance from Column face (mm)	563	844	1125	1406
Critical length (mm)	6300	8550	10800	13050
Allowable shear stress vc (MPa)	0.55	0.55	0.55	0.55
Shear force capacity Vc (kN)	1306	1773	2239	2706
Effective shear force Veff (kN)	1783	1783	1783	1783
Total reqd. reinforcement Asv (mm^2)	2414	3276	0	0
Suggested reinforcement configurations	31Y10	29Y12		
	2435 mm^2	3280 mm^2		
	22Y12	17Y16		
	2488 mm^2	3418 mm^2		
	13Y16	11Y20		
	2614 mm^2	3456 mm^2		
	8Y20	7Y25		
	2513 mm^2	3436 mm^2		
Shear reinforment should be placed in a band 1.5-d wide inside each critcical perimeter. Maximum spacing 0.75-d.				

APPENDIX J

Post-tension Slab – Punching Shear Reinforcement

PROKON Software Consultants (Pty) Ltd Internet: http://www.prokon.com E-Mail : mail@prokon.com	Job Number		Sheet
	Job Title PT 7.5m Light		
	Client		
	Calcs by	Checked by	Date

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UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

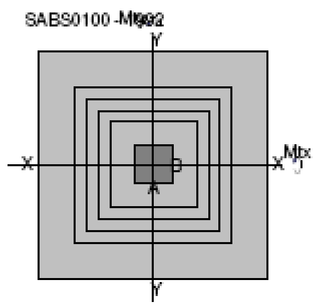
Punching shear data: column 3

Design data

A	(mm)	450
B	(mm)	450
C	(mm)	0
D	(mm)	0
DeffX	(mm)	185
DeffY	(mm)	185
X	(mm)	7500
Y	(mm)	7500
Corner	(Y.N)	N
Vt	(kN)	635.4
Mtx	(kNm)	53.5
Mty	(kNm)	53.5
Pcx	(kN)	4254.4
Pcy	(kN)	709.0
UDL	(kN/m²)	10.4
slope-X		0.0521
slope-Y		0.0521
Cable type no.		1
N cables	X	Y
Perim 1	10	1
Perim 2	12	2
Perim 3	12	2
Perim 4	12	3
Ast (mm²)	X	Y
Perim 1	524.0	524.0
Perim 2	524.0	524.0
Perim 3	524.0	524.0
Perim 4	524.0	524.0

Perimeter output

Perimeter	Ucrit (mm)	vc (MPa)	Vcap (kN)	Veff (kN)	Asv (mm²)
1	4020.00	0.79	586.55	460.04	0.00
2	5130.00	0.81	765.66	452.44	0.00
3	6240.00	0.77	884.13	443.01	0.00
4	7350.00	0.75	1024.90	431.74	0.00



PROKON Software Consultants (Pty) Ltd
Internet: http://www.prokon.com
E-Mail : mail@prokon.com
Job Number
Sheet
Job Title PT 7.5m Medium
Client
Calcs by
Checked by
Date

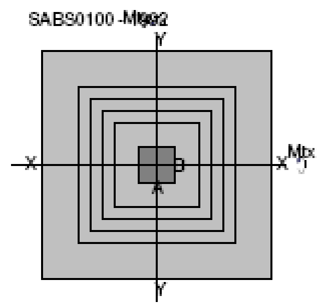
Punching shear data: column 3

Design data

A	(mm)	450
B	(mm)	450
C	(mm)	0
D	(mm)	0
DeffX	(mm)	195
DeffY	(mm)	195
X	(mm)	7500
Y	(mm)	7500
Corner	(Y.N)	N
Vt	(kN)	850.0
Mtx	(kNm)	69.7
Mty	(kNm)	69.7
Pcx	(kN)	4555.0
Pcy	(kN)	1051.0
UDL	(kN/m²)	13.9
slope-X		0.0544
slope-Y		0.0544
Cable type no.		1
N cables	X	Y
Perim 1	10	2
Perim 2	13	3
Perim 3	16	3
Perim 4	16	4
Ast (mm²)	X	Y
Perim 1	524.0	524.0
Perim 2	524.0	524.0
Perim 3	524.0	524.0
Perim 4	524.0	524.0

Perimeter output

Perimeter	Ucrit (mm)	vc (MPa)	Vcap (kN)	Veff (kN)	Asv (mm²)
1	4140.00	0.81	656.43	655.41	0.00
2	5310.00	0.82	847.34	644.36	0.00
3	6480.00	0.80	1007.51	630.58	0.00
4	7650.00	0.78	1170.89	614.07	0.00



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APPENDIX K

Post-tension Slabs – Cable Design

MATHCAD V12.0

Prestressed Flat Slab - Light loading - 7.5m spans

{3 Span X 3 Span Slab Configuration}

Adapted from an example by Marshall & Robberts

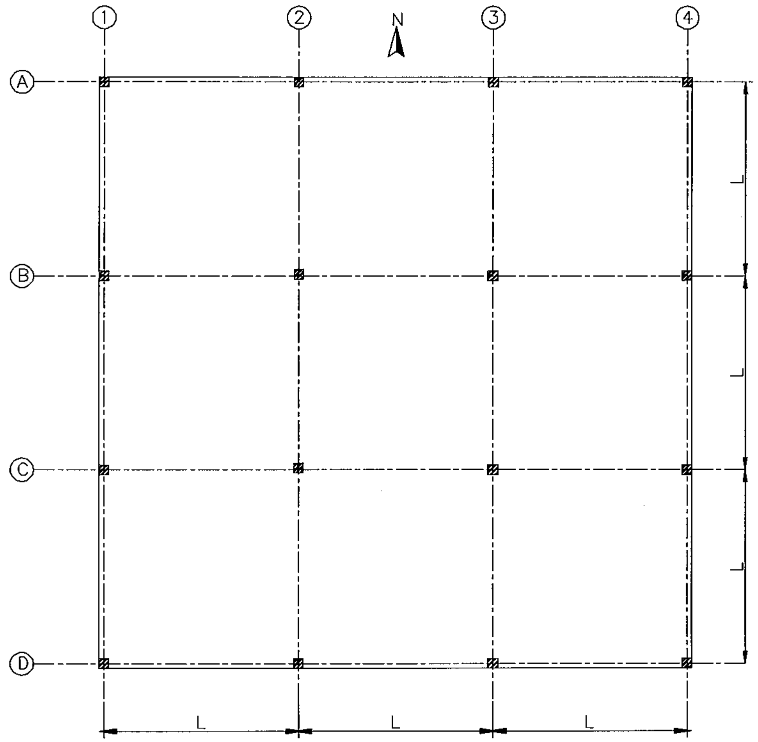

Figure 1: Layout

Design Codes:

SANS 10100-1: 2000
SABS 0160: 1989

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Unit Declarations:

$GPa := Pa \cdot 10^9$ $MPa := Pa \cdot 10^6$ $kPa := Pa \cdot 10^3$ $kN := N \cdot 10^3$

Material Properties:

Concrete Parameters:

28-day compressive strength		$f_{cu} := 30MPa$
Compressive strength at transfer		$f_{ci} := 18MPa$
		$K_o := 20 \cdot GPa$
Modulus of elasticity at 28 days	$E_c := K_o + 0.2GPa \cdot \frac{f_{cu}}{MPa}$	$E_c = 26 \cdot GPa$
Modulus of elasticity at transfer	$E_{ct} := E_c \cdot \left(0.4 + 0.6 \cdot \frac{f_{ci}}{f_{cu}}\right)$	$E_{ct} = 19.76 \cdot GPa$
Unit weight of concrete		$\gamma_c := 25 \frac{kN}{m^3}$

Non-prestressed reinforcement:

Main	$fy := 450MPa$
Shear	$fyv := 450MPa$
Modulus of elasticity	$Es := 200GPa$
Diameter bottom rebar	$\phi_b := 10mm$
Diameter top rebar	$\phi_t := 10mm$

Prestressed Reinforcement

Unbonded prestress

(15.7mm diameter 7-wire unbonded low relaxation super grade strand)

Characteristic breaking load per strand $P_{tnd} := 265kN$

Steel area per strand $A_{ps} := 150mm^2$

Modulus of elasticity $E_p := 195GPa$

Loads:

Service Loads

Assume $h := 220mm$

Slab Self-weight $w_{sw} := h \cdot \gamma_c$ $w_{sw} = 5.5 \cdot kPa$

Additional Dead Load $w_{ADL} := 0.5kPa$

Total dead load $w_D := w_{sw} + w_{ADL}$ $w_D = 6.0 \cdot kPa$

Imposed Live Load $w_L := 2kPa$

Ultimate Loads

Ultimte UDL $w_{ult} := 1.2 \cdot w_D + 1.6 \cdot w_L$ $w_{ult} = 10.4 \cdot kPa$

Percentage Dead Load to be Balanced $Bal_D := 70\%$

Load Balanced $w_{bal} := w_D \cdot Bal_D$ $w_{bal} = 4.2 \cdot kPa$

Dimensional Parameters:

Slab span $L := 7500mm$ {Assuming equal spans}

Calculation of slab depth

Factors $K_1 := 0.9$ (0.9 for End-Span and 1.0 for Internal Span)

$K_2 := 1.0$ (0.95 for temperature or shrinkage cracking and 1.0 for cracking not likely)

$$K_3 := \left(\frac{E_c}{26 \cdot GPa}\right)^{\frac{1}{3}} \qquad K_3 = 1$$

$K_4 := 1.0$ (1.0 no drops & 1.15 drops present)

Slab Depth

$$h := \frac{L}{\left[14 + \frac{53}{\left(\frac{3.5 \cdot w_D + w_L - 3.32 \cdot Bal_D \cdot w_D}{kPa}\right)^{\frac{1}{3}}}\right] \cdot K_1 \cdot K_2 \cdot K_3 \cdot K_4}$$

$h = 211.36 \cdot mm$

Keep $h := 220mm$

Allowable slab depth $h := \max(h, 200mm)$ $h = 220 \cdot mm$

Cover to reinforcement

Top $C_{top} := 25mm$

Bottom $C_{bot} := 25mm$

Tendon Profile:

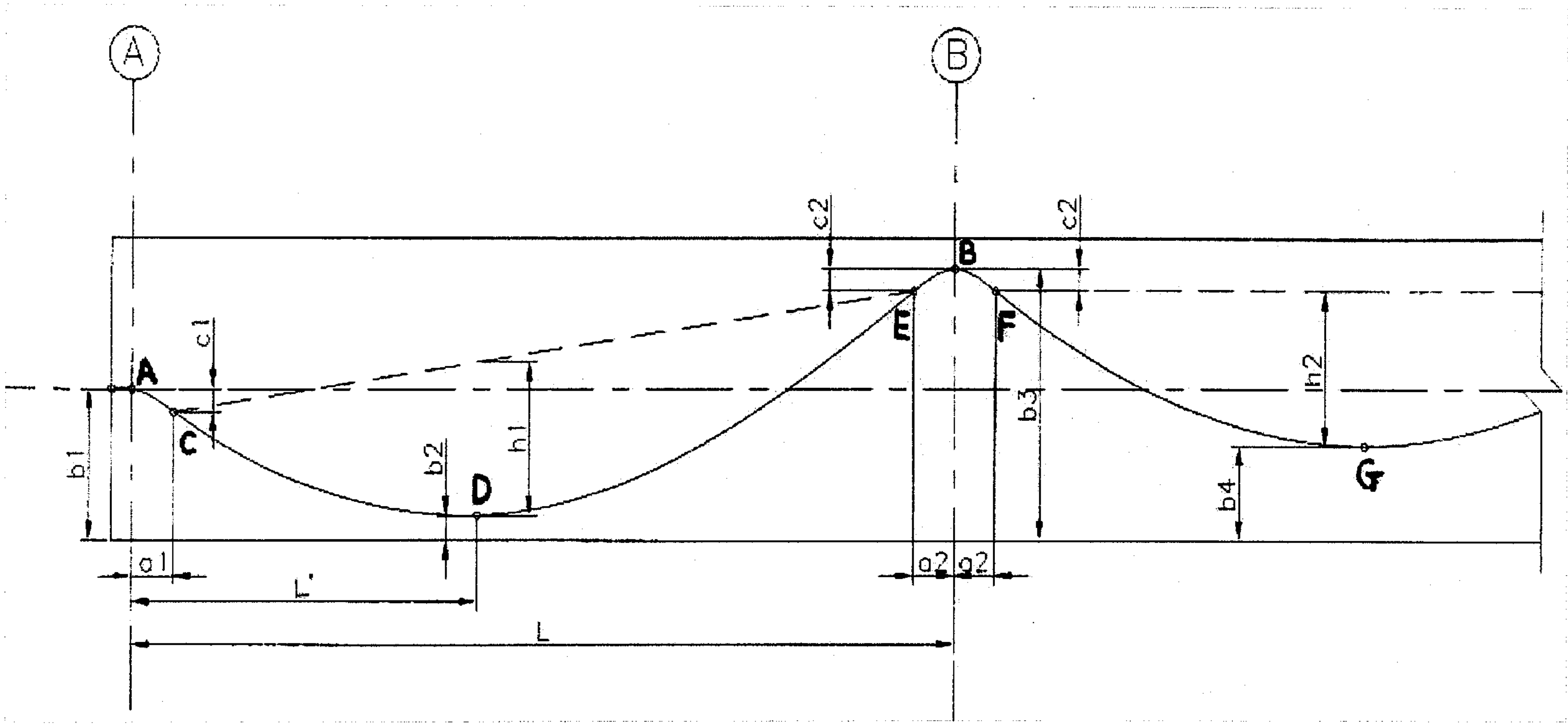

Figure 2: Tendon Profile Parameters

Maximum drape in North-south direction. Distance from centre of supports to the inflection points of the profile taken equal to 0.05 times the span.

$a_1 := 0.05 \cdot L$ $\quad$ $a_1 = 375 \cdot mm$

$a_2 := 0.05L$ $\quad$ $a_2 = 375 \cdot mm$

$b_1 := \frac{h}{2}$ $\quad$ $b_1 = 110 \cdot mm$

$S_p := 9mm$ (Strand position in sheath)

$b_2 := C_{bot} + \phi_b + 9mm \qquad b_2 = 44 \cdot mm$

Distance top to centre tendon direction 1 $\quad t_1 := C_{top} + \phi_t + 9mm \qquad t_1 = 44 \cdot mm$

$b_3 := h - t_1 \qquad b_3 = 176 \cdot mm$

$l := b_3 - b_1 \qquad l = 66 \cdot mm$

$m_1 := (2 \cdot L - a_2) \cdot (b_1 - b_2) - a_1 \cdot (b_3 - b_2) \qquad m_1 = 9.158 \times 10^5 \cdot mm^2$

$n := -(b_1 - b_2) \cdot (L - a_2) \cdot L \qquad n = -3.527 \times 10^9 \cdot mm^3$

$$L' := \frac{-m_1 + \sqrt{m_1^2 - 4 \cdot l \cdot n}}{2l} \qquad L' = 3140.5 \cdot mm$$

$$c_1 := \frac{[(b_1 - b_2) \cdot a_1]}{L'} \qquad c_1 = 7.881 \cdot mm$$

$$c_2 := \frac{[(b_3 - b_2) \cdot a_2]}{(L - L')} \qquad c_2 = 11.355 \cdot mm$$

Drape $\quad h_1 := \dfrac{(b_1 - b_2) \cdot (L - a_1 - a_2)^2}{4 \cdot L' \cdot (L' - a_1)} \qquad h_1 = 86.559 \cdot mm$

Prestressing Force

$w_b=(8Ph)/(L-a_1-a_2)^2$

Per column Strip :

Load to be balanced $\quad w_b := L \cdot w_{bal} \qquad w_b = 31.5 \cdot \frac{kN}{m}$

Required Prestressing Force $P := \frac{w_b \cdot (L - a_1 - a_2)^2}{8 \cdot h_1}$ $P = 2.073 \times 10^3 \cdot kN$

Required internal span drape to maintain load balancing $h_2 := \frac{\left[w_b \cdot (L - a_2 - a_2)^2\right]}{8 \cdot P}$ $h_2 = 86.559 \cdot mm$

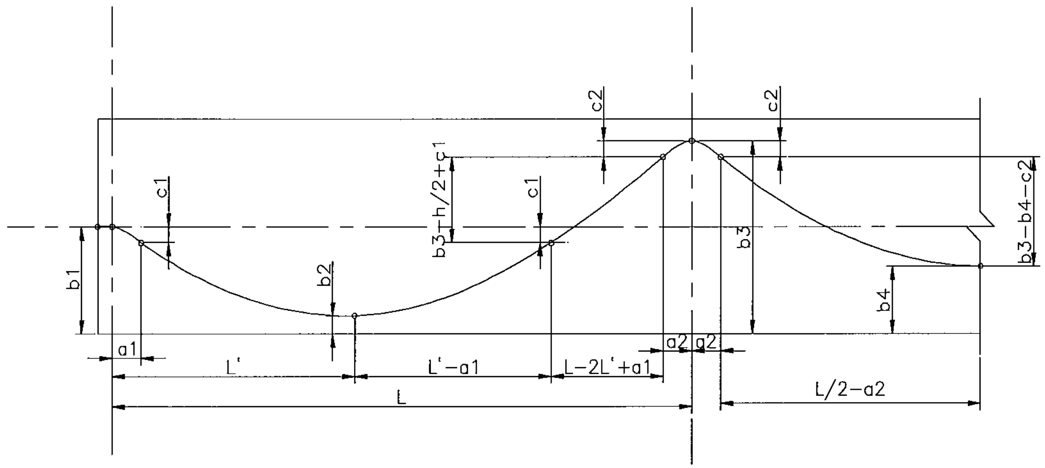

Figure 3: Parameter Calculations

PRESTRESSING LOSSES

Percentage Stressed $P_{Stressed} := 80\%$

SHORT-TERM LOSSES

Coefficient of Friction $\mu := 0.06$

Wobble coefficient $K_W := 0.00025 \cdot m^{-1}$

Anchorage seating $\delta := 5mm$

Cumulative Change in angle:

$\theta_{AC} := \operatorname{atan}\left(\frac{2c_1}{a_1}\right)$ $\theta_{AC} = 0.04201 \cdot rad$

$\theta_{CD} := \operatorname{atan}\left[\frac{2(b_1 - c_1 - b_2)}{L' - a_1}\right]$ $\theta_{CD} = 0.04201 \cdot rad$

$\theta_{DE} := \operatorname{atan}\left[\frac{2(b_3 - c_2 - b_2)}{L - L' - a_2}\right]$ $\theta_{DE} = 0.06048 \cdot rad$

$\theta_{EB} := \operatorname{atan}\left(\frac{2c_2}{a_2}\right)$ $\theta_{EB} = 0.06048 \cdot rad$

$\theta_{BF} := \operatorname{atan}\left(\frac{2c_2}{a_2}\right)$ $\theta_{BF} = 0.06048 \cdot rad$

$\theta_{FG} := \operatorname{atan}\left[\frac{2(b_3 - c_2 - b_4)}{\frac{L}{2} - a_2}\right]$ $\theta_{FG} = 0.05125 \cdot rad$

Angle changes over entire span lengths displayed in Figure 1

$\alpha_{AB} := \theta_{AC} + \theta_{CD} + \theta_{DE} + \theta_{EB}$ $\qquad \alpha_{AB} = 0.2050 \cdot rad$

$\alpha_{BC} := 2\theta_{FG} + 2\theta_{BF}$ $\qquad \alpha_{BC} = 0.2235 \cdot rad$

$\alpha_{AC} := \alpha_{AB} + \alpha_{BC}$ $\qquad \alpha_{AC} = 0.4284 \cdot rad$

$\alpha_{AD} := 2 \cdot \alpha_{AB} + \alpha_{BC}$ $\qquad \alpha_{AD} = 0.6334 \cdot rad$

Half of the tendons are tensioned from one end while the remainder is tensioned from the opposite end.

Percentage stressed $\qquad P_{Stressed} = 80 \cdot \%$

Jacking force per tendon $\qquad P_{tndJ} := P_{Stressed} \cdot -P_{tnd}$ $\qquad P_{tndJ} = -212 \cdot kN$

$Loss_{tot} := 0.185$ (Assumed total losses)

$$n_{tnd} := round\left[\frac{P}{(1 - Loss_{tot}) \cdot (-P_{tndJ})}\right] \qquad n_{tnd} = 12$$

Tendon forces after friction losses

$$P_{AA} := \frac{n_{tnd}}{2} \cdot P_{tndJ} \qquad P_{AA} = -1.272 \times 10^3 \cdot kN$$

$$P_{BA} := P_{AA} \cdot e^{-(\mu \cdot \alpha_{AB} + K_w \cdot L)} \qquad P_{BA} = -1.254 \times 10^3 \cdot kN$$

$$P_{CA} := P_{AA} \cdot e^{-(\mu \cdot \alpha_{AC} + K_w \cdot 2 \cdot L)} \qquad P_{CA} = -1.235 \times 10^3 \cdot kN$$

$$P_{DA} := P_{AA} \cdot e^{-(\mu \cdot \alpha_{AD} + K_w \cdot 3 \cdot L)} \qquad P_{DA} = -1.218 \times 10^3 \cdot kN$$

The change in tendon force is approximated by using the jacking force (at A) and tendon force (at D):

$$p := \frac{P_{AA} - P_{DA}}{3L} \qquad p = -2.414 \cdot \frac{kN}{m}$$

$$\Delta P_L := \left[\frac{\delta \cdot \frac{n_{tnd}}{2} \cdot A_{ps} \cdot E_p}{3L} - (-p \cdot 3L) \right] \qquad \Delta P_L = -15.305 \cdot kN$$

Since $\Delta P_L < 0$ the tendon force at D will remain the same

$$P_{DA} = -1.218 \times 10^3 \cdot kN$$

For a second attempt, the change in tendon force is approximated by using the jacking force (at A) and tendon force (at C)

$$p := \frac{P_{AA} - P_{CA}}{2L} \qquad p = -2.462 \cdot \frac{kN}{m}$$

Due to anchorage seating:

$$\Delta P_L := \left[\frac{\delta \cdot \frac{n_{tnd}}{2} \cdot A_{ps} \cdot E_p}{2L} - (-p \cdot 2L) \right] \qquad \Delta P_L = 21.577 \cdot kN$$

Tendon forces after anchorage seating

Since $\Delta P_L > 0$ the tendon force at C will become:

$P_{CA} := P_{CA} + \Delta P_L$ $\qquad P_{CA} = -1.214 \times 10^3 \cdot kN$

$P_{AA} := P_{CA} \cdot e^{-\left(\mu \cdot \alpha_{AC} + K_w \cdot 2L\right)}$ $\qquad P_{AA} = -1.178 \times 10^3 \cdot kN$

$P_{BA} := P_{AA} \cdot e^{\left(\mu \cdot \alpha_{AB} + K_w \cdot L\right)}$ $\qquad P_{BA} = -1.195 \times 10^3 \cdot kN$

From symmetry, taking the jacking force at D:

$P_{AD} := P_{DA}$

$P_{BD} := P_{CA}$

$P_{CD} := P_{BA}$

$P_{DD} := P_{AA}$

The total prestressing force is the summation of the tendon forces tensioned from A and D:

$P_A := P_{AA} + P_{AD}$ $\qquad P_A = -2.396 \times 10^3 \cdot kN$

$P_B := P_{BA} + P_{BD}$ $\qquad P_B = -2.409 \times 10^3 \cdot kN$

$P_C := P_{CA} + P_{CD}$ $\qquad P_C = -2.409 \times 10^3 \cdot kN$

$P_D := P_{DA} + P_{DD}$ $\qquad P_D = -2.396 \times 10^3 \cdot kN$

Elastic shortening of concrete:

Average cable force	$P_{avg} := \frac{(P_A + P_B + P_C + P_D)}{4}$	$P_{avg} = -2.402 \times 10^3 \cdot kN$
Area of concrete section	$A := h \cdot L$	$A = 1.650 \times 10^6 \cdot mm^2$
Average stress produced by prestress at the centroid of the section	$f_{c.cgsPJ'} := \frac{P_{avg}}{A}$	$f_{c.cgsPJ'} = -1.456 \cdot MPa$
Change in steel stress	$\Delta f_{pES} := \frac{1}{2} \cdot f_{c.cgsPJ'} \cdot \frac{E_p}{E_{ct}}$	$\Delta f_{pES} = -7.184 \cdot MPa$
Loss in prestress	$\Delta P_{ES} := -n_{tnd} \cdot A_{ps} \cdot \Delta f_{pES}$	$\Delta P_{ES} = 12.931 \cdot kN$

Prestressing force at transfer

$P_{tA} := P_A + \Delta P_{ES}$	$P_{tA} = -2.383 \times 10^3 \cdot kN$
$P_{tB} := P_B + \Delta P_{ES}$	$P_{tB} = -2.396 \times 10^3 \cdot kN$
$P_{tC} := P_C + \Delta P_{ES}$	$P_{tC} = -2.396 \times 10^3 \cdot kN$
$P_{tD} := P_D + \Delta P_{ES}$	$P_{tD} = -2.383 \times 10^3 \cdot kN$

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LONG-TERM LOSSES

30 year Shrinkage Strain
Assuming 50% Humidity

Approximation from SABS chart

{50% Humidity -
150 Slab : 400
300 Slab : 350
600 Slab : 290}

$$\varepsilon_{su} := \begin{cases} \left[\frac{(h - 150mm)}{300mm - 150mm}\cdot(350 - 400) + 400\right]\cdot -10^{-6} & \text{if } 150mm \le h \le 300mm \\ \left[\frac{(h - 300mm)}{600mm - 300mm}\cdot(290 - 350) + 350\right]\cdot -10^{-6} & \text{if } 300mm < h \le 600mm \\ 350\cdot -10^{-6} & \text{otherwise} \end{cases}$$

$$\varepsilon_{su} = -377 \times 10^{-6}$$

30 year Creep Coefficient

Approximation from SABS chart

{50% Humidity, 3 days -
150 Slab : 4
300 Slab : 3.1
600 Slab : 2.8}

$$\phi_u := \begin{cases} \left[\frac{(h - 150mm)}{300mm - 150mm}\cdot(3.1 - 4) + 4\right] & \text{if } 150mm \le h \le 300mm \\ \left[\frac{(h - 300mm)}{600mm - 300mm}\cdot(2.8 - 3.1) + 3.1\right] & \text{if } 300mm < h \le 600mm \\ 3 & \text{otherwise} \end{cases}$$

$$\phi_u = 3.6$$

Relaxation Losses

Average prestressing force immediatley after transfer $P_{tavg} := \frac{(P_{tA} + P_{tB} + P_{tC} + P_{tD})}{4}$ $P_{tavg} = -2389\cdot kN$

P_{tavg} expressed as a percentage of characteristic breaking load of the tendons $Per_P := \frac{P_{tavg}\cdot 100}{n_{tnd}\cdot -P_{tnd}}$ $Per_P = 75.13\%$

Percentage relaxation loss $PR_{Loss} := \begin{vmatrix} \varepsilon \leftarrow 500 \cdot 10^{-6} \\ \left[\frac{1}{2} \cdot \left[3 + \left(\frac{8.5 - 3}{80 - 50}\right) \cdot (Per_P - 50)\right]\right] \text{ if } \varepsilon \ge 500 \cdot 10^{-6} \\ \frac{1}{2} \cdot \left[3 + \left(\frac{10 - 3}{80 - 50}\right) \cdot (Per_P - 50)\right] \text{ otherwise} \end{vmatrix}$

$PR_{Loss} = 3.804$

Loss of prestress due to relaxation of the steel $\Delta P_r := -PR_{Loss} \cdot \% \cdot P_{tavg}$ $\Delta P_r = 90.896 \cdot kN$

Shrinkage Losses

$\varepsilon_{su} = -377 \times 10^{-6}$

Loss of steel stress due to shrinkage of concrete $\Delta f_{ps} := \varepsilon_{su} \cdot E_p$ $\Delta f_{ps} = -73.45 \cdot MPa$

Loss in force due to shrinkage $\Delta P_s := -\Delta f_{ps} \cdot n_{tnd} \cdot A_{ps}$ $\Delta P_s = 132.21 \cdot kN$

Creep Losses

Stress in concrete at the level of the centroid of the prestressing steel $f_c := \frac{P_{tavg}}{A}$ $f_c = -1.448 \cdot MPa$

Creep Strain $\varepsilon_c := \phi_u \cdot \frac{f_c}{E_{ct}}$ $\varepsilon_c = -262.36 \times 10^{-6}$

Loss of steel sress due to creep of the concrete $\Delta f_{pC} := \varepsilon_c \cdot E_p$ $\Delta f_{pC} = -51.16 \cdot MPa$

Loss of force due to creep $\Delta P_c := -(\Delta f_{pC} \cdot n_{tnd} \cdot A_{ps})$ $\Delta P_c = 92.087 \cdot kN$

Creep plus shrinkage strain $Strain := |\varepsilon_{su} + \varepsilon_c|$ $Strain = 639.02 \times 10^{-6}$ which is greater than 500E-6 as assumed

Final Prestressing Force

Total long-time loss of prestressing force $\Delta P_{time} := \Delta P_r + \Delta P_s + \Delta P_c$ $\Delta P_{time} = 315.193 \cdot kN$

Final prestressing force after all losses

$P_A := P_{tA} + \Delta P_{time}$ $P_A = -2.068 \times 10^3 \cdot kN$

$P_B := P_{tB} + \Delta P_{time}$ $P_B = -2.08 \times 10^3 \cdot kN$

$P_C := P_{tC} + \Delta P_{time}$ $P_C = -2.08 \times 10^3 \cdot kN$

$P_D := P_{tD} + \Delta P_{time}$ $P_D = -2.068 \times 10^3 \cdot kN$

Total loss $\Delta P_{total} := n_{tnd} \cdot P_{tndJ} - \frac{P_A + P_B + P_C + P_D}{4}$

$\Delta P_{total} = -469.841 \cdot kN$

Actual Losses (Percentage of Jacking Force) $PLosses_{Act} := \frac{\Delta P_{total}}{n_{tnd} \cdot P_{tndJ}}$ $PLosses_{Act} = 18.5 \cdot \%$ which is the same as assumed

Equivalent Loads *{Equivalent loads imposed by the prestressing tendons on the concrete}*

At transfer

External Support

$$w_{bACt} := \left|\frac{2P_{tavg} \cdot c_1}{{a_1}^2}\right|$$

$$w_{bACt} = 267.807 \cdot kN \cdot m^{-1}$$

External Span

$$w_{bCEt} := \left|\frac{8P_{tavg} \cdot h_1}{(L - a_1 - a_2)^2}\right|$$

$$w_{bCEt} = 36.314 \cdot kN \cdot m^{-1}$$

Internal support

$$w_{bEFt} := \left|\frac{2P_{tavg} \cdot c_2}{{a_2}^2}\right|$$

$$w_{bEFt} = 385.849 \cdot kN \cdot m^{-1}$$

Internal Span

$$w_{bFGt} := \left|\frac{8P_{tavg} \cdot h_2}{(L - a_1 - a_2)^2}\right|$$

$$w_{bFGt} = 36.314 \cdot kN \cdot m^{-1}$$

Spacing of banded tendons over columns: $S_{tndB} := 100mm$

Width containing banded tendons: $Band := n_{tnd} \cdot S_{tndB}$ $\quad Band = 1200 \cdot mm$

After Transfer

$$P_{avg} := \frac{P_A + P_B + P_C + P_D}{4} \qquad P_{avg} = -2074 \cdot kN$$

External Support

$$w_{bAC} := \left|\frac{2P_{avg} \cdot c_1}{{a_1}^2}\right|$$

$$w_{bAC} = 232.479 \cdot kN \cdot m^{-1}$$

$$a_1 = 375 \cdot mm$$

External Span

$$w_{bCE} := \left|\frac{8P_{avg} \cdot h_1}{(L - a_1 - a_2)^2}\right|$$

$$w_{bCE} = 31.524 \cdot kN \cdot m^{-1}$$

Internal support

$$w_{bEF} := \left|\frac{2P_{avg} \cdot c_2}{{a_2}^2}\right|$$

$$w_{bEF} = 334.95 \cdot kN \cdot m^{-1}$$

$$a_2 = 375 \cdot mm$$

Internal Span

$$w_{bFG} := \left|\frac{8P_{avg} \cdot h_2}{(L - a_1 - a_2)^2}\right|$$

$$w_{bFG} = 31.524 \cdot kN \cdot m^{-1}$$

	External Support		External Span		Internal support		Internal Span	
UDL banded	$W_{1B} := \frac{w_{bAC}}{Band}$	$W_{1B} = 194 \cdot kPa$	$W_{2B} := \frac{w_{bCE}}{Band}$	$W_{2B} = 26.3 \cdot kPa$	$W_{3B} := \frac{w_{bEF}}{Band}$	$W_{3B} = 279 \cdot kPa$	$W_{4B} := \frac{w_{bFG}}{Band}$	$W_{4B} = 26.3 \cdot kPa$
UDL uniform	$W_{1U} := \frac{w_{bAC}}{L}$	$W_{1U} = 31 \cdot kPa$	$W_{2U} := \frac{w_{bCE}}{L}$	$W_{2U} = 4.2 \cdot kPa$	$W_{3U} := \frac{w_{bEF}}{L}$	$W_{3U} = 44.7 \cdot kPa$	$W_{4U} := \frac{w_{bFG}}{L}$	$W_{4U} = 4.2 \cdot kPa$

Shear reinforcement for punching:

Assume 450mm x 450mm columns:

Column width: $b_c := 450mm$

Average depth of tension steel: $d := h - \phi_t - C_{top}$ $\quad d = 185 \cdot mm$

Spacing of banded tendons over columns: $S_{tndB} := 100mm$

Width containing banded tendons: $Band := n_{tnd} \cdot S_{tndB}$ $\quad Band = 1200 \cdot mm$

Spacing of uniformly distributed tendons over columns: $S_{tndU} := \frac{L}{n_{tnd} - 1}$ $\quad S_{tndU} = 681.818 \cdot mm$

Side lengths of critical perimeters:		No of banded tendons passing through:		No of uniformly distributed tendons passing through	
$s_1 := 2 \cdot \left(\frac{b_c}{2} + 1.5 \cdot d\right)$	$s_1 = 1005 \cdot mm$	$n_{1B} := round\left(\frac{if(Band < s_1, Band, s_1)}{S_{tndB}}\right)$	$n_{1B} = 10$	$n_{1U} := round\left(\frac{s_1}{S_{tndU}}\right)$	$n_{1U} = 1$
$s_2 := 2 \cdot \left(\frac{b_c}{2} + 1.5 \cdot d + .75 \cdot d\right)$	$s_2 = 1282 \cdot mm$	$n_{2B} := round\left(\frac{if(Band < s_2, Band, s_2)}{S_{tndB}}\right)$	$n_{2B} = 12$	$n_{2U} := round\left(\frac{s_2}{S_{tndU}}\right)$	$n_{2U} = 2$
$s_3 := 2 \cdot \left(\frac{b_c}{2} + 1.5 \cdot d + 2 \cdot 0.75 \cdot d\right)$	$s_3 = 1560 \cdot mm$	$n_{3B} := round\left(\frac{if(Band < s_3, Band, s_3)}{S_{tndB}}\right)$	$n_{3B} = 12$	$n_{3U} := round\left(\frac{s_3}{S_{tndU}}\right)$	$n_{3U} = 2$
$s_4 := 2 \cdot \left(\frac{b_c}{2} + 1.5 \cdot d + 3 \cdot 0.75 \cdot d\right)$	$s_4 = 1837 \cdot mm$	$n_{4B} := round\left(\frac{if(Band < s_4, Band, s_4)}{S_{tndB}}\right)$	$n_{4B} = 12$	$n_{4U} := round\left(\frac{s_4}{S_{tndU}}\right)$	$n_{4U} = 3$

Cost Parameters:

Nominal Mass of prestressing tendons $\gamma_{ps} := \mathrm{if}\left(P_{tnd} = 186\mathrm{kN}, 0.785\frac{\mathrm{kg}}{\mathrm{m}}, 1.18\frac{\mathrm{kg}}{\mathrm{m}}\right)$ $\gamma_{ps} = 1.18\frac{\mathrm{kg}}{\mathrm{m}}$

Cost of Tendons per kg $UwCostTnds := 33.00\mathrm{kg}^{-1}$

Cost of Dead Anchor $UCostDAnch := 58.00$

Cost of Stressing Anchor $UCostSAnch := 65.00$

Tendon Length:

Perimeter of Parabola Lp= 2x $\sqrt{B_p^{\,2} + \frac{4}{3}H_p^{\,2}}$

$L_{p1} := \sqrt{a_1^{\,2} + \frac{4}{3}c_1^{\,2}}$ $L_{p1} = 375\cdot\mathrm{mm}$

$L1 := L - 2L' + a_1$ $L1 = 1594\cdot\mathrm{mm}$

$L2 := b_3 - \frac{h}{2} + c_1$ $L2 = 74\cdot\mathrm{mm}$

$L_{p2} := 2\cdot\sqrt{(L' - a_1)^2 + \frac{4}{3}\left(\frac{h}{2} - b_2 - c_1\right)^2} + \sqrt{L1^2 + L2^2}$ $L_{p2} = 7128\cdot\mathrm{mm}$

{Part of Parabola approximated as a straight line}

$L_{p3} := 2\cdot\sqrt{a_2^{\,2} + \frac{4}{3}c_2^{\,2}}$ $L_{p3} = 750\cdot\mathrm{mm}$

$L_{p4} := 2\cdot\sqrt{\left(\frac{L}{2} - a_2\right)^2 + \frac{4}{3}\cdot(b_3 - b_4 - c_2)^2}$ $L_{p4} = 6753\cdot\mathrm{mm}$

Length of Prestressing tendon: $L_{t1} := 2 \cdot L_{p1} + 2 \cdot L_{p2} + 2L_{p3} + L_{p4}$ $L_{t1} = 23.261 \cdot m$

Weight of tendon: $W_{ten} := \gamma_{ps} \cdot L_{t1}$ $W_{ten} = 27.448\,kg$

Weight of tendons over total slab area: $W_{tenT} := W_{ten} \cdot 2 \cdot n_{tnd}$ $W_{tenT} = 659\,kg$

<u>Total cost of prestressing:</u>

$Cost_{PT} := 2 \cdot n_{tnd} \left(W_{ten} \cdot UwCostTnds + UCostDAnch + UCostSAnch \right)$ $Cost_{PT} = 24690.59$

COST / m2

$COST_{PT} := \frac{Cost_{PT}}{(3 \cdot L)^2}$ $COST_{PT} = 48.77 \cdot m^{-2}$

Cost of Reinforcement per kg $UCostR := 9.50kg^{-1}$

Cost of Concrete per m^3 $UCostC := 1100.00m^{-3}$

PROKON Software Consultants (Pty) Ltd Internet: http://www.prokon.com E-Mail : mail@prokon.com	Job Number		Sheet
	Job Title PT 7.5m Heavy		
	Client		
	Calcs by	Checked by	Date

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Punching shear data: column 3

Design data

A	(mm)	450
B	(mm)	450
C	(mm)	0
D	(mm)	0
DeffX	(mm)	215
DeffY	(mm)	215
X	(mm)	7500
Y	(mm)	7500
Corner	(Y.N)	N
Vt	(kN)	1316.3
Mtx	(kNm)	87.1
Mty	(kNm)	87.1
Pcx	(kN)	4870.0
Pcy	(kN)	1391.0
UDL	(kN/m²)	21.5
slope-X		0.0592
slope-Y		0.0592
Cable type no.		1
N cables	X	Y
Perim 1	11	3
Perim 2	14	4
Perim 3	17	4
Perim 4	20	5
Ast (mm²)	X	Y
Perim 1	1340.0	1340.0
Perim 2	1340.0	1340.0
Perim 3	1340.0	1340.0
Perim 4	1340.0	1340.0

Perimeter output

Perimeter	Ucrit (mm)	vc (MPa)	Vcap (kN)	Veff (kN)	Asv (mm²)
1	4380.00	0.84	794.87	1113.45	962.15
2	5670.00	0.83	1016.62	1093.41	1245.52
3	6960.00	0.81	1212.87	1068.24	0.00
4	8250.00	0.81	1429.38	1037.92	0.00