



Metrodeck Structural Calculations

Sheet M1 of 26

Metrodeck

The following is a transcript of the original notes and structural calculations prepared by the Clark Smith Partnership. The original is hand written and this transcript has been prepared for clearer fax and modem transmission.

Introduction

The following calculations detail load carrying capacity of a standard steeldeck unit of 2m x 1m in overall plan size. The sides are made up of four trusses welded to four corner posts. All elements are ex-mild steel. All box sections used to form trusses of a standard deck is manufactured using ERW (Electric Resistance Welded) forming sections. All elements of the truss are welded all round. The top is typically made of 18mm plywood. This has flame-retardent felt glued to the underside for sound damping. The top is secured to the frame with 1.5in no. 12 self tapping screws. Once the top has been attached it is not expected to be removed other than to be replaced due to wear and tear &c.

Further details of a standard steeldeck can be obtained from sheet 6 attached. The attached calculations are based upon current British Standards:

- BS5950: Part 1: 1990 – Structural use of steelwork *
- BS5268: Part 2: 1996 – Structural use of timber
- Technical Literatures's page 11 by Hub Tubes

* p_y = Yield strength referred by Hub tubes as $R_{e \min} = 200 \text{ N/mm}^2$
 p_t = Tensile strength referred by Hub tubes as $R_{m \min} = 300 \text{ N/mm}^2$

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Section Properties and Capacities

Tubes – Scaffolding tubes (mild Steel) with overall diameter of 48.5mm and 4mm thick

$$A = \frac{\pi d^2}{4} = 5.57\text{cm}^2 \quad r_x = r_y = 1.57\text{cm}$$

$$I_x = I_y = 13.8\text{cm}^4$$

$$Z_x = Z_y = 5.70\text{cm}^3$$

$$S_x = S_y = 7.87\text{cm}^3$$

$p_y = 235\text{N/mm}^2$ (Table 12 of BS5973:1993 complying to BS1139:part 1 1990)

Compression capacity

$$p_c = A_y p_c$$

where $p_c \Rightarrow \lambda = \frac{l_E}{r_y} = \frac{(2.0 \times 1.0\text{m}) \times 10^3}{1.57\text{cm} \times 10} = 127.4$

$\therefore p_c = 103.3 \text{ N/mm}^2$ (Table 27A)

$p_l = 5.57\text{cm}^2 \times 103.3\text{N/mm}^2 \times 10^{-1} = 57.5\text{kN}$ base on l =

1.0m

Shear capacity $p_v = 0.6p_y A_v$ where $A_v = 0.6A$

$$= 0.6 \times 235\text{N/mm}^2 \times (0.6 \times 5.57\text{cm}^2) \times 10^{-3} = 47.1$$

kN

Moment Capacity $M_c = p_y S$ but $\leq 1.2p_y Z$

$$1.2p_y Z = 1.2 \times 235\text{N/mm}^2 \times 5.70\text{cm}^2 \times 10^{-3} =$$

1.61kNm

$$p_y S = 235\text{N/mm}^2 \times 7.87\text{cm}^3 \times 10^{-3} = 1.85\text{kNm}$$

$$\therefore M_c = 1.61\text{kNm}$$

Corner Posts

- 160 long x 60 x 60 x 5.0mm hollow sections

$$A = 10.9\text{cm}^2 \quad r_x = r_y = 2.23\text{cm}$$

$$I_x = I_y = 54.4\text{cm}^4$$

$$Z_x = Z_y = 18.1\text{cm}^3$$

$$S_x = S_y = 22.3\text{cm}^3$$

$$J = 83.188\text{cm}^4$$

$$p_y = 200\text{N/mm}^2 \quad \& \quad p_t = 300\text{N/mm}^2$$

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Compression capacity - $p_c = A_y p_c = 10.9\text{cm}^2 \times 200\text{N/mm}^2 \times 10^{-1} = 218\text{kN}$

Tension Capacity - $p_t = A_c p_t = 10.9\text{cm}^2 \times 300\text{N/mm}^2 \times 10^{-1} = 327\text{kN}$

Shear capacity - $p_v = 0.6 p_y A$ where $A_v = \left(\frac{D}{D+B} \right) A$

$$= 0.6 \times 200\text{N/mm}^2 \times \left(\frac{60\text{mm}}{60+60\text{mm}} \right) \times 10.9\text{cm}^2 \times 10^{-1}$$

$$= 65.4\text{kN}$$

Moment Capacity $M_c = p_y S$, but $\leq 1.2 p_y Z$

$$1.2 p_y Z = 1.2 \times 235\text{N/mm}^2 \times 18.1\text{cm}^3 \times 10^{-3} = 4.34\text{kNm}$$

$$p_y S = 235\text{N/mm}^2 \times 22.3\text{cm}^3 \times 10^{-3} = 4.46\text{kNm}$$

$\therefore M_c = 4.34\text{kNm}$

38 x 19 x 1.6mm thick section top member

$A = 1.72\text{cm}^2$	$r_x = 1.35\text{cm}$
$I_x = 3.13\text{cm}^4$	$r_y = 0.77\text{cm}$
$I_y = 1.02\text{cm}^4$	$J = 2.386\text{cm}^4$
$Z_x = 1.72\text{cm}^3$	$p_y = 200\text{N/mm}^2$
	$p_t = 300\text{N/mm}^2$

Compression capacity $p_c = A_y p_c$

Where $p_{cx} \Rightarrow \lambda_x = \frac{L_E}{r_x} = \frac{(0.85 \times 0.364\text{m}) \times 10^3}{1.35\text{cm} \times 10} = 22.92$

$\therefore p_{cx} = 198\text{N/mm}^2$
(Appendix C)

$p_{cy} \Rightarrow \lambda_y = \frac{L_E}{r_y} = \frac{(0.7 \times 0.495\text{m}) \times 10^3}{0.77\text{cm} \times 10} = 45$

$\therefore p_{cy} = 181\text{N/mm}^2$

\therefore Compression capacity $p_{cx} = 1.72\text{cm}^2 \times 198\text{N/mm}^2 \times 10^{-1} = 34\text{kN}$

$p_{cy} = 1.72\text{cm}^2 \times 181\text{N/mm}^2 \times 10^{-1} = 31.13\text{kN}$

Tension Capacity $p_t = A_c p_t = 1.72\text{cm}^2 \times 300\text{N/mm}^2 \times 10^{-1} = 51.6\text{kNm}$

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Shear capacity $p_v = 0.6p_y A_v$ where $A_v = \left(\frac{D}{D+B}\right)A$

$$= 0.6 \times 200 \text{N/mm}^2 \times \left[\left(\frac{38}{38+19}\right) \times 1.72 \text{cm}^2 \right] \times 10^{-1} = 13.8 \text{kN}$$

Moment capacity $M_{cx} = 1.2p_y Z_x = 1.2 \times 200 \text{N/mm}^2 \times 1.72 \text{cm}^3 \times 10^{-3} = 0.413 \text{kNm}$

$M_{cy} = 1.2p_y Z_y = 1.2 \times 200 \text{N/mm}^2 \times 1.17 \text{cm}^3 \times 10^{-3} = 0.28 \text{kNm}$

since $\lambda = \frac{L_t}{r_y} < \frac{350 \times 275}{200} = 481$ (Table38) hence lateral torsional buckling effects need not be checked

19 x 19 x 2.0mm thick section bottom member

$A = 2.25 \text{cm}^2$	$r_x = 1.84 \text{cm}$
$I_x = 0.66 \text{cm}^4$	$r_y = 1.84 \text{cm}$
$I_y = 0.66 \text{cm}^4$	
$Z_x = 0.70 \text{cm}^3$	
$Z_y = 0.70 \text{cm}^3$	

Compression capacity $p_c = A_y p_c$

Where $p_{cx} \Rightarrow \lambda_x = \frac{L_E}{r_x} = \frac{(0.85 \times 0.364 \text{m}) \times 10^3}{1.84 \times 10} = 16.8$

$\therefore p_{cx} = 200 \text{N/mm}^2$
(Appendix C)

$p_{cy} \Rightarrow \lambda_y = \frac{L_E}{r_y} = \frac{(0.85 \times 1.940 \text{m}) \times 10^3}{1.84 \text{cm} \times 10} = 89.62$

$\therefore p_{cy} = 132.2 \text{N/mm}^2$ (Appendix C)

\therefore Compression capacity $p_{cx} = 2.25 \text{cm}^2 \times 200 \text{N/mm}^2 \times 10^{-1} = 45 \text{kN}$
 $p_{cy} = 2.25 \text{cm}^2 \times 132.2 \text{N/mm}^2 \times 10^{-1} = 29.7 \text{kN}$

Tension Capacity $p_t = A_c p_t = 2.25 \text{cm}^2 \times 300 \text{N/mm}^2 \times 10^{-1} = 67.5 \text{kNm}$

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Shear capacity $p_v = 0.6p_yA_v = 0.6 \times 200\text{N/mm}^2 \times 0.5 \times 2.25\text{cm}^2 \times 10^{-1} = 13.5\text{kN}$

Moment capacity $M_c = 1.2p_yZ = 1.2 \times 200\text{N/mm}^2 \times 0.7\text{cm}^3 \times 10^{-3} = 0.168\text{kNm}$

38 x 19 x 1.6mm thick Vertical spacer: original

$A = 1.72\text{cm}^2$	$r_x = 1.35\text{cm}$
$I_x = 3.13\text{cm}^4$	$r_y = 0.77\text{cm}$
$I_y = 1.02\text{cm}^4$	$J = 2.386\text{cm}^4$
$Z_x = 1.72\text{cm}^3$	$p_y = 200\text{N/mm}^2$
$Z_y = 1.17\text{cm}^3$	$p_t = 300\text{N/mm}^2$

Tension Capacity	$p_t = 51.6\text{kNm}$	}
Shear capacity	$p_v = 13.8\text{kN}$	} As per sheet 4
Moment capacity	$M_{cx} = 0.413\text{kNm}$	}
	$M_{cy} = 0.28\text{kNm}$	}

Compression capacity $p_c = A_y p_t$

Where $p_c \Rightarrow \lambda = \frac{L_E}{r_y} = \frac{(0.85 \times 50\text{mm})}{0.77\text{cm} \times 10} = 5.5$

$\therefore p_c = 200\text{N/mm}^2$

\therefore Compression capacity $p_c = 1.72\text{cm}^2 \times 200\text{N/mm}^2 \times 10^{-1} = 34.4\text{kN}$

38 x 19 x 2.0mm thick Vertical intermediates: new

$A = 2.12\text{cm}^2$	$Z_x = 1.98\text{cm}^3$
$I_x = 3.76\text{cm}^4$	$Z_y = 1.27\text{cm}^3$
$I_y = 1.20\text{cm}^4$	

Tension Capacity $p_t = A_e p_t = 2.12\text{cm}^2 \times 300\text{N/mm}^2 \times 10^{-1} = 63.60\text{kN}$

Shear capacity $p_v = 0.6p_yA_v = 0.6 \times 200\text{N/mm}^2 \times \left[\left(\frac{38\text{mm}}{38\text{mm} + 19\text{mm}} \right) \times 2.12\text{cm}^2 \right] \times 10^{-1} = 16.96\text{kN}$

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Moment capacity $M_c = 1.2p_y Z = 1.2p_y \times 200N/mm^2 \times 1.98cm^3 \times 10^{-3} = 0.475kNm$

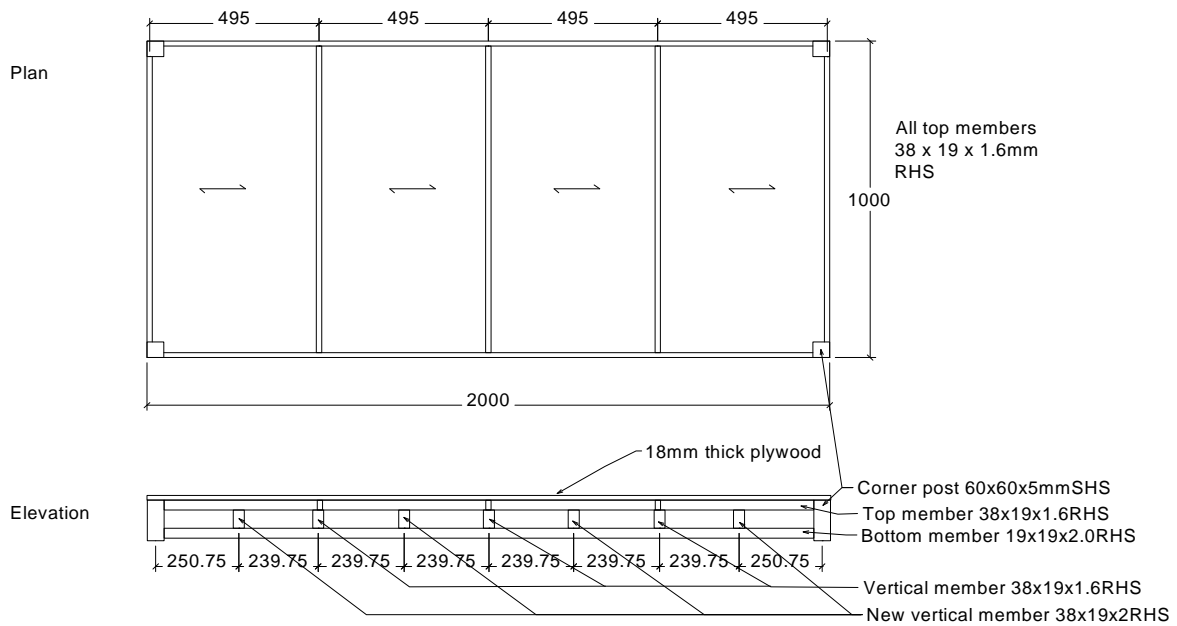
Compression capacity $p_c = A_y p_t$

$$p_c \Rightarrow \lambda = \frac{L_E}{r_y} = \frac{(0.85 \times 50mm)}{0.75cm \times 10} = 5.7$$

$\therefore p_c = 200N/mm^2$

\therefore Compression capacity $p_c = 1.72cm^2 \times 200N/mm^2 \times 10^{-1} = 34.4kN$

Typical Metrodeck Details



Loading

Dead Load =>
0.110kN/m²

18mm thick plywood =

2mm felt = 0.004kN/m²

3mm washer (insulation like material) = 0.0001kN/m²

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	0.115kN/m ²
Steelwork frame	= <u>0.084</u> kN/m ²
	G _k = 0.199kN/m ²
Imposed load	Q _k = 5.0kN/m ²

$$\therefore \text{Design load} = 1.4G_k + 1.6Q_k = 1.4 \times 0.199 + 1.6 \times 5.0 = 8.279\text{kN/m}^2$$





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Metrodeck Structural Calculations

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Job Information

	Engineer	Checked	Approved
Name:	JL		
Date:	9.3.99		

Structure type	Plane frame
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Number of Nodes	18	Highest Node	18
Number of Elements	28	Highest Element	25

Number of Basic Load Cases	2
Number of Combination Load Cases	2
Number of Envelope Cases	0

Included in this printout are data for:

All	The Whole Structure
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Included in this printout are results for load cases:

Type	L/C	Name
Comb.	C1	1.4G _k + 1.6Q _k

Section Properties

Prop	Section	A (cm ²)	I _{yy} (cm ⁴)	I _{zz} (cm ⁴)	J (cm ⁴)	Material
1	Corn 60 x 60 x 5 SHS	11.000	55.460	55.460		1
2	Top 38 x 19 x 1.6 RHS	1.720	3.130	1.020		1
3	Bot 19 x 19 x 2.0 RHS	2.250	0.660	0.660		1
4	Vert 38 x 19 x 1.6 RHS	1.720	3.130	1.020		1
5	Vert 38 x 19 x 2.0 RHS	2.120	3.760	3.760		1

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Combination Load Cases

Name	Combination L/C Name	Basic	Basic L/C Name	Factor
C1	1.4G _k + 1.6Q _k	DL1	G _k	1.40
		LL1	Q _k	1.60
C2	1.0Q _k	LL1	Q _k	1.00

Loadings

For Temp Diff loads: D = distance to neutral axis (m).

L/C	N/E	Ref	Type	Axis	F _A	D _A (m [*])	F _B	D _B (m [*])
DL1	N	10	Point kN	Global Z	-0.024			
	N	12	Point kN	Global Z	-0.048			
	N	14	Point kN	Global Z	-0.048			
	N	16	Point kN	Global Z	-0.048			
	N	18	Point kN	Global Z	-0.024			
LL1	N	10	Point kN	Global Z	-0.607			
	N	12	Point kN	Global Z	-1.214			
	N	14	Point kN	Global Z	-1.214			
	N	16	Point kN	Global Z	-1.214			
	N	18	Point kN	Global Z	-0.607			

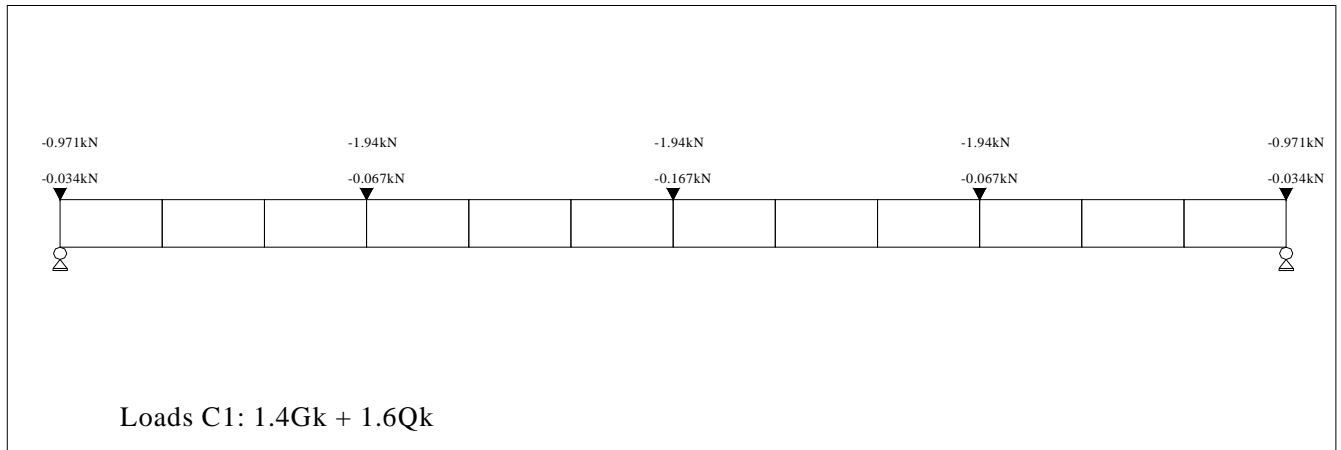


Metrodeck Structural Calculations

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Element Maximum Forces by Section Property

Axial	Shear	Torsion	Bending
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Node		F _x (kN)	F _y (kN)	F _z (kN)	M _x (kNm)	M _y (kNm)	M _z (kNm)
Corn60x60x5SH S	Max +ve	3.880	0.000	6.884	0.000	0.274	0.000
	Max -ve	0.000	0.000	-6.884	0.000	-0.274	0.000
Top38x19x1.6R HS	Max +ve	31.728	0.000	2.375	0.000	0.274	0.000
	Max -ve	0.000	0.000	-2.375	0.000	-0.403	0.000
Bot 19x19x1.6RHS	Max +ve	0.000	0.000	0.729	0.000	0.070	0.000
	Max -ve	-31.728	0.000	-0.729	0.000	-0.113	0.000
Vert38x19x1.6R HS	Max +ve	0.430	0.000	8.265	0.000	0.301	0.000
	Max -ve	0.000	0.000	-8.271	0.000	-0.302	0.000
Vert38x19x2.0R HS	Max +ve	0.108	0.000	12.365	0.000	0.466	0.000
	Max -ve	-0.090	0.000	-12.36	0.000	-0.466	0.000



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Metrodeck Structural Calculations

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Metrodeck Structural Calculations

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Element Force Detail

Sign conventions as diagrams – positive above line, negative below line except Fx where positive is compression. Distance d is given from element end A.

Emt	L/C	d (m)	Axial	Shear		Torsion	Bending	
			Fx (kN)	Fy (kN)	Fz (kN)	Mx (kN)	My (kN)	Mz (kNm)
1	C1	0.000	-6.884		-0.640		0.070	
		0.125	-6.884		-0.640		-	
		0.251	-6.884		-0.640		-	0.010
2	C1	0.000	-19.249		-0.729		0.062	
		0.120	-19.249		-0.729		-	0.026
		0.240	-19.249		-0.729		-	0.113
3	C1	0.000	-27.513		-0.299		-	0.001
		0.120	-27.513		-0.299		-	0.037
		0.240	-27.513		-0.299		-	0.073
4	C1	0.000	-31.723		-0.212		-	0.017
		0.120	-31.723		-0.212		-	0.043
		0.240	-31.723		-0.212		-	0.068
5	C1	0.000	-31.728		0.212		-	0.068
		0.120	-31.728		0.212		-	0.043
		0.239	-31.728		0.212		-	0.017
6	C1	0.000	-27.520		0.300		-	0.073
		0.120	-27.520		0.300		-	0.037



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		0.240	-27.520		0.300		-	0.001
7	C1	0.000	-19.249		0.729		-	0.113
		0.120	-19.249		0.729		-	0.026
		0.240	-19.249		0.729		0.062	
8	C1	0.000	-6.884		0.639		-	0.090
		0.125	-6.884		0.639		-	0.010
		0.251	-6.884		0.639		0.070	
9	C1	0.000	6.884		-2.375		0.274	
		0.125	6.884		-2.375		-	0.024
		0.251	6.884		-2.375		-	0.321
10	C1	0.000	19.249		-2.286		0.145	
		0.120	19.249		-2.286		-	0.129
		0.240	19.249		-2.286		-	0.403
11	C1	0.000	27.513		-0.706		-	0.102
		0.120	27.513		-0.706		-	0.186
		0.240	27.513		-0.706		-	0.271
12	C1	0.000	31.723		-0.793		-	0.116
		0.120	31.723		-0.793		-	0.211
		0.240	31.723		-0.793		-	0.306
13	C1	0.000	31.728		0.792		-	0.306
		0.119	31.728		0.792		-	0.211
		0.239	31.728		0.792		-	



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							0.117	
14	C1	0.000	27.520		0.705		-	
							0.271	
		0.120	27.520		0.705		-	
							0.186	
		0.240	27.520		0.705		-	
							0.102	
15	C1	0.000	19.249		2.285		-	
							0.403	
		0.120	19.249		2.285		-	
							0.129	
		0.240	19.249		2.285		-	
							1.145	
16	C1	0.000	6.884		2.375		-	
							0.321	
		0.125	6.884		2.375		-	
							0.024	
		0.251	6.884		2.375		-	
							0.274	
17	C1	0.000	3.380		6.884		-	
							0.070	
		0.025	3.380		6.884		-	
							0.102	
		0.050	3.380		6.884		-	
							0.274	
18	C1	0.000	3.380		-6.884		-	
							0.070	
		0.025	3.380		-6.884		-	
							0.102	
		0.050	3.380		-6.884		-	
							0.274	
19	C1	0.000	-0.089		12.365		-	
							0.152	
		0.025	-0.089		12.365		-	
							0.157	
		0.050	-0.089		12.365		-	
							0.466	
20	C1	0.000	0.430		8.265		-	
							0.112	
		0.025	0.430		8.265		-	
							0.095	
		0.050	0.430		8.265		-	
							0.301	
21	C1	0.000	0.087		4.210		-	
							0.056	
		0.025	0.087		4.210		-	
							0.050	
		0.050	0.087		4.210		-	
							0.155	
22	C1	0.000	0.425		0.004		-	



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							0.000	
		0.025	0.425		0.004		0.000	
		0.050	0.425		0.004		0.000	
23	C1	0.000	0.108		4.207		-	
		0.025	0.108		4.207		0.056	
		0.050	0.108		4.207		0.049	
24	C1	0.000	0.429		-8.271		0.112	
		0.025	0.429		-8.271		-	
		0.050	0.429		-8.271		0.095	
		0.025	0.429		-8.271		-	
		0.050	0.429		-8.271		0.302	
25	C1	0.000	-0.090		-	12.365	0.152	
		0.025	-0.090		-	12.365	-	
		0.050	-0.090		-	12.365	1.157	
		0.025	-0.090		-	12.365	-	
		0.050	-0.090		-	12.365	0.466	

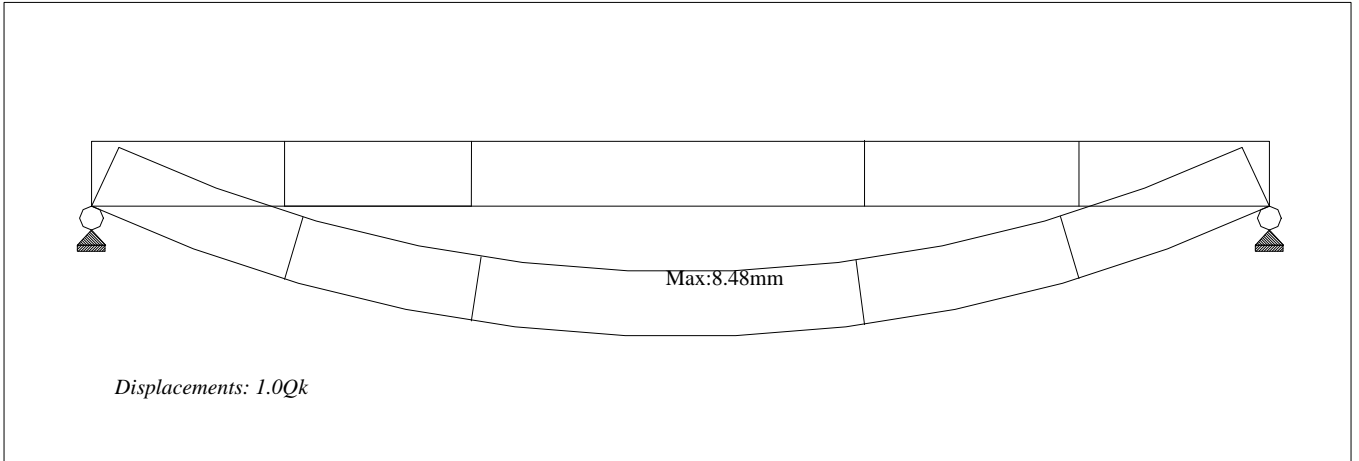
Element Displacement Summary

Displacements shown in italic indicate the presence of a rigid link

	Emt	L/C	d (m)	X (mm)	Y (mm)	Z (mm)	Resultant (mm)
Max X	9	C2	0.000	0.621	0.000	0.621	
Min X	16	C2	0.251	-0.083	0.000	0.083	
Max Y	1	C2	0.000	0.000	0.000	0.000	
Min Y	1	C2	0.000	0.000	0.000	0.000	
Max Z	1	C2	0.000	0.000	0.000	0.000	
MinZ	12	C2	0.240	0.269	0.000	8.476	
Max rX	12	C2	0.240	0.269	0.000	8.476	

Metrodeck Structural Calculations

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Check Corner Post 60 x 60 x 4mm SHS

Using overall buckling check, simplified approach: -

$$\frac{F}{A_y p_c} + \frac{M_x}{M_{cx}} + \frac{M_y}{M_{cy}} \leq 1$$

$$\frac{3.80}{218} + \frac{0.274}{4.34} + 0 = 0.08 < 1 \quad \therefore \text{Satisfactory}$$

Check top member 38 x 19 x 1.6 RHS (ERW)

Using $\frac{F}{A_y p_c} + \frac{M_x}{M_{cx}} + \frac{M_y}{M_{cy}} \leq 1$

$$\frac{31.728}{31.13} + \frac{0.306}{0.413} + 0 = 1.76 > 1 \quad \therefore \text{not satisfactory, however design top member as composite}$$

(refer page

21)

Check bottom member 19 x 19 x 2.0 RHS (ERW)

Using $\frac{F}{p_t} + \frac{M_x}{M_{cx}} + \frac{M_y}{M_{cy}} \leq 1$

$$\frac{31.728}{67.5} + \frac{0.06}{0.168} + 0 = 0.88 < 1 \quad \therefore \text{Satisfactory}$$

Metrodeck Structural Calculations

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Check vertical Intermediate 38 x 19 x 1.6 RHS (ERW):Original

$$\text{Using } \frac{F}{A_y p_c} + \frac{M_x}{M_{cx}} + \frac{M_y}{M_{cy}} \leq 1$$

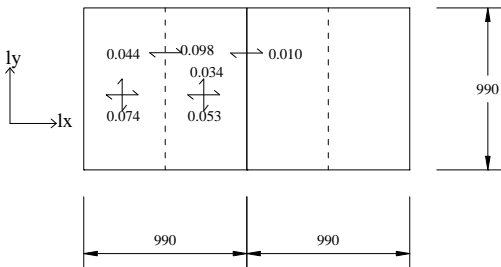
$$\frac{0.491}{34.4} + \frac{0.303}{0.413} + 0 = 0.75 < 1 \therefore \text{Satisfactory}$$

Check vertical intermediate spacers 38 x 19 x 2.0 RHS (ERW):New

$$\text{Using } \frac{F}{p_t} + \frac{M_x}{M_{cx}} + \frac{M_y}{M_{cy}} \leq 1$$

$$\frac{0.050}{63.60} + \frac{0.466}{0.475} + 0 = 0.98 < 1 \therefore \text{Satisfactory}$$

Checking of Timber Ply and intermediate 38 x 19 x 1.6 thick member for 5.0kN/m² imposed loading (D + I = 8.279kN/m²)



$$\text{Value } \frac{l_y}{l_x} = \frac{990}{495} = 2$$

$$\begin{aligned} \text{Span: } m_{sx, \max} &= \beta_{sx} n l_x^2 \\ &= 0.074 \times 8.279 \text{ kN/m}^2 \times (0.495 \text{ m})^2 \\ &= 0.303 \text{ kNm/m} \end{aligned}$$

$$\begin{aligned} m_{sy, \max} &= \beta_{sy} n l_x^2 \\ &= 0.044 + 8.279 \text{ kN/m}^2 \times (0.495 \text{ m})^2 \\ &= 0.180 \text{ kNm/m} \end{aligned}$$

Support: only $m_{sx, \max} = \beta_{sx} n l_x^2$
 $= 0.098 \times 8.279 \text{ kN/m}^2 \times (0.495 \text{ m})^2 = 0.199 \text{ kNm/m}$

BS5268:Part 2:1996 => 18mm thick plywood with 5 plies (assuming)

Table 25: $A = 17.5 \times 10^3 \text{ mm}^2$ per metre width

$Z = 51.0 \times 10^3 \text{ mm}^3$ per metre width

$\tau = 446.6 \times 10^3 \text{ mm}^4$ per metre width

Mass = 10.8kg/m²

Stress and moduli: Assume worst case (i.e. from table 34)

\therefore stress, $\sigma_z = 8.82 \text{ N/mm}^2$ (bending parallel to grain)

$\sigma_{\perp} = 4.33 \text{ N/mm}^2$ (bending perpendicular to grain)

Metrodeck Structural Calculations

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Moduli $E_x = 2900\text{N/mm}^2$ (E parallel to grain)
 $E_{\perp} = 2150\text{N/mm}^2$ (E Perpendicular to grain)

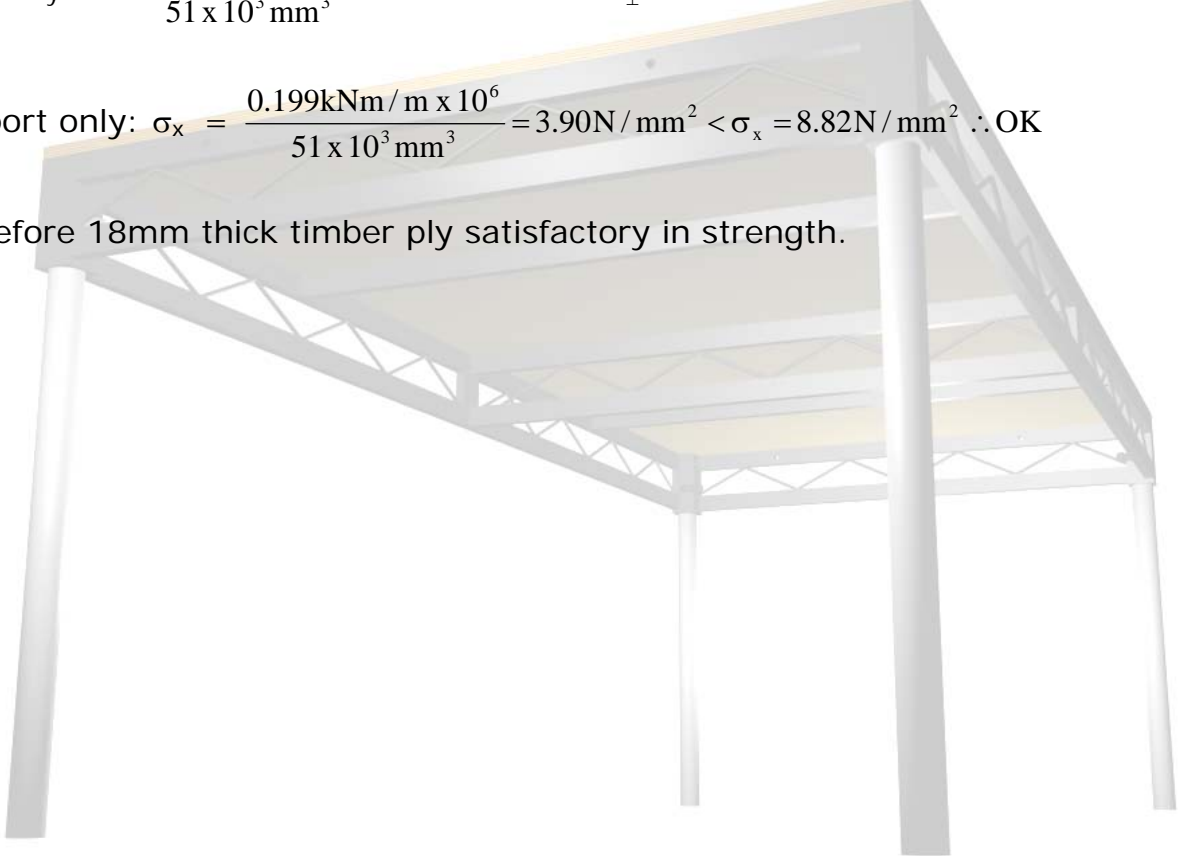
Actual stress, $\sigma = \frac{M}{Z}$

$$\text{Span: } \sigma_x = \frac{0.303\text{kNm/m} \times 10^6}{51 \times 10^3 \text{mm}^3} = 5.94\text{N/mm}^2 < \sigma_x = 8.82\text{N/mm}^2 \therefore \text{OK}$$

$$\text{Span: } \sigma_y = \frac{0.180\text{kNm/m} \times 10^6}{51 \times 10^3 \text{mm}^3} = 3.53\text{N/mm}^2 < \sigma_{\perp} = 4.33\text{N/mm}^2 \therefore \text{OK}$$

$$\text{Support only: } \sigma_x = \frac{0.199\text{kNm/m} \times 10^6}{51 \times 10^3 \text{mm}^3} = 3.90\text{N/mm}^2 < \sigma_x = 8.82\text{N/mm}^2 \therefore \text{OK}$$

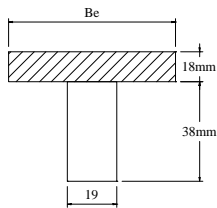
Therefore 18mm thick timber ply satisfactory in strength.



Metrodeck Structural Calculations

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Check intermediate 38 x 39 x 1.6mm member as composite T-beams:-



$$B_e = 2b_e = 2 \times \frac{L_z}{8} = 2 \times \frac{0.988}{8} = 0.25\text{m} \quad \text{OR}$$

$$B_e = b \times 2 = 0.495\text{m}$$

therefore $B_e = 0.495\text{m}$

Young's modulus E : $E_{\text{ply}} = 3467\text{N/mm}^2$
 $E_{\text{steel}} = 200\text{N/mm}^2$

$$\therefore \text{Modular ratio, } \alpha = \frac{E_{\text{steel}}}{E_{\text{ply}}} = \frac{200\text{kN/mm}^2 \times 10^3}{3467\text{N/mm}^2} = 57.7$$

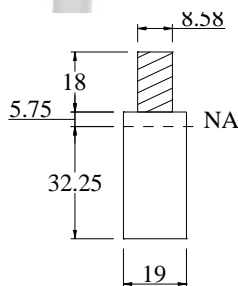
Elastic section properties

Flange in terms of equivalent steel section, $B_e' = \frac{0.495\text{m} \times 10^3}{57.7} = 8.58\text{m}$

Elastic N.A. =>

$$\bar{y} \left[(8.58\text{mm} \times 18\text{mm}) + (1.72\text{cm}^2 \times 10^2) \right] = \left(8.58\text{mm} \times 18\text{mm} \times \frac{18\text{mm}}{2} \right) + \left[(1.72\text{cm}^2 \times 10^2) \times \left(\frac{38}{2} + 18\text{mm} \right) \right]$$

$$\therefore \bar{y} = 23.75\text{mm}$$

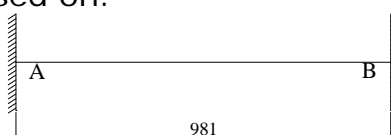


$$I_y = \left\{ 8.58\text{mm} \times (18\text{mm})^3 + \left[(8.58\text{mm} \times 18\text{mm}) \times \left(\frac{18\text{mm}}{2} + 5.25\text{mm} \right)^2 \right] \right\} + \left\{ (3.13\text{cm} \times 10^4) + \left[(1.72\text{cm}^2 \times 10^2) \times \left(32.25\text{mm} - \frac{38\text{mm}}{2} \right)^2 \right] \right\}$$

$$= 99267\text{mm}^4$$

$$Z_y = \frac{I_y}{32.25\text{mm}} = \frac{99267\text{mm}^4}{32.25\text{mm}} = 3078\text{mm}^3 = 30.78\text{cm}^3$$

Moment based on:



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$$Q_k = 1.4(0.199\text{kN/m}^2 \times 0.495\text{m}) = 0.138\text{kNm}$$

$$Q_k = 1.6(5.00\text{kN/m}^2 \times 0.498\text{m}) = 3.96\text{kNm}$$

$$\omega = 4.098\text{kN/m}$$

Metrodeck Structural Calculations

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$$\therefore \text{moment} = \frac{\omega l^2}{12} = \frac{4.098 \text{ kN/m} \times (0.981 \text{ m})^2}{12} = 0.329 \text{ kNm}$$

$$\text{Therefore stress } \sigma = \frac{M_y}{I} = \frac{0.329 \text{ kNm} \times 32.25 \text{ mm} \times 10^6}{99267 \text{ mm}^4} = 106 \text{ N/mm}^2$$

since $\sigma < 200 \text{ N/mm}^2$ the beam section is satisfactory in bending

$$\text{Deflection: } \delta_{\max} = \frac{5\omega l^4}{384EI} = \frac{5 \times (5.00 \text{ kN/m}^2 \times 0.495 \text{ m}) \times (0.981 \text{ m})^3 \times 10^5}{384 \times 205 \text{ N/mm}^2 \times 9.9267 \text{ cm}^4}$$

$$= 1.47 \text{ mm}$$

$$\delta_{\lim} = \frac{\text{Span}}{360} = \frac{981}{360} = 2.73 \text{ mm}$$

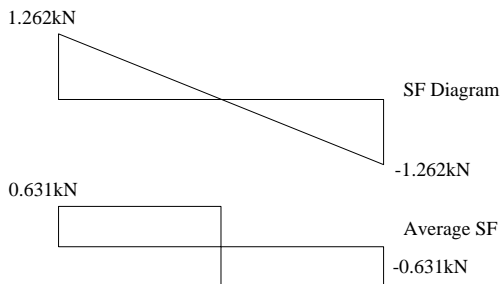
$$\therefore \delta_{\max} < \delta_{\lim} \therefore \text{OK}$$

Screw connections

$$\text{Shear stress } f_q = \frac{S \bar{A}_y}{I}$$

where S = Shear force (working load) = 0.849kN (see below)

$$\text{Retn from beam} = \left[(5.00 \text{ kN/m}^2 \times 0.495 \text{ m}) + (0.199 \text{ kN/m}^2 \times 0.495) \right] \times \frac{0.981}{2} = 0.53 \text{ kN}$$



$$A = \text{Area above point of consideration} = 18 \text{ mm} \times 8.58 \text{ mm} = 154.44 \text{ mm}^2$$

Metrodeck Structural Calculations

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$$\begin{aligned} \bar{y} &= \text{Extreme fibre} & &= 18\text{mm}/2 & &= 9\text{mm} \\ I &= \text{moment of inertia} & &= 145136\text{mm}^4 \end{aligned}$$

$$\therefore f_q = \frac{0.631\text{kN} \times 154.44\text{mm}^2 \times 9\text{mm} \times 10^3}{99267\text{mm}^4} = 8.838\text{N/mm per metre}$$

Permissible screw load (steel) $F_{adm} = F \times K_{52} \times K_{53} \times K_{54} \times 1.5$ (for steel)

Where $F =$ Basic load for a screw $= 1322\text{N}$ (Table 62)

$K_{52} =$ Modification factor for duration of loading $= 1.25$

$K_{53} =$ Modification factor for moisture content $= 1.0$

$K_{54} =$ Modification factor for no of screws in each line $= 1.0$

$$\therefore F_{adm} = 1322 \times 1.25 \times 1.0 \times 1.0 \times 1.5 = 2479\text{N}$$

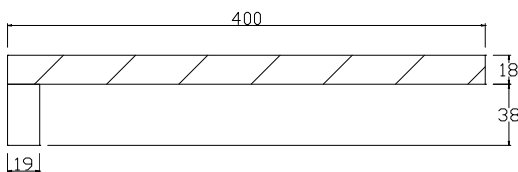
$$\therefore \text{No of screws req'd} = \frac{8.838\text{N/mm} \times 981\text{mm}}{2479\text{kN}} = 3.5 \therefore \text{say } 5 \text{ no}$$

\therefore provide 5 no 12 screws at 200mm spacing to fix plywood to top member 38 x 19 x 1.6 steel sections inserted into pre-drilled holes

Check top member as composite 'L' section 38 x 19 x 1.6 RHS (ERW)

$$B_e = b_e = \frac{L_z}{8} = \frac{2.0\text{m}}{8} = 0.25 \quad \text{OR}$$

$$b_e = 0.8b = 0.8 \times \frac{1.0}{2} = 0.40\text{m} \quad \therefore \text{say } B_e = 0.40\text{m}$$



$$\begin{aligned} \text{Modular Ratio } \alpha &= \frac{E_{\text{steel}}}{E_{\text{ply}}} = \frac{200\text{N/mm}^2 \times 10^3}{3467\text{N/mm}^2} \\ &= 57.7 \end{aligned}$$

Flange in terms of equivalent steel section, $B_e = \frac{0.40\text{m} \times 10^3}{57.7} = 6.93\text{mm}$

Metrodeck Structural Calculations

Sheet M22 of 26

Cross sectional area, $A_y = (6.93\text{mm} \times 18\text{mm}) + (1.72\text{cm}^2 \times 10^2) = 296.74\text{mm}^2$

$$\text{Elastic N.A} \geq \bar{y}[(6.93\text{mm} \times 18\text{mm}) + (1.72\text{cm}^2 \times 10^2)]$$

$$= 6.93\text{mm} \times 18\text{mm} \times \frac{18\text{mm}}{2} + \left[1.72\text{cm}^2 \times 10^2 \times \left(\frac{38\text{mm}}{2} + 18\text{mm} \right) \right]$$

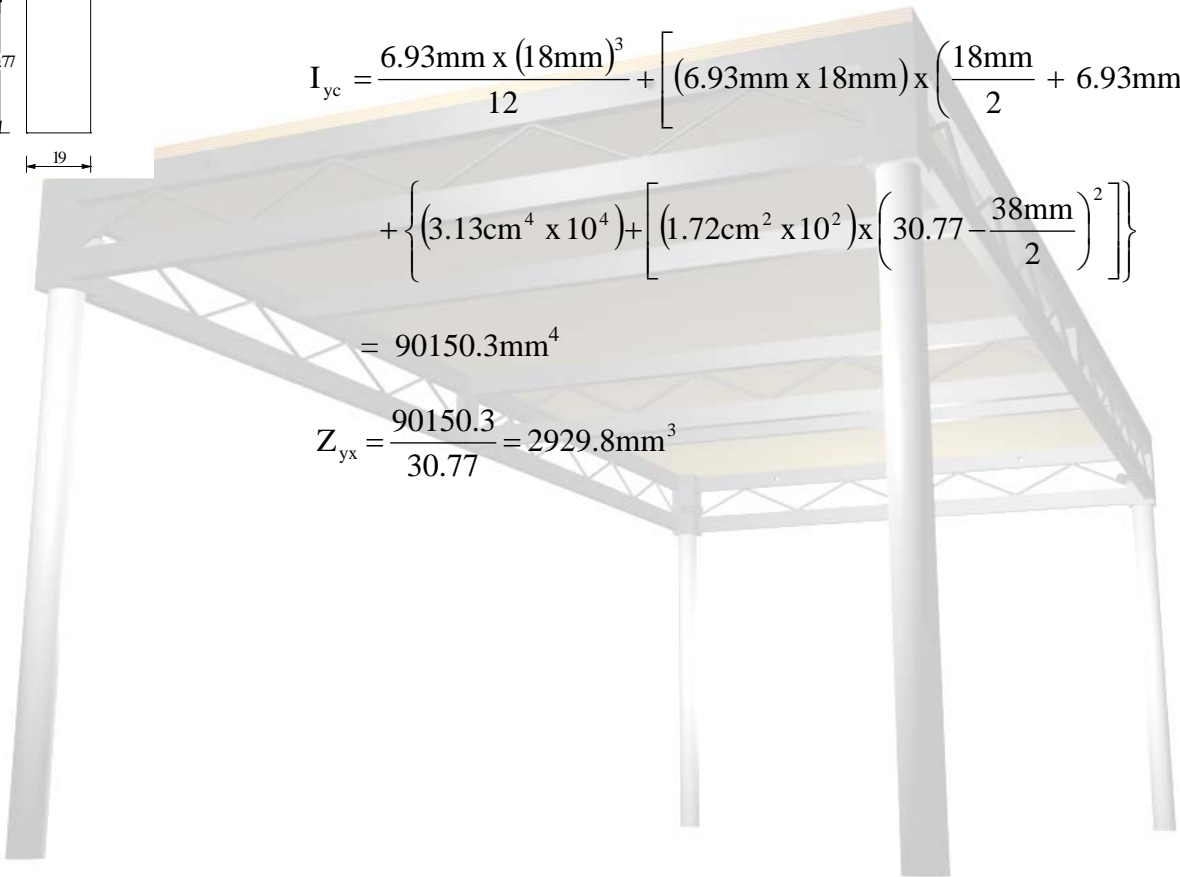
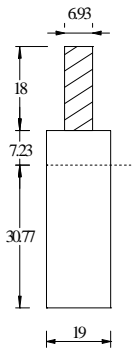
$$\bar{y} = 25.23\text{mm}$$

$$I_{yc} = \frac{6.93\text{mm} \times (18\text{mm})^3}{12} + \left[(6.93\text{mm} \times 18\text{mm}) \times \left(\frac{18\text{mm}}{2} + 6.93\text{mm} \right)^2 \right]$$

$$+ \left\{ (3.13\text{cm}^4 \times 10^4) + \left[(1.72\text{cm}^2 \times 10^2) \times \left(30.77 - \frac{38\text{mm}}{2} \right)^2 \right] \right\}$$

$$= 90150.3\text{mm}^4$$

$$Z_{yx} = \frac{90150.3}{30.77} = 2929.8\text{mm}^3$$



Metrodeck Structural Calculations

Sheet M23 of 26

Due to composite action steel section is assumed fully restraint having the above properties:

Compression capacity, $p_{cy} = A_y p_y = 296.74\text{mm}^2 \times 181\text{N/mm}^2 \times 10^{-3} = 53.71\text{kN}$

Moment capacity, $M_{cx} = 1.2 p_y Z = 1.2 \times 200\text{N/mm}^2 \times 2929.8\text{mm}^3 \times 10^{-3} = 0.703\text{kNm}$

$\therefore \text{Unity} = \frac{31.728}{53.71} + \frac{0.306}{0.703} + 0 = 1.026 > 1$ However design loads conservative therefore by

inspection satisfactory

Check overall deflection

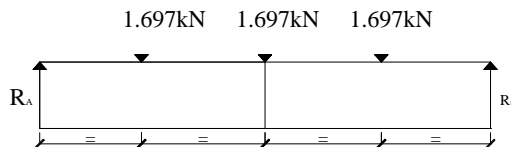
$\delta_{\max} = 8.48\text{mm}$ (see page 15)

$\delta_{\text{lim}} = \frac{\text{Span}}{230} = \frac{1981}{230} = 8.61\text{mm}$

since $\delta_{\max} < \delta_{\text{lim}}$ \therefore OK

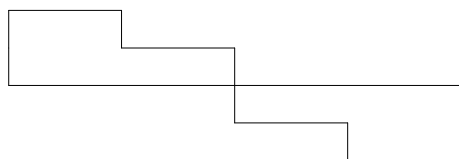
Check screw connections

Shear Stress $f_q = \frac{S A \bar{y}}{I}$



$R_A = R_B = 3 \times 1.697\text{kN} / 2 = 2.55\text{kN}$

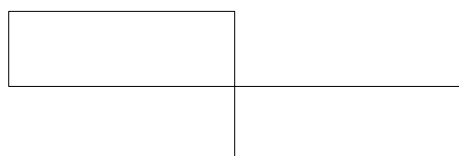
2.55kN



(SF Diag)

-2.55kN

1.27kN



(Avg SF)

-1.27kN

Metrodeck Structural Calculations

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Retn from intermediate members (38 x 19 x 1.6) = 1.697kN (see page 21)

$$\begin{aligned} \therefore S &= \text{Average shear force (working loads)} &= 1.27\text{kN} \\ A &= \text{Area above point of consideration} &= 18\text{mm} \times 6.93\text{mm} = 124.7\text{mm}^2 \\ \bar{y} &= \text{Extreme fibre} &= \frac{18\text{mm}}{2} = 9\text{mm} \\ I &= \text{moment of inertia} &= 90150.3\text{mm}^4 \end{aligned}$$

$$f_q = \frac{1.27\text{kN} \times 124.74\text{mm}^2 \times 9\text{mm} \times 10^3}{90150.3\text{mm}^4} = 15.82\text{N/mm per metre}$$

Permissible screw load F_{adm} = $F \times K_{52} \times K_{53} \times K_{54} \times 1.5$ (for steel)

Where F = Basic load for a screw = 1322N (Table 62)

K_{52} = Modification factor for duration of loading = 1.25

K_{53} = Modification factor for moisture content = 1.0

K_{54} = Modification factor for no of screws in each line = 1.0

$\therefore F_{adm} = 1322 \times 1.25 \times 1.0 \times 1.0 \times 1.5 = 2479\text{N}$

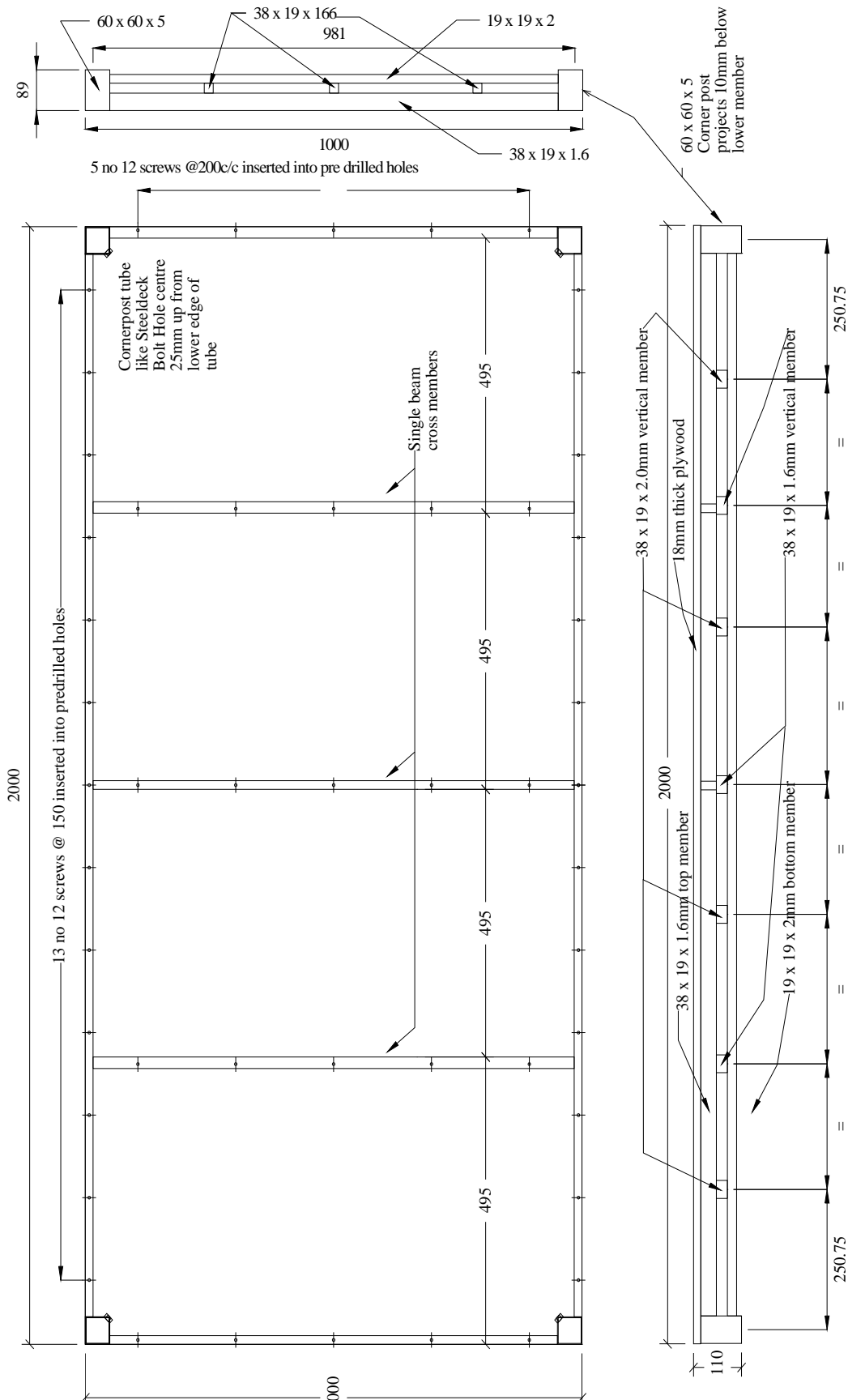
\therefore No of screws req'd = $\frac{15.82\text{N/mm} \times 1981\text{mm}}{2479\text{N}} = 12.6 \therefore$ say 13 no

\therefore provide 13 no 12 screws at 150mm spacing to fix plywood to top member 38 x 19 x 1.6 steel sections inserted into pre-drilled holes



Metrodeck Structural Calculations

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Metrodeck 2m x 1m

General Arrangement



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Metrodeck Structural Calculations

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