



PHILIP WRIGHT
ASSOCIATES

**STRUCTURAL CALCULATIONS
FOR
ASSESSMENT OF EXISTING STEEL FRAMES
BARN 2
WHITTLE HALL FARM
LANGHO**

SHEET NOS 201-220

CONTRACT NO. 2577	PHILIP WRIGHT ASSOCIATES LTD 21 UNION STREET RAMSBOTTOM BURY BL0 9AN
MARCH 2022	TEL. 01706 828781 E 



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ASSOCIATES LTD

Contract

WHITTLE HALL FARM

Contract No.

2577

Sheet No.

201

Rev.

Date.

MAR 22

Consulting Structural Engineers

Part of Structure

BARN 2

LOADING

ROOF DEAD

CLADDING 0.14
TIMBER PURLINS 0.03
S WT STEEL 0.10 *

TOTAL 0.27 KN/m²

ULT 0.38 KN/m²

IMPOSED

ROOF

TOTAL 0.60
0.60 KN/m²

ULT 0.96 KN/m²

TOTAL 0.87 KN/m²

Y= 1.54

1.34 KN/m²

*S WT INPUTTED IN FRAME

SIDE PANEL SELF SUPPORTING



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Part of Structure

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MILES HILL FARM

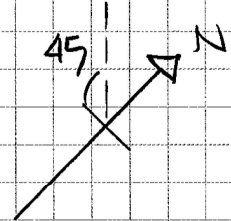
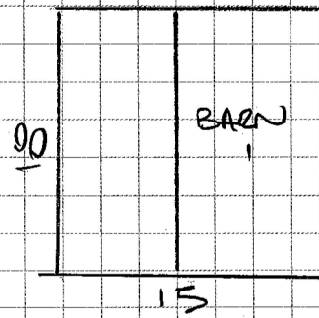
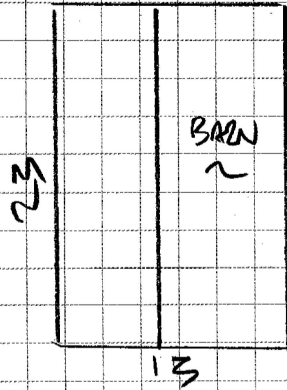
2577

202

Rev.

MAR 22

WIND ANALYSIS.



GRID REF. SD 7225 3464

SITE HT 186m

BARN 1

EAVES . 3.4m
RIDGE . 5.65m

BARN 2

EAVES . 2.55m
RIDGE . 4.55m

Wind Analysis to BS6399-2 - Wind Loads for Roofs

DATA ENTRY:-

Width of Bay

13.000 m

Reference Height 4.550m

Length of Bay

23.000 m

Roof Pitch

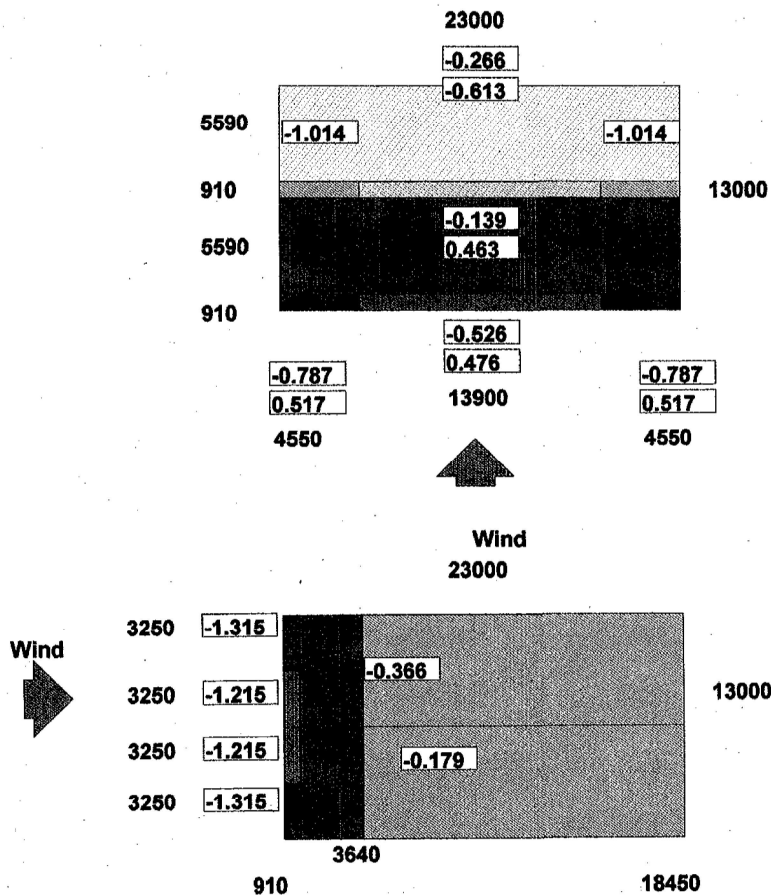
17.000 deg.

Roof Type

Ridged Duopitch roof

Bay type

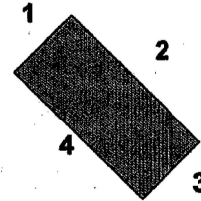
Single bay building



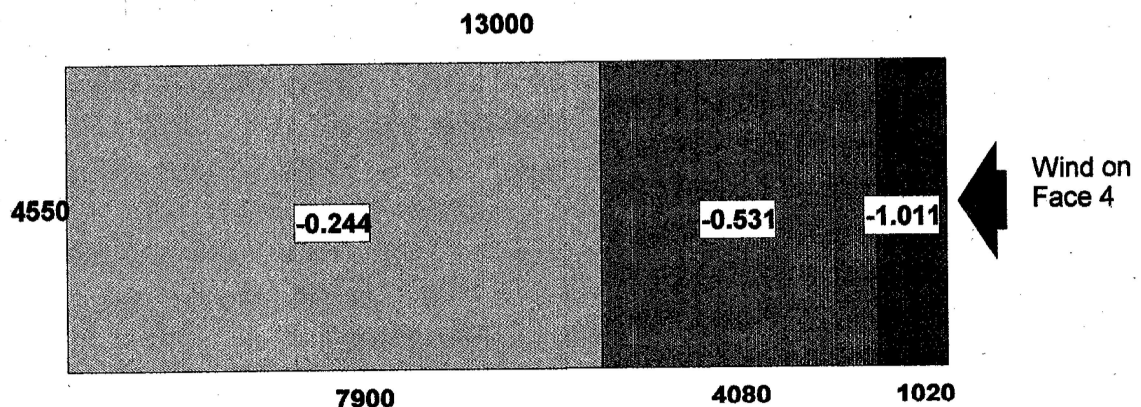
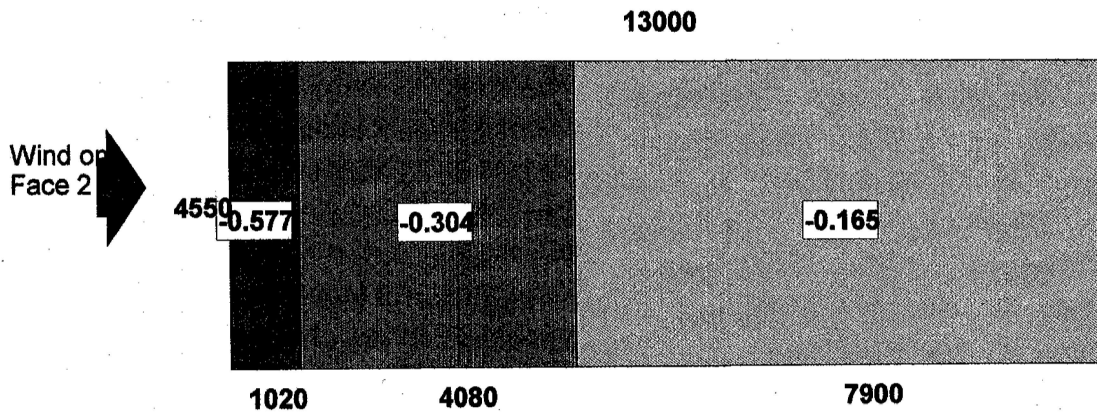
Wind Analysis to BS6399-2 - Wind Loads for Walls

DATA ENTRY:-

Short Face 1 or 3	13.000 m
Long Face 2 or 4	23.000 m
Reference Face	Face 1 (Gable)
Reference Height	4.550 m
Gap Between Buildings	0.000 m



Reference Face



Suction(kN/m²) On Reference Face1

Pressure (kN/m²) On Reference Face = +0.811

Pressure/Suction (kN/m²) On Opposite(Leeward) Face = -0.244

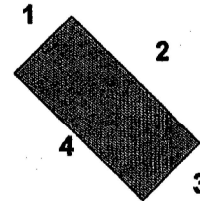
Note: The above loads are not applicable to parapets which must be designed separately.

NB: All dimensions are in millimetres and wind loads in kN/m²

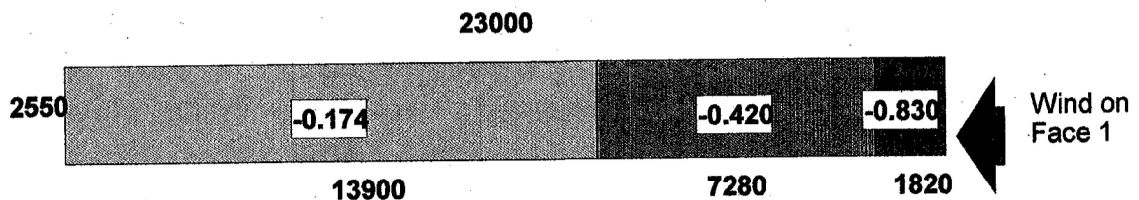
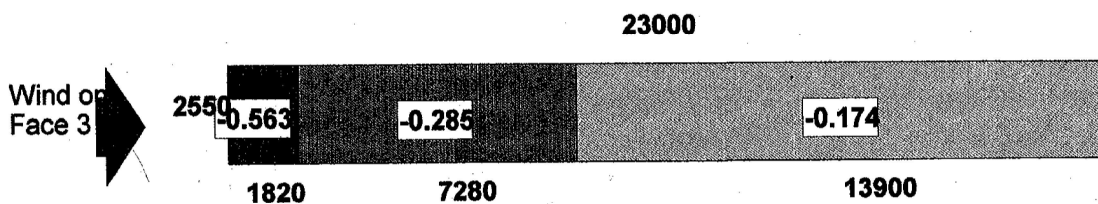
Wind Analysis to BS6399-2 - Wind Loads for Walls

DATA ENTRY:-

Short Face 1 or 3	13.000 m
Long Face 2 or 4	23.000 m
Reference Face	Face 2 (Side)
Reference Height	2.550 m
Gap Between Buildings	0.000 m



Reference Face



Suction(kN/m²) On Reference Face2

Pressure (kN/m²) On Reference Face = +0.416

Pressure/Suction (kN/m²) On Opposite(Leeward) Face = -0.099

Note: The above loads are not applicable to parapets which must be designed separately.

NB: All dimensions are in millimetres and wind loads in kN/m²

Wind Analysis to BS6399-2 - Wind Loads for Walls**DATA ENTRY:-**

Short Face 1 or 3

13.000 m

Long Face 2 or 4

23.000 m

Reference Face

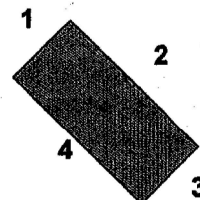
Face 3 (Gable)

Reference Height

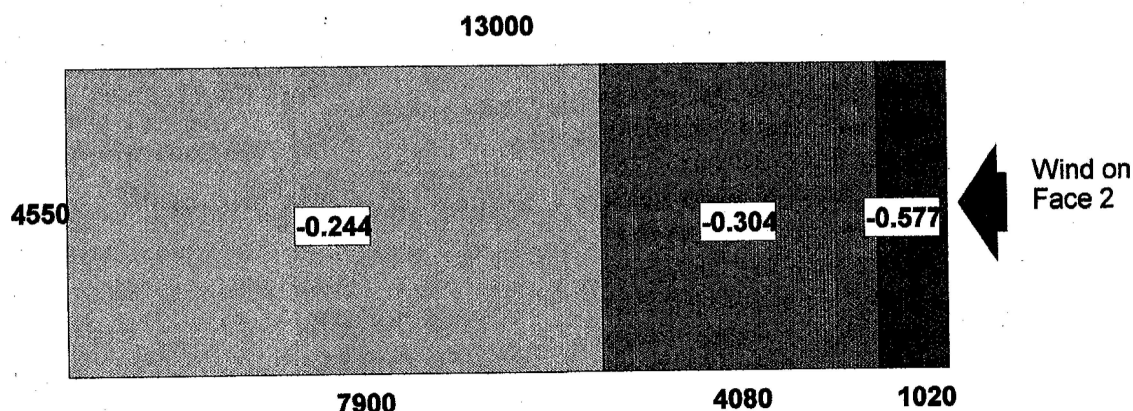
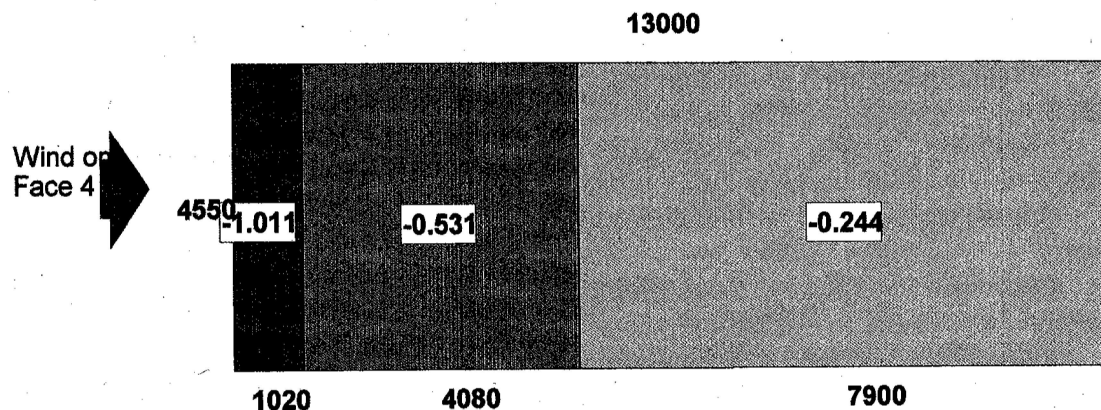
4.550 m

Gap Between Buildings

0.000 m



Reference Face

**Suction(kN/m²) On Reference Face3**

Pressure (kN/m²) On Reference Face = +0.550

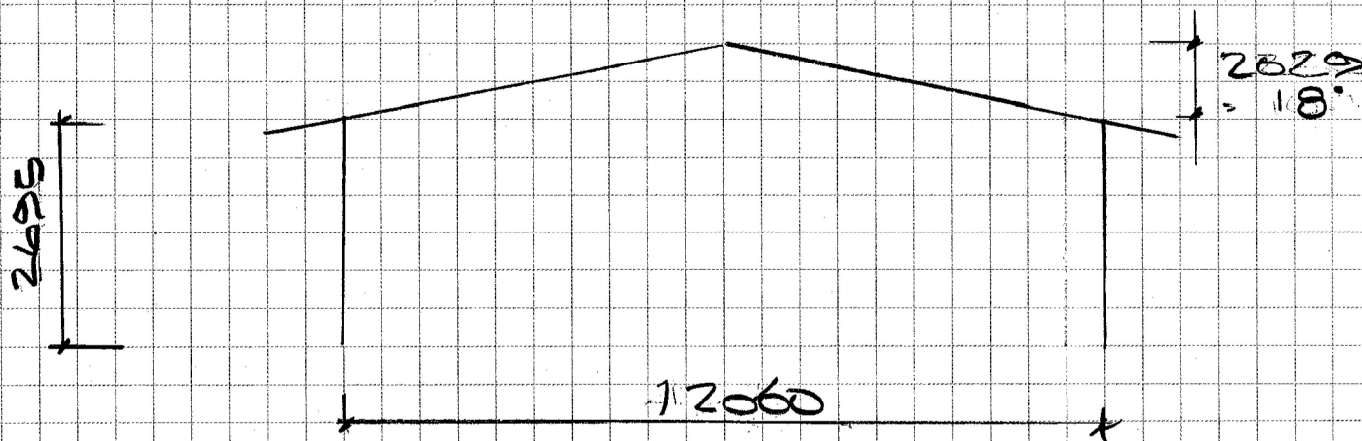
Pressure/Suction (kN/m²) On Opposite(Leeward) Face = -0.165

Note: The above loads are not applicable to parapets which must be designed separately.

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BARN 2

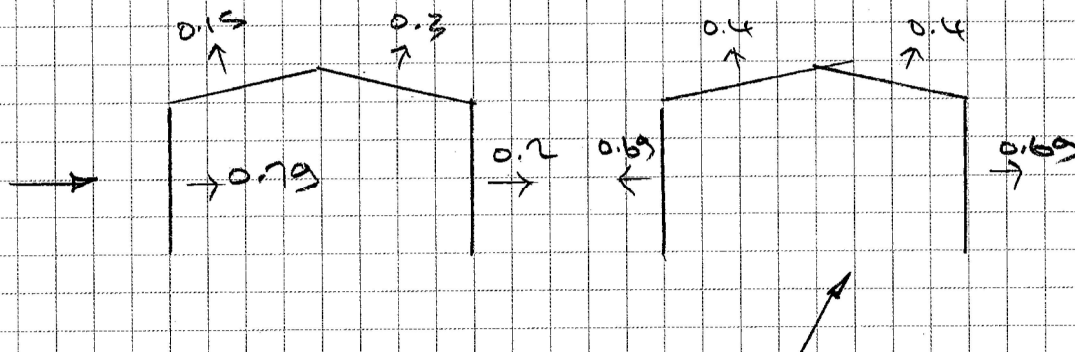


CTRS 4570

DL - 0.17

LL - 0.60 kN/m

WIND LOAD



Column	-	178	102	19	UB	OK	✓
RAFTER		178	102	19	UB	OK	✓

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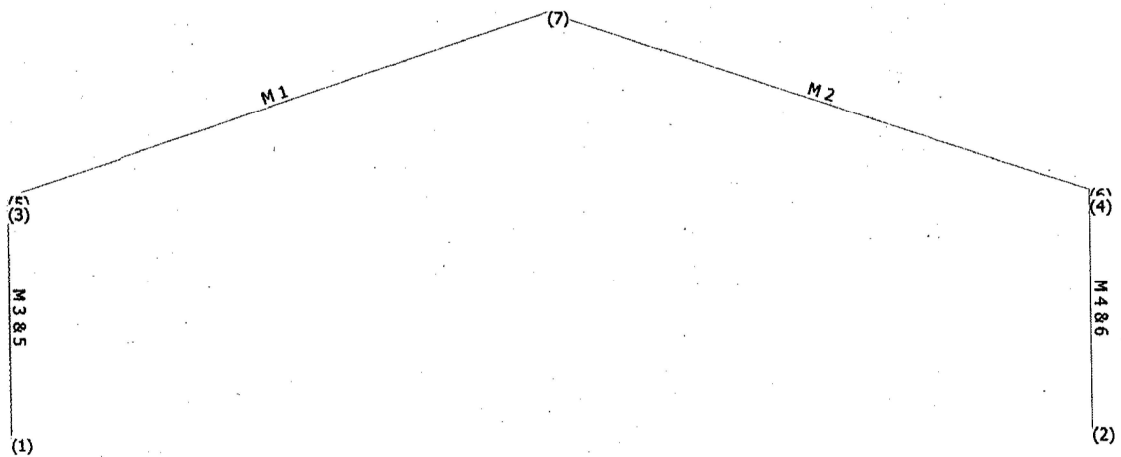
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Bolton, Lancs, BL5 3YW
Tel: 01942 811532

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Y

Z — X

**Frame Geometry - (Full Frame) - Front View****Not to Scale**

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MasterPort Data File

Loading Cases and Load Combination

Load Group Labels

Load Group UT	Unity Load Factor (All Cases)
Load Group D1	Dead Load
Load Group D2	Services
Load Group L1	Live Load
Load Group W1	Wind Load
Load Group W2	Wind Load

Load Case 001 : 1.4 (Dead+Services) + 1.6 Live

Load Combination + 1.00 UT + 1.40 D1 + 1.40 D2 + 1.60 L1

Load Case 002 : Dead + Services + Live (Service)

Load Combination + 1.00 UT + 1.00 D1 + 1.00 D2 + 1.00 L1

Load Case 003 : Live Only (Service)

Load Combination + 1.00 UT + 1.00 L1

Load Case 004 : (Sway Stability)

Load Combination + 1.00 UT
Notional Loads Apply horizontal notional loads at 0.0 degrees from X axis equal to 0.5% of the factored vertical loads in case 1

Level	@ (m)	F (kN)	Level	@ (m)	F (kN)	Level	@ (m)	F (kN)
0	0.000	0.003	1	2.569	0.004	2	2.695	0.185
3	4.724	0.162						

Node	F (kN)	Node	F (kN)	Node	F (kN)	Node	F (kN)
1	0.002	2	0.002	3	0.002	4	0.002
5	0.092	6	0.092	7	0.162		

Load Case 005 : 1.4 (Dead+Services) + 1.6 Live + Notional -->

Load Combination + 1.00 UT + 1.40 D1 + 1.40 D2 + 1.60 L1
Notional Loads Apply horizontal notional loads at 0.0 degrees from X axis equal to 0.5% of the factored vertical loads in case 1

Level	@ (m)	F (kN)	Level	@ (m)	F (kN)	Level	@ (m)	F (kN)
0	0.000	0.003	1	2.569	0.004	2	2.695	0.185
3	4.724	0.162						

Node	F (kN)	Node	F (kN)	Node	F (kN)	Node	F (kN)
1	0.002	2	0.002	3	0.002	4	0.002
5	0.092	6	0.092	7	0.162		

Load Case 006 : 1.4WIND SIDE - 1.0D (Ultimate)

Load Combination + 1.00 UT + 1.00 D1 + 1.40 W1

Load Case 007 : 1.4WIND SIDE - 1.0D (Serviceability)

Load Combination + 1.00 UT + 1.00 D1 + 1.00 W1

Load Case 008 : 1.4WIND END - 1.0D (Ultimate)

Load Combination + 1.00 UT + 1.00 D1 + 1.40 W2

Load Case 009 : 1.4WIND END - 1.0D (Serviceability)

Load Combination + 1.00 UT + 1.00 D1 + 1.00 W2

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The Nodal Co-ordinates

Node	X (m)	Y (m)	Z (m)	Node	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000	2	12.060	0.000	0.000
3	0.000	2.569	0.000	4	12.060	2.569	0.000
5	0.000	2.695	0.000	6	12.060	2.695	0.000
7	6.030	4.724	0.000				

Member Properties

Members 1-2 (1.013m Haunch at End 1, Depth 355.6mm to 177.8mm)

MH ... 178x102 UB 19 [S 275]
A 24.26E-4 Ix 1357E-8 Iy 137.6E-8 J 4.41E-8
E 205.0E6 G 78.85E6

Members 3-6 (0.245m Haunch at End 2, Depth 177.8mm to 355.6mm)

MH ... 178x102 UB 19 [S 275]
A 24.26E-4 Ix 1357E-8 Iy 137.6E-8 J 4.41E-8
E 205.0E6 G 78.85E6

Member Loading

Note: Partial Fixity - Use 0% in Ultimate, 10% in Sway Stability and 20% in Serviceability Loading Cases

Member Self Weight Density Load Included in Load Group D1, defined by Modulus of Elasticity

E kN/mm ²	Density kN/m ³
≥ 200.00	77.01
≥ 20.00	24.00
≥ 2.00	10.00

Member 1

UT Spacing 04.570 [Multiply AllLoads]	Rafter 1 of Bay 1	
D1 UDLY -000.170 [kN/m]	D2 UDLY -000.000	[kN/m]
L1 UDLY -000.600 [kN/m]	W1 UDLN +000.150	[kN/m]
W2 UDLN +000.400 [kN/m]	W3 UDLN -000.460	[kN/m]

Member 2

UT Spacing 04.570 [Multiply AllLoads]	Rafter 2 of Bay 1	
D1 UDLY -000.170 [kN/m]	D2 UDLY -000.000	[kN/m]
L1 UDLY -000.600 [kN/m]	W1 UDLN +000.300	[kN/m]
W2 UDLN +000.400 [kN/m]	W3 UDLN +000.300	[kN/m]

Members 3 & 5

UT Spacing 04.570 [Multiply AllLoads]	Column 1	
UT PartFix 20.00 +++ --- (0/10/20)	W1 UDLX +000.790	[kN/m]
W2 UDLX -000.700 [kN/m]	W3 UDLY +000.790	[kN/m]

Members 4 & 6

UT Spacing 04.570 [Multiply AllLoads]	Column 2	
UT PartFix 20.00 +++ --- (0/10/20)	W1 UDLX +000.200	[kN/m]
W2 UDLX +000.700 [kN/m]	W3 UDLX +000.200	[kN/m]

Member Orientation

Members 2, 4 & 6 B +180.00

Nodal Loading and Support Conditions**NODES 1-2**

UT Rs 1 1 1 1 1 1 (20.00% Fixity)

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Nodal Deflections Serviceability (002 : Dead + Services + Live (Service))

Node	Nodal Def. (mm and Degrees)				Node	Nodal Def. (mm and Degrees)			
	$\delta X \rightarrow$	$\delta Y \uparrow$	$\phi Z \curvearrowright$	δXY		$\delta X \rightarrow$	$\delta Y \uparrow$	$\phi Z \curvearrowright$	δXY
1	0.00	0.00	0.00	0.00	2	0.00	0.00	0.00	0.00
3	-13.85	-0.12	-0.14	13.85	4	13.85	-0.12	0.14	13.85
5	-13.52	-0.13	-0.16	13.52	6	13.52	-0.13	0.16	13.52
7	0.00	-40.98	0.00	40.98					

Nodal Deflections Serviceability (003 : Live Only (Service))

Node	Nodal Def. (mm and Degrees)				Node	Nodal Def. (mm and Degrees)			
	$\delta X \rightarrow$	$\delta Y \uparrow$	$\phi Z \curvearrowright$	δXY		$\delta X \rightarrow$	$\delta Y \uparrow$	$\phi Z \curvearrowright$	δXY
1	0.00	0.00	0.00	0.00	2	0.00	0.00	0.00	0.00
3	-10.21	-0.09	-0.10	10.21	4	10.21	-0.09	0.10	10.21
5	-9.97	-0.09	-0.12	9.97	6	9.97	-0.09	0.12	9.97
7	0.00	-30.23	0.00	30.23					

Nodal Deflections Serviceability (004 : (Sway Stability))

Node	Nodal Def. (mm and Degrees)				Node	Nodal Def. (mm and Degrees)			
	$\delta X \rightarrow$	$\delta Y \uparrow$	$\phi Z \curvearrowright$	δXY		$\delta X \rightarrow$	$\delta Y \uparrow$	$\phi Z \curvearrowright$	δXY
1	0.00	0.00	0.00	0.00	2	0.00	0.00	0.00	0.00
3	0.78	0.00	-0.01	0.78	4	0.78	0.00	-0.01	0.78
5	0.81	0.00	-0.01	0.81	6	0.81	0.00	-0.01	0.81
7	0.81	0.00	0.01	0.81					

Nodal Deflections Serviceability (007 : 1.4WIND SIDE - 1.0D (Serviceability))

Node	Nodal Def. (mm and Degrees)				Node	Nodal Def. (mm and Degrees)			
	$\delta X \rightarrow$	$\delta Y \uparrow$	$\phi Z \curvearrowright$	δXY		$\delta X \rightarrow$	$\delta Y \uparrow$	$\phi Z \curvearrowright$	δXY
1	0.00	0.00	0.00	0.00	2	0.00	0.00	0.00	0.00
3	16.89	0.00	-0.26	16.89	4	15.38	0.00	-0.30	15.38
5	17.46	0.00	-0.25	17.46	6	16.03	0.00	-0.29	16.03
7	16.75	2.12	0.20	16.89					

Nodal Deflections Serviceability (009 : 1.4WIND END - 1.0D (Serviceability))

Node	Nodal Def. (mm and Degrees)				Node	Nodal Def. (mm and Degrees)			
	$\delta X \rightarrow$	$\delta Y \uparrow$	$\phi Z \curvearrowright$	δXY		$\delta X \rightarrow$	$\delta Y \uparrow$	$\phi Z \curvearrowright$	δXY
1	0.00	0.00	0.00	0.00	2	0.00	0.00	0.00	0.00
3	-0.14	0.03	0.01	0.14	4	0.14	0.03	-0.01	0.14
5	-0.16	0.03	0.01	0.16	6	0.16	0.03	-0.01	0.16
7	0.00	-0.14	0.00	0.14					

Member Forces Ultimate (001 : 1.4 (Dead+Services) + 1.6 Live)

Mem ber No.	Node End1 End2	Axial Force (kN)	Shear Force (kN)	Bending Moment (kN.m)	Maximum Moment (kN.m @ m)	Maximum Deflection (mm @ m)
1	5 7	29.158C 18.096C	26.791 -6.088	-51.456 14.400	17.984 @ 5.153	11.770 @ 4.453

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Member Forces Ultimate (001 : 1.4 (Dead+Services) + 1.6 Live)

Mem ber No.	Node End1 End2	Axial Force (kN)	Shear Force (kN)	Bending Moment (kN.m)	Maximum Moment (kN.m @ m)	Maximum Deflection (mm @ m)
2	6 7	29.158C	26.791	-51.456	@ 17.984	@ 11.770
		18.096C	-6.088	14.400		
3	1 3	35.392C	-19.093	0.000	@ 5.153	@ 8.697
		34.731C	-19.093	-49.056		
4	2 4	35.392C	-19.093	0.000	@ 5.153	@ 8.697
		34.731C	-19.093	-49.056		
5	3 5	34.731C	-19.093	-49.056	@ 5.153	@ 8.697
		34.690C	-19.093	-51.456		
6	4 6	34.731C	-19.093	-49.056	@ 5.153	@ 8.697
		34.690C	-19.093	-51.456		

Member Forces Ultimate (005 : 1.4 (Dead+Services) + 1.6 Live + Notional -->)

Mem ber No.	Node End1 End2	Axial Force (kN)	Shear Force (kN)	Bending Moment (kN.m)	Maximum Moment (kN.m @ m)	Maximum Deflection (mm @ m)
1	5 7	29.048C	26.717	-50.984	@ 18.074	@ 12.080
		17.986C	-6.163	14.400		
2	6 7	29.269C	26.865	-51.928	@ 17.899	@ 11.460
		18.207C	-6.014	14.400		
3	1 3	35.286C	-18.918	0.000	@ 5.217	@ 8.617
		34.625C	-18.918	-48.605		
4	2 4	35.498C	-19.268	0.000	@ 5.217	@ 8.777
		34.837C	-19.268	-49.506		
5	3 5	34.625C	-18.919	-48.605	@ 5.217	@ 8.617
		34.585C	-18.919	-50.984		
6	4 6	34.837C	-19.267	-49.506	@ 5.217	@ 8.777
		34.796C	-19.267	-51.928		

Member Forces Ultimate (006 : 1.4WIND SIDE - 1.0D (Ultimate))

Mem ber No.	Node End1 End2	Axial Force (kN)	Shear Force (kN)	Bending Moment (kN.m)	Maximum Moment (kN.m @ m)	Maximum Deflection (mm @ m)
1	5 7	1.570T	-3.542	19.323	@ -11.150	@ 15.733
		3.446T	-3.011	-1.522		
2	6 7	0.950C	-2.154	-8.926	@ 2.036	@ 17.574
		0.925T	4.482	-1.522		
3	1 3	3.356T	13.981	0.000	@ 2.036	@ 4.518
		3.828T	0.994	19.238		

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Member Forces Ultimate (006 : 1.4WIND SIDE - 1.0D (Ultimate))

Mem ber No.	Node End1 End2	Axial Force (kN)	Shear Force (kN)	Bending Moment (kN.m)	Maximum Moment (kN.m @ m)	Maximum Deflection (mm @ m)
4	2	1.237T	-5.030	0.000		1.822
	4	1.710T	-1.742	-8.699	@	1.516
5	3	3.828T	0.994	19.238		4.518
	5	3.857T	0.359	19.323	@	1.490
6	4	1.710T	-1.749	-8.716		1.822
	6	1.739T	-1.588	-8.926	@	1.516

Member Forces Ultimate (008 : 1.4WIND END - 1.0D (Ultimate))

Mem ber No.	Node End1 End2	Axial Force (kN)	Shear Force (kN)	Bending Moment (kN.m)	Maximum Moment (kN.m @ m)	Maximum Deflection (mm @ m)
1	5	11.725T	-6.131	8.418		2.441
	7	13.601T	4.576	3.471	@ -2.749 3.626	@ 3.626
2	6	11.725T	-6.131	8.418		2.441
	7	13.601T	4.576	3.471	@ -2.749 3.626	@ 3.626
3	1	9.048T	-2.912	0.000		0.400
	3	9.520T	8.595	7.302	@ -0.946 0.642	@ 1.978
4	2	9.048T	-2.888	0.000		0.409
	4	9.520T	8.619	7.362	@ -0.931 0.642	@ 1.978
5	3	9.520T	8.595	7.302		0.400
	5	9.550T	9.158	8.418	@ -0.946 0.642	@ 1.978
6	4	9.520T	8.595	7.302		0.409
	6	9.550T	9.158	8.418	@ -0.931 0.642	@ 1.978

Support Reactions (001 : 1.4 (Dead+Services) + 1.6 Live)

Node	Support Reactions (kN and kN.m)			Node	Support Reactions (kN and kN.m)		
	Rx→ (kN)	Ry↑ (kN)	Mz↺ (kN.m)		Rx→ (kN)	Ry↑ (kN)	Mz↺ (kN.m)
1	19.093	35.392	0.000	2	-19.093	35.392	0.000
Total	0.000	70.784	0.000				

Support Reactions (002 : Dead + Services + Live (Service))

Node	Support Reactions (kN and kN.m)			Node	Support Reactions (kN and kN.m)		
	Rx→ (kN)	Ry↑ (kN)	Mz↺ (kN.m)		Rx→ (kN)	Ry↑ (kN)	Mz↺ (kN.m)
1	14.045	22.918	-6.057	2	-14.045	22.918	6.057
Total	0.000	45.836	0.000				

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Support Reactions (003 : Live Only (Service))

Node	Support Reactions (kN and kN.m)			Node	Support Reactions (kN and kN.m)		
	Rx→ (kN)	Ry↑ (kN)	Mz↻ (kN.m)		Rx→ (kN)	Ry↑ (kN)	Mz↻ (kN.m)
1	10.359	16.534	-4.467	2	-10.359	16.534	4.467
Total	0.000	33.069	0.000				

Support Reactions (004 : (Sway Stability))

Node	Support Reactions (kN and kN.m)			Node	Support Reactions (kN and kN.m)		
	Rx→ (kN)	Ry↑ (kN)	Mz↻ (kN.m)		Rx→ (kN)	Ry↑ (kN)	Mz↻ (kN.m)
1	-0.177	-0.088	0.109	2	-0.177	0.088	0.109
Total	-0.354	0.000	0.217				

Support Reactions (005 : 1.4 (Dead+Services) + 1.6 Live + Notional -->)

Node	Support Reactions (kN and kN.m)			Node	Support Reactions (kN and kN.m)		
	Rx→ (kN)	Ry↑ (kN)	Mz↻ (kN.m)		Rx→ (kN)	Ry↑ (kN)	Mz↻ (kN.m)
1	18.916	35.286	0.000	2	-19.270	35.498	0.000
Total	-0.354	70.784	0.000				

Support Reactions (006 : 1.4WIND SIDE - 1.0D (Ultimate))

Node	Support Reactions (kN and kN.m)			Node	Support Reactions (kN and kN.m)		
	Rx→ (kN)	Ry↑ (kN)	Mz↻ (kN.m)		Rx→ (kN)	Ry↑ (kN)	Mz↻ (kN.m)
1	-13.981	-3.356	0.000	2	-5.030	-1.237	0.000
Total	-19.010	-4.594	0.000				

Support Reactions (007 : 1.4WIND SIDE - 1.0D (Serviceability))

Node	Support Reactions (kN and kN.m)			Node	Support Reactions (kN and kN.m)		
	Rx→ (kN)	Ry↑ (kN)	Mz↻ (kN.m)		Rx→ (kN)	Ry↑ (kN)	Mz↻ (kN.m)
1	-9.205	0.140	4.811	2	-4.378	0.227	3.790
Total	-13.584	0.367	8.600				

Support Reactions (008 : 1.4WIND END - 1.0D (Ultimate))

Node	Support Reactions (kN and kN.m)			Node	Support Reactions (kN and kN.m)		
	Rx→ (kN)	Ry↑ (kN)	Mz↻ (kN.m)		Rx→ (kN)	Ry↑ (kN)	Mz↻ (kN.m)
1	2.912	-9.048	0.000	2	-2.888	-9.048	0.000
Total	0.023	-18.097	0.000				

Support Reactions (009 : 1.4WIND END - 1.0D (Serviceability))

Node	Support Reactions (kN and kN.m)			Node	Support Reactions (kN and kN.m)		
	Rx→ (kN)	Ry↑ (kN)	Mz↻ (kN.m)		Rx→ (kN)	Ry↑ (kN)	Mz↻ (kN.m)
1	3.073	-4.639	-0.245	2	-3.073	-4.639	0.245
Total	0.000	-9.278	0.000				

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List of Checks - Results Summary

Column 1 : M 3 & 5 (N.1-N.5)	00.000 to 01.460 m, in Case 002	0.592	A+M Pass
	01.460 to 02.460 m, in Case 001	0.996	A+M Pass
	02.460 to 02.695 m, in Case 001	0.872	A+M Pass
Column 1 : M 3 & 5 (N.1-N.5)	02.460 to 02.695 m, in Case 005	0.144	App-G Pass
Rafter 1 of Bay 1 : M 1 (N.5-N.7)	00.094 to 01.500 m, in Case 001	0.607	A+M Pass
	01.500 to 03.000 m, in Case 007	0.428	A+M Pass
	03.000 to 04.500 m, in Case 007	0.428	A+M Pass
	04.500 to 06.000 m, in Case 007	0.428	A+M Pass

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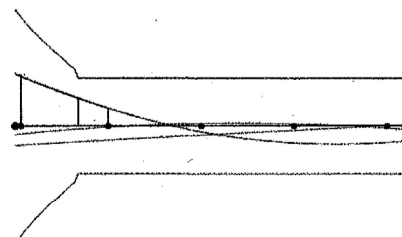
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Axial with Moments (Member)
Rafter 1 of Bay 1 : Member 1 (N.5-N.7)
Between 0.094 and 1.500 m, in Load Case 1

Member Loading and Member Forces

Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1
UT Spacing 04.570 [Multiply All Loads]
D1 UDLY -000.170 [kN/m]
D2 UDLY -000.000 [kN/m]
L1 UDLY -000.600 [kN/m]

**Member Forces in Load Case 1 and Maximum Deflection from Load Case 7**

Mem ber No.	Node End1 End2	Axial Force (kN)	Shear Force (kN)	Bending Moment (kN.m)	Maximum Moment (kN.m @ m)	Maximum Deflection (mm @ m)
1	5 7	29.158C 18.096C	26.791 -6.088	-51.456 14.400	@ 17.984 5.153	@ 7.563 2.799

Classification and Properties (BS 5950: 2000)

Section (19.04 kg/m) 178x102 UB 19 [S 275]
Class = $F_n(b/T, d/t, p_y, F, M_x, M_y)$ 6.41, 30.58, 275, 29.16, 51.46, 0 (Axial: Non-Slender) Plastic
Auto Design Load Cases 1, 5-6 & 8

Local Capacity Check

F_{vx}/P_{vx} 21.555 / 140.818 = 0.153 Low Shear
 $M_{cx} = p_y.S_{xx} \leq 1.2 p_y.Z_{xx}$ 275 x 171.3 $\leq$ 1.2 x 275 x 152.53 = 47.108 kN.m
 $P_z = A_g.p_y$ 24.26 x 275 = 667.15 kN
 $n = F/P_z$ 29.158 / 667.15 = 0.044 OK
 $S_{rx} = F_n(S_{xx}, n)$ 171.3, 0.044
 $M_{rx} = S_{rx}.p_y$ 170.71 x 275 = 46.946 kN.m
 $(M_x/M_{rx})^{2.1} + (M_y/M_{ry})^{2.2}$ (26.966/46.946)^{2.1} + (0)^{2.2} = 0.33 OK

Compression Resistance P_c

$\lambda_x = L_{ex}/r_{xx}$ 100x1x6.362/7.48 = 85.1
 $P_{cx} = A_{area}.p_{cx}$ 24.26x191.829/10 = 465.378 kN Table 24 a
 $\lambda_y = L_{ey}/r_{yy}$ 100x1x1.406/2.37 = 59.2
 $P_{cy} = A_{area}.p_{cy}$ 24.26x221.89/10 = 538.303 kN Table 24 b

Equivalent Uniform Moment Factors m_{LT} , m_x , m_y and m_{yx}

$m_{LT} = 0.2 + (1.5M_2 + 5M_3 + 1.5M_4)/M_{max}$ 0.2 + (1.5x40 + 5x32 + 1.5x24)/49 $\geq$ 0.44 1 Table 18
 $m_y = 0.2 + (1M_2 + 6M_3 + 1M_4)/M_{max}$ 0.2 + (1x0 + 6x0 + 1x0)/0 $\geq$ 0.8x0/0 1 Table 26
 $m_x = 0.2 + (1M_2 + 6M_3 + 1M_4)/M_{max}$ 0.2 + (1x-15 + 6x8 + 1x18)/51 $\geq$ 0.8x18/51 0.293 Table 26
 $m_{yx} = 0.2 + (1M_2 + 6M_3 + 1M_4)/M_{max}$ 0.2 + (1x0 + 6x0 + 1x0)/0 $\geq$ 0.8x0/0 1 Table 26

Lateral Buckling Check M_b

$L_e = 1.00 L$ 1 x 1.406 = 1.406 m
 $\lambda = L_e/r_{yy}$ 1.406 / 2.37 = 59.23
 $v = F_n(x, L_e, r_{yy}, \lambda)$ 22.54, 1.406, 2.37, 59.23
 $\lambda_{LT} = u.v.\lambda.\sqrt{\beta_w}$ 0.888 x 0.929 x 59.23 $\sqrt{1}$ = 48.85
 $p_b = F_n(p_y, \lambda_{LT})$ 275, 48.85 240.78 N/mm² Table 19
 $M_b = S_{xx}.p_b \leq M_c$ 171.3 x 240.78 $\leq$ 47.108 = 41.246 kN.m Table 16

Combined Axial Compression and Bending to Annex I

$r_b = m_{LT}.M_{LT}/M_b$ 1x-27/41.2 = 0.654
 $r_c = F_o/P_{cy}$ 29.2/538.3 = 0.054
 $\lambda_r = (r_b\lambda_{LT} + r_c\lambda_y)/(r_b + r_c)$ (0.654x48.8 + 0.054x59.2)/(0.654 + 0.054) = 49.642
 $\lambda_{ro} = 17.15_E (2r_b + r_c)/(r_b + r_c)$ 17.15 * (2*0.654 + 0.054)/(0.654 + 0.054) = 32.988
 $M_{ob} = M_b(1 - F_o/P_{cy})$ 41.246(1 - 29.2/538.3) = 39.011

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$M_{xy} = M_{cx}(1 - F_c/P_{cy})^{1/4}$	47.108(1-29.2/538.3) ^{1/4}	45.814	
$M_{ox} = M_{cx}(1 - F_c/P_{cx})/(1 + 0.5F_c/P_{cx})$	47.108(1-29.2/465.4)/(1+0.5*29.2/465.4)	42.815	
$M_{oy} = M_{cy}(1 - F_c/P_{cy})/(1 + k_y(F_c/P_{cy}))$	8.915(1-29.2/538.3)/(1+1.0(29.2/538.3))	7.999	
$M_{ab} = \text{fn}(\lambda_{rx}, \lambda_{ry}, \epsilon, M_{xy}, M_{ob})$	49.642, 32.988, 1.000, 45.814, 39.011	44.444	
$M_{ax} = \text{fn}(\lambda_{rx}, \epsilon, M_{rx}, M_{ox})$	85.098, 1.000, 46.946, 42.815	42.857	
$M_{ay} = \text{fn}(\lambda_{ry}, \epsilon, M_{ry}, M_{oy})$	59.231, 1.000, 8.915, 7.999	8.354	
$m_x M_x/M_{ax}$	0.293x27/42.9	0.184	OK
$m_{LT} M_{LT}/M_{ab}$	1x-27/44.4	0.607	OK
$m_x M_x/M_{ax}$	0.293x27/42.9	0.184	OK
Compare with Simplified to 4.8.3.3	0.251, 0.708, 0.716	0.716	
Compare with MoreExact to 4.8.3.3	0.236, 0.708, 0.63	0.708	

Deflection Check - Load Case 7

In-span $\delta \leq \text{Span}/360$	7.56 $\leq$ 6362 / 360	7.56 mm	OK
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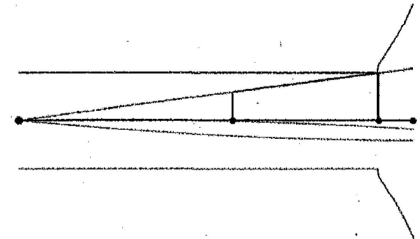
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Axial with Moments (Member)
Column 1 : Members 3 & 5 (N.1-N.5)
Between 1.460 and 2.460 m, in Load Case 1

Member Loading and Member Forces

Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1
UT Spacing 04.570 [Multiply AllLoads]
UT PartFix 20.00 +++ --- (Mt My Mz)

**Member Forces in Load Case 1 and Maximum Deflection from Load Case 2**

Mem ber No.	Node End1 End2	Axial Force (kN)	Shear Force (kN)	Bending Moment (kN.m)	Maximum Moment (kN.m @ m)	Maximum Deflection (mm @ m)
	1 5	35.392C 34.690C	-19.093 -19.093	0.000 -51.456		@ 4.432 1.619

Classification and Properties (BS 5950: 2000)

Section (19.04 kg/m) 178x102 UB 19 [S 275]
Class = $F_n(b/T, d/t, p_y, F, M_x, M_y)$ 6.41, 30.58, 275, 35.39, 51.46, 0 (Axial: Non-Slender) Plastic
Auto Design Load Cases 1, 5-6 & 8

Local Capacity Check

F_{vx}/P_{vx} 19.093 / 140.818 = 0.136 Low Shear
 $M_{cx} = p_y.S_{xx} \leq 1.2 p_y.Z_{xx}$ 275 x 171.3 $\leq$ 1.2 x 275 x 152.53 = 47.108 kN.m
 $P_z = A_g.p_y$ 24.26 x 275 = 667.15 kN
 $n = F/P_z$ 35.392 / 667.15 = 0.053 OK
 $S_{rx} = F_n(S_{xx}, n)$ 171.3, 0.053 170.44 cm³
 $M_{rx} = S_{rx}.p_y$ 170.44 x 275 = 46.87 kN.m
 $(M_x/M_{rx})^{2.1} + (M_y/M_{ry})^{2.2}$ (46.78/46.87)^{2.1} + (0)^{2.2} = 0.996 OK

Compression Resistance P_c

$\lambda_x = L_{ex}/r_{xx}$ 100x1x2.695/7.48 = 36
 $P_{cx} = A_{area}.p_{cx}$ 24.26x263.041/10 = 638.137 kN Table 24 a
 $\lambda_y = L_{ey}/r_{yy}$ 100x1x1/2.37 = 42.1
 $P_{cy} = A_{area}.p_{cy}$ 24.26x247.39/10 = 600.158 kN Table 24 b

Equivalent Uniform Moment Factors mLT , m_x , m_y and m_{yx}

$m_{LT} = 0.2 + (0.15M_2 + 0.5M_3 + 0.15M_4)/M_{max}$ 0.2 + (0.15x33 + 0.5x37 + 0.15x42)/47 $\geq$ 0.44 1 Table 18
 $m_y = 0.2 + (0.1M_2 + 0.6M_3 + 0.1M_4)/M_{max}$ 0.2 + (0.1x0 + 0.6x0 + 0.1x0)/0 $\geq$ 0.8x0/0 1 Table 26
 $m_x = 0.2 + (0.1M_2 + 0.6M_3 + 0.1M_4)/M_{max}$ 0.2 + (0.1x-13 + 0.6x-26 + 0.1x-39)/51 $\geq$ 0.8x39/51 0.6 Table 26
 $m_{yx} = 0.2 + (0.1M_2 + 0.6M_3 + 0.1M_4)/M_{max}$ 0.2 + (0.1x0 + 0.6x0 + 0.1x0)/0 $\geq$ 0.8x0/0 1 Table 26

Lateral Buckling Check M_b

$L_e = 1.00 L$ 1 x 1 = 1 m
 $\lambda = L_e/r_{yy}$ 1 / 2.37 = 42.13
 $v = F_n(x, L_e, r_{yy}, \lambda)$ 22.54, 1, 2.37, 42.13 0.961 Table 19
 $\lambda_{LT} = u.v.\lambda.\sqrt{\beta_w}$ 0.888 x 0.961 x 42.13 $\sqrt{1}$ = 35.94
 $p_b = F_n(p_y, \lambda_{LT})$ 275, 35.94 271.26 N/mm² Table 16
 $M_b = S_{xx}.p_b \leq M_c$ 171.3 x 271.26 $\leq$ 47.108 = 46.466 kN.m

Simplified Approach

$p_y.Z_x$ 275x152.53 = 41.946 kN.m
 $F/P_c + m_x.M_x/p_y.Z_x$ 35.392/600.158 + 0.6x46.8/41.9 = 0.728 OK
 $F/P_{cy} + m_{LT}.M_{LT}/M_b$ 35.392/600.158 + 1x-46.8/46.5 = 1.066 N.A.

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More Exact Approach

$Max = Mcx / (1 + .5F/Pcx)$	$47.1 / (1 + .5 \times 35.4 / 638.1)$	45.836 kN.m	
$F/Pcx + mx.Mx/Max$	$35.4 / 638.1 + 0.6 \times 46.8 / 45.8$	0.668	OK
$F/Pcy + m_{LT}.M_{LT}/Mb$	$35.4 / 600.2 + 1 \times 46.8 / 46.5$	1.066	N.A.

The Maximum Distance Lm : 5.3.5

$Lm = Fn(ry, fc, py, x)$	2.374, 14.589, 275, 23.595	1.225 m	
L/Lm	$1 / 1.225 =$	0.816	OK

Deflection Check - Load Case 2

$In-span \delta \leq Span / 360$	$4.43 \leq 2695 / 360$	4.43 mm	OK
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