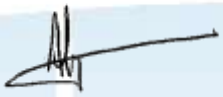
Diamond Wood & Shaw Limited

Class Q Structural Inspection

Client:	Mr Webster
Project:	Former Agriculture Barns, Heath Farm, Osbaston
Project No:	26-23232
Document No:	0-030
Issue:	2
Date:	17 November 2026
Engineer:	



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Andrew Kenyon, MEng (Hons) DIS ILM MIStructE
Director, DWS Ltd

The Old School, Blaby Road, Enderby, Leicester LE19 4AR
T: *+44 (0)116 284 8989* E: *mail@dwsltd.co.uk* W: *www.diamondwoodandshaw.co.uk*

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1. Introduction

1.1. Further to instructions, we visited the former barns and agricultural buildings at Heath Farm, Osbaston, on 28 September 2026.

1.2. The property is a series of purpose built barns that were used for agricultural purposes. They appear to have been used as a feed stores, tractor sheds and animal housing.



1.3. The purpose of our visit was to undertake a visual structural inspection of the buildings prior to a Class Q planning application to convert them to residential accommodation.

1.3.1. Barn 3 is excluded from the application and will be demolished.

1.4. We did not inspect woodwork or any other part of the structure which was not visible or inaccessible, and we are unable, therefore, to advise that any such part is free from defect.

1.5. This report may not be used or relied upon by any unauthorised third party, or for any other proposed use than that specified above, without the explicit written agreement of Diamond Wood and Shaw Limited.

2. Class Q Eligibility (Planning Context)

2.1. Based on our inspection and the available evidence, the buildings are considered to satisfy the principal eligibility requirements of Schedule 2, Part 3, Class Q of the GPDO.

2.2. Established Agricultural Unit

The site formed part of an established agricultural unit and wider farm holding on 24 July 2023.

2.3. Permanent Construction

The structure comprises of a series of fixed and permanent buildings, constructed from steel and concrete elements, and are neither temporary nor mobile in nature.

2.4. Floorspace Compliance

The cumulative floorspace of the buildings does not exceed the maximum threshold of 1,000 m^2, and the individual unit will comply with the relevant Class Q floorspace limit of 150 m^2.

2.5. Site Constraints. The buildings are:

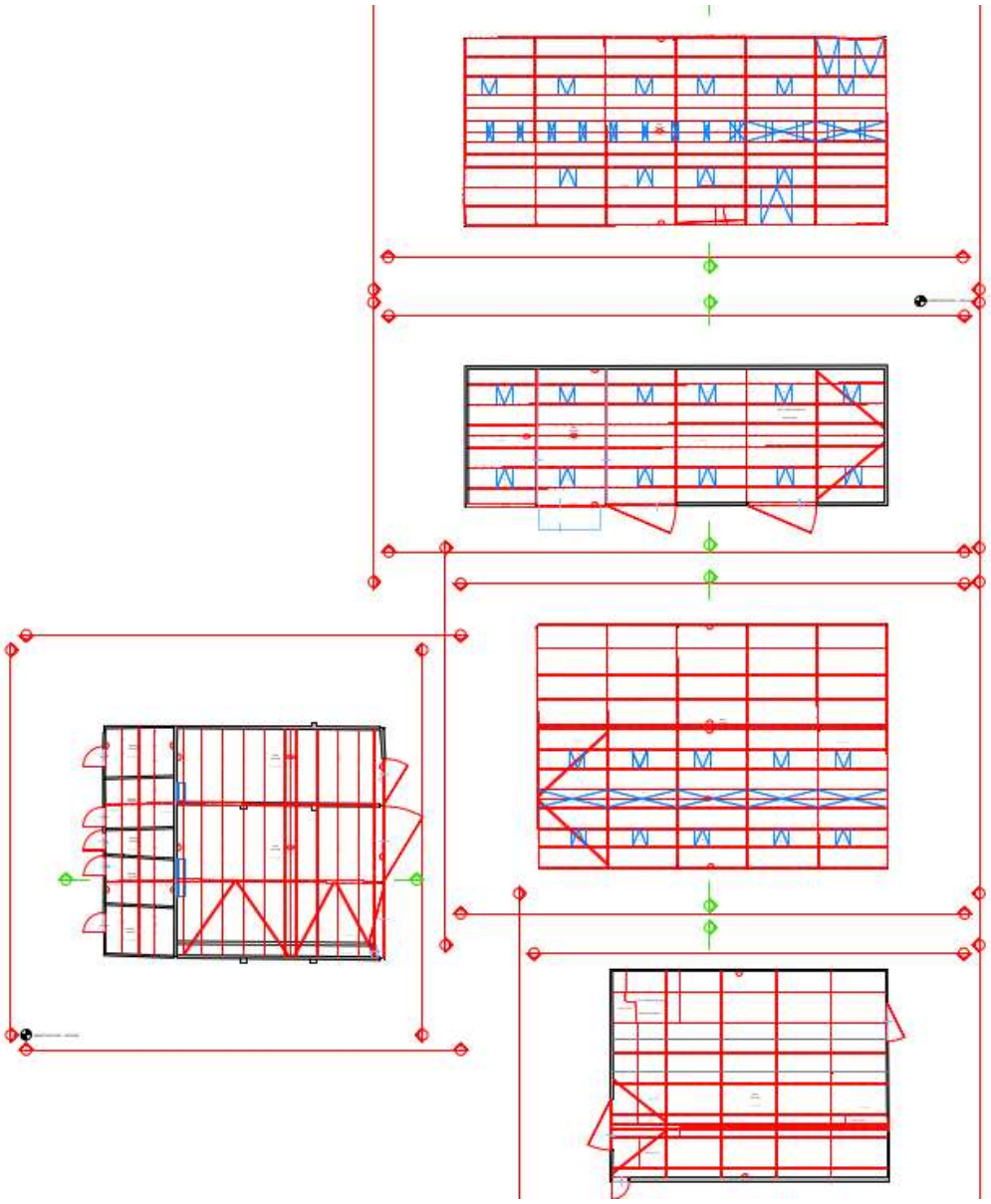
- Not listed
- Not located within restricted designations
- Not subject to any known planning constraints that would preclude Class Q development

2.6. Structural Capability

Importantly, the buildings are structurally capable of functioning in its current form, and do not exhibit defects that would necessitate substantial rebuilding. The proposed works are therefore considered to constitute conversion, rather than reconstruction.

3. Observations

3.1. The buildings are of steel framed construction as indicated on the below plan.



3.2. The principal structure comprises a corrugated steel roofs with a mixture of profiled cladding, yorkshire boarding and blockwork supported on portal framed steel structures. The buildings are of typical agricultural style, historically utilised for animal feed storage, tractor sheds and a housing animals.

3.2.1. The buildings are generally enclosed and weather-resistant, with the coverings forming a continuous external envelope. Localised defects and

pinholes are present within the roof sheeting and will require repair as part of the conversion works. It is anticipated that thermal upgrading measures, including internal insulation and lining, will be required as part of the proposed conversion.

3.2.2. The primary steel roofs exhibit no signs of distortion, instability or buckling typically associated with a failing roof structure. The geometry remains true and stable in its present form. The structure represents a sound and serviceable loadbearing system, capable of supporting conversion works without structural rebuilding.

3.2.3. Structural calculations have been provided in Appendix C to demonstrate the suitability of the steel frames under the new loads.

3.2.4. The proposals include the installation of new windows and doors. These have been arranged around the existing columns, such that only minor alterations to the cladding rails are required to facilitate their introduction.

3.3. The existing corrugated roofing sheets are to be retained and re-used as part of the proposed conversion. These works do not involve removal and replacement of the roof covering or reconstruction of the building envelope. The sheets are to be patch repaired where required and painted with a fibre-reinforced coating to close pinholes and improve the weather-tightness of the envelope, thereby preserving and upgrading the existing building fabric rather than rebuilding it.

3.3.1. Additional works will be required to provide rainwater goods, including gutters and downpipes. These works are ancillary to the retention and repair of the existing roof covering and are required to improve water management to the existing building envelope as part of the proposed conversion, rather than as part of any rebuilding or reconstruction works.

3.3.2. An independent, self-supporting internal ceiling shall be installed, incorporating any breather membranes and internal weather protection measures required. This lining and thermal upgrade are ancillary works associated with the proposed conversion and do not constitute the rebuilding, reconstruction, replacement, or renewal of the existing roof covering, or primary building envelope, all of which are to be retained.

3.4. The existing steel frame and external cladding will remain in place as the primary building envelope, with only minor localised repairs undertaken where required. A non-loadbearing internal stud leaf will be installed independently of the existing external envelope to support the new insulation, breather membranes and internal weather-protection measures as required. This internal lining and upgrade is ancillary to the retained building fabric and forms part of the proposed conversion, rather than constituting rebuilding, reconstruction or replacement of the existing cladding or primary building envelope.

3.5. A part height blockwork wall is present along three sides of some of the buildings and forms the lower wall construction. This element is to be retained in its entirety and will require only internal insulation as part of the building envelope upgrade and proposed conversion works. No alteration, replacement or reconstruction of the concrete upstand is proposed except where new windows and doors are to be installed.

3.6. The existing floor comprises recycled compacted hardcore or a concrete slab, which is typical for barns of this type. In all cases, it was found to be in good condition and is considered suitable for re-use. The existing floor will be retained and incorporated into the proposed floor build-up. No replacement of the floor slab or floor formation is proposed. The existing floor provides an established and

stable floor construction that is capable of supporting the proposed conversion works without the need for structural replacement or reconstruction.

3.6.1. Upgrade works will be required, including the installation of a damp-proof membrane, insulation and screed to distribute loads to the ground below, together with the usual improvements to thermal and damp performance. These works are therefore required for conversion and building performance purposes, rather than to address any deficiency in structural integrity.

3.6.2. The proposed works constitute the upgrading of an existing floor construction rather than the formation of a new floor and are ancillary to the conversion of the building to residential use.

4. Conclusions and Recommendations

4.1. In our opinion, the proposed development comprises the conversion of existing agricultural buildings through the repair, improvement and adaptation of retained building fabric. The works do not amount to substantial rebuilding, reconstruction or replacement of the building and are therefore consistent with the principles established for Class Q development. The proposed development can be undertaken as a conversion, with works limited to repair, upgrading and internal adaptation, without alteration to the primary structural systems.

4.2. The scope of works should be controlled to ensure that interventions remain proportionate and consistent with conversion, in particular avoiding wholesale removal or replacement of structural or envelope elements.

4.3. The proposed conversion retains the existing steel frames, roof coverings, walls cladding and existing floor formation. The works comprise repair, weatherproofing, thermal upgrading and internal adaptation of retained building fabric. No wholesale replacement of the external envelope is proposed.

4.4. Subject to the above, it is our opinion that the building satisfies the structural requirements of Class Q, and is suitable for conversion to residential use.

4.5. A schedule of works has been prepared and included in Appendix B describing the works required to convert the building in accordance with the Class Q regulations.

Appendix A – Photos



Photo 1 – Barn 4



Photo 2 – Barn 5



Photo 3 – Barn 1



Photo 4 – Barn 2

Appendix B– Schedule of Works

The following schedule has been prepared to assess the extent of the proposed development against the requirements of Schedule 2, Part 3, Class Q of the Town and Country Planning (General Permitted Development) (England) Order 2015 (as amended).

The assessment has regard to established case law and appeal decisions which confirm that Class Q permits the conversion of an existing agricultural building, but does not permit works amounting to its substantial rebuilding or reconstruction. In particular, consideration has been given to whether the building would remain capable of functioning as a building prior to conversion and whether the proposed works are proportionate to the conversion of the existing structure.

For the purposes of this assessment, the proposed works have been categorised as follows:

Status	Classification	Assessment Outcome
●	GREEN	Works that comprise repair, maintenance, improvement or adaptation of retained building fabric and structural elements, and are considered wholly consistent with a conversion under Class Q.
●	AMBER	Works that may be capable of being undertaken as part of a Class Q conversion where they are limited in extent, proportionate to the conversion proposed, and ancillary to the retention of the existing building. Such works require consideration in the context of the development as a whole to ensure they do not cumulatively result in substantial rebuilding.
●	RED	Works that would constitute substantial rebuilding, reconstruction or replacement of the existing building or its primary structural components, such that the proposal would cease to represent a conversion and would extend beyond the scope of development permitted under Class Q.

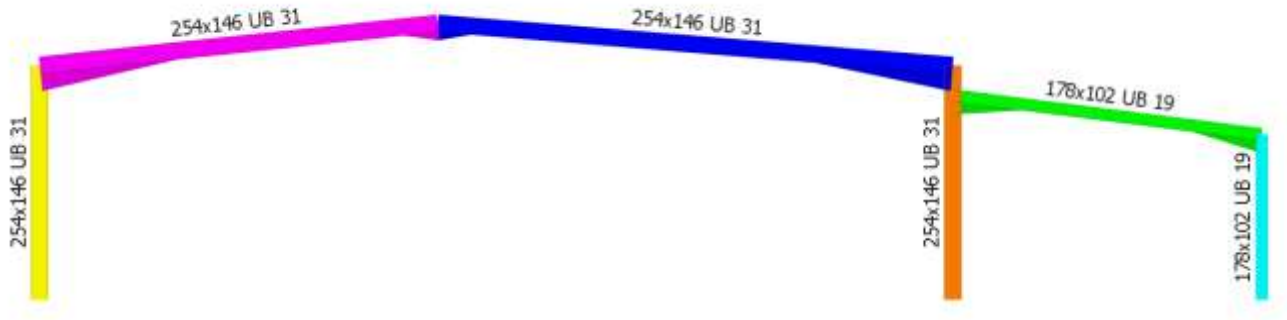
The categorisation of individual elements should not be considered in isolation. The overall assessment of Class Q compliance is based upon the extent of works proposed to the building as a whole, having regard to the retention of the existing structure, envelope and loadbearing elements.

Schedule of Works			
Status	Classification	Element	Proposed works
●	GREEN	Roof	Retain the existing corrugated roofs. Carry out localised sealing of joints, patch repairs and replacement fixings as necessary. Apply a fibre-reinforced roof coating to provide a continuous weatherproof layer and seal minor pinholes. Install ridge and eaves ventilation as required. Provide an independent internal ceiling incorporating insulation, breather membranes, vapour control layers and internal finishes as necessary to achieve the required thermal and environmental performance. Existing rooflights and ridge vents, where present, are to be upgraded with suitable rooflights in accordance with the Architect's details.
●	GREEN	Steel Frame	Retain the existing steel frames, purlins, rails, columns and foundations. Undertake localised cleaning, corrosion treatment and protective coating works where required. No strengthening, replacement or reconstruction of the primary structural frame is proposed.
●	GREEN	Blockwork walls	Retain the existing blockwork walls. Install internal insulation, airtightness and vapour control layers as necessary to achieve compliance with the Building Regulations. Provide internal plasterboard linings and associated finishes as required.
●	AMBER	Steel Cladded walls	Retain the existing steel-framed clad walls as part of the primary building envelope. Undertake localised repairs to the cladding and fixings where necessary. Install an independent, non-loadbearing studwork inner leaf to support a weatherproof lining, insulation, breather membrane, vapour control layer and internal finishes as required. Form new localised openings openings or re-use existing openings where shown for windows and doors in the locations shown on the Architectural drawings, including associated timber framing and support structures as required to accommodate glazing and ancillary access arrangements associated with the proposed residential conversion. The remainder of the existing wall construction including purlins and cladding will be retained.

●	AMBER	Timber Cladded walls	Retain the existing timber clad walls as part of the primary building envelope. Undertake localised repairs to the cladding and fixings where necessary. Install additional vertical boards internally to close the air-gaps while maintaining the Yorkshire board aesthetic. Install an independent, non-loadbearing studwork inner leaf to support a weatherproof lining, insulation, breather membrane, vapour control layer and internal finishes as required. Form new localised openings or re-use existing openings where shown for windows and doors in the locations shown on the Architectural drawings, including associated timber framing and support structures as required to accommodate glazing and ancillary access arrangements associated with the proposed residential conversion. The remainder of the existing wall construction including purlins and cladding will be retained.
●	GREEN	Compacted Stone Floor	Retain the existing compacted stone floor in situ and incorporate it into the proposed floor build-up. No replacement of the existing floor is proposed. Install a damp-proof membrane, insulation and screed over the retained floor construction to achieve the thermal and moisture performance requirements of the Building Regulations.
●	GREEN	Concrete Floors	Retain the existing concrete floor in situ and incorporate it into the proposed floor build-up. No replacement of the existing floor is proposed. Install a damp-proof membrane, insulation and screed over the retained floor construction to achieve the thermal and moisture performance requirements of the Building Regulations.
●	GREEN	Internal layout	Install internal partitions to create bedrooms, bathrooms, circulation spaces and ancillary accommodation.
●	GREEN	Building services	Install water, drainage, electrical, heating, hot water, ventilation and telecommunications services necessary for residential occupation.
●	GREEN	Internal fit-out	Install kitchen, bathroom, fixtures, fittings, finishes and associated domestic accommodation.

●	GREEN	External works	Construct drainage infrastructure, hardstanding, access arrangements and domestic curtilage works associated with the proposed dwelling.

Barn 1



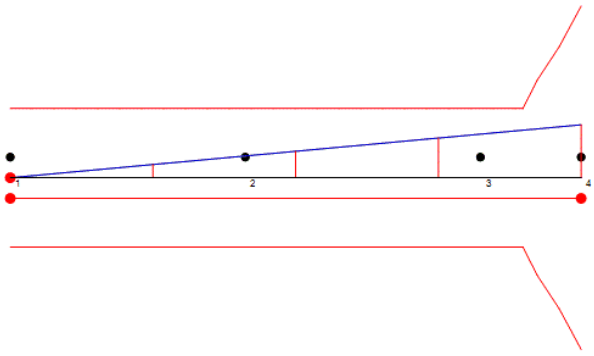
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AXIAL WITH MOMENTS : G.2.(A).2
Column 1 : Members 7 & 10 (N.1-N.8) in Load Case 6

Member Loading and Member Forces
Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1

UT Spacing 05.000 [Multiply AllLoads]
UT PartFix 20.00 +++ --- (Mt My Mz)
Lateral and Torsional Restraints
Side rails @ 1.4, 2.8 and 3.4 m

Stay @ 3.4 m



Member Forces in Load Case 6 and Maximum Deflection from Load Case 2						
Member No.	**Node End 1 End 2**	**Axial Force (kN)**	**Shear Force (kN)**	**Bending Moment (kNm)**	**Maximum Moment (kNm)**	**Maximum Deflection (mm @ m)**
-	1	44.684C	-24.333	0.000		0.004
	8	43.204C	-24.329	-82.730		@ 2.015

Classification and Properties (BS 5950: 2000)

Section (31.14 kg/m)	254x146 UB 31 [S 275]		
Class = Fn(b/T,d/t,py,F,Mx,My)	8.49, 36.5, 275, 44.68, -82.73, 0	(Axial: Non-Slender)	Plastic
Haunched Section	Mid flange included in section classification and properties		
Auto Design Load Cases	1 & 5-6		

Unrestrained Compression Flange Check - Appendix G

Design Portion	0 m to 3.4 m		

Compression Resistance Pc

λy = L/ryy	100x3.4/3.36 =	101.23	OK
y = Fn(a,hs,x,λy)	150.84, 242.8, 64.218, 101.231	0.902	G.2.3
λTC = y.λ	0.902x101.23 =	91.27	OK
Pcy = Area.pcy	39.67x157.91/10 =	626.433 kN	Table 24 b

Slenderness Correction Factor nt

R_1 Mx_1(py.Sxx)	0.000(.001x 275x393.1) ≥ 0	0.000
R_2 Mx_2(py.Sxx)	20.683(.001x 275x393.1) ≥ 0	0.191
R_3 Mx_3(py.Sxx)	41.367(.001x 275x393.1) ≥ 0	0.383
R_4 Mx_4(py.Sxx)	62.050(.001x 275x393.1) ≥ 0	0.574
R_5 Mx_5(py.Sxx)	82.730(.001x 275x977.2) ≥ 0	0.308

R_S-R_E	0.574 - 0.308 ≥ 0	0.266	
R_{max}		0.574	
nt=Fn(All above)	0.000, 0.191, 0.383, 0.574, 0.308, 0.266, 0.574	0.624	G.4.3

Lateral Buckling Resistance Moment Mb

Mp = py.Sxx≤1.2 py.Zxx	275 x 393.1 ≤ 1.2 x 275 x 351.18 =	108.103 kN.m	
λy = L/ryy	100x3.4/3.36 =	101.23	OK
vt = Fn(a,x,hs,λ)	150.84, 64.218, 242.8, 101.231	0.891	G.2.4.2
c=Fn(R,q,x)	2, 0.102, 64.218	1.047	G.2.5
λTB = c.nt.vty	1.047 x 0.624 x 0.891 x 101.231	58.875	G.2.4.2
pb = Fn (py,λTB)	275, 58.88	216.03 N/mm²	Table 16
Mb = Sxx.pb≤ Mp ≤ py.Zxx	393100 x 216.03 ≤ 108.103 ≤ 275 x 351.11 =	84.682 kN.m	

Elastic Stability of Tapered Members : G.2.2

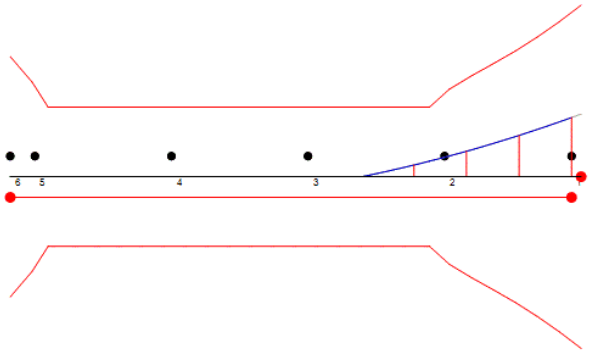
F/Pc+M/Mb	44.684 / 626.43 + 74.288 / 84.68	0.949	OK

AXIAL WITH MOMENTS : G.2.(A).2
Rafter 2 of Bay 1 : Members 4-6 (N.9-N.14)
Between 0.126 and 7.525 m, in Load Case 5

Member Loading and Member Forces
Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1

UT Spacing 05.000 [Multiply AllLoads]
D1 UDLY -000.200 [kN/m]
D2 UDLY -000.000 [kN/m]
L1 UDLY -000.600 [kN/m]
Lateral and Torsional Restraints
Purlins @ 1.8, 3.6, 5.4, 7.2 and 7.525 m

Stay @ 7.525 m



Member Forces in Load Case 5 and Maximum Deflection from Load Case 2						
Member No.	**Node End 1 End 2**	**Axial Force (kN)**	**Shear Force (kN)**	**Bending Moment (kNm)**	**Maximum Moment (kNm)**	**Maximum Deflection (mm @ m)**
-	9	28.045C	43.290	-97.439	44.103	0.009
	14	23.804C	-6.389	41.013	@ 6.572	@ 5.065

Classification and Properties (BS 5950: 2000)

Section (31.14 kg/m)	254x146 UB 31 [S 275]		
Class = Fn(b/T,d/t,py,F,Mx,My)	8.49, 36.5, 275, 28.05, 85.19, 0	(Axial: Non-Slender)	Plastic
Auto Design Load Cases	1 & 5-6		

Unrestrained Compression Flange Check - Appendix G

Design Portion	0.126 m to 2.895 m		

Compression Resistance Pc

λy = L/ryy	100x2.769/3.36 =	82.45	OK
y = Fn(a,hs,x,λy)	150.84, 242.8, 29.582, 82.448	0.931	G.2.3
λTC = y.λ	0.931x82.45 =	76.79	OK
Pcy = Area.pcy	39.67x188.09/10 =	746.162 kN	Table 24 b

Slenderness Correction Factor nt

R_1 Mx_1(py.Sxx)	92.035(.001x 275x928.5) ≥ 0	0.360	
R_2 Mx_2(py.Sxx)	64.244(.001x 275x723.6) ≥ 0	0.323	
R_3 Mx_3(py.Sxx)	39.643(.001x 275x562.4) ≥ 0	0.256	
R_4 Mx_4(py.Sxx)	18.236(.001x 275x393.1) ≥ 0	0.169	
R_5 Mx_5(py.Sxx)	0.000(.001x 275x393.1) ≥ 0	0.000	
R_S-R_E	0.360 - 0.360 ≥ 0	0.000	
R_{max}		0.360	
nt=Fn(All above)	0.360, 0.323, 0.256, 0.169, 0.000, 0.000, 0.360	0.488	G.4.3

Lateral Buckling Resistance Moment Mb

Mp = py.Sxx≤1.2 py.Zxx	275 x 928.51 ≤ 1.2 x 275 x 351.18 =	255.34 kN.m	
λy = L/ryy	100x2.769/3.36 =	82.45	OK
vt = Fn(a,x,hs,λ)	150.84, 29.582, 242.8, 82.448	0.921	G.2.4.2

c=Fn(R,q,x)	1.928, 0.677, 29.582	1.114	G.2.5
λTB = c.nt.vty	1.114 x 0.488 x 0.921 x 82.448	41.283	G.2.4.2
pb = Fn (py,λTB)	275, 41.28	258.84 N/mm²	Table 16
Mb = Sxx.pb≤ Mp ≤ py.Zxx	928508.6 x 258.84 ≤ 255.34 ≤ 275 x 809.26 =	222.547 kN.m	

Elastic Stability of Tapered Members : G.2.2

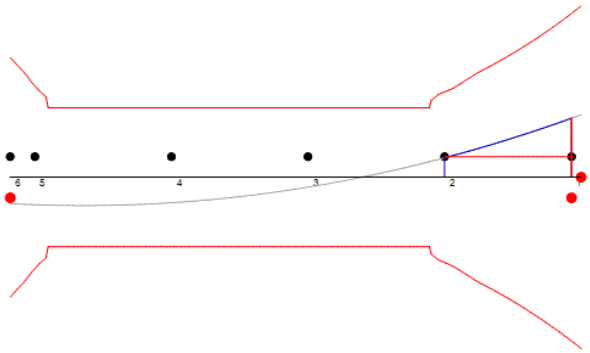
F/Pc+M/Mb	28.045 / 746.16 + 92.035 / 222.55	0.451	OK

AXIAL WITH MOMENTS
Rafter 2 of Bay 1 : Members 4-6 (N.9-N.14)
Between 0.126 and 1.800 m, in Load Case 5

Member Loading and Member Forces
Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1

UT Spacing 05.000 [Multiply AllLoads]
D1 UDLY -000.200 [kN/m]
D2 UDLY -000.000 [kN/m]
L1 UDLY -000.600 [kN/m]
Lateral and Torsional Restraints
Purlins @ 1.8, 3.6, 5.4, 7.2 and 7.525 m

Stay @ 7.525 m



Member Forces in Load Case 5 and Maximum Deflection from Load Case 2						
Member No.	**Node End 1 End 2**	**Axial Force (kN)**	**Shear Force (kN)**	**Bending Moment (kNm)**	**Maximum Moment (kNm)**	**Maximum Deflection (mm @ m)**
-	9	28.045C	43.290	-97.439	44.103	8.845
	14	23.804C	-6.389	41.013	@ 6.572	@ 5.065

Classification and Properties (BS 5950: 2000)

Section (31.14 kg/m)	254x146 UB 31 [S 275]		
Class = Fn(b/T,d/t,py,F,Mx,My)	8.49, 36.5, 275, 28.05, 89.41, 0	(Axial: Non-Slender)	Plastic
Haunched Section	Mid flange included in section classification and properties		
Sec. Depth = Fn(X)	Moment Capacity X = 0.126 m	484.6 mm	
Sec. Depth = Fn(X)	Lateral Buckling X = 0.126 m	484.6 mm	
Auto Design Load Cases	1 & 5-6		

Shear Capacity Check

Fvx/Pvx	31.301 / 479.76 =	0.065	OK

Local Capacity Check @ 0.126 m

Fvx/Pvx	42.45 / 479.76 =	0.088	Low Shear
Mcx = py.Sxx≤1.2 py.Zxx	275 x 928.51≤1.2 x 275 x 809.26 =	255.34 kN.m	
Pz = Ag.py	65.71 x 275 =	1807.052 kN	
n = F/Pz	28.045 / 1807.052 =	0.016	OK
Srx = Fn(Sxx,)	928.51, 0.016	928.49 cm³	
Mrx = Srx.py	928.49 x 275	255.335 kN.m	
$(Mx/Mrx)^{Z1}+(My/Mry)^{Z2}$	$(92.035/255.335)^{2}+(0)^{1}$=	0.13	OK

Compression Resistance Pc

λx = Lex/rxx	100x1x7.525/17.22 =	43.7	OK
Pcx = Area.pcx	65.71x256.982/10 =	1688.655 kN	Table 24 a
λy = Ley/ryy	100x1x1.674/3.2 =	52.4	OK
Pcy = Area.pcy	65.71x233.02/10 =	1531.192 kN	Table 24 b

Equivalent Uniform Moment Factors mLT, mx, my and myx

$m_{LT}=0.2+(.15M_2+.5M_3+.15M_4)/M_{max}$	0.2+(.15x75+.5x59+.15x44)/92 ≥ 0.44	1	Table 18
$m_y=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 ≥ .8x0/0	1	Table 26
$m_x=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x28+.6x-18+.1x-41)/97 ≥ .8x41/97	0.34	Table 26
$m_yx=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 ≥ .8x0/0	1	Table 26

Lateral Buckling Check Mb @ 0.126 m

Le = 1.0 L	1 x 1.674 =	1.674 m	
λ = Le/ryy	1.674 / 3.2	52.37	OK
v = Fn (x,Le,ryy,λ)	61.633, 1.674, 3.2, 52.37	0.991	Table 19

λ_{LT} = u.v.λ.√β_W	0.852 x 0.991 x 52.37 √ 1	44.24	
pb = Fn (py,λ_{LT})	275, 44.24	251.86 N/mm²	Table 16
Mb = Sxx.pb ≤ Mc	928.51 x 251.86 ≤ 255.34 =	233.855 kN.m	

Combined Axial Compression and Bending to Annex I @ 0.126 m

$r_b=m_{LT}.M_{LT}/M_b$	1x92/233.9	0.394	
$r_c=F_c/P_cy$	28/1531.2	0.018	
$\lambda_r=(r_b\ \lambda_{LT}+r_c\ \lambda_y)/(r_b+r_c)$	(0.394•44.2+0.018•52.4)/(0.394+0.018)	44.599	
$\lambda_r o=17.15\ \varepsilon\ (2r_b+r_c)/(r_b+r_c)$	17.15•1(2•0.394+0.018)/(0.394+0.018)	33.537	
$M_{ob} = M_b(1-F_c/P_cy)$	233.855(1-28/1531.2)	229.571	
$M_{xy} = M_cx\ (1-F_c / P_cy)^{½}$	255.340(1-28/1531.2)^{½}	252.991	
$M_{ox} = M_cx(1-F_c/P_cx)/(1+0.5F_c/P_cx)$	255.340(1-28/1688.7)/(1+0.5•28/1688.7)	249.031	
$M_{oy} = M_cy(1-F_c/P_cy)/(1+k_y(F_c/P_cy))$	30.330(1-28/1531.2)/(1+1.0(28/1531.2))	29.239	
M_{ab}=fn(λ_r, $\lambda_r o$, ε, M_{xy}, M_{ob})	44.599, 33.537, 1.000, 252.991, 229.571	249.882	
M_{ax}=fn(λ_x, ε, $M_r x$, M_{ox})	43.706, 1.000, 255.335, 249.031	252.897	
M_{ay}=fn(λ_y, ε, $M_r y$, M_{oy})	52.370, 1.000, 30.330, 29.239	29.770	
$m_x.M_x/M_{ax}$	0.34x92/252.9	0.124	OK
$m_{LT}.M_{LT}/M_{ab}$	1x92/249.9	0.368	OK
$m_x.M_x/M_{ax}$	0.34x92/252.9	0.124	OK
Compare with Simplied to 4.8.3.3	0.159, 0.412, 0.412	0.412	
Compare with MoreExact to 4.8.3.3	0.14, 0.412, 0.37	0.412	

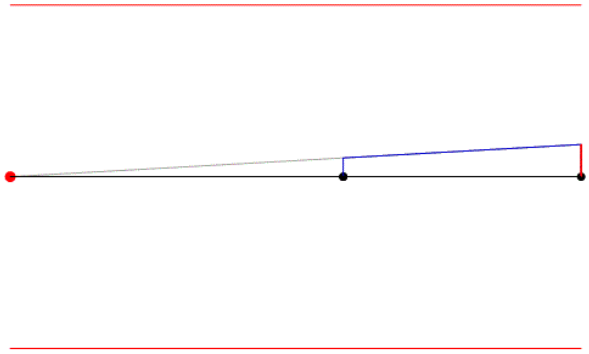
Deflection Check - Load Case 2

In-span δ ≤ Span/360	8.85 ≤ 7525 / 360	8.85 mm	OK

AXIAL WITH MOMENTS
Lean-To Column 2 : Member 12 (N.3-N.4)
Between 1.400 and 2.400 m, in Load Case 5

Member Loading and Member Forces
Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1

UT Spacing 05.000 [Multiply AllLoads]
UT PartFix 20.00 +++ --- (Mt My Mz)



Member Forces in Load Case 5 and Maximum Deflection from Load Case 2						
Member No.	**Node End 1 End 2**	**Axial Force (kN)**	**Shear Force (kN)**	**Bending Moment (kNm)**	**Maximum Moment (kNm)**	**Maximum Deflection (mm @ m)**
12	3	12.142C	-3.693	0.000		0.521
	4	11.514C	-3.693	-8.862		@ 1.512

Classification and Properties (BS 5950: 2000)

Section (19.04 kg/m)	178x102 UB 19 [S 275]		
Class = Fn(b/T,d/t,py,F,Mx,My)	6.41, 30.58, 275, 12.14, -8.86, 0	(Axial: Non-Slender)	Plastic
Auto Design Load Cases	1 & 5-6		

Local Capacity Check

Fvx/Pvx	3.693 / 140.818 =	0.026	Low Shear
Mcx = py.Sxx≤1.2 py.Zxx	275 x 171.3≤1.2 x 275 x 152.63 =	47.108 kN.m	
Pz = Ag.py	24.26 x 275 =	667.15 kN	
n = F/Pz	12.142 / 667.15 =	0.018	OK
Srx = Fn(Sxx,)	171.3, 0.018	171.2 cm³	
Mrx = Srx.py	171.2 x 275	47.08 kN.m	
$(Mx/Mrx)^{Z1}+(My/Mry)^{Z2}$	$(8.862/47.08)^2+(0)^1$=	0.035	OK

Compression Resistance Pc

λx = Lex/rxx	100x1x2.4/7.48 =	32.1	OK
Pcx = Area.pcx	24.26x265.821/10 =	644.881 kN	Table 24 a
λy = Ley/ryy	100x1x1/2.38 =	42	OK

Pcy = Area.pcy	24.26x247.53/10 =	600.502 kN	Table 24 b

Equivalent Uniform Moment Factors mLT, mx, my and myx

$m_{LT}=0.2+(.15M_2+.5M_3+.15M_4)/M_{max}$	0.2+(.15x6+.5x7+.15x8)/9 ≥ 0.44	0.834	Table 18
$m_y=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 ≥ .8x0/0	1	Table 26
$m_x=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x-2+.6x-4+.1x-7)/9 ≥ .8x7/9	0.6	Table 26
$m_yx=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 ≥ .8x0/0	1	Table 26

Lateral Buckling Check Mb

Le = 1.0 L	1 x 1 =	1 m	
λ = Le/ryy	1 / 2.38	42.02	OK
v = Fn (x,Le,ryy,λ)	22.562, 1, 2.38, 42.02	0.961	Table 19
$\lambda_{LT} = u.v.\lambda.\sqrt{\beta_W}$	0.889 x 0.961 x 42.02 √ 1	35.91	
pb = Fn (py,λ_{LT})	275, 35.91	271.33 N/mm²	Table 16
Mb = Sxx.pb ≤ Mc	171.3 x 271.33 ≤ 47.108 =	46.478 kN.m	

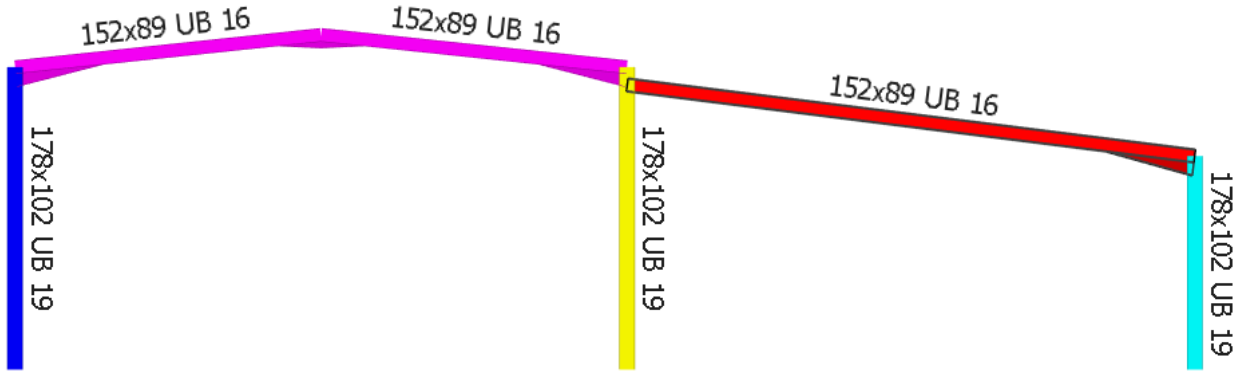
Combined Axial Compression and Bending to Annex I

$r_b=m_{LT}.M_{LT}/M_b$	0.834x-8.9/46.5	0.159	
$r_c=F_c/P_cy$	12.1/600.5	0.020	
$\lambda_r=(r_b\ \lambda_{LT}+r_c\ \lambda_y)/(r_b+r_c)$	(0.159•35.9+0.02•42)/(0.159+0.02)	36.598	
$\lambda_ro=17.15\ \varepsilon\ (2r_b+r_c)/(r_b+r_c)$	17.15•1(2•0.159+0.02)/(0.159+0.02)	32.364	
$M_{ob} = M_b(1-F_c/P_cy)$	46.478(1-12.1/600.5)	45.539	
$M_{xy} = M_cx\ (1-F_c\ /\ P_cy)^{½}$	47.108(1-12.1/600.5)^{½}	46.629	
$M_{ox} = M_cx(1-F_c/P_cx)/(1+0.5F_c/P_cx)$	47.108(1-12.1/644.9)/(1+0.5•12.1/644.9)	45.789	
$M_{oy} = M_cy(1-F_c/P_cy)/(1+k_y(F_c/P_cy))$	8.973(1-12.1/600.5)/(1+1.0(12.1/600.5))	8.617	
$M_{ab}=fn(\ \lambda_r,\ \lambda_ro,\ \varepsilon,\ M_{xy},\ M_{ob})$	36.598, 32.364, 1.000, 46.629, 45.539	46.629	
$M_{ax}=fn(\ \lambda_x,\ \varepsilon,\ M_rx,\ M_{ox})$	32.086, 1.000, 47.080, 45.789	46.799	
$M_{ay}=fn(\ \lambda_y,\ \varepsilon,\ M_ry,\ M_{oy})$	42.017, 1.000, 8.973, 8.617	8.844	
$m_x.M_x/M_{ax}$	0.6x8.9/46.8	0.114	OK
$m_{LT}.M_{LT}/M_{ab}$	0.834x-8.9/46.6	0.158	OK
$m_x.M_x/M_{ax}$	0.6x8.9/46.8	0.114	OK
Compare with Simplied to 4.8.3.3	0.147, 0.179, 0.179	0.179	
Compare with MoreExact to 4.8.3.3	0.133, 0.179, 0.161	0.179	

Deflection Check - Load Case 2

In-span δ ≤ Span/360	0.52 ≤ 2400 / 360	0.52 mm	OK

Barn 2



P:\2026 Amber Jobs\26-23232 - Heath Farm Osbaston\03 Calculations\Structure\barn 2.MP

ELASTIC CRITICAL LOAD FACTOR

Load Case 001 : 1.4 (Dead+Services) + 1.6 Live		
λ_{cr}	From Buckling Analysis	14.685
Load Case 004 : (Sway Stability)		
	Critical Level 1 - Member 12, h/(200δ)	17.472
Load Case 005 : 1.4 (Dead+Services) + 1.6 Live + Notional -->		
λ_{cr}	From Buckling Analysis	14.685
Load Case 006 : 1.4 (Dead+Services) + 1.6 Live + Notional <--		
λ_{cr}	From Buckling Analysis	14.700

Note: For portal frames a more accurate value of λ_{cr} can be calculated from a buckling analysis.

SWAY STABILITY SUMMARY

Load Case	λ_{cr}	Sway Amp†	Plastic LF	Method	From Case	P-~D ON	Verdict
001 : 1.4 (Dead+Services) + 1.6 Li	14.69	1.000	N.A	Buckling Anal.	001	No	OK
005 : 1.4 (Dead+Services) + 1.6 Li	14.69	1.000	N.A	Buckling Anal.	005	No	OK
006 : 1.4 (Dead+Services) + 1.6 Li	14.70	1.000	N.A	Buckling Anal.	006	No	OK

Second-Order Elastic Analysis has been used in the following cases

None

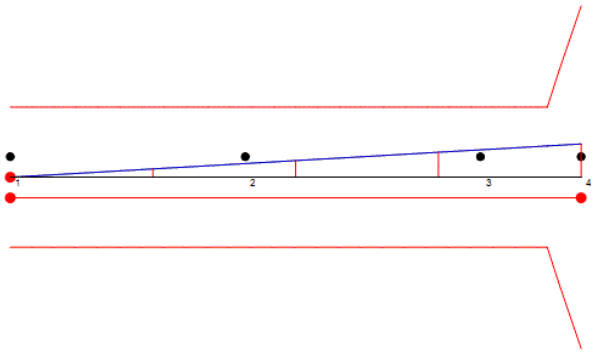
AXIAL WITH MOMENTS : G.2.(A).2

Column 1 : Members 7 & 9 (N.1-N.8) in Load Case 6

Member Loading and Member Forces
Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1

UT Spacing 05.000 [Multiply AllLoads]
UT PartFix 20.00 +++ --- (Mt My Mz)
Lateral and Torsional Restraints
Side rails @ 1.4, 2.8 and 3.4 m

Stay @ 3.4 m



Member Forces in Load Case 6 and Maximum Deflection from Load Case 2						
Member No.	**Node End 1 End 2**	**Axial Force (kN)**	**Shear Force (kN)**	**Bending Moment (kNm)**	**Maximum Moment (kNm)**	**Maximum Deflection (mm @ m)**
-	1	22.465C	-6.576	0.000		0.003
	8	21.567C	-6.573	-22.357		@ 2.047

Classification and Properties (BS 5950: 2000)

Section (19.04 kg/m)	178x102 UB 19 [S 275]		
Class = Fn(b/T,d/t,py,F,Mx,My)	6.41, 30.58, 275, 22.46, -22.36, 0	(Axial: Non-Slender)	Plastic
Haunched Section	Mid flange included in section classification and properties		
Auto Design Load Cases	1 & 5-6		

Unrestrained Compression Flange Check - Appendix G

Design Portion	0 m to 3.4 m		

Compression Resistance Pc

λy = L/ryy	100x3.4/2.37 =	143.23	OK
y = Fn(a,hs,x,λy)	106.68, 169.9, 49.988, 143.232	0.749	G.2.3
λTC = y.λ	0.749x143.23 =	107.25	OK
Pcy = Area.pcy	24.26x127.76/10 =	309.954 kN	Table 24 b

Slenderness Correction Factor nt

R_1 Mx_1(py.Sxx)	0.000(.001x 275x171.3) ≥ 0	0.000	
R_2 Mx_2(py.Sxx)	5.589(.001x 275x171.3) ≥ 0	0.119	
R_3 Mx_3(py.Sxx)	11.179(.001x 275x171.3) ≥ 0	0.237	
R_4 Mx_4(py.Sxx)	16.768(.001x 275x171.3) ≥ 0	0.356	
R_5 Mx_5(py.Sxx)	22.356(.001x 275x418.0) ≥ 0	0.194	
R_S-R_E	0.356 - 0.194 ≥ 0	0.161	
R_{max}		0.356	
nt=Fn(All above)	0.000, 0.119, 0.237, 0.356, 0.194, 0.161, 0.356	0.491	G.4.3

Lateral Buckling Resistance Moment Mb

Mp = py.Sxx≤1.2 py.Zxx	275 x 171.3 ≤ 1.2 x 275 x 152.63 =	47.108 kN.m	
λy = L/ryy	100x3.4/2.37 =	143.23	OK
vt = Fn(a,x,hs,λ)	106.68, 49.988, 169.9, 143.232	0.739	G.2.4.2
c=Fn(R,q,x)	2, 0.059, 49.988	1.054	G.2.5
λTB = c.nt.vty	1.054 x 0.491 x 0.739 x 143.232	54.771	G.2.4.2
pb = Fn (py,λTB)	275, 54.77	226.24 N/mm²	Table 16
Mb = Sxx.pb≤ Mp ≤ py.Zxx	171300 x 226.24 ≤ 47.108 ≤ 275 x 152.53 =	38.676 kN.m	

Elastic Stability of Tapered Members : G.2.2

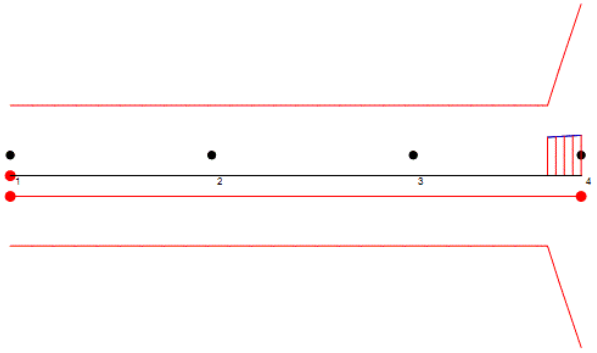
F/Pc+M/Mb	22.465 / 309.95 + 21.029 / 38.68	0.616	OK

AXIAL WITH MOMENTS : G.2.(A).2
Column 2 : Members 8 & 10-11 (N.2-N.9) in Load Case 5

Member Loading and Member Forces
Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1

UT Spacing 05.000 [Multiply AllLoads]
UT PartFix 20.00 +++ --- (Mt My Mz)
Lateral and Torsional Restraints
Side rails @ 1.2, 2.4 and 3.4 m

Stay @ 3.4 m



Member Forces in Load Case 5 and Maximum Deflection from Load Case 2						
Member No.	**Node End 1 End 2**	**Axial Force (kN)**	**Shear Force (kN)**	**Bending Moment (kNm)**	**Maximum Moment (kNm)**	**Maximum Deflection (mm @ m)**
-	2	45.032C	0.079	0.000	0.251	0.000
	9	22.959C	-6.620	-27.106	@ 3.197	@ 1.744

Classification and Properties (BS 5950: 2000)

Section (19.04 kg/m)	178x102 UB 19 [S 275]		
Class = Fn(b/T,d/t,py,F,Mx,My)	6.41, 30.58, 275, 45.03, -27.11, 0	(Axial: Non-Slender)	Plastic
Haunched Section	Mid flange included in section classification and properties		
Auto Design Load Cases	1 & 5-6		

Unrestrained Compression Flange Check - Appendix G

Design Portion	3.2 m to 3.4 m		

Compression Resistance Pc

λy = L/ryy	100x0.2/2.37 =	8.43	OK
y = Fn(a,hs,x,λy)	106.68, 169.9, 49.988, 8.425	0.999	G.2.3
λTC = y.λ	0.999x8.43 =	8.41	OK
Pcy = Area.pcy	24.26x275/10 =	667.15 kN	Table 24 b

Slenderness Correction Factor nt

R_1 Mx_1(py.Sxx)	25.784(.001x 275x171.3) ≥ 0	0.547	
R_2 Mx_2(py.Sxx)	26.113(.001x 275x242.0) ≥ 0	0.392	
R_3 Mx_3(py.Sxx)	26.444(.001x 275x291.5) ≥ 0	0.330	
R_4 Mx_4(py.Sxx)	26.775(.001x 275x350.2) ≥ 0	0.278	
R_5 Mx_5(py.Sxx)	27.105(.001x 275x418.0) ≥ 0	0.236	
R_S-R_E	0.547 - 0.547 ≥ 0	0.000	
R_{max}		0.547	
nt=Fn(All above)	0.547, 0.392, 0.330, 0.278, 0.236, 0.000, 0.547	0.586	G.4.3

Lateral Buckling Resistance Moment Mb

Mp = py.Sxx≤1.2 py.Zxx	275 x 171.3 ≤ 1.2 x 275 x 152.63 =	47.108 kN.m	
λy = L/ryy	100x0.2/2.37 =	8.43	OK
vt = Fn(a,x,hs,λ)	106.68, 49.988, 169.9, 8.425	0.986	G.2.4.2
c=Fn(R,q,x)	2, 1, 49.988	1.222	G.2.5
λTB = c.nt.vty	1.222 x 0.586 x 0.986 x 8.425	5.941	G.2.4.2
pb = Fn (py,λTB)	275, 5.94	275 N/mm²	Table 16
Mb = Sxx.pb≤ Mp ≤ py.Zxx	171300 x 275 ≤ 47.108 ≤ 275 x 152.62 =	41.971 kN.m	

Elastic Stability of Tapered Members : G.2.2

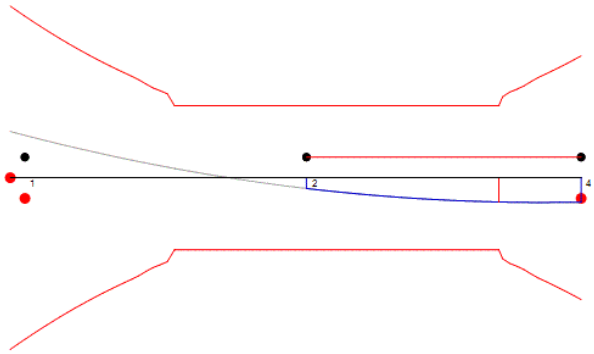
F/Pc+M/Mb	45.032 / 619.7 + 25.782 / 41.97	0.687	OK

AXIAL WITH MOMENTS
Rafter 1 of Bay 1 : Members 1-3 (N.8-N.14)
Between 1.800 and 3.469 m, in Load Case 5

Member Loading and Member Forces
Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1

UT Spacing 05.000 [Multiply AllLoads]
D1 UDLY -000.200 [kN/m]
D2 UDLY -000.000 [kN/m]
L1 UDLY -000.600 [kN/m]
Lateral and Torsional Restraints
Purlins @ 1.8, 3.469 and 3.469 m

Stay @ 3.469 m



Member Forces in Load Case 5 and Maximum Deflection from Load Case 2						
Member No.	**Node End 1 End 2**	**Axial Force (kN)**	**Shear Force (kN)**	**Bending Moment (kNm)**	**Maximum Moment (kNm)**	**Maximum Deflection (mm @ m)**
-	8	8.616C	20.606	-21.745	11.606	2.428
	14	6.383C	-1.458	11.439	@ 3.234	@ 2.339

Classification and Properties (BS 5950: 2000)

Section (15.95 kg/m)	152x89 UB 16 [S 275]		
Class = Fn(b/T,d/t,py,F,Mx,My)	5.76, 27.07, 275, 8.62, 11.6, 0	(Axial: Non-Slender)	Plastic
Auto Design Load Cases	1 & 5-6		

Shear Capacity Check

Fvx/Pvx	9.146 / 113.157 =	0.081	OK

Local Capacity Check

Fvx/Pvx	1.73 / 113.157 =	0.015	Low Shear
Mcx = py.Sxx≤1.2 py.Zxx	275 x 123.3≤1.2 x 275 x 109.49 =	33.908 kN.m	
Pz = Ag.py	20.32 x 275 =	558.8 kN	
n = F/Pz	8.616 / 558.8 =	0.015	OK

Srx = Fn(Sxx,)	123.3, 0.015	123.25 cm³	
Mrx = Srx.py	123.25 x 275	33.893 kN.m	
$(Mx/Mrx)^{Z1}+(My/Mry)^{Z2}$	$(11.374/33.893)^{2}+(0)^{1}$=	0.113	OK

Compression Resistance Pc

λx = Lex/rxx	100x1x3.469/6.41 =	54.1	OK
Pcx = Area.pcx	20.32x246.619/10 =	501.130 kN	Table 24 a
λy = Ley/ryy	100x1x1.669/2.1 =	79.4	OK
Pcy = Area.pcy	20.32x182.67/10 =	371.176 kN	Table 24 b

Equivalent Uniform Moment Factors mLT, mx, my and myx

$m_{LT}=0.2+(.15M_2+.5M_3+.15M_4)/M_{max}$	0.2+(.15x8+.5x10+.15x11)/12 ≥ 0.44	1	Table 18
$m_y=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 ≥ .8x0/0	1	Table 26
$m_x=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x-6+.6x4+.1x10)/22 ≥ .8x10/22	0.379	Table 26
$m_yx=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 ≥ .8x0/0	1	Table 26

Lateral Buckling Check Mb

Le = 1.0 L	1 x 1.669 =	1.669 m	
λ = Le/ryy	1.669 / 2.1	79.39	OK
v = Fn (x,Le,ryy,λ)	19.539, 1.669, 2.1, 79.39	0.86	Table 19
λ_{LT} = u.v.λ.√βw	0.891 x 0.86 x 79.39 √ 1	60.84	
pb = Fn (py,λ_{LT})	275, 60.84	211.13 N/mm²	Table 16
Mb = Sxx.pb ≤ Mc	123.3 x 211.13 ≤ 33.908 =	26.032 kN.m	

Combined Axial Compression and Bending to Annex I

$r_b=m_{LT}.M_{LT}/M_b$	1x11.4/26	0.437	
$r_c=F_c/P_cy$	8.6/371.2	0.023	
$\lambda_r=(r_b\ \lambda_{LT}+r_c\ \lambda_y)/(r_b+r_c)$	(0.437•60.8+0.023•79.4)/(0.437+0.023)	61.772	
$\lambda_ro=17.15\ \varepsilon\ (2r_b+r_c)/(r_b+r_c)$	17.15•1(2•0.437+0.023)/(0.437+0.023)	33.435	
$M_{ob} = M_b(1-F_c/P_cy)$	26.032(1-8.6/371.2)	25.428	
$M_{xy} = M_cx\ (1-F_c\ /\ P_cy)^{½}$	33.908(1-8.6/371.2)^{½}	33.512	
$M_{ox} = M_cx(1-F_c/P_cx)/(1+0.5F_c/P_cx)$	33.908(1-8.6/501.1)/(1+0.5•8.6/501.1)	33.040	
$M_{oy} = M_cy(1-F_c/P_cy)/(1+k_y(F_c/P_cy))$	6.682(1-8.6/371.2)/(1+1.0(8.6/371.2))	6.379	
M_{ab}=fn(λ_r, λ_ro, ε, M_{xy}, M_{ob})	61.772, 33.435, 1.000, 33.512, 25.428	29.312	
M_{ax}=fn(λ_x, ε, M_rx, M_{ox})	54.138, 1.000, 33.893, 33.040	33.433	
M_{ay}=fn(λ_y, ε, M_ry, M_{oy})	79.393, 1.000, 6.682, 6.379	6.407	
$m_x.M_x/M_{ax}$	0.379x11.4/33.4	0.129	OK
$m_{LT}.M_{LT}/M_{ab}$	1x11.4/29.3	0.388	OK
$m_x.M_x/M_{ax}$	0.379x11.4/33.4	0.129	OK
Compare with Simplied to 4.8.3.3	0.166, 0.46, 0.46	0.46	
Compare with MoreExact to 4.8.3.3	0.146, 0.46, 0.344	0.46	

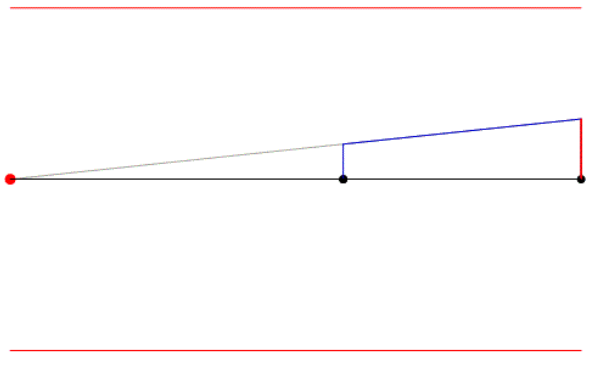
Deflection Check - Load Case 2

In-span δ ≤ Span/360	2.43 ≤ 3469 / 360	2.43 mm	OK

AXIAL WITH MOMENTS
Lean-To Column 2 : Member 12 (N.3-N.4)
Between 1.400 and 2.400 m, in Load Case 5

Member Loading and Member Forces
Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1

UT Spacing 05.000 [Multiply AllLoads]
UT PartFix 20.00 +++ --- (Mt My Mz)



Member Forces in Load Case 5 and Maximum Deflection from Load Case 2						
Member No.	**Node End 1 End 2**	**Axial Force (kN)**	**Shear Force (kN)**	**Bending Moment (kNm)**	**Maximum Moment (kNm)**	**Maximum Deflection (mm @ m)**
12	3	20.547C	-6.908	0.000		1.442
	4	19.919C	-6.908	-16.578		@ 1.392

Classification and Properties (BS 5950: 2000)

Section (19.04 kg/m)	178x102 UB 19 [S 275]		
Class = Fn(b/T,d/t,py,F,Mx,My)	6.41, 30.58, 275, 20.55, -16.58, 0	(Axial: Non-Slender)	Plastic
Auto Design Load Cases	1 & 5-6		

Local Capacity Check

Fvx/Pvx	6.908 / 140.818 =	0.049	Low Shear
Mcx = py.Sxx≤1.2 py.Zxx	275 x 171.3≤1.2 x 275 x 152.63 =	47.108 kN.m	
Pz = Ag.py	24.26 x 275 =	667.15 kN	
n = F/Pz	20.547 / 667.15 =	0.031	OK
Srx = Fn(Sxx,)	171.3, 0.031	171.01 cm³	
Mrx = Srx.py	171.01 x 275	47.028 kN.m	
$(Mx/Mrx)^{Z1}+(My/Mry)^{Z2}$	$(16.578/47.028)^{2}+(0)^{1}$=	0.124	OK

Compression Resistance Pc

λx = Lex/rxx	100x1x2.4/7.48 =	32.1	OK
Pcx = Area.pcx	24.26x265.821/10 =	644.881 kN	Table 24 a
λy = Ley/ryy	100x1x1/2.38 =	42	OK
Pcy = Area.pcy	24.26x247.53/10 =	600.502 kN	Table 24 b

Equivalent Uniform Moment Factors mLT, mx, my and myx

$m_{LT}=0.2+(.15M_2+.5M_3+.15M_4)/M_{max}$	0.2+(.15x11+.5x13+.15x15)/17 ≥ 0.44	0.834	Table 18
$m_y=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 ≥ .8x0/0	1	Table 26
$m_x=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x-4+.6x-8+.1x-12)/17 ≥ .8x12/17	0.6	Table 26
$m_yx=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 ≥ .8x0/0	1	Table 26

Lateral Buckling Check Mb

Le = 1.0 L	1 x 1 =	1 m	
λ = Le/ryy	1 / 2.38	42.02	OK
v = Fn (x,Le,ryy,λ)	22.562, 1, 2.38, 42.02	0.961	Table 19
λ_{LT} = u.v.λ.√βw	0.889 x 0.961 x 42.02 √ 1	35.91	
pb = Fn (py,λ_{LT})	275, 35.91	271.33 N/mm²	Table 16
Mb = Sxx.pb ≤ Mc	171.3 x 271.33 ≤ 47.108 =	46.478 kN.m	

Combined Axial Compression and Bending to Annex I

$r_b=m_{LT}.M_{LT}/M_b$	0.834x-16.6/46.5	0.297	
$r_c=F_c/P_cy$	20.5/600.5	0.034	
$\lambda_r=(r_b\ \lambda_{LT}+r_c\ \lambda_y)/(r_b+r_c)$	(0.297•35.9+0.034•42)/(0.297+0.034)	36.539	
$\lambda_ro=17.15\ \varepsilon\ (2r_b+r_c)/(r_b+r_c)$	17.15•1(2•0.297+0.034)/(0.297+0.034)	32.530	
$M_{ob} = M_b(1-F_c/P_cy)$	46.478(1-20.5/600.5)	44.888	
$M_{xy} = M_cx\ (1-F_c\ /\ P_cy)^{½}$	$47.108(1-20.5/600.5)^{½}$	46.295	
$M_{ox} = M_cx(1-F_c/P_cx)/(1+0.5F_c/P_cx)$	47.108(1-20.5/644.9)/(1+0.5•20.5/644.9)	44.891	
$M_{oy} = M_cy(1-F_c/P_cy)/(1+k_y(F_c/P_cy))$	8.973(1-20.5/600.5)/(1+1.0(20.5/600.5))	8.379	
M_{ab}=fn(λ_r, λ_ro, ε, M_{xy}, M_{ob})	36.539, 32.530, 1.000, 46.295, 44.888	46.295	
M_{ax}=fn(λ_x, ε, M_rx, M_{ox})	32.086, 1.000, 47.028, 44.891	46.563	
M_{ay}=fn(λ_y, ε, M_ry, M_{oy})	42.017, 1.000, 8.973, 8.379	8.758	
$m_x.M_x/M_{ax}$	0.6x16.6/46.6	0.214	OK
$m_{LT}.M_{LT}/M_{ab}$	0.834x-16.6/46.3	0.299	OK
$m_x.M_x/M_{ax}$	0.6x16.6/46.6	0.214	OK
Compare with Simplied to 4.8.3.3	0.271, 0.332, 0.332	0.332	
Compare with MoreExact to 4.8.3.3	0.246, 0.332, 0.308	0.332	

Deflection Check - Load Case 2

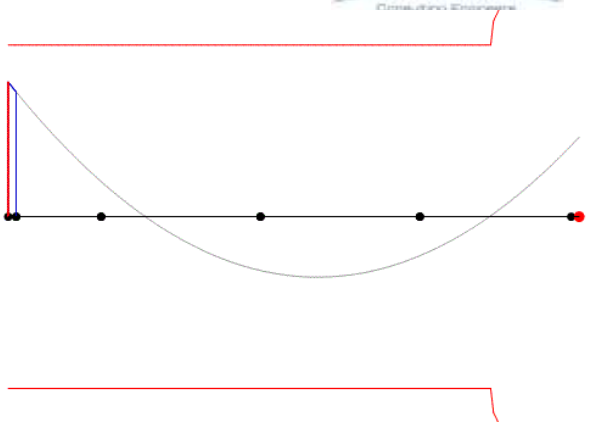
In-span δ ≤ Span/360	1.44 ≤ 2400 / 360	1.44 mm	OK

AXIAL WITH MOMENTS
Lean-To Beam 2 : Member 13 (N.4-N.7)
Between 6.360 and 6.450 m, in Load Case 6

Member Loading and Member Forces
Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1

UT Spacing 05.000 [Multiply AllLoads]
D1 UDLY -000.200 [kN/m]
D2 UDLY -000.000 [kN/m]

L1 UDLY -000.600 [kN/m]



Member Forces in Load Case 6 and Maximum Deflection from Load Case 2						
Member No.	**Node End 1 End 2**	**Axial Force (kN)**	**Shear Force (kN)**	**Bending Moment (kNm)**	**Maximum Moment (kNm)**	**Maximum Deflection (mm @ m)**
13	4	9.041C	18.697	-15.699	11.947	12.435
	7	3.944C	-22.080	-26.610	@ 2.967	@ 3.031

Classification and Properties (BS 5950: 2000)

Section (15.95 kg/m)	152x89 UB 16 [S 275]		
Class = Fn(b/T,d/t,py,F,Mx,My)	5.76, 27.07, 275, 9.04, 26.61, 0	(Axial: Non-Slender)	Plastic
Auto Design Load Cases	1 & 5-6		

Local Capacity Check

Fvx/Pvx	22.08 / 113.157 =	0.195	Low Shear
Mcx = py.Sxx≤1.2 py.Zxx	275 x 123.3≤1.2 x 275 x 109.61 =	33.908 kN.m	
Pz = Ag.py	20.32 x 275 =	558.8 kN	
n = F/Pz	9.041 / 558.8 =	0.016	OK
Srx = Fn(Sxx,)	123.3, 0.016	123.24 cm³	
Mrx = Srx.py	123.24 x 275	33.891 kN.m	
$(Mx/Mrx)^{Z1}+(My/Mry)^{Z2}$	$(26.61/33.891)^{2}+(0)^{1}$=	0.616	OK

Compression Resistance Pc

λx = Lex/rxx	100x1x6.45/6.41 =	100.6	OK
Pcx = Area.pcx	20.32x156.064/10 =	317.122 kN	Table 24 a
λy = Ley/ryy	100x1x0.09/2.11 =	4.3	OK
Pcy = Area.pcy	20.32x275/10 =	558.800 kN	Table 24 b

Equivalent Uniform Moment Factors mLT, mx, my and myx

$m_{LT}=0.2+(.15M_2+.5M_3+.15M_4)/M_{max}$	0.2+(.15x25+.5x26+.15x26)/27 ≥ 0.44	0.97	Table 18
$m_y=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 ≥ .8x0/0	1	Table 26
$m_x=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x-6+.6x-12+.1x-1)/27 ≥ .8x12/27	0.49	Table 26
$m_yx=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 ≥ .8x0/0	1	Table 26

Lateral Buckling Check Mb

Le = 1.0 L	1 x 0.09 =	0.09 m	
λ = Le/ryy	0.09 / 2.11	4.26	OK
v = Fn (x,Le,ryy,λ)	19.589, 0.09, 2.11, 4.26	0.999	Table 19
λ_{LT} = u.v.λ.√βw	0.892 x 0.999 x 4.26 √ 1	3.8	
pb = Fn (py,λ_{LT})	275, 3.8	275 N/mm²	Table 16
Mb = Sxx.pb ≤ Mc	123.3 x 275 ≤ 33.908 =	33.908 kN.m	

Combined Axial Compression and Bending to Annex I

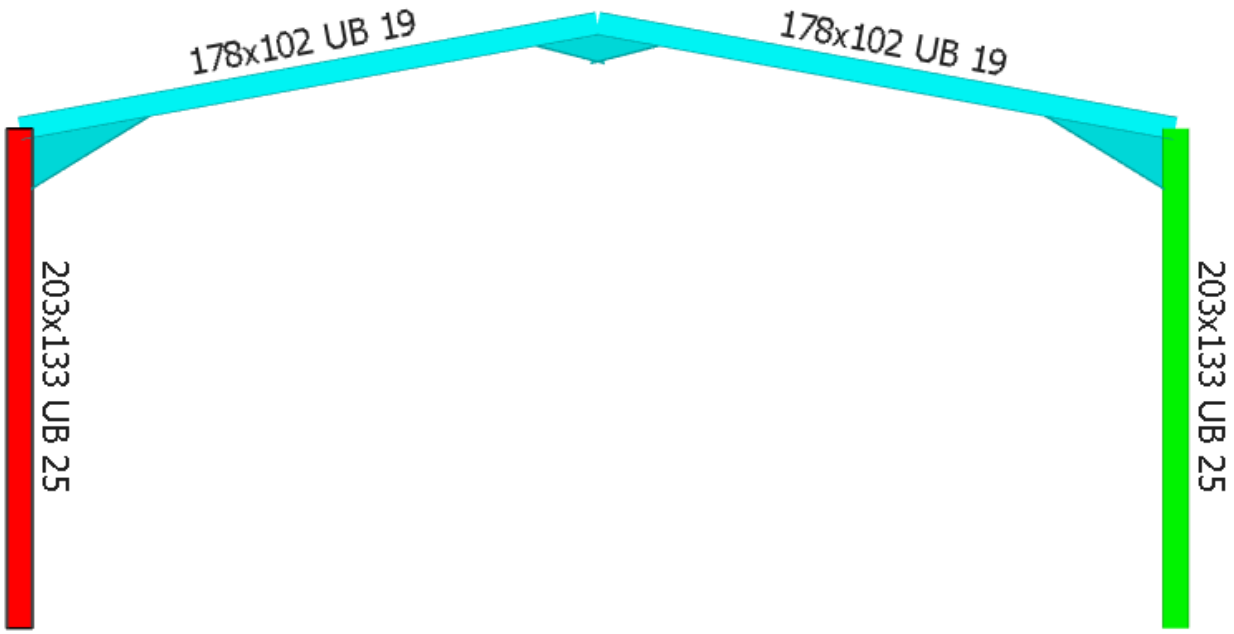
$r_b=m_{LT}.M_{LT}/M_b$	0.97x26.6/33.9	0.762	
$r_c=F_c/P_cy$	9/558.8	0.016	
$\lambda_r=(r_b\ \lambda_{LT}+r_c\ \lambda_y)/(r_b+r_c)$	(0.762•3.8+0.016•4.3)/(0.762+0.016)	3.806	
$\lambda_ro=17.15\ \varepsilon\ (2r_b+r_c)/(r_b+r_c)$	17.15•1(2•0.762+0.016)/(0.762+0.016)	33.943	
M_{ob} = $M_b(1-F_c/P_cy)$	33.908(1-9/558.8)	33.359	
M_{xy} = $M_cx\ (1-F_c\ /\ P_cy)^{½}$	$33.908(1-9/558.8)^{½}$	33.632	
M_{ox} = $M_cx(1-F_c/P_cx)/(1+0.5F_c/P_cx)$	33.908(1-9/317.1)/(1+0.5•9/317.1)	32.478	
M_{oy} = $M_cy(1-F_c/P_cy)/(1+k_y(F_c/P_cy))$	6.742(1-9/558.8)/(1+1.0(9/558.8))	6.527	
M_{ab}=fn(λ_r, λ_ro, ε, M_{xy}, M_{ob})	3.806, 33.943, 1.000, 33.632, 33.359	33.632	
M_{ax}=fn(λ_x, ε, M_rx, M_{ox})	100.621, 1.000, 33.891, 32.478	32.478	
M_{ay}=fn(λ_y, ε, M_ry, M_{oy})	4.256, 1.000, 6.742, 6.527	6.742	
$m_x.M_x/M_{ax}$	0.49x26.6/32.5	0.402	OK
$m_{LT}.M_{LT}/M_{ab}$	0.97x26.6/33.6	0.768	OK
$m_x.M_x/M_{ax}$	0.49x26.6/32.5	0.402	OK

Compare with Simplied to 4.8.3.3	0.461, 0.778, 0.79	0.79	
Compare with MoreExact to 4.8.3.3	0.419, 0.778, 0.795	0.795	

Deflection Check - Load Case 2

In-span δ ≤ Span/360	12.44 ≤ 6450 / 360	12.44 mm	OK

Barn 4



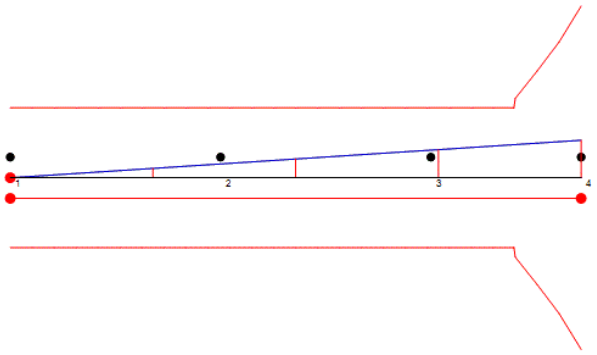
P:\2026 Amber Jobs\26-23232 - Heath Farm Osbaston\03 Calculations\Structure\barn 4.MP

AXIAL WITH MOMENTS : G.2.(A).2
Column 1 : Members 7 & 9 (N.1-N.5) in Load Case 6

Member Loading and Member Forces
Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1

UT Spacing 05.000 [Multiply AllLoads]
UT PartFix 20.00 +++ --- (Mt My Mz)
Lateral and Torsional Restraints
Side rails @ 1.4, 2.8 and 3.8 m

Stay @ 3.8 m



Member Forces in Load Case 6 and Maximum Deflection from Load Case 2						
Member No.	**Node End 1 End 2**	**Axial Force (kN)**	**Shear Force (kN)**	**Bending Moment (kNm)**	**Maximum Moment (kNm)**	**Maximum Deflection (mm @ m)**
-	1	30.653C	-10.024	0.000		0.004
	5	29.318C	-10.020	-38.089		@ 2.246

Classification and Properties (BS 5950: 2000)

Section (25.09 kg/m)	203x133 UB 25 [S 275]		
Class = Fn(b/T,d/t,py,F,Mx,My)	8.54, 30.25, 275, 30.65, -38.09, 0	(Axial: Non-Slender)	Plastic
Haunched Section	Mid flange included in section classification and properties		
Auto Design Load Cases	1 & 5-6		

Unrestrained Compression Flange Check - Appendix G

Design Portion	0 m to 3.8 m		

Compression Resistance Pc

λy = L/ryy	100x3.8/3.1 =	122.49	OK

y = Fn(a,hs,x,λy)	121.92, 195.4, 55.342, 122.488	0.831	G.2.3
λTC = y.λ	0.831x122.49 =	101.79	OK
Pcy = Area.pcy	31.96x137.47/10 =	439.342 kN	Table 24 b

Slenderness Correction Factor nt

R_1 Mx_1(py.Sxx)	0.000(.001x 275x257.7) ≥ 0	0.000	
R_2 Mx_2(py.Sxx)	9.522(.001x 275x257.7) ≥ 0	0.134	
R_3 Mx_3(py.Sxx)	19.045(.001x 275x257.7) ≥ 0	0.269	
R_4 Mx_4(py.Sxx)	28.568(.001x 275x257.7) ≥ 0	0.403	
R_5 Mx_5(py.Sxx)	38.089(.001x 275x633.7) ≥ 0	0.219	
R_S-R_E	0.403 - 0.219 ≥ 0	0.185	
R_{max}		0.403	
nt=Fn(All above)	0.000, 0.134, 0.269, 0.403, 0.219, 0.185, 0.403	0.522	G.4.3

Lateral Buckling Resistance Moment Mb

Mp = py.Sxx≤1.2 py.Zxx	275 x 257.7 ≤ 1.2 x 275 x 230.42 =	70.868 kN.m	
λy = L/ryy	100x3.8/3.1 =	122.49	OK
vt = Fn(a,x,hs,λ)	121.92, 55.342, 195.4, 122.488	0.821	G.2.4.2
c=Fn(R,q,x)	2, 0.118, 55.342	1.062	G.2.5
λTB = c.nt.vty	1.062 x 0.522 x 0.821 x 122.488	55.796	G.2.4.2
pb = Fn (py,λTB)	275, 55.8	223.7 N/mm²	Table 16
Mb = Sxx.pb≤ Mp ≤ py.Zxx	257700 x 223.7 ≤ 70.868 ≤ 275 x 230.33 =	57.525 kN.m	

Elastic Stability of Tapered Members : G.2.2

F/Pc+M/Mb	30.653 / 439.34 + 33.6 / 57.53	0.654	OK

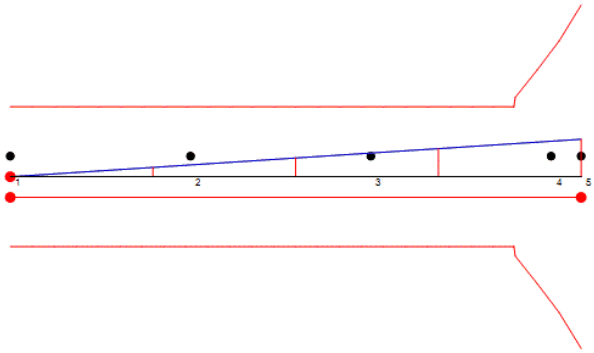
AXIAL WITH MOMENTS : G.2.(A).2

Column 2 : Members 8 & 10 (N.2-N.6) in Load Case 5

Member Loading and Member Forces
Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1

UT Spacing 05.000 [Multiply AllLoads]
UT PartFix 20.00 +++ --- (Mt My Mz)
Lateral and Torsional Restraints
Side rails @ 1.2, 2.4, 3.6 and 3.8 m

Stay @ 3.8 m



Member Forces in Load Case 5 and Maximum Deflection from Load Case 2						
Member No.	**Node End 1 End 2**	**Axial Force (kN)**	**Shear Force (kN)**	**Bending Moment (kNm)**	**Maximum Moment (kNm)**	**Maximum Deflection (mm @ m)**
-	2	30.653C	-10.024	0.000		0.004
	6	29.318C	-10.020	-38.089		@ 2.246

Classification and Properties (BS 5950: 2000)

Section (25.09 kg/m)	203x133 UB 25 [S 275]		
Class = Fn(b/T,d/t,py,F,Mx,My)	8.54, 30.25, 275, 30.65, -38.09, 0	(Axial: Non-Slender)	Plastic
Haunched Section	Mid flange included in section classification and properties		
Auto Design Load Cases	1 & 5-6		

Unrestrained Compression Flange Check - Appendix G

Design Portion	0 m to 3.8 m		

Compression Resistance Pc

λy = L/ryy	100x3.8/3.1 =	122.49	OK
y = Fn(a,hs,x,λy)	121.92, 195.4, 55.342, 122.488	0.831	G.2.3
λTC = y.λ	0.831x122.49 =	101.79	OK
Pcy = Area.pcy	31.96x137.47/10 =	439.342 kN	Table 24 b

Slenderness Correction Factor nt

R_1 Mx_1(py.Sxx)	0.000(.001x 275x257.7) ≥ 0	0.000	
R_2 Mx_2(py.Sxx)	9.522(.001x 275x257.7) ≥ 0	0.134	
R_3 Mx_3(py.Sxx)	19.045(.001x 275x257.7) ≥ 0	0.269	
R_4 Mx_4(py.Sxx)	28.568(.001x 275x257.7) ≥ 0	0.403	

R_5 Mx_5(py.Sxx)	38.089(.001x 275x633.7) ≥ 0	0.219	
R_S-R_E	0.403 - 0.219 ≥ 0	0.185	
R_{max}		0.403	
nt=Fn(All above)	0.000, 0.134, 0.269, 0.403, 0.219, 0.185, 0.403	0.522	G.4.3

Lateral Buckling Resistance Moment Mb

Mp = py.Sxx≤1.2 py.Zxx	275 x 257.7 ≤ 1.2 x 275 x 230.42 =	70.868 kN.m	
λy = L/ryy	100x3.8/3.1 =	122.49	OK
vt = Fn(a,x,hs,λ)	121.92, 55.342, 195.4, 122.488	0.821	G.2.4.2
c=Fn(R,q,x)	2, 0.118, 55.342	1.062	G.2.5
λTB = c.nt.vty	1.062 x 0.522 x 0.821 x 122.488	55.796	G.2.4.2
pb = Fn (py,λTB)	275, 55.8	223.7 N/mm²	Table 16
Mb = Sxx.pb≤ Mp ≤ py.Zxx	257700 x 223.7 ≤ 70.868 ≤ 275 x 230.33 =	57.525 kN.m	

Elastic Stability of Tapered Members : G.2.2

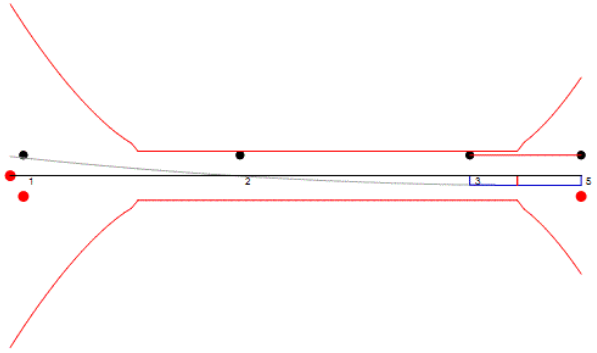
F/Pc+M/Mb	30.653 / 439.34 + 33.6 / 57.53	0.654	OK

AXIAL WITH MOMENTS
Rafter 1 of Bay 1 : Members 1-3 (N.5-N.11)
Between 3.600 and 4.472 m, in Load Case 5

Member Loading and Member Forces
Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1

UT Spacing 05.000 [Multiply AllLoads]
D1 UDLY -000.200 [kN/m]
D2 UDLY -000.000 [kN/m]
L1 UDLY -000.600 [kN/m]
Lateral and Torsional Restraints
Purlins @ 1.8, 3.6, 4.472 and 4.472 m

Stay @ 4.472 m



Member Forces in Load Case 5 and Maximum Deflection from Load Case 2						
Member No.	**Node End 1 End 2**	**Axial Force (kN)**	**Shear Force (kN)**	**Bending Moment (kNm)**	**Maximum Moment (kNm)**	**Maximum Deflection (mm @ m)**
-	5	14.785C	26.822	-36.954	18.575	3.429
	11	9.680C	-1.904	18.304	@ 4.182	@ 3.051

Classification and Properties (BS 5950: 2000)

Section (19.04 kg/m)	178x102 UB 19 [S 275] with 457x191 UB 82 haunch cut		
Class = Fn(b/T,d/t,py,F,Mx,My)	6.41, 30.58, 275, 14.79, 18.57, 0	(Axial: Non-Slender)	Plastic
Auto Design Load Cases	1 & 5-6		

Shear Capacity Check

Fvx/Pvx	3.773 / 140.818 =	0.027	OK

Local Capacity Check

Fvx/Pvx	1.447 / 140.818 =	0.01	Low Shear
Mcx = py.Sxx≤1.2 py.Zxx	275 x 171.3≤1.2 x 275 x 152.53 =	47.108 kN.m	
Pz = Ag.py	24.26 x 275 =	667.15 kN	
n = F/Pz	14.785 / 667.15 =	0.022	OK
Srx = Fn(Sxx,)	171.3, 0.022	171.15 cm³	
Mrx = Srx.py	171.15 x 275	47.066 kN.m	
$(Mx/Mrx)^{Z1}+(My/Mry)^{Z2}$	$(18.424/47.066)^2+(0)^1$=	0.153	OK

Compression Resistance Pc

λx = Lex/rxx	100x1x4.472/7.48 =	59.8	OK
Pcx = Area.pcx	24.26x239.539/10 =	581.121 kN	Table 24 a
λy = Ley/ryy	100x1x0.872/2.37 =	36.7	OK
Pcy = Area.pcy	24.26x254.04/10 =	616.300 kN	Table 24 b

Equivalent Uniform Moment Factors mLT, mx, my and myx

m_{LT}=0.2+(.15M_2+.5M_3+.15M_4)/M_{max}	0.2+(.15x18+.5x18+.15x19)/19 ≥ 0.44	1	Table 18
m_y=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}	0.2+(.1x0+.6x0+.1x0)/0 ≥ .8x0/0	1	Table 26
m_x=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}	0.2+(.1x-11+.6x6+.1x16)/37 ≥ .8x16/37	0.354	Table 26

$m_yx=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 ≥ .8x0/0	1	Table 26

Lateral Buckling Check Mb

Le = 1.0 L	1 x 0.872 =	0.872 m	
λ = Le/ryy	0.872 / 2.37	36.73	OK
v = Fn (x,Le,ryy,λ)	22.54, 0.872, 2.37, 36.73	0.969	Table 19
λ_{LT} = u.v.λ.√β_w	0.888 x 0.969 x 36.73 √ 1	31.63	
pb = Fn (py,λ_{LT})	275, 31.63	275 N/mm²	Table 16
Mb = Sxx.pb ≤ Mc	171.3 x 275 ≤ 47.108 =	47.108 kN.m	

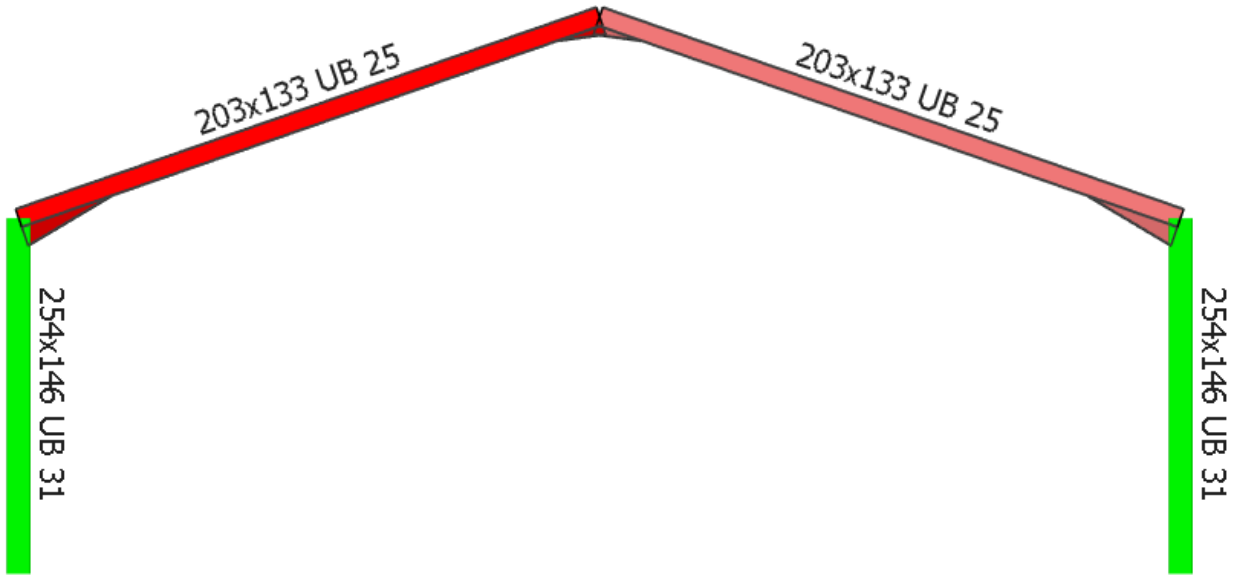
Combined Axial Compression and Bending to Annex I

$r_b=m_{LT}.M_{LT}/M_b$	1x18.4/47.1	0.391	
$r_c=F_c/P_cy$	14.8/616.3	0.024	
$\lambda_r=(r_b\ \lambda_{LT}+r_c\ \lambda_y)/(r_b+r_c)$	(0.391•31.6+0.024•36.7)/(0.391+0.024)	31.921	
$\lambda_ro=17.15\ \varepsilon\ (2r_b+r_c)/(r_b+r_c)$	17.15•1(2•0.391+0.024)/(0.391+0.024)	33.309	
M_{ob} = $M_b(1-F_c/P_cy)$	47.108(1-14.8/616.3)	45.977	
M_{xy} = $M_cx\ (1-F_c\ /\ P_cy)^{½}$	47.108(1-14.8/616.3)^{½}	46.539	
M_{ox} = $M_cx(1-F_c/P_cx)/(1+0.5F_c/P_cx)$	47.108(1-14.8/581.1)/(1+0.5•14.8/581.1)	45.332	
M_{oy} = $M_cy(1-F_c/P_cy)/(1+k_y(F_c/P_cy))$	8.915(1-14.8/616.3)/(1+1.0(14.8/616.3))	8.497	
M_{ab}=fn(λ_r, λ_ro, ε, M_{xy}, M_{ob})	31.921, 33.309, 1.000, 46.539, 45.977	46.539	
M_{ax}=fn(λ_x, ε, M_rx, M_{ox})	59.818, 1.000, 47.066, 45.332	45.988	
M_{ay}=fn(λ_y, ε, M_ry, M_{oy})	36.735, 1.000, 8.915, 8.497	8.796	
$m_x.M_x/M_{ax}$	0.354x18.4/46	0.142	OK
$m_{LT}.M_{LT}/M_{ab}$	1x18.4/46.5	0.396	OK
$m_x.M_x/M_{ax}$	0.354x18.4/46	0.142	OK
Compare with Simplied to 4.8.3.3	0.181, 0.415, 0.417	0.417	
Compare with MoreExact to 4.8.3.3	0.166, 0.415, 0.406	0.415	

Deflection Check - Load Case 2

In-span δ ≤ Span/360	3.43 ≤ 4472 / 360	3.43 mm	OK

Barn 5



P:\2026 Amber Jobs\26-23232 - Heath Farm Osbaston\03 Calculations\Structure\barn 5.MP

ELASTIC CRITICAL LOAD FACTOR

Load Case 001 : 1.4 (Dead+Services) + 1.6 Live		
λ_{cr}	From Buckling Analysis	9.998
Sway Amplfication Factor†	$\lambda_r = 0.9.\lambda_{cr} / (\lambda_{cr} - 1)$	1.000
Load Case 004 : (Sway Stability)		
	Critical Level 1 - Member 7, h/(200δ)	15.303
Load Case 005 : 1.4 (Dead+Services) + 1.6 Live + Notional -->		
λ_{cr}	From Buckling Analysis	9.998
Sway Amplfication Factor†	$\lambda_r = 0.9.\lambda_{cr} / (\lambda_{cr} - 1)$	1.000
Load Case 006 : 1.4 (Dead+Services) + 1.6 Live + Notional <--		
λ_{cr}	From Buckling Analysis	9.998
Sway Amplfication Factor†	$\lambda_r = 0.9.\lambda_{cr} / (\lambda_{cr} - 1)$	1.000

Note: For portal frames a more accurate value of λ_{cr} can be calculated from a buckling analysis.

SWAY STABILITY SUMMARY

Load Case	λ_{cr}	Sway Amp†	Plastic LF	Method	From Case	P-~D ON	Verdict
001 : 1.4 (Dead+Services) + 1.6 Li	9.998	1.000	N.A	Buckling Anal.	001	No	OK
005 : 1.4 (Dead+Services) + 1.6 Li	9.998	1.000	N.A	Buckling Anal.	005	No	OK
006 : 1.4 (Dead+Services) + 1.6 Li	9.998	1.000	N.A	Buckling Anal.	006	No	OK

Second-Order Elastic Analysis has been used in the following cases

None

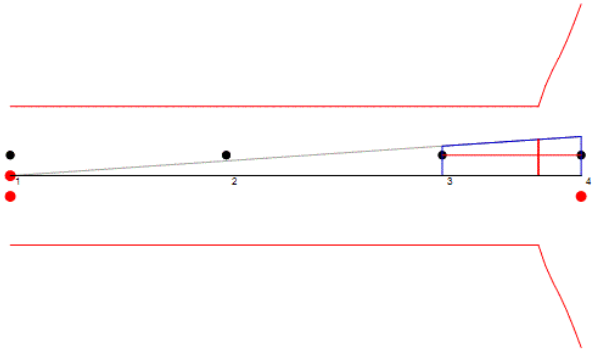
†Note that k_{amp} factors are given for information purposes only and are not applied to the forces in the frame.
In all cases of sway sensitivity it is recommended to carry out appropriate P-Delta analysis.

AXIAL WITH MOMENTS
Column 1 : Members 7 & 9 (N.1-N.5)
Between 2.800 and 3.700 m, in Load Case 6

Member Loading and Member Forces
Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1

UT Spacing 05.000 [Multiply AllLoads]
UT PartFix 20.00 +++ --- (Mt My Mz)
Lateral and Torsional Restraints
Side rails @ 1.4, 2.8 and 3.7 m

Stay @ 3.7 m



Member Forces in Load Case 6 and Maximum Deflection from Load Case 2						
Member No.	**Node End 1 End 2**	**Axial Force (kN)**	**Shear Force (kN)**	**Bending Moment (kNm)**	**Maximum Moment (kNm)**	**Maximum Deflection (mm @ m)**
-	1	41.211C	-16.564	0.000		3.093
	5	39.920C	-16.561	-61.287		@ 2.224

Classification and Properties (BS 5950: 2000)

Section (31.14 kg/m)	254x146 UB 31 [S 275]		
Class = Fn(b/T,d/t,py,F,Mx,My)	8.49, 36.5, 275, 41.21, -61.29, 0	(Axial: Non-Slender)	Plastic
Auto Design Load Cases	1 & 5-6		

Local Capacity Check

Fvx/Pvx	16.561 / 248.886 =	0.067	Low Shear
Mcx = py.Sxx≤1.2 py.Zxx	275 x 393.1≤1.2 x 275 x 352.79 =	108.103 kN.m	
Pz = Ag.py	39.67 x 275 =	1090.925 kN	
n = F/Pz	41.211 / 1090.925 =	0.038	OK
Srx = Fn(Sxx,)	393.1, 0.038	392.16 cm³	
Mrx = Srx.py	392.16 x 275	107.844 kN.m	
$(Mx/Mrx)^{Z1}+(My/Mry)^{Z2}$	$(56.698/107.844)^{2}+(0)^{1}$=	0.276	OK

Compression Resistance Pc

λx = Lex/rxx	100x1x3.7/10.55 =	35.1	OK
Pcx = Area.pcx	39.67x263.739/10 =	1046.253 kN	Table 24 a
λy = Ley/ryy	100x1x0.9/3.36 =	26.8	OK
Pcy = Area.pcy	39.67x265.12/10 =	1051.747 kN	Table 24 b

Equivalent Uniform Moment Factors mLT, mx, my and myx

m_{LT}	Cantilever	1	Table 18
$m_y=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 ≥ .8x0/0	1	Table 26
$m_x=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x-15+.6x-31+.1x-46)/61 ≥ .8x46/61	0.6	Table 26
$m_yx=0.2+(.1M_2+.6M_3+.1M_4)/M_{max}$	0.2+(.1x0+.6x0+.1x0)/0 ≥ .8x0/0	1	Table 26

Lateral Buckling Check Mb

Le = 0.85 L	0.85 x 0.9 =	0.765 m	
λ = Le/ryy	0.765 / 3.36	22.78	OK
v = Fn (x,Le,ryy,λ)	29.711, 0.765, 3.36, 22.78	0.993	Table 19
λ_{LT} = u.v.λ.√βw	0.88 x 0.993 x 22.78 √ 1	19.89	
pb = Fn (py,λ_{LT})	275, 19.89	275 N/mm²	Table 16
Mb = Sxx.pb ≤ Mc	393.1 x 275 ≤ 108.103 =	108.103 kN.m	

Combined Axial Compression and Bending to Annex I

$r_b=m_{LT}.M_{LT}/M_b$	1x-56.7/108.1	0.524	
$r_c=F_c/P_cy$	41.2/1051.7	0.039	
$\lambda_r=(r_b\ \lambda_{LT}+r_c\ \lambda_y)/(r_b+r_c)$	(0.524•19.9+0.039•26.8)/(0.524+0.039)	20.374	
$\lambda_ro=17.15\ \varepsilon\ (2r_b+r_c)/(r_b+r_c)$	17.15•1(2•0.524+0.039)/(0.524+0.039)	33.108	
$M_{ob}=M_b(1-F_c/P_cy)$	108.103(1-41.2/1051.7)	103.867	
$M_{xy}=M_cx\ (1-F_c\ /\ P_cy)^{½}$	$108.103(1-41.2/1051.7)^{½}$	105.963	
$M_{ox}=M_cx(1-F_c/P_cx)/(1+0.5F_c/P_cx)$	108.103(1-41.2/1046.3)/(1+0.5•41.2/1046.3)	101.839	
$M_{oy}=M_cy(1-F_c/P_cy)/(1+k_y(F_c/P_cy))$	20.216(1-41.2/1051.7)/(1+1.0(41.2/1051.7))	18.691	
M_{ab}=fn(λ_r, λ_ro, ε, M_{xy}, M_{ob})	20.374, 33.108, 1.000, 105.963, 103.867	105.963	
M_{ax}=fn(λ_x, ε, M_rx, M_{ox})	35.079, 1.000, 107.844, 101.839	106.276	
M_{ay}=fn(λ_y, ε, M_ry, M_{oy})	26.796, 1.000, 20.216, 18.691	20.001	
$m_x.M_x/M_{ax}$	0.6x56.7/106.3	0.320	OK
$m_{LT}.M_{LT}/M_{ab}$	1x-56.7/106	0.535	OK
$m_x.M_x/M_{ax}$	0.6x56.7/106.3	0.320	OK

Compare with Simplied to 4.8.3.3	0.39, 0.564, 0.564	0.564	
Compare with MoreExact to 4.8.3.3	0.36, 0.564, 0.557	0.564	

Deflection Check In-Span - Load Case 2

δ ≤ Span/360	3.09 ≤ 3700 / 360	3.09 mm	OK

Deflection Check Lateral Sway - Load Case 2

δ ≤ Span/250	12.89 ≤ 3700 / 250	12.89 mm	OK

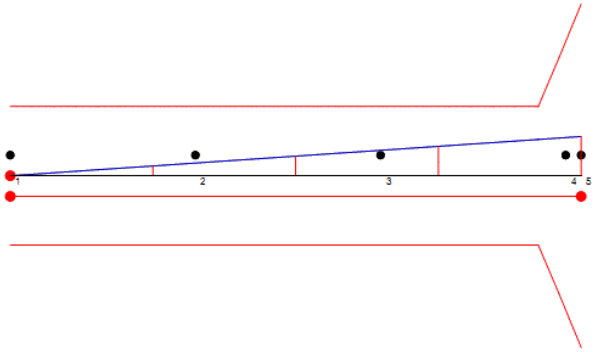
AXIAL WITH MOMENTS : G.2.(A).2

Column 2 : Members 8 & 10 (N.2-N.6) in Load Case 5

Member Loading and Member Forces
Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1

UT Spacing 05.000 [Multiply AllLoads]
UT PartFix 20.00 +++ --- (Mt My Mz)
Lateral and Torsional Restraints
Side rails @ 1.2, 2.4, 3.6 and 3.7 m

Stay @ 3.7 m



Member Forces in Load Case 5 and Maximum Deflection from Load Case 2						
Member No.	**Node End 1 End 2**	**Axial Force (kN)**	**Shear Force (kN)**	**Bending Moment (kNm)**	**Maximum Moment (kNm)**	**Maximum Deflection (mm @ m)**
-	2	41.211C	-16.564	0.000		0.006
	6	39.920C	-16.561	-61.287		@ 2.224

Classification and Properties (BS 5950: 2000)

Section (31.14 kg/m)	254x146 UB 31 [S 275]		
Class = Fn(b/T,d/t,py,F,Mx,My)	8.49, 36.5, 275, 41.21, -61.29, 0	(Axial: Non-Slender)	Plastic
Haunched Section	Mid flange included in section classification and properties		
Auto Design Load Cases	1 & 5-6		

Unrestrained Compression Flange Check - Appendix G

Design Portion	0 m to 3.7 m		

Compression Resistance Pc

λy = L/ryy	100x3.7/3.36 =	110.16	OK
y = Fn(a,hs,x,λy)	150.84, 242.8, 64.216, 110.163	0.886	G.2.3
λTC = y.λ	0.886x110.16 =	97.65	OK
Pcy = Area.pcy	39.67x145.25/10 =	576.197 kN	Table 24 b

Slenderness Correction Factor nt

R_1 Mx_1(py.Sxx)	0.000(.001x 275x393.1) ≥ 0	0.000	
R_2 Mx_2(py.Sxx)	15.322(.001x 275x393.1) ≥ 0	0.142	
R_3 Mx_3(py.Sxx)	30.644(.001x 275x393.1) ≥ 0	0.283	
R_4 Mx_4(py.Sxx)	45.967(.001x 275x393.1) ≥ 0	0.425	
R_5 Mx_5(py.Sxx)	61.287(.001x 275x977.1) ≥ 0	0.228	
R_S-R_E	0.425 - 0.228 ≥ 0	0.197	
R_{max}		0.425	
nt=Fn(All above)	0.000, 0.142, 0.283, 0.425, 0.228, 0.197, 0.425	0.537	G.4.3

Lateral Buckling Resistance Moment Mb

Mp = py.Sxx≤1.2 py.Zxx	275 x 393.1 ≤ 1.2 x 275 x 351.18 =	108.103 kN.m	
λy = L/ryy	100x3.7/3.36 =	110.16	OK
vt = Fn(a,x,hs,λ)	150.84, 64.216, 242.8, 110.163	0.876	G.2.4.2
c=Fn(R,q,x)	2, 0.075, 64.216	1.04	G.2.5
λTB = c.nt.vty	1.04 x 0.537 x 0.876 x 110.163	53.876	G.2.4.2
pb = Fn (py,λTB)	275, 53.88	228.46 N/mm²	Table 16
Mb = Sxx.pb≤ Mp ≤ py.Zxx	393100 x 228.46 ≤ 108.103 ≤ 275 x 351.11 =	89.592 kN.m	

Elastic Stability of Tapered Members : G.2.2

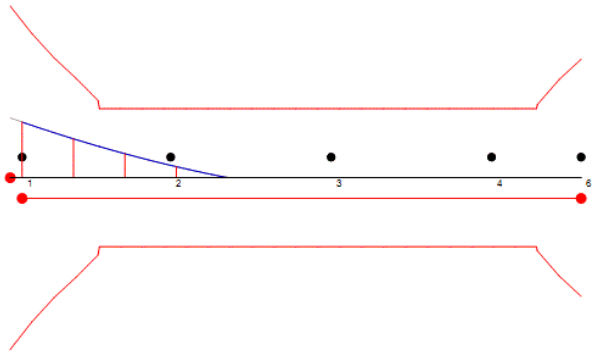
F/Pc+M/Mb	41.211 / 576.2 + 56.683 / 89.59	0.704	OK

AXIAL WITH MOMENTS : G.2.(A).2
Rafter 1 of Bay 1 : Members 1-3 (N.5-N.11)
Between 0.133 and 6.404 m, in Load Case 6

Member Loading and Member Forces
Loading Combination : 1 UT + 1.4 D1 + 1.4 D2 + 1.6 L1

UT Spacing 05.000 [Multiply AllLoads]
D1 UDLY -000.200 [kN/m]
D2 UDLY -000.000 [kN/m]
L1 UDLY -000.600 [kN/m]
Lateral and Torsional Restraints
Purlins @ 1.8, 3.6, 5.4, 6.404 and 6.404 m

Stay @ 6.404 m



Member Forces in Load Case 6 and Maximum Deflection from Load Case 2						
Member No.	**Node End 1 End 2**	**Axial Force (kN)**	**Shear Force (kN)**	**Bending Moment (kNm)**	**Maximum Moment (kNm)**	**Maximum Deflection (mm @ m)**
-	5	28.719C	32.288	-61.287	27.590	0.007
	11	15.516C	-5.219	25.262	@ 5.512	@ 4.335

Classification and Properties (BS 5950: 2000)

Section (25.09 kg/m)	203x133 UB 25 [S 275]		
Class = Fn(b/T,d/t,py,F,Mx,My)	8.54, 30.25, 275, 28.72, -53.51, 0	(Axial: Non-Slender)	Plastic
Auto Design Load Cases	1 & 5-6		

Unrestrained Compression Flange Check - Appendix G

Design Portion	0.133 m to 2.441 m		

Compression Resistance Pc

λy = L/ryy	100x2.308/3.1 =	74.39	OK
y = Fn(a,hs,x,λy)	121.92, 195.4, 25.586, 74.387	0.926	G.2.3
λTC = y.λ	0.926x74.39 =	68.91	OK
Pcy = Area.pcy	31.96x204.06/10 =	652.177 kN	Table 24 b

Slenderness Correction Factor nt

R_1 Mx_1(py.Sxx)	57.043(.001x 275x581.7) ≥ 0	0.357	
R_2 Mx_2(py.Sxx)	39.853(.001x 275x379.3) ≥ 0	0.382	
R_3 Mx_3(py.Sxx)	24.623(.001x 275x257.7) ≥ 0	0.347	
R_4 Mx_4(py.Sxx)	11.333(.001x 275x257.7) ≥ 0	0.160	
R_5 Mx_5(py.Sxx)	0.000(.001x 275x257.7) ≥ 0	0.000	
R_S-R_E	0.382 - 0.357 ≥ 0	0.026	
R_{max}		0.382	
nt=Fn(All above)	0.357, 0.382, 0.347, 0.160, 0.000, 0.026, 0.382	0.534	G.4.3

Lateral Buckling Resistance Moment Mb

Mp = py.Sxx≤1.2 py.Zxx	275 x 257.7 ≤ 1.2 x 275 x 230.42 =	70.868 kN.m	
λy = L/ryy	100x2.308/3.1 =	74.39	OK
vt = Fn(a,x,hs,λ)	121.92, 25.586, 195.4, 74.387	0.915	G.2.4.2
c=Fn(R,q,x)	1.878, 0.376, 25.586	1.102	G.2.5
λTB = c.nt.vty	1.102 x 0.534 x 0.915 x 74.387	40.059	G.2.4.2
pb = Fn (py,λTB)	275, 40.06	261.71 N/mm²	Table 16
Mb = Sxx.pb≤ Mp ≤ py.Zxx	257700 x 261.71 ≤ 70.868 ≤ 275 x 230.37 =	63.351 kN.m	

Elastic Stability of Tapered Members : G.2.2

F/Pc+M/Mb	28.719 / 652.18 + 31.956 / 63.35	0.548	OK