CIVIL & STRUCTURAL CONSULTING ENGINEERS

Westhill Pavilion

Structural Calculations

For

Westfield Parish Council

Date:

23/02/2023

Project Reference: M2-2572

Document Reference: SE-01-A1

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Document Issue History and Status

	Prepared By		Checked By		Approved By	
Revision	**Name**	**Date**	**Name**	**Date**	**Name**	**Date**
A1	**Max Day**	23.02.23	**Matthieu Crosnier**	23.02.23	**Max Day**	23.02.23

General Notes:

Calculations to be checked by Building Control Authority before work commences. Client to ensure all of contractors' works on site comply with and meet Approval of the relevant British Standards and the Local Authority including Building Control and Planning Departments. All temporary works to be the responsibility of the contractor and should be in accordance with BS 5975 to ensure temporary stability during the course of the works.

Dimensions: Note that all dimensions shown on the calculations are indicative and have been used for calculation purposes only. All dimensions should be checked prior to start of the works on site. It is the responsibility of the client to notify the Engineer of any discrepancies. The same applies to the alignment of walls and general layouts. All existing foundations and lintels to be exposed to verify suitability and to be checked for adequacy and/or replaced or surrounded in 150mm concrete cover if necessary. Prior to commencement a trial hole and /or soil report/investigation and an inspection of any trees in the areas may be required.

Introduction:

The following design calculations are for the proposed extension at Westhill Pavilion. In the absence of a formal SI the British Geological maps were consulted and a conservative bearing pressure of 100kN/m^2 was taken.

Design Codes - British Standards:

BS 5268:2002	“The Structural Use of Timber”
BS 5628:1992	“Code of Practice for use of Masonry”
BS 5950:2000	“The Structural Use of Steel in Building”
BS 5977:1983	“Lintels”
BS 6399:1997	“Loadings for Buildings”
BS 8004:1986	“Code of Practice for Foundations”
BS 8110:1997	“Structural Use of Concrete” 2001
BS 8500:2006	“Concrete”

Loadings

Roof Loading (Pitched Tiled Roof)

Roof slope; A = **30°**

Dead Load

Tiles;	$Roof_{D1}$	=	**0.60** kN/m²
Felt & Battens;	$Roof_{D2}$	=	**0.05** kN/m²
Rafters;	$Roof_{D3}$	=	**0.12** kN/m²
Insulation;	$Roof_{D4}$	=	**0.05** kN/m²
Services;	$Roof_{D5}$	=	**0.05** kN/m²
Plasterboard & Skim;	$Roof_{D6}$	=	**0.15** kN/m²
Dead Load on slope;	$Roof_{DL\_sroof}$ = sum($Roof_{D1}$,$Roof_{D2}$,$Roof_{D3}$,$Roof_{D4}$,$Roof_{D5}$,$Roof_{D6}$)	=	**1.020** kN/m²
Total Dead Load (on plan);	$Roof_{DL}$ = $Roof_{DL\_sroof}$ / cos(A)	=	**1.178** kN/m²

Imposed Load

Roof Imposed Load (on plan);	$Roof_{IL1}$	=	**0.60** kN/m²

Roof Loading (Mono-pitched Tiled Roof)

Roof slope; A = **6°**

Dead Load

Tiles;	$Roof_{D1}$	=	**0.60** kN/m²
Felt & Battens;	$Roof_{D2}$	=	**0.05** kN/m²
Rafters;	$Roof_{D3}$	=	**0.12** kN/m²
Insulation;	$Roof_{D4}$	=	**0.05** kN/m²
Services;	$Roof_{D5}$	=	**0.05** kN/m²
Plasterboard & Skim;	$Roof_{D6}$	=	**0.15** kN/m²
Dead Load on slope;	$Roof_{DL\_sroof}$ = sum($Roof_{D1}$,$Roof_{D2}$,$Roof_{D3}$,$Roof_{D4}$,$Roof_{D5}$,$Roof_{D6}$)	=	**1.020** kN/m²
Total Dead Load (on plan);	$Roof_{DL}$ = $Roof_{DL\_sroof}$ / cos(A)	=	**1.026** kN/m²

Imposed Load

Roof Imposed Load (on plan);	$Roof_{IL1}$	=	**0.75** kN/m²

Cavity Wall Loading

Dead Load

Masonry (Outer Leaf);	CW_{D1}	=	**2.20** kN/m²
Insulation;	CW_{D2}	=	**0.05** kN/m²
Masonry (Inner Leaf);	CW_{D3}	=	**1.80** kN/m²
Plasterboard & Skim;	CW_{D4}	=	**0.15** kN/m²
Total Dead Load;	CW_{DL} = sum(CW_{D1},CW_{D2},CW_{D3},CW_{D4})	=	**4.20** kN/m²

Internal Blockwork Wall Loading

Dead Load

Masonry;	IW_{D1}	=	**1.80** kN/m²
Plasterboard & Skim (both sides);	IW_{D2}	=	**0.30** kN/m²
Total Dead Load;	IW_{DL} = sum(IW_{D1},IW_{D2})	=	**2.10** kN/m²

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Beam 1 Design:

Loadings

UDL from Pitched Roof

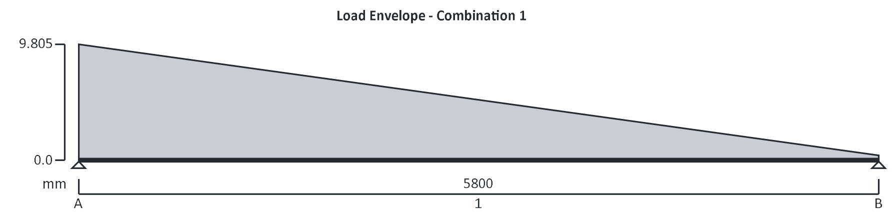
Width of roof being carried;	x_1 = **3.6** m		
Dead Load;	$DL_1 = 1.178$ kN/m$^2 \times x_1$	=	**4.241** kN/m
Imposed Load;	$IL_1 = 0.60$ kN/m$^2 \times x_1$	=	**2.160** kN/m

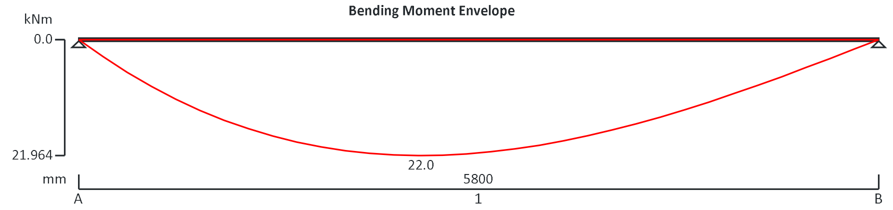
STEEL BEAM ANALYSIS & DESIGN (BS5950)

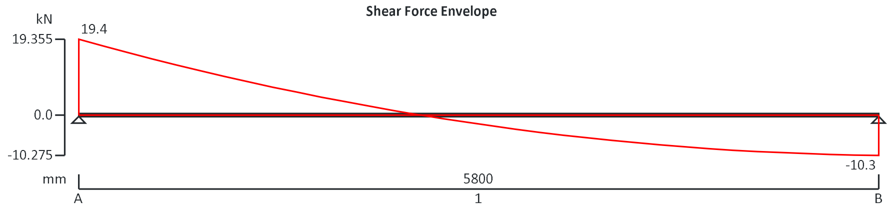
STEEL BEAM ANALYSIS & DESIGN (BS5950)

In accordance with BS5950-1:2000 incorporating Corrigendum No.1

TEDDS calculation version 3.0.07







Support conditions

Support A	Vertically restrained
	Rotationally free
Support B	Vertically restrained
	Rotationally free

Applied loading

Beam loads Dead self weight of beam × 1

Dead full VDL 4.241 kN/m to 0 kN/m

Imposed full VDL 2.16 kN/m to 0 kN/m

Load combinations

Load combination 1 Support A Dead × 1.40

Imposed × 1.60

Dead × 1.40

Imposed × 1.60

Support B Dead × 1.40

Imposed × 1.60

Analysis results

Maximum moment; M_{max} = **22** kNm; M_{min} = **0** kNm

Maximum shear; V_{max} = **19.4** kN; V_{min} = **-10.3** kN

Deflection; δ_{max} = **8.7** mm; δ_{min} = **0** mm

Maximum reaction at support A; R_{A_max} = **19.4** kN; R_{A_min} = **19.4** kN

Unfactored dead load reaction at support A; R_{A_Dead} = **9.1** kN

Unfactored imposed load reaction at support A; $R_{A\_Imposed}$ = **4.2** kN

Maximum reaction at support B; R_{B_max} = **10.3** kN; R_{B_min} = **10.3** kN

Unfactored dead load reaction at support B; R_{B_Dead} = **5** kN

Unfactored imposed load reaction at support B; $R_{B\_Imposed}$ = **2.1** kN

Section details

Section type; **UB 203x133x30 (BS4-1)**

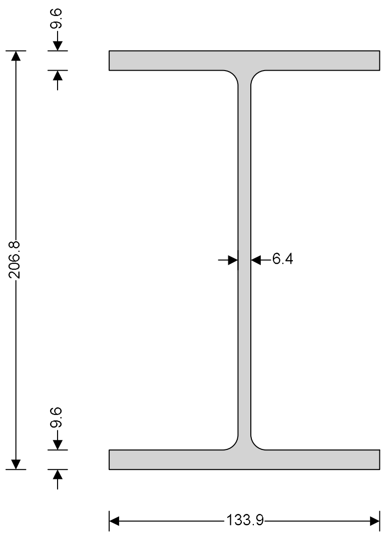
Steel grade; **S275**

From table 9: Design strength p_y

Thickness of element; max(T, t) = **9.6** mm

Design strength; p_y = **275** N/mm^2

Modulus of elasticity; E = **205000** N/mm^2



Lateral restraint

Span 1 has lateral restraint at supports only

Effective length factors

Effective length factor in major axis; K_x = **1.00**

Effective length factor in minor axis; K_y = **1.00**

Effective length factor for lateral-torsional buckling; $K_{LT.A}$ = **1.00**;

$K_{LT.B}$ = **1.00**;

Classification of cross sections - Section 3.5

$\varepsilon = \sqrt{[275 \text{ N/mm}^2 / p_y]}$ = **1.00**

Internal compression parts - Table 11

Depth of section; d = **172.4** mm

$d / t = 26.9 \times \varepsilon <= 80 \times \varepsilon$; Class 1 plastic

Outstand flanges - Table 11

Width of section; b = B / 2 = **67** mm

$b / T = 7.0 \times \varepsilon <= 9 \times \varepsilon$; Class 1 plastic

Section is class 1 plastic

Shear capacity - Section 4.2.3

Design shear force; $F_v = \max(\text{abs}(V_{max}), \text{abs}(V_{min}))$ = **19.4** kN

$d / t < 70 \times \varepsilon$

Web does not need to be checked for shear buckling

Shear area; $A_v = t \times D$ = **1324** mm^2

Design shear resistance; $P_v = 0.6 \times p_y \times A_v$ = **218.4** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment; $M = \max(\text{abs}(M_{s1\_max}), \text{abs}(M_{s1\_min}))$ = **22** kNm

Moment capacity low shear - cl.4.2.5.2; $M_c = \min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx})$ = **86.5** kNm

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling; $L_E = 1.0 \times L_{s1}$ = **5800** mm

Slenderness ratio; $\lambda = L_E / r_{yy}$ = **182.805**

Equivalent slenderness - Section 4.3.6.7

Buckling parameter; u = **0.881**

Torsional index; x = **21.493**

Slenderness factor; $v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25}$ = **0.682**

Ratio - cl.4.3.6.9; β_W = **1.000**

Equivalent slenderness - cl.4.3.6.7; $\lambda_{LT} = u \times v \times \lambda \times \sqrt{[\beta_W]}$ = **109.928**

Limiting slenderness - Annex B.2.2; $\lambda_{L0} = 0.4 \times (\pi^2 \times E / p_y)^{0.5}$ = **34.310**

$\lambda_{LT} > \lambda_{L0}$ - Allowance should be made for lateral-torsional buckling

Bending strength - Section 4.3.6.5

Robertson constant; α_{LT} = **7.0**

Perry factor; $\eta_{LT} = \max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0) = \mathbf{0.529}$

Euler stress; $p_E = \pi^2 \times E / \lambda_{LT}^2 = \mathbf{167.4}$ N/mm^2

$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2 = \mathbf{265.5}$ N/mm^2

Bending strength - Annex B.2.1; $p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5}) = \mathbf{109.1}$ N/mm^2

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment; $M_2 = \mathbf{18.6}$ kNm

Moment at centre-line of segment; $M_3 = \mathbf{21.5}$ kNm

Moment at three quarter point of segment; $M_4 = \mathbf{13.6}$ kNm

Maximum moment in segment; $M_{abs} = \mathbf{22}$ kNm

Maximum moment governing buckling resistance; $M_{LT} = M_{abs} = \mathbf{22}$ kNm

Equivalent uniform moment factor for lateral-torsional buckling;

$m_{LT} = \max(0.2 + (0.15 \times M_2 + 0.5 \times M_3 + 0.15 \times M_4) / M_{abs}, 0.44) = \mathbf{0.909}$

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment; $M_b = p_b \times S_{xx} = \mathbf{34.3}$ kNm

$M_b / m_{LT} = \mathbf{37.7}$ kNm

PASS - Buckling resistance moment exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to dead and imposed loads

Limiting deflection; $\delta_{lim} = L_{s1} / 360 = \mathbf{16.111}$ mm

Maximum deflection span 1; $\delta = \max(\mathrm{abs}(\delta_{max}), \mathrm{abs}(\delta_{min})) = \mathbf{8.688}$ mm

PASS - Maximum deflection does not exceed deflection limit

MASONRY BEARING DESIGN (BS5628)

MASONRY BEARING DESIGN TO BS5628-1:2005

TEDDS calculation version 1.0.08

Masonry details

Masonry type; **Aggregate concrete blocks (25% or less formed voids)**

Compressive strength; $p_{unit} = \mathbf{3.6}$ N/mm^2; Mortar designation; **iii**

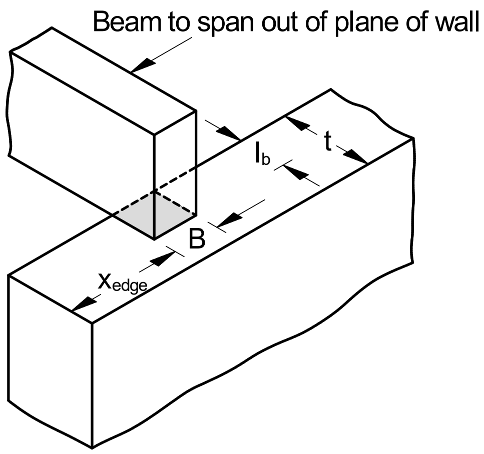
Least horiz dim of units; $l_{unit} = \mathbf{100}$ mm; Height of units; $h_{unit} = \mathbf{215}$ mm

Masonry units; **Category II**; Construction control; **Normal**

Partial safety factor; $\gamma_m = \mathbf{3.5}$; Characteristic strength; $f_k = \mathbf{3.5}$ N/mm^2

Leaf thickness; t = **100** mm; Effective wall thickness; $t_{ef} = \mathbf{100}$ mm

Wall height; h = **2400** mm; Effective height of wall; $h_{ef} = \mathbf{2400}$ mm



Bearing details

Beam spanning out of plane of wall

Width of bearing; B = **100** mm; Length of bearing; l_b = **100** mm

Edge distance; x_{edge} = **50** mm

Loading details

Concentrated dead load; G_k = **5** kN; Concentrated imposed load; Q_k = **2** kN

Design concentrated load; F = **10.4** kN

Distributed dead load; g_k = **0.0** kN/m; Distributed imposed load; q_k = **0.0** kN/m

Design distributed load; f = **0.0** kN/m

Masonry bearing type

Bearing type; **Type 1** ; Bearing safety factor; γ_{bear} = **1.25**

Check design bearing without a spreader

Design bearing stress; f_{ca} = **1.036** N/mm^2; Allowable bearing stress; f_{cp} = **1.250** N/mm^2

PASS - Allowable bearing stress exceeds design bearing stress

Check design bearing at 0.4 × h below the bearing level

Design bearing stress; f_{ca} = **0.093** N/mm^2; Allowable bearing stress; f_{cp} = **0.605** N/mm^2

PASS - Allowable bearing stress at 0.4 × h below bearing level exceeds design bearing stress

Provide 203x133x30 UB S.275 – Beam to bear onto 300x300long x 215deep x 100thick concrete corner padstone

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Doc. Ref SE-01-A1	Chk'd by MC	Date Feb-23

Beam 2 Design:

Loadings

UDL from Pitched Roof

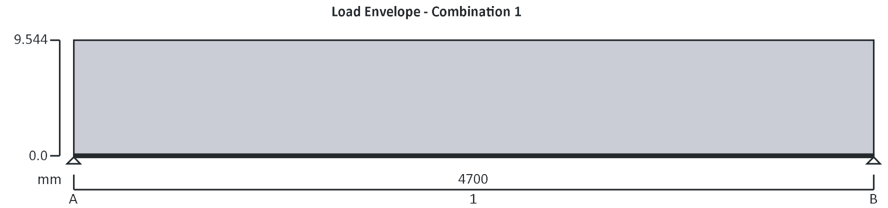
Width of roof being carried;	x_1 = **3.5** m		
Dead Load;	$DL_1 = 1.178\ kN/m^2 \times x_1$	=	**4.123** kN/m
Imposed Load;	$IL_1 = 0.60\ kN/m^2 \times x_1$	=	**2.100** kN/m

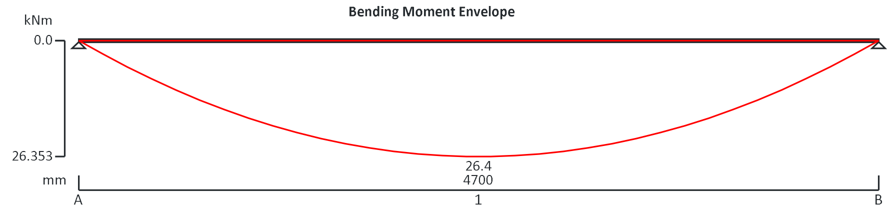
STEEL BEAM ANALYSIS & DESIGN (BS5950)

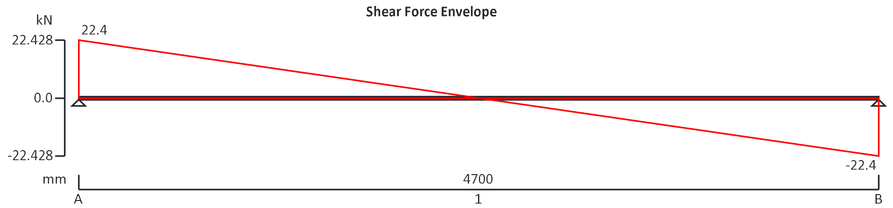
STEEL BEAM ANALYSIS & DESIGN (BS5950)

In accordance with BS5950-1:2000 incorporating Corrigendum No.1

TEDDS calculation version 3.0.07







Support conditions

Support A	Vertically restrained
	Rotationally free
Support B	Vertically restrained
	Rotationally free

Applied loading

Beam loads Dead self weight of beam × 1

Dead full UDL 4.123 kN/m

Imposed full UDL 2.1 kN/m

Load combinations

Load combination 1 Support A Dead × 1.40

Imposed × 1.60

Dead × 1.40

Imposed × 1.60

Support B Dead × 1.40

Imposed × 1.60

Analysis results

Maximum moment; M_{max} = **26.4** kNm; M_{min} = **0** kNm

Maximum shear; V_{max} = **22.4** kN; V_{min} = **-22.4** kN

Deflection; δ_{max} = **7** mm; δ_{min} = **0** mm

Maximum reaction at support A; R_{A_max} = **22.4** kN; R_{A_min} = **22.4** kN

Unfactored dead load reaction at support A; R_{A_Dead} = **10.4** kN

Unfactored imposed load reaction at support A; $R_{A\_Imposed}$ = **4.9** kN

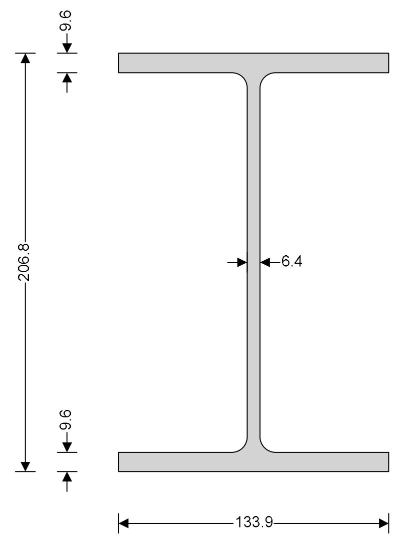
Maximum reaction at support B; R_{B_max} = **22.4** kN; R_{B_min} = **22.4** kN

Unfactored dead load reaction at support B; R_{B_Dead} = **10.4** kN

Unfactored imposed load reaction at support B; $R_{B\_Imposed}$ = **4.9** kN

Section details

Section type; **UB 203x133x30 (BS4-1)**; Steel grade; **S275**



Classification of cross sections - Section 3.5

Tensile strain coefficient; ε = **1.00**; Section classification; **Plastic**

Shear capacity - Section 4.2.3

Design shear force; F_v = **22.4** kN; Design shear resistance; P_v = **218.4** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment; M = **26.4** kNm; Moment capacity low shear; M_c = **86.5** kNm

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment; M_b = **41.3** kNm; M_b / m_{LT} = **44.7** kNm

PASS - Buckling resistance moment exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to dead and imposed loads

Limiting deflection δ_{lim} = **13.056** mm;Maximum deflection; δ = **6.976** mm

PASS - Maximum deflection does not exceed deflection limit

MASONRY BEARING DESIGN (BS5628)

MASONRY BEARING DESIGN TO BS5628-1:2005

TEDDS calculation version 1.0.08

Masonry details

Masonry type; **Aggregate concrete blocks (25% or less formed voids)**

Compressive strength; p_{unit} = **3.6** N/mm^2; Mortar designation; **iii**

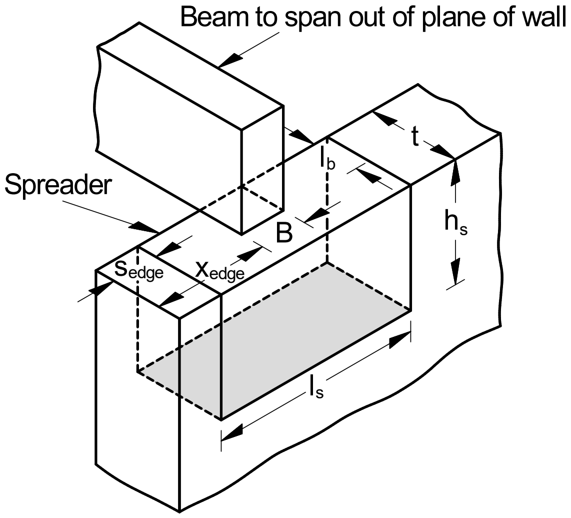
Least horiz dim of units; l_{unit} = **100** mm; Height of units; h_{unit} = **215** mm

Masonry units; **Category II**; Construction control; **Normal**

Partial safety factor; γ_m = **3.5**; Characteristic strength; f_k = **3.5** N/mm^2

Leaf thickness; t = **100** mm; Effective wall thickness; t_{ef} = **100** mm

Wall height; h = **2400** mm; Effective height of wall; h_{ef} = **2400** mm



Bearing details

Beam spanning out of plane of wall

Width of bearing; B = **100** mm; Length of bearing; l_b = **100** mm

Edge distance; x_{edge} = **300** mm

Loading details

Concentrated dead load; G_k = **10** kN; Concentrated imposed load; Q_k = **4** kN

Design concentrated load; F = **20.8** kN

Distributed dead load; g_k = **0.0** kN/m; Distributed imposed load; q_k = **0.0** kN/m

Design distributed load; f = **0.0** kN/m

Masonry bearing type

Bearing type; **Type 2** ; Bearing safety factor; γ_{bear} = **1.50**

Check design bearing without a spreader

Design bearing stress; f_{ca} = **2.080** N/mm^2; Allowable bearing stress; f_{cp} = **1.500** N/mm^2

FAIL - Design bearing stress exceeds allowable bearing stress, use a spreader

Spreader details

Length of spreader; l_s = **440** mm; Depth of spreader; h_s = **215** mm

Edge distance; s_{edge} = **130** mm

Spreader bearing type

Bearing type; **Type 1** ; Bearing safety factor; γ_{bear} = **1.25**

Check design bearing with a spreader

Loading acts at midpoint of spreader

Design bearing stress; f_{ca} = **0.473** N/mm^2; Allowable bearing stress; f_{cp} = **1.250** N/mm^2

PASS - Allowable bearing stress exceeds design bearing stress

Check design bearing at 0.4 × h below the bearing level

Design bearing stress; f_{ca} = **0.153** N/mm^2; Allowable bearing stress; f_{cp} = **0.605** N/mm^2

PASS - Allowable bearing stress at 0.4 × h below bearing level exceeds design bearing stress

Provide 203x133x30 UB S.275 – Beam to bear onto 440long x 215deep x 100thick concrete padstone

	Project Westhill Pavilion	Sheet no./rev. 14
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Beam 3 Design:

Loadings

UDL from Pitched Roof

Width of roof being carried;	x_1 = **3.5** m		
Dead Load;	$DL_1 = 1.178\ kN/m^2 \times x_1$	=	**4.123** kN/m
Imposed Load;	$IL_1 = 0.60\ kN/m^2 \times x_1$	=	**2.100** kN/m

Point Load from Beam 1 x 2

Dead Load;	PL_{DL1}	=	**18.200** kN
Imposed Load;	PL_{IL1}	=	**8.400** kN
Total Point Load;	$PL_T = PL_{DL1} + PL_{IL1}$	=	**26.600** kN

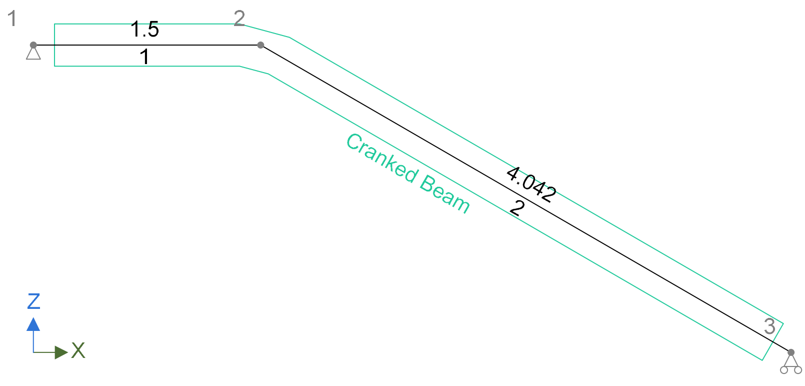
2D ANALYSIS

ANALYSIS

Tedds calculation version 1.0.37

Geometry

Geometry (m) - Steel (BS5950) - UB 203x133x30



Loading

Self weight included

Load combination factors

Load combination	Self Weight	Permanent	Imposed
1.4D + 1.6I + 1.6RI (Strength)	1.40	1.40	1.60
1.0D + 1.0I + 1.0RI (Service)	1.00	1.00	1.00

Node loads

Node	Load case	Force		Moment
		X	Z	
		(kN)	(kN)	(kNm)
2	Permanent	0	18.2	0
2	Imposed	0	4.2	0

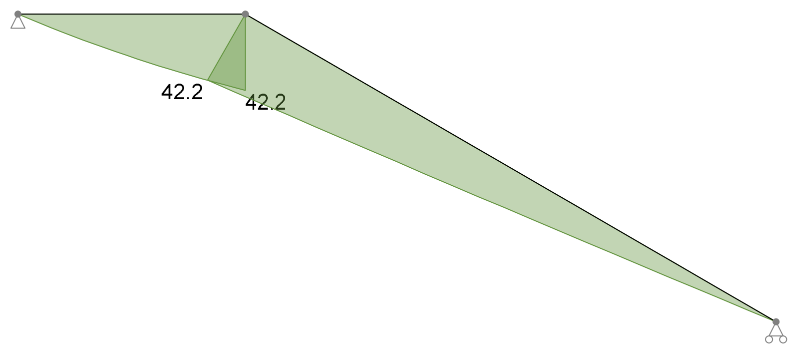
Element Loads

Element	Load case	Load Type	Orientation	Description
1	Permanent	UDL	GlobalZ	4.12 kN/m
1	Imposed	UDL	GlobalZ	2.1 kN/m

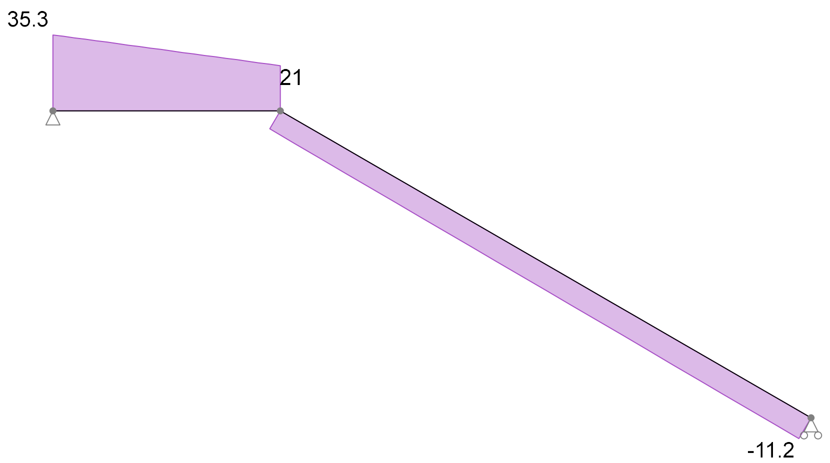
Results

Forces

Strength combinations - Moment envelope (kNm)



Strength combinations - Shear envelope (kN)



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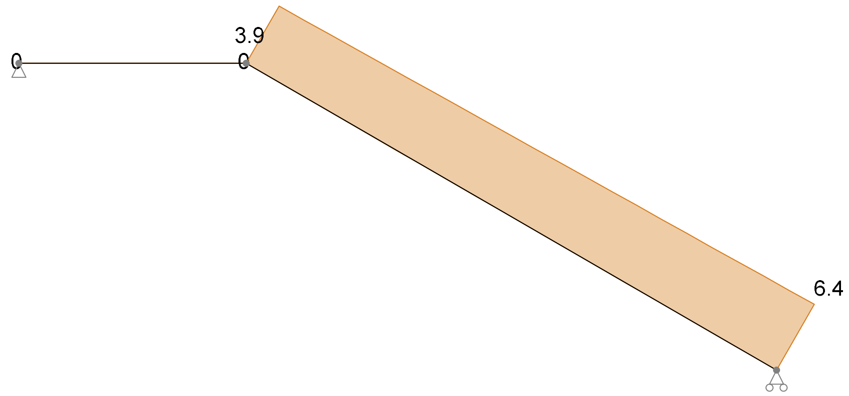
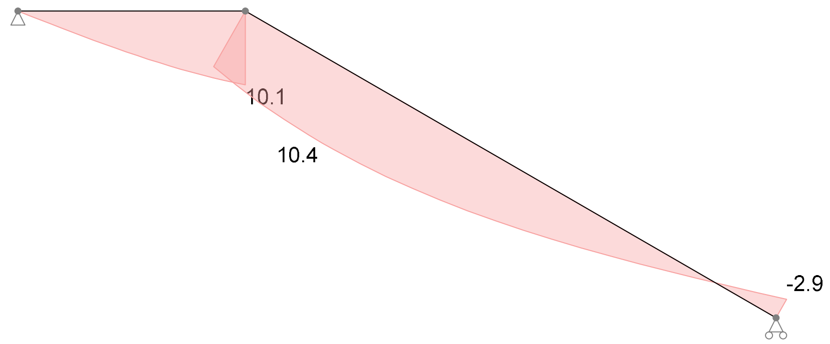
All combinations - Axial force envelope (kN)



Service combinations - Deflection envelope (mm)



Element results

Envelope - Strength combinations

Element	Shear force		Moment			
	Pos (m)	Max abs (kN)	Pos (m)	Max (kNm)	Pos (m)	Min (kNm)
1	0	35.3 (max abs)	1.5	42.2 (max)	0	0 (min)
2	4.042	-11.2	0	42.2 (max)	4.042	0 (min)

Envelope - All combinations

Element	Axial force			
	Pos (m)	Max (kN)	Pos (m)	Min (kN)
1	0	0 (min)	0	0 (min)
2	4.042	6.4 (max)	0	3.9

Envelope - Service combinations

Element	Deflection			
	Pos (m)	Max (mm)	Pos (m)	Min (mm)
1	1.5	10.1	0	0
2	0.875	10.4 (max)	4.042	-2.9 (min)

;

STEEL MEMBER DESIGN (BS5950)

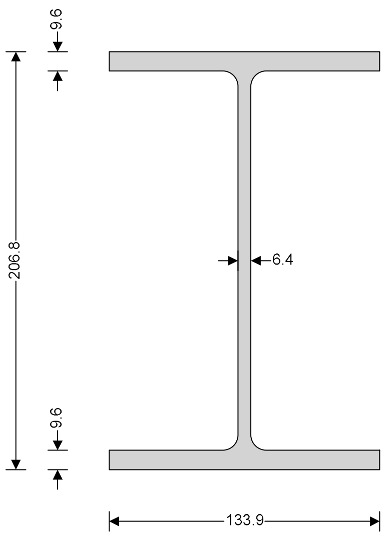
STEEL MEMBER DESIGN (BS5950)

In accordance with BS5950-1:2000 incorporating Corrigendum No.1

TEDDS calculation version 3.0.07

Section details

Section type; **UB 203x133x30 (BS4-1)**; Steel grade; **S275**



Classification of cross sections - Section 3.5

Tensile strain coefficient; ε = **1.00**; Section classification; **Plastic**

Shear capacity - Section 4.2.3

Design shear force; F_v = **35.3** kN; Design shear resistance; $P_{y,v}$ = **218.4** kN

PASS - Design shear resistance exceeds design shear force

Shear capacity - Section 4.2.3

Moment capacity - Section 4.2.5

Design bending moment; M = **42.2** kNm; Moment capacity low shear; M_c = **86.5** kNm

PASS - Moment capacity exceeds design bending moment

Compression members - Section 4.7

Design compression force; F_c = **6.4** kN; Compression resistance; P_{cx} = **927.2** kN

PASS - Compression resistance exceeds design compression force

Compression members with moments - Section 4.8.3

Comp.and bending check; $F_c / (A \times p_y) + M / M_c$ = **0.494**

PASS - Combined bending and compression check is satisfied

Member buckling resistance - cl.4.8.3.3.2

Buckling resistance check; $F_c / P_{cx} + m_x \times M / M_c \times (1 + 0.5 \times F_c / P_{cx})$ = **0.497**

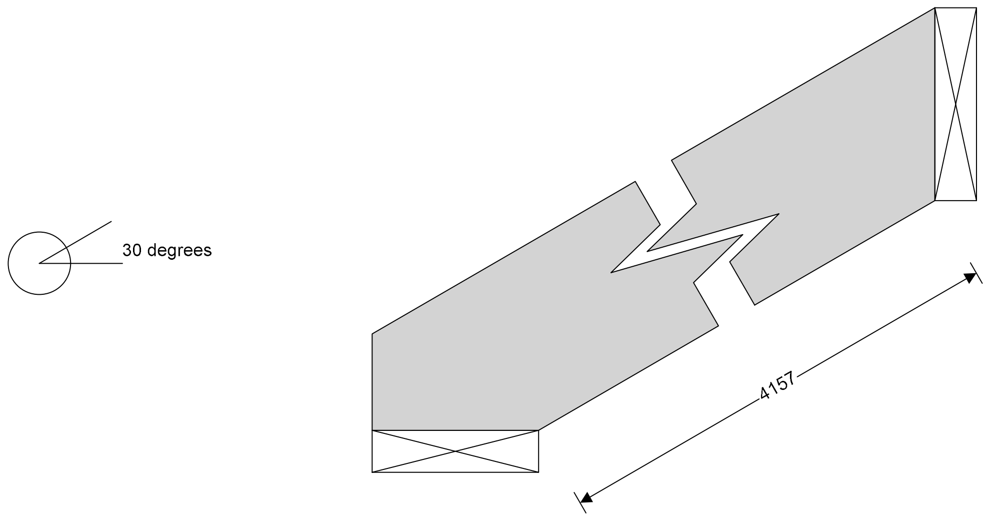
PASS - Member buckling resistance checks are satisfied

<u>Provide Cranked 203x133x30 UB S.275 – Beam to bear onto 440long x 215deep x 100thick concrete padstone</u>

MAIN RAFTER DESIGN

TIMBER RAFTER DESIGN (BS5268-2:2002)

TEDDS calculation version 1.0.03



Rafter details

Breadth of timber sections; b = **50** mm; Depth of timber sections; h = **200** mm

Rafter spacing; s = **400** mm; Rafter span; **Single span**

Clear length of span on slope; L_{cl} = **4157** mm; Rafter slope; α = **30.0** deg

Timber strength class; **C24**

Section properties

Cross sectional area of rafter; A = **10000** mm^2; Section modulus; Z = **333333** mm^3

Radius of gyration; r = **58** mm; Second moment of area; I = **33333333** mm^4

Loading details

Rafter self weight; F_j = **0.03** kN/m; Dead load on slope; F_d = **1.02** kN/m^2

Imposed snow load on plan; F_u = **0.60** kN/m^2; Imposed point load; F_p = **0.90** kN

Modification factors

Section depth factor; K_7 = **1.05**; Load sharing factor; K_8 = **1.10**

Consider long term load condition

Load duration factor; K_3 = **1.00**; Total UDL perp. to rafter; F = **0.383** kN/m

Notional bearing length; L_b = **6** mm; Effective span; L_{eff} = **4163** mm

Check bending stress

Permissible bending stress; σ_{m_adm} = **8.626** N/mm^2; Applied bending stress; σ_{m_max} = **2.489** N/mm^2

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Permissible comp. stress; σ_{c_adm} = **5.038** N/mm^2; Applied compressive stress; σ_{c_max} = **0.276** N/mm^2

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Combined loading check; **0.349 < 1**

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Permissible shear stress; τ_{adm} = **0.781** N/mm^2; Applied shear stress; τ_{max} = **0.120** N/mm^2

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection; δ_{adm} = **12.489** mm; Total deflection; δ_{max} = **4.309** mm

PASS - Total deflection within permissible limits

<u>Consider medium term load condition</u>

Load duration factor; K_3 = **1.25**; Total UDL perp. to rafter; F = **0.563** kN/m

Notional bearing length; L_b = **9** mm; Effective span; L_{eff} = **4166** mm

Check bending stress

Permissible bending stress; σ_{m_adm} = **10.783** N/mm^2; Applied bending stress; σ_{m_max} = **3.664** N/mm^2

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Permissible comp. stress; σ_{c_adm} = **5.828** N/mm^2; Applied compressive stress; σ_{c_max} = **0.406** N/mm^2

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Combined loading check; **0.418 < 1**

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Permissible shear stress; τ_{adm} = **0.976** N/mm^2; Applied shear stress; τ_{max} = **0.176** N/mm^2

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection; δ_{adm} = **12.497** mm; Total deflection; δ_{max} = **6.350** mm

PASS - Total deflection within permissible limits

<u>Consider short term load condition</u>

Load duration factor; K_3 = **1.50**; Total UDL perp. to rafter; F = **0.383** kN/m

Notional bearing length; L_b = **9** mm; Effective span; L_{eff} = **4166** mm

Check bending stress

Permissible bending stress; σ_{m_adm} = **12.939** N/mm^2; Applied bending stress; σ_{m_max} = **4.928** N/mm^2

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Permissible comp. stress; σ_{c_adm} = **6.461** N/mm^2; Applied compressive stress; σ_{c_max} = **0.321** N/mm^2

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Combined loading check; **0.437 < 1**

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Permissible shear stress; τ_{adm} = **1.172** N/mm^2; Applied shear stress; τ_{max} = **0.237** N/mm^2

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection; δ_{adm} = **12.498** mm; Total deflection; δ_{max} = **7.726** mm

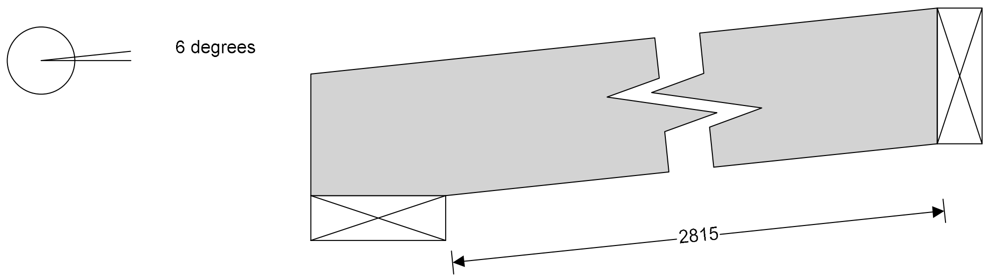
PASS - Total deflection within permissible limits

<u>Provide 50x200 C24 at max. 400mm centres</u>

MONOPITCH RAFTER DESIGN

TIMBER RAFTER DESIGN (BS5268-2:2002)

TEDDS calculation version 1.0.03



Rafter details

Breadth of timber sections; b = **50** mm; Depth of timber sections; h = **150** mm

Rafter spacing; s = **400** mm; Rafter span; **Single span**

Clear length of span on slope; L_{cl} = **2815** mm; Rafter slope; α = **6.0** deg

Timber strength class; **C24**

Section properties

Cross sectional area of rafter; A = **7500** mm^2; Section modulus; Z = **187500** mm^3

Radius of gyration; r = **43** mm; Second moment of area; I = **14062500** mm^4

Loading details

Rafter self weight; F_j = **0.03** kN/m; Dead load on slope; F_d = **1.02** kN/m^2

Imposed snow load on plan; F_u = **0.75** kN/m^2; Imposed point load; F_p = **0.90** kN

Modification factors

Section depth factor; K_7 = **1.08**; Load sharing factor; K_8 = **1.10**

Consider long term load condition

Load duration factor; K_3 = **1.00**; Total UDL perp. to rafter; F = **0.431** kN/m

Notional bearing length; L_b = **5** mm; Effective span; L_{eff} = **2820** mm

Check bending stress

Permissible bending stress; σ_{m_adm} = **8.904** N/mm^2; Applied bending stress; σ_{m_max} = **2.287** N/mm^2

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Permissible comp. stress; σ_{c_adm} = **5.475** N/mm^2; Applied compressive stress; σ_{c_max} = **0.797** N/mm^2

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Combined loading check; **0.415 < 1**

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Permissible shear stress; τ_{adm} = **0.781** N/mm^2; Applied shear stress; τ_{max} = **0.122** N/mm^2

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection; δ_{adm} = **8.460** mm; Total deflection; δ_{max} = **2.441** mm

PASS - Total deflection within permissible limits

Consider medium term load condition

Load duration factor; K_3 = **1.25**; Total UDL perp. to rafter; F = **0.728** kN/m

Notional bearing length; L_b = **8** mm; Effective span; L_{eff} = **2823** mm

Check bending stress

Permissible bending stress; σ_{m_adm} = **11.130** N/mm^2; Applied bending stress; σ_{m_max} = **3.869** N/mm^2

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Permissible comp. stress; σ_{c_adm} = **6.440** N/mm^2; Applied compressive stress; σ_{c_max} = **1.347** N/mm^2

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Combined loading check; **0.584 < 1**

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Permissible shear stress; τ_{adm} = **0.976** N/mm^2; Applied shear stress; τ_{max} = **0.206** N/mm^2

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection; δ_{adm} = **8.470** mm; Total deflection; δ_{max} = **4.138** mm

PASS - Total deflection within permissible limits

Consider short term load condition

Load duration factor; K_3 = **1.50**; Total UDL perp. to rafter; F = **0.431** kN/m

Notional bearing length; L_b = **8** mm; Effective span; L_{eff} = **2823** mm

Check bending stress

Permissible bending stress; σ_{m_adm} = **13.355** N/mm^2; Applied bending stress; σ_{m_max} = **5.662** N/mm^2

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Permissible comp. stress; σ_{c_adm} = **7.250** N/mm^2; Applied compressive stress; σ_{c_max} = **0.811** N/mm^2

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Combined loading check; **0.554 < 1**

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Permissible shear stress; τ_{adm} = **1.172** N/mm^2; Applied shear stress; τ_{max} = **0.301** N/mm^2

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection; δ_{adm} = **8.470** mm; Total deflection; δ_{max} = **5.365** mm

PASS - Total deflection within permissible limits

Provide 50x150 C24 rafters at max. 400mm centres

Foundation Design:

Loadings

UDL from Pitched Roof

Width of roof being carried;	x_1 = **2.0** m		
Dead Load;	$DL_1 = 1.178\ kN/m^2 \times x_1$	=	**2.356** kN/m
Imposed Load;	$IL_1 = 0.60\ kN/m^2 \times x_1$	=	**1.200** kN/m

UDL from Mono-pitched Roof

Width of roof being carried;	x_2 = **1.4** m		
Dead Load;	$DL_2 = 1.026\ kN/m^2 \times x_2$	=	**1.436** kN/m
Imposed Load;	$IL_2 = 0.75\ kN/m^2 \times x_2$	=	**1.050** kN/m

UDL from Masonry Wall

Height of wall being carried;	x_3 = **3.0** m		
Dead Load (Inner Leaf);	$DL_{3a} = 2.00\ kN/m^2 \times x_3$	=	**6.000** kN/m
Dead Load (Outer Leaf);	$DL_{3b} = 2.20\ kN/m^2 \times x_3$	=	**6.600** kN/m

UDL from Beam and Block Floor

Width of roof being carried;	x_4 = **1.4** m		
Dead Load;	$DL_4 = 4.50\ kN/m^2 \times x_4$	=	**6.300** kN/m
Imposed Load;	$IL_4 = 2.50\ kN/m^2 \times x_4$	=	**3.500** kN/m

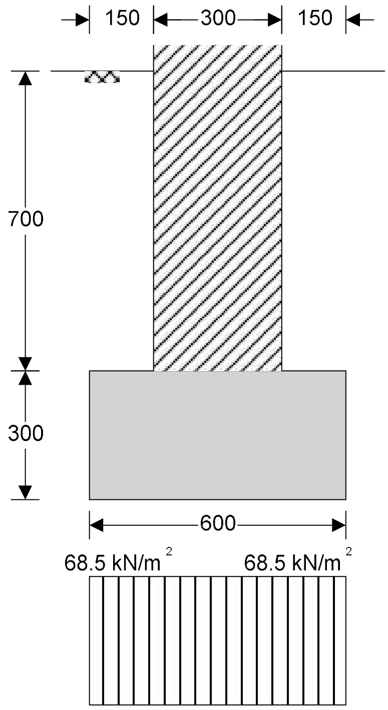
Total UDL

Total Dead UDL;	$DL_T = sum(DL_1, DL_2, DL_{3a}, DL_{3b}, DL_4)$	=	**22.692** kN/m
Total Imposed UDL;	$IL_T = sum(IL_1, IL_2, IL_4)$	=	**5.750** kN/m
Total UDL;	$w_T = DL_T + IL_T$	=	**28.442** kN/m

STRIP FOOTING ANALYSIS & DESIGN (BS8110)

STRIP FOOTING ANALYSIS AND DESIGN (BS8110-1:1997)

Tedds calculation version 2.0.07



Strip footing details

Width of strip footing; B = **600** mm; Depth of strip footing; h = **300** mm

Depth of soil over strip footing; h_{soil} = **700** mm; Density of concrete; ρ_{conc} = **23.6** kN/m^3

Load details

Load width; b = **300** mm; Load eccentricity; e_P = **0** mm

Soil details

Depth of soil over pad footing; h_{soil} = **700** mm; Density of soil; ρ_{soil} = **20.0** kN/m^3

Allowable bearing pressure; $P_{bearing}$ = **100** kN/m^2

Axial loading on strip footing

Dead axial load; P_G = **22.7** kN/m; Imposed axial load; P_Q = **5.8** kN/m

Wind axial load; P_W = **0.0** kN/m; Total axial load; P = **28.4** kN/m

Foundation loads

Dead surcharge load; F_{Gsur} = **0.000** kN/m^2; Imposed surcharge load; F_{Qsur} = **0.000** kN/m^2

Strip footing self weight; F_{swt} = **7.080** kN/m^2; Soil self weight; F_{soil} = **14.000** kN/m^2

Total foundation load; F = **12.6** kN/m

Calculate base reaction

Total base reaction; T = **41.1** kN/m; Eccentricity of base reaction; e_T = **0** mm

Base reaction acts within middle third of base

Calculate pad base pressures

Base pressures; q_1 = **68.483** kN/m^2; q_2 = **68.483** kN/m^2

Minimum base pressure; q_{min} = **68.483** kN/m^2; Maximum base pressure; q_{max} = **68.483** kN/m^2

PASS - Maximum base pressure is less than allowable bearing pressure

Material details

Char.strength of concrete; f_{cu} = **20** N/mm^2

Calculate minimum depth of unreinforced strip footing

Ave.pressure to left of footing; q_L = **68.483** kN/m^2; Min.depth to left of footing; h_{Lmin} = **150** mm

Ave.pressure to right of footing; q_R = **68.483** kN/m^2; Min.depth to right of footing; h_{Rmin} = **150** mm

Min.depth unreinforced footing; h_{min} = **300** mm

PASS - Unreinforced strip footing depth is greater than minimum

<u>Provide 600w x 300thk GEN3 mass concrete foundation</u>