Structural Calculations

For

Alterations and extensions

At

40a Park Hill Road,
London,
NW3 2YP

July 2017

Contents:

Krystal Engineering

Nicole@krystalengineering.co.uk - 07841659213

Job: **40a Park Hill** Job No: **5016**

By: **NB** Date: **July 2017** Sheet No: **L1**

	kN/m²		
	DL	IL	Total
Pitched Roofs			
Tiles	0.50		
Battens and Felt	0.10		
Rafters	0.15	0.75	
Joists, Insulation and Ceiling	0.25	0.25	
	1.00	1.00	2.00
Flat Roofs			
Chippings and Felt	0.20		
Boards, Joists and Fittings	0.35		
Ceiling and Insulation	0.20		
	0.75	0.75	1.50
Suspended Floors			
Timber			
Boards and Joists	0.35		
Ceiling	0.15		
	0.50	1.50	2.00
PC Ground Floor (Beam and Block)			
Finish	1.87		
150 Slab	2.40		
	4.27	1.50	5.77
PC Garage Floor (Beam and Block)			
Finish	1.70		
150 Slab	2.40		
	4.10	2.50	6.66
In situ Ground Floor			
Finish	1.20		
150 Slab	3.60		
	4.80	1.50	6.30
Finish	1.20		
200 Slab	4.80		
	6.00	1.50	7.50

Nicole@krystalengineering.co.uk - 07841659213

Job: **40a Park Hill** Job No: **5016**

By: **NB** Date**: July 2017** Sheet No: **L2**

	kN/m²		
	DL	IL	Total
In situ Garage Floor			
150 Slab (self finish)	3.60	2.50	6.10
200 Slab (self finish)	4.80	2.50	7.30
PC Upper Floors (units)			
Finish	1.50		
150 Slab	2.40		
Ceiling	0.20		
	4.10	1.50	6.20
PC Upper Floors (units)			
Finish	1.50		
200 Slab	2.85		
Ceiling	0.20		
	4.55	1.50	6.20
PC Upper Floors (communal areas)			
Finish	1.50		
150 Slab	2.40		
Ceiling	0.20		
	4.10	3.00	7.70
PC Upper Floors (communal areas)			
Finish	1.50		
200 Slab	2.85		
Ceiling	0.20		
	4.55	3.00	7.70

Job: **40a Park Hill** Job No: **5016**

By: **NB** Date**: July 2017** Sheet No: **L3**

	kN/m²		
	DL	IL	Total
Walls			
Timber Stud Internal			
Plasterboard 2 sides	0.20		
Studs	0.10		
	0.30		0.30
Lath and Plaster 2 sides	0.70		
Studs	0.10		
	0.80		0.80
Timber Stud External			
Tiles	0.60		
Battens, Felt, Insulation	0.10		
Studs	0.10		
Plasterboard and Set	0.20		
	1.00		1.00
External Cavity Wall			
Brick 102mm	2.30		
Block 100mm	1.50		
Plaster one side	0.10		
	3.90		3.90
100 Solid Block Internal (1500kG/m³ density)			
Block 100	1.50		
Plaster both sides	0.20		
	1.70		1.70
Party Cavity Wall			
Block 100	2.00		
Plaster one side	0.10		
Block 100	2.00		
Plaster one side	0.10		
	4.20		4.20

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Job: **40a Park Hill** Job No: **5016**

By: **NB** Date**: July 2017** Sheet No: **L4**

	kN/m²		
	DL	IL	Total
102 Solid Brick			
Brick 102mm	2.30		
Plaster two sides	0.20		
	2.50		2.50
215 Solid Block (1400kg/m³ density)			
Block 215mm	3.00		
Plaster two sides	0.20		
	3.20		3.20
215 Solid Block Party			
Block 215mm	4.00		
Plaster two sides	0.20		
	4.20		4.20
215 Solid Brick			
Brick 215mm	4.60		
Plaster two faces	0.20		
	4.80		4.80
330 Solid Brick			
Brick 330mm	6.80		
Plaster two sides	0.20		
	7.00		7.00

DESIGN CODES

1.	Weights of Materials	BS 648
2.	Structural Steelwork	BS 5950 - 1
3.	Reinforced Concrete	BS 8110
4.	Timber	BS 5268
5.	Masonry	BS 5628: 2005
6.	Design Loading	BS 6399
7.	Foundations	BS 8004
8.	Foundation Depths	NHBC Appendix 4.2
9.	General	The Building regulations 1991
10.	Others as Listed Below:	

Note: Codes are those current for August 2012, unless another version is specifically referred to above or within the calculations.

Nicole@krystalengineering.co.uk - 07841659213

Job: **40a Park Hill** Job No: **5016**

By: **NB** Date**: July 2017** Sheet No: **L6**

PADSTONE LOAD CHECK:

$$N = \frac{1.25 \times f_k}{\gamma_m} xAb$$

Beams supported on existing brick wall – use 15N/mm^2 bricks with (IV) mortar therefore

Brick Strength = 3.5N/mm^2
Fk = 3.6
Allowable stress = 1.29N/mm^2
Safety factor = 3.5

Padstone size = 440x100x215	**=**	**Max load =**	**57kN**
Padstone size = 660x100x215	**=**	**Max load =**	**85kN**
Padstone size = 880x100x215	**=**	**Max load =**	**113kN**
Padstone size = 440x215x215	**=**	**Max load =**	**122kN**
Padstone size = 660x215x215	**=**	**Max load =**	**182kN**
Padstone size = 880x215x215	**=**	**Max load =**	**243kN**

Beams supported on new block wall – use 7.3N/mm^2 blocks with (iii) mortar therefore

Brick Strength = 7.3N/mm^2
Fk = 6.4
Allowable stress = 2.29N/mm^2
Safety factor = 3.5

Padstone size = 440x100x215	**=**	**Max load =**	**101kN**
Padstone size = 660x100x215	**=**	**Max load =**	**151kN**
Padstone size = 880x100x215	**=**	**Max load =**	**201kN**
Padstone size = 440x215x215	**=**	**Max load =**	**216kN**
Padstone size = 660x215x215	**=**	**Max load =**	**324kN**
Padstone size = 880x215x215	**=**	**Max load =**	**432kN**

Job: **40a Park Hill** Job No: **5016**

By: **NB** Date**: July 2017** Sheet No: **L7**

Table 36 Permissible clear spans for joists for flat roofs with access for maintenance and repair only

Imposed load 0.75 kN/m^2.

Strength Class C16 Service Class 1 or 2

		Dead loads (kN/m^2) excluding self-weight of joist								
		Not more than 0.50			More than 0.50 but not more than 0.75			More than 0.75 but not more than 1.00		
Size of joist		Spacing of joists (mm)								
Breadth (mm)	Depth (mm)	400	450	600	400	450	600	400	450	600
		Maximum clear span (m)								
38	97	1.74	1.72	1.67	1.67	1.65	1.58	1.61	1.58	1.51
38	120	2.33	2.30	2.21	2.21	2.17	2.08	2.12	2.08	1.97
38	145	2.98	2.94	2.82	2.82	2.76	2.63	2.68	2.63	2.48
38	170	3.66	3.60	3.38	3.43	3.36	3.18	3.26	3.18	2.99
38	195	4.34	4.26	3.88	4.06	3.97	3.65	3.83	3.74	3.46
38	220	4.99	4.80	4.37	4.68	4.52	4.11	4.42	4.30	3.90
47	97	1.93	1.90	1.84	1.84	1.81	1.74	1.77	1.74	1.66
47	120	2.56	2.52	2.43	2.43	2.39	2.27	2.32	2.27	2.16
47	145	3.27	3.22	3.08	3.08	3.02	2.87	2.93	2.87	2.70
47	170	4.00	3.93	3.63	3.75	3.67	3.42	3.55	3.47	3.25
47	195	4.73	4.57	4.16	4.41	4.31	3.92	4.17	4.07	3.72
47	220	5.34	5.14	4.68	5.04	4.85	4.41	4.79	4.61	4.19
63	97	2.20	2.17	2.10	2.10	2.06	1.98	2.01	1.98	1.88
63	120	2.91	2.87	2.75	2.75	2.70	2.57	2.63	2.57	2.43
63	145	3.70	3.64	3.42	3.48	3.41	3.22	3.30	3.23	3.04
63	170	4.50	4.39	4.00	4.21	4.12	3.77	3.98	3.89	3.58
63	195	5.21	5.02	4.58	4.92	4.74	4.31	4.66	4.51	4.10
63	220	5.85	5.64	5.15	5.53	5.33	4.86	5.27	5.07	4.62
75	120	3.13	3.08	2.96	2.96	2.90	2.76	2.82	2.76	2.61
75	145	3.97	3.90	3.62	3.72	3.65	3.41	3.53	3.45	3.24
75	170	4.81	4.64	4.23	4.50	4.38	3.99	4.25	4.15	3.79
75	195	5.50	5.30	4.84	5.19	5.01	4.57	4.95	4.77	4.34
75	220	6.17	5.96	5.45	5.84	5.63	5.14	5.57	5.36	4.89
ALS/CLS										
38	140	2.85	2.81	2.69	2.69	2.64	2.51	2.57	2.51	2.38
38	184	4.04	3.97	3.66	3.78	3.70	3.44	3.58	3.49	3.27
38	235	5.32	5.12	4.66	5.02	4.83	4.38	4.76	4.59	4.16

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Table 28 Permissible clear spans for common or jack rafters

Slope of roof 30.0° to 45.0° Imposed load 0.75 kN/m²

Strength Class C16 Service Class 1 or 2

		Dead load (kN/m²) excluding self weight of rafter								
		Not more than 0.5			More than 0.5 but not more than 0.75			More than 0.75 but not more than 1.00		
Size of rafter		Spacing of rafters (mm)								
Breadth (mm)	Depth (mm)	400	450	600	400	450	600	400	450	600
		Maximum clear span (m)								
38	100	2.30	2.24	2.11	2.11	2.06	1.91	1.97	1.91	1.77
38	125	3.09	2.97	2.70	2.89	2.78	2.52	2.67	2.58	2.36
38	150	3.70	3.56	3.23	3.46	3.33	3.03	3.28	3.15	2.86
47	100	2.66	2.55	2.32	2.47	2.39	2.17	2.29	2.22	2.04
47	125	3.31	3.18	2.90	3.10	2.98	2.71	2.94	2.83	2.57
47	150	3.96	3.81	3.47	3.71	3.57	3.25	3.52	3.39	3.08
ALS/CLS										
38	89	1.92	1.88	1.78	1.78	1.74	1.63	1.67	1.63	1.51
38	140	3.45	3.32	3.02	3.24	3.11	2.83	3.06	2.95	2.67

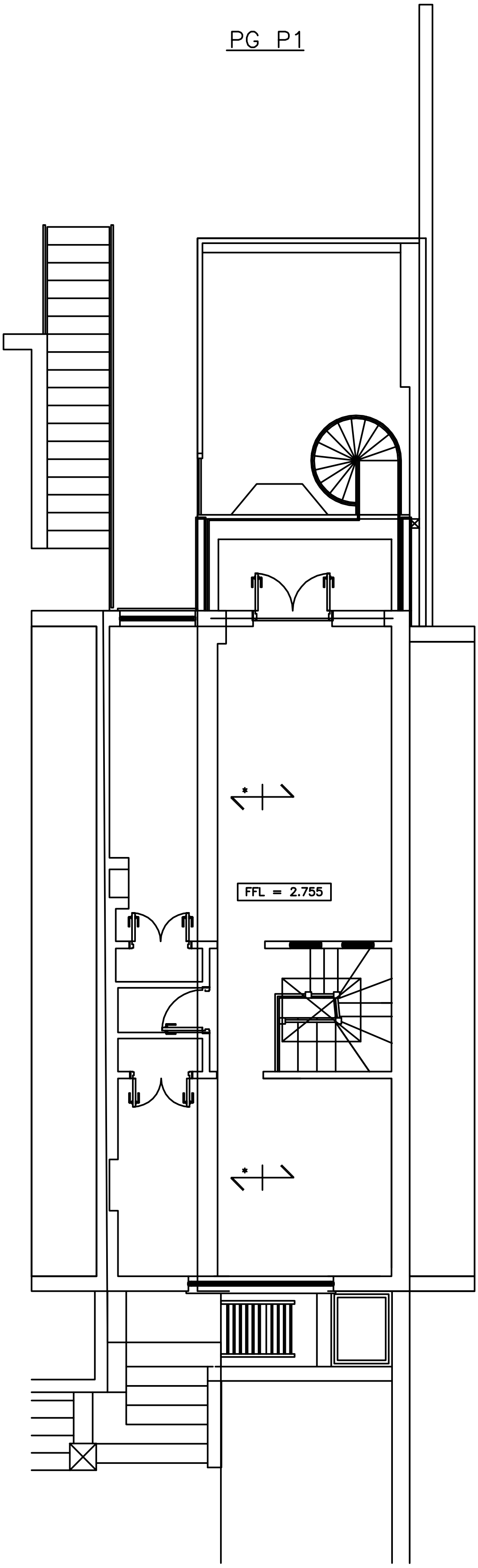
Table 29 Permissible Clear Spans for Common or Jack Rafters

Slope of roof 30.0° to 45.0° Imposed load 0.75 kN/m²

Strength Class C24 Service Class 1 or 2

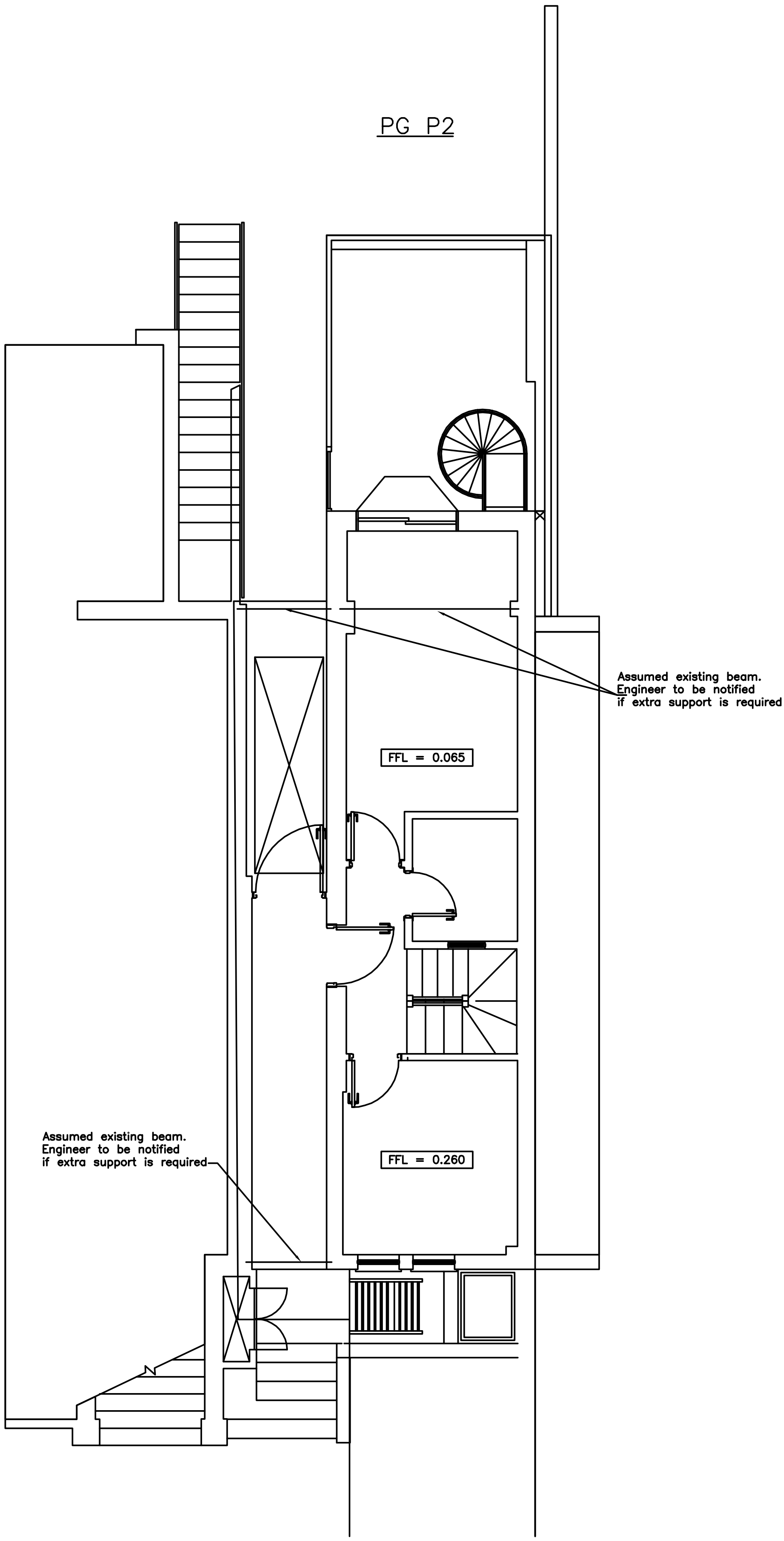
		Dead loads (kN/m²) excluding self weight of rafter								
		Not more than 0.5			More than 0.5 but not more than 0.75			More than 0.75 but not more than 1.00		
Size of rafter		Spacing of rafters (mm)								
Breadth (mm)	Depth (mm)	400	450	600	400	450	600	400	450	600
		Maximum clear span (m)								
38	100	2.65	2.55	2.32	2.48	2.39	2.17	2.35	2.26	2.05
38	125	3.30	3.18	2.89	3.10	2.98	2.71	2.93	2.82	2.56
38	150	3.95	3.81	3.46	3.71	3.57	3.24	3.51	3.38	3.07
47	100	2.84	2.73	2.49	2.66	2.56	2.33	2.52	2.43	2.20
47	125	3.54	3.41	3.10	3.32	3.20	2.91	3.15	3.03	2.75
47	150	4.23	4.08	3.71	3.97	3.82	3.48	3.77	3.62	3.29
ALS/CLS										
38	89	2.36	2.27	2.06	2.21	2.13	1.93	2.09	2.01	1.83
38	140	3.69	3.56	3.23	3.46	3.33	3.03	3.28	3.16	2.86

PG P1



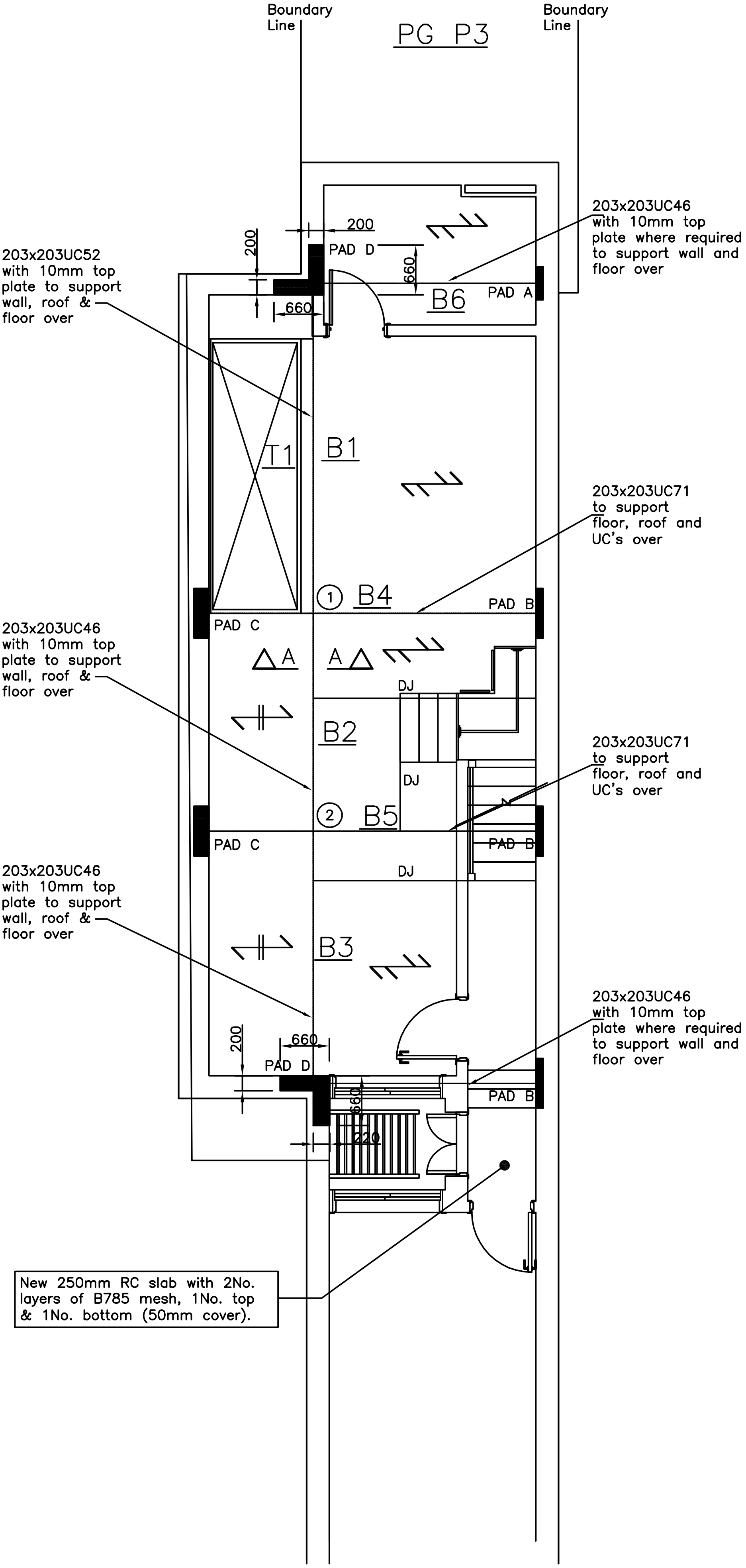
First Floor Plan Indicating Roof Structure Over

PG P2

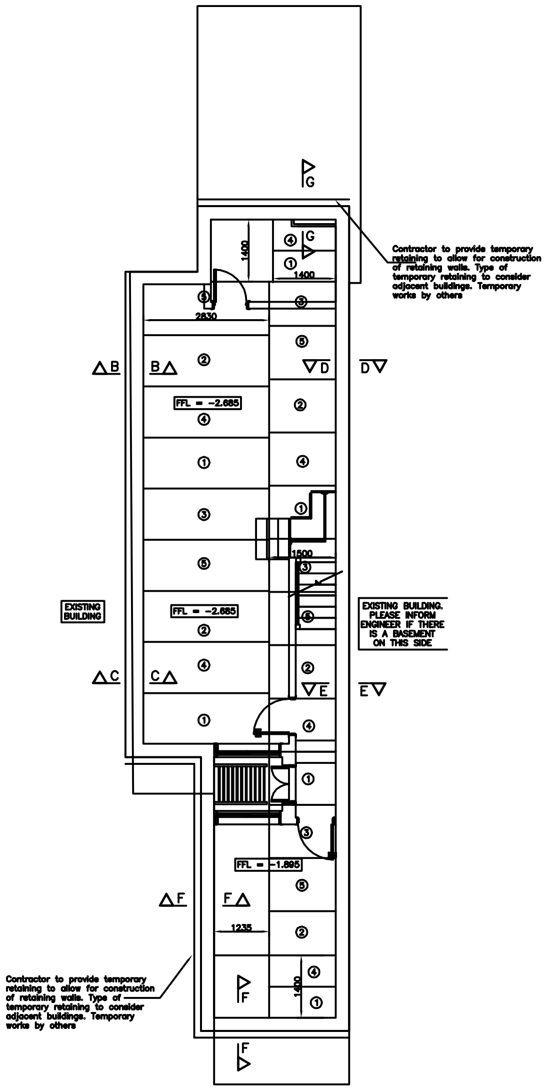


Ground Floor Plan Indicating Structure Over

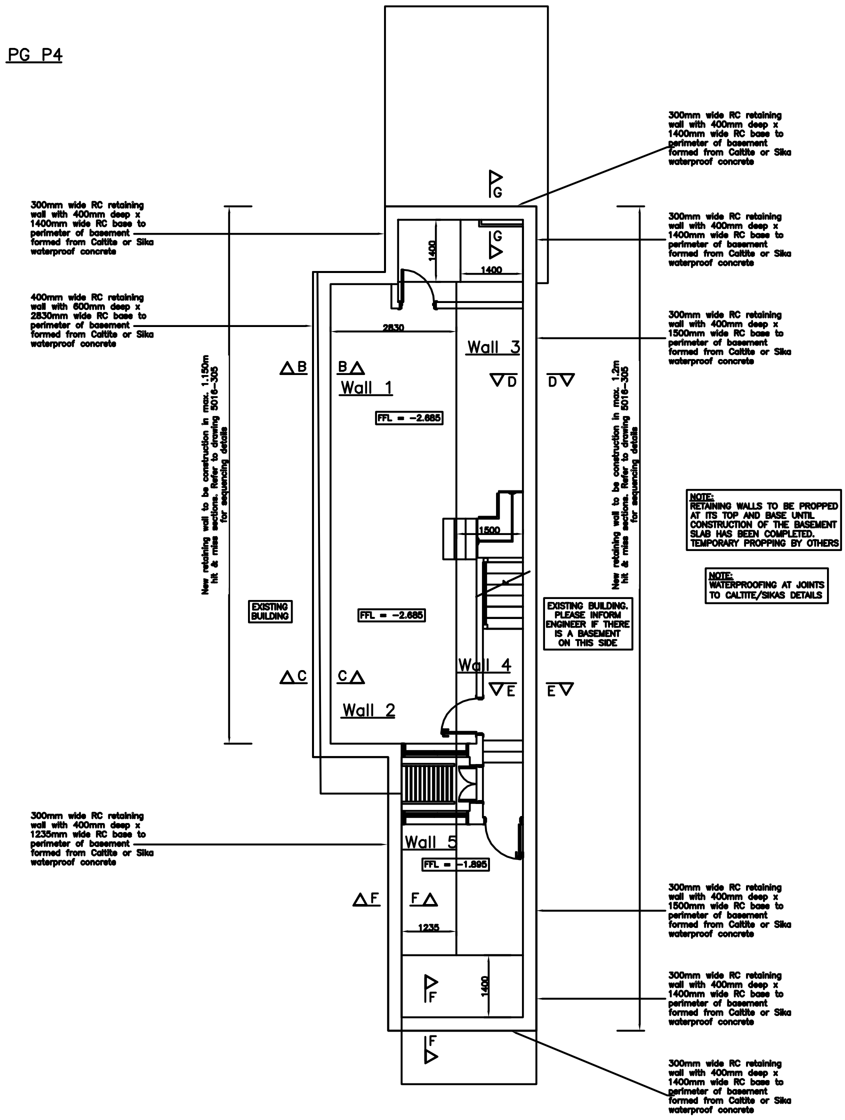
PG P3



Basement Floor Plan Indicating Structure Over



Retaining Wall and Base Hit & Miss Sequencing Plan



Basement

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Nicole@krystalengineering.co.uk - 07841659213

Job: **40a ParkHill**

Job No: **5016**

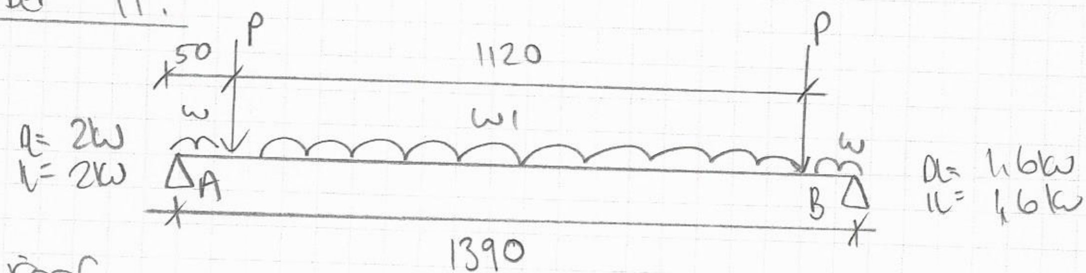
By: **NB**

Date: **July 2017**

Sheet No: S1

Structural Design:

Timber T1:



W = roof

Wd = WL = 0,75 x 0,4 = 0,3 kN/m

W1 = roof + rooflight

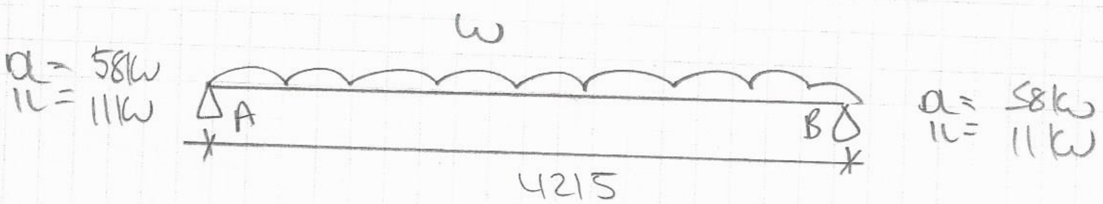
W1d = W1L = 0,75x (3,5+0,4)/2 = 1,46 kN/m

P = Trimmer

Pd = PL = (0,75 x 1,4/2)(3,5/2) = 0,9 kN

From Tedds use 50x150dp C16 timbers

Beam B1:



w = floor + roof + wall + floor

wd = (0,5 x 3/2) + (0,75 x 1,4/2) + (4,8 x 5,2) + (0,5 x 3/2) = 27 kN/m

wL = (1,5 x 3/2) + (0,75 x 1,4/2) + (1,5 x 3/2) = 5 kN/m

From Tedds use 203UC52

RA load = RB load = 98 kN (uls)

RA connects to beam

RB bears onto wall along with B6. Total load = 98 + 27 = 125 kN (uls)

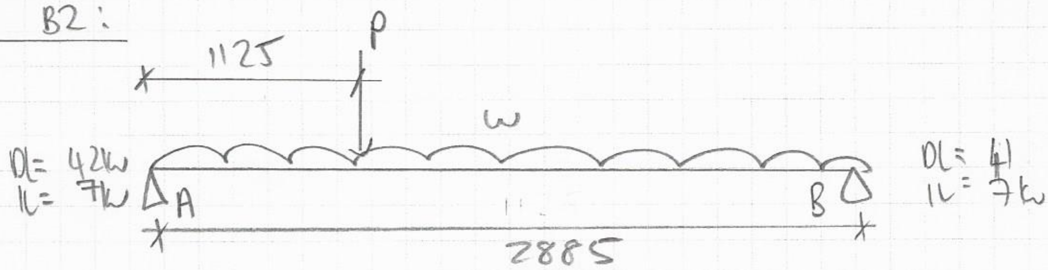
use 660x 200x 215dp padstone

Nicole@krystalengineering.co.uk - 07841659213

Job: **40a ParkHill** Job No: **5016**

By: **NB** Date: **July 2017** Sheet No: S2

Beam B2:



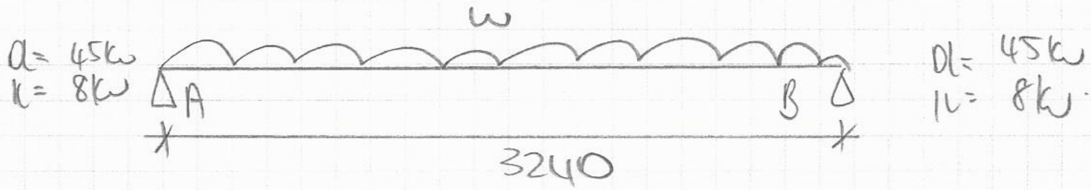
W – as B1
Wd = 27 kN/m
WL = 5kN/m

P = wall
Pd = (1×2.5)(3/2) = 3.8 kN

From Tedds use 203UC46

RA load = RB load = 70kN (ULS)
RA & RB connect to beams

Beam B3:



W – as B1
Wd = 27 kN/m
WL = 5kN/m

From Tedds use 203UC46

RA load = RB load = 75 kN (ULS)

RA connects to beam

RB bears onto wall. From pg L6 use 440 × 200 × 215dp padstone

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Job: **40a ParkHill**

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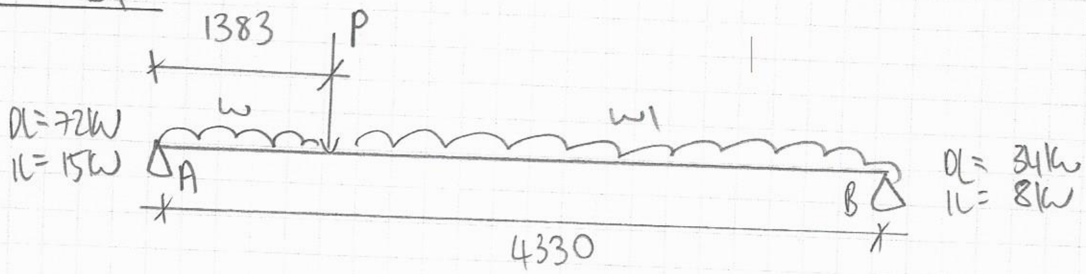
Beam B4:



w= rooflight + roof
wd = wL = 0.75 x (3.5+0.4)/2 = 1.46 kN/m

w1 = floor + partitions
w1 d = 0.5 x 0.4 = 0.2 kN/m
w1 L = 2.5 x 0.4 = 1 kN/m

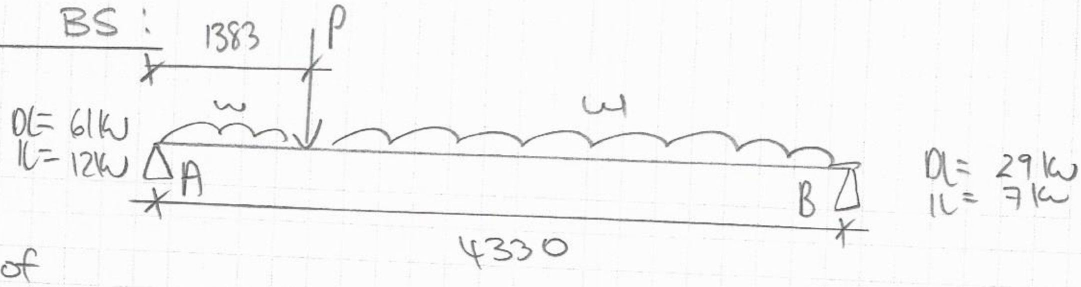
P = B1 + B2
Pd = 58 + 42 = 100 kN
PL = 11 + 7 = 18 kN

From Tedds use 203UC71

RA load = 124 kN (ULS)
RB load = 61 kN (ULS)

RA & RB bear onto wall. From pg L6 use
660 x 200 x 215dp padstone
+ 660 x 100 x 215dp padstone

Beam B5:



w= roof
wd = wL = 0.75 x 0.4 = 0.3 kN/m

w1 = floor
w1 d = 0.2 kN/m
w1 L = 1 kN/m
As B4

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Nicole@krystalengineering.co.uk - 07841659213

Job: **40a ParkHill** Job No: **5016**

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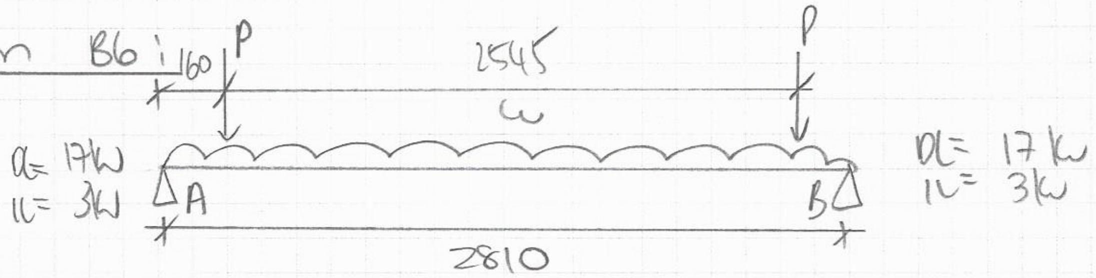
P = B2 + B3
Pd = 41 + 45 = 86kN
PL = 7 + 8 = 15kN

From Tedds use 203UC71

RA load = 103kN (uls) } Padstones as B4
RB load = 52kN (uls) }

Beam B6:



w = floor
wd = 0.2 kN/m
wL = 1 kN/m

P = existing beam
Pd = [(4.8 x 2.5) + (0.5 x 1.2/2)](2.6/2) = 16kN
PL = [(1.5 x 1.2/2)](2.6/2) = 1kN

From Tedds use 203UC46

RA load = RB load = 27kN (uls). From pg L6 use 440x100x215 dp padstones

Floor joists:

Span = 3000mm

From Tedds use 50x200dp C16 joists @ 400c/c

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Job: **40a ParkHill**

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Sheet No: 55

Retaining Walls:

Wall 1: Height = 2150mm

Loads on wall:

Dead:

NO 40a {
wall = 4.8 x 2.5 = 12 kN/m
B4/6 = 72/6 = 12 kN/m
roof = 0.75 x 1.4/2 = 0.53 kN/m

NO 40 {
wall = 4.8 x 9.2 = 44 kN/m
floor = (0.5 x 3/2)(3) = 2.25 kN/m
Roof = 1 x 0.5 = 0.5 kN/m

} 71 kN/m

Live:

NO 40a {
B4/6 = 15/6 = 2.5 kN/m
roof = 0.75 x 1.4/2 = 0.53 kN/m

floor = (1.5 x 3/2)(3) = 6.8 kN/m
roof = 1 x 0.5 = 0.5 kN/m

} 10 kN/m

Refer to Tedds calc for design

Wall 2: Height = 2250 mm.

Loads as wall 1 - Design as wall 1

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Sheet No: S6

Wall 3: (Wall 4 similar)

Height = 2150mm

Loads on wall:

Dead:

38+40A

Wall = 4.8 × 6.7 = 32kN/m
Floor = 2(0.5 × 8.2/2) = 4kN/m
Roof = 0.75 × 9.6/2 = 3.6kN/m
} 40kN/m

Live:

floor = 2(1.5 × 8.2/2) = 12kN/m
roof = 0.75 × 9.6/2 = 3.6kN/m
} 15.6kN/m

Refer to Tedds calc for design.

Wall 5:

Height = 2150 mm

Loads on wall:

Dead:

Wall = 4.8 × 3.1 = 15kN/m
B6/2.8 = 17/2.8 = 6kN/m
B1/2.8 = 58/2.8 = 21kN/m
floor = 2(0.5 × 2.8/2) = 1.4kN/m
} 43kN/m

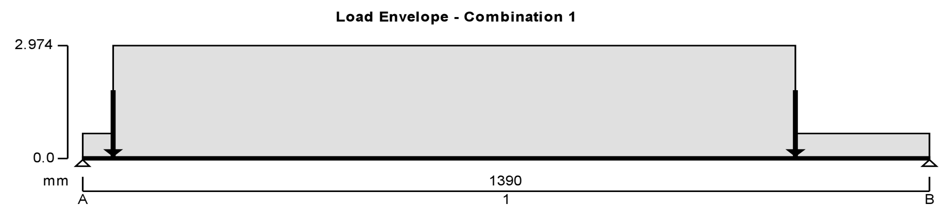
Live:

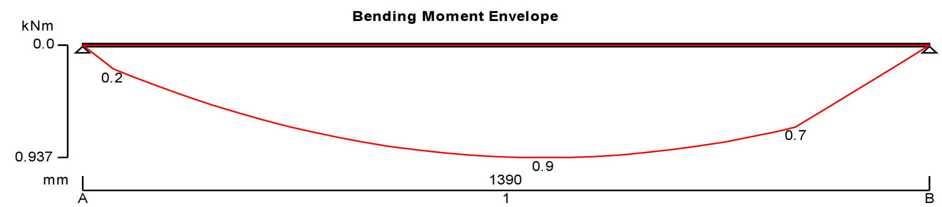
B6/2.8 = 3/2.8 = 1.1 kN/m
B1/2.8 = 11/2.8 = 4kN/m
floor = 2(1.5 × 2.8/2) = 4.2kN/m
} 9kN/m

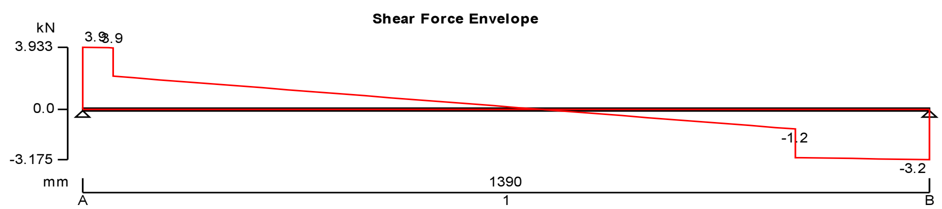
Refer to Tedds calc for design

TIMBER BEAM ANALYSIS & DESIGN TO BS5268-2:2002

TEDDS calculation version 1.6.00







Applied loading

Beam loads

Dead partial UDL 0.300 kN/m from 0 mm to 50 mm
Imposed partial UDL 0.300 kN/m from 0 mm to 50 mm
Dead partial UDL 1.460 kN/m from 50 mm to 1170 mm
Imposed partial UDL 1.460 kN/m from 50 mm to 1170 mm
Dead partial UDL 0.300 kN/m from 1170 mm to 1390 mm
Imposed partial UDL 0.300 kN/m from 1170 mm to 1390 mm
Dead point load 0.900 kN at 50 mm
Imposed point load 0.900 kN at 50 mm
Dead point load 0.900 kN at 1170 mm
Imposed point load 0.900 kN at 1170 mm
Dead self weight of beam × 1

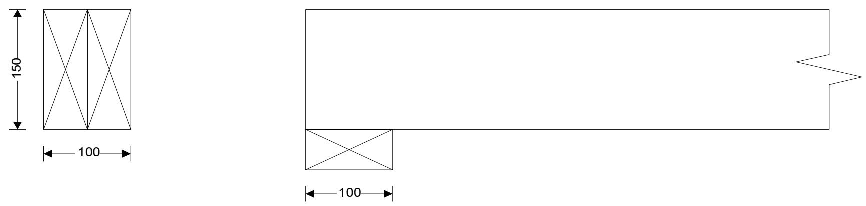
Load combinations

Load combination 1	Support A	Dead × 1.00
		Imposed × 1.00
	Span 1	Dead × 1.00
		Imposed × 1.00
	Support B	Dead × 1.00

Imposed × 1.00

Analysis results

Maximum moment	M_{max} = **0.937** kNm	M_{min} = **0.000** kNm
Design moment	M = max(abs(M_{max}),abs(M_{min})) = **0.937** kNm	
Maximum shear	F_{max} = **3.933** kN	F_{min} = **-3.175** kN
Design shear	F = max(abs(F_{max}),abs(F_{min})) = **3.933** kN	
Total load on beam	W_{tot} = **7.108** kN	
Reactions at support A	R_{A_max} = **3.933** kN	R_{A_min} = **3.933** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **1.985** kN	
Unfactored imposed load reaction at support A	$R_{A\_Imposed}$ = **1.948** kN	
Reactions at support B	R_{B_max} = **3.175** kN	R_{B_min} = **3.175** kN
Unfactored dead load reaction at support B	R_{B_Dead} = **1.606** kN	
Unfactored imposed load reaction at support B	$R_{B\_Imposed}$ = **1.569** kN	



Timber section details

Breadth of sections	b = **50** mm
Depth of sections	h = **150** mm
Number of sections in member	N = **2**
Overall breadth of member	b_b = N × b = **100** mm
Timber strength class	**C16**

Member details

Service class of timber	**1**
Load duration	**Long term**
Length of bearing	L_b = **100** mm

Section properties

Cross sectional area of member	A = N × b × h = **15000** mm^2
Section modulus	Z_x = N × b × h^2 / 6 = **375000** mm^3
	Z_y = h × $(N \times b)^2$ / 6 = **250000** mm^3
Second moment of area	I_x = N × b × h^3 / 12 = **28125000** mm^4
	I_y = h × $(N \times b)^3$ / 12 = **12500000** mm^4
Radius of gyration	i_x = $\sqrt{(I_x / A)}$ = **43.3** mm
	i_y = $\sqrt{(I_y / A)}$ = **28.9** mm

Modification factors

Duration of loading - Table 17	K_3 = **1.00**
Bearing stress - Table 18	K_4 = **1.00**
Total depth of member - cl.2.10.6	K_7 = (300 mm / h)$^{0.11}$ = **1.08**
Load sharing - cl.2.10.11	K_8 = **1.10**
Minimum modulus of elasticity - Table 20	K_9 = **1.14**

Lateral support - cl.2.10.8

Ends held in position

Permissible depth-to-breadth ratio - Table 19 **3.00**

Actual depth-to-breadth ratio $h / (N \times b)$ = **1.50**

PASS - Lateral support is adequate

Compression perpendicular to grain

Permissible bearing stress (no wane) $\sigma_{c\_adm} = \sigma_{cp1} \times K_3 \times K_4 \times K_8$ = **2.420** N/mm^2

Applied bearing stress $\sigma_{c\_a} = R_{A\_max} / (N \times b \times L_b)$ = **0.393** N/mm^2

$\sigma_{c\_a} / \sigma_{c\_adm}$ = **0.163**

PASS - Applied compressive stress is less than permissible compressive stress at bearing

Bending parallel to grain

Permissible bending stress $\sigma_{m\_adm} = \sigma_m \times K_3 \times K_7 \times K_8$ = **6.292** N/mm^2

Applied bending stress $\sigma_{m\_a} = M / Z_x$ = **2.500** N/mm^2

$\sigma_{m\_a} / \sigma_{m\_adm}$ = **0.397**

PASS - Applied bending stress is less than permissible bending stress

Shear parallel to grain

Permissible shear stress $\tau_{adm} = \tau \times K_3 \times K_8$ = **0.737** N/mm^2

Applied shear stress $\tau_a = 3 \times F / (2 \times A)$ = **0.393** N/mm^2

τ_a / τ_{adm} = **0.534**

PASS - Applied shear stress is less than permissible shear stress

Deflection

Modulus of elasticity for deflection $E = E_{min} \times K_9$ = **6612** N/mm^2

Permissible deflection δ_{adm} = min(0.551 in, 0.003 $\times L_{s1}$) = **4.170** mm

Bending deflection δ_{b_s1} = **1.047** mm

Shear deflection δ_{v_s1} = **0.181** mm

Total deflection $\delta_a = \delta_{b\_s1} + \delta_{v\_s1}$ = **1.229** mm

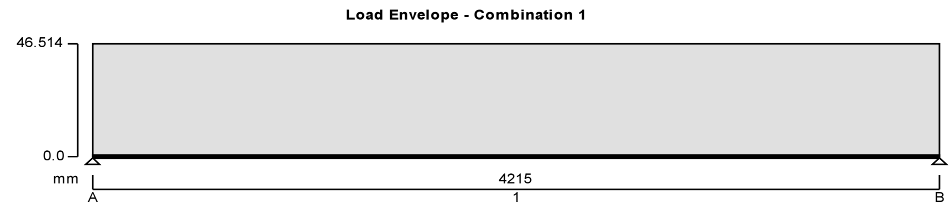
δ_a / δ_{adm} = **0.295**

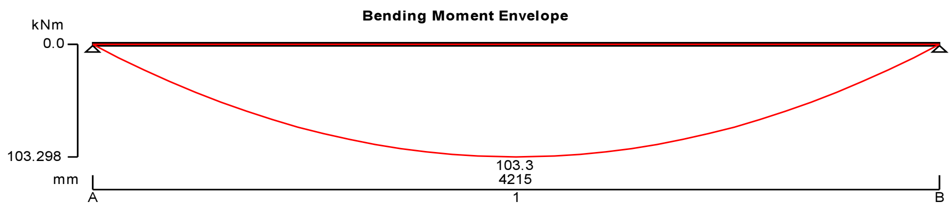
PASS - Total deflection is less than permissible deflection

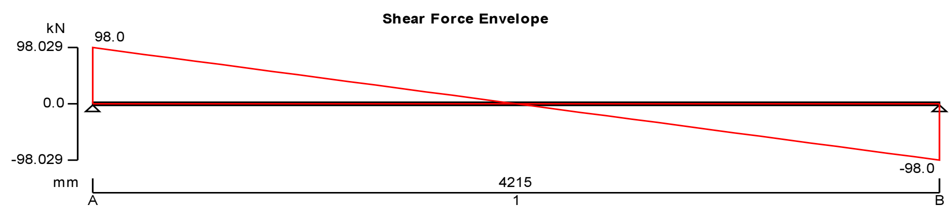
STEEL BEAM ANALYSIS & DESIGN (BS5950)

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

TEDDS calculation version 3.0.05







Support conditions

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

Applied loading

Beam loads	Dead full UDL 27 kN/m	
	Imposed full UDL 5 kN/m	
	Dead self weight of beam × 1	

Load combinations

Load combination 1	Support A	Dead × 1.40
		Imposed × 1.60
	Span 1	Dead × 1.40
		Imposed × 1.60
	Support B	Dead × 1.40
		Imposed × 1.60

Analysis results

Maximum moment	M_{max} = **103.3** kNm	M_{min} = **0** kNm
Maximum shear	V_{max} = **98** kN	V_{min} = **-98** kN
Deflection	δ_{max} = **12.4** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **98** kN	R_{A_min} = **98** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **58** kN	
Unfactored imposed load reaction at support A	$R_{A\_Imposed}$ = **10.5** kN	
Maximum reaction at support B	R_{B_max} = **98** kN	R_{B_min} = **98** kN
Unfactored dead load reaction at support B	R_{B_Dead} = **58** kN	
Unfactored imposed load reaction at support B	$R_{B\_Imposed}$ = **10.5** kN	

Section details

Section type **UC 203x203x52 (BS4-1)**

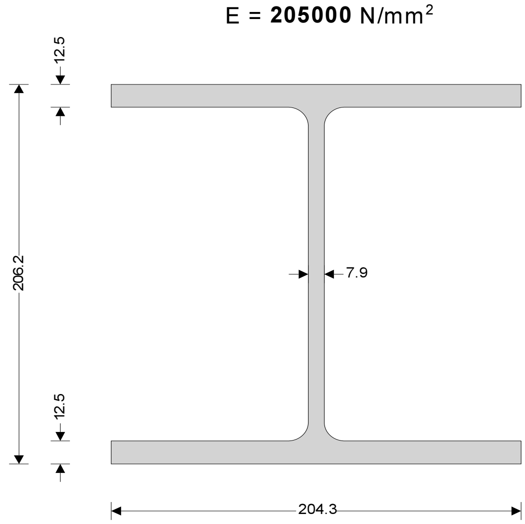
Steel grade **S275**

From table 9: Design strength p_y

Thickness of element max(T, t) = **12.5** 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 $K_{LT.A}$ = **1.20** + 2 × D

$K_{LT.B}$ = **1.20** + 2 × D

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 = **160.8** mm

$d / t = 20.4 \times \varepsilon \le 80 \times \varepsilon$ Class 1 plastic

Outstand flanges - Table 11

Width of section $b = B / 2 =$ **102.2** mm

$b / T = 8.2 \times \varepsilon <= 9 \times \varepsilon$ Class 1 plastic

Section is class 1 plastic

Shear capacity - Section 4.2.3

Design shear force $F_v = \max(\text{abs}(V_{max}), \text{abs}(V_{min})) =$ **98** kN

$d / t < 70 \times \varepsilon$

Web does not need to be checked for shear buckling

Shear area $A_v = t \times D =$ **1629** mm^2

Design shear resistance $P_v = 0.6 \times p_y \times A_v =$ **268.8** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment $M = \max(\text{abs}(M_{s1\_max}), \text{abs}(M_{s1\_min})) =$ **103.3** kNm

Moment capacity low shear - cl.4.2.5.2 $M_c = \min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx}) =$ **156** kNm

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling $L_E = 1.2 \times L_{s1} + 2 \times D =$ **5470** mm

Slenderness ratio $\lambda = L_E / r_{yy} =$ **105.633**

Equivalent slenderness - Section 4.3.6.7

Buckling parameter $u =$ **0.848**

Torsional index $x =$ **15.838**

Slenderness factor $v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25} =$ **0.746**

Ratio - cl.4.3.6.9 $\beta_W =$ **1.000**

Equivalent slenderness - cl.4.3.6.7 $\lambda_{LT} = u \times v \times \lambda \times \sqrt{[\beta_W]} =$ **66.850**

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 $\alpha_{LT} =$ **7.0**

Perry factor $\eta_{LT} = \max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0) =$ **0.228**

Euler stress $p_E = \pi^2 \times E / \lambda_{LT}^2 =$ **452.7** N/mm^2

$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2 =$ **415.4** N/mm^2

Bending strength - Annex B.2.1 $p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5}) =$ **196.2** N/mm^2

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment $M_2 =$ **77.5** kNm

Moment at centre-line of segment $M_3 =$ **103.3** kNm

Moment at three quarter point of segment $M_4 =$ **77.5** kNm

Maximum moment in segment $M_{abs} =$ **103.3** kNm

Maximum moment governing buckling resistance $M_{LT} = M_{abs} =$ **103.3** kNm

Equivalent uniform moment factor for lateral-torsional buckling

$m_{LT} = \max(0.2 + (0.15 \times M_2 + 0.5 \times M_3 + 0.15 \times M_4) / M_{abs}, 0.44) =$ **0.925**

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment $M_b = p_b \times S_{xx} =$ **111.3** kNm

$M_b / m_{LT} =$ **120.3** 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} = L_{s1} / 200 = **21.075** mm

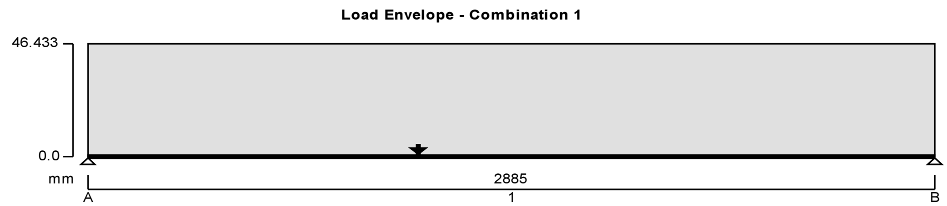
Maximum deflection span 1 δ = max(abs(δ_{max}), abs(δ_{min})) = **12.394** mm

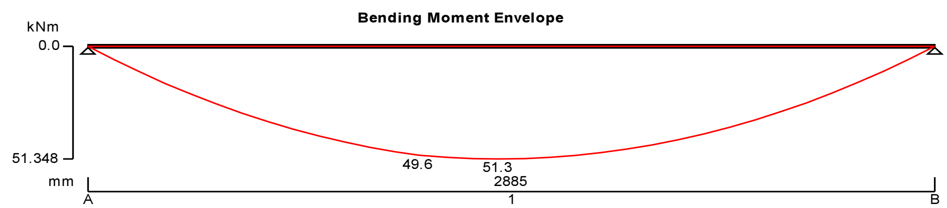
PASS - Maximum deflection does not exceed deflection limit

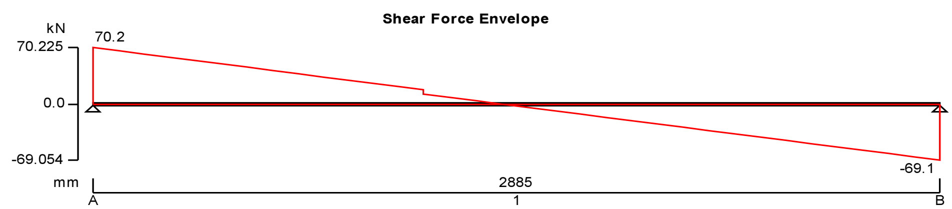
STEEL BEAM ANALYSIS & DESIGN (BS5950)

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

TEDDS calculation version 3.0.05







Support conditions

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

Applied loading

Beam loads	Dead point load 3.8 kN at 1125 mm	
	Dead full UDL 27 kN/m	
	Imposed full UDL 5 kN/m	
	Dead self weight of beam × 1	

Load combinations

Load combination 1	Support A	Dead × 1.40
		Imposed × 1.60
	Span 1	Dead × 1.40
		Imposed × 1.60
	Support B	Dead × 1.40
		Imposed × 1.60

Analysis results

Maximum moment	M_{max} = **51.3** kNm	M_{min} = **0** kNm
Maximum shear	V_{max} = **70.2** kN	V_{min} = **-69.1** kN
Deflection	δ_{max} = **3.3** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **70.2** kN	R_{A_min} = **70.2** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **41.9** kN	
Unfactored imposed load reaction at support A	$R_{A\_Imposed}$ = **7.2** kN	
Maximum reaction at support B	R_{B_max} = **69.1** kN	R_{B_min} = **69.1** kN
Unfactored dead load reaction at support B	R_{B_Dead} = **41.1** kN	
Unfactored imposed load reaction at support B	$R_{B\_Imposed}$ = **7.2** kN	

Section details

Section type — **UC 203x203x46 (BS4-1)**

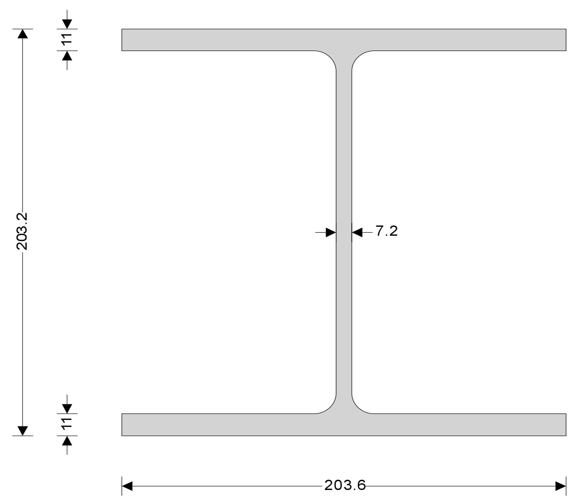
Steel grade — **S275**

From table 9: Design strength p_y

Thickness of element — max(T, t) = **11.0** 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 — $K_{LT.A}$ = **1.20** + 2 × D

$K_{LT.B}$ = **1.20** + 2 × D

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 = **160.8** mm

$d / t = 22.3 \times \varepsilon <= 80 \times \varepsilon$ — Class 1 plastic

Outstand flanges - Table 11

Width of section $b = B / 2 =$ **101.8** mm

$b / T = 9.3 \times \varepsilon <= 10 \times \varepsilon$ Class 2 compact

Section is class 2 compact

Shear capacity - Section 4.2.3

Design shear force $F_v = max(abs(V_{max}), abs(V_{min})) =$ **70.2** kN

$d / t < 70 \times \varepsilon$

Web does not need to be checked for shear buckling

Shear area $A_v = t \times D =$ **1463** mm^2

Design shear resistance $P_v = 0.6 \times p_y \times A_v =$ **241.4** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment $M = max(abs(M_{s1\_max}), abs(M_{s1\_min})) =$ **51.3** kNm

Moment capacity low shear - cl.4.2.5.2 $M_c = min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx}) =$ **136.8** kNm

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling $L_E = 1.2 \times L_{s1} + 2 \times D =$ **3868** mm

Slenderness ratio $\lambda = L_E / r_{yy} =$ **75.345**

Equivalent slenderness - Section 4.3.6.7

Buckling parameter $u =$ **0.847**

Torsional index $x =$ **17.713**

Slenderness factor $v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25} =$ **0.851**

Ratio - cl.4.3.6.9 $\beta_W =$ **1.000**

Equivalent slenderness - cl.4.3.6.7 $\lambda_{LT} = u \times v \times \lambda \times \sqrt{[\beta_W]} =$ **54.291**

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 $\alpha_{LT} =$ **7.0**

Perry factor $\eta_{LT} = max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0) =$ **0.140**

Euler stress $p_E = \pi^2 \times E / \lambda_{LT}^2 =$ **686.4** N/mm^2

$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2 =$ **528.7** N/mm^2

Bending strength - Annex B.2.1 $p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5}) =$ **227.4** N/mm^2

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment $M_2 =$ **38.6** kNm

Moment at centre-line of segment $M_3 =$ **51.3** kNm

Moment at three quarter point of segment $M_4 =$ **37.7** kNm

Maximum moment in segment $M_{abs} =$ **51.3** kNm

Maximum moment governing buckling resistance $M_{LT} = M_{abs} =$ **51.3** kNm

Equivalent uniform moment factor for lateral-torsional buckling

$m_{LT} = max(0.2 + (0.15 \times M_2 + 0.5 \times M_3 + 0.15 \times M_4) / M_{abs}, 0.44) =$ **0.922**

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment $M_b = p_b \times S_{xx} =$ **113.1** kNm

$M_b / m_{LT} =$ **122.6** 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} = L_{s1} / 200 = **14.425** mm

Maximum deflection span 1 δ = max(abs(δ_{max}), abs(δ_{min})) = **3.316** mm

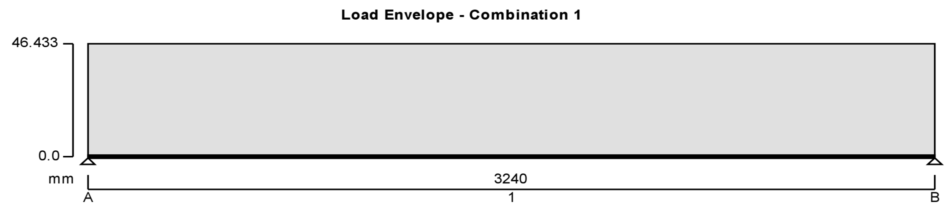
PASS - Maximum deflection does not exceed deflection limit

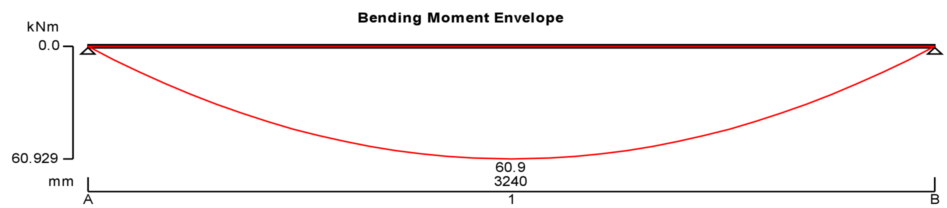
Project				Job no.	
40A Park Hill				5016	
Calcs for				Start page no./Revision	
Beam B3				C 12	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
NB	7/9/2017	KH			

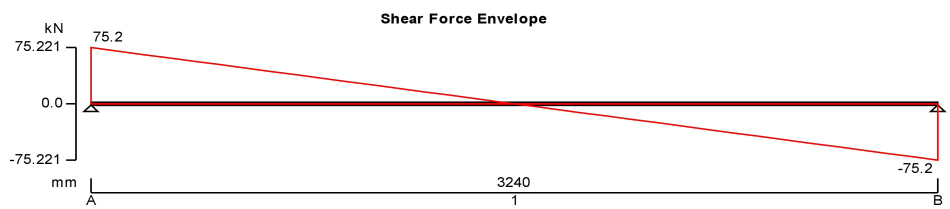
STEEL BEAM ANALYSIS & DESIGN (BS5950)

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

TEDDS calculation version 3.0.05







Support conditions

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

Applied loading

Beam loads	Dead full UDL 27 kN/m
	Imposed full UDL 5 kN/m
	Dead self weight of beam × 1

Load combinations

Load combination 1	Support A	Dead × 1.40
		Imposed × 1.60
	Span 1	Dead × 1.40
		Imposed × 1.60
	Support B	Dead × 1.40
		Imposed × 1.60

Analysis results

Maximum moment	M_{max} = **60.9** kNm	M_{min} = **0** kNm
Maximum shear	V_{max} = **75.2** kN	V_{min} = **-75.2** kN
Deflection	δ_{max} = **5** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **75.2** kN	R_{A_min} = **75.2** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **44.5** kN	
Unfactored imposed load reaction at support A	$R_{A\_Imposed}$ = **8.1** kN	
Maximum reaction at support B	R_{B_max} = **75.2** kN	R_{B_min} = **75.2** kN
Unfactored dead load reaction at support B	R_{B_Dead} = **44.5** kN	
Unfactored imposed load reaction at support B	$R_{B\_Imposed}$ = **8.1** kN	

Section details

Section type — **UC 203x203x46 (BS4-1)**

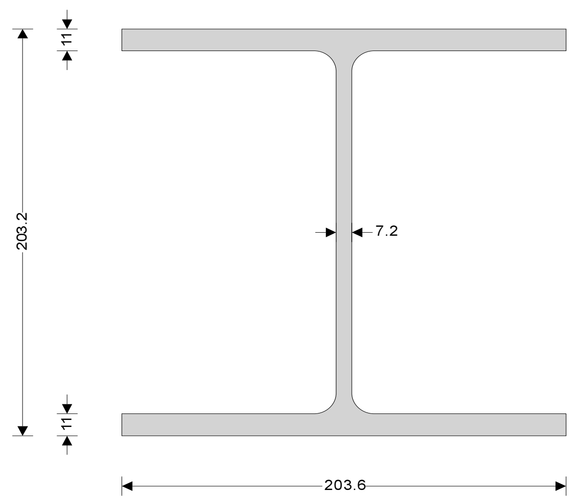
Steel grade — **S275**

From table 9: Design strength p_y

Thickness of element — max(T, t) = **11.0** 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 — $K_{LT.A}$ = **1.20** + 2 × D

$K_{LT.B}$ = **1.20** + 2 × D

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 = **160.8** mm

$d / t = 22.3 \times \varepsilon <= 80 \times \varepsilon$ — Class 1 plastic

Outstand flanges - Table 11

Width of section $b = B / 2 = \mathbf{101.8}$ mm

$b / T = 9.3 \times \varepsilon <= 10 \times \varepsilon$ Class 2 compact

Section is class 2 compact

Shear capacity - Section 4.2.3

Design shear force $F_v = \max(\text{abs}(V_{max}), \text{abs}(V_{min})) = \mathbf{75.2}$ kN

$d / t < 70 \times \varepsilon$

Web does not need to be checked for shear buckling

Shear area $A_v = t \times D = \mathbf{1463}$ mm^2

Design shear resistance $P_v = 0.6 \times p_y \times A_v = \mathbf{241.4}$ kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment $M = \max(\text{abs}(M_{s1\_max}), \text{abs}(M_{s1\_min})) = \mathbf{60.9}$ kNm

Moment capacity low shear - cl.4.2.5.2 $M_c = \min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx}) = \mathbf{136.8}$ kNm

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling $L_E = 1.2 \times L_{s1} + 2 \times D = \mathbf{4294}$ mm

Slenderness ratio $\lambda = L_E / r_{yy} = \mathbf{83.642}$

Equivalent slenderness - Section 4.3.6.7

Buckling parameter $u = \mathbf{0.847}$

Torsional index $x = \mathbf{17.713}$

Slenderness factor $v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25} = \mathbf{0.829}$

Ratio - cl.4.3.6.9 $\beta_W = \mathbf{1.000}$

Equivalent slenderness - cl.4.3.6.7 $\lambda_{LT} = u \times v \times \lambda \times \sqrt{[\beta_W]} = \mathbf{58.713}$

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

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

Bending strength - Section 4.3.6.5

Robertson constant $\alpha_{LT} = \mathbf{7.0}$

Perry factor $\eta_{LT} = \max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0) = \mathbf{0.171}$

Euler stress $p_E = \pi^2 \times E / \lambda_{LT}^2 = \mathbf{586.9}$ N/mm^2

$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2 = \mathbf{481.1}$ N/mm^2

Bending strength - Annex B.2.1 $p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5}) = \mathbf{216.4}$ N/mm^2

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment $M_2 = \mathbf{45.7}$ kNm

Moment at centre-line of segment $M_3 = \mathbf{60.9}$ kNm

Moment at three quarter point of segment $M_4 = \mathbf{45.7}$ kNm

Maximum moment in segment $M_{abs} = \mathbf{60.9}$ kNm

Maximum moment governing buckling resistance $M_{LT} = M_{abs} = \mathbf{60.9}$ kNm

Equivalent uniform moment factor for lateral-torsional buckling

$m_{LT} = \max(0.2 + (0.15 \times M_2 + 0.5 \times M_3 + 0.15 \times M_4) / M_{abs}, 0.44) = \mathbf{0.925}$

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment $M_b = p_b \times S_{xx} = \mathbf{107.7}$ kNm

$M_b / m_{LT} = \mathbf{116.4}$ 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 $\delta_{lim} = L_{s1} / 200 =$ **16.2** mm

Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) =$ **4.973** mm

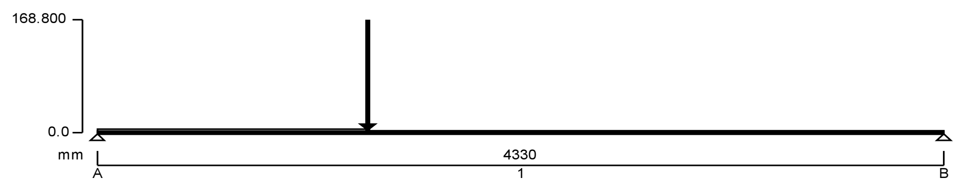
PASS - Maximum deflection does not exceed deflection limit

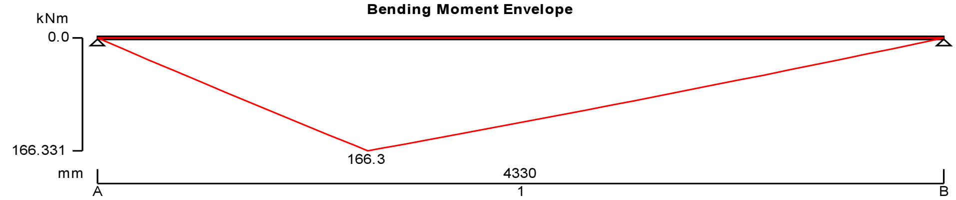
Project				Job no.	
40A Park Hill				5016	
Calcs for				Start page no./Revision	
Beam B4				C 16	
Calcs by NB	Calcs date 7/9/2017	Checked by KH	Checked date	Approved by	Approved date

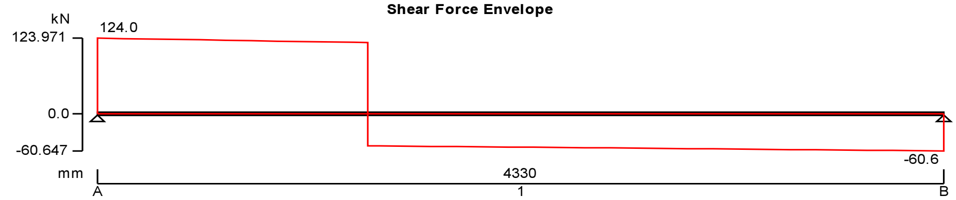
STEEL BEAM ANALYSIS & DESIGN (BS5950)

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

TEDDS calculation version 3.0.05







Support conditions

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

Applied loading

Beam loads	Dead partial UDL 1.46 kN/m from 0 mm to 1383 mm
	Imposed partial UDL 1.46 kN/m from 0 mm to 1383 mm
	Dead partial UDL 0.2 kN/m from 1383 mm to 4330 mm
	Imposed partial UDL 1 kN/m from 1383 mm to 4330 mm
	Dead point load 100 kN at 1383 mm
	Imposed point load 18 kN at 1383 mm
	Dead self weight of beam × 1

Load combinations

Load combination 1	Support A	Dead × 1.40
		Imposed × 1.60
	Span 1	Dead × 1.40

		Imposed × 1.60
	Support B	Dead × 1.40
		Imposed × 1.60

Analysis results

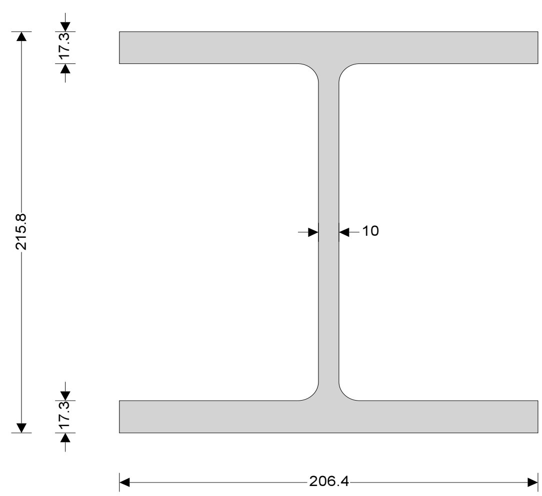
Maximum moment	M_{max} = **166.3** kNm	M_{min} = **0** kNm
Maximum moment span 1 segment 1	$M_{s1\_seg1\_max}$ = **166.3** kNm	$M_{s1\_seg1\_min}$ = **0** kNm
Maximum moment span 1 segment 2	$M_{s1\_seg2\_max}$ = **166.3** kNm	$M_{s1\_seg2\_min}$ = **0** kNm
Maximum shear	V_{max} = **124** kN	V_{min} = **-60.6** kN
Maximum shear span 1 segment 1	$V_{s1\_seg1\_max}$ = **124** kN	$V_{s1\_seg1\_min}$ = **-52.2** kN
Maximum shear span 1 segment 2	$V_{s1\_seg2\_max}$ = **0** kN	$V_{s1\_seg2\_min}$ = **-60.6** kN
Deflection segment 3	δ_{max} = **11.4** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **124** kN	R_{A_min} = **124** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **71.5** kN	
Unfactored imposed load reaction at support A	$R_{A\_Imposed}$ = **15** kN	
Maximum reaction at support B	R_{B_max} = **60.6** kN	R_{B_min} = **60.6** kN
Unfactored dead load reaction at support B	R_{B_Dead} = **34.2** kN	
Unfactored imposed load reaction at support B	$R_{B\_Imposed}$ = **8** kN	

Section details

Section type	**UC 203x203x71 (BS4-1)**
Steel grade	**S275**

From table 9: Design strength p_y

Thickness of element	max(T, t) = **17.3** mm
Design strength	p_y = **265** N/mm^2
Modulus of elasticity	E = **205000** N/mm^2



Lateral restraint

Span 1 has lateral restraint at supports plus 1383 mm

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	$K_{LT.A}$ = **1.20** + 2 × D
	$K_{LT.B}$ = **1.20** + 2 × D

Classification of cross sections - Section 3.5

$\varepsilon = \sqrt{[275 \text{ N/mm}^2 / p_y]}$ = **1.02**

Internal compression parts - Table 11

Depth of section — d = **160.8** mm

$d / t = 15.8 \times \varepsilon <= 80 \times \varepsilon$ — Class 1 plastic

Outstand flanges - Table 11

Width of section — b = B / 2 = **103.2** mm

$b / T = 5.9 \times \varepsilon <= 9 \times \varepsilon$ — Class 1 plastic

Section is class 1 plastic

Shear capacity - Section 4.2.3

Design shear force — $F_v = \max(\text{abs}(V_{max}), \text{abs}(V_{min}))$ = **124** kN

$d / t < 70 \times \varepsilon$

Web does not need to be checked for shear buckling

Shear area — $A_v = t \times D$ = **2158** mm^2

Design shear resistance — $P_v = 0.6 \times p_y \times A_v$ = **343.1** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity at span 1 segment 2 - Section 4.2.5

Design bending moment — $M = \max(\text{abs}(M_{s1\_seg2\_max}), \text{abs}(M_{s1\_seg2\_min}))$ = **166.3** kNm

Moment capacity low shear - cl.4.2.5.2 — $M_c = \min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx})$ = **211.7** kNm

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling — $L_E = ((1.0 + 1.2) \times L_{s1\_seg2} + 2 \times D) / 2$ = **3458** mm

Slenderness ratio — $\lambda = L_E / r_{yy}$ = **65.272**

Equivalent slenderness - Section 4.3.6.7

Buckling parameter — u = **0.853**

Torsional index — x = **11.926**

Slenderness factor — $v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25}$ = **0.795**

Ratio - cl.4.3.6.9 — β_W = **1.000**

Equivalent slenderness - cl.4.3.6.7 — $\lambda_{LT} = u \times v \times \lambda \times \sqrt{[\beta_W]}$ = **44.265**

Limiting slenderness - Annex B.2.2 — $\lambda_{L0} = 0.4 \times (\pi^2 \times E / p_y)^{0.5}$ = **34.951**

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

Bending strength - Section 4.3.6.5

Robertson constant — α_{LT} = **7.0**

Perry factor — $\eta_{LT} = \max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0)$ = **0.065**

Euler stress — $p_E = \pi^2 \times E / \lambda_{LT}^2$ = **1032.6** N/mm^2

$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2$ = **682.5** N/mm^2

Bending strength - Annex B.2.1 — $p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5})$ = **244.2** N/mm^2

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment — M_2 = **127.1** kNm

Moment at centre-line of segment — M_3 = **86.3** kNm

Moment at three quarter point of segment — M_4 = **43.9** kNm

Maximum moment in segment — M_{abs} = **166.3** kNm

Maximum moment governing buckling resistance — $M_{LT} = M_{abs}$ = **166.3** kNm

Equivalent uniform moment factor for lateral-torsional buckling

$m_{LT} = \max(0.2 + (0.15 \times M_2 + 0.5 \times M_3 + 0.15 \times M_4) / M_{abs}, 0.44)$ = **0.614**

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment $M_b = p_b \times S_{xx} =$ **195** kNm

$M_b / m_{LT} =$ **317.9** kNm

PASS - Moment capacity exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to dead and imposed loads

Limiting deflection $\delta_{lim} = L_{s1} / 200 =$ **21.65** mm

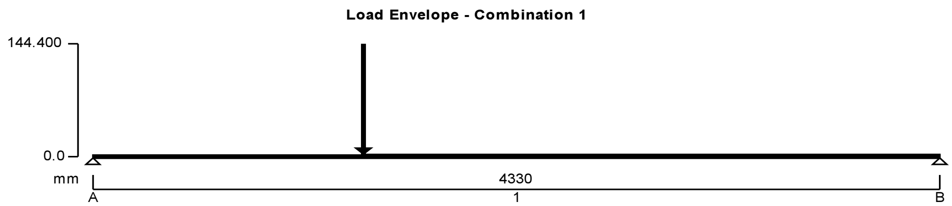
Maximum deflection span 1 $\delta = max(abs(\delta_{max}), abs(\delta_{min})) =$ **11.362** mm

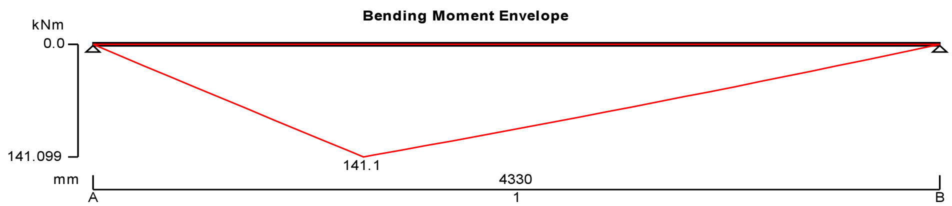
PASS - Maximum deflection does not exceed deflection limit

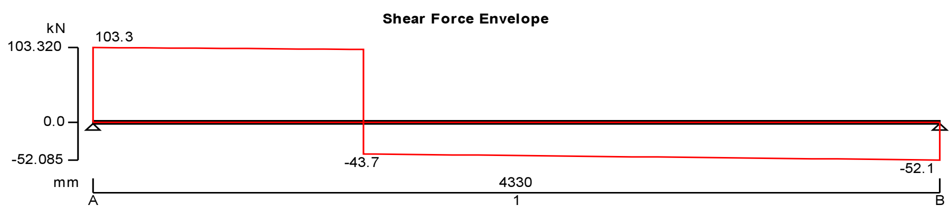
STEEL BEAM ANALYSIS & DESIGN (BS5950)

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

TEDDS calculation version 3.0.05







Support conditions

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

Applied loading

Beam loads	Dead partial UDL 0.3 kN/m from 0 mm to 1383 mm
	Imposed partial UDL 0.3 kN/m from 0 mm to 1383 mm
	Dead partial UDL 0.2 kN/m from 1383 mm to 4330 mm
	Imposed partial UDL 1 kN/m from 1383 mm to 4330 mm
	Dead point load 86 kN at 1383 mm
	Imposed point load 15 kN at 1383 mm
	Dead self weight of beam × 1

Load combinations

Load combination 1	Support A	Dead × 1.40
		Imposed × 1.60
	Span 1	Dead × 1.40

		Imposed × 1.60
	Support B	Dead × 1.40
		Imposed × 1.60

Analysis results

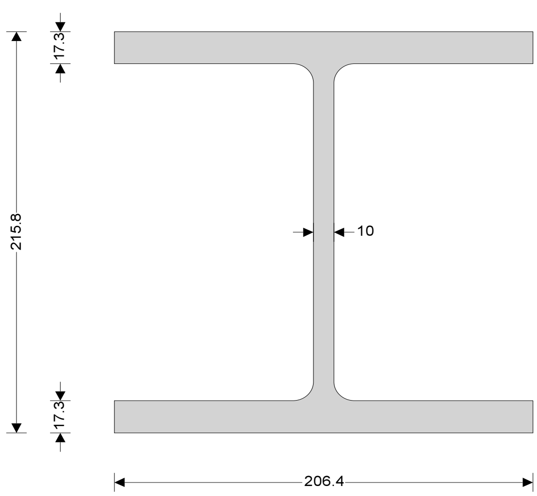
Maximum moment	M_{max} = **141.1** kNm	M_{min} = **0** kNm
Maximum moment span 1 segment 1	$M_{s1\_seg1\_max}$ = **141.1** kNm	$M_{s1\_seg1\_min}$ = **0** kNm
Maximum moment span 1 segment 2	$M_{s1\_seg2\_max}$ = **141.1** kNm	$M_{s1\_seg2\_min}$ = **0** kNm
Maximum shear	V_{max} = **103.3** kN	V_{min} = **-52.1** kN
Maximum shear span 1 segment 1	$V_{s1\_seg1\_max}$ = **103.3** kN	$V_{s1\_seg1\_min}$ = **-43.7** kN
Maximum shear span 1 segment 2	$V_{s1\_seg2\_max}$ = **0** kN	$V_{s1\_seg2\_min}$ = **-52.1** kN
Deflection segment 3	δ_{max} = **9.7** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **103.3** kN	R_{A_min} = **103.3** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **60.6** kN	
Unfactored imposed load reaction at support A	$R_{A\_Imposed}$ = **11.6** kN	
Maximum reaction at support B	R_{B_max} = **52.1** kN	R_{B_min} = **52.1** kN
Unfactored dead load reaction at support B	R_{B_Dead} = **29.4** kN	
Unfactored imposed load reaction at support B	$R_{B\_Imposed}$ = **6.8** kN	

Section details

Section type	**UC 203x203x71 (BS4-1)**
Steel grade	**S275**

From table 9: Design strength p_y

Thickness of element	max(T, t) = **17.3** mm
Design strength	p_y = **265** N/mm^2
Modulus of elasticity	E = **205000** N/mm^2



Lateral restraint

Span 1 has lateral restraint at supports plus 1383 mm

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	$K_{LT.A}$ = **1.20** + 2 × D
	$K_{LT.B}$ = **1.20** + 2 × D

Classification of cross sections - Section 3.5

$\varepsilon = \sqrt{[275 \text{ N/mm}^2 / p_y]}$ = **1.02**

Internal compression parts - Table 11

Depth of section — d = **160.8** mm

$d / t = 15.8 \times \varepsilon <= 80 \times \varepsilon$ — Class 1 plastic

Outstand flanges - Table 11

Width of section — $b = B / 2$ = **103.2** mm

$b / T = 5.9 \times \varepsilon <= 9 \times \varepsilon$ — Class 1 plastic

Section is class 1 plastic

Shear capacity - Section 4.2.3

Design shear force — $F_v = \max(\text{abs}(V_{max}), \text{abs}(V_{min}))$ = **103.3** kN

$d / t < 70 \times \varepsilon$

Web does not need to be checked for shear buckling

Shear area — $A_v = t \times D$ = **2158** mm^2

Design shear resistance — $P_v = 0.6 \times p_y \times A_v$ = **343.1** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity at span 1 segment 2 - Section 4.2.5

Design bending moment — $M = \max(\text{abs}(M_{s1\_seg2\_max}), \text{abs}(M_{s1\_seg2\_min}))$ = **141.1** kNm

Moment capacity low shear - cl.4.2.5.2 — $M_c = \min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx})$ = **211.7** kNm

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling — $L_E = ((1.0 + 1.2) \times L_{s1\_seg2} + 2 \times D) / 2$ = **3458** mm

Slenderness ratio — $\lambda = L_E / r_{yy}$ = **65.272**

Equivalent slenderness - Section 4.3.6.7

Buckling parameter — u = **0.853**

Torsional index — x = **11.926**

Slenderness factor — $v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25}$ = **0.795**

Ratio - cl.4.3.6.9 — β_W = **1.000**

Equivalent slenderness - cl.4.3.6.7 — $\lambda_{LT} = u \times v \times \lambda \times \sqrt{[\beta_W]}$ = **44.265**

Limiting slenderness - Annex B.2.2 — $\lambda_{L0} = 0.4 \times (\pi^2 \times E / p_y)^{0.5}$ = **34.951**

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

Bending strength - Section 4.3.6.5

Robertson constant — α_{LT} = **7.0**

Perry factor — $\eta_{LT} = \max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0)$ = **0.065**

Euler stress — $p_E = \pi^2 \times E / \lambda_{LT}^2$ = **1032.6** N/mm^2

$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2$ = **682.5** N/mm^2

Bending strength - Annex B.2.1 — $p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5})$ = **244.2** N/mm^2

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment — M_2 = **108.1** kNm

Moment at centre-line of segment — M_3 = **73.6** kNm

Moment at three quarter point of segment — M_4 = **37.6** kNm

Maximum moment in segment — M_{abs} = **141.1** kNm

Maximum moment governing buckling resistance — $M_{LT} = M_{abs}$ = **141.1** kNm

Equivalent uniform moment factor for lateral-torsional buckling

$m_{LT} = \max(0.2 + (0.15 \times M_2 + 0.5 \times M_3 + 0.15 \times M_4) / M_{abs}, 0.44)$ = **0.616**

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment $M_b = p_b \times S_{xx} =$ **195** kNm

$M_b / m_{LT} =$ **316.6** kNm

PASS - Moment capacity exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to dead and imposed loads

Limiting deflection $\delta_{lim} = L_{s1} / 200 =$ **21.65** mm

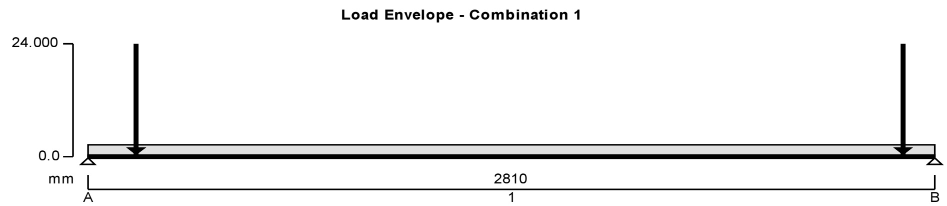
Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) =$ **9.664** mm

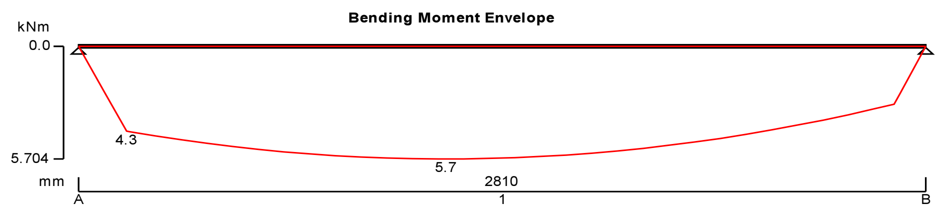
PASS - Maximum deflection does not exceed deflection limit

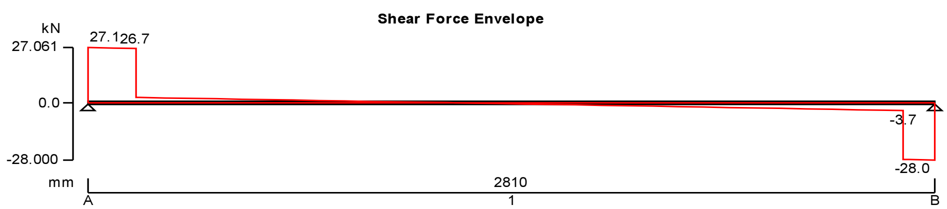
STEEL BEAM ANALYSIS & DESIGN (BS5950)

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

TEDDS calculation version 3.0.05







Support conditions

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

Applied loading

Beam loads	Dead full UDL 0.2 kN/m
	Imposed full UDL 1 kN/m
	Dead point load 16 kN at 160 mm
	Imposed point load 1 kN at 160 mm
	Dead point load 16 kN at 2705 mm
	Imposed point load 1 kN at 2705 mm
	Dead self weight of beam × 1

Load combinations

Load combination 1	Support A	Dead × 1.40
		Imposed × 1.60
	Span 1	Dead × 1.40

		Imposed × 1.60
	Support B	Dead × 1.40
		Imposed × 1.60

Analysis results

Maximum moment	M_{max} = **5.7** kNm	M_{min} = **0** kNm
Maximum shear	V_{max} = **27.1** kN	V_{min} = **-28** kN
Deflection	δ_{max} = **0.4** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **27.1** kN	R_{A_min} = **27.1** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **16.6** kN	
Unfactored imposed load reaction at support A	$R_{A\_Imposed}$ = **2.4** kN	
Maximum reaction at support B	R_{B_max} = **28** kN	R_{B_min} = **28** kN
Unfactored dead load reaction at support B	R_{B_Dead} = **17.2** kN	
Unfactored imposed load reaction at support B	$R_{B\_Imposed}$ = **2.4** kN	

Section details

Section type **UC 203x203x46 (BS4-1)**

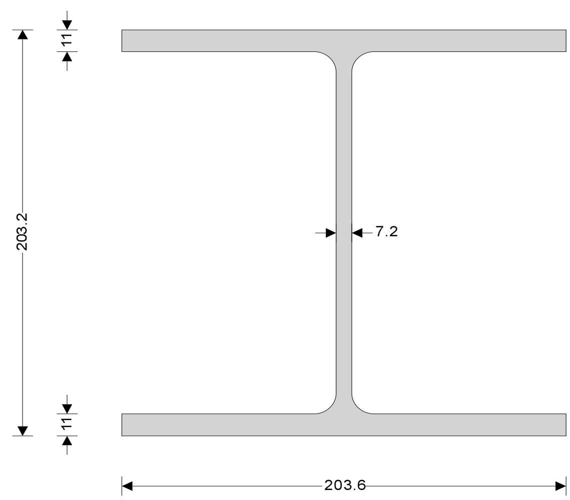
Steel grade **S275**

From table 9: Design strength p_y

Thickness of element max(T, t) = **11.0** 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 $K_{LT.A}$ = **1.20** + 2 × D

$K_{LT.B}$ = **1.20** + 2 × D

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 = **160.8** mm

$d / t = 22.3 \times \varepsilon <= 80 \times \varepsilon$ Class 1 plastic

Outstand flanges - Table 11

Width of section $b = B / 2$ = **101.8** mm

$b / T = 9.3 \times \varepsilon <= 10 \times \varepsilon$ Class 2 compact

Section is class 2 compact

Shear capacity - Section 4.2.3

Design shear force $F_v = max(abs(V_{max}), abs(V_{min}))$ = **28** kN

$d / t < 70 \times \varepsilon$

Web does not need to be checked for shear buckling

Shear area $A_v = t \times D$ = **1463** mm^2

Design shear resistance $P_v = 0.6 \times p_y \times A_v$ = **241.4** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment $M = max(abs(M_{s1\_max}), abs(M_{s1\_min}))$ = **5.7** kNm

Moment capacity low shear - cl.4.2.5.2 $M_c = min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx})$ = **136.8** kNm

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling $L_E = 1.2 \times L_{s1} + 2 \times D$ = **3778** mm

Slenderness ratio $\lambda = L_E / r_{yy}$ = **73.592**

Equivalent slenderness - Section 4.3.6.7

Buckling parameter u = **0.847**

Torsional index x = **17.713**

Slenderness factor $v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25}$ = **0.856**

Ratio - cl.4.3.6.9 β_W = **1.000**

Equivalent slenderness - cl.4.3.6.7 $\lambda_{LT} = u \times v \times \lambda \times \sqrt{[\beta_W]}$ = **53.322**

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 $\eta_{LT} = max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0)$ = **0.133**

Euler stress $p_E = \pi^2 \times E / \lambda_{LT}^2$ = **711.6** N/mm^2

$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2$ = **540.7** N/mm^2

Bending strength - Annex B.2.1 $p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5})$ = **229.8** N/mm^2

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment M_2 = **5.4** kNm

Moment at centre-line of segment M_3 = **5.7** kNm

Moment at three quarter point of segment M_4 = **4.7** kNm

Maximum moment in segment M_{abs} = **5.7** kNm

Maximum moment governing buckling resistance $M_{LT} = M_{abs}$ = **5.7** kNm

Equivalent uniform moment factor for lateral-torsional buckling

$m_{LT} = max(0.2 + (0.15 \times M_2 + 0.5 \times M_3 + 0.15 \times M_4) / M_{abs}, 0.44)$ = **0.961**

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment $M_b = p_b \times S_{xx}$ = **114.3** kNm

M_b / m_{LT} = **118.9** 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 $\delta_{lim} = L_{s1} / 200$ = **14.05** mm

Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min}))$ = **0.38** mm

PASS - Maximum deflection does not exceed deflection limit

TIMBER JOIST DESIGN (BS5268-2:2002)

Tedds calculation version 1.1.04

Joist details

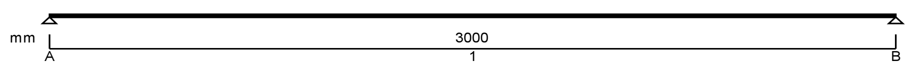
Joist breadth — b = **50** mm

Joist depth — h = **200** mm

Joist spacing — s = **400** mm

Timber strength class — **C16**

Service class of timber — **1**

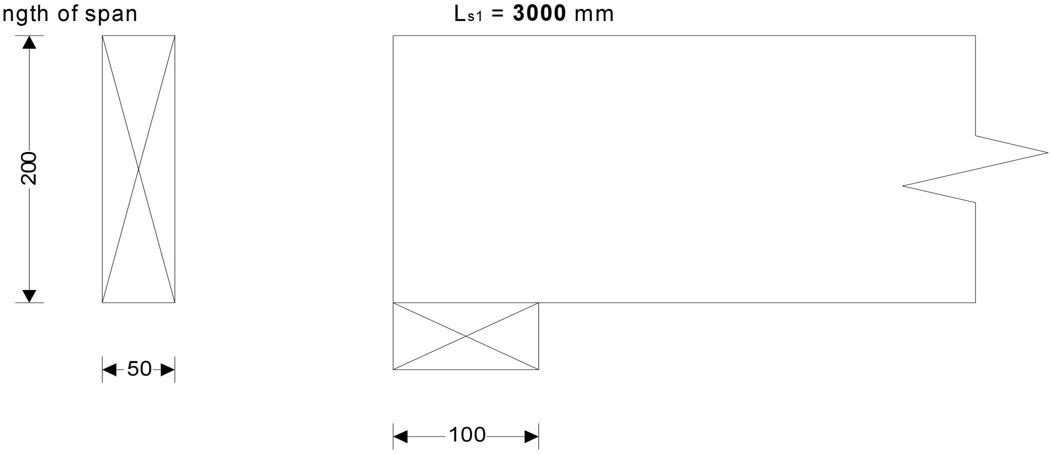


Span details

Number of spans — N_{span} = **1**

Length of bearing — L_b = **100** mm

Effective length of span — L_{s1} = **3000** mm



Section properties

Second moment of area — $I = b \times h^3 / 12 =$ **33333333** mm^4

Section modulus — $Z = b \times h^2 / 6 =$ **333333** mm^3

Loading details

Joist self weight — $F_{swt} = b \times h \times \rho_{char} \times g_{acc} =$ **0.03** kN/m

Dead load — F_{d_udl} = **0.50** kN/m^2

Imposed UDL(Long term) — F_{i_udl} = **1.50** kN/m^2

Imposed point load (Medium term) — F_{i_pt} = **1.40** kN

Modification factors

Service class for bending parallel to grain — K_{2m} = **1.00**

Service class for compression — K_{2c} = **1.00**

Service class for shear parallel to grain — K_{2s} = **1.00**

Service class for modulus of elasticity K_{2e} = **1.00**
Section depth factor K_7 = **1.05**
Load sharing factor K_8 = **1.10**

Consider long term loads

Load duration factor K_3 = **1.00**
Maximum bending moment M = **0.934** kNm
Maximum shear force V = **1.246** kN
Maximum support reaction R = **1.246** kN
Maximum deflection δ = **3.190** mm

Check bending stress

Bending stress σ_m = **5.300** N/mm^2
Permissible bending stress $\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8$ = **6.096** N/mm^2
Applied bending stress σ_{m_max} = M / Z = **2.803** N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress τ = **0.670** N/mm^2
Permissible shear stress $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = **0.737** N/mm^2
Applied shear stress $\tau_{max} = 3 \times V / (2 \times b \times h)$ = **0.187** N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane) σ_{cp1} = **2.200** N/mm^2
Permissible bearing stress $\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8$ = **2.420** N/mm^2
Applied bearing stress $\sigma_{c\_max} = R / (b \times L_b)$ = **0.249** N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection $\delta_{adm} = \min(L_{s1} \times 0.003, 14\ mm)$ = **9.000** mm
Bending deflection (based on E_{mean}) $\delta_{bending}$ = **2.986** mm
Shear deflection δ_{shear} = **0.204** mm
Total deflection $\delta = \delta_{bending} + \delta_{shear}$ = **3.190** mm

PASS - Actual deflection within permissible limits

Consider medium term loads

Load duration factor K_3 = **1.25**
Maximum bending moment M = **1.309** kNm
Maximum shear force V = **1.746** kN
Maximum support reaction R = **1.746** kN
Maximum deflection δ = **3.799** mm

Check bending stress

Bending stress σ_m = **5.300** N/mm^2
Permissible bending stress $\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8$ = **7.620** N/mm^2
Applied bending stress σ_{m_max} = M / Z = **3.928** N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress τ = **0.670** N/mm^2
Permissible shear stress $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = **0.921** N/mm^2

Applied shear stress $\tau_{max} = 3 \times V / (2 \times b \times h) = \mathbf{0.262}$ N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane) $\sigma_{cp1} = \mathbf{2.200}$ N/mm^2

Permissible bearing stress $\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8 = \mathbf{3.025}$ N/mm^2

Applied bearing stress $\sigma_{c\_max} = R / (b \times L_b) = \mathbf{0.349}$ N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection $\delta_{adm} = \min(L_{s1} \times 0.003, 14 \text{ mm}) = \mathbf{9.000}$ mm

Bending deflection (based on E_{mean}) $\delta_{bending} = \mathbf{3.513}$ mm

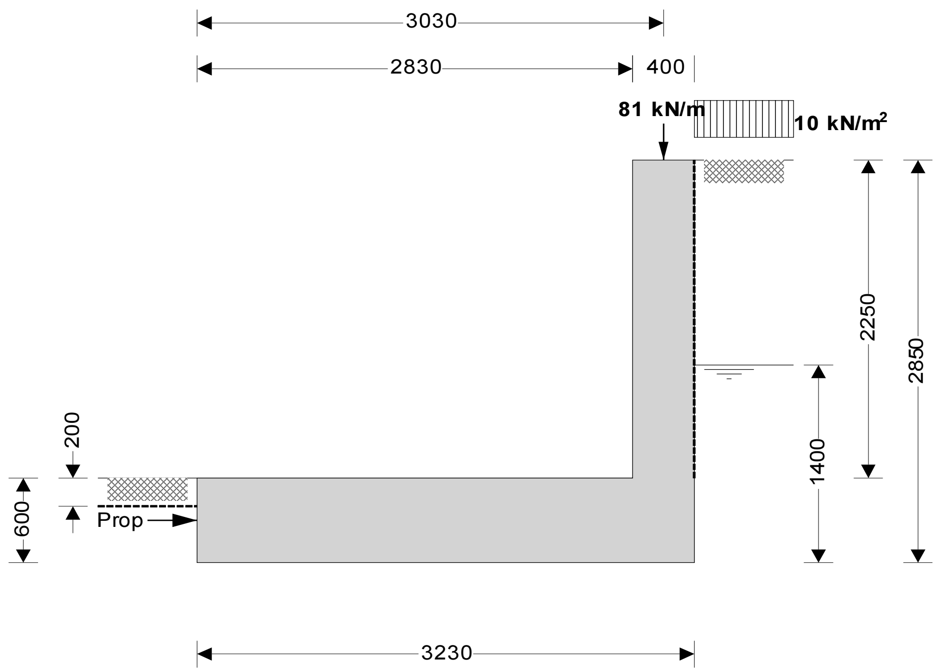
Shear deflection $\delta_{shear} = \mathbf{0.286}$ mm

Total deflection $\delta = \delta_{bending} + \delta_{shear} = \mathbf{3.799}$ mm

PASS - Actual deflection within permissible limits

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.06



Wall details

Retaining wall type	**Cantilever**		
Height of wall stem	h_{stem} = **2250** mm	Wall stem thickness	t_{wall} = **400** mm
Length of toe	l_{toe} = **2830** mm	Length of heel	l_{heel} = **0** mm
Overall length of base	l_{base} = **3230** mm	Base thickness	t_{base} = **600** mm
Height of retaining wall	h_{wall} = **2850** mm		
Depth of downstand	d_{ds} = **0** mm	Thickness of downstand	t_{ds} = **600** mm
Position of downstand	l_{ds} = **1800** mm		
Depth of cover in front of wall	d_{cover} = **0** mm	Unplanned excavation depth	d_{exc} = **200** mm
Height of ground water	h_{water} = **1400** mm	Density of water	γ_{water} = 9.81 kN/m^3
Density of wall construction	γ_{wall} = **24.0** kN/m^3	Density of base construction	γ_{base} = **24.0** kN/m^3
Angle of soil surface	β = **0.0** deg	Effective height at back of wall	h_{eff} = **2850** mm
Mobilisation factor	M = **1.5**		
Moist density	γ_m = **21.0** kN/m^3	Saturated density	γ_s = **23.0** kN/m^3
Design shear strength	ϕ' = **24.2** deg	Angle of wall friction	δ = **18.6** deg
Design shear strength	ϕ'_b = **24.2** deg	Design base friction	δ_b = **18.6** deg
Moist density	γ_{mb} = **18.0** kN/m^3	Allowable bearing	$P_{bearing}$ = **105** kN/m^2

Using Coulomb theory

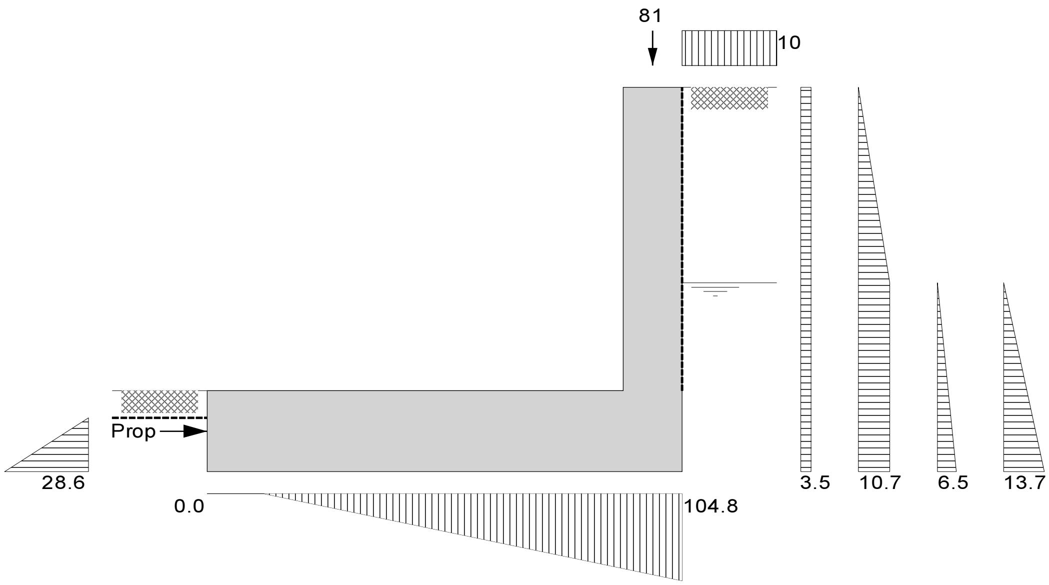
Active pressure	K_a =**0.369**	Passive pressure	K_p = **4.187**
At-rest pressure	K_0 = **0.590**		

Loading details

Surcharge load	Surcharge = **10.0** kN/m^2		
Vertical dead load	W_{dead} = **71.0** kN/m	Vertical live load	W_{live} = **10.0** kN/m
Horizontal dead load	F_{dead} = **0.0** kN/m	Horizontal live load	F_{live} = **0.0** kN/m

Tekla Tedds	Project: 40a Park Hill			Job no.: 5016	
	Calcs for: Retaining Wall 1 - Permanent			Start page no./Revision: C 32	
	Calcs by: NB	Calcs date: 7/11/2017	Checked by: KH	Checked date:	Approved by:	Approved date:

Position of vertical load l_{load} = **3030** mm Height of horizontal load h_{load} = **0** mm



Loads shown in kN/m, pressures shown in kN/m²

Calculate propping force

Propping force F_{prop} = **0.0** kN/m

Check bearing pressure

Total vertical reaction R = **149.1** kN/m Distance to reaction x_{bar} = **2282** mm

Eccentricity of reaction e = **667** mm

Reaction acts outside middle third of base

Bearing pressure at toe p_{toe} = **0.0** kN/m^2 Bearing pressure at heel p_{heel} = **104.8** kN/m^2

PASS - Maximum bearing pressure is less than allowable bearing pressure

RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.06

Ultimate limit state load factors

Dead load factor γ_{f_d} = **1.4** | Live load factor γ_{f_l} = **1.6**

Earth pressure factor γ_{f_e} = **1.4**

Calculate propping force

Propping force F_{prop} = **0.0** kN/m

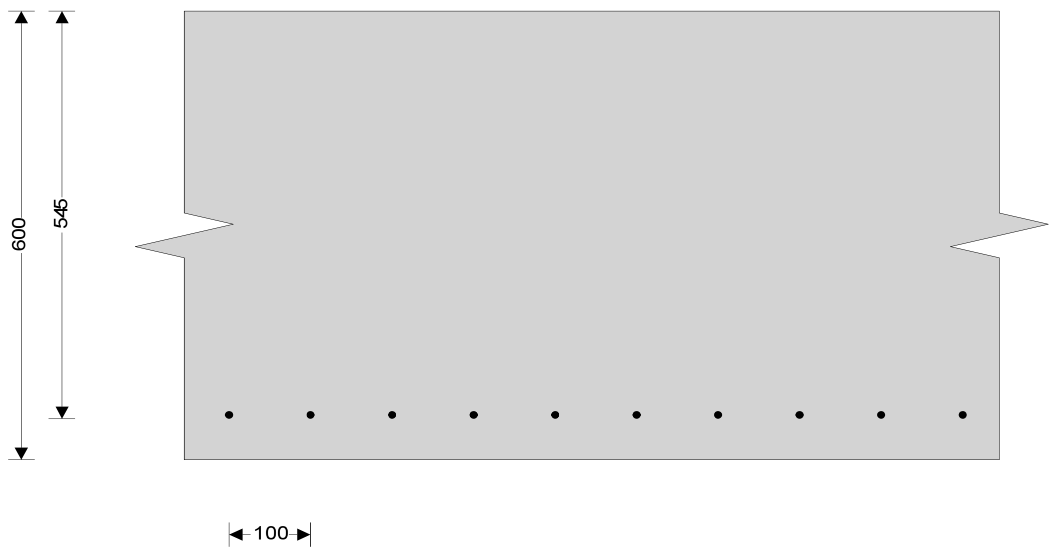
Design of reinforced concrete retaining wall toe (BS 8002:1994)

Material properties

Strength of concrete f_{cu} = **40** N/mm^2 | Strength of reinforcement f_y = **500** N/mm^2

Base details

Minimum reinforcement k = **0.13** % | Cover in toe c_{toe} = **50** mm



Design of retaining wall toe

Shear at heel V_{toe} = **108.0** kN/m | Moment at heel M_{toe} = **110.6** kNm/m

Compression reinforcement is not required

Check toe in bending

Reinforcement provided **B785 mesh**

Area required $A_{s\_toe\_req}$ = **780.0** mm^2/m | Area provided $A_{s\_toe\_prov}$ = **785** mm^2/m

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress v_{toe} = **0.198** N/mm^2 | Allowable shear stress v_{adm} = **5.000** N/mm^2

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress v_{c_toe} = **0.388** N/mm^2

v_{toe} < v_{c_toe} - No shear reinforcement required

Design of reinforced concrete retaining wall stem (BS 8002:1994)

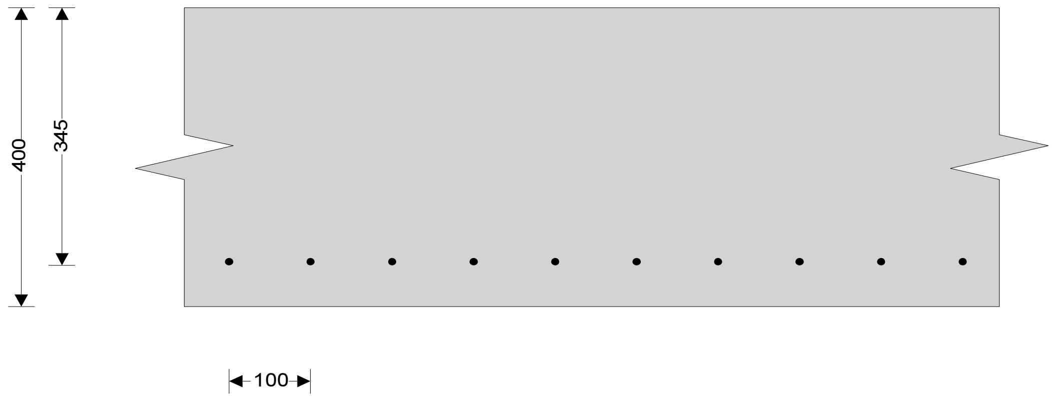
Material properties

Strength of concrete f_{cu} = **40** N/mm^2 | Strength of reinforcement f_y = **500** N/mm^2

Wall details

Minimum reinforcement k = **0.13** %

Cover in stem c_{stem} = **50** mm Cover in wall c_{wall} = **50** mm



Design of retaining wall stem

Shear at base of stem V_{stem} = **36.5** kN/m Moment at base of stem M_{stem} = **69.3** kNm/m

Compression reinforcement is not required

Check wall stem in bending

Reinforcement provided **B785 mesh**

Area required $A_{s\_stem\_req}$ = **520.0** mm^2/m Area provided $A_{s\_stem\_prov}$ = **785** mm^2/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress v_{stem} = **0.106** N/mm^2 Allowable shear stress v_{adm} = **5.000** N/mm^2

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress v_{c_stem} = **0.468** N/mm^2

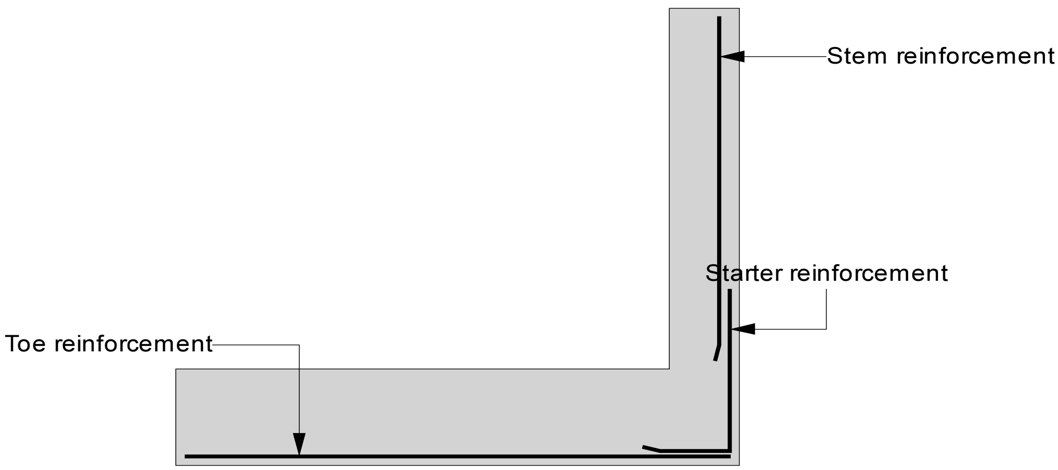
v_{stem} < v_{c_stem} - No shear reinforcement required

Check retaining wall deflection

Max span/depth ratio $ratio_{max}$ = **13.94** Actual span/depth ratio $ratio_{act}$ = **6.52**

PASS - Span to depth ratio is acceptable

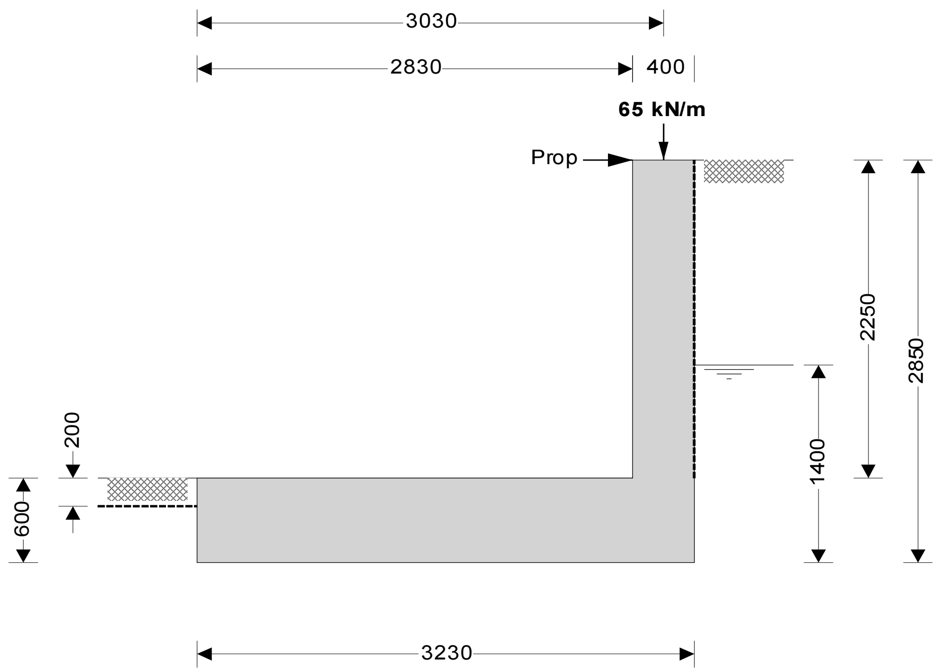
Indicative retaining wall reinforcement diagram



Toe mesh - B785 - (785 mm^2/m)
Stem mesh - B785 - (785 mm^2/m)

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.06



Wall details

Retaining wall type	**Cantilever**		
Height of wall stem	h_{stem} = **2250** mm	Wall stem thickness	t_{wall} = **400** mm
Length of toe	l_{toe} = **2830** mm	Length of heel	l_{heel} = **0** mm
Overall length of base	l_{base} = **3230** mm	Base thickness	t_{base} = **600** mm
Height of retaining wall	h_{wall} = **2850** mm		
Depth of downstand	d_{ds} = **0** mm	Thickness of downstand	t_{ds} = **600** mm
Position of downstand	l_{ds} = **1800** mm		
Depth of cover in front of wall	d_{cover} = **0** mm	Unplanned excavation depth	d_{exc} = **200** mm
Height of ground water	h_{water} = **1400** mm	Density of water	γ_{water} = 9.81 kN/m^3
Density of wall construction	γ_{wall} = **24.0** kN/m^3	Density of base construction	γ_{base} = **24.0** kN/m^3
Angle of soil surface	β = **0.0** deg	Effective height at back of wall	h_{eff} = **2850** mm
Mobilisation factor	M = **1.5**		
Moist density	γ_m = **21.0** kN/m^3	Saturated density	γ_s = **23.0** kN/m^3
Design shear strength	ϕ' = **24.2** deg	Angle of wall friction	δ = **18.6** deg
Design shear strength	ϕ'_b = **24.2** deg	Design base friction	δ_b = **18.6** deg
Moist density	γ_{mb} = **18.0** kN/m^3	Allowable bearing	$P_{bearing}$ = **105** kN/m^2

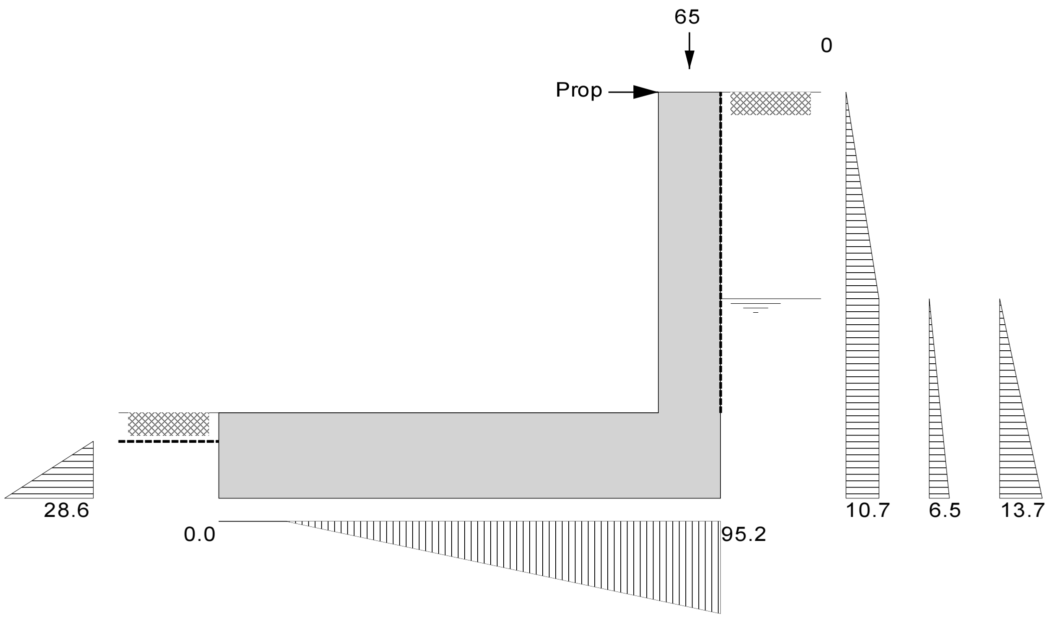
Using Coulomb theory

Active pressure	K_a =**0.369**	Passive pressure	K_p = **4.187**
At-rest pressure	K_0 = **0.590**		

Loading details

Surcharge load	Surcharge = **0.0** kN/m^2		
Vertical dead load	W_{dead} = **58.0** kN/m	Vertical live load	W_{live} = **7.0** kN/m
Horizontal dead load	F_{dead} = **0.0** kN/m	Horizontal live load	F_{live} = **0.0** kN/m

Position of vertical load l_{load} = **3030** mm Height of horizontal load h_{load} = **0** mm



Loads shown in kN/m, pressures shown in kN/m^2

Calculate propping force

Propping force F_{prop} = **0.0** kN/m

Check bearing pressure

Total vertical reaction R = **133.1** kN/m Distance to reaction x_{bar} = **2298** mm

Eccentricity of reaction e = **683** mm

Reaction acts outside middle third of base

Bearing pressure at toe p_{toe} = **0.0** kN/m^2 Bearing pressure at heel p_{heel} = **95.2** kN/m^2

PASS - Maximum bearing pressure is less than allowable bearing pressure

RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.06

Ultimate limit state load factors

Dead load factor γ_{f_d} = **1.4** Live load factor γ_{f_l} = **1.6**

Earth pressure factor γ_{f_e} = **1.4**

Calculate propping force

Propping force F_{prop} = **0.0** kN/m

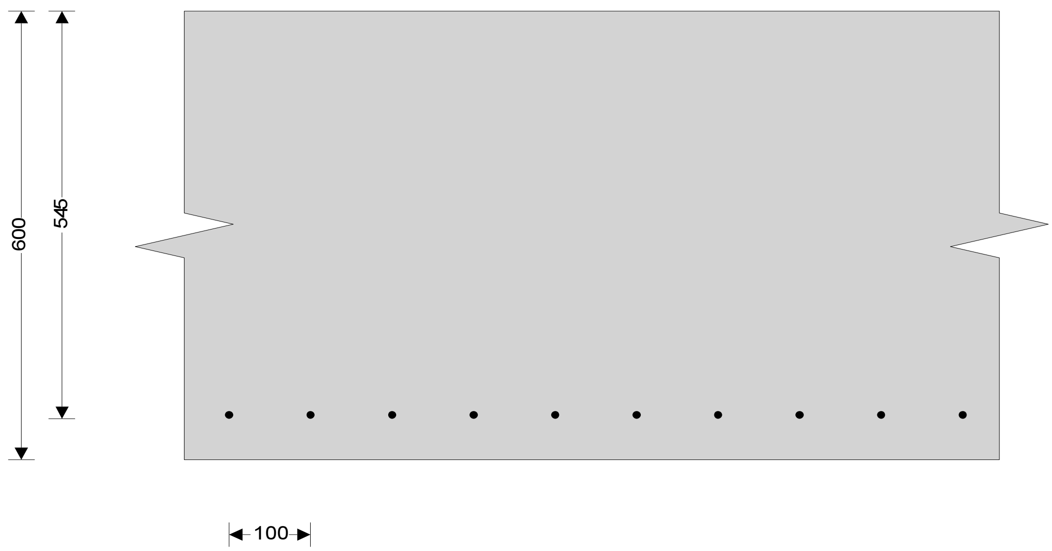
Design of reinforced concrete retaining wall toe (BS 8002:1994)

Material properties

Strength of concrete f_{cu} = **40** N/mm^2 Strength of reinforcement f_y = **500** N/mm^2

Base details

Minimum reinforcement k = **0.13** % Cover in toe c_{toe} = **50** mm



Design of retaining wall toe

Shear at heel V_{toe} = **79.7** kN/m Moment at heel M_{toe} = **43.5** kNm/m

Compression reinforcement is not required

Check toe in bending

Reinforcement provided **B785 mesh**

Area required $A_{s\_toe\_req}$ = **780.0** mm^2/m Area provided $A_{s\_toe\_prov}$ = **785** mm^2/m

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress v_{toe} = **0.146** N/mm^2 Allowable shear stress v_{adm} = **5.000** N/mm^2

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress v_{c_toe} = **0.388** N/mm^2

v_{toe} < v_{c_toe} - No shear reinforcement required

Design of reinforced concrete retaining wall stem (BS 8002:1994)

Material properties

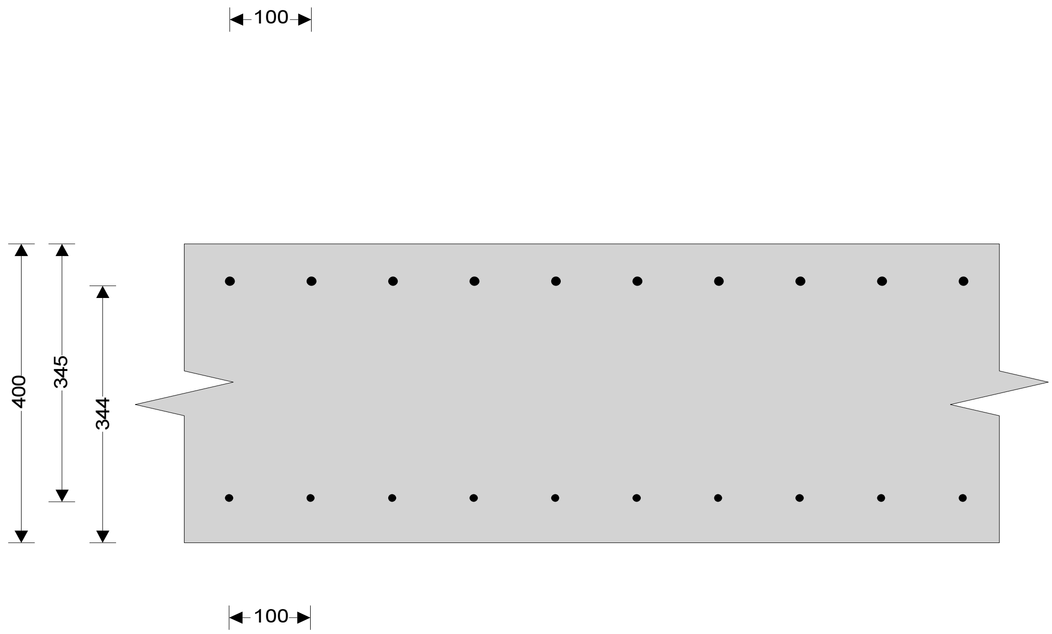
Strength of concrete f_{cu} = **40** N/mm^2 Strength of reinforcement f_y = **500** N/mm^2

Tekla Tedds	Project 40a Park Hill				Job no. 5016	
	Calcs for Retaining Wall 1 - Temp				Start page no./Revision C 39	
	Calcs by NB	Calcs date 7/11/2017	Checked by KH	Checked date	Approved by	Approved date

Wall details

Minimum reinforcement k = **0.13** %

Cover in stem c_{stem} = **50** mm Cover in wall c_{wall} = **50** mm



Design of retaining wall stem

Shear at base of stem V_{stem} = **35.7** kN/m Moment at base of stem M_{stem} = **15.9** kNm/m

Compression reinforcement is not required

Check wall stem in bending

Reinforcement provided **B785 mesh**

Area required $A_{s\_stem\_req}$ = **520.0** mm^2/m Area provided $A_{s\_stem\_prov}$ = **785** mm^2/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress v_{stem} = **0.103** N/mm^2 Allowable shear stress v_{adm} = **5.000** N/mm^2

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress v_{c_stem} = **0.468** N/mm^2

v_{stem} < v_{c_stem} - No shear reinforcement required

Design of retaining wall at mid height

Moment at mid height M_{wall} = **8.5** kNm/m

Compression reinforcement is not required

Reinforcement provided **12 mm dia.bars @ 100 mm centres**

Area required $A_{s\_wall\_req}$ = **520.0** mm^2/m Area provided $A_{s\_wall\_prov}$ = **1131** mm^2/m

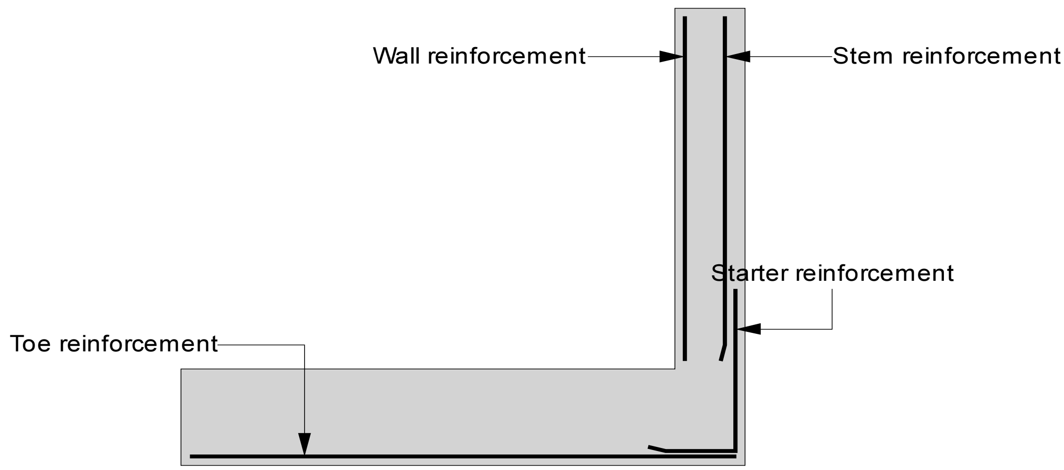
PASS - Reinforcement provided to the retaining wall at mid height is adequate

Check retaining wall deflection

Max span/depth ratio $ratio_{max}$ = **40.00** Actual span/depth ratio $ratio_{act}$ = **6.52**

PASS - Span to depth ratio is acceptable

Indicative retaining wall reinforcement diagram



Toe mesh - B785 - (785 mm^2/m)

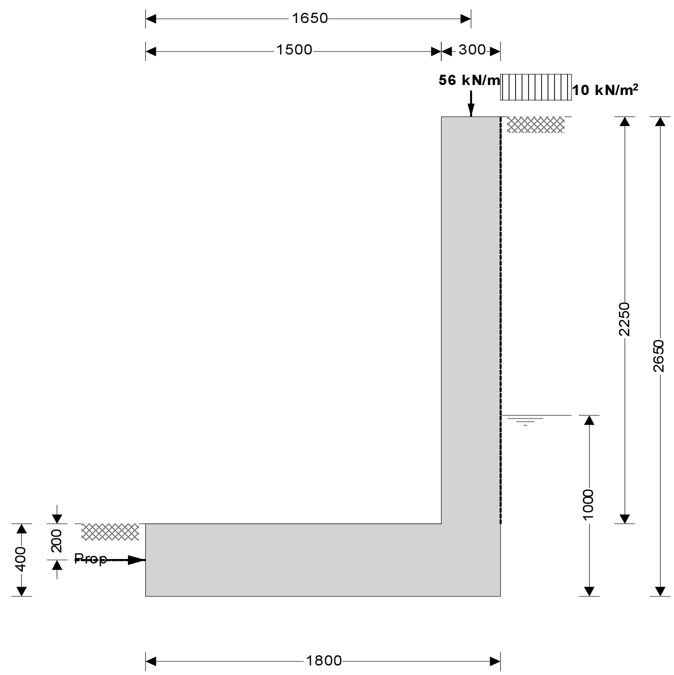
Wall bars - 12 mm dia.@ 100 mm centres - (1131 mm^2/m)

Stem mesh - B785 - (785 mm^2/m)

Tekla Tedds	Project: 40a Park Hill			Job no.: 5016	
	Calcs for: Retaining Wall 3 - Permanent			Start page no./Revision: C 41	
	Calcs by: NB	Calcs date: 7/11/2017	Checked by: KH	Checked date:	Approved by:	Approved date:

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.06



Wall details

Retaining wall type	**Cantilever**		
Height of wall stem	h_{stem} = **2250** mm	Wall stem thickness	t_{wall} = **300** mm
Length of toe	l_{toe} = **1500** mm	Length of heel	l_{heel} = **0** mm
Overall length of base	l_{base} = **1800** mm	Base thickness	t_{base} = **400** mm
Height of retaining wall	h_{wall} = **2650** mm		
Depth of downstand	d_{ds} = **0** mm	Thickness of downstand	t_{ds} = **400** mm
Position of downstand	l_{ds} = **0** mm		
Depth of cover in front of wall	d_{cover} = **0** mm	Unplanned excavation depth	d_{exc} = **200** mm
Height of ground water	h_{water} = **1000** mm	Density of water	γ_{water} = 9.81 kN/m^3
Density of wall construction	γ_{wall} = **24.0** kN/m^3	Density of base construction	γ_{base} = **24.0** kN/m^3
Angle of soil surface	β = **0.0** deg	Effective height at back of wall	h_{eff} = **2650** mm
Mobilisation factor	M = **1.5**		
Moist density	γ_m = **21.0** kN/m^3	Saturated density	γ_s = **23.0** kN/m^3
Design shear strength	ϕ' = **24.2** deg	Angle of wall friction	δ = **18.6** deg
Design shear strength	ϕ'_b = **24.2** deg	Design base friction	δ_b = **18.6** deg
Moist density	γ_{mb} = **18.0** kN/m^3	Allowable bearing	$P_{bearing}$ = **105** kN/m^2

Using Coulomb theory

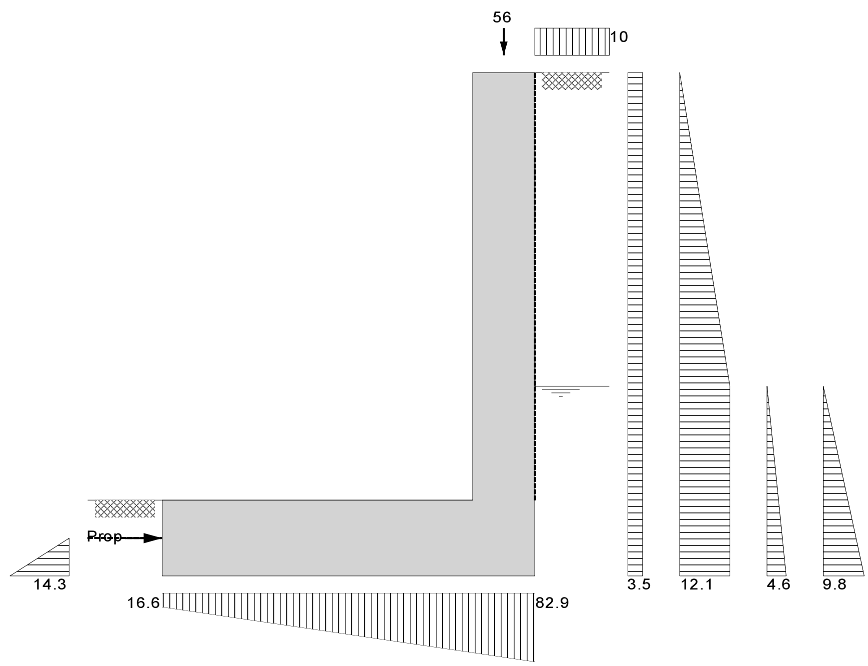
Active pressure	K_a =**0.369**	Passive pressure	K_p = **4.187**
At-rest pressure	K_0 = **0.590**		

Loading details

Surcharge load	Surcharge = **10.0** kN/m^2		
Vertical dead load	W_{dead} = **40.0** kN/m	Vertical live load	W_{live} = **16.0** kN/m
Horizontal dead load	F_{dead} = **0.0** kN/m	Horizontal live load	F_{live} = **0.0** kN/m

Project				Job no.	
40a Park Hill				5016	
Calcs for				Start page no./Revision	
Retaining Wall 3 - Permanent				C 42	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
NB	7/11/2017	KH			

Position of vertical load l_{load} = **1650** mm Height of horizontal load h_{load} = **0** mm



Loads shown in kN/m, pressures shown in kN/m^2

Calculate propping force

Propping force F_{prop} = **12.4** kN/m

Check bearing pressure

Total vertical reaction R = **89.5** kN/m Distance to reaction x_{bar} = **1100** mm

Eccentricity of reaction e = **200** mm

Reaction acts within middle third of base

Bearing pressure at toe p_{toe} = **16.6** kN/m^2 Bearing pressure at heel p_{heel} = **82.9** kN/m^2

PASS - Maximum bearing pressure is less than allowable bearing pressure

RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.06

Ultimate limit state load factors

Dead load factor γ_{f_d} = **1.4** Live load factor γ_{f_l} = **1.6**

Earth pressure factor γ_{f_e} = **1.4**

Calculate propping force

Propping force F_{prop} = **12.4** kN/m

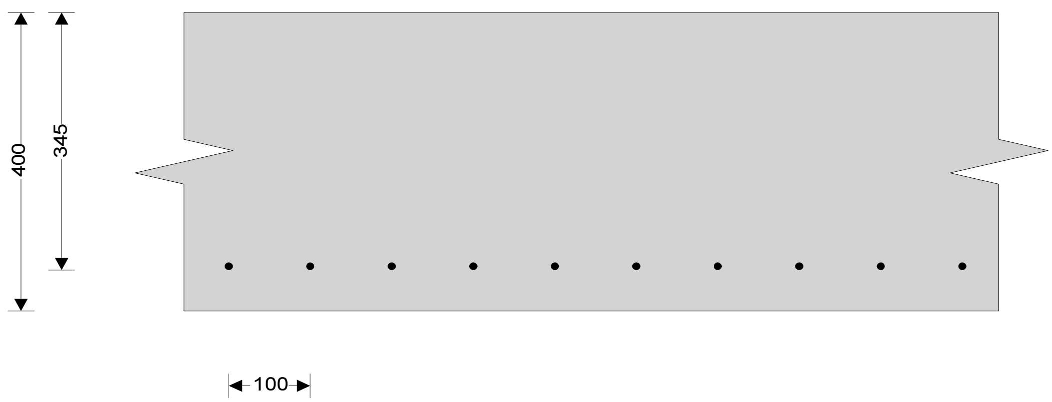
Design of reinforced concrete retaining wall toe (BS 8002:1994)

Material properties

Strength of concrete f_{cu} = **40** N/mm^2 Strength of reinforcement f_y = **500** N/mm^2

Base details

Minimum reinforcement k = **0.13** % Cover in toe c_{toe} = **50** mm



Design of retaining wall toe

Shear at heel V_{toe} = **91.5** kN/m Moment at heel M_{toe} = **88.6** kNm/m

Compression reinforcement is not required

Check toe in bending

Reinforcement provided **B785 mesh**

Area required $A_{s\_toe\_req}$ = **621.6** mm^2/m Area provided $A_{s\_toe\_prov}$ = **785** mm^2/m

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress v_{toe} = **0.265** N/mm^2 Allowable shear stress v_{adm} = **5.000** N/mm^2

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress v_{c_toe} = **0.468** N/mm^2

v_{toe} < v_{c_toe} - No shear reinforcement required

Design of reinforced concrete retaining wall stem (BS 8002:1994)

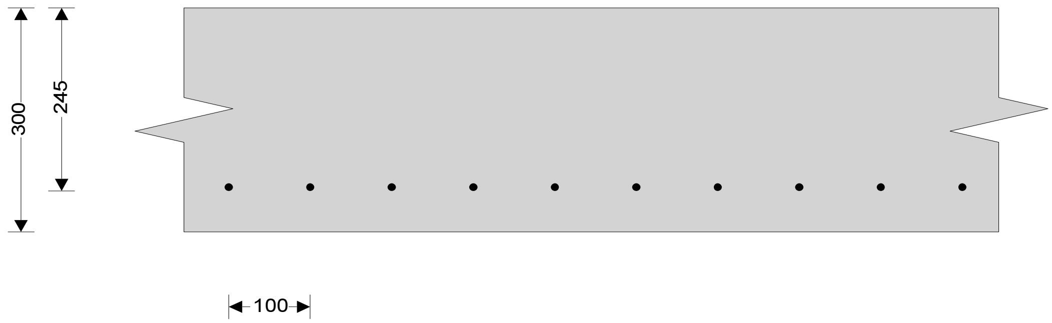
Material properties

Strength of concrete f_{cu} = **40** N/mm^2 Strength of reinforcement f_y = **500** N/mm^2

Wall details

Minimum reinforcement k = **0.13** %

Cover in stem c_{stem} = **50** mm Cover in wall c_{wall} = **50** mm



Design of retaining wall stem

Shear at base of stem V_{stem} = **13.5** kN/m   Moment at base of stem M_{stem} = **66.1** kNm/m

Compression reinforcement is not required

Check wall stem in bending

Reinforcement provided **B785 mesh**

Area required $A_{s\_stem\_req}$ = **652.5** mm^2/m   Area provided $A_{s\_stem\_prov}$ = **785** mm^2/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress v_{stem} = **0.055** N/mm^2 Allowable shear stress v_{adm} = **5.000** N/mm^2

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress v_{c_stem} = **0.572** N/mm^2

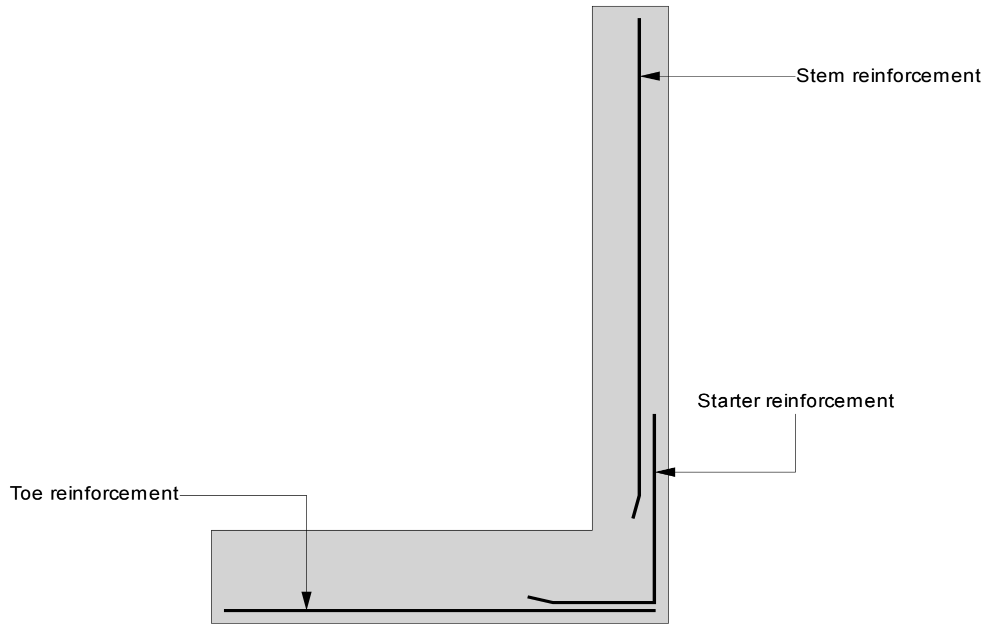
v_{stem} < v_{c_stem} - No shear reinforcement required

Check retaining wall deflection

Max span/depth ratio $ratio_{max}$ = **9.68**   Actual span/depth ratio $ratio_{act}$ = **9.18**

PASS - Span to depth ratio is acceptable

Indicative retaining wall reinforcement diagram

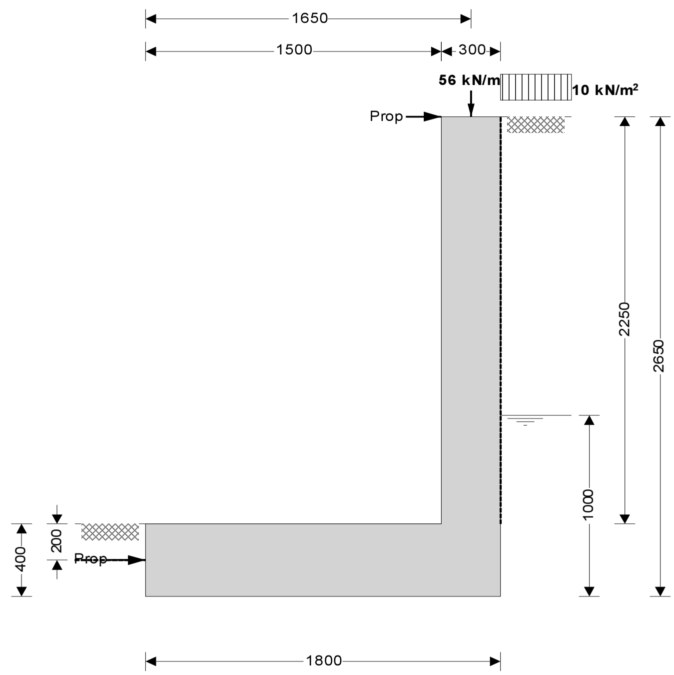


Toe mesh - B785 - (785 mm^2/m)

Stem mesh - B785 - (785 mm^2/m)

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.06



Wall details

Retaining wall type	**Cantilever**		
Height of wall stem	h_{stem} = **2250** mm	Wall stem thickness	t_{wall} = **300** mm
Length of toe	l_{toe} = **1500** mm	Length of heel	l_{heel} = **0** mm
Overall length of base	l_{base} = **1800** mm	Base thickness	t_{base} = **400** mm
Height of retaining wall	h_{wall} = **2650** mm		
Depth of downstand	d_{ds} = **0** mm	Thickness of downstand	t_{ds} = **400** mm
Position of downstand	l_{ds} = **0** mm		
Depth of cover in front of wall	d_{cover} = **0** mm	Unplanned excavation depth	d_{exc} = **200** mm
Height of ground water	h_{water} = **1000** mm	Density of water	γ_{water} = 9.81 kN/m^3
Density of wall construction	γ_{wall} = **24.0** kN/m^3	Density of base construction	γ_{base} = **24.0** kN/m^3
Angle of soil surface	β = **0.0** deg	Effective height at back of wall	h_{eff} = **2650** mm
Mobilisation factor	M = **1.5**		
Moist density	γ_m = **21.0** kN/m^3	Saturated density	γ_s = **23.0** kN/m^3
Design shear strength	ϕ' = **24.2** deg	Angle of wall friction	δ = **18.6** deg
Design shear strength	ϕ'_b = **24.2** deg	Design base friction	δ_b = **18.6** deg
Moist density	γ_{mb} = **18.0** kN/m^3	Allowable bearing	$P_{bearing}$ = **105** kN/m^2

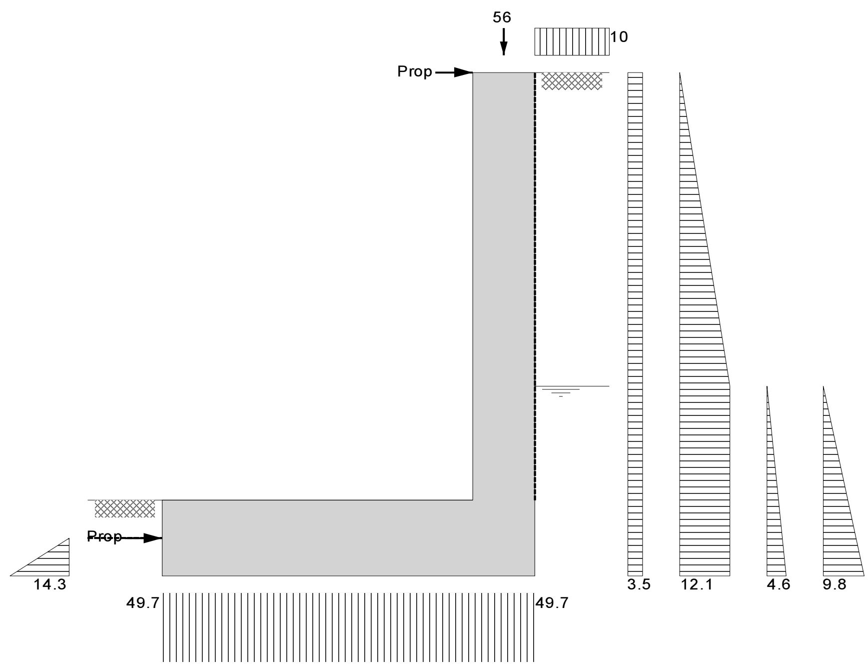
Using Coulomb theory

Active pressure	K_a =**0.369**	Passive pressure	K_p = **4.187**
At-rest pressure	K_0 = **0.590**		

Loading details

Surcharge load	Surcharge = **10.0** kN/m^2		
Vertical dead load	W_{dead} = **40.0** kN/m	Vertical live load	W_{live} = **16.0** kN/m
Horizontal dead load	F_{dead} = **0.0** kN/m	Horizontal live load	F_{live} = **0.0** kN/m

Position of vertical load l_{load} = **1650** mm
Height of horizontal load h_{load} = **0** mm



Loads shown in kN/m, pressures shown in kN/m²

Calculate propping force

Propping force F_{prop} = **12.4** kN/m

Check bearing pressure

Total vertical reaction R = **89.5** kN/m
Distance to reaction x_{bar} = **900** mm

Eccentricity of reaction e = **0** mm

Reaction acts within middle third of base

Bearing pressure at toe p_{toe} = **49.7** kN/m²
Bearing pressure at heel p_{heel} = **49.7** kN/m²

PASS - Maximum bearing pressure is less than allowable bearing pressure

Calculate propping forces to top and base of wall

Propping force to top of wall F_{prop_top} = **2.453** kN/m
Propping force to base of wall F_{prop_base} = **9.996** kN/m

RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.06

Ultimate limit state load factors

Dead load factor γ_{f_d} = **1.4** Live load factor γ_{f_l} = **1.6**

Earth pressure factor γ_{f_e} = **1.4**

Calculate propping force

Propping force F_{prop} = **12.4** kN/m

Calculate propping forces to top and base of wall

Propping force to top of wall $F_{prop\_top\_f}$ = **-0.257** kN/m Propping force to base of wall $F_{prop\_base\_f}$ = **53.211** kN/m

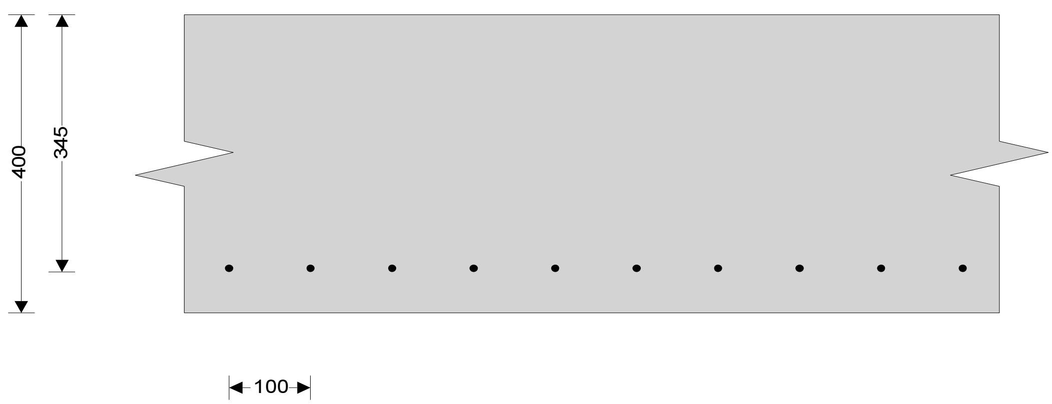
Design of reinforced concrete retaining wall toe (BS 8002:1994)

Material properties

Strength of concrete f_{cu} = **40** N/mm^2 Strength of reinforcement f_y = **500** N/mm^2

Base details

Minimum reinforcement k = **0.13** % Cover in toe c_{toe} = **50** mm



Design of retaining wall toe

Shear at heel V_{toe} = **86.9** kN/m Moment at heel M_{toe} = **78.9** kNm/m

Compression reinforcement is not required

Check toe in bending

Reinforcement provided **B785 mesh**

Area required $A_{s\_toe\_req}$ = **553.1** mm^2/m Area provided $A_{s\_toe\_prov}$ = **785** mm^2/m

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress v_{toe} = **0.252** N/mm^2 Allowable shear stress v_{adm} = **5.000** N/mm^2

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress v_{c_toe} = **0.468** N/mm^2

v_{toe} < v_{c_toe} - No shear reinforcement required

Design of reinforced concrete retaining wall stem (BS 8002:1994)

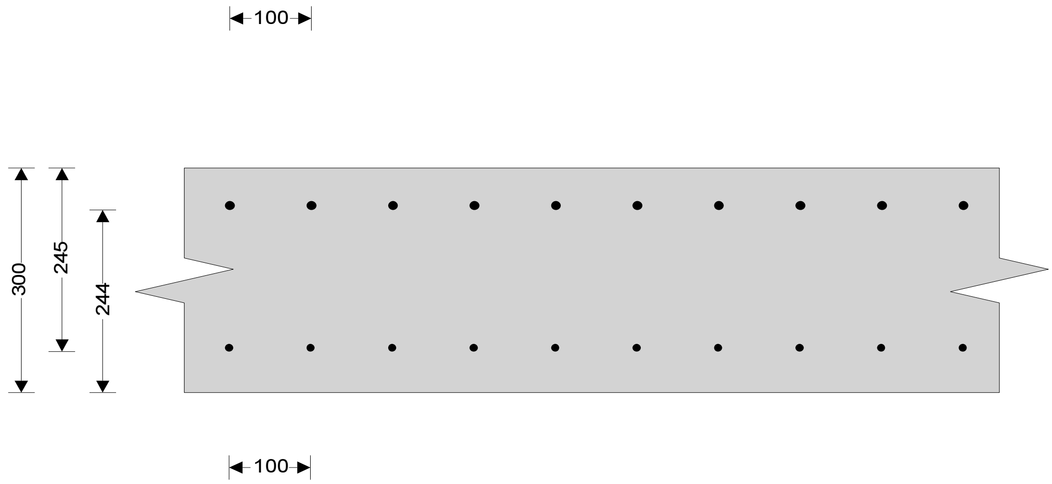
Material properties

Strength of concrete f_{cu} = **40** N/mm^2 Strength of reinforcement f_y = **500** N/mm^2

Wall details

Minimum reinforcement k = **0.13** %

Cover in stem c_{stem} = **50** mm Cover in wall c_{wall} = **50** mm



Design of retaining wall stem

Shear at base of stem V_{stem} = **48.4** kN/m   Moment at base of stem M_{stem} = **21.7** kNm/m

Compression reinforcement is not required

Check wall stem in bending

Reinforcement provided **B785 mesh**

Area required $A_{s\_stem\_req}$ = **390.0** mm^2/m   Area provided $A_{s\_stem\_prov}$ = **785** mm^2/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress v_{stem} = **0.198** N/mm^2 Allowable shear stress v_{adm} = **5.000** N/mm^2

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress v_{c_stem} = **0.572** N/mm^2

v_{stem} < v_{c_stem} - No shear reinforcement required

Design of retaining wall at mid height

Moment at mid height M_{wall} = **11.5** kNm/m

Compression reinforcement is not required

Reinforcement provided **12 mm dia.bars @ 100 mm centres**

Area required $A_{s\_wall\_req}$ = **390.0** mm^2/m   Area provided $A_{s\_wall\_prov}$ = **1131** mm^2/m

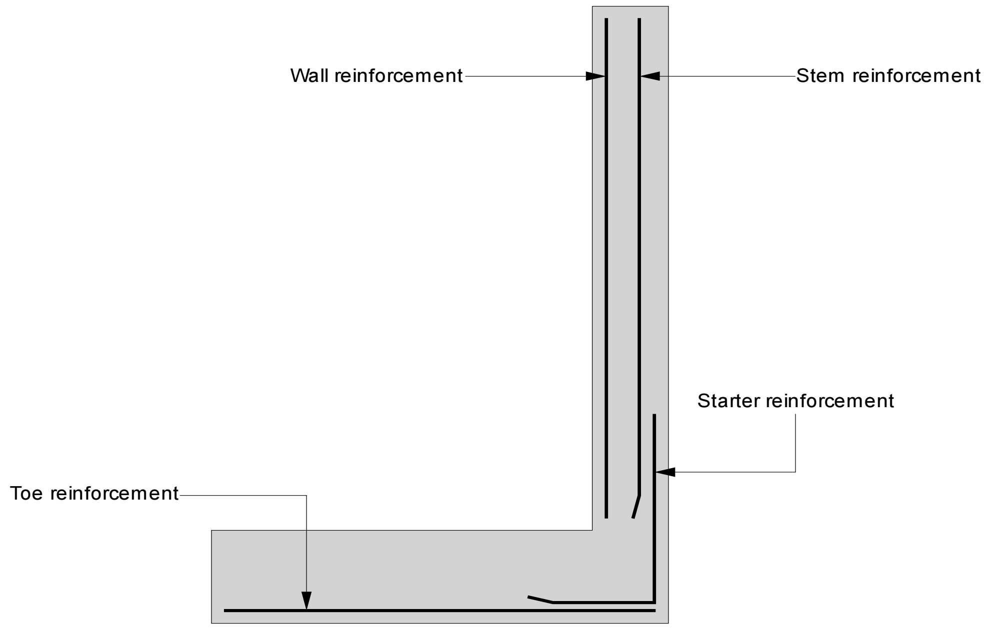
PASS - Reinforcement provided to the retaining wall at mid height is adequate

Check retaining wall deflection

Max span/depth ratio $ratio_{max}$ = **40.00**   Actual span/depth ratio $ratio_{act}$ = **9.18**

PASS - Span to depth ratio is acceptable

Indicative retaining wall reinforcement diagram



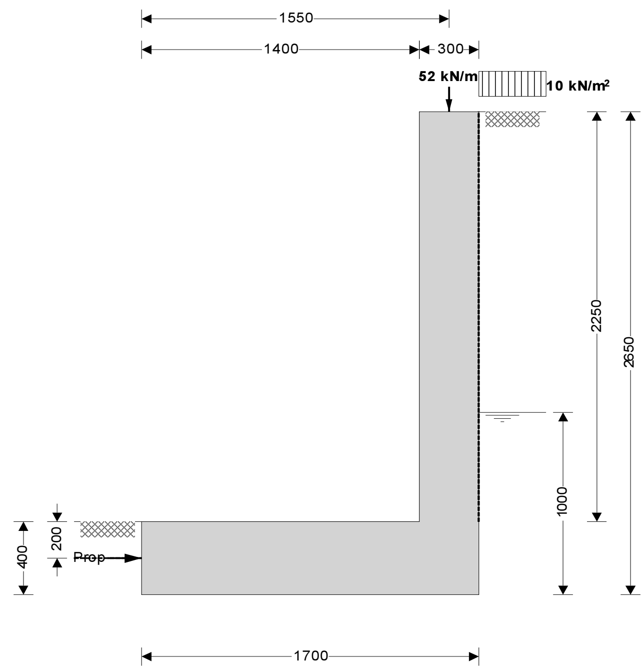
Toe mesh - B785 - (785 mm^2/m)

Wall bars - 12 mm dia.@ 100 mm centres - (1131 mm^2/m)

Stem mesh - B785 - (785 mm^2/m)

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.06



Wall details

Retaining wall type	**Cantilever**		
Height of wall stem	h_{stem} = **2250** mm	Wall stem thickness	t_{wall} = **300** mm
Length of toe	l_{toe} = **1400** mm	Length of heel	l_{heel} = **0** mm
Overall length of base	l_{base} = **1700** mm	Base thickness	t_{base} = **400** mm
Height of retaining wall	h_{wall} = **2650** mm		
Depth of downstand	d_{ds} = **0** mm	Thickness of downstand	t_{ds} = **400** mm
Position of downstand	l_{ds} = **0** mm		
Depth of cover in front of wall	d_{cover} = **0** mm	Unplanned excavation depth	d_{exc} = **200** mm
Height of ground water	h_{water} = **1000** mm	Density of water	γ_{water} = 9.81 kN/m^3
Density of wall construction	γ_{wall} = **24.0** kN/m^3	Density of base construction	γ_{base} = **24.0** kN/m^3
Angle of soil surface	β = **0.0** deg	Effective height at back of wall	h_{eff} = **2650** mm
Mobilisation factor	M = **1.5**		
Moist density	γ_m = **21.0** kN/m^3	Saturated density	γ_s = **23.0** kN/m^3
Design shear strength	ϕ' = **24.2** deg	Angle of wall friction	δ = **18.6** deg
Design shear strength	ϕ'_b = **24.2** deg	Design base friction	δ_b = **18.6** deg
Moist density	γ_{mb} = **18.0** kN/m^3	Allowable bearing	$P_{bearing}$ = **105** kN/m^2

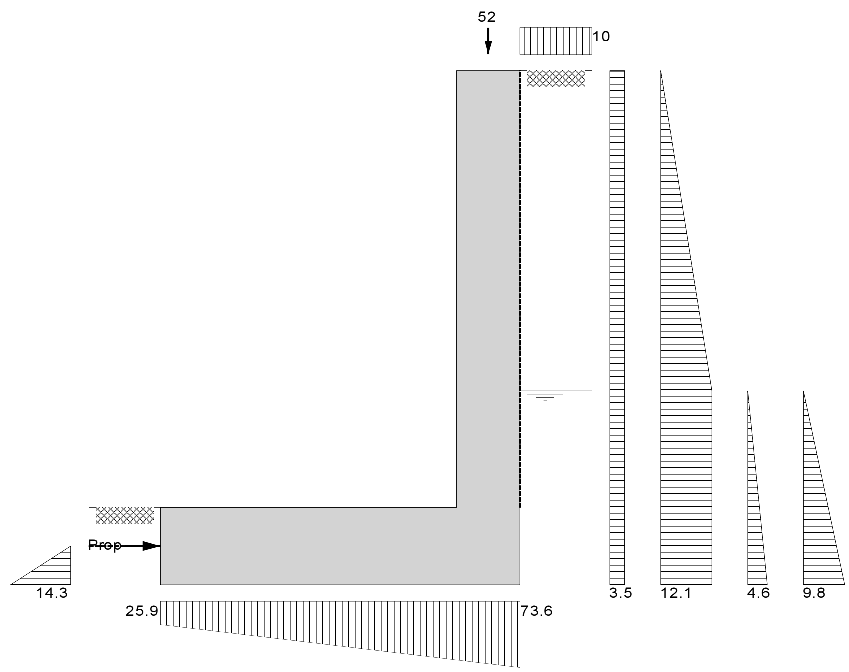
Using Coulomb theory

Active pressure	K_a =**0.369**	Passive pressure	K_p = **4.187**
At-rest pressure	K_0 = **0.590**		

Loading details

Surcharge load	Surcharge = **10.0** kN/m^2		
Vertical dead load	W_{dead} = **43.0** kN/m	Vertical live load	W_{live} = **9.0** kN/m
Horizontal dead load	F_{dead} = **0.0** kN/m	Horizontal live load	F_{live} = **0.0** kN/m

Position of vertical load l_{load} = **1550** mm Height of horizontal load h_{load} = **0** mm



Loads shown in kN/m, pressures shown in kN/m²

Calculate propping force

Propping force F_{prop} = **11.8** kN/m

Check bearing pressure

Total vertical reaction R = **84.5** kN/m Distance to reaction x_{bar} = **986** mm

Eccentricity of reaction e = **136** mm

Reaction acts within middle third of base

Bearing pressure at toe p_{toe} = **25.9** kN/m^2 Bearing pressure at heel p_{heel} = **73.6** kN/m^2

PASS - Maximum bearing pressure is less than allowable bearing pressure

RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.06

Ultimate limit state load factors

Dead load factor γ_{f_d} = **1.4** Live load factor γ_{f_l} = **1.6**

Earth pressure factor γ_{f_e} = **1.4**

Calculate propping force

Propping force F_{prop} = **11.8** kN/m

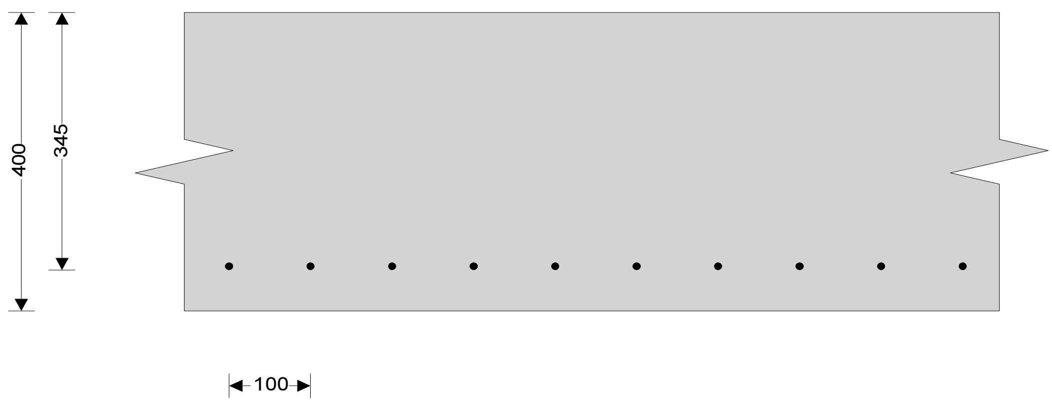
Design of reinforced concrete retaining wall toe (BS 8002:1994)

Material properties

Strength of concrete f_{cu} = **40** N/mm^2 Strength of reinforcement f_y = **500** N/mm^2

Base details

Minimum reinforcement k = **0.13** % Cover in toe c_{toe} = **50** mm



Design of retaining wall toe

Shear at heel V_{toe} = **90.4** kN/m Moment at heel M_{toe} = **88.4** kNm/m

Compression reinforcement is not required

Check toe in bending

Reinforcement provided **B785 mesh**

Area required $A_{s\_toe\_req}$ = **619.9** mm^2/m Area provided $A_{s\_toe\_prov}$ = **785** mm^2/m

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress v_{toe} = **0.262** N/mm^2 Allowable shear stress v_{adm} = **5.000** N/mm^2

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress v_{c_toe} = **0.468** N/mm^2

$v_{toe} < v_{c\_toe}$ - No shear reinforcement required

Design of reinforced concrete retaining wall stem (BS 8002:1994)

Material properties

Strength of concrete f_{cu} = **40** N/mm^2 Strength of reinforcement f_y = **500** N/mm^2

Wall details

Minimum reinforcement k = **0.13** %

Cover in stem c_{stem} = **50** mm Cover in wall c_{wall} = **50** mm

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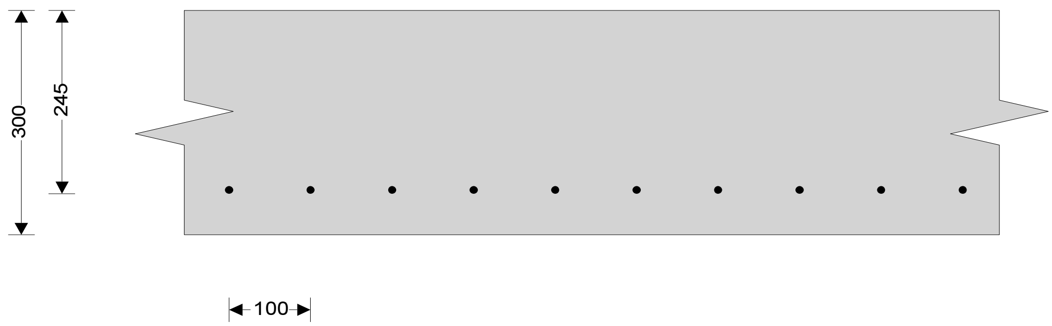
Retaining Wall 5 - Permanent				C 54	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
NB	7/11/2017	KH			



Design of retaining wall stem

Shear at base of stem V_{stem} = **14.5** kN/m

Moment at base of stem M_{stem} = **66.1** kNm/m

Compression reinforcement is not required

Check wall stem in bending

Reinforcement provided **B785 mesh**

Area required $A_{s\_stem\_req}$ = **652.5** mm^2/m

Area provided $A_{s\_stem\_prov}$ = **785** mm^2/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress v_{stem} = **0.059** N/mm^2

Allowable shear stress v_{adm} = **5.000** N/mm^2

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress v_{c_stem} = **0.572** N/mm^2

v_{stem} < v_{c_stem} - No shear reinforcement required

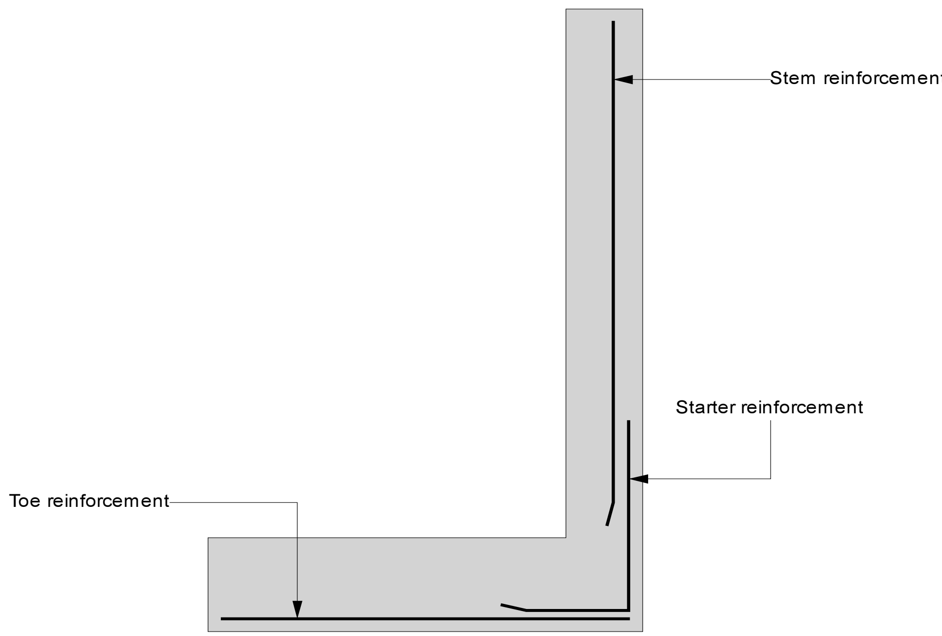
Check retaining wall deflection

Max span/depth ratio $ratio_{max}$ = **9.68**

Actual span/depth ratio $ratio_{act}$ = **9.18**

PASS - Span to depth ratio is acceptable

Indicative retaining wall reinforcement diagram



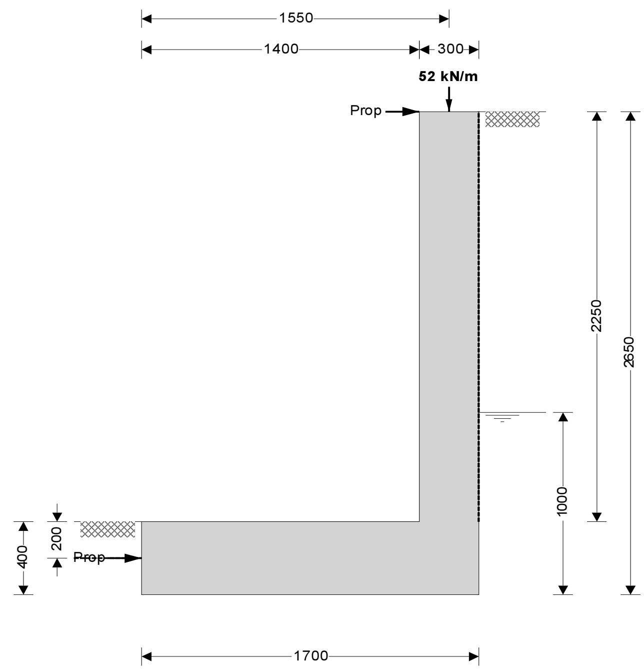
Toe mesh - B785 - (785 mm^2/m)

Stem mesh - B785 - (785 mm^2/m)

Project				Job no.	
40a Park Hill				5016	
Calcs for				Start page no./Revision	
Retaining Wall 5 - Temp				C 56	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
NB	7/11/2017	KH			

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.06



Wall details

Retaining wall type	**Cantilever**		
Height of wall stem	h_{stem} = **2250** mm	Wall stem thickness	t_{wall} = **300** mm
Length of toe	l_{toe} = **1400** mm	Length of heel	l_{heel} = **0** mm
Overall length of base	l_{base} = **1700** mm	Base thickness	t_{base} = **400** mm
Height of retaining wall	h_{wall} = **2650** mm		
Depth of downstand	d_{ds} = **0** mm	Thickness of downstand	t_{ds} = **400** mm
Position of downstand	l_{ds} = **0** mm		
Depth of cover in front of wall	d_{cover} = **0** mm	Unplanned excavation depth	d_{exc} = **200** mm
Height of ground water	h_{water} = **1000** mm	Density of water	γ_{water} = 9.81 kN/m^3
Density of wall construction	γ_{wall} = **24.0** kN/m^3	Density of base construction	γ_{base} = **24.0** kN/m^3
Angle of soil surface	β = **0.0** deg	Effective height at back of wall	h_{eff} = **2650** mm
Mobilisation factor	M = **1.5**		
Moist density	γ_m = **21.0** kN/m^3	Saturated density	γ_s = **23.0** kN/m^3
Design shear strength	ϕ' = **24.2** deg	Angle of wall friction	δ = **18.6** deg
Design shear strength	ϕ'_b = **24.2** deg	Design base friction	δ_b = **18.6** deg
Moist density	γ_{mb} = **18.0** kN/m^3	Allowable bearing	$P_{bearing}$ = **105** kN/m^2

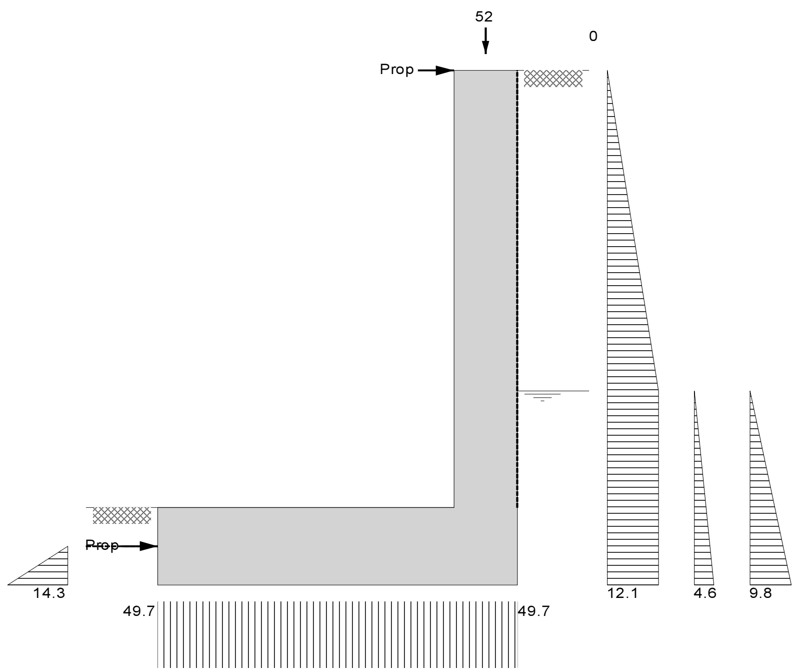
Using Coulomb theory

Active pressure	K_a =**0.369**	Passive pressure	K_p = **4.187**
At-rest pressure	K_0 = **0.590**		

Loading details

Surcharge load	Surcharge = **0.0** kN/m^2		
Vertical dead load	W_{dead} = **43.0** kN/m	Vertical live load	W_{live} = **9.0** kN/m
Horizontal dead load	F_{dead} = **0.0** kN/m	Horizontal live load	F_{live} = **0.0** kN/m

Position of vertical load l_{load} = **1550** mm Height of horizontal load h_{load} = **0** mm



Loads shown in kN/m, pressures shown in kN/m²

Calculate propping force

Propping force F_{prop} = **2.5** kN/m

Check bearing pressure

Total vertical reaction R = **84.5** kN/m Distance to reaction x_{bar} = **850** mm

Eccentricity of reaction e = **0** mm

Reaction acts within middle third of base

Bearing pressure at toe p_{toe} = **49.7** kN/m^2 Bearing pressure at heel p_{heel} = **49.7** kN/m^2

PASS - Maximum bearing pressure is less than allowable bearing pressure

Calculate propping forces to top and base of wall

Propping force to top of wall F_{prop_top} = **-4.213** kN/m Propping force to base of wall F_{prop_base} = **6.705** kN/m

RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.06

Ultimate limit state load factors

Dead load factor γ_{f_d} = **1.4**

Live load factor γ_{f_l} = **1.6**

Earth pressure factor γ_{f_e} = **1.4**

Calculate propping force

Propping force F_{prop} = **2.5** kN/m

Calculate propping forces to top and base of wall

Propping force to top of wall $F_{prop\_top\_f}$ = **-7.539** kN/m

Propping force to base of wall $F_{prop\_base\_f}$ = **34.513** kN/m

Design of reinforced concrete retaining wall toe (BS 8002:1994)

Material properties

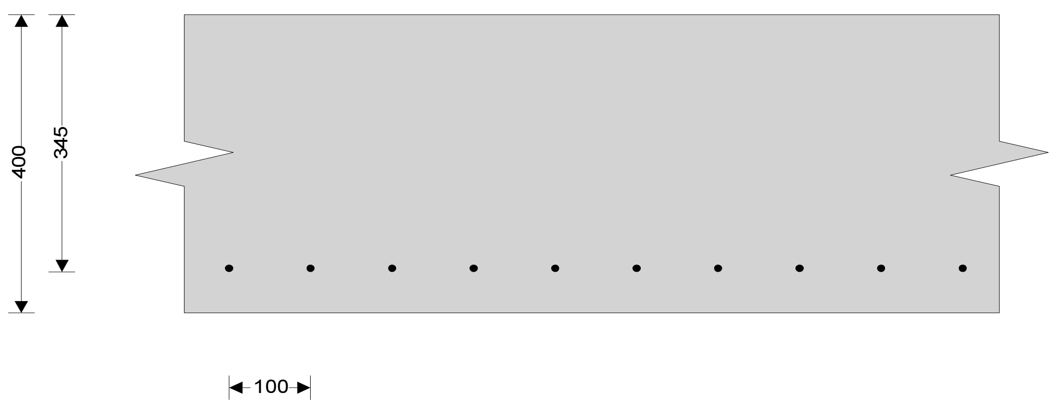
Strength of concrete f_{cu} = **40** N/mm^2

Strength of reinforcement f_y = **500** N/mm^2

Base details

Minimum reinforcement k = **0.13** %

Cover in toe c_{toe} = **50** mm



Design of retaining wall toe

Shear at heel V_{toe} = **80.1** kN/m

Moment at heel M_{toe} = **68.7** kNm/m

Compression reinforcement is not required

Check toe in bending

Reinforcement provided **B785 mesh**

Area required $A_{s\_toe\_req}$ = **520.0** mm^2/m

Area provided $A_{s\_toe\_prov}$ = **785** mm^2/m

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress v_{toe} = **0.232** N/mm^2

Allowable shear stress v_{adm} = **5.000** N/mm^2

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress v_{c_toe} = **0.468** N/mm^2

v_{toe} < v_{c_toe} - No shear reinforcement required

Design of reinforced concrete retaining wall stem (BS 8002:1994)

Material properties

Strength of concrete f_{cu} = **40** N/mm^2

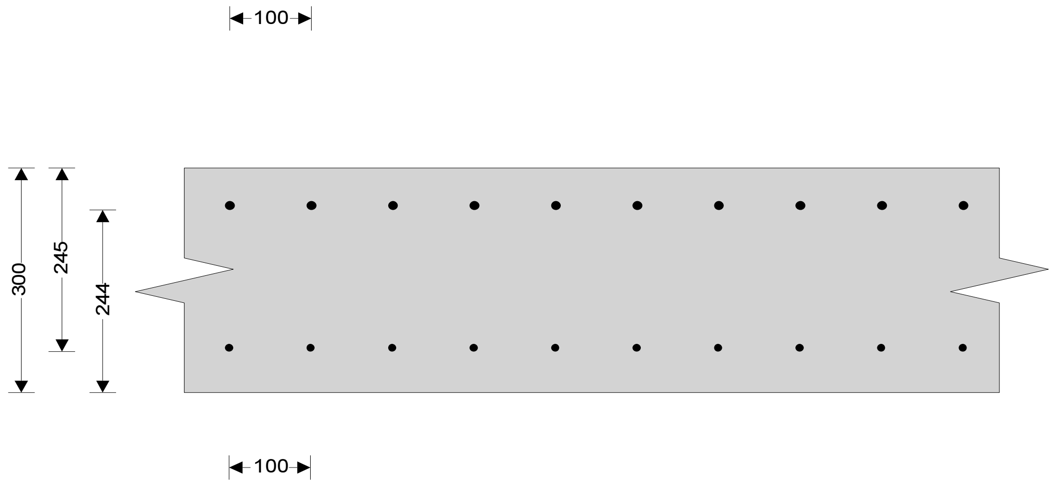
Strength of reinforcement f_y = **500** N/mm^2

Wall details

Minimum reinforcement k = **0.13** %

Cover in stem c_{stem} = **50** mm

Cover in wall c_{wall} = **50** mm



Design of retaining wall stem

Shear at base of stem V_{stem} = **35.1** kN/m Moment at base of stem M_{stem} = **15.2** kNm/m

Compression reinforcement is not required

Check wall stem in bending

Reinforcement provided **B785 mesh**

Area required $A_{s\_stem\_req}$ = **390.0** mm^2/m Area provided $A_{s\_stem\_prov}$ = **785** mm^2/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress v_{stem} = **0.143** N/mm^2 Allowable shear stress v_{adm} = **5.000** N/mm^2

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress v_{c_stem} = **0.572** N/mm^2

v_{stem} < v_{c_stem} - No shear reinforcement required

Design of retaining wall at mid height

Moment at mid height M_{wall} = **7.8** kNm/m

Compression reinforcement is not required

Reinforcement provided **12 mm dia.bars @ 100 mm centres**

Area required $A_{s\_wall\_req}$ = **390.0** mm^2/m Area provided $A_{s\_wall\_prov}$ = **1131** mm^2/m

PASS - Reinforcement provided to the retaining wall at mid height is adequate

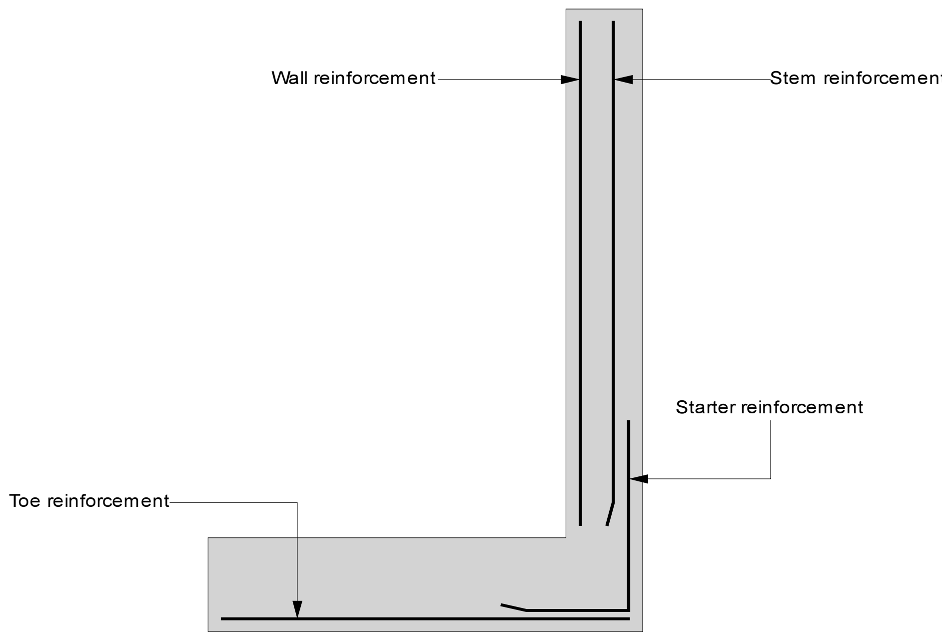
Check retaining wall deflection

Max span/depth ratio $ratio_{max}$ = **40.00** Actual span/depth ratio $ratio_{act}$ = **9.18**

PASS - Span to depth ratio is acceptable

Tekla Tedds	Project: 40a Park Hill			Job no.: 5016	
	Calcs for: Retaining Wall 5 - Temp			Start page no./Revision: C 60	
	Calcs by: NB	Calcs date: 7/11/2017	Checked by: KH	Checked date:	Approved by:	Approved date:

Indicative retaining wall reinforcement diagram



Toe mesh - B785 - (785 mm^2/m)

Wall bars - 12 mm dia.@ 100 mm centres - (1131 mm^2/m)

Stem mesh - B785 - (785 mm^2/m)