

Structural Calculations

For

Alterations and extensions

At

40a Park Hill Road, London, NW3 2YP

July 2017

Job: 40a Park Hill

Job No: 5016

By: NB

Date: July 2017

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	kN/m ²				
	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 Roots					
Chippings and Felt	0.20				
Boards Joists and Fittings	0.20				
Ceiling and Insulation	0.35				
	0.20	0.75	1 50		
	0.75	0.75	1.50		
Suspended Floors					
Timber					
Boards and Joists	0.35				
Ceiling	0.35				
	0.15	1 50	2 00		
	0.20	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)					
TC Garage Floor (Dealli and Diock)					
Finish	1.70				
150 Slab	2.40				
	4.10	2.50	6.66		
In situ Ground Floor					
	1.00				
Finish 150 GL I	1.20				
150 Slab	3.60	1.50	(20		
	4.80	1.50	6.30		
Finish	1 20				
200 Slab	4 80				
	6.00	1.50	7.50		

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		kN/m ²		
	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	

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		kN/m ²				
	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/m ³ 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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	kN/m²			
	DL	IL	Total	
102 Solid Brick				
Prick 102mm	2 20			
Plaster two sides	0.20			
	2.50		2.50	
215 Solid Block (1400kg/m ³ density)				
215 Sond Diock (1400kg/iii 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	

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Sheet No: L5

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.

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Sheet No: L6

PADSTONE LOAD CHECK: $N = \frac{1.25 \times f_k}{\gamma_m} xAb$ Beams supported on existing brick wall - use 15N/mm² bricks with (IV) mortar therefore Brick Strength = 3.5N/mm² Fk = 3.6 Allowable stress = 1.29N/mm² Safety factor = 3.5

 Padstone size = 440x100x215
 =
 Max load = 57kN

 Padstone size = 660x100x215
 =
 Max load = 85kN

 Padstone size = 880x100x215
 =
 Max load = 113kN

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/mm² Fk = 6.4 Allowable stress = 2.29N/mm² Safety factor = 3.5 Padstone size = 440x100x215 = Max load = 101kN Padstone size = 660x100x215=Padstone size = 880x100x215= Max load = 151kN Max load = 201kN Padstone size = 440x215x215=Max load =216kNPadstone size = 660x215x215=Max load =324kNPadstone size = 880x215x215=Max load =432kN

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Imposed	load 0.75 kN	/m².								
Strength	Class C16	Service C	lass 1 or 2	2						
				Dead load	is (kN/m²) e	xcluding s	elf-weight	t of joist		
	Γ	Not mo	Not more than 0.50 More than 0.50 but not more than 0.75).75 but no an 1.00	t more
Size of jo	oist				Spacing	of joists (n	nm)			
Breadth	Depth	400	450	600	400	450	600	400	450	600
(mm)	(mm)				Maximum	clear spar	n (m)			
3	8 97	1.74	1.72	1.67	1.67	1.65	1.58	1.61	1.58	1.51
3	8 120	2.33	2.30	2.21	2.21	2.17	2.08	2.12	2.08	1.97
3	8 145	2.98	2.94	2.82	2.82	2.76	2.63	2.68	2.63	2.48
3	8 170	3.66	3.60	3.38	3.43	3.36	3.18	3.26	3.18	2.99
3	8 195	4.34	4.26	3.88	4.06	3.97	3.65	3.83	3.74	3.46
3	8 220	4.99	4.80	4.37	4.68	4.52	4.11	4.42	4.30	3.90
4	7 97	1.93	1.90	1.84	1.84	1.81	1.74	1.77	1.74	1.66
4	7 120	2.56	2.52	2.43	2.43	2.39	2.27	2.32	2.27	2.16
4	7 145	3.27	3.22	3.08	3.08	3.02	2.87	2.93	2.87	2.70
4	7 170	4.00	3.93	3.63	3.75	3.67	3.42	3.55	3.47	3.25
4	7 195	4.73	4.57	4.16	4.41	4.3 <mark>1</mark>	3.92	4.17	4.07	3.72
4	7 220	5.34	5.14	4.68	5.04	4.85	4.41	4.79	4.61	4.19
6	3 97	2.20	2.17	2.10	2.10	2.06	1.98	2,01	1.98	1.88
6	3 120	2.91	2.87	2.75	2.75	2.70	2.57	2.63	2.57	2.43
6	3 145	3.70	3.64	3.42	3.48	3.41	3.22	3.30	3.23	3.04
6	3 170	4.50	4.39	4.00	4.21	4.12	3.77	3,98	3.89	3.58
6	3 195	5.21	5.02	4.58	4.92	4.74	4.31	4.66	4.51	4.10
6	3 220	5.85	5.64	5.15	5.53	5.33	4.86	5.27	5.07	4.62
7	5 120	3.13	3.08	2.96	2.96	2.90	2.76	2.82	2.76	2.61
7	5 145	3.97	3.90	3.62	3.72	3.65	3.41	3.53	3.45	3.24
7	5 170	4.81	4.64	4.23	4.50	4.38	3.99	4.25	4.15	3.79
7	5 195	5.50	5.30	4.84	5.19	5.01	4.57	4.95	4.77	4.34
7	5 220	6.17	5.96	5.45	5.84	5.63	5.14	5.57	5.36	4.89
ALS	S/CLS									
3	8 140	2.85	2.81	2.69	2.69	2.64	2.51	2.57	2.51	2.38
3	8 184	4.04	3.97	3.66	3.78	3.70	3.44	3.58	3.49	3.27
3	8 235	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 spa	ins for co	mmon o	r jack rafters	5				
Slope of r	oof 30.0° to	45.0°				Impose	ed load 0	.75 kN/m ²		
Strength (Class C16	Service	Class 1 o	r2						
	1		1	Dead loa	d (kN/m ²) ex	cluding se	lf weight	of rafter		
		Not m	ore than 0.	.5	More than (th	0.75 but no an 1.00	t more			
Size of ra	fter				Spacing of	of rafters (mm)			
Breadth	Depth	400	450	600	400	450	600	400	450	600
(mm)	(mm)	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	e Clear Sp	ans for Co	ommon o	or Jack Raft	ers				
Slope of r	oof 30.0° to	45.0°				Impose	ed load 0	.75 kN/m ²		
Strength (Class C24	Servi	ce Class 1	or 2						
			0	Dead load	is (kN/m²) e:	xcluding se	olf weight	t of rafter		
		Not m	ore than 0.	5	More than th	0.5 but not an 0.75	more	More than (th	0.75 but no an 1.00	t more
Size of ra	fter				Spacing	of rafters (mm)			
Breadth	Depth	400	450	600	400	450	600	400	450	600
(mm)	(mm)	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



First Floor Plan Indicating Roof Structure Over



Ground Floor Plan Indicating Structure Over





Retaining Wall and Base Hit & Miss Sequencing Plan

<u>Basement</u>

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Job No: 5016 Job: 40a ParkHill Sheet No: 57 By: NB Date: July 2017 B2: Ream 1125 w 01= 4) 11= 7 k D= 42W AA 2885 as 276 SKu P = Wall $P = (1 \times 215)(3|2) = 3,8 K$ Tedds use zosucyb B load = 70th (us) connect to beams load = B3 '. Beam w 1= 45K AA 01= 45W 11= 8K1 X 3240 as B) Wd = 27 WmWL = SWmFrom Tedds USP zosucyb load = B load = 75 ku (ULS) connects to beam PA RB bears onto woul. From pg 16 use 440x 200 x 215 0p padstone

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Job: 40a ParkHill Job No: 5016 By: NB Date: July 2017 Sheet No: 53 Beam By: 1383 DL=72W wi IL= ISW JA 01= 3416 4330 w = rooflight + roof wd = wt = 075x (3,5+0,4)/2 = 1,46 w/m $w_1 = floor + partitions$ $w_1 = 0,5 \times 0,4 = 0,2 w/m$ $w_1 = 1,5 \times 0,4 = 1 w/m$ P = BI + BZ P = S8 + 42 = 100 W P = 11 + 7 = 18 WFrom Tedds We 2034C71 By load = 124/W (UIS) 2 By 2 By bear onto wall. By load = 61 W (UIS) 2 660 × 200× 2150p padstone + 660× 100× 2150p padstone Beam BS : 1383 05 61KU DE= 29 K R W = roof $Wd = WL = 0.75 \times 0.4 = 0.3 \text{ W/m}$ 4330 $W_1 = floor$ $W_1 d = 0.2ku/m$ $W_1 L = 1.ku/m$ AS BY

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Job No: 5016 Job: 40a ParkHill Sheet No: 54 Date: July 2017 By: NB P = 82 + 63Pd = 41 + 45 = 86 WPL = 7 + 8 = 151WFrom Tedds Use 2034C71Pt 10ad = 108W (We) 7 Padstores as 64P3 10ad = 521W (WS) <math>-Beam Blo i 160 p t f t f t A it= 360 A A 2545 2810 W = floor W = 02 km W = 1 km $P_{d} = \frac{((1,8\times 2,5)+(0,5\times 1,2)2)(2,6/2)}{P_{d}} = \frac{((1,8\times 2,5)+(0,5\times 1,2)2)(2,6/2)}{P_{L}} = \frac{16W}{11}$ From Tedds use 2034(46 24 load = BB load = 27 KD (413). From pg 16 Use 440×100×215 op padstones Floor joists! Span = 3000 mm From Tedds use sox 2002p (16 joists e 4004c

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Job: 40a ParkHill Job No: 5016 By: NB Date: July 2017 Sheet No: 56 Wall 3: (Wall 4 Similar) Height = 2150mm Loads on wall : Dead: $\frac{Dead}{2}$ $\frac{1}{28+404}$ (Wall = 4,8× 6,7 = 32ku/m $\frac{1}{2(05\times 8,2/2)}$ = 4ku/m $\frac{1}{2(05\times 8,2/2)}$ = 4ku/m $\frac{1}{2(05\times 8,2/2)}$ = 4ku/m $\frac{1}{2(05\times 8,2/2)}$ = 4ku/m yow/m $\frac{11ve1}{floor} = 2(115 \times 812/2) = 1260/m \int 15660/m$ $roof = 0.75 \times 916/2 = 3.660/m \int 15660/m$ Refer to Tedds calc for derign. Wall <u>s</u>: Height = 2150 mm Loads on wall ! $\frac{\text{Dead}}{\text{Wall}} = \frac{4.8 \times 3.1}{1.1248} = \frac{15 \text{W}}{15 \text{W}} \frac{7}{1218} = \frac{171218}{1218} = \frac{15 \text{W}}{100} \frac{7}{1218} = \frac{171218}{1218} = \frac{171218}{1218} = \frac{171218}{1100} = \frac{111100}{1100} \frac{7}{1100} = \frac{171218}{1100} = \frac{111218}{1100} = \frac{1111218}{1100} = \frac{111218}{1100} =$ Refer to Tedds calc for design



Beam loads

Load combinations

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 combination 1	Support A	Dead × 1.00
		Imposed \times 1.00
	Span 1	Dead × 1.00
		Imposed \times 1.00
	Support B	Dead × 1.00

Project	40A F	Job no. 5	Job no. 5016		
Calcs for	Timl	Start page no./F	Start page no./Revision C 2		
Calcs by NB	Calcs date 7/9/2017	Checked by KH	Checked date	Approved by	Approved date

Imposed \times 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	Fmin = -3.175 kN
Design shear	$F = max(abs(F_{max}), abs(F_{min})) = 3.9$	933 kN
Total load on beam	Wtot = 7.108 kN	
Reactions at support A	R _{A_max} = 3.933 kN	RA_min = 3.933 kN
Unfactored dead load reaction at support A	RA_Dead = 1.985 kN	
Unfactored imposed load reaction at support A	RA_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	
		>
← 100→		
✓ 100 →		
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	

b_b = N × b = **100** mm C16

1 Long term

L_b = **100** mm

 $A = N \times b \times h = 15000 \text{ mm}^2$ $Z_x = N \times b \times h^2 / 6 = 375000 \text{ mm}^3$ $Z_y = h \times (N \times b)^2 / 6 = 250000 \text{ mm}^3$ $I_x = N \times b \times h^3 / 12 = 28125000 \text{ mm}^4$ $I_y = h \times (N \times b)^3 / 12 = 12500000 \text{ mm}^4$ $i_x = \sqrt{(I_x / A)} = 43.3 \text{ mm}$ $i_y = \sqrt{(I_y / A)} = 28.9 \text{ mm}$

K₃ = 1.00 K₄ = **1.00** $K_7 = (300 \text{ mm} / \text{h})^{0.11} = 1.08$ K₈ = **1.10** K9 = **1.14**

Lateral support - cl.2.10.8

Duration of loading - Table 17

Total depth of member - cl.2.10.6

Minimum modulus of elasticity - Table 20

Bearing stress - Table 18

Load sharing - cl.2.10.11

Ends held in position

Timber strength class Member details Service class of timber

Load duration Length of bearing

Section properties

Second moment of area

Section modulus

Radius of gyration

Modification factors

Cross sectional area of member

Tekla Tedds	Project	40A	Park Hill		Job no.	5016			
	Calcs for	Tin	Start page no./	Start page no./Revision C 3					
	Calcs by NB	Calcs date 7/9/2017	Checked by KH	Checked date	Approved by	Approved date			
Permissible depth-to-bread	Ith ratio - Table 19	3.00							
Actual depth-to-breadth rat	io	h / (N \times b)	= 1.50						
				PASS -	Lateral suppo	ort is adequate			
Compression perpendicu	lar to grain								
Permissible bearing stress	(no wane)	$\sigma_{c_{adm}} = \sigma$	$_{\tt cp1} imes {\sf K}_3 imes {\sf K}_4 imes {\sf k}_4$	K8 = 2.420 N/mm ²	2				
Applied bearing stress		$\sigma_{c_a} = R_{A_a}$	max / (N $ imes$ b $ imes$ Lt	b) = 0.393 N/mm ²					
		σc_a / σc_ac	im = 0.163						
P	PASS - Applied co	ompressive stres	ss is less than	permissible co	mpressive str	ess at bearing			
Bending parallel to grain									
Permissible bending stress	;	$\sigma_{m_{adm}} = \sigma_{adm}$	$\sigma_{m_adm} = \sigma_m \times K_3 \times K_7 \times K_8 = \textbf{6.292} \text{ N/mm}^2$						
Applied bending stress		$\sigma_{m_a} = M / Z_x = 2.500 N/mm^2$							
		σm_a / σm_a	adm = 0.397						
		PASS - Applie	d bending str	ess is less than	permissible b	ending stress			
Shear parallel to grain									
Permissible shear stress		$ au_{adm}$ = $ au$ $ imes$	K3 × K8 = 0.737	N /mm²					
Applied shear stress		τ_a = 3 \times F	/ (2 × A) = 0.39	3 N /mm²					
		$\tau_a / \tau_{adm} =$	0.534						
		PASS - A	pplied shear s	stress is less the	an permissibl	e shear stress			
Deflection									
Modulus of elasticity for de	flection	$E = E_{min} \times$	K9 = 6612 N/m	1m²					
Permissible deflection		$\delta_{adm} = mir$	(0.551 in, 0.00	3 × L _{s1}) = 4.170 r	nm				
Bending deflection		δ _{b_s1} = 1.0	47 mm						
Shear deflection		δ _{v_s1} = 0.1	81 mm						
Total deflection		$\delta_a = \delta_{b_s1}$	+ δ _{v_s1} = 1.229	mm					
		$\delta_a / \delta_{adm} =$	0.295						
		F	ASS - Total de	eflection is less	than permiss	ible deflectior			



	Project	40A F	Park Hill	Job no. 5016		
icuus	Calcs for	Bea	am B1		Start page no./F	Revision
	Calcs by NB	Calcs date 7/9/2017	Checked by KH	Checked date	Approved by	Approved d
Analysis results			-			-
Maximum moment		M _{max} = 103	.3 kNm	M _{min} =	0 kNm	
Maximum shear		V _{max} = 98 k	<n< td=""><td>V_{min} =</td><td>-98 kN</td><td></td></n<>	V _{min} =	-98 kN	
Deflection		δ _{max} = 12.4	mm	δ _{min} = () mm	
Maximum reaction at support A	١	RA_max = 98	3 kN	R _{A_min} :	= 98 kN	
Unfactored dead load reaction	at support A	$R_{A_{Dead}} = 5$	8 kN			
Unfactored imposed load react	ion at support A	$R_{A_{Imposed}} =$	10.5 kN			
Maximum reaction at support E	3	R _{B_max} = 98	3 kN	R _{B_min} :	= 98 kN	
Unfactored dead load reaction	at support B	$R_{B_{Dead}} = 5$	8 kN			
Unfactored imposed load react	ion at support B	$R_{B_{Imposed}} =$	10.5 kN			
Section details						
Section type		UC 203x2	03x52 (BS4-1)			
Steel grade		S275	,			
From table 9: Design strengt	h p _v					
Thickness of element	• •	max(T, t) =	: 12.5 mm			
Design strength		py = 275 N	/mm²			
Modulus of elasticity		E = 20500	0 N/mm²			
	12.5					
	→ →					
	62		79			
	•	204.3-				
l atoral rostraint						
Lateral restraint		Span 1 ha	s lateral restrai	nt at supports on	ly	
Lateral restraint Effective length factors		Span 1 ha	s lateral restrai	nt at supports on	ly	
Lateral restraint Effective length factors Effective length factor in major	axis	Span 1 ha K _x = 1.00	s lateral restrai	nt at supports on	ly	
Lateral restraint Effective length factors Effective length factor in major Effective length factor in minor	axis axis	Span 1 ha K _x = 1.00 K _y = 1.00	s lateral restrai	nt at supports on	ly	
Lateral restraint Effective length factors Effective length factor in major Effective length factor in minor Effective length factor for latera	axis axis łl-torsional bucklir	Span 1 ha K _x = 1.00 K _y = 1.00 ng K _{LT,A} = 1.20 K _{LT,B} = 1.20	s lateral restrai 0 + 2 × D 0 + 2 × D	nt at supports on	ly	
Lateral restraint Effective length factors Effective length factor in major Effective length factor in minor Effective length factor for latera Classification of cross sectio	axis axis al-torsional bucklir I ns - Section 3.5	Span 1 has $K_x = 1.00$ $K_y = 1.00$ $K_{LT,A} = 1.20$ $K_{LT,B} = 1.20$ $\epsilon = \sqrt{275}$	s lateral restrai $0 + 2 \times \mathbf{D}$ $0 + 2 \times \mathbf{D}$ $\mathbf{N}/\mathbf{mm}^2 / \mathbf{p}_y] = 1$	nt at supports on	ly	
Lateral restraint Effective length factors Effective length factor in major Effective length factor in minor Effective length factor for latera Classification of cross section Internal compression parts -	axis axis al-torsional bucklir ons - Section 3.5 Table 11	Span 1 ha K _x = 1.00 K _y = 1.00 K _{LT.A} = 1.20 K _{LT.B} = 1.20 ε = √[275 Ν	s lateral restrai 0 + 2 × D 0 + 2 × D N/mm² / py] = 1	nt at supports on	ly	

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Outstand flanges - Table 11								
Width of section		b = B / 2 =	102.2 mm					
		b / T = 8.2	3 × θ => 3 × ε	Class	1 plastic			
					Section is	class 1 plastic		
Shear capacity - Section 4.2.3								
Design shear force		F _v = max(a	lbs(V _{max}), abs(V	√ _{min})) = 98 kN				
-		d / t < 70 ×	3					
			Web does	not need to be	checked for s	shear buckling		
Shear area		$A_v = t \times D =$	= 1629 mm²					
Design shear resistance		$P_v = 0.6 \times$	p _y × A _v = 268.8	kN				
		PAS	SS - Design sh	ear resistance e	exceeds desi	gn shear force		
Moment capacity - Section 4.2	2.5							
Design bending moment		M = max(a	bs(Ms1_max), ab	$s(M_{s1_{min}})) = 103.$	3 kNm			
Moment capacity low shear - cl.	4.2.5.2	M₀ = min(p	$y \times S_{xx}$, 1.2 × p	y × Zxx) = 156 kNi	m			
Effective length for lateral-tor	sional buckling	a - Section 4.3.	5					
Effective length for lateral torsio	onal buckling	J ∈ = 1 2 ×	- Is1 + 2 × D = 5/	470 mm				
Slenderness ratio	a b a citaing	$\lambda = 1 = / r_{\rm W}$	= 105.633					
	tian 4 0 0 7		1001000					
Equivalent sienderness - Sec	tion 4.3.6./	0.949						
Torsional index		u = 0.040 v - 15.838						
Slenderness factor		x = 15.000	$0.05 \times (\lambda / x)^{2}$	^{0.25} = 0 746				
Patio cl 4 3 6 9		6 1 000	0.00 × (λ / λ)]	- 0.740				
Equivalent slenderness of 4.3	67		′ ∽	6 850				
Limiting clondornoop Annoy B	2.2	$\lambda L I = \mathbf{U} \times \mathbf{V}$	$(\pi^2 \times E / p)^{0.5}$	- 34 310				
Limiting siendemess - Annex D		$\lambda = 0.4 \times$	$(\pi \times \Box \gamma py)$	- 34.310 ould be made fr	r latoral-tors	ional huckling		
		XLT = XLO -	Anowance sh	ould be made it		ional buckning		
Bending strength - Section 4.	3.6.5							
Robertson constant		$\alpha_{LT} = 7.0$	<i>(</i> , , , , , , , , , , , , , , , , , , ,					
Perry factor		η∟⊤ = max(αιτ × (λιτ - λιο)	(/ 1000, 0) = 0.22	28			
Euler stress		$p_E = \pi^2 \times E$	$1/\lambda_{LT^2} = 452.7$	N/mm²	2			
		$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2 = 415.4 \text{ N/mm}^2$						
Bending strength - Annex B.2.1		pb = pe × p	рь = ре × ру / (ф∟т + (ф∟т² - ре × ру) ^{0.5}) = 196.2 N/mm²					
Equivalent uniform moment f	actor - Section	4.3.6.6						
Moment at quarter point of segr	nent	M ₂ = 77.5	< N m					
Moment at centre-line of segme	ent	M ₃ = 103.3	kNm					
Moment at three quarter point o	of segment	M4 = 77.5	<nm< td=""><td></td><td></td><td></td></nm<>					
Maximum moment in segment	uokling register	$M_{abs} = 103$.3 KNM					
Equivalent uniform moment fact	tor for lateral-to	sional buckling	- 103.3 KINIII					
			0 2 + (0 15 v M	l₂ + 0 5 × M₂ + 0	15 v Ma) / Mah	(0.44) = 0.925		
Puckling registered moment	Section 4 2 6	111LT - 1110X()	0.2 (0.15 × 10	$12 + 0.5 \times 1013 + 0.5$	10×1014 / $101ab$	s, 0.44) - 0.323		
Bucking resistance moment	- Section 4.3.6.		S = 111 3 kMn	n				
Buckling registance moment			777 - TIIJ (NIN)					
Buckling resistance moment		M _k / m _i = -	120 3 kNm					

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Check vertical deflection - Section 2.5.2

Consider deflection due to dead and imposed loads

Limiting deflection

Maximum deflection span 1

 $\delta_{\text{lim}} = L_{s1} / 200 = 21.075 \text{ mm}$

 $\delta = max(abs(\delta_{max}), abs(\delta_{min})) = 12.394 \text{ mm}$

PASS - Maximum deflection does not exceed deflection limit



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iedus	Calcs for			Start page no./F	Revision	
		Bea	Beam B2 C 9			
	Calcs by NB	Calcs date 7/9/2017	Checked by KH	Checked date	Approved by	Approved date
Analysis results						
Maximum moment		M _{max} = 51.3	8 kNm	M _{min} = 0	0 kNm	
Maximum shear		V _{max} = 70.2	kN	V _{min} = -	69.1 kN	
Deflection		δ_{max} = 3.3 r	nm	δmin = 0	mm	
Maximum reaction at support A		RA_max = 70	. 2 kN	R _{A_min} =	70.2 kN	
Unfactored dead load reaction a	at support A	$R_{A_{Dead}} = 4$	1.9 kN			
Unfactored imposed load reaction	on 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 a	at support B	$R_{B_{Dead}} = 4$	1.1 kN			
Unfactored imposed load reaction	on at support B	$R_{B_{Imposed}} =$	7.2 kN			
Section details						
Section type		UC 203x20	3x46 (BS4-1)			
Steel grade		S275				
From table 9: Design strength	p _y					
Thickness of element		max(T, t) =	11.0 mm			
Design strength		py = 275 N/	/mm²			
Modulus of elasticity		E = 205000) N /mm²			
7	⊾			_		
			-7.2			
	↑	203.6-		→		
Lateral restraint						
		Span 1 has	s lateral restrai	nt at supports onl	у	
Effective length factors						
Effective length factor in major a	axis	K _x = 1.00				
Effective length factor in minor a	axis	K _y = 1.00				
Effective length factor for lateral	-torsional bucklin	ng K _{LT.A} = 1.20 K _{LT.B} = 1.20) + 2 × D) + 2 × D			
Classification of cross section	ns - Section 3.5	ε = √[275 Ν	l/mm² / p _v] = 1	.00		
Internal compression parts	Table 11	-				
Denth of section		d = 160 8 m	nm			
		d / + - 22 2	 		nlastic	
		u / i = 22.3	~ c ~= 00 × C		plastic	

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Tedus	Calcs for		Revision				
		Bea	m B2		Start page no./Revision C 10		
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Outstand flanges - Table 11			1			•	
Width of section		b = B / 2 =	101.8 mm				
		b / T = 9.3	×ε<=10×ε	Class	2 compact		
					Section is cla	ass 2 compact	
Shear capacity - Section 4.2.3	5					-	
Design shear force		F _v = max(a	bs(V _{max}), abs(\	√ _{min})) = 70.2 kN			
C C		d / t < 70 ×	ε	.,			
			Web does	not need to be	checked for s	hear buckling	
Shear area		A _v = t × D =	1463 mm²				
Design shear resistance		P _v = 0.6 × p	o _y × A _v = 241.4	kN			
-		PAS	S - Design sh	ear resistance (exceeds desig	gn shear force	
Moment capacity - Section 4.	2.5						
Design bending moment		M = max(al	bs(Ms1_max), abs	s(Ms1_min)) = 51.3	kNm		
Moment capacity low shear - cl	.4.2.5.2	$M_c = min(p)$	y × Sxx, 1.2 × py	_y × Z _{xx}) = 136.8 k	Nm		
Effective length for lateral-to	sional buckling	- Section 4.3.5	5				
Effective length for lateral torsic	onal buckling	LE = 1.2 × I	_ _{s1} + 2 × D = 3 8	868 mm			
Slenderness ratio		$\lambda = L_E / r_{vv}$	= 75.345				
	tion 1267						
Equivalent sienderness - Sec	1011 4.3.0.7	0.847					
Torsional index		u = 0.047 x = 17.713					
Slenderness factor		v = 1 / [1 + 1]	$0.05 \times (\lambda / x)^{21}$	^{0.25} = 0.851			
Ratio - cl 4 3 6 9		ßw = 1.000					
Equivalent slenderness - cl 4 3	67	λιτ = u × v	× λ × √[βw] = 5	4.291			
Limiting slenderness - Annex B	22	$\lambda_{10} = 0.4 \times$	$(\pi^2 \times F / p_v)^{0.5}$	= 34.310			
		$\lambda_{IT} > \lambda_{IO} - \lambda$	Allowance sh	ould be made fo	or lateral-tors	ional buckling	
Ponding strongth Section 4	265					5	
Robertson constant	5.0.5	aut = 7 0					
Perry factor				(1000, 0) - 01	10		
		$n_{\rm E} = \pi^2 \times {\rm E}$	$(\lambda_{1} + \lambda_{2}^{2}) = 686.4$	N/mm^2	+0		
		$p_E = \pi \times E$	$(n_1 + 1) \times n_2$	() - 528 7 N/mm	2 ²		
Ponding strongth Annov B 2.1		$\psi_{L1} = (p_y + (\eta_{L1} + 1) \times p_{E})/2 = 320.7 \text{ N/mm}^2$					
Bending Strength - Annex B.2.1		$p_{P} - p_{F} \times p_{2}$	//(φιι+(φιι -	pe × py)) = 227	.4 N/IIIII		
Equivalent uniform moment f	actor - Section	4.3.6.6	N				
Moment at quarter point of segi	ment	M2 = 38.6 k	(Nm (Nm				
Moment at three quarter point of	of segment	1VI3 - 51.5 K M4 - 37.7 L	Nm				
Maximum moment in segment	n segment	$M_{abs} = 51.3$	kNm				
Maximum moment governing b	uckling resistand	e MLT = Mabs	= 51.3 kNm				
Equivalent uniform moment fac	tor for lateral-tor	sional buckling					
		m⊾⊤ = max((0.2 + (0.15 × M	I₂ + 0.5 × M₃ + 0.	$15 imes M_4) / M_{abs}$	s, 0.44) = 0.922	
Buckling resistance moment	- Section 4.3.6.	4					
Puckling registence moment		$M_{b} = p_{b} \times S$	5 _{xx} = 113.1 kNm	n			
Ducking resistance moment							
bucking resistance moment		M♭ / m∟⊤ = '	122.6 kNm				

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Check vertical deflection - Section 2.5.2

Consider deflection due to dead and imposed loads

Limiting deflection

Maximum deflection span 1

δlim = Ls1 / 200 = **14.425** mm

 $\delta = max(abs(\delta_{max}), abs(\delta_{min})) = 3.316 \text{ mm}$

PASS - Maximum deflection does not exceed deflection limit



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ieuus	Calcs for	Poo			Start page no./F	Revision
	Calcs by NB	Calcs date 7/9/2017	Checked by KH	Checked date	Approved by	Approved
Analysis results			<u>.</u>		_	-1
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 mr	n	δ _{min} = () mm	
Maximum reaction at suppo	rt A	RA_max = 75	. 2 kN	RA_min :	= 75.2 kN	
Unfactored dead load reacti	on at support A	$R_{A_{Dead}} = 4$	4.5 kN			
Unfactored imposed load re	action at support A	$R_{A_{Imposed}} =$	8.1 kN			
Maximum reaction at suppo	rt B	R _{B_max} = 75	. 2 kN	R _{B_min} :	= 75.2 kN	
Unfactored dead load reacti	on at support B	$R_{B_{Dead}} = 4$	4.5 kN			
Unfactored imposed load re	action at support B	$R_{B_{Imposed}} =$	8.1 kN			
Section details						
Section type		UC 203x20	3x46 (BS4-1)			
Steel grade		S275				
From table 9: Design stren	ոgth p _y					
Thickness of element		max(T, t) =	11.0 mm			
Design strength		py = 275 N/	mm²			
Modulus of elasticity		E = 205000) N /mm²			
	<u>↓</u> <u>↓</u>					
	7					
			-7.2			
Lateral restraint		Snan 1 has	a lateral restrai	ri	lv	
Effective longth fectors		opun i nat			'y	
Effective length factor in mo	ior axis	K. = 1 00				
Effective length factor in mit	nor axis	$K_{\rm x} = 1.00$				
Effective length factor for lat	teral-torsional bucklin	na Kita = 1.00) + 2 × D			
		Кыт.в = 1.20) + 2 × D			
Classification of cross see	ctions - Section 3.5	ε = √[275 N	l/mm² / p _v] = 1	.00		
Internal compression part	e - Tahlo 11					
Depth of section	σ - ιανίς ΙΙ	d = 160 8 m	am			
Depth of Section		d / t = 22.2		Class	1 plastic	
		u / (- 22.0		01235		

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		Be	am B3		2 14		
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Outstand flanges - Table 11							
Width of section		b = B / 2 =	• 101.8 mm				
		b / T = 9.3	$ \times \epsilon \le 10 \times \epsilon $	Class	2 compact		
					Section is cla	iss 2 compact	
Shear capacity - Section 4.2.3							
Design shear force		$F_v = max(a)$	abs(V _{max}), abs(\	/ _{min})) = 75.2 kN			
		d / t < 70 ;	3 ×				
			Web does	not need to be	checked for s	hear buckling	
Shear area		$A_v = t \times D$	= 1463 mm ²				
Design shear resistance		$P_v = 0.6 \times$	p _y × A _v = 241.4	kN			
		PA	SS - Design sh	ear resistance e	exceeds desig	In shear force	
Moment capacity - Section 4.2	.5						
Design bending moment		M = max(a	abs(Ms1_max), ab	$s(M_{s1_min})) = 60.9$	kNm		
Moment capacity low shear - cl.4	4.2.5.2	M₀ = min(µ	$\mathbf{b}_{y} \times \mathbf{S}_{xx}, \ 1.2 \times \mathbf{p}_{y}$, × Z _{xx}) = 136.8 k	Nm		
Effective length for lateral-tors	sional buckling	- Section 4.3	.5				
Effective length for lateral torsion	nal buckling	Le = 1.2 ×	L _{s1} + 2 × D = 42	294 mm			
Slenderness ratio		$\lambda = L_E / r_{yy} = 83.642$					
Equivalent slenderness - Sect	ion 4.3.6.7						
Buckling parameter		u = 0.847					
Torsional index		x = 17.713	3				
Slenderness factor		v = 1 / [1 +	+ 0.05 × (λ / x)²]	^{0.25} = 0.829			
Ratio - cl.4.3.6.9		βw = 1.00	0				
Equivalent slenderness - cl.4.3.6	6.7	$\lambda_{LT} = \mathbf{u} \times \mathbf{v}$	$v \times \lambda \times \sqrt{[\beta w]} = 5$	8.713			
Limiting slenderness - Annex B.	2.2	$\lambda_{L0} = 0.4 >$	$(\pi^2 \times E / p_y)^{0.5}$	= 34.310			
		λιτ > λιο -	Allowance sh	ould be made fo	or lateral-torsi	onal buckling	
Bending strength - Section 4.3	3.6.5						
Robertson constant		αLT = 7.0					
Perry factor		η ∟ ⊤ = max	(αιτ × (λιτ - λιο)	/ 1000, 0) = 0.17	71		
Euler stress		$p_E = \pi^2 \times E$	$\Xi / \lambda_{LT^2} = 586.9$	N/mm ²			
		φιτ = (p _v +	(η _{LT} + 1) × p _E) /	2 = 481.1 N/mm	1 ²		
Bending strength - Annex B.2.1		$p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5}) = 216.4 \text{ N/mm}^2$					
Equivalent uniform moment fa	ictor - Section	4366		, ,			
Moment at quarter point of segre	nent	4.5.0.0 $M_2 = 45.7$	kNm				
Moment at centre-line of segme	nt	$M_2 = 40.7$ $M_3 = 60.9$	kNm				
Moment at three guarter point of	fsegment	$M_4 = 45.7$	kNm				
Maximum moment in segment	-	Mabs = 60.	9 kNm				
Maximum moment governing bu	ckling resistand	e MLT = Mabs	s = 60.9 kNm				
Equivalent uniform moment fact	or for lateral-tor	sional buckling					
		m∟⊤ = max	(0.2 + (0.15 × M	$_{2}$ + 0.5 × M ₃ + 0.	$15 imes M_4)$ / Mabs	, 0.44) = 0.925	
Buckling resistance moment -	Section 4.3.6.	4					
Buckling resistance moment		Мь = рь ×	S _{××} = 107.7 kNn	n			
		Mb / mlt =	116.4 kNm				
		PASS - Buckl	ing resistance	moment excee	ds design ben	nding moment	

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Check vertical deflection - Section 2.5.2

Consider deflection due to dead and imposed loads

Limiting deflection

Maximum deflection span 1

 $\delta_{\text{lim}} = L_{s1} / 200 = 16.2 \text{ mm}$

 $\delta = max(abs(\delta_{max}), abs(\delta_{min})) = 4.973 \text{ mm}$

PASS - Maximum deflection does not exceed deflection limit


두 Tekla	Project	404	Park Hill		Job no.	5016	
Tedds		40A		Start page no /Revision			
	Calcs for	Bea	am B4		C 17		
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				Impose	ed × 1.60		
		Support B		Dead >	< 1.40		
				Impose	ed × 1.60		
Analysis results							
Maximum moment		M _{max} = 160	5.3 kNm	M _{min} =	0 kNm		
Maximum moment span 1 s	egment 1	Ms1_seg1_ma	x = 166.3 kNm	Ms1_seg	$1_{\min} = 0 \text{ kNm}$		
Maximum moment span 1 s	egment 2	Ms1_seg2_ma	x = 166.3 kNm	Ms1_seg	$2_{\min} = 0 \text{ kNm}$		
Maximum shear		Vmax = 124		Vmin =	-60.6 KN		
Maximum shear span 1 seg	ment 1	Vs1_seg1_max	a = 124 KN	Vs1_seg1		N .	
waximum snear span 1 seg	ment 2	Vs1_seg2_max		Vs1_seg2	2_min = -6U.6 Kľ	N	
Defiection segment 3		δmax = 11.4	• mm	ðmin = (mm		
Maximum reaction at suppo	rt A	$R_{A_{max}} = 1$	24 KN	RA_min *	= 124 kN		
Unfactored dead load reacti	on at support A	$R_{A_{Dead}} = 7$	1.5 kN				
Unfactored imposed load re	action at support A	RA_Imposed =	= 15 kN	-			
Maximum reaction at suppo	rt B	$RB_{max} = 60.6 \text{ KN}$		RB_min [:]	= 60.6 kN		
Unfactored dead load reacti	on at support B	RB_Dead = 3	94.2 KN				
Unfactored imposed load re	action at support B	K B_Imposed =	= 8 KN				
Section details							
Section type		UC 203x2	03x71 (BS4-1)				
Steel grade		S275					
From table 9: Design strer	ngth p _y	. <u> </u>					
Thickness of element		max(T, t) =	= 17.3 mm				
Design strength		p _y = 265 N	/mm²				
Modulus of elasticity		E = 20500	0 N/mm²				
	355.8 73	-	⊢ 10				
Lateral restraint	▼ 14 14 14 14	206.4		→			
Effective length fortage		Span 1 ha	s lateral restrai	nt at supports plu	ıs 1383 mm		
Effective length factors	ior avis	K 1 00					
Effective length factor in mis	jui anis	K = 1.00					
Lineouve length lactor in mill	101 0/15	1xy - 1.00					

 $K_{\text{LT.B}} = \textbf{1.20} + 2 \times D$

Effective length factor for lateral-torsional buckling ~ K_{LT.A} = 1.20~ + 2 \times D ~

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ieuus	Calcs for	Bo	am B4		Start page no./R	evision
		Dea				10
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Classification of cross sec	tions - Section 3.5					
		ε = √[275 Ι	N/mm² / p _y] = 1 .	02		
Internal compression parts	i - Table 11					
Depth of section		d = 160.8	mm			
		d / t = 15.8	3×6 => 3×6	Class 1	plastic	
Outstand flanges - Table 1	1					
Width of section		b = B / 2 =	103.2 mm			
		b / T = 5.9	3 × θ => 3 × ε	Class 1	plastic	
					Section is c	lass 1 plastic
Shear capacity - Section 4.	2.3					
Design shear force		F _v = max(a	abs(V _{max}), abs(V	′ _{min})) = 124 kN		
		d / t < 70 ×	3			
0			Web does	not need to be c	hecked for s	hear buckling
Snear area		$A_v = t \times D$	= 2158 mm ²	LAI		
Design shear resistance		$P_v = 0.6 \times$	$p_y \times A_v = 343.1$	KN	vaaada daala	n abaar faraa
•••••••••••••••••••••••••••••••••••••••		FAS	55 - Design sin	ear resistance e	ceeus uesig	n shear lorce
Moment capacity at span 1	segment 2 - Section	on 4.2.5			- 166 2 kNm	
Moment canacity low shear -	cl 4 2 5 2	$M_{\circ} = min(r)$	IDS(IVIS1_seg2_max),	$\sim 7_{\rm vv}$) = 211 7 kN	– 100.3 KNIII	
Effective law with few latered	6.4.2.0.2		r -	~ Zm) = 211 Ki	••••	
Effective length for lateral-	torsional buckling	- Section 4.3.	5	(2,, D) / 2 = 248		
Effective length for lateral for	Sional buckling	$L_{E} = ((1.0 + 1.0))$	+ 1.2) × Ls1_seg2	$+ 2 \times D) / 2 = 34$	o mm	
Siendemess ratio		λ - LE / Tyy	- 05.272			
Equivalent slenderness - S	ection 4.3.6.7					
Buckling parameter		u = 0.853				
Slenderness factor		x = 1.023	· 0.05 × (λ / x)²1 ⁰	^{0.25} = 0.795		
Ratio - cl 4 3 6 9		Bw = 1.00)	01100		
Equivalent slenderness - cl 4	367	λιτ = u × v	 × λ × √[βw] = 4	4.265		
Limiting slenderness - Anney	< B.2.2	$\lambda_{L0} = 0.4 \times$	$(\pi^2 \times E / p_v)^{0.5} =$	= 34.951		
J		λ LT > λLO -	Allowance sho	ould be made fo	r lateral-torsi	onal buckling
Bending strength - Section	4.3.6.5					-
Robertson constant	4101010	αι τ = 7.0				
Perry factor		nLT = max(αιτ × (λιτ - λιο)	/ 1000. 0) = 0.06	5	
Euler stress		$p_E = \pi^2 \times E$	$1/\lambda_{LT}^2 = 1032.6$	N/mm ²		
		$\phi_{LT} = (p_y +$	(nlt + 1) × pe) /	2 = 682.5 N/mm ²	2	
Bending strength - Annex B.2	2.1	рь = р _Е × р	ο _γ / (φιτ + (φιτ ² - Ι	pe × py) ^{0.5}) = 244.	2 N/mm ²	
Equivalent uniform momen	It factor - Section 4	1.3.6.6				
Moment at quarter point of se	egment	M ₂ = 127. 1	l kNm			
Moment at centre-line of seg	ment	M3 = 86.3	kNm			
Moment at three quarter poir	nt of segment	M ₄ = 43.9	kNm			
Maximum moment in segme	nt	Mabs = 166	.3 kNm			
Maximum moment governing) buckling resistance	e M∟⊤=Mabs	= 166.3 kNm			
Equivalent uniform moment f	actor for lateral-tors	ional buckling				(0, 4, 4) = 0, 0, 4, 4
		m∟⊤ = max($0.2 + (0.15 \times M)$	$_{2} + 0.5 \times M_{3} + 0.1$	$5 \times M_4) / M_{abs}$	U.44) = U.614

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Buckling resistance momen Buckling resistance moment	t - Section 4.3	.6.4 M _b = p _b × 3 M _b / m _{LT} =	S _{xx} = 195 kNm 317.9 kNm			
Buckling resistance momen Buckling resistance moment	t - Section 4.3	.6.4 Μ _b = p _b × 3 Μ _b / m _L τ =	S _{xx} = 195 kNm 317.9 kNm 4 <i>SS - Momen</i> t	canacity excee	ds design her	nding mome
Buckling resistance moment Buckling resistance moment	t - Section 4.3	.6.4 Mb = pb × 3 Mb / mLT = Pa	S∞ = 195 kNm 317.9 kNm ASS - Moment	capacity excee	ds design ber	nding momen
Buckling resistance momen Buckling resistance moment Check vertical deflection - S	ection 2.5.2	.6.4 Μ _b = p _b × 3 Μ _b / m _{LT} = <i>P</i> ₂	S _{xx} = 195 kNm 317.9 kNm ASS - Moment	capacity excee	ds design ber	nding momer
Buckling resistance moment Buckling resistance moment Check vertical deflection - S Consider deflection due to dea	it - Section 4.3 Section 2.5.2 ad and imposed	.6.4 $M_b = p_b \times S$ $M_b / m_{LT} = P_a$ d loads	S _{xx} = 195 kNm 317.9 kNm ASS - Moment	capacity excee	ds design ber	nding momer
Buckling resistance moment Buckling resistance moment Check vertical deflection - S Consider deflection due to dea Limiting deflection	ot - Section 4.3 Section 2.5.2 ad and imposed	.6.4 $M_{b} = p_{b} \times S$ $M_{b} / m_{LT} = P_{z}$ d loads $\delta_{lim} = L_{s1} / S$	S _{xx} = 195 kNm 317.9 kNm ASS - Moment 200 = 21.65 m	r capacity excee m	ds design ber	nding momei
Buckling resistance moment Buckling resistance moment Check vertical deflection - S Consider deflection due to dea Limiting deflection Maximum deflection span 1	it - Section 4.3 Section 2.5.2 ad and imposed	.6.4 $M_{b} = p_{b} \times S$ $M_{b} / m_{LT} = P_{a}$ d loads $\delta_{lim} = L_{s1} / \delta = max(a)$	S _{xx} = 195 kNm 317.9 kNm ASS - Moment 200 = 21.65 m bs(δmax), abs(δι	t <i>capacity excee</i> m min)) = 11.362 mm	ds design ber	nding momei



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				Impose	ed × 1.60	
		Support B		Dead ×	1.40	
				Impose	ed × 1.60	
Analysis results						
Maximum moment		M _{max} = 141	. 1 kNm	M _{min} =	0 kNm	
Maximum moment span 1 s	eament 1	Ms1 seq1 max	= 141.1 kNm	Ms1 seq1	min = 0 kNm	
Maximum moment span 1 s	egment 2	_ 0_ Ms1_seg2_max	= 141.1 kNm	 Ms1_seg2	_ = 0 kNm	
Maximum shear	0	V _{max} = 103	.3 kN	V _{min} = -	- 52.1 kN	
Maximum shear span 1 seg	ment 1	Vs1_seg1_max	= 103.3 kN	Vs1_seg1	_min = -43.7 kN	l
Maximum shear span 1 seg	ment 2	Vs1_seg2_max	= 0 kN	Vs1_seg2	_min = -52.1 kN	l
Deflection segment 3		δ _{max} = 9.7 r	nm	δmin = 0	mm	
Maximum reaction at suppo	rt A	RA_max = 10	3.3 kN	RA_min =	= 103.3 kN	
Unfactored dead load reacti	ion at support A	$R_{A_Dead} = 6$	0.6 kN			
Unfactored imposed load re	action 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	ion at support B	RB_Dead = 2	9.4 kN			
Unfactored imposed load re	action at support B	R _{B_Imposed} = 6.8 kN				
Section details						
Section type		UC 203x20)3x71 (BS4-1)			
Steel grade		S275				
From table 9: Design stren	ngth p _y					
Thickness of element		max(T, t) =	17.3 mm			
Design strength		py = 265 N	/mm²			
Modulus of elasticity		E = 20500) N/mm²			
	<u>→</u> <u>⇔</u>					
	4					
	ي. ي	_	-10			
	21					
	<u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u></u>					
	◀────	206.4		→		
Lateral restraint		Casa 4 b	latoral	+ o+ o,	a 1202	
		Spaninas	s lateral restrain	n at supports plu	s 1303 mm	
Effective length factors						
Effective length factor in ma	ijor axis	K _x = 1.00				
Effective length factor in min	nor axis	K _y = 1.00				

Effective length factor for lateral-torsional buckling $K_{LT,A}$ = 1.20 + 2 × D

KLT.B = 1.20 + 2 × D

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Classification of cross sec	tions - Section 3.5						
		ε = √[275 Ν	N/mm² / py] = 1.	02			
Internal compression parts	s - Table 11						
Depth of section		d = 160.8 r	nm				
		d / t = 15.8	3 × 08 => 3 × ε	Class 1	plastic		
Outstand flanges - Table 1	1						
Width of section		b = B/2 =	103.2 mm		nlaatia		
		D/T = 5.9	× ε <= 9 × ε	Class	Section is	class 1 nlastic	
Shoar aanaaitu Saatia- 4	• •				5601011 18 (ιασο ι μιασιίζ	
Design shear force	2.3	Fv = max(a	lbs(V _{max}) ahs(\	(_{min})) = 103.3 kN			
		d / t < 70 ×	E				
			Web does	not need to be d	hecked for s	hear buckling	
Shear area		$A_v = t \times D =$	= 2158 mm ²				
Design shear resistance		$P_v = 0.6 \times$	p _y × A _v = 343.1	kN			
		PASS - Design shear resistance exceeds design shear force					
Moment capacity at span 1	segment 2 - Sectio	on 4.2.5					
Design bending moment		M = max(a	bs(Ms1_seg2_max)	, abs(Ms1_seg2_min))) = 141.1 kNm	1	
Moment capacity low shear -	- cl.4.2.5.2	M₀ = min(p	$y \times S_{xx}, 1.2 \times p_y$	/ × Zxx) = 211.7 kN	۱m		
Effective length for lateral-	torsional buckling	- Section 4.3.	5				
Effective length for lateral to	rsional buckling	LE = ((1.0 -	+ 1.2) × Ls1_seg2	+ 2 × D) / 2 = 34	58 mm		
Slenderness ratio		$\lambda = L_E / r_{yy}$	= 65.272				
Equivalent slenderness - S	ection 4.3.6.7						
Buckling parameter		u = 0.853					
Torsional index		x = 11.926	0.05 (0.1.)21				
Slenderness factor		v = 1 / [1 + 0.000]	$0.05 \times (\lambda / x)^2$	0.20 = 0.795			
Ratio - cl.4.3.6.9	1267	βw = 1.000	······································	4 96E			
Limiting clonderness - Cl.2	F.3.0.7	$\lambda_{LT} = \mathbf{U} \times \mathbf{V}$	$\times \lambda \times \sqrt{[\beta W]} = 4$	- 31 951			
Linning sienderness - Anne	CD.2.2	$\lambda_{L0} = 0.4 \times$	$(\pi \times E / p_y) - Allowance sh$	- 54.551 ould he made fo	r latoral-tors	ional buckling	
Ponding strongth Sostion	A 2 6 E					ional bucking	
Behaing strength - Section	4.3.0.5	au t = 7 0					
Perry factor		$a_{LT} = max($	() T × () T -) ()	(1000 0) = 0.06	5		
Fuler stress		$p_{\rm F} = \pi^2 \times {\rm F}$	$(\lambda_1 \tau^2 = 1032.6)$	N/mm ²	•		
		φ _{LT} = (p _v +	(nlt + 1) × pe) /	2 = 682.5 N/mm	2		
Bending strength - Annex B.	2.1	рь = ре × р	у / (фіт + (фіт ² -	$p_E \times p_y)^{0.5}$ = 244.	2 N/mm ²		
Equivalent uniform momer	nt factor - Section 4	.3.6.6					
Moment at quarter point of s	egment	M ₂ = 108.1	kNm				
Moment at centre-line of seg	ment	M₃ = 73.6	< N m				
Moment at three quarter poir	nt of segment	M4 = 37.6	< N m				
Maximum moment in segme	nt	Mabs = 141	.1 kNm				
Maximum moment governing	g buckling resistance	e MLT = Mabs	= 141.1 kNm				
			∩ 2 + /∩ 15 √ M	2 + 0 5 ∨ M ₂ + 0 1	5 × M4) / M.	0 44) = 0 616	
		ax(5.2 · (0.15 × W	2 · 0.0 ^ W13 · 0.1	v ^ ivi4 / / iviabs	, 5.77) - 5.010	

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		•	•		•		
Buckling resistance mome	nt - Section 4.3	.6.4					
Buckling resistance moment		$M_{b} = p_{b} \times S_{xx} = 195 \text{ kNm}$					
		M _b / m _{LT} = 316.6 kNm					
		P	ASS - Moment	capacity exceed	ds design bend	ding mome	
Check vertical deflection -	Section 2.5.2						
Check vertical deflection - Consider deflection due to deflection due to deflection due to deflect deflection due to deflect d	Section 2.5.2 ead and imposed	d loads					
Check vertical deflection - Consider deflection due to de Limiting deflection	Section 2.5.2 ead and imposed	d loads $\delta_{\text{lim}} = L_{s1} /$	200 = 21.65 m	m			
Check vertical deflection - Consider deflection due to de Limiting deflection Maximum deflection span 1	Section 2.5.2 ead and imposed	d loads δlim = Ls1 / δ = max(al	200 = 21.65 m bs(δ _{max}), abs(δι	m nin)) = 9.664 mm			
Check vertical deflection - Consider deflection due to de Limiting deflection Maximum deflection span 1	Section 2.5.2 ead and imposed	d loads δiim = Ls1 / δ = max(al PAS	200 = 21.65 m bs(ðmax), abs(ðr S S - Maximum	m _{min})) = 9.664 mm <i>deflection does</i>	not exceed de	eflection lin	
Check vertical deflection - Consider deflection due to de Limiting deflection Maximum deflection span 1	Section 2.5.2 ead and imposed	d loads δlim = Ls1 / δ = max(al PAS	200 = 21.65 m bs(δ _{max}), abs(δι SS - Maximum	m _{min})) = 9.664 mm <i>deflection does</i>	not exceed de	flection lin	
Check vertical deflection - Consider deflection due to de Limiting deflection Maximum deflection span 1	Section 2.5.2 ead and imposed	d loads δlim = Ls1 / δ = max(al PAS	200 = 21.65 m bs(δ _{max}), abs(δι S S - Maximum	m _{nin})) = 9.664 mm <i>deflection does</i>	not exceed de	flection lii	
Check vertical deflection - Consider deflection due to de Limiting deflection Maximum deflection span 1	Section 2.5.2 ead and imposed	d loads δlim = Ls1 / δ = max(al PAS	200 = 21.65 m bs(δ _{max}), abs(δr SS - Maximum	m _{nin})) = 9.664 mm <i>deflection does</i>	not exceed de	flection lii	
Check vertical deflection - Consider deflection due to de Limiting deflection Maximum deflection span 1	Section 2.5.2 ead and imposed	d loads δ _{lim} = L _{s1} / δ = max(al PAS	200 = 21.65 m bs(δ _{max}), abs(δr SS - Maximum	m _{nin})) = 9.664 mm <i>deflection does</i>	not exceed de	flection l	
Check vertical deflection - Consider deflection due to de Limiting deflection Maximum deflection span 1	Section 2.5.2 ead and imposed	d loads δim = Ls1 / δ = max(al PAS	200 = 21.65 m bs(δ _{max}), abs(δr SS - Maximum	m _{nin})) = 9.664 mm <i>deflection does</i>	not exceed de	flection l	



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				Impose	d × 1.60		
		Support B		Dead ×	1.40		
				Impose	d × 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 r	nm	δmin = 0	mm		
Maximum reaction at support	rt A	RA_max = 27	′ .1 kN	R _{A_min} =	27.1 kN		
Unfactored dead load reacti	on at support A	$R_{A_Dead} = 1$	6.6 kN				
Unfactored imposed load re	action at support A	$R_{A_Imposed} =$	2.4 kN				
Maximum reaction at support	rt B	R _{B_max} = 28	k N	R _{B_min} =	28 kN		
Unfactored dead load reacti	on at support B	$R_{B_{Dead}} = 1$	7.2 kN				
Unfactored imposed load re	action at support B	$R_{B_{Imposed}} =$	2.4 kN				
Section details							
Section type		UC 203x20)3x46 (BS4-1)				
Steel grade		S275					
From table 9: Design stren	gth p _y						
Thickness of element		max(T, t) =	11.0 mm				
Design strength		py = 275 N	/mm²				
Modulus of elasticity		E = 20500) N/mm²				
	<u>→</u> <u>+</u>						
	203.2	→ ◄	-7.2				
	◀	203.6		→			
Lateral restraint		Span 1 had	latoral rootra	int at supports only			
Effective law with feetens		Span That		int at supports offi	у		
Effective length factors		V - 1 00					
Effective length factor in ma	jor axis	$K_{x} = 1.00$					
Effective length factor for lat	eral-toreional buckli	ng K ₁₊₄ - 1.00)+2∨D				
		K) + 2 × D				
		NLT.B = 1.20	J T Z X U				
Classification of cross see	tions - Section 3.5	ε = √[275 Ν	l/mm² / py] = 1	.00			

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Internal compression parts -	Table 11								
Depth of section		d = 160.8	mm						
		d / t = 22.3	d / t = $22.3 \times \epsilon \le 80 \times \epsilon$ Class 1 plastic						
Outstand flanges - Table 11									
Width of section		b = B / 2 =	b = B / 2 = 101.8 mm						
		b / T = 9.3	$\times \epsilon \le 10 \times \epsilon$	Class	2 compact				
					Section is cla	ss 2 compact			
Shear capacity - Section 4.2.3									
Design shear force		F _v = max(a	abs(V _{max}), abs(\	/min)) = 28 kN					
		d / t < 70 >	3 >						
			Web does	not need to be o	checked for s	hear buckling			
Shear area	Shear area								
Design shear resistance		$P_v = 0.6 \times$	$p_{y} \times A_{v} = 241.4$	kN					
		PAS	SS - Design sh	ear resistance e	exceeds desig	n shear force			
Moment capacity - Section 4.	2.5								
Design bending moment		M = max(a	abs(Ms1_max), ab	s(Ms1_min)) = 5.7 k	Nm				
Moment capacity low shear - cl	4.2.5.2	M₀ = min(p	$M_{c} = min(p_{y} \times S_{xx}, 1.2 \times p_{y} \times Z_{xx}) = 136.8 \text{ kNm}$						
Effective length for lateral-to	sional buckli	ng - Section 4.3.	5						
Effective length for lateral torsic	nal buckling	LE = 1.2 ×	L _{s1} + 2 × D = 3	778 mm					
Slenderness ratio	0	$\lambda = L_E / r_{yy}$	= 73.592						
Equivalent clenderness - Sec	tion 1 3 6 7								
Buckling parameter	1011 4.3.0.7	u = 0.847							
Torsional index		x = 17.713	3						
Slenderness factor		v = 1 / [1 +	- 0.05 × (λ / x)²]	^{0.25} = 0.856					
Ratio - cl.4.3.6.9		βw = 1.00	0						
Equivalent slenderness - cl.4.3	6.7	λιτ = u × v	$\lambda \times \lambda \times \sqrt{[\beta w]} = 5$	3.322					
Limiting slenderness - Annex B	.2.2	$\lambda_{L0} = 0.4 \times$	$(\pi^2 \times E / p_y)^{0.5}$	= 34.310					
C C		λιτ > λιο -	$\lambda_{LT} > \lambda_{Lo}$ - Allowance should be made for lateral-torsional buckling						
Bending strength - Section 4	365					-			
Robertson constant	0.0.0	αι τ = 7 .0							
Perry factor		nit = max	(αιτ × (λιτ - λιο)	(1000 0) = 0.13	3				
Euler stress		$p_F = \pi^2 \times E$	$E / \lambda_1 \tau^2 = 711.6$	N/mm ²					
		$\phi_{1T} = (p_{y} +$	(nit + 1) × DE)	/2 = 540.7 N/mm	2				
Bending strength - Annex B 2 1		φ_{L} (P) $p_{\text{L}} = p_{\text{E}} \times p_{\text{E}}$	(ημη + (φιτ ² -	$p_{\rm F} \times p_{\rm V})^{0.5}$ = 229	.8 N/mm ²				
Equivalent uniform moment f	aatar Saatia								
Moment at quarter point of sequ	nent	$M_2 = 5.4 \text{ k}$	Nm						
Moment at centre-line of segme	ant	M ₂ = 5.7 k	Nm						
Moment at three quarter point of	ofsegment	$M_4 = 4.7 \text{ k}$	Nm						
Maximum moment in segment	. .	Mabs = 5.7	kNm						
Maximum moment governing b	uckling resista	nce MLT = Mabs	= 5.7 kNm						
Equivalent uniform moment fac	tor for lateral-t	orsional buckling							
		m⊾⊤ = max((0.2 + (0.15 × M	$_{2}$ + 0.5 × M ₃ + 0.	$15 imes M_4) / M_{abs}$, 0.44) = 0.961			
Buckling resistance moment	- Section 4.3.	6.4							
Buckling resistance moment		$M_{\rm b} = p_{\rm b} \times 3$	S _{xx} = 114.3 kNn	n					

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M♭ / m∟⊤ **= 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

 $\delta_{\text{lim}} = L_{s1} / 200 = 14.05 \text{ mm}$

Maximum deflection span 1

 $\delta = max(abs(\delta_{max}), abs(\delta_{min})) = 0.38 \text{ mm}$

PASS - Maximum deflection does not exceed deflection limit

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TIMBER JOIST DESIGN (BS5268	-2:2002)				Tedds calcula	ation version
Joist details						
Joist breadth		b = 50 mn	า			
Joist depth		h = 200 m	m			
Joist spacing		s = 400 m	m			
Timber strength class		C16				
Service class of timber		1				
Δ					A	
mm [A			3000 1] B	
Span details		N _ 4				
Number of spans		$N_{span} = 1$				
Effective length of ener						
		Ls1 = 3000	mm			
500				-		
_★VV						
∢ -50- ▶						
		 ◀───100──►				
Section properties						
Second moment of area		$I = b \times h^3$	/ 12 = 3333333	3 mm⁴		
Section modulus		$Z = b \times h^2$	/ 6 = 333333 m	1m³		
Loading details			h x ostar x a =	= 0.03 kN/m		
Loading details Joist self weight		$F_{swt} = b \times$	II & Uchar × Uacc =			
Loading details Joist self weight Dead load		$F_{swt} = b \times$	50 kN/m ²			
Loading details Joist self weight Dead load Imposed UDL(Long term)		F _{swt} = b × F _{d_udl} = 0.4 F _{i udl} = 1.5	50 kN/m ² 0 kN/m ²			
Loading details Joist self weight Dead load Imposed UDL(Long term) Imposed point load (Medium term)		F _{swt} = b × F _{d_udl} = 0.{ F _{i_udl} = 1.5 F _{i_pt} = 1.4	50 kN/m ² 0 kN/m ² 0 kN			
Loading details Joist self weight Dead load Imposed UDL(Long term) Imposed point load (Medium term) Modification factors		F _{swt} = b × F _{d_udl} = 0.{ F _{i_udl} = 1.5 F _{i_pt} = 1.40	50 kN/m ² 0 kN/m ²) kN			
Loading details Joist self weight Dead load Imposed UDL(Long term) Imposed point load (Medium term) Modification factors Service class for bending parallel t	to grain	$F_{swt} = b \times F_{d_udl} = 0.8$ $F_{i_udl} = 1.5$ $F_{i_pt} = 1.40$ $K_{2m} = 1.00$	50 kN/m ² 0 kN/m ²) kN			
Loading details Joist self weight Dead load Imposed UDL(Long term) Imposed point load (Medium term) Modification factors Service class for bending parallel f Service class for compression	to grain	$F_{swt} = b \times F_{d_udl} = 0.4$ $F_{i_udl} = 1.5$ $F_{i_pt} = 1.40$ $K_{2m} = 1.00$ $K_{2c} = 1.00$	50 kN/m ² 0 kN/m ² 0 kN			

두 Tekla	Project	40A F	Park Hill	Job no. 5016				
Tedas	Calcs for				Start nage no /R	evision		
		Floo	r joists		C	29		
	Calcs by NB	Calcs date 7/9/2017	Checked by KH	Checked date	Approved by	Approved date		
Service class for modulus of e	elasticity	K _{2e} = 1.00						
Section depth factor		K7 = 1.05						
Load sharing factor		K ₈ = 1.10						
Consider long term loads								
Load duration factor		K3 = 1.00						
Maximum bending moment		M = 0.934	kNm					
Maximum shear force		∨ = 1.246 ⊧	٢N					
Maximum support reaction		R = 1.246	×N					
Maximum deflection		δ = 3.190 n	nm					
Check bending stress								
Bending stress		σm = 5.300	N/mm²					
Permissible bending stress		$\sigma_{m_{adm}} = \sigma_{m}$	$m \times K_{2m} \times K_3 \times K_3$	7 × K8 = 6.096 N/	mm²			
Applied bending stress		$\sigma_{m_{max}} = M$	/ Z = 2.803 N/m	1m²				
			PASS - Applie	d bending stres	s within perm	issible limits		
Check shear stress								
Shear stress		τ = 0.670 N	l/mm²					
Permissible shear stress		$ au_{adm}$ = $ au imes k$	$K_{2s} \times K_3 \times K_8 = 0$.737 N/mm²				
Applied shear stress		τ_{max} = 3 \times V / (2 \times b \times h) = 0.187 N/mm ²						
			PASS - App	lied shear stres	s within perm	issible limits		
Check bearing stress								
Compression perpendicular to	o grain (no wane)	σ _{cp1} = 2.20	0 N/mm²					
Permissible bearing stress		$\sigma_{c_{adm}} = \sigma_{cp}$	$_{ m 01} imes { m K}_{ m 2c} imes { m K}_{ m 3} imes { m K}_{ m 3}$	8 = 2.420 N/mm ²				
Applied bearing stress		$\sigma_{c_{max}} = R / (b \times L_b) = 0.249 \text{ N/mm}^2$						
			PASS - Applie	ed bearing stres	s within perm	issible limits		
Check deflection								
Permissible deflection		$\delta_{adm} = min($	$L_{s1}\times 0.003,\ 14$	mm) = 9.000 mm	1			
Bending deflection (based on	E _{mean})	$\delta_{bending} = 2.$	986 mm					
Shear deflection		$\delta_{shear} = 0.20$	04 mm					
Total deflection		δ = δ bending	+ δ_{shear} = 3.190	mm				
			PASS - J	Actual deflectio	n within perm	issible limits		
Consider medium term load	s							
Load duration factor		K₃ = 1.25						
Maximum bending moment		M = 1.309	kNm					
Maximum shear force		∨ = 1.746 ⊧	٨N					
Maximum support reaction		R = 1.746	×N					
Maximum deflection		δ = 3.799 n	nm					
Check bending stress								
Bending stress		σm = 5.300	N/mm ²					
Permissible bending stress		$\sigma_{m_{adm}} = \sigma_{m}$	$1 \times K_{2m} \times K_3 \times K_3$	7 × K8 = 7.620 N/	mm²			
Applied bending stress		$\sigma_{m_{max}} = M$	/ Z = 3.928 N/m	1m²				
-			PASS - Applie	d bending stres	s within perm	issible limits		
Check shear stress								
Shear stress		τ = 0.670 Ν	l/mm²					
Permissible shear stress		$\tau_{adm} = \tau \times K$	K2s × K3 × K8 = 0	.921 N/mm ²				
-			-					

M Tekla	Project				Job no.		
Tedds		40A Park Hill					
	Calcs for	Calcs for				Start page no./Revision	
		Floor joists				C 30	
	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date	
	NB	7/9/2017	KH				
Applied shear stress		T may = 3 ×	$V/(2 \times h \times h) =$	= 0 262 N/mm ²			
Applied silear siless		$max = 3 \times \sqrt{7} (2 \times 0 \times 11) = 0.202 \text{ infinition}$					
.			TAGO AP				
Check bearing stress							
eneen zezing eneee							
Compression perpendicula	ar to grain (no wane)	σ _{cp1} = 2.20	00 N/mm²				
Compression perpendicula Permissible bearing stress	ar to grain (no wane) s	$\sigma_{cp1} = 2.20$ $\sigma_{c_adm} = \sigma_{c}$	00 N/mm ² $_{p1} \times K_{2c} \times K_3 \times K_3$	K₅ = 3.025 N/mm	2		

 δ_{bending} = 3.513 mm

 $\delta = \delta_{\text{bending}} + \delta_{\text{shear}} = 3.799 \text{ mm}$

 δ_{shear} = 0.286 mm

Check deflection

Shear deflection

Total deflection

Permissible deflection

Bending deflection (based on Emean)

PASS - Applied bearing stress within permissible limits

PASS - Actual deflection within permissible limits

 δ_{adm} = min(Ls1 × 0.003, 14 mm) = 9.000 mm





Retaining wall type	Cantilever		
Height of wall stem	h _{stem} = 2250 mm	Wall stem thickness	t _{wall} = 400 mm
Length of toe	Itoe = 2830 mm	Length of heel	I _{heel} = 0 mm
Overall length of base	I _{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	$\gamma_{base} = 24.0 \text{ kN/m}^3$
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	γm = 21.0 kN/m ³	Saturated density	γs = 23.0 kN/m ³
Design shear strength	φ' = 24.2 deg	Angle of wall friction	δ = 18.6 deg
Design shear strength	φ'ь = 24.2 deg	Design base friction	δь = 18.6 deg
Moist density	γ _{mb} = 18.0 kN/m ³	Allowable bearing	$P_{bearing} = 105 \text{ kN/m}^2$
Using Coulomb theory			
Active pressure	Ka = 0.369	Passive pressure	Kp = 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



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ledds	O alva far	404			Otart name na //	
	Calcs for	Retaining Wa	all 1 - Permanent		Start page no./F	C 33
	Calcs by NB	Calcs date 7/11/2017	Checked by KH	Checked date	Approved by	Approved date
RETAINING WALL DESIGN ((BS 8002:1994)				TEDDS calculatio	n version 1.2.01.0
Ultimate limit state load fact	tors					
Dead load factor	$\gamma_{f_d} = 1.4$		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	ı				
Design of reinforced concre	ete retaining wall	toe (BS 8002:	1994)			
Material properties	-	·	<u>.</u>			
Strength of concrete	f _{cu} = 40 N/mm ²		Strength of rein	forcement	f _y = 500 N/m	m²
Base details						
Minimum reinforcement	k = 0.13 %		Cover in toe		c _{toe} = 50 mm	
-545	>				>	
€00 • 545	 ▲ 100→ 	• • •	•••	• •	•	
Design of retaining wall toe Shear at heel	> 	• • •	Moment at hee	• •	• Mtoe = 110.6 einforcement is	kNm/m s not require
Design of retaining wall toe Shear at heel Check toe in bending	> ←100→ V _{toe} = 108.0 kN	• • •	• • Moment at hee Co	• •	• Mtoe = 110.6 einforcement is	kNm/m s not require
Design of retaining wall toe Shear at heel Check toe in bending Reinforcement provided	> 100-→ V _{toe} = 108.0 kN B785 mesh	 /m	Moment at hee Co	• •	• M _{toe} = 110.6 einforcement is	kNm/m s not require
Design of retaining wall toe Shear at heel Check toe in bending Reinforcement provided Area required	> ↓ 100-↓ ↓<	/m 0 mm²/m PASS - Rei	Moment at hee Co Area provided	• •	• Mtoe = 110.6 einforcement is As_toe_prov = 74 etaining wall to	kNm/m s not require 85 mm²/m be is adequat
Design of retaining wall toe Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at to	> ↓ ↓ 100→↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓	/m 0 mm²/m <i>PASS - Rei</i>	Moment at hee Co Area provided nforcement prov	• •	• M _{toe} = 110.6 einforcement is A _{s_toe_prov} = 74 etaining wall to	kNm/m s not require 85 mm²/m be is adequat
Design of retaining wall toe Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at to Design shear stress	> ↓ 100-↓ ↓ V _{toe} = 108.0 kN. B785 mesh As_toe_req = 780.4 oe v _{toe} = 0.198 N/n	/m 0 mm²/m PASS - Rei nm² PASS	Moment at hee Co Area provided nforcement prov Allowable shea - Design shear s	• • ompression re vided at the re r stress stress is less	• M _{toe} = 110.6 einforcement is A _{s_toe_prov} = 74 etaining wall to v _{adm} = 5.000 than maximum	kNm/m s not require 85 mm²/m be is adequat N/mm² n shear stres
Design of retaining wall toe Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at to Design shear stress Concrete shear stress	> ↓ 100→↓ ↓ toe = 108.0 kN. B785 mesh As_toe_req = 780.0 oe ∨toe = 0.198 N/n ∨c_toe = 0.388 N	/m 0 mm²/m PASS - Rei nm² PASS /mm²	Moment at hee Co Area provided nforcement prov Allowable shea - Design shear s	• • ompression re vided at the re r stress stress is less	• M _{toe} = 110.6 einforcement is A _{s_toe_prov} = 74 etaining wall to v _{adm} = 5.000 than maximum	kNm/m s not require 85 mm²/m be is adequat N/mm² n shear stres
Design of retaining wall toe Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at to Design shear stress Concrete shear stress	↓ 100→↓ ↓	/m 0 mm²/m PASS - Rei nm² PASS /mm²	Moment at hee Co Area provided nforcement prov Allowable shea - Design shear s Vtoe	• • compression re vided at the re r stress stress is less < v _{c_toe} - No s	• M _{toe} = 110.6 einforcement is: A _{s_toe_prov} = 7 etaining wall to v _{adm} = 5.000 than maximum hear reinforces	kNm/m s not require 85 mm²/m be is adequat N/mm² n shear stres ment require
Design of retaining wall toe Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at to Design shear stress Concrete shear stress	> ↓ 100→↓<	/m 0 mm²/m PASS - Rei nm² PASS /mm² stem (BS 800)	Moment at hee Co Area provided nforcement prov Allowable shea - Design shear s Vtoe 2:1994)	• • compression re vided at the re r stress stress is less stress is less < v _{c_toe} - No s	• Mtoe = 110.6 einforcement is As_toe_prov = 74 etaining wall to Vadm = 5.000 than maximum hear reinforce	kNm/m s not require 85 mm²/m be is adequat N/mm² n shear stres ment require

Tekla	Project	40a I	Park Hill		Job no.	5016
Tedas	Cales for		antin		Start page po /	Povision
		Retaining Wa	all 1 - Permanent			C 34
	Calcs by NB	Calcs date 7/11/2017	Checked by KH	Checked date	Approved by	Approved
Wall details						
Minimum reinforcement	k = 0.13 %					
Cover in stem	c _{stem} = 50 mm		Cover in wall		_{Cwall} = 50 mm	ו
400	-				•	
	∢ -100- >					
Design of retaining wall ste	m Value = 36.5 kN/	m	Moment at bas	o of stom	Maure - 69 3	kNm/m
Shear at base of stem				ompression r	einforcement i	is not requ
						o not roqu
Check wall stem in bending	B705 mach					
Reinforcement provided	B/85 mesn	• 21	A		•	205 21
Area required	$A_{s_{stem_{req}}} = 520.$	0 mm²/m	Area provided		As_stem_prov =	785 mm²/n
		PASS - Reini	orcement provi	ded at the ret	aining wan ste	m is adeq
Check shear resistance at v	wall stem					
Design shear stress	v _{stem} = 0.106 N/r	nm²	Allowable shea	r stress	V _{adm} = 5.000	N/mm ²
	- 0.4C9 N	PA55	- Design snear :	stress is less	than maximur	n snear st
Concrete snear stress	Vc_stem = U.468 N	l/mm²	Veters	No star - No s	haar rainfarca	mont roqu
			V stem	vc_stem - NO S	silear reinforce	ment iequ
Check retaining wall deflect	tion					
Max span/depth ratio	ratio _{max} = 13.94		Actual span/de	pth ratio PASS - Spar	ratio _{act} = 6.5 In to depth ratio	2) is accept
max spandeptir ratio	ratiomax - 13.34		Actual span/de	PASS - Spar	n to depth ratio	- o is acco







Density of wall construction Angle of soil surface Mobilisation factor Moist density Design shear strength Design shear strength Moist density

Using Coulomb theory Active pressure At-rest pressure

Loading details Surcharge load Vertical dead load Horizontal dead load $\gamma_{wall} = 24.0 \text{ kN/m}^3$ $\beta = 0.0 \text{ deg}$ M = 1.5 $\gamma_{m} = 21.0 \text{ kN/m}^{3}$ **φ'** = **24.2** deg φ'_b = **24.2** deg

Ka =0.369 K₀ = **0.590**

 $\gamma_{mb} = 18.0 \text{ kN/m}^3$

Surcharge = 0.0 kN/m^2 $W_{dead} = 58.0 \text{ kN/m}$ $F_{dead} = 0.0 \text{ kN/m}$

Effective height at back of wall heff = 2850 mm

Saturated density Angle of wall friction Design base friction Allowable bearing

Passive pressure

Vertical live load Horizontal live load $\delta_{b} = 18.6 \text{ deg}$ Pbearing = 105 kN/m² Kp = 4.187

 $\gamma_{s} = 23.0 \text{ kN/m}^{3}$

δ = **18.6** deg

W_{live} = **7.0** kN/m Flive = 0.0 kN/m



текіа	Project 40a Park Hill				Job no. 5016	
Tedds		40a			5	
	Calcs for	Retaining	Wall 1 - Temp		Start page no./F	evision 38
	Calcs by NB	Calcs date 7/11/2017	Checked by KH	Checked date	Approved by	Approved date
RETAINING WALL DESIGN	(BS 8002:1994)				TEDDS calculatio	n version 1.2.01.0
Ultimate limit state load fac	tors					
Dead load factor	$\gamma_{f_d} = 1.4$		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 concre	ete retaining wall	toe (BS 8002:	1994)			
Material properties	-		<u>.</u>			
Strength of concrete	$f_{cu} = 40 \text{ N/mm}^2$		Strength of rein	forcement	f _y = 500 N/mr	m²
Base details						
Minimum reinforcement	k = 0.13 %		Cover in toe		_{Ctoe} = 50 mm	
-600	>					
€00 •	→				•	
Design of retaining wall toe Shear at heel	←100→ V _{toe} = 79.7 kN/n	• •	• • Moment at heel	• •	• M _{toe} = 43.5 kl	Nm/m s not require
Design of retaining wall toe Shear at heel Check toe in bending	> - 100-> V _{toe} = 79.7 kN/n	• •	Moment at heel	• •	• M _{toe} = 43.5 kl	Nm/m s not require
Design of retaining wall toe Shear at heel Check toe in bending Reinforcement provided		•••	Moment at heel	• •	• Mtoe = 43.5 kl	Nm/m s not require
Design of retaining wall toe Shear at heel Check toe in bending Reinforcement provided Area required	←100→ V _{toe} = 79.7 kN/n B785 mesh A _{s_toe_req} = 780.0	• • • • • •	Moment at heel Co Area provided	• •	• Mtoe = 43.5 kl einforcement is As_toe_prov = 78 etaining wall to	Nm/m s not require 35 mm²/m e is adequat
Design of retaining wall toe Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at t	> ↓ <p< td=""><td>o mm²/m PASS - Rei</td><td>Moment at heel Co Area provided nforcement prov</td><td>• •</td><td>• M_{toe} = 43.5 kl einforcement is A_{s_toe_prov} = 78 etaining wall to</td><td>Nm/m s not required 35 mm²/m e is adequat</td></p<>	o mm²/m PASS - Rei	Moment at heel Co Area provided nforcement prov	• •	• M _{toe} = 43.5 kl einforcement is A _{s_toe_prov} = 78 etaining wall to	Nm/m s not required 35 mm²/m e is adequat
Design of retaining wall toe Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at t Design shear stress	> vtoe = 0.146 N/m	0 mm²/m PASS - Rei	Moment at heel Co Area provided nforcement prov Allowable shear - Design shear s	• • ompression re vided at the re stress stress is less	• Mtoe = 43.5 kl einforcement is As_toe_prov = 78 etaining wall to Vadm = 5.000 than maximum	Nm/m 5 not required 35 mm²/m e is adequat N/mm² 5 shear stres
Design of retaining wall toe Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at t Design shear stress Concrete shear stress	> Vtoe = 79.7 kN/n B785 mesh As_toe_req = 780.0 coe vtoe = 0.146 N/m vc_toe = 0.388 N/	o mm²/m PASS - Rei Im² PASS mm²	Moment at heel Co Area provided nforcement prov Allowable shear - Design shear s	• • ompression re rided at the re stress stress is less	• Mtoe = 43.5 kl einforcement is As_toe_prov = 78 etaining wall to Vadm = 5.000 than maximum	Nm/m s not required 35 mm²/m e is adequat N/mm² s shear stres
Design of retaining wall toe Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at t Design shear stress Concrete shear stress	↓ <p< td=""><td>o mm²/m PASS - Rei Im² PASS mm²</td><td>Moment at heel Co Area provided nforcement prov Allowable shear 5 Design shear s</td><td>• • ompression re rided at the re r stress stress is less < vc_toe - No st</td><td>M_{toe} = 43.5 kl einforcement is A_{s_toe_prov} = 74 etaining wall to v_{adm} = 5.000 than maximum hear reinforce</td><td>Nm/m s not required 35 mm²/m e is adequate N/mm² s shear stress ment required</td></p<>	o mm²/m PASS - Rei Im² PASS mm²	Moment at heel Co Area provided nforcement prov Allowable shear 5 Design shear s	• • ompression re rided at the re r stress stress is less < vc_toe - No st	M _{toe} = 43.5 kl einforcement is A _{s_toe_prov} = 74 etaining wall to v _{adm} = 5.000 than maximum hear reinforce	Nm/m s not required 35 mm²/m e is adequate N/mm² s shear stress ment required
Design of retaining wall toe Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at t Design shear stress Concrete shear stress Design of reinforced concrete	> > I = 100→ V _{toe} = 79.7 kN/n B785 mesh As_toe_req = 780.0 voe v _{toe} = 0.146 N/m v _{c_toe} = 0.388 N/ ete retaining wall	• • • • • • • • • • • • • • • • • • • •	Moment at heel Co Area provided nforcement prov Allowable shear - Design shear s Vtoe 2:1994)	• • ompression re vided at the re stress stress is less < v _{c_toe} - No st	• M _{toe} = 43.5 kl einforcement is A _{s_toe_prov} = 78 etaining wall to v _{adm} = 5.000 than maximum hear reinforce	Nm/m s not required 35 mm²/m e is adequate N/mm² n shear stress ment required
Design of retaining wall toe Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at t Design shear stress Concrete shear stress Design of reinforced concret Material properties	► 100-► Vtoe = 79.7 kN/n B785 mesh As_toe_req = 780.0 vtoe = 0.146 N/m vc_toe = 0.388 N/ ete retaining wall	• • • • • • • • • • • • • • • • • • • •	Moment at heel Co Area provided nforcement prov Allowable shear Design shear s Vtoe 2:1994)	• • ompression re vided at the re r stress stress is less < v _{c_toe} - No st	M _{toe} = 43.5 kl einforcement is A _{s_toe_prov} = 74 etaining wall to v _{adm} = 5.000 than maximum hear reinforce	Nm/m s not required 35 mm²/m e is adequate N/mm² n shear stress ment required

	Project	40a F	Park Hill		Job no. 50	16
	Calcs for	Retaining V	Vall 1 - Temp		Start page no./Re	evision 39
	Calcs by NB	Calcs date 7/11/2017	Checked by KH	Checked date	Approved by	Approve
Wall details						
Minimum reinforcement Cover in stem	k = 0.13 % _{Cstem} = 50 mm ∢ -100- >		Cover in wall		c _{wall} = 50 mm	
	•••	• •	••	•••	•	
4 00 345 345			• •	• •		
↓ ↓						
	∢ -100- ▶					
Design of retaining wall ste	em					
Shear at base of stem	V _{stem} = 35.7 kN/	m	Moment at base Co	e of stem mpression re	M _{stem} = 15.9 k einforcement is	Nm/m <i>not req</i>
Check wall stem in bending	g					
Reinforcement provided	B785 mesh	• • • •			. –	
Area required	As_stem_req = 520	.0 mm²/m PASS - Reinfo	Area provided Drcement provid	led at the reta	As_stem_prov = 78	85 mm²/ I <i>is ade</i> o
	wall stom				-	
Check shear resistance at	wali stelli					
Check shear resistance at Design shear stress	v _{stem} = 0.103 N/	mm² PASS -	Allowable shear	stress tress is less t	_{Vadm} = 5.000 N than maximum	l/mm² shear s
Check shear resistance at Design shear stress Concrete shear stress	v _{stem} = 0.103 N/ v _{c_stem} = 0.468 N	mm² PASS - I/mm²	Allowable shear • Design shear s	stress tress is less t	v _{adm} = 5.000 N than maximum	l/mm² shear s
Check shear resistance at Design shear stress Concrete shear stress	v _{stem} = 0.103 N/ v _{c_stem} = 0.468 N	mm² PASS - I/mm²	Allowable shear • Design shear s • v _{stem} <	stress tress is less t vc_stem - No sl	_{Vadm} = 5.000 N than maximum hear reinforcem	l/mm² shear s nent req
Check shear resistance at Design shear stress Concrete shear stress Design of retaining wall at	v _{stem} = 0.103 N/ v _{c_stem} = 0.468 N mid height	mm² PASS - I/mm²	Allowable shear • Design shear s • v _{stem} <	stress tress is less t vc_stem - No sl	v _{adm} = 5.000 N than maximum hear reinforcem	l/mm² shear s nent req
Check shear resistance at Design shear stress Concrete shear stress Design of retaining wall at Moment at mid height	v _{stem} = 0.103 N/ v _{c_stem} = 0.468 N mid height M _{wall} = 8.5 kNm/	mm² PASS - I/mm² ′m	Allowable shear • Design shear s • v _{stem} <	stress tress is less t v _{c_stem} - No sl	_{Vadm} = 5.000 N than maximum hear reinforcem	l/mm² shear s nent req
Check shear resistance at Design shear stress Concrete shear stress Design of retaining wall at Moment at mid height	v _{stem} = 0.103 N/ v _{c_stem} = 0.468 N mid height M _{wall} = 8.5 kNm.	mm² PASS - I/mm² /m	Allowable shear • Design shear s • v _{stem} < Co	stress tress is less t v _{c_stem} - No sl mpression re	_{Vadm} = 5.000 N than maximum hear reinforcem	l/mm² shear s nent req not req
Check shear resistance at Design shear stress Concrete shear stress Design of retaining wall at Moment at mid height Reinforcement provided Area required	v _{stem} = 0.103 N/ v _{c_stem} = 0.468 N mid height M _{wall} = 8.5 kNm 12 mm dia.bars	mm ² <i>PASS -</i> <i>I</i> /mm ² /m s @ 100 mm ce 0 mm ² /m	Allowable shear Design shear s v _{stem} < Co entres Area provided	stress tress is less t v _{c_stem} - No sl mpression re	v _{adm} = 5.000 N than maximum hear reinforcem einforcement is As well prov = 11	l/mm ² shear s nent req not req 31 mm ²
Check shear resistance at Design shear stress Concrete shear stress Design of retaining wall at Moment at mid height Reinforcement provided Area required	vstem = 0.103 N/ vc_stem = 0.468 M mid height M _{wall} = 8.5 kNm, 12 mm dia.bar A _{s_wall_req} = 520. <i>PASS -</i>	mm ² <i>PASS -</i> I/mm ² 'm s @ 100 mm ce 0 mm ² /m <i>Reinforcemen</i>	Allowable shear Design shear s v _{stem} < Co co entres Area provided t provided to the	stress tress is less t v _{c_stem} - No sl mpression re e retaining wa	Vadm = 5.000 N than maximum hear reinforcem sinforcement is As_wall_prov = 11 all at mid height	l/mm ² shear s nent req not req 31 mm ² t is adeo
Check shear resistance at a Design shear stress Concrete shear stress Design of retaining wall at Moment at mid height Reinforcement provided Area required Check retaining wall deflect	v _{stem} = 0.103 N/ v _{c_stem} = 0.468 M mid height M _{wall} = 8.5 kNm. 12 mm dia.bars A _{s_wall_req} = 520. <i>PASS -</i>	mm ² <i>PASS</i> - I/mm ² /m s @ 100 mm ce 0 mm ² /m <i>Reinforcemen</i>	Allowable shear Design shear s V _{stem} < Co co entres Area provided t provided to the	stress tress is less t v _{c_stem} - No sl mpression re e retaining wa	_{Vadm} = 5.000 N than maximum hear reinforcem sinforcement is A _{s_wall_prov} = 11 all at mid height	l/mm ² shear s nent req not req 31 mm ² t is adeo
Check shear resistance at a Design shear stress Concrete shear stress Design of retaining wall at Moment at mid height Reinforcement provided Area required Check retaining wall deflect Max span/depth ratio	v _{stem} = 0.103 N/ v _{c_stem} = 0.468 N mid height M _{wall} = 8.5 kNm. 12 mm dia.bar A _{s_wall_req} = 520. <i>PASS -</i> tion ratiomax = 40.00	mm ² PASS - I/mm ² /m s @ 100 mm ce 0 mm ² /m Reinforcemen	Allowable shear Design shear s v _{stem} < Co co entres Area provided t provided to the Actual span/dep	stress tress is less to v _{c_stem} - No sl mpression re e retaining wa oth ratio PASS - Span	Vadm = 5.000 N than maximum hear reinforcem sinforcement is As_wall_prov = 11 all at mid height ratioact = 6.52 to depth ratio i	l/mm ² shear s nent req not req 31 mm ² t is adeo s accep



Tekla Tedds	Project	Project 40a Park Hill				Job no. 5016	
	Calcs for	Retaining Wa	ll 3 - Permane	nt	Start page no./F	Start page no./Revision C 41	
	Calcs by NB	Calcs date 7/11/2017	Checked by KH	Checked date	Approved by	Approved date	



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	I _{heel} = 0 mm
Overall length of base	I _{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	$\beta = 0.0 \text{ deg}$	Effective height at back of wall	h _{eff} = 2650 mm
Mobilisation factor	M = 1.5		
Moist density	γm = 21.0 kN/m ³	Saturated density	γs = 23.0 kN/m ³
Design shear strength	φ' = 24.2 deg	Angle of wall friction	δ = 18.6 deg
Design shear strength	φ'ь = 24.2 deg	Design base friction	δь = 18.6 deg
Moist density	γmb = 18.0 kN/m ³	Allowable bearing	P_{bearing} = 105 kN/m ²
Using Coulomb theory			
Active pressure	Ka = 0.369	Passive pressure	Kp = 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



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leads	Calcs for				Start nage no	Start page no./Revision	
		Retaining Wa	ll 3 - Permanent		Start page no.	C 43	
	Calcs by NB	Calcs date 7/11/2017	Checked by KH	Checked date	Approved by	Approved d	
RETAINING WALL DESIGN	N (BS 8002:1994)				TEDDS calculati	on version 1.2.0	
Ultimate limit state load fa	ctors						
Dead load factor	$\gamma_{f_d} = 1.4$		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/r	n					
Design of reinforced conc	rete retaining wall	toe (BS 8002:1	994)				
Material properties			<u>,</u>				
Strength of concrete	f _{cu} = 40 N/mm ²		Strength of rein	forcement	f _y = 500 N/m	1m²	
Base details							
Minimum reinforcement	k = 0.13 %		Cover in toe		_{Ctoe} = 50 mn	n	
400	•••		•••		•		
 400 400 400 45- 	- • • • ← 100-▶	• •	••	• •	•		
Design of retaining wall to	←100-▶ Pe	• •	••	• •	•		
Design of retaining wall to Shear at heel	← 100→ ← 100→ Pe V _{toe} = 91.5 kN/m	••	• •	•••	• Mtoe = 88.6	kNm/m	
Design of retaining wall to Shear at heel		••	• • Moment at heel Co	• •	• Mtoe = 88.6 f reinforcement	kNm/m is not requi	
Design of retaining wall to Shear at heel Check toe in bending	←100→ e V _{toe} = 91.5 kN/m	••	• • Moment at heel Co	• •	• Mtoe = 88.6 F reinforcement	kNm/m is not requi	
Design of retaining wall to Shear at heel Check toe in bending Reinforcement provided	← 100-> ne V _{toe} = 91.5 kN/m B785 mesh	•••	• • Moment at heel Co	• •	• M _{toe} = 88.6 F reinforcement	kNm/m is not requi	
Design of retaining wall to Shear at heel Check toe in bending Reinforcement provided Area required	- 100-→ Pe V _{toe} = 91.5 kN/m B785 mesh A _{s_toe_req} = 621.6	• • • mm²/m PASS - Reir	Moment at heel Co Area provided	• •	• Mtoe = 88.6 F reinforcement As_toe_prov = 7 retaining wall f	kNm/m <i>is not requi</i> 785 mm²/m oe is adequ	
Design of retaining wall to Shear at heel Check toe in bending Reinforcement provided Area required	← 100-> ee V _{toe} = 91.5 kN/m B785 mesh A _{s_toe_req} = 621.6	• • • mm²/m PASS - Rein	• • Moment at heel Co Area provided oforcement prov	• •	• M _{toe} = 88.6 F reinforcement A _{s_toe_prov} = 7 retaining wall t	kNm/m <i>is not requi</i> 785 mm²/m foe is adequ	
Design of retaining wall to Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at Design shear stress	<pre></pre>	• • • mm²/m PASS - Rein m²	Moment at heel Co Area provided forcement prov	• • ompression r vided at the r	• Mtoe = 88.6 F reinforcement As_toe_prov = 7 retaining wall t Vadm = 5.000	kNm/m <i>is not requi</i> 785 mm²/m oe <i>is adequ</i> 0 N/mm²	
Design of retaining wall to Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at Design shear stress	← 100-> ee V _{toe} = 91.5 kN/m B785 mesh A _{s_toe_req} = 621.6 toe v _{toe} = 0.265 N/m	o mm²/m PASS - Rein m² PASS -	Moment at heel Co Area provided oforcement prov Allowable shear Design shears	• • • ompression r vided at the r r stress stress is less	• M _{toe} = 88.6 f reinforcement A _{s_toe_prov} = 7 retaining wall t Vadm = 5.000 than maximut	kNm/m <i>is not requi</i> 785 mm²/m foe is adequ 0 N/mm² m shear stra	
Design of retaining wall to Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at Design shear stress Concrete shear stress	<pre></pre>	o mm²/m PASS - Reir m² PASS - mm²	Moment at heel Co Area provided forcement prov Allowable shear Design shear s	• • ompression r vided at the r r stress stress is less	• M _{toe} = 88.6 H reinforcement A _{s_toe_prov} = 7 retaining wall t Vadm = 5.000 than maximum	kNm/m <i>is not requi</i> 785 mm²/m oe <i>is adequ</i>) N/mm² m shear stra	
Design of retaining wall to Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at Design shear stress Concrete shear stress	-100-→ Pre Vtoe = 91.5 kN/m B785 mesh As_toe_req = 621.6 toe vtoe = 0.265 N/m vc_toe = 0.468 N/	e mm²/m PASS - Rein m² PASS - mm²	• • Moment at heel Co Area provided forcement prov Allowable shear Design shear s Vtoe	• • • ompression r vided at the r r stress stress is less < vc_toe - No s	• M _{toe} = 88.6 F reinforcement A _{s_toe_prov} = 7 retaining wall t V _{adm} = 5.000 than maximum shear reinforce	kNm/m is not requi 785 mm²/m oe is adequ) N/mm² m shear stra ement requi	
Design of retaining wall to Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at Design shear stress Concrete shear stress Design of reinforced conc	<pre></pre>	• •	Moment at heel Co Area provided oforcement prov Allowable shear Design shear s Vtoe 2:1994)	• • • ompression r vided at the r r stress stress is less < v _{c_toe} - No s	• M _{toe} = 88.6 f reinforcement A _{s_toe_prov} = 7 retaining wall t V _{adm} = 5.000 than maximum shear reinforce	kNm/m is not requi 785 mm²/m oe is adequ) N/mm² m shear stra ement requi	
Design of retaining wall to Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at Design shear stress Concrete shear stress Design of reinforced conc Material properties	← 100-> Pe V _{toe} = 91.5 kN/m B785 mesh A _{s_toe_req} = 621.6 v _{toe} = 0.265 N/m v _{c_toe} = 0.468 N/ rete retaining wall	• • • • mm²/m PASS - Rein m² PASS - mm² stem (BS 8002	• • Moment at heel Co Area provided of orcement prov Allowable shear Design shear s Vtoe 2:1994)	• • • ompression r vided at the r r stress stress is less stress is less < v _{c_toe} - No s	• M _{toe} = 88.6 f reinforcement A _{s_toe_prov} = 7 retaining wall t V _{adm} = 5.000 than maximum shear reinforce	kNm/m is not requi 785 mm²/m oe is adequ) N/mm² m shear stra ement requi	
Design of retaining wall to Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at Design shear stress Concrete shear stress Design of reinforced conc Material properties Strength of concrete	<pre></pre>	• • • • mm²/m PASS - Rein m² PASS - mm² stem (BS 8002	Moment at heel Co Area provided oforcement prov Allowable shear Design shear s Vroe 2:1994) Strength of rein	• • • ompression r vided at the r r stress stress is less < v _{c_toe} - No s forcement	• M _{toe} = 88.6 H reinforcement A _{s_toe_prov} = 7 retaining wall t v _{adm} = 5.000 than maximum shear reinforce f _y = 500 N/m	kNm/m is not requi 785 mm²/m foe is adequ 0 N/mm² m shear str ement requi	
Design of retaining wall to Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at Design shear stress Concrete shear stress Concrete shear stress Strength of concrete Wall details	<pre></pre>	• • • • mm²/m PASS - Reir m² PASS - mm² stem (BS 8002	Moment at heel Co Area provided oforcement prov Allowable shear Design shear s Vtoe 2:1994) Strength of rein	• • • ompression r vided at the r r stress stress is less stress is less stress is less forcement	• M _{toe} = 88.6 H reinforcement A _{s_toe_prov} = 7 retaining wall t V _{adm} = 5.000 than maximum shear reinforce f _y = 500 N/m	kNm/m is not requi 785 mm²/m oe is adequ 0 N/mm² m shear stru ement requi 1m²	
Design of retaining wall to Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance at Design shear stress Concrete shear stress Concrete shear stress Design of reinforced conc Material properties Strength of concrete Wall details Minimum reinforcement	← 100-> Pe Vtoe = 91.5 kN/m B785 mesh As_toe_req = 621.6 toe vtoe = 0.265 N/m vc_toe = 0.468 N/ rete retaining wall fcu = 40 N/mm ² k = 0.13 %	• • • • mm²/m PASS - Rein m² PASS - mm² stem (BS 8002	Moment at heel Co Area provided of orcement prov Allowable shear Design shear s Vtoe 2:1994) Strength of rein	• • • ompression r vided at the r r stress stress is less < v _{c_toe} - No s forcement	• Mtoe = 88.6 H reinforcement As_toe_prov = 7 retaining wall t Vadm = 5.000 than maximum shear reinforce fy = 500 N/m	kNm/m is not requi 785 mm²/m ioe is adequ 0 N/mm² m shear stra ement requi 1m²	

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		Retaining Wa	ll 3 - Permanent		C	44
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Design of retaining wall sten	n					
Shear at base of stem	V _{stem} = 13.5 kN/	'n	Moment at base	e of stem	M _{stem} = 66.1 k	Nm/m
			Co	mpression rei	nforcement is	not required
Check wall stem in bending						
Reinforcement provided	B785 mesh	- 0.				
Area required	As_stem_req = 652	.5 mm²/m	Area provided		$A_{s_{stem_{prov}}} = 7$	' 85 mm²/m
.		PASS - Reinto	prcement provid	ed at the retai	ning wall sten	n is adequate
Check shear resistance at w	all stem	2				1 / 2
Design shear stress	Vstem = 0.055 N/	mm² ₽499.	Allowable shears	stress	$V_{adm} = 5.000$ i	N/MM² shoar stross
Concrete shear stress	Vc stem = 0.572 N	/ 433 - 1/mm²	Design shear s	11633 13 1633 11		311601 311633
			Vstem <	vc_stem - No sh	ear reinforcen	nent required
Check retaining wall deflecti	ion					
Max span/depth ratio	ratio _{max} = 9.68		Actual span/dep	oth ratio	ratio _{act} = 9.18	
				PASS - Span t	o depth ratio	is acceptable



Tekla Tedds	Project	Project 40a Park Hill				Job no. 5016	
	Calcs for	Retaining V	Vall 3 - Temp		Start page no./R C	Start page no./Revision C 46	
	Calcs by NB	Calcs date 7/11/2017	Checked by KH	Checked date	Approved by	Approved date	



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	I _{heel} = 0 mm
Overall length of base	I _{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	γm = 21.0 kN/m ³	Saturated density	γs = 23.0 kN/m ³
Design shear strength	φ' = 24.2 deg	Angle of wall friction	δ = 18.6 deg
Design shear strength	φ'ь = 24.2 deg	Design base friction	δь = 18.6 deg
Moist density	γmb = 18.0 kN/m ³	Allowable bearing	$P_{bearing}$ = 105 kN/m ²
Using Coulomb theory			
Active pressure	Ka = 0.369	Passive pressure	Kp = 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



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Tedds		40a F	Park Hill		50	016
	Calcs for R	etaining \	Vall 3 - Temp		Start page no./R C	evision 48
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RETAINING WALL DESIG	N (BS 8002:1994)				TEDDS calculation	1 version 1.2.01.0
Ultimate limit state load fa	actors					
Dead load factor	$\gamma_{f_d} = 1.4$		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	s to top and base of wall					
Propping force to top of wa	II Fprop_top_f = -0.257 kN/	m	Propping force	to base of wall	Fprop_base_f = 5	3.211 kN/m
Design of reinforced con	crete retaining wall toe (E	3S 8002:1	(994)			
Material properties						
Strength of concrete	$f_{cu} = 40 \text{ N/mm}^2$		Strength of rein	forcement	f _v = 500 N/mn	n ²
Pasa dataila			etterigtit et terit		iy 000 iiiiii	•
Minimum reinforcement	k = 0 13 %		Cover in toe		$c_{\text{trac}} = 50 \text{ mm}$	
▲ ▲ 400- 4400-	<pre>></pre>	• •			•	
	← 100- →					
Design of retaining wall to Shear at heel	oe V _{toe} = 86.9 kN/m		Moment at heel	mpression re	M _{toe} = 78.9 kN inforcement is	Nm/m a not require
Check toe in bending				-		-
Reinforcement provided	B785 mesh					
Area required	A _{s_toe_req} = 553.1 mm ² <i>PA</i>	/m SS - Reir	Area provided aforcement prov	ided at the ret	A _{s_toe_prov} = 78	85 mm²/m e <i>is adequat</i>
Check shear resistance a	t toe		-		-	-
Design shear stress	v _{toe} = 0.252 N/mm ²	PASS	Allowable shear	stress tress is less t	v _{adm} = 5.000 N han maximum	N/mm² shear stres
Concrete shear stress	v _{c_toe} = 0.468 N/mm ²		_ ce.g., circui d	< Va tas - No sh	ear reinforcen	nent require
Dealers of solutions of solutions				<u>.</u>		
Design of reinforced cond	crete retaining wall stem	(82 8002	(:1994)			
Material properties				r		2
Strength of concrete	t _{cu} = 40 N/mm ²		Strength of rein	torcement	t _y = 500 N/mn	۱ ^ـ
Wall details						
Minimum reinforcement	k = 0.13 %					
Cover in stem	Cstem = 50 mm		Cover in wall		_{Cwall} = 50 mm	

		Project 40a Park Hill			
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Design of retaining wall st	am				
Beolgin of retaining wan of	5111				
Shear at base of stem	V _{stem} = 48.4 kN/m	Moment at base of stem	M _{stem} = 21.7 kNm/m		
Shear at base of stem	V _{stem} = 48.4 kN/m	Moment at base of stem Compressic	M _{stem} = 21.7 kNm/m on reinforcement is not required		
Check wall stem in bendin Reinforcement provided	V _{stem} = 48.4 kN/m g B785 mesh	Moment at base of stem Compressic	M _{stem} = 21.7 kNm/m on reinforcement is not required		
Shear at base of stem Check wall stem in bendin Reinforcement provided Area required	V _{stem} = 48.4 kN/m g B785 mesh A _{s_stem_req} = 390.0 mm ² /m	Moment at base of stem Compressio Area provided	M _{stem} = 21.7 kNm/m on reinforcement is not required A _{s_stem_prov} = 785 mm ² /m		
Shear at base of stem Check wall stem in bendin Reinforcement provided Area required Check shear resistance at	V _{stem} = 48.4 kN/m g B785 mesh A _{s_stem_} req = 390.0 mm ² /m <i>PASS - Reii</i> wall stem	Moment at base of stem <i>Compressio</i> Area provided nforcement provided at the	M _{stem} = 21.7 kNm/m on reinforcement is not required A _{s_stem_prov} = 785 mm ² /m a retaining wall stem is adequate		
Shear at base of stem Check wall stem in bendin Reinforcement provided Area required Check shear resistance at Design shear stress	V _{stem} = 48.4 kN/m g B785 mesh A _{s_stem_} req = 390.0 mm ² /m <i>PASS - Rein</i> wall stem _{Vstem} = 0.198 N/mm ²	Moment at base of stem Compressio Area provided aforcement provided at the Allowable shear stress	M _{stem} = 21.7 kNm/m on reinforcement is not required A _{s_stem_prov} = 785 mm ² /m o retaining wall stem is adequate v _{adm} = 5.000 N/mm ²		
Shear at base of stem Check wall stem in bendin Reinforcement provided Area required Check shear resistance at Design shear stress	V _{stem} = 48.4 kN/m 9 B785 mesh A _{s_stem_req} = 390.0 mm ² /m <i>PASS - Rein</i> wall stem v _{stem} = 0.198 N/mm ² <i>PASS</i>	Moment at base of stem Compression Area provided Aforcement provided at the Allowable shear stress S - Design shear stress is lo	M _{stem} = 21.7 kNm/m on reinforcement is not required A _{s_stem_prov} = 785 mm ² /m or retaining wall stem is adequate v _{adm} = 5.000 N/mm ² fess than maximum shear stress		
Shear at base of stem Check wall stem in bendin Reinforcement provided Area required Check shear resistance at Design shear stress Concrete shear stress	V _{stem} = 48.4 kN/m g B785 mesh A _{s_stem_req} = 390.0 mm ² /m <i>PASS - Rein</i> wall stem v _{stem} = 0.198 N/mm ² <i>PASS</i> v _{c_stem} = 0.572 N/mm ²	Moment at base of stem <i>Compressio</i> Area provided nforcement provided at the Allowable shear stress S - Design shear stress is I v _{stem} < v _{c_stem} - N	M _{stem} = 21.7 kNm/m on reinforcement is not required A _{s_stem_prov} = 785 mm ² /m or retaining wall stem is adequate v _{adm} = 5.000 N/mm ² fess than maximum shear stress No shear reinforcement required		
Shear at base of stem Check wall stem in bendin Reinforcement provided Area required Check shear resistance at Design shear stress Concrete shear stress Design of retaining wall at	V _{stem} = 48.4 kN/m g B785 mesh A _{s_stem_req} = 390.0 mm ² /m <i>PASS - Rein</i> wall stem v _{stem} = 0.198 N/mm ² <i>PASS</i> v _{c_stem} = 0.572 N/mm ² mid height	Moment at base of stem <i>Compressio</i> Area provided <i>aforcement provided at the</i> Allowable shear stress S - Design shear stress is Io v _{stem} < v _{c_stem} - N	M _{stem} = 21.7 kNm/m on reinforcement is not required A _{s_stem_prov} = 785 mm ² /m retaining wall stem is adequate v _{adm} = 5.000 N/mm ² ess than maximum shear stress No shear reinforcement required		
Shear at base of stem Check wall stem in bendin Reinforcement provided Area required Check shear resistance at Design shear stress Concrete shear stress Design of retaining wall at Moment at mid height	Vstem = 48.4 kN/m g B785 mesh As_stem_req = 390.0 mm ² /m <i>PASS - Rein</i> wall stem vstem = 0.198 N/mm ² <i>PASS</i> vc_stem = 0.572 N/mm ² mid height Mwall = 11.5 kNm/m	Moment at base of stem Compression Area provided Aforcement provided at the Allowable shear stress S - Design shear stress is for Vstem < Vc_stem - N	M _{stem} = 21.7 kNm/m on reinforcement is not required A _{s_stem_prov} = 785 mm ² /m o retaining wall stem is adequate v _{adm} = 5.000 N/mm ² tess than maximum shear stress No shear reinforcement required		
Shear at base of stem Check wall stem in bendin Reinforcement provided Area required Check shear resistance at Design shear stress Concrete shear stress Design of retaining wall at Moment at mid height Reinforcement provided	Vstem = 48.4 kN/m g B785 mesh As_stem_req = 390.0 mm ² /m <i>PASS - Reii</i> wall stem vstem = 0.198 N/mm ² <i>PASS</i> vc_stem = 0.572 N/mm ² mid height Mwall = 11.5 kNm/m 12 mm dia.bars @ 100 mm	Moment at base of stem Compression Area provided Inforcement provided at the Allowable shear stress S - Design shear stress is In V _{stem} < v _{c_stem} - N Compression centres	M _{stem} = 21.7 kNm/m on reinforcement is not required A _{s_stem_prov} = 785 mm ² /m or retaining wall stem is adequate v _{adm} = 5.000 N/mm ² dess than maximum shear stress No shear reinforcement required		
Shear at base of stem Check wall stem in bendin Reinforcement provided Area required Check shear resistance at Design shear stress Concrete shear stress Design of retaining wall at Moment at mid height Reinforcement provided Area required	Vstem = 48.4 kN/m g B785 mesh As_stem_req = 390.0 mm ² /m <i>PASS - Rein</i> wall stem vstem = 0.198 N/mm ² <i>PASS</i> vc_stem = 0.572 N/mm ² mid height Mwall = 11.5 kNm/m 12 mm dia.bars @ 100 mm As_wall_req = 390.0 mm ² /m	Moment at base of stem Compression Area provided Aforcement provided at the Allowable shear stress S - Design shear stress is for vstem < vc_stem - N Compression centres Area provided	$M_{stem} = 21.7 \text{ kNm/m}$ on reinforcement is not required $A_{s_stem_prov} = 785 \text{ mm}^2/\text{m}$ or retaining wall stem is adequate $v_{adm} = 5.000 \text{ N/mm}^2$ ess than maximum shear stress No shear reinforcement required on reinforcement is not required $A_{s_wall_prov} = 1131 \text{ mm}^2/\text{m}$		
Shear at base of stem Check wall stem in bendin Reinforcement provided Area required Check shear resistance at Design shear stress Concrete shear stress Design of retaining wall at Moment at mid height Reinforcement provided Area required	Vstem = 48.4 kN/m 9 B785 mesh As_stem_req = 390.0 mm ² /m <i>PASS - Rein</i> wall stem vstem = 0.198 N/mm ² <i>PASS</i> vc_stem = 0.572 N/mm ² mid height Mwall = 11.5 kNm/m 12 mm dia.bars @ 100 mm As_wall_req = 390.0 mm ² /m <i>PASS - Reinforceme</i>	Moment at base of stem Compression Area provided offorcement provided at the Allowable shear stress S - Design shear stress is lo vstem < vc_stem - N Compression centres Area provided ent provided to the retainin	$M_{stem} = 21.7 \text{ kNm/m}$ on reinforcement is not required $A_{s_stem_prov} = 785 \text{ mm}^2/\text{m}$ or retaining wall stem is adequate $v_{adm} = 5.000 \text{ N/mm}^2$ dess than maximum shear stress No shear reinforcement required $A_{s_wall_prov} = 1131 \text{ mm}^2/\text{m}$ og wall at mid height is adequate		
Shear at base of stem Check wall stem in bendin Reinforcement provided Area required Check shear resistance at Design shear stress Concrete shear stress Design of retaining wall at Moment at mid height Reinforcement provided Area required Check retaining wall deflect	Vstem = 48.4 kN/m g B785 mesh As_stem_req = 390.0 mm ² /m <i>PASS - Rein</i> wall stem vstem = 0.198 N/mm ² <i>PASS</i> vc_stem = 0.572 N/mm ² mid height Mwall = 11.5 kNm/m 12 mm dia.bars @ 100 mm As_wall_req = 390.0 mm ² /m <i>PASS - Reinforceme</i> ction	Moment at base of stem Compression Area provided aforcement provided at the Allowable shear stress S - Design shear stress is low vstem < vc_stem - N Compression centres Area provided ant provided to the retainin	$M_{stem} = 21.7 \text{ kNm/m}$ on reinforcement is not required $A_{s_stem_prov} = 785 \text{ mm}^2/\text{m}$ retaining wall stem is adequate $v_{adm} = 5.000 \text{ N/mm}^2$ less than maximum shear stress No shear reinforcement required on reinforcement is not required $A_{s_wall_prov} = 1131 \text{ mm}^2/\text{m}$ og wall at mid height is adequate		



두 Tekla	Project			Job no.	Job no.	
Tedds	40a Park Hill				5016	
	Calcs for				Start page no./F	Revision
	Retaining Wall 5 - Permanent			C 51		
	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	NB	7/11/2017	КН			



Train dotanio			
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	I _{heel} = 0 mm
Overall length of base	I _{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	$\gamma_{base} = 24.0 \text{ kN/m}^3$
Angle of soil surface	$\beta = 0.0 \text{ deg}$	Effective height at back of wall	h _{eff} = 2650 mm
Mobilisation factor	M = 1.5		
Moist density	γm = 21.0 kN/m ³	Saturated density	γs = 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	δь = 18.6 deg
Moist density	γmb = 18.0 kN/m ³	Allowable bearing	$P_{bearing}$ = 105 kN/m ²
Using Coulomb theory			
Active pressure	Ka = 0.369	Passive pressure	Kp = 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


두 Tekla	Project	40			Job no.	5040	
Tedds		40a Park Hill				5016	
	Calcs for	Retaining Wa	Vall 5 - Permanent		Start page no./Revision C 53		
	Calcs by NB	Calcs date 7/11/2017	Checked by KH	Checked date	Approved by	Approved o	
RETAINING WALL DESIG	GN (BS 8002:1994)				TEDDS calculati	on version 1.2.0	
Ultimate limit state load	factors						
Dead load factor	$\gamma_{f_d} = 1.4$		Live load factor		γ _{f_1} = 1.6		
Earth pressure factor	γ _{f_e} = 1.4						
Calculate propping force Propping force	F _{prop} = 11.8 kN/r	n					
Design of reinforced con	crete retaining wall	toe (BS 8002:′	1994)				
Material properties	_						
Strength of concrete	f _{cu} = 40 N/mm ²		Strength of rein	forcement	f _y = 500 N/m	nm²	
Base details							
Minimum reinforcement	k = 0.13 %		Cover in toe		_{Ctoe} = 50 mm	n	
400							
▲ 400 ■ 345					•		
Design of retaining wall Shear at heel	-100-→ toe V _{toe} = 90.4 kN/m	•••	• •	•••	• Mtoe = 88.4 H	kNm/m	
Design of retaining wall Shear at heel	- 100→ toe V _{toe} = 90.4 kN/m	•••	• • Moment at heel	• •	Mtoe = 88.4 H reinforcement	kNm/m <i>is not requ</i>	
Design of retaining wall Shear at heel Check toe in bending	-100→ toe V _{toe} = 90.4 kN/m	•••	• • Moment at heel Co	• •	• Mtoe = 88.4 H reinforcement	kNm/m <i>is not requ</i>	
Design of retaining wall Shear at heel Check toe in bending Reinforcement provided		•••	• • Moment at heel Co	• •	Mtoe = 88.4 H reinforcement	kNm/m <i>is not requ</i>	
Design of retaining wall Shear at heel Check toe in bending Reinforcement provided Area required	Intering the state of the stat	• •	Moment at heel Co Area provided	• •	• Mtoe = 88.4 H reinforcement As_toe_prov = 7	kNm/m <i>is not requ</i> 785 mm²/m	
Design of retaining wall Shear at heel Check toe in bending Reinforcement provided Area required	← 100→ toe V _{toe} = 90.4 kN/m B785 mesh A _{s_toe_req} = 619.9	• • • • mm²/m PASS - Rein	• • Moment at heel Co Area provided nforcement prov	• •	• Mtoe = 88.4 H reinforcement As_toe_prov = 7 retaining wall t	kNm/m <i>is not requ</i> 785 mm²/m foe is adequ	
Design of retaining wall Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance a Design shear stress	<pre></pre>	• • 'mm²/m PASS - Rei i	• • Moment at heel Co Area provided oforcement prov	• •	• Mtoe = 88.4 H reinforcement As_toe_prov = 7 retaining wall t Vote = 5.000	kNm/m <i>is not requ</i> 785 mm²/m foe is adequ	
Design of retaining wall Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance a Design shear stress	<pre></pre>	mm²/m PASS - Rein m² PASS -	• • Moment at heel Co Area provided nforcement prov Allowable shear Design shears	• • ompression r vided at the r r stress stress is less	Mtoe = 88.4 H reinforcement As_toe_prov = 7 retaining wall t Vadm = 5.000 than maximut	kNm/m <i>is not requ</i> 785 mm²/m foe is adequ 0 N/mm² m shear stu	
Design of retaining wall Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance a Design shear stress Concrete shear stress	<pre></pre>	mm²/m PASS - Rein m² PASS - mm²	• • Moment at heel Co Area provided nforcement prov Allowable shear Design shear s	• • • ompression r vided at the r r stress stress is less stress is less	• Mtoe = 88.4 H reinforcement As_toe_prov = 7 retaining wall t Vadm = 5.000 than maximum shear reinforce	kNm/m is not requ 785 mm²/m foe is adequ 0 N/mm² m shear str ement requ	
Design of retaining wall Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance a Design shear stress Concrete shear stress	<pre></pre>	mm²/m PASS - Rein m² PASS - mm²	• • Moment at heel Co Area provided nforcement prov Allowable shear Design shear s Vtoe	• • ompression r vided at the r r stress stress is less stress is less < vc_toe - No s	M _{toe} = 88.4 k reinforcement A _{s_toe_prov} = 7 retaining wall t v _{adm} = 5.000 than maximut shear reinforce	kNm/m <i>is not requ</i> 785 mm²/m foe is adequ 0 N/mm² m shear str ement requ	
Design of retaining wall Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance a Design shear stress Concrete shear stress Design of reinforced com	Itoe Vtoe = 90.4 kN/m B785 mesh As_toe_req = 619.9 at toe vtoe = 0.262 N/m vc_toe = 0.468 N/m Crete retaining wall	• • • • mm²/m • PASS - Reii m² • PASS - mm² • stem (BS 8002	Moment at heel Co Area provided nforcement prov Allowable shear Design shear s Vtoe 2:1994)	• • • ompression r vided at the r r stress stress is less stress is less < vc_toe - No s	• M _{toe} = 88.4 k reinforcement A _{s_toe_prov} = 7 retaining wall t V _{adm} = 5.000 s than maximum shear reinforce	kNm/m is not requ 785 mm²/m foe is adequ 0 N/mm² m shear str ement requ	
Design of retaining wall Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance a Design shear stress Concrete shear stress Design of reinforced com Material properties Strength of concrete	Interest end of the second	• • • • mm²/m PASS - Reir m² PASS • mm² Stem (BS 8002	• • Moment at heel Co Area provided nforcement prov Allowable shear Design shear s Vtoe 2:1994) Strength of rein	• • • ompression r vided at the r r stress stress is less stress is less stress is less stress is less stress is less stress is less	• Mtoe = 88.4 H reinforcement As_toe_prov = 7 retaining wall t Vadm = 5.000 than maximum shear reinforce fu = 500 N/m	kNm/m <i>is not requ</i> 785 mm²/m foe <i>is adequ</i> 0 N/mm² <i>m shear str</i> <i>ement requ</i>	
Design of retaining wall Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance a Design shear stress Concrete shear stress Design of reinforced com Material properties Strength of concrete Wall data:	Itoe Vtoe = 90.4 kN/m B785 mesh As_toe_req = 619.9 at toe vtoe = 0.262 N/m vc_toe = 0.468 N/m fcu = 40 N/mm ²	• • • • mm²/m • PASS - Reii m² • PASS - mm² • stem (BS 8002	Moment at heel Co Area provided nforcement prov Allowable shear Design shear s Vtoe 2:1994) Strength of rein	• • • ompression r vided at the r r stress stress is less stress is less stress is less stress is less stress is less stress is less stress is less	• M _{toe} = 88.4 H reinforcement A _{s_toe_prov} = 7 retaining wall t V _{adm} = 5.000 than maximum shear reinforce f _y = 500 N/m	kNm/m <i>is not requ</i> 785 mm²/m foe <i>is adequ</i> 0 N/mm² <i>m shear sti</i> <i>ement requ</i> 11m²	
Design of retaining wall Shear at heel Check toe in bending Reinforcement provided Area required Check shear resistance a Design shear stress Concrete shear stress Concrete shear stress Design of reinforced com Material properties Strength of concrete Wall details Minimum reinforcement	<pre></pre>	• • • • mm²/m PASS - Rein m² PASS - mm² stem (BS 8002	• • Moment at heel Co Area provided nforcement prov Allowable shear • Design shear s Vtoe 2:1994) Strength of rein	• • • ompression r rided at the r r stress stress is less stress is less stress is less stress is less stress is less stress is less stress is less	• Mtoe = 88.4 H reinforcement As_toe_prov = 7 retaining wall t Vadm = 5.000 than maximum shear reinforce fy = 500 N/m	kNm/m <i>is not requ</i> 785 mm²/m foe <i>is adequ</i> 0 N/mm² <i>m shear str</i> <i>ement requ</i> 11m²	

Tekl a [®]	Project Job no. 40a Park Hill 5016			
redus	Calcs for		Start page no./Revision	
	Retaining W	Vall 5 - Permanent	C 54	
	Calcs by Calcs date	Checked by Checked date	Approved by Approved date	
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	∢ -100- >			
Design of retaining wall s	tem			
Shear at base of stem	V _{stem} = 14.5 kN/m	Moment at base of stem	M _{stem} = 66.1 kNm/m	
		Compression r	einforcement is not required	
Check wall stem in bendir	ng Daor an h			
Reinforcement provided	B785 mesh $-562.5 \text{ mm}^2/\text{m}$	Area provided	∧ – 795 mm ² /m	
Area required	As_stem_req = 652.5 mm ⁻ /m PASS - Reju	Area provided at the ref	As_stem_prov = 785 mm²/m	
Chack chack registered of	Augustam	noreement provided at the ret	unning wan stein is adequate	
Design shear stress	$v_{stem} = 0.059 \text{ N/mm}^2$	Allowable shear stress	$V_{adm} = 5.000 \text{ N/mm}^2$	
Design shear stress	PAS	S - Design shear stress is less than maximum shear st		
Concrete shear stress	vc_stem = 0.572 N/mm ²	0		
		Vstem < Vc_stem - No s	shear reinforcement required	
Check retaining wall defle	ction			
Max span/depth ratio	ratio _{max} = 9.68	Actual span/depth ratio PASS - Spar	ratio _{act} = 9.18 n 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 56	
	Calcs by NB	Calcs date 7/11/2017	Checked by KH	Checked date	Approved by	Approved date



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	I _{heel} = 0 mm
Overall length of base	I _{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	$\gamma_{wall} = 24.0 \text{ kN/m}^3$	Density of base construction	$\gamma_{base} = 24.0 \text{ kN/m}^3$
Angle of soil surface	$\beta = 0.0 \text{ deg}$	Effective height at back of wall	h _{eff} = 2650 mm
Mobilisation factor	M = 1.5		
Moist density	γm = 21.0 kN/m ³	Saturated density	γs = 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	γmb = 18.0 kN/m ³	Allowable bearing	$P_{bearing}$ = 105 kN/m ²
Using Coulomb theory			
Active pressure	Ka = 0.369	Passive pressure	Kp = 4.187
At-rest pressure	Ko = 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



🗲 Tekla	Project				Job no.		
Tedds		40a Park Hill				5016	
	Calcs for R	etaining \	Vall 5 - Temp		Start page no./R C	evision 58	
	Calcs by Calcs NB 7/	^{date} 11/2017	Checked by KH	Checked date	Approved by	Approved date	
RETAINING WALL DESIG	N (BS 8002:1994 <u>)</u>				TEDDS calculation	1 version 1.2.01.0	
Ultimate limit state load f	actors						
Dead load factor	$\gamma_{f_d} = 1.4$		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	s to top and base of wall						
Propping force to top of wa	ing force to top of wall $F_{prop_top_f} = -7.539 \text{ kN/m}$		Propping force	to base of wall	F _{prop_base_f} = 34.513 kN/m		
Design of reinforced con	crete retaining wall toe (I	3S 8002:1	(994)				
Matarial proparties	<u> </u>						
Strength of concrete	$f_{m} = 40 \text{ N/mm}^2$		Strength of rein	forcement	$f_{\rm v} = 500 {\rm N}/{\rm mm}^2$		
			ouchgar of fem			1	
Minimum reinforcement	k - 0 13 %		Cover in toe		out = 50 mm		
▲ 400 ▲ 345-	_ 	•••			•		
	∢ -100- >						
Design of retaining wall t Shear at heel	oe V _{toe} = 80.1 kN/m		Moment at heel Co	mpression re	Mtoe = 68.7 kN inforcement is	Nm/m ≋ not require ∉	
Check toe in bending							
Reinforcement provided	B785 mesh						
Area required	As_toe_req = 520.0 mm ² PA	/m SS - Reir	Area provided	ided at the ret	As_toe_prov = 78	85 mm²/m e is adequat	
Chack shear recistance a	t toe						
Design shear stress	$V_{\text{toe}} = 0.232 \text{ N/mm}^2$		Allowable shear	stress	Vadm = 5.000 N	N/mm ²	
Design anear areas	VIDE - U.LUL IN/IIIII	PASS	· Design shear s	tress is less t	han maximum	shear stres	
Concrete shear stress	vc_toe = 0.468 N/mm ²		Vice	< Va taa - Na ch	ear reinforcen	nent require	
Design of reinforced con-	crata rataining wall stom	(BS 8004	0.1994)				
	ciele relatiting wall stem	(03 0002					
Material properties	$f_{\rm m} = 40 \mathrm{N}/\mathrm{mm}^2$		Strength of roin	forcement	f. = 500 N/mm	n ²	
	icu — 4∪ in/iii [[] ⁻		Strength of relf	orcement	iy - 300 N/M	1	
Wall details							
	$\mathbf{r} = 0.13 \ 70$		Cover in wall		Cural = 50 mm		

Tedas	40;	Job no. 5016			
	Calcs for		Start page no./Revision C 59		
	Calcs by Calcs date	Checked by Checked date	C 59 Approved by Approved date		
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Design of retaining wall ste	∍m				
Shear at base of stem	V _{stem} = 35.1 kN/m	Moment at base of stem Compression	M _{stem} = 15.2 kNm/m reinforcement is not required		
Check wall stem in bending	9				
Reinforcement provided	B785 mesh				
Area required	As_stem_req = 390.0 mm²/m PASS - Rei t	Area provided nforcement provided at the re	As_stem_prov = 785 mm²/m etaining wall stem is adequate		
Check shear resistance at	wall stem	·····			
Design shear stress	v _{stem} = 0.143 N/mm ²	Allowable shear stress	$v_{adm} = 5.000 \text{ N/mm}^2$		
Concrete shear stress	Vc stem = 0.572 N/mm ²	5 - Design shear stress is les	s than maximum shear stress		
	··	v _{stem} < v _{c_stem} - No	shear reinforcement required		
			eneur rennereennene requirea		
Design of retaining wall at	mid height		encar remercement required		
Design of retaining wall at Moment at mid height	mid height M _{wall} = 7.8 kNm/m	0			
Design of retaining wall at Moment at mid height Reinforcement provided	mid height M _{wall} = 7.8 kNm/m 12 mm dia bars @ 100 mm	Compression	reinforcement is not required		
Design of retaining wall at Moment at mid height Reinforcement provided Area required	mid height M _{wall} = 7.8 kNm/m 12 mm dia.bars @ 100 mm A _{s_wall_req} = 390.0 mm ² /m	Compression centres Area provided	reinforcement is not required As_wall_prov = 1131 mm ² /m		
Design of retaining wall at Moment at mid height Reinforcement provided Area required	mid height M _{wall} = 7.8 kNm/m 12 mm dia.bars @ 100 mm A _{s_wall_req} = 390.0 mm ² /m <i>PASS - Reinforceme</i>	Compression centres Area provided ant provided to the retaining	reinforcement is not required As_wall_prov = 1131 mm²/m wall at mid height is adequate		
Design of retaining wall at Moment at mid height Reinforcement provided Area required Check retaining wall deflec	mid height Mwall = 7.8 kNm/m 12 mm dia.bars @ 100 mm As_wall_req = 390.0 mm ² /m <i>PASS - Reinforceme</i> tion	Compression centres Area provided ent provided to the retaining	reinforcement is not required As_wall_prov = 1131 mm²/m wall at mid height is adequate		
Design of retaining wall at Moment at mid height Reinforcement provided Area required Check retaining wall deflec Max span/depth ratio	mid height M _{wall} = 7.8 kNm/m 12 mm dia.bars @ 100 mm A _{s_wall_req} = 390.0 mm ² /m <i>PASS - Reinforceme</i> tion ratiomax = 40.00	Compression centres Area provided ent provided to the retaining Actual span/depth ratio	reinforcement is not required A _{s_wall_prov} = 1131 mm ² /m wall at mid height is adequate ratio _{act} = 9.18		

