Project number:	TH LODGE	Povision	elliottwood
2170605	5	nevision,	
Date:	Engineer:	Checked:	
	RETAINING WALL	DESIGNS CALCUL	ATION
	7 350 8	C Desamuel in	
	200		
	-7 500mm Te	DE DOWELLED	INTO SLAB
	> PROPED TOP	+ BOTTOM IN	TEMPORARY CASE
	> NEW GROUND	FLOOR SCAB F	props top
	- FROUND RETA	INSO ACIOSS FU	L HEIGHT
	> DESIGN	out from Sit	E INVESTIGATION
	> LINE LOAD NEW RC	ACTING UPON G-ROUND BLAN	STEM FROM
	DL=	20 ku/m	
	LL =	10 KN/m	
	-> AT REST PRESCU	as Contractor pp	PLIED TO GOIL
	SEE TEDDS	CALCUCATION	OVERLEAF
	=>		
		*	

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<b>Tekla</b> <sup>®</sup> Tedds	Project	South	Lodge		Job no. 2170	)605
Elliott Wood 46-48	Calcs for	Retaini	Retaining Wall		Start page no./Re	vision 1
London	Calcs by W	Calcs date	Checked by	Checked date	Approved by	Approved date

# **RETAINING WALL ANALYSIS**

In accordance with EN1997-1:2004 incorporating Corrigendum dated February 2009 and the UK National Annex incorporating Corrigendum No.1

Tedds calculation version 2.9.00

Retaining wall details	
Stem type	Propped cantilever
Stem height	h <sub>stem</sub> = <b>3300</b> mm
Prop height	h <sub>prop</sub> = <b>3300</b> mm
Stem thickness	t <sub>stem</sub> = <b>350</b> mm
Angle to rear face of stem	α = <b>90</b> deg
Stem density	$\gamma_{\text{stem}}$ = 25 kN/m <sup>3</sup>
Toe length	I <sub>toe</sub> = <b>1500</b> mm
Base thickness	t <sub>base</sub> = <b>350</b> mm
Base density	$\gamma_{\text{base}}$ = 25 kN/m <sup>3</sup>
Height of retained soil	h <sub>ret</sub> = <b>3300</b> mm
Angle of soil surface	$\beta = 0 \deg$
Depth of cover	d <sub>cover</sub> = <b>0</b> mm
Retained soil properties	
Moist density	γ <sub>mr</sub> = <b>20</b> kN/m <sup>3</sup>
Saturated density	γ <sub>sr</sub> = <b>22.3</b> kN/m <sup>3</sup>
Base soil properties	
Soil type	Medium dense well graded sand and gravel
Soil density	γ <sub>b</sub> = <b>20</b> kN/m <sup>3</sup>
Presumed bearing capacity	P <sub>bearing</sub> = 90 kN/m <sup>2</sup>
Loading details	
Permanent surcharge load	Surcharge <sub>G</sub> = 2.5 kN/m <sup>2</sup>
Variable surcharge load	Surcharge <sub>Q</sub> = 5 kN/m <sup>2</sup>
Vertical line load at 1675 mm	P <sub>G1</sub> = <b>70</b> kN/m
	P <sub>Q1</sub> = <b>10</b> kN/m





Length of surcharge load

- Distance to vertical component

Effective height of wall

- Distance to horizontal component Area of wall stem

- Distance to vertical component Area of wall base

- Distance to vertical component

# Soil coefficients

Coefficient of friction to back of wall Coefficient of friction to front of wall Coefficient of friction beneath base At rest pressure coefficient Passive pressure coefficient

Bearing pressure check

# Vertical forces on wall Wall stem Wall base

 $l_{base} = l_{toe} + t_{stem} = 1850 \text{ mm}$   $h_{moist} = h_{soil} = 3300 \text{ mm}$   $l_{sur} = l_{heel} = 0 \text{ mm}$   $x_{sur_v} = l_{base} - l_{heel} / 2 = 1850 \text{ mm}$   $h_{eff} = h_{base} + d_{cover} + h_{ret} = 3650 \text{ mm}$   $x_{sur_h} = h_{eff} / 2 = 1825 \text{ mm}$   $A_{stem} = h_{stem} \times t_{stem} = 1.155 \text{ m}^2$   $x_{stem} = l_{toe} + t_{stem} / 2 = 1675 \text{ mm}$   $A_{base} = l_{base} \times t_{base} = 0.648 \text{ m}^2$   $x_{base} = l_{base} / 2 = 925 \text{ mm}$ 

# $$\begin{split} & \mathsf{K}_{\rm fr} = \mathbf{0.325} \\ & \mathsf{K}_{\rm fb} = \mathbf{0.325} \\ & \mathsf{K}_{\rm fbb} = \mathbf{0.325} \\ & \mathsf{K}_{\rm 0} = \mathbf{0.500} \\ & \mathsf{K}_{\rm P} = \mathbf{4.977} \end{split}$$

 $F_{stem} = A_{stem} \times \gamma_{stem} = 28.9 \text{ kN/m}$  $F_{base} = A_{base} \times \gamma_{base} = 16.2 \text{ kN/m}$ 

	Project	Sou	th Lodge		Job no.	/0605	
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46-48	Retaining Wall				3		
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Line loads		F <sub>P_v</sub> = P <sub>G</sub>	<sub>1</sub> + P <sub>Q1</sub> = <b>80</b> kN/	m			
Total		$F_{total_v} = F$	stem + F <sub>base</sub> + F <sub>P</sub>	_v = <b>125.1</b> kN/m			
Horizontal forces on wall							
Surcharge load		F <sub>sur_h</sub> = K	$_{0} \times (Surcharge_{G})$	+ Surcharge <sub>Q</sub> ) $\times$	h <sub>eff</sub> = <b>13.7</b> kN/r	n	
Moist retained soil		F <sub>moist_h</sub> = 1	$K_0  imes \gamma_{mr}'  imes h_{eff}^2$ / 2	2 = <b>66.6</b> kN/m			
Base soil		F <sub>pass_h</sub> = -	$K_P  imes \gamma_b'  imes (d_{cover})$	+ h <sub>base</sub> ) <sup>2</sup> / 2 = -6.4	<b>1</b> kN/m		
Total		F <sub>total_h</sub> = F	moist_h + Fpass_h +	<sub>oist_h</sub> + F <sub>pass_h</sub> + F <sub>sur_h</sub> = <b>74.2</b> kN/m			
Moments on wall							
Wall stem		M <sub>stem</sub> = F <sub>s</sub>	stem × <b>x</b> stem = <b>48.4</b>	<b>\$</b> kNm/m			
Wall base		M <sub>base</sub> = F <sub>t</sub>	base × Xbase = 15 k	<nm m<="" td=""><td></td><td></td></nm>			
Surcharge load		M <sub>sur</sub> = -F <sub>s</sub>	.ur_h × <b>X</b> sur_h = <b>-25</b>	kNm/m			
Line loads		M <sub>P</sub> = (P <sub>G1</sub>	1 + P <sub>Q1</sub> ) × p <sub>1</sub> = <b>1</b> ;	<b>34</b> kNm/m			
Moist retained soil		M <sub>moist</sub> = -F	$-$ moist_h $\times$ Xmoist_h =	= <b>-81</b> kNm/m			
Total		$M_{total} = M_s$	<sub>stem</sub> + M <sub>base</sub> + M <sub>m</sub>	$M_{\rm oist} + M_{\rm sur} + M_{\rm P} =$	91.3 kNm/m		
Check bearing pressure							
Propping force to stem		F <sub>prop_stem</sub> =	= ( $F_{total_v} \times I_{base}$ /	2 - M <sub>total</sub> ) / (h <sub>prop</sub> -	+ t <sub>base</sub> ) <b>= 6.7</b> kN	/m	
Propping force to base		F <sub>prop_base</sub> :	= F <sub>total_h</sub> - F <sub>prop_ste</sub>	<sub>em</sub> = <b>67.5</b> kN/m	•		
Moment from propping force		$M_{prop} = F_{pr}$	prop_stem $\times$ (hprop +	t <sub>base</sub> ) = <b>24.4</b> kNm	ı/m		
Distance to reaction		$\overline{\mathbf{x}} = (\mathbf{M}_{\text{total}})$	al + Mprop) / F <sub>total_</sub>	v = <b>925</b> mm			
Eccentricity of reaction		$e = \overline{x} - I_b$	<sub>ase</sub> / 2 <b>= 0</b> mm				
Loaded length of base		I <sub>load</sub> = I <sub>base</sub>	∍ <b>= 1850</b> mm				
Bearing pressure at toe		$q_{toe} = F_{tota}$	$_{al_v}$ / $I_{base}$ $ imes$ (1 - 6	$\times$ e / I <sub>base</sub> ) = 67.6	kN/m²		
Bearing pressure at heel		$q_{heel} = F_{to}$	$_{tal_v}$ / $I_{base}$ $ imes$ (1 + (	$6 \times e / I_{base}$ ) = 67.	<b>6</b> kN/m <sup>2</sup>		
Factor of safety		$FoS_{bp} = F$	<sup>o</sup> bearing / max(q <sub>toe</sub> ,	, q <sub>heel</sub> ) = <b>1.331</b>			
	PASS -	Allowable bear	ing pressure ex	ceeds maximu	m applied bea	ring pressure	

# **RETAINING WALL DESIGN**

In accordance with EN1992-1-1:2004 incorporating Corrigendum dated January 2008 and the UK National Annex incorporating National Amendment No.1

Tedds calculation version 2.9.00

# Concrete details - Table 3.1 - Strength and deformation characteristics for concrete

Concrete strength class	C32/40
Characteristic compressive cylinder strength	f <sub>ck</sub> = <b>32</b> N/mm <sup>2</sup>
Characteristic compressive cube strength	f <sub>ck,cube</sub> = <b>40</b> N/mm <sup>2</sup>
Mean value of compressive cylinder strength	$f_{cm} = f_{ck} + 8 \text{ N/mm}^2 = 40 \text{ N/mm}^2$
Mean value of axial tensile strength	$f_{ctm}$ = 0.3 N/mm <sup>2</sup> × ( $f_{ck}$ / 1 N/mm <sup>2</sup> ) <sup>2/3</sup> = <b>3.0</b> N/mm <sup>2</sup>
5% fractile of axial tensile strength	$f_{ctk,0.05} = 0.7 \times f_{ctm} = 2.1 \text{ N/mm}^2$
Secant modulus of elasticity of concrete	$E_{cm}$ = 22 kN/mm <sup>2</sup> × (f <sub>cm</sub> / 10 N/mm <sup>2</sup> ) <sup>0.3</sup> = <b>33346</b> N/mm <sup>2</sup>
Partial factor for concrete - Table 2.1N	γc = 1.50
Compressive strength coefficient - cl.3.1.6(1)	α <sub>cc</sub> = <b>0.85</b>
Design compressive concrete strength - exp.3.15	$f_{cd} = \alpha_{cc} \times f_{ck} / \gamma_C = 18.1 \text{ N/mm}^2$
Maximum aggregate size	h <sub>agg</sub> = <b>20</b> mm
Reinforcement details	
Characteristic yield strength of reinforcement	f <sub>yk</sub> = <b>500</b> N/mm <sup>2</sup>
Modulus of elasticity of reinforcement	Es <b>= 200000</b> N/mm <sup>2</sup>



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London	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	VV					
Structural system factor - Table	7.4N	K <sub>b</sub> = 1				
Reinforcement factor - exp.7.17		K <sub>s</sub> = min(50	00 N/mm² / (f <sub>vk</sub> :	× AsfM.reg / AsfM.prov	), 1.5) <b>= 1.5</b>	
Limiting span to depth ratio - ex	p.7.16.a	$K_s \times K_b \times [1]$	$1 + 1.5 \times \sqrt{(f_{ck})}$	$1 \text{ N/mm}^2) \times \rho_0 /$	ρ + 3.2 × √(f <sub>ck</sub> /	$1 \text{ N/mm}^2$ ) ×
	•	(ρ <sub>0</sub> / ρ - 1) <sup>3/</sup>	<sup>2</sup> ] = <b>982</b>	, 11		,
Actual span to depth ratio		$h_{prop} / d = 1$	1.3			
		PASS	- Span to dept	h ratio is less th	nan deflection	control limit
Check stem design at base of	stem					
Depth of section	otonii	h = <b>350</b> mn	n			
Rectangular section in flexure	- Section 6 1					
Desian bending moment combined	nation 1	M = 39.7 ki	Nm/m			
Depth to tension reinforcement		d = h - C <sub>sr</sub> -	φ <sub>sr</sub> / 2 = <b>294</b> mi	m		
		$K = M / (d^2)$	$\times f_{ck}$ = 0.014			
		K' = 0.207				
			K' > K - I	No compression	reinforcemer	nt is required
Lever arm		z = min(0.5	+ 0.5 × (1 - 3.5	53 × K) <sup>0.5</sup> , 0.95) ×	: d = <b>279</b> mm	-
Depth of neutral axis		$x = 2.5 \times (d$	– z) <b>= 37</b> mm			
Area of tension reinforcement re	equired	$A_{sr.req} = M /$	(f <sub>yd</sub> × z) = <b>327</b> i	mm²/m		
Tension reinforcement provided		12 dia.bars	@ 200 c/c			
Area of tension reinforcement p	rovided	$A_{sr.prov} = \pi \times$	$<\phi_{ m sr}^2$ / (4 $\times$ s <sub>sr</sub> ) =	<b>= 565</b> mm²/m		
Minimum area of reinforcement	- exp.9.1N	A <sub>sr.min</sub> = ma	$x(0.26  imes f_{ctm} / f_y)$	<sub>k</sub> , 0.0013) × d = 4	<b>l62</b> mm²/m	
Maximum area of reinforcement	t - cl.9.2.1.1(3)	$A_{sr.max} = 0.0$	04 × h = <b>14000</b>	mm²/m		
		max(A <sub>sr.req</sub> ,	Asr.min) / Asr.prov	= 0.817		
	PASS - Area or	f reinforcement	provided is g	reater than area	of reinforcen	nent required
Deflection control - Section 7	.4					
Reference reinforcement ratio		$ ho_0$ = $\sqrt{f_{ck}}$ / 1	l N/mm²) / 1000	) <b>= 0.006</b>		
Required tension reinforcement	ratio	$\rho = A_{sr.req} / c$	d <b>= 0.001</b>			
Required compression reinforce	ement ratio	$\rho' = A_{sr.2.req}$	/ d <sub>2</sub> = <b>0.000</b>			
Structural system factor - Table	7.4N	K <sub>b</sub> = <b>1</b>				
Reinforcement factor - exp.7.17		K <sub>s</sub> = min(50	00 N/mm² / (f <sub>yk</sub> :	× A <sub>sr.req</sub> / A <sub>sr.prov</sub> ),	1.5) <b>= 1.5</b>	
Limiting span to depth ratio - ex	p.7.16.a	$K_s  imes K_b  imes [1]$	1 + 1.5 × $\sqrt{(f_{ck} / f_{ck})}$	1 N/mm <sup>2</sup> ) $\times \rho_0$ /	$\rho$ + 3.2 × $\sqrt{f_{ck}}$	$1 \text{ N/mm}^2) \times$
		(ρ₀ / ρ - 1) <sup>3/</sup>	<sup>2</sup> ] <b>= 305.1</b>			
Actual span to depth ratio		$h_{prop} / d = 1$	1.2			
		PASS	- Span to dept	h ratio is less th	nan deflection	control limit
Rectangular section in shear	- Section 6.2					
Design shear force		V = <b>70</b> kN/r	n			
		$C_{Rd,c} = 0.18$	3 / γ <sub>C</sub> = 0.120			
		k = min(1 +	√(200 mm / d)	, 2) <b>= 1.825</b>		
Longitudinal reinforcement ratio	•	ρι = min(A <sub>sr</sub>	.prov / d, 0.02) =	0.002		
		v <sub>min</sub> = 0.035	$5 \text{ N}^{1/2}/\text{mm} \times \text{k}^{3/2}$	× f <sub>ck</sub> <sup>0.5</sup> = <b>0.488</b> N	l/mm²	
Design shear resistance - exp.6	.2a & 6.2b	V <sub>Rd.c</sub> = max	$(C_{Rd.c} \times k \times (10))$	$0 \text{ N}^2/\text{mm}^4 \times \rho_1 \times \text{f}$	$_{\rm ck})^{1/3}, V_{\rm min})  imes d$	
		V <sub>Rd.c</sub> = <b>143</b> .	. <b>5</b> kN/m			
		$V / V_{Rd.c} = 0$	).488 C. Decision (			
		PAS	esign she ں ۔ د	ear resistance e	xceeas desigi	i snear force
Check stem design at prop						
Depth of section		h = <b>350</b> mn	n			

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Rectangular section in shear -	Section 6.2								
Design shear force		V <b>= 21.4</b> k	N/m						
		$C_{Rd,c} = 0.13$	8 / γ <sub>C</sub> = <b>0.120</b>						
		k = min(1 -	k = min(1 + √(200 mm / d), 2) = <b>1.825</b>						
Longitudinal reinforcement ratio		ρι = min(A₅	$p_l = min(A_{sr1.prov} / d, 0.02) = 0.002$						
	v <sub>min</sub> = 0.03	$5 \text{ N}^{1/2}/\text{mm} \times \text{k}^{3/2}$	<sup>/2</sup> × f <sub>ck</sub> <sup>0.5</sup> = <b>0.488</b> I	N/mm <sup>2</sup>					
Design shear resistance - exp.6.	V <sub>Rd.c</sub> = max	$(C_{Rd.c} \times k \times (10))$	00 N <sup>2</sup> /mm <sup>4</sup> $ imes$ $ ho_{l}$ $ imes$	$f_{ck})^{1/3}, v_{min})  imes d$					
	V <sub>Rd.c</sub> = 143	<b>.5</b> kN/m							
		$V / V_{Rd.c} =$	0.149						
		PAS	SS - Design sh	near resistance e	exceeds desig	In shear forc			
Horizontal reinforcement paral	lel to face of s	tem - Section	9.6						
Minimum area of reinforcement -	- cl.9.6.3(1)	A <sub>sx.req</sub> = ma	$ax(0.25  imes A_{sr.pro})$	w, $0.001 \times t_{stem}$ ) =	<b>350</b> mm²/m				
Maximum spacing of reinforceme	ent – cl.9.6.3(2)	s <sub>sx_max</sub> = 40	s <sub>sx_max</sub> = <b>400</b> mm						
I ransverse reinforcement provid	ed	12 dia.bars	s@200 c/c						
Area of transverse reinforcement	provided	$A_{sx.prov} = \pi$	$A_{sx,prov} = \pi \times \phi_{sx}^2 / (4 \times s_{sx}) = 565 \text{ mm}^2/\text{m}$						
ŀ	ASS - Area of	reinforcemen	t provided is g	greater than area	a of reinforcei	ment require			
Check base design at toe									
Depth of section		h = <b>350</b> mi	n						
Rectangular section in flexure	- Section 6.1								
Design bending moment combin	ation 1	M = 90.3 k	Nm/m						
Depth to tension reinforcement		d = h - c <sub>bb</sub> - φ <sub>bb</sub> / 2 = <b>267</b> mm							
		$K = M / (d^2)$	$\times$ f <sub>ck</sub> ) = <b>0.040</b>						
		K' <b>= 0.207</b>							
			K' > K -	No compression	n reinforceme	nt is require			
_ever arm		z = min(0.8	$5 + 0.5 \times (1 - 3)$	.53 × K) <sup>0.5</sup> , 0.95)	× d = <b>254</b> mm				
Depth of neutral axis									
		$x = 2.5 \times (0)$	d – z) <b>= 33</b> mm	l					
Area of tension reinforcement re	quired	$x = 2.5 \times (0$ $A_{bb.req} = M$	d – z) = <b>33</b> mm / (f <sub>yd</sub> × z) = <b>819</b>	) mm²/m					
Area of tension reinforcement re Tension reinforcement provided	quired	$x = 2.5 \times (d)$ $A_{bb,req} = M$ 16 dia.bars	d – z) <b>= 33</b> mm / (f <sub>yd</sub> × z) <b>= 819</b> s @ 200 c/c	) mm²/m					
Area of tension reinforcement reaction Tension reinforcement provided Area of tension reinforcement pro	quired	$x = 2.5 \times (a$ $A_{bb,req} = M$ 16 dia.bars $A_{bb,prov} = \pi$	d - z) = 33  mm / (f <sub>yd</sub> × z) = 819 s @ 200 c/c × $\phi_{bb}^2$ / (4 × s <sub>bb</sub>	) mm²/m ) = <b>1005</b> mm²/m					
Area of tension reinforcement rea Tension reinforcement provided Area of tension reinforcement pro Minimum area of reinforcement -	quired ovided exp.9.1N	$x = 2.5 \times (d$ $A_{bb,req} = M$ $16 \text{ dia.bars}$ $A_{bb,prov} = \pi$ $A_{bb,min} = ma$	d - z) = <b>33</b> mm / (f <sub>yd</sub> × z) = <b>819</b> s @ 200 c/c × $\phi_{bb}^2$ / (4 × sbt ax(0.26 × f <sub>ctm</sub> /	9 mm²/m 5) = <b>1005</b> mm²/m f <sub>yk</sub> , 0.0013) × d =	<b>420</b> mm²/m				
Area of tension reinforcement reaction reinforcement provided Area of tension reinforcement provided Minimum area of reinforcement - Maximum area of reinforcement	quired ovided exp.9.1N - cl.9.2.1.1(3)	$x = 2.5 \times (a + bb.req = M)$ $16 \text{ dia.bars}$ $A_{bb.prov} = \pi$ $A_{bb.min} = ma$ $A_{bb.max} = 0.$	d - z) = 33  mm / (f <sub>yd</sub> × z) = 819 s @ 200 c/c × $\phi_{bb}^2$ / (4 × sbc ax(0.26 × f_{ctm} / 04 × h = 14000)	) mm²/m b) = <b>1005</b> mm²/m f <sub>yk</sub> , 0.0013) × d = <b>0</b> mm²/m	<b>420</b> mm²/m				
Area of tension reinforcement re Tension reinforcement provided Area of tension reinforcement pr Minimum area of reinforcement - Maximum area of reinforcement	quired ovided exp.9.1N - cl.9.2.1.1(3)	$x = 2.5 \times (d$ $A_{bb,req} = M$ $16 \text{ dia.bars}$ $A_{bb,prov} = \pi$ $A_{bb,min} = ma$ $A_{bb,max} = 0$ $max(A_{bb,req}$	d - z) = 33  mm / (f <sub>yd</sub> × z) = 819 s @ 200 c/c × $\phi_{bb}^2$ / (4 × sbt ax(0.26 × fctm / 04 × h = 14000 , Abb.min) / Abb.pr	$f_{yk} = 1005 \text{ mm}^2/\text{m}^$	<b>420</b> mm²/m				
Area of tension reinforcement rea Tension reinforcement provided Area of tension reinforcement pro Minimum area of reinforcement - Maximum area of reinforcement	quired ovided exp.9.1N - cl.9.2.1.1(3) PASS - Area of	$x = 2.5 \times (a + bb, req = M)$ $16 \text{ dia.bars}$ $A_{bb, prov} = \pi$ $A_{bb, min} = ma$ $A_{bb, max} = 0$ $max(A_{bb, req})$	$d - z) = 33 \text{ mm} / (f_{yd} \times z) = 819$ $s @ 200 \text{ c/c} / (4 \times s_{bb}^2 /$	$f_{yk} = 1005 \text{ mm}^2/\text{m}$ $f_{yk} = 1005 \text{ mm}^2/\text{m}$ $f_{yk} = 0.0013 \times \text{d} = 0 \text{ mm}^2/\text{m}$ $f_{yv} = 0.814$ $f_{yreater than area$	<b>420</b> mm²/m a of reinforce	nent require			
Area of tension reinforcement re Tension reinforcement provided Area of tension reinforcement pr Minimum area of reinforcement Maximum area of reinforcement <b>Rectangular section in shear -</b>	quired ovided exp.9.1N - cl.9.2.1.1(3) PASS - Area of Section 6.2	$x = 2.5 \times (a$ $A_{bb,req} = M$ $16 \text{ dia.bars}$ $A_{bb,prov} = \pi$ $A_{bb,min} = ma$ $A_{bb,max} = 0$ $max(A_{bb,req}$	$d - z) = 33 \text{ mm} / (f_{yd} \times z) = 819$ $s @ 200 \text{ c/c} / (4 \times s_{bb}^2 / (4 \times s_{bb}^2 / (4 \times s_{bb}^2 / (4 \times s_{bb}^2 / (4 \times s_{bb} - 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1$	$f_{yk} = 1005 \text{ mm}^2/\text{m}^2$ $f_{yk} = 0.0013 \times \text{d} = 0 \text{ mm}^2/\text{m}^2$ $f_{yr} = 0.814$ $f_{yr} = 0.814$	<b>420</b> mm²/m a of reinforce	nent require			
Area of tension reinforcement re- Tension reinforcement provided Area of tension reinforcement pro- Minimum area of reinforcement - Maximum area of reinforcement <b>Rectangular section in shear -</b> Design shear force	quired ovided exp.9.1N - cl.9.2.1.1(3) PASS - Area of Section 6.2	$x = 2.5 \times (a$ $A_{bb,req} = M$ $16 \text{ dia.bars}$ $A_{bb,prov} = \pi$ $A_{bb,min} = ma$ $A_{bb,max} = 0$ $max(A_{bb,req}$ $Treinforcemen$ $V = 120.4$	$d - z) = 33 \text{ mm} / (f_{yd} \times z) = 819$ $s @ 200 \text{ c/c} / (4 \times s_{bb}^2 / (4 \times s_{bb}^2 / (4 \times s_{bb}^2 / (4 \times s_{bb}^2 / (4 \times s_{bb} / ($	$f_{yk} = 1005 \text{ mm}^2/\text{m}$ $f_{yk} = 1005 \text{ mm}^2/\text{m}$ $f_{yk} = 0.0013 \times \text{d} = 0 \text{ mm}^2/\text{m}$ $f_{yv} = 0.814$ $f_{yreater than area}$	<b>420</b> mm²/m a of reinforce	nent require			
Area of tension reinforcement rea Tension reinforcement provided Area of tension reinforcement pro- Minimum area of reinforcement - Maximum area of reinforcement <b>Rectangular section in shear -</b> Design shear force	quired ovided exp.9.1N - cl.9.2.1.1(3) PASS - Area of Section 6.2	$x = 2.5 \times (a + b) + c = 0$ $A_{bb,req} = M$ $16 \text{ dia.bars}$ $A_{bb,prov} = \pi$ $A_{bb,min} = ma$ $A_{bb,max} = 0$ $max(A_{bb,req}$ $reinforcemen$ $V = 120.4$ $C_{Rd,c} = 0.14$	d - z) = 33  mm / (fyd × z) = 819 s @ 200 c/c × $\phi_{bb}^2$ / (4 × sbb ax(0.26 × fctm / 04 × h = 14000 , Abb.min) / Abb.pr t provided is g kN/m 8 / $\gamma_c$ = 0.120	$f_{yk}$ mm <sup>2</sup> /m b) = <b>1005</b> mm <sup>2</sup> /m $f_{yk}$ , 0.0013) × d = 0 mm <sup>2</sup> /m $r_{ov}$ = <b>0.814</b> greater than area	<b>420</b> mm²/m a of reinforcei	nent require			
Area of tension reinforcement rea Tension reinforcement provided Area of tension reinforcement pro- Minimum area of reinforcement - Maximum area of reinforcement <b>Rectangular section in shear -</b> Design shear force	quired ovided exp.9.1N - cl.9.2.1.1(3) PASS - Area of Section 6.2	$x = 2.5 \times (a$ $A_{bb,req} = M$ $16 \text{ dia.bars}$ $A_{bb,prov} = \pi$ $A_{bb,min} = ma$ $A_{bb,max} = 0$ $max(A_{bb,req}$ $Freinforcemen$ $V = 120.4$ $C_{Rd,c} = 0.14$ $k = min(1 - b$	d - z) = 33  mm / (fyd × z) = 819 s @ 200 c/c × $\phi_{bb}^2$ / (4 × sbt ax(0.26 × fctm / 04 × h = 14000 , Abb.min) / Abb.pr t provided is g kN/m B / $\gamma_{C} = 0.120$ + $\sqrt{(200 \text{ mm } / d)}$	$f_{yk} = 1005 \text{ mm}^2/\text{m}$ $f_{yk}, 0.0013) \times d = 0 \text{ mm}^2/\text{m}$ $f_{yk} = 0.814$ greater than area $f_{yk} = 1.865$	<b>420</b> mm²/m a of reinforce	ment require			
Area of tension reinforcement re Tension reinforcement provided Area of tension reinforcement pr Minimum area of reinforcement - Maximum area of reinforcement <b>Rectangular section in shear -</b> Design shear force Longitudinal reinforcement ratio	quired ovided exp.9.1N - cl.9.2.1.1(3) PASS - Area of Section 6.2	$x = 2.5 \times (a + b) + c = 0$ $A_{bb,req} = M$ $16 \text{ dia.bars}$ $A_{bb,prov} = \pi$ $A_{bb,min} = ma$ $A_{bb,max} = 0$ $max(A_{bb,req}$ $Freinforcemen$ $V = 120.4$ $C_{Rd,c} = 0.13$ $k = min(1 - p) = min(A_{b})$	d - z) = 33  mm / (fyd × z) = 819 s @ 200 c/c × $\phi_{bb}^2$ / (4 × sbb ax(0.26 × form / 04 × h = 14000 , Abb.min) / Abb.pr t provided is g kN/m 8 / $\gamma_c = 0.120$ + $\sqrt{(200 \text{ mm / d})}$	$f_{yk} = 1005 \text{ mm}^2/\text{m}$ $f_{yk} = 0.0013 \times \text{d} = 0 \text{ mm}^2/\text{m}$ $f_{yv} = 0.814$ $f_{yreater than area$ $f_{y} = 1.865$ $f_{y} = 0.004$	<b>420</b> mm²/m	nent require			
Area of tension reinforcement re Tension reinforcement provided Area of tension reinforcement pr Minimum area of reinforcement - Maximum area of reinforcement Maximum area of reinforcement - Maximum area of reinforcement - Maximum area of reinforcement ratio	quired ovided exp.9.1N - cl.9.2.1.1(3) PASS - Area of Section 6.2	$x = 2.5 \times (a$ $A_{bb,req} = M$ $16 \text{ dia.bars}$ $A_{bb,prov} = \pi$ $A_{bb,min} = ma$ $A_{bb,max} = 0$ $max(A_{bb,req}$ $Treinforcemen$ $V = 120.4$ $C_{Rd,c} = 0.14$ $k = min(1 - \rho_{I} = min(A_{bb} + min))$	d - z) = 33  mm / (fyd × z) = 819 s @ 200 c/c × $\phi_{bb}^2$ / (4 × sbt ax(0.26 × fctm / 04 × h = 14000 , Abb.min) / Abb.pr t provided is g kN/m B / $\gamma_c = 0.120$ + $\sqrt{(200 \text{ mm / d})}$ b.prov / d, 0.02) 5 N <sup>1/2</sup> /mm × k <sup>3/</sup>	$p mm^{2}/m$ $p = 1005 mm^{2}/m$ $f_{yk}, 0.0013) \times d =$ $0 mm^{2}/m$ $greater than area$ $(1), 2) = 1.865$ $= 0.004$ $f^{2} \times f_{ck}^{0.5} = 0.504 f^{2}$	<b>420</b> mm²/m <b>a of reinforce</b> V/mm²	nent require			
Area of tension reinforcement re Tension reinforcement provided Area of tension reinforcement pr Minimum area of reinforcement - Maximum area of reinforcement Maximum area of reinforcement - Maximum area of reinforcement - Maximum area of reinforcement - Maximum area of reinforcement ratio Design shear resistance - exp.6.	quired ovided exp.9.1N - cl.9.2.1.1(3) PASS - Area of Section 6.2 2a & 6.2b	$x = 2.5 \times (a$ $A_{bb,req} = M$ $16 \text{ dia.bars}$ $A_{bb,prov} = \pi$ $A_{bb,min} = ma$ $A_{bb,max} = 0$ $max(A_{bb,req}$ $Teinforcemen$ $V = 120.4$ $C_{Rd,c} = 0.12$ $k = min(1 - \rho_{I} = min(A_{b})$ $V_{rd,c} = max$	d - z) = 33  mm / (fyd × z) = 819 s @ 200 c/c × $\phi_{bb}^2$ / (4 × Sbt ax(0.26 × fctm / 04 × h = 14000 , Abb.min) / Abb.pr t provided is g kN/m 8 / $\gamma_c$ = 0.120 + $\sqrt{(200 \text{ mm / d})}$ b.prov / d, 0.02) 5 N <sup>1/2</sup> /mm × k <sup>3/</sup> x(C <sub>Rd.c</sub> × k × (10)	$f_{yk} = 1005 \text{ mm}^2/\text{m}$ $f_{yk} = 1005 \text{ mm}^2/\text{m}$ $f_{yk} = 0.0013 \times \text{d} = 0 \text{ mm}^2/\text{m}$ $f_{yv} = 0.814$ $greater than area f_{y} = 0.814greater than area f_{y} = 0.004f_{y} = 0.504 \text{ f}f_{y} = 0.804 \text{ f}$	420 mm <sup>2</sup> /m a of reinforces $V/mm^2$ $f_{ck})^{1/3}$ , Vmin) × d	nent require			
Area of tension reinforcement re Tension reinforcement provided Area of tension reinforcement pr Minimum area of reinforcement - Maximum area of reinforcement Maximum area of reinforcement Maximum area of reinforcement Maximum area of reinforcement Longitudinal reinforcement ratio Design shear resistance - exp.6.	quired exp.9.1N - cl.9.2.1.1(3) PASS - Area of Section 6.2 2a & 6.2b	$x = 2.5 \times (a + bb) + c = 1$ $Abb.req = M$ $16 dia.bars$ $Abb.prov = \pi$ $Abb.max = 0$ $max(Abb) + c = 0$ $Treinforcemen$ $V = 120.4$ $C_{Rd,c} = 0.14$ $k = min(1 - c)$ $\rho_I = min(Ab)$ $V_{rd,c} = max$ $V_{Rd,c} = 137$	d - z) = 33  mm / (fyd × z) = 819 s @ 200 c/c × $\phi_{bb}^2$ / (4 × sub ax(0.26 × form / 04 × h = 14000 , Abb.min) / Abb.pr t provided is g kN/m B / $\gamma_c = 0.120$ + $\sqrt{(200 \text{ mm / d})}$ b.prov / d, 0.02) 5 N <sup>1/2</sup> /mm × k <sup>3/</sup> x(C <sub>Rd.c</sub> × k × (10))	$p mm^{2}/m$ $p = 1005 mm^{2}/m$ $f_{yk}, 0.0013) \times d =$ $p mm^{2}/m$ $rov = 0.814$ $greater than area$ $(1), 2) = 1.865$ $= 0.004$ $r^{2} \times f_{ck}^{0.5} = 0.504 \text{ I}$ $r^{2} \times f_{ck}^{0.5} = 0.504 \text{ I}$	420 mm <sup>2</sup> /m a of reinforces V/mm <sup>2</sup> $f_{ck}$ ) <sup>1/3</sup> , Vmin) × d	nent require			
Area of tension reinforcement re Tension reinforcement provided Area of tension reinforcement pr Minimum area of reinforcement - Maximum area of reinforcement Maximum area of reinforcement Maximum area of reinforcement Maximum area of reinforcement F Rectangular section in shear - Design shear force Longitudinal reinforcement ratio Design shear resistance - exp.6.	quired ovided exp.9.1N - cl.9.2.1.1(3) <b>PASS - Area of</b> <b>Section 6.2</b> 2a & 6.2b	$x = 2.5 \times (a$ $A_{bb,req} = M$ $16 \text{ dia.bars}$ $A_{bb,prov} = \pi$ $A_{bb,min} = ma$ $A_{bb,max} = 0$ $max(A_{bb,req}$ $Teinforcemen$ $V = 120.4$ $C_{Rd,c} = 0.13$ $k = min(1 - \rho_{I} = min(A_{b})$ $V_{min} = 0.03$ $V_{Rd,c} = max$ $V_{Rd,c} = 137$ $V / V_{Rd,c} = 137$	$d - z) = 33 \text{ mm}$ $/ (f_{yd} \times z) = 819$ $s @ 200 \text{ c/c}$ $\times \phi_{bb}^2 / (4 \times s_{bt})^2 + (4 \times s_{bt})^2$	$p mm^{2}/m$ $p = 1005 mm^{2}/m$ $f_{yk}, 0.0013) \times d =$ $p mm^{2}/m$ $r_{ov} = 0.814$ $greater than area$ $1), 2) = 1.865$ $= 0.004$ $1/2 \times f_{ck}^{0.5} = 0.504 I$ $00 N^{2}/mm^{4} \times \rho_{I} \times 10^{10}$	<b>420</b> mm²/m <b>a of reinforce</b> V/mm² f <sub>ck</sub> ) <sup>1/3</sup> , v <sub>min</sub> ) × d	nent require			
Area of tension reinforcement rea Tension reinforcement provided Area of tension reinforcement provided Minimum area of reinforcement - Maximum area of reinforcement Maximum area of reinforcement <b>F</b> Rectangular section in shear - Design shear force Longitudinal reinforcement ratio Design shear resistance - exp.6.	quired ovided exp.9.1N - cl.9.2.1.1(3) PASS - Area of Section 6.2 2a & 6.2b	$x = 2.5 \times (a$ $A_{bb,req} = M$ $16 \text{ dia.bars}$ $A_{bb,prov} = \pi$ $A_{bb,min} = ma$ $A_{bb,max} = 0$ $max(A_{bb,req}$ $Treinforcemen$ $V = 120.4$ $C_{Rd,c} = 0.12$ $k = min(1 - p_{I} = min(A_{b} + min(1 - p_{I} = min(A_{b} + min(1 - p_{I} = min(A_{b} + mi$	$d - z) = 33 \text{ mm}$ $/ (f_{yd} \times z) = 819$ $s @ 200 \text{ c/c}$ $\times \phi_{bb}^2 / (4 \times s_{bb}^2) / (4 \times s_{bb}^2)$	$p = 1005 \text{ mm}^2/\text{m}$ $f_{yk}, 0.0013) \times d = 0 \text{ mm}^2/\text{m}$ $f_{yk}, 0.0013) \times d = 0 \text{ mm}^2/\text{m}$ $f_{yv} = 0.814$ $greater than area f_{y}(x) = 1.865= 0.004f_{y}^2 \times f_{ck}^{0.5} = 0.504 \text{ m}^2f_{ck}^{0.5} = 0.504 \text{ m}^2f_{ck}^{0.5} = 0.504 \text{ m}^2$	<b>420</b> mm²/m a of reinforce V/mm² f <sub>ck</sub> ) <sup>1/3</sup> , v <sub>min</sub> ) × d	nent require			
Area of tension reinforcement re Tension reinforcement provided Area of tension reinforcement provided Minimum area of reinforcement - Maximum area of reinforcement Maximum area of reinforcement ratio Design shear force Design shear resistance - exp.6. Secondary transverse reinforc	quired ovided exp.9.1N - cl.9.2.1.1(3) PASS - Area of Section 6.2 2a & 6.2b	$x = 2.5 \times (a$ $A_{bb,req} = M$ $16 \text{ dia.bars}$ $A_{bb,prov} = \pi$ $A_{bb,min} = ma$ $A_{bb,max} = 0$ $max(A_{bb,req}$ $Treinforcemen$ $V = 120.4$ $C_{Rd,c} = 0.13$ $k = min(1 - \rho_{I} = min(A_{b} + min))$ $V_{Rd,c} = max$ $V_{Rd,c} = 137$ $V / V_{Rd,c} = 137$ $V / V_{Rd,c} = 137$ $V / V_{Rd,c} = 137$ $V - Section 9.3$	$d - z) = 33 \text{ mm}$ $/ (f_{yd} \times z) = 819$ $s @ 200 \text{ c/c}$ $\times \phi_{bb}^2 / (4 \times s_{bb}^2) / (4 \times s_{bb}^2)$	$p mm^{2}/m$ $p = 1005 mm^{2}/m$ $f_{yk}, 0.0013) \times d =$ $p mm^{2}/m$ $rov = 0.814$ $greater than area$ $p = 0.004$ $r^{2} \times f_{ck}^{0.5} = 0.504 \text{ H}$ $r^{2} \times f_{ck}^{0.5} = 0.504 \text{ H}$ $r^{2} \times f_{ck}^{0.5} = 0.504 \text{ H}$	<b>420</b> mm²/m <b>a of reinforce</b> V/mm² f <sub>ck</sub> ) <sup>1/3</sup> , v <sub>min</sub> ) × d <b>exceeds desig</b>	ment require In shear forc			

