BIA Appendix 5: Structural Engineer's Statement and Calculations

54 Sumatra Road London NW6 1PR

Bini Struct-e	Project 54 Sumatr NW6 1PR	a road, London,	Job Ref 11654		
Consulting Structural	Drawing Ref	Calculations by BD	Checked by VC	Sheet of	
Engineers	Part of Structure		Date 10.2018		



Description of the Structural Works:

The structural alteration consists of extending and enlarging the existing cellar to form a new habitable space under the foot print of the main house. The basement construction will be in the form of reinforced concrete cantilevering retaining with reinforced base raft slab.

The requirement of Building Regulations will be met via providing full structural calculations and provided at detailed design in accordance to the following design standards and codes as well as relevant reports and document produced to support the planning application:

Relevant Design Standards and guidance notes

- BS 8103-1: 1995 Structural Design of Low Rise Buildings
- BS 648: 1964 Schedule of Weights of Building Materials
- BS 6399: Part 1: 1996 Loading for Buildings: Code of Practice for Dead and Imposed Loads
- BS 6399: Part 3: 1988 Loading for Buildings: Code of Practice for Imposed Roof Loads
- BS 8110;Part 1: 1997 Structural use of Concrete

The design takes into consideration vertical loads from existing building and any adjacent building or highway, lateral loads from wind, soil water and adjacent properties as well as surcharge loads applied as lateral loads to the retaining walls, loadings in the temporary condition, uplift forces from hydrostatic effects and soil heave.

The design must provide stability and robustness to both during temporary and permanent conditions. The design takes into account the method of construction in order to ensure that the proposed alterations can be achieved. The enclosed calculations are pertinent to the planning application process.

	Project		Job Ref	
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Consulting		BD	EDD	Sheet of
Structural	Dart of Structure-			
Engineers	Part of Structure		Date	
LOAD SUM	MARY:			
Dead Loads:				
	FLOORS: - Timber	Floor: ceiling, joists	s, insulation, boards, finis	shes: 0.6 kN/m ²
	- Concre	te Floor:		24 kN/m^3
	+ Finisl	hes:		0.2 kN/m ²
	ROOF: Timber Roo	f: ceiling, rafters, in	sulation, battens, tiles:	1.0 kN/m ²
	WALLS: - Brick W	all:		19 kN/m ³
	+ Finisl	hes:		0.2 kN/m ²
	- Blockwo	ork Wall:		16 kN/m ³
	+ Finisl	hes:		0.2 kN/m ²
	- Stud Wa	11:		0.45 or 0.6 kN/m ²
	-Lav&Pa	aster stud wall:		1.0kN/m ²
Imposed Load	<u>s:</u>			
	FLOORS: - Resider	ntial:		1.5 kN/m ²
	- Storage			0.75 kN/m ²
	ROOF:			0.6 kN/m ²
	Terrace Roof:			1.0kN/m ²

Bini Struct-e	Project 54 Sum: NW6 1P	atra road, London, R	Job Ref 11654			
Ltd. Consulting Structural	Drawing Ref	Calculations by MR	Checked by VC	Sheet of		
Engineers	Part of Structure	Date 10.2018				
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UE	$1.5 \times \frac{2}{2} = 1$	Fell/m				
SURCHPAR	he low/u	L				

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Tedds	Project 54 Sumatra road, London, NW6 1PR				Job no. 11654	
Bini Engineering Unit 415, 241-251 Ferndale Road,	Calcs for	Start page no./Revision 1 P1				
London SW9 8BJ	Calcs by VC	Calcs date 21/10/2018	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 2.6.04

Retaining wall details	
Stem type	Cantilever
Stem height	h _{stem} = 2700 mm
Prop height	h _{prop} = 2000 mm
Stem thickness	t _{stem} = 300 mm
Angle to rear face of stem	$\alpha = 90 \text{ deg}$
Stem density	$\gamma_{stem} = 25 \text{ kN/m}^3$
Toe length	l _{toe} = 3000 mm
Base thickness	t _{base} = 400 mm
Base density	$\gamma_{base} = 25 \text{ kN/m}^3$
Height of retained soil	h _{ret} = 2500 mm
Angle of soil surface	$\beta = 0 \deg$
Depth of cover	d _{cover} = 200 mm
Depth of excavation	d _{exc} = 200 mm
Retained soil properties	
Soil type	Organic clay
Moist density	$\gamma_{mr} = 15 \text{ kN/m}^3$
Saturated density	$\gamma_{sr} = 15 \text{ kN/m}^3$
Characteristic effective shear resistance angle	φ'r.k = 18 deg
Characteristic wall friction angle	$\delta_{r,k} = 9 \text{ deg}$
Base soil properties	
Soil type	Stiff or hard glacial silty clay
Moist density	$\gamma_{mb} = 21 \text{ kN/m}^3$
Characteristic cohesion	$c'_{b.k} = 0 \ kN/m^2$
Characteristic effective shear resistance angle	φ' _{b.k} = 22 deg
Characteristic wall friction angle	δь.k = 11 deg
Characteristic base friction angle	$\delta_{bb,k} = 14.7 \text{ deg}$
Loading details	
Variable surcharge load	Surchargea = 10 kN/m ²
Vertical line load at 3150 mm	P _{G1} = 1.1 kN/m
	Po1 = 1.7 kN/m



Todds	Project 54 Sumatra road, London, NW6 1PR				Job no. 1	1654		
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Unit 415, 241-251 Ferndale Road,	Retaining Wall - Front Wall				;	3 P1		
London SW9 8BJ	Calcs by VC	Calcs date 21/10/2018	Checked by	Checked date	Approved by	Approved date		
Partial factors for soil param	eters – Table	A.4 - Combinatio	n 1					
Angle of shearing resistance		$\gamma_{\Phi'} = 1.00$						
Effective cohesion		$\gamma_{c'} = 1.00$						
Weight density		$\gamma_{\gamma} = 1.00$						
Retained soil properties								
Design effective shear resistar	nce angle	∳'r.d = atan([tan(φ'r.k) / γ _φ ') =	18 deg				
Design wall friction angle	Ū	$\delta_{r.d} = atan(t)$	$tan(\delta_{r.k}) / \gamma_{\phi'}) =$	9 deg				
Base soil properties		,	() ()	Ū				
Design effective shear resistar		h'⊨ - atan	(tan(d'su) / yu) -	- 22 deg				
Design wall friction angle	ice angle	$\psi_{B,0} = atan$	$(tan(\psi_{B,k}) / \psi_{\phi}) -$	- 22 deg				
Design base friction angle			$(\tan(00.\kappa) / \gamma_{\phi}) =$					
			$(\alpha + - 0 k N / \gamma \phi')$	– 1 4. 1 uey				
Design enective conesion		C b.d = C b.k /	$\gamma_{c'} = \mathbf{U} \text{KIN}/\Pi^2$					
Using Coulomb theory								
Active pressure coefficient		$K_{A} = \sin(\alpha + \phi' r.d)^{2} / (\sin(\alpha)^{2} \times \sin(\alpha - \delta r.d) \times [1 + \sqrt{[\sin(\phi' r.d + \delta r.d])} \times (1 + \sqrt{[\sin(\phi' r.d + \delta r.d])})$						
		$\sin(\phi' \cdot d - \beta) / (\sin(\alpha - \delta \cdot d) \times \sin(\alpha + \beta))]]^2) = 0.483$						
Passive pressure coefficient		K _P = sin(90	$K_{P} = \sin(90 - \phi'_{b.d})^{2} / (\sin(90 + \delta_{b.d}) \times [1 - \sqrt{[\sin(\phi'_{b.d} + \delta_{b.d})} \times \sin(\phi'_{b.d}) / (1 - \sqrt{[\sin(\phi'_{b.d} +$					
		(sin(90 + δ	b.d))]] ²) = 2.958					
Overturning check								
Vertical forces on wall								
Wall stem		$F_{stem} = \gamma Gf >$	< Astem × γstem =	20.3 kN/m				
Wall base		$F_{base} = \gamma Gf$	\times Abase \times γ base =	33 kN/m				
Line loads		$F_{P_v} = \gamma_{Gf} \times$	$P_{G1} + \gamma_{Qf} \times P_Q$	1 = 1.1 kN/m				
Total		$F_{total_v} = F_{st}$	em + Fbase + FP	_v = 54.4 kN/m				
Horizontal forces on wall								
Surcharge load		$F_{sur_h} = K_A$	× $\cos(\delta_{r.d})$ × γ_Q	\times Surcharge $_{Q} \times h$	n _{eff} = 22.2 kN/n	n		
Moist retained soil		$F_{moist_h} = \gamma G$	$F_{moist_h} = \gamma_G \times K_A \times cos(\delta_{r.d}) \times \gamma_{mr} \times h_{eff}^2 / 2 = 46.4 \text{ kN/m}$					
Base soil		$F_{exc_h} = -\gamma G$	$f \times K_{P} \times cos(\delta_{b})$	d) $\times \gamma_{mb} \times$ (hpass +	h _{base}) ² / 2 = -4 .	9 kN/m		
Total		$F_{total_h} = F_m$	oist_h + F_{exc_h} +	Fsur_h = 63.7 kN/n	า			
Overturning moments on wa	11							
Surcharge load		$M_{sur_OT} = F_{st}$	sur_h × Xsur_h = 3	4.4 kNm/m				
Moist retained soil		M _{moist_OT} =	$F_{moist_h} imes \mathbf{x}_{moist_h}$	h = 48 kNm/m				
Total	Mtotal_OT = Mmoist_OT + Msur_OT = 82.4 kNm/m							
Restoring moments on wall								
Wall stem		$M_{\text{stem}_R} = F$	stem × Xstem = 63	3.8 kNm/m				
Wall base	M _{base_R} = F _{base} × x _{base} = 54.5 kNm/m							
Line loads		$M_{P_R} = (ab)$	s(γgf × Pg1 + γc	$p_f \times P_{Q1}) \times p_1 = 3.$	5 kNm/m			
Total		M _{total_R} = M _{stem_R} + M _{base_R} + M _{P_R} = 121.7 kNm/m						
Check stability against over	urnina							
Factor of safety		FoSot = Mto	otal R / Mtotal OT =	1.478				
		PASS - Maximu	m restoring m	oment is areate	r than overtu	rnina mome		

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Bearing pressure check							
Vertical forces on wall							
Wall stem		$F_{stem} = \gamma_G \times$	Astem $\times \gamma$ stem =	27.3 kN/m			
Wall base		$F_{base} = \gamma_G \times$	$A_{base} \times \gamma_{base} =$	44.6 kN/m			
Line loads		$F_{P_v} = \gamma G \times$	PG1 + γQ × PQ1	= 4 kN/m			
Base soil		F _{pass_v} = γ _G	× Apass × γ mb =	17 kN/m			
Total	$F_{\text{total}_v} = F_{\text{stem}} + F_{\text{base}} + F_{\text{pass}} + F_{\text{P}} = 92.9 \text{ k}$			kN/m			
Horizontal forces on wall							
Surcharge load		$F_{sur_h} = K_A$	× cos(δr.d) × γq	× Surchargeo ×	h _{eff} = 22.2 kN/r	n	
Moist retained soil		$F_{moist_h} = \gamma_G \times K_A \times cos(\delta_{r.d}) \times \gamma_{mr} \times h_{eff}^2 / 2 = 46.4 \text{ kN/m}$					
Base soil	$F_{\text{pass h}} = -\gamma_{\text{Gf}} \times K_{\text{P}} \times \cos(\delta_{\text{h}d}) \times \gamma_{\text{mh}} \times \sin(\gamma_{\text{P}} - \gamma_{\text{O}})$			$+ h_{base})^2 / 2 = -$	11 kN/m		
Total	$F_{total_h} = F_{moist_h} + F_{pass_h} + F_{sur_h} = 57.6 \text{ kN/m}$						
Moments on wall							
Wall stem		M _{stem} = F _{ste}	m × X _{stem} = 86.*	l kNm/m			
Wall base		Mbase = Fbas	ase × Xbase = 73.5 kNm/m				
Surcharge load		Msur = -Fsur	_h × Xsur_h = -34	.4 kNm/m			
Line loads		$M_P = (\gamma_G \times$	P _{G1} + γ _Q × P _{Q1}) × p₁ = 12.7 kNm	n/m		
Moist retained soil		Mmoist = -Fm	ioist_h × Xmoist_h =	= -48 kNm/m			
Base soil		M _{pass} = F _{pas}	$s_{s_v} \times \mathbf{x}_{pass_v} = \mathbf{z}$	2 5.5 kNm/m			
Total		Mtotal = Mste	m + Mbase + Mm	noist + Mpass + Msur	+ MP = 115.5	<nm m<="" td=""></nm>	
Check bearing pressure							
Propping force		F _{prop_base} =	$F_{total_h} = 57.6 k$	N/m			
Distance to reaction		$\bar{x} = l_{base} / 2 = 1650 \text{ mm}$					
Eccentricity of reaction		$e = \overline{x} - I_{bas}$	_e / 2 = 0 mm				
Loaded length of base	lioad = Ibase = 3300 mm						
Bearing pressure at toe	$q_{toe} = F_{total_v} / I_{base} = 28.2 \text{ kN/m}^2$						
Bearing pressure at heel	$q_{heel} = F_{total_v} / I_{base} = 28.2 \text{ kN/m}^2$						
Effective overburden pressure	$q = (t_{base} + d_{cover}) \times \gamma_{mb} = 12.6 \text{ kN/m}^2$						
Design effective overburden pres	ssure	sure $q' = q / \gamma_{\gamma} = 12.6 \text{ kN/m}^2$					
Bearing resistance factors		$N_q = Exp(\pi$	\times tan($\phi'_{b.d}$)) \times	(tan(45 deg + φ'ь	.d / 2)) ² = 7.821		
	$N_{c} = (N_{q} - 1) \times \cot(\phi'_{b.d}) = 16.883$						

Foundation shape factors

Load inclination factors

$$\begin{split} N_{\gamma} &= (N_{q} - 1) \times \text{cot}(\phi \text{ b.d}) = \textbf{10.003} \\ N_{\gamma} &= 2 \times (N_{q} - 1) \times \tan(\phi'\text{b.d}) = \textbf{5.512} \\ s_{q} &= 1 \\ s_{\gamma} &= 1 \\ s_{c} &= 1 \\ H &= F_{sur_{-}h} + F_{moist_{-}h} + F_{pass_{-}h} - F_{prop_{-}base} = \textbf{0} \text{ kN/m} \\ V &= F_{total_{-}v} = \textbf{92.9} \text{ kN/m} \\ m &= 2 \\ i_{q} &= [1 - H / (V + I_{load} \times C'_{b.d} \times \cot(\phi'_{b.d}))]^{m} = \textbf{1} \\ i_{\gamma} &= [1 - H / (V + I_{load} \times C'_{b.d} \times \cot(\phi'_{b.d}))]^{(m+1)} = \textbf{1} \\ i_{c} &= i_{q} - (1 - i_{q}) / (N_{c} \times \tan(\phi'_{b.d})) = \textbf{1} \end{split}$$

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	vc	21/10/2016							
Net ultimate bearing capacity		$n_f = c'_{b,d} \times N$	lc × sc × ic + q'	$\times N_{g} \times s_{g} \times i_{g} + 0$	$.5 \times \gamma_{mb} \times I_{load}$	$\langle N_{\gamma} \times S_{\gamma} \times i_{\gamma} =$			
		289.5 kN/m	1 ²						
Factor of safety		$FoS_{bp} = n_f / $	max(q _{toe} , q _{hee}	ı) = 10.281					
	PASS -	Allowable bearin	g pressure ex	xceeds maximu	m applied bea	ring pressure			
Partial factors on actions - Ta	ble A.3 - Com	bination 2							
Permanent unfavourable action		γg = 1.00							
Permanent favourable action		γGf = 1.00							
Variable unfavourable action		γ Q = 1.30							
Variable favourable action		$\gamma_{Qf} = 0.00$							
Partial factors for soil parame	eters – Table /	A.4 - Combinatio	n 2						
Angle of shearing resistance		$\gamma_{\Phi'} = 1.25$							
Effective cohesion		γc' = 1.25							
Weight density		$\gamma_{\gamma} = 1.00$							
Retained soil properties									
Design effective shear resistance	ce angle	φ'r.d = atan($\phi'_{r,d} = \operatorname{atan}(\operatorname{tan}(\phi'_{r,k}) / \gamma_{\phi'}) = 14.6 \operatorname{deg}$						
Design wall friction angle	3	$\delta_{r.d} = atan(t)$	$\delta_{r,d} = \operatorname{atan}(\operatorname{tan}(\delta_{r,k}) / \gamma_{\theta}) = 7.2 \text{ deg}$						
Base soil properties		× ×	() ()	5					
Design effective shear resistance	ce angle	φ'rd = atan(tan(d'ьк) / үм) =	= 17.9 dea					
Design wall friction angle	se angle	$\delta_{b,d} = atan(t)$	$\delta_{\mathbf{b},\mathbf{d}} = \operatorname{atan}(\operatorname{tan}(\delta_{\mathbf{b},\mathbf{k}}) / \gamma_{\mathbf{a}'}) = 8.8 \operatorname{deg}$						
Design base friction angle		$\delta_{bb,d} = atan$	$\delta_{\text{bb} d} = \operatorname{atan}(\operatorname{tan}(\delta_{\text{bb} k}) / v_{a'}) = 11.9 \operatorname{deg}$						
Design effective cohesion		$C'_{bd} = C'_{bk}/$	$C'_{hd} = C'_{hk} / \gamma_{C'} = 0 \text{ kN/m}^2$						
Ling Coulomb theory			10						
Active pressure coefficient		$\mathbf{K}_{1} = \sin(\alpha)$	$\mathbf{L} \mathbf{A}' \mathbf{A}^2 / (\operatorname{cin}) \alpha$	$)^2 \times \sin(\alpha - \delta) \times$	$[1 \pm \sqrt{1} \sin(\phi')]$	+ 8 J v			
Active pressure coemcient		$R_A = Sin(\alpha + \beta)$	$\sin(\phi_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta)) ^2) = 0.553$						
Passivo prossuro coofficient		$\sin(\psi r.a - p)$	$K_{\rm P} = \sin(90 + \delta_{\rm Pd})^2 / (\sin(90 + \delta_{\rm Pd}) \times (1 + \sqrt{(\sin(\delta_{\rm Pd} + \delta_{\rm Pd}))} \times \sin(\delta_{\rm Pd}) / (1 + \sqrt{(\sin(\delta_{\rm Pd} + \delta_{\rm Pd}))} \times \sin(\delta_{\rm Pd}) / (1 + \delta_{\rm Pd}) \times (1 + \delta_{\rm Pd}) \times (1 + \delta_{\rm Pd}) / (1 + \delta_{\rm Pd}) \times (1 + \delta_{$						
rassive pressure coenicient		$(\sin(90 + \delta))$	$(\sin(90 + \delta_{\rm bd}))^{12} = 2.340$						
		(311(00 1 0)							
Vertical forces on wall		-	•	00.01.01/0					
wall stem		$F_{stem} = \gamma_{Gf} \times$	$F_{stem} = \gamma_{Gf} \times A_{stem} \times \gamma_{stem} = 20.3 \text{ kN/m}$						
wall base		Fbase = γGf ×	Abase $\times \gamma$ base =	33 kN/m					
	$F_{P_v} = \gamma_{Gf} \times$	$F_{P_v} = \gamma_{Gf} \times P_{G1} + \gamma_{Qf} \times P_{Q1} = 1.1 \text{ kN/m}$							
Total	F total_v = F ste	$+ total_v = Fstem + Fbase + FP_v = 54.4 \text{ kN/m}$							
Horizontal forces on wall			(a.).						
Surcharge load	$F_{sur_h} = K_A$	$F_{sur_h} = K_A \times \cos(\delta r.d) \times \gamma_Q \times Surcharge_Q \times h_{eff} = 22.1 \text{ kN/m}$							
Moist retained soil	$F_{moist_h} = \gamma_G$	$F_{\text{moist}_h} = \gamma_G \times K_A \times COS(\delta_{r.d}) \times \gamma_{mr} \times h_{eff^2} / 2 = 39.5 \text{ kN/m}$							
Base soil			$F_{exc_h} = -\gamma Gf \times K_P \times COS(\partial b.d) \times \gamma mb \times (hpass + hbase)^2 / 2 = -3.9 \text{ kN/m}$						
I OTAI		⊢ _{total_h} = F _m	pist_h + ⊢exc_h +	⊢ _{sur_h} = 57.8 kN/r	n				
Overturning moments on wal	I								
Surcharge load		$M_{sur_OT} = F_s$	$M_{sur_OT} = F_{sur_h} \times X_{sur_h} = 34.3 \text{ kNm/m}$						
Moist retained soil		$M_{moist_OT} = I$	moist_h × Xmoist_h	h = 40.9 kNm/m					

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Unit 415, 241-251 Ferndale Road,	it 415, 241-251 Ferndale Road, Retaining Wall - F				6	P1		
London SW9 8BJ	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date		
	VC	21/10/2018						
Total		Mtotal_OT = I	Mmoist_OT + Msur_(от = 75.1 kNm/m				
Restoring moments on wall								
Wall stem		$M_{stem_R} = F$	$s_{stem} \times x_{stem} = 63$.8 kNm/m				
Wall base		$M_{base_R} = F$	$b_{base} \times x_{base} = 54$.5 kNm/m				
Line loads		M _{P_R} = (ab	s(γgf × Pg1 + γα	$f \times P_{Q1}) \times p_1 = 3.$. 5 kNm/m			
Total		$M_{total_R} = N$	I _{stem_R} + M _{base_R}	+ M _{P_R} = 121.7	kNm/m			
Check stability against overt	urning							
Factor of safety	_	FoSot = Mt	otal_R / Mtotal_OT =	1.62				
		PASS - Maximu	m restoring m	oment is greate	r than overtur	ning moment		
Bearing pressure check								
Vertical forces on wall								
Wall stem		F _{stem} = γ _G >	× A _{stem} × γ _{stem} =	20.3 kN/m				
Wall base		$F_{base} = \gamma_G$	$\langle A_{base} \times \gamma_{base} =$	33 kN/m				
Line loads		$F_{P_v} = \gamma_G \times P_{G1} + \gamma_Q \times P_{Q1} = 3.3 \text{ kN/m}$						
Base soil		$F_{pass_v} = \gamma_G \times A_{pass} \times \gamma_{mb} = 12.6 \text{ kN/m}$						
Total		$F_{total_v} = F_s$	$F_{total_v} = F_{stem} + F_{base} + F_{Pass_v} + F_{P_v} = 69.2 \text{ kN/m}$					
Horizontal forces on wall								
Surcharge load		$F_{sur_h} = K_A$	$\times \cos(\delta_{r.d}) \times \gamma_Q$	× Surcharge _Q × ł	n _{eff} = 22.1 kN/m	I		
Moist retained soil		$F_{moist_h} = \gamma c$	$\mathbf{s} \times \mathbf{K}_{A} \times \mathbf{cos}(\delta_{r.d})$) × γ_{mr} × h_{eff}^2 / 2 =	= 39.5 kN/m			
Base soil		$F_{pass_h} = -\gamma$	Gf × KP × cos(δь	.d) × γmb × (d cover -	+ h _{base}) ² / 2 = -8	8.7 kN/m		
Total		F _{total_h} = Fn	noist_h + Fpass_h +	Fsur_h = 52.9 kN/	'n			
Moments on wall								
Wall stem		Mstem = Fste	em × Xstem = 63.8	kNm/m				
Wall base		Mbase = Fba	se \times Xbase = 54.5	kNm/m				
Surcharge load		$M_{sur} = -F_{sur}$	$-h \times X_{sur_h} = -34$. 3 kNm/m				
Line loads		$M_P = (\gamma_G \times$	$P_{G1} + \gamma_Q \times P_{Q1}$	× p1 = 10.4 kNm	/m			
Moist retained soil		Mmoist = -Fr	noist_h × Xmoist_h =	-40.9 kNm/m				
Base soil		$M_{pass} = F_{pa}$	$ss_v \times x_{pass_v} = 1$	8.9 kNm/m				
Total		$M_{total} = M_{ste}$	em + Mbase + Mm	pist + Mpass + Msur	+ M _P = 72.5 kN	m/m		
Check bearing pressure								
Propping force		Fprop_base =	$F_{total_h} = 52.9 \text{ k}$	N/m				
Distance to reaction		$\bar{x} = I_{\text{base}} / 2 = 1650 \text{ mm}$						
Eccentricity of reaction	reaction $e = \bar{x} - I_{base} / 2 = 0 mm$							
Loaded length of base	$I_{load} = I_{base} = 3300 \text{ mm}$							
Bearing pressure at toe	$q_{toe} = F_{total_v} / I_{base} = 21 \text{ kN/m}^2$							
Bearing pressure at heel	$q_{heel} = F_{total_v} / I_{base} = 21 \text{ kN/m}^2$							
Effective overburden pressure	ure $q = (t_{base} + d_{cover}) \times \gamma_{mb} = 12.6 \text{ kN/m}^2$							
Design effective overburden pr	essure	$q' = q / \gamma_{\gamma} =$	= 12.6 kN/m ²					
Bearing resistance factors		$N_q = Exp(\tau)$	$x \times tan(\phi'_{b.d})) \times ($	tan(45 deg + φ'ь.α	d / 2)) ² = 5.213			
		$N_c = (N_q -$	$1) \times \cot(\phi'_{b.d}) = 1$	13.034				
		$N_{\gamma} = 2 \times (N_{\gamma})$	$I_q - 1) \times tan(\phi'_{b.d})$) = 2.723				

edds'	Project 54 Sumatra road, London, NW6 1PR				Job no. 11654	
Bini Engineering Unit 415, 241-251 Ferndale Road,	Calcs for	Retaining Wa	Start page no./Revision 7 P1			
London SW9 8BJ	Calcs by VC	Calcs date 21/10/2018	Checked by	Checked date	Approved by	Approved date
Foundation shape factors		s _q = 1				
		$s_{\gamma} = 1$				
		sc = 1				
Load inclination factors		$H = F_{sur_h} +$	Fmoist_h + Fpass	_h - $F_{prop_base} = 0 \mathbf{k}$	N/m	
		V = F _{total_v} =	= 69.2 kN/m			
		m = 2				
		i _q = [1 - H /	(V + $I_{load} \times c'_{b.d}$	$\times \text{ cot}(\phi'_{b.d}))]^m = 1$		
		$i_{\gamma} = [1 - H /$	$(V + I_{load} \times C'_{b.d})$	$\times \text{ cot}(\phi'_{b.d}))]^{(m + 1)}$	= 1	
		i _c = i _q - (1 -	i _q) / (N _c × tan(∢	o' _{b.d})) = 1		
Net ultimate bearing capacity		nf = c'b.d × ▮	Nc×sc×ic+q'	\times Ng \times sg \times ig + 0.	$5 \times \gamma_{mb} \times I_{load} \times$	$N_{\gamma} \times S_{\gamma} \times i_{\gamma} =$
	160 kN/m ²					
Factor of safety		$FoS_{bp} = n_f$	max(q _{toe} , q _{heel}) = 7.637		
	PASS -	Allowable bearin	g pressure ex	ceeds maximun	n applied bear	ing pressure

$$\begin{array}{c} \begin{array}{c} \mbox{Bin Structe}\\ \mbox{Ld}\\ \mbox{Consulting}\\ \mbox{Structural}\\ \mbox{Engineers} \end{array} \end{array} \begin{array}{c} \mbox{Proton Structural}\\ \mbox{Disc}\\ \mbox{Structural}\\ \mbox{Engineers} \end{array} \end{array} \end{array} \begin{array}{c} \mbox{Structural}\\ \mbox{Disc}\\ \mbox{Disc}\\ \mbox{Engineers} \end{array} \end{array} \end{array} \begin{array}{c} \mbox{Calculations by}\\ \mbox{Consulting}\\ \mbox{Disc}\\ \mbox{Di$$

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Tedds	Project 54 Sumatra road, London, NW6 1PR				Job no. 11654	
Bini Engineering Unit 415, 241-251 Ferndale Road,	Calcs for Retaining Wall - Wall WITH NO. 52				Start page no./Revision 1 P1	
London SW9 8BJ	Calcs by VC	Calcs date 21/10/2018	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 2.6.04

Retaining wall details	
Stem type	Cantilever
Stem height	h _{stem} = 900 mm
Prop height	h _{prop} = 900 mm
Stem thickness	t _{stem} = 300 mm
Angle to rear face of stem	$\alpha = 90 \text{ deg}$
Stem density	$\gamma_{stem} = 25 \text{ kN/m}^3$
Toe length	l _{toe} = 2000 mm
Base thickness	t _{base} = 400 mm
Base density	$\gamma_{base} = 25 \text{ kN/m}^3$
Height of retained soil	h _{ret} = 700 mm
Angle of soil surface	$\beta = 0 \deg$
Depth of cover	d _{cover} = 200 mm
Depth of excavation	d _{exc} = 200 mm
Retained soil properties	
Soil type	Organic clay
Moist density	$\gamma_{mr} = 15 \text{ kN/m}^3$
Saturated density	$\gamma_{sr} = 15 \text{ kN/m}^3$
Characteristic effective shear resistance angle	φ'r.k = 18 deg
Characteristic wall friction angle	$\delta_{r.k} = 9 \text{ deg}$
Base soil properties	
Soil type	Stiff or hard glacial silty clay
Moist density	$\gamma_{mb} = 21 \text{ kN/m}^3$
Characteristic cohesion	$c'_{b.k} = 0 \ kN/m^2$
Characteristic effective shear resistance angle	φ'ь.k = 22 deg
Characteristic wall friction angle	δ _{b.k} = 11 deg
Characteristic base friction angle	$\delta_{bb.k} = 14.7 \text{ deg}$
Loading details	
Vertical line load at 2150 mm	P _{G1} = 67 kN/m
	P _{Q1} = 8 kN/m



Project Job no.								
Tedds		54 Sumatra road,	London, NW6	1PR	11	654		
Bini Engineering	Calcs for				Start page no./R	evision		
Unit 415, 241-251 Ferndale Road,		Retaining Wall - Wall WITH NO. 52 3 P1						
London SW9 8BJ	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date		
	VC	21/10/2018						
Design wall friction angle		δ _{r.d} = atan(t	$an(\delta_{r.k}) / \gamma_{\phi'}) = 9$	9 deg				
Base soil properties								
Design effective shear resistan	ice angle	∮' _{b.d} = atan(tan(φ' _{b.k}) / γ _{φ'}) =	= 22 deg				
Design wall friction angle	-	δ _{b.d} = atan(t	$tan(\delta_{b.k}) / \gamma_{\phi'}) =$	11 deg				
Design base friction angle		$\delta_{bb.d} = atan$	(tan(δ _{bb.k}) / γ _{φ'})	= 14.7 deg				
Design effective cohesion		$C'_{b.d} = C'_{b.k} /$	$\gamma c' = 0 \text{ kN/m}^2$	-				
Using Coulomb theory								
Active pressure coefficient		$K_{A} = \sin(\alpha + \beta)$	+ φ'rd) ² / (sin(α)	$)^2 \times \sin(\alpha - \delta_{rd}) \times$	[1 + √[sin(d'rd +	⊦δrd)×		
		$\sin(\phi'_{rd} - \beta)$	$/(\sin(\alpha - \delta_{rd}))$	$(\sin(\alpha + \beta))$ ²) =	0.483			
Passive pressure coefficient		$K_{\rm P} = \sin(90$	$- \phi'_{bd}^2 / (\sin(9)^2)$	(α + β),]]) = 0 + δ⊳d) × [1 - √[sin(d'rd + 2rd) >	< sin(d'b d) /		
		(sin(90 + δ _b	$(0.1)^{112} = 2.958$					
Overturning check		(0(00 - 0.)						
Vertical forces on wall		Γ	Δ	C B ((b))/m				
wall stem		Fstem = γGf×	Astem × γstem =	6.8 KN/M				
w all base	Wallbase			23 KN/M				
Line loads	$F_{P_v} = \gamma_{Gf} \times$	PG1 + γQf × PQ1	= 67 KN/m					
		Γ total_v = Γ ste	em + Fbase + FP_	v = 90.8 KIN/M				
Horizontal forces on wall		_			0.01.01/			
Moist retained soil		$F_{\text{moist}_h} = \gamma_G \times K_A \times \text{COS}(\delta_{r.d}) \times \gamma_{mr} \times \Pi_{eff^-} / 2 = 8.2 \text{ KN/m}$						
Base soll		$F_{exc_h} = -\gamma_{Gf}$	× KP × COS(Ob.c	$(Ob.d) \times \gamma mb \times (Hpass + Hbase)^{-} / 2 = -4.9 KIN/III$				
		Γ total_h = Γ mo	$pist_h + \Gamma exc_h = $	3.3 KIN/III				
Overturning moments on wa	11	N4	-	2 E k m/m				
		$\mathbf{W}_{moist_OT} = \mathbf{r}$	moist_h × Xmoist_h	h = 3.3 KN/III/III				
		Witotal_01 - W	Imoist_01 – 3.3 K					
Restoring moments on wall								
		IVIstem_R = Fs	stem × Xstem = 14	.5 KINIM/III				
		M = F	base \times Xbase = 20	.4 KNm/m	4 4 1.51			
Line loads		MP_R = (abs	$S(\gamma Gf \times PG1 + \gamma Qf)$	$f \times PQ1) \times P1 = 14$	14.1 KNM/M			
Total		$IVItotal_R = IVIs$	stem_R + IVIbase_R	+ $IVIP_R = 100 KIN$	m/m			
Check stability against overt	urning	- o . M		F				
Factor of safety		$FOS_{ot} = M_{tot}$	tal_R / Mtotal_OT =	52.297	r than avartur	ning momont		
		FASS - Maximun	n restoring in	oment is greate	i illali övertur	ning moment		
Bearing pressure check								
Vertical forces on wall		_						
Wall stem		$F_{stem} = \gamma_G \times$	$A_{stem} \times \gamma_{stem} =$	9.1 kN/m				
Wall base		$F_{base} = \gamma G \times$	Abase × γbase =	31.1 kN/m				
Line loads		$F_{P_v} = \gamma_G \times $	$P_{G1} + \gamma_Q \times P_{Q1}$	= 102.5 kN/m				
Base soil		$F_{pass_v} = \gamma G$	$\times A_{pass} \times \gamma_{mb} =$	11.3 kN/m				
Total		$F_{total_v} = F_{ste}$	em + Fbase + Fpa	ss_v + FP_v = 154	kN/m			

Project Job no. 54 Sumatra road, London, NW6 1PR 110							1654
	Bini Engineering	Calcs for				Start page no./F	Revision
	Unit 415, 241-251 Ferndale Road,	F	2	4 P1			
	London SW9 8BJ	Calcs by VC	Calcs date 21/10/2018	Checked by	Checked date	Approved by	Approved date
	Horizontal forces on wall						
	Moist retained soil		$F_{moist} h = \gamma G$	$\mathbf{s} \times \mathbf{K} \mathbf{A} \times \mathbf{cos}(\delta \mathbf{r}.\mathbf{c})$	a) $\times \gamma_{mr} \times h_{eff}^2 / 2 =$	= 8.2 kN/m	
	Base soil		$F_{pass h} = m_{i}$	$ax(-\gamma_{Gf} \times K_{P} \times C)$, , :os(δ _{b.d}) × γ _{mb} × (d	_{cover} + h _{base}) ² /	2, -(F _{moist h})) =
			-8.2 kN/m		(12)	,	, (
	Total		Ftotal_h = Fm	oist_h + Fpass_h =	0 kN/m		
	Moments on wall						
	Wall stem		Mstem = Fste	$m \times x_{stem} = 19.6$	រ kNm/m		
	Wall base		M _{base} = F _{bas}	$_{se} \times x_{base} = 35.7$	7 kNm/m		
	Line loads		Mρ = (γg ×	Pg1 + γα × Pq1)	× p1 = 220.3 kNr	n/m	
	Moist retained soil		Mmoist = -Fm	noist_h × Xmoist_h =	- 3.5 kNm/m		
	Base soil		Mpass = Fpas	ss v × \mathbf{x}_{pass} v = 1	1.3 kNm/m		
	Total		M _{total} = M _{ste}	m + M _{base} + M _m	oist + Mpass + Mp =	283.4 kNm/m	
	Check bearing pressure						
	Propping force		Fprop_base =	$F_{total_h} = 0 \text{ kN/r}$	n		
	Distance to reaction		$\overline{\mathbf{x}} = \mathbf{I}_{\text{base}} / 2$	2 = 1150 mm			
	Eccentricity of reaction		$e = \bar{x} - I_{bas}$	_{se} / 2 = 0 mm			
	Loaded length of base		I _{load} = I _{base} =	= 2300 mm			
	Bearing pressure at toe		q _{toe} = F _{total} _	v / Ibase = 66.9	⟨N/m²		
	Bearing pressure at heel		q _{heel} = F _{total}	_v / I _{base} = 66.9	kN/m²		
	Effective overburden pressure		$q = (t_{base} +$	$d_{cover}) \times \gamma_{mb} = 1$	12.6 kN/m²		
	Design effective overburden pre	essure	$q' = q / \gamma_{\gamma} =$	12.6 kN/m ²			
	Bearing resistance factors		$N_q = Exp(\pi$	$\times tan(\phi'_{b.d})) \times ($	(tan(45 deg + \u00ed'b.c	(1 / 2)) ² = 7.821	
			$N_{c} = (N_{q} - 1)$	$I) \times cot(\phi'_{b.d}) =$	16.883		
			$N_{\gamma} = 2 \times (N_{\gamma})$	$q - 1) \times tan(\phi'_{b.a})$	d) = 5.512		
	Foundation shape factors		s _q = 1	. ,			
			$s_{\gamma} = 1$				
			s _c = 1				
	Load inclination factors		$H = F_{moist_h}$	+ Fpass_h - Fprop	o_base = 0 kN/m		
			$V = F_{total_v}$	= 154 kN/m			
			m = 2				
			iq = [1 - H /	$(V + I_{load} \times c'_{b.c})$	$\mathbf{u} \times \operatorname{cot}(\phi'_{b.d}))]^m = 1$		
			i _γ = [1 - Η /	(V + Iload \times C'b.d	$(\times \text{ cot}(\phi'b.d))]^{(m + 1)}$	= 1	
			i _c = i _q - (1 -	i_q) / (N _c × tan(d	¢'b.d)) = 1		
	Net ultimate bearing capacity		$Nf = C'_{b.d} \times I$	$N_c \times s_c \times i_c + q'$	$\times \ N_{q} \times s_{q} \times i_{q} + 0$	$.5 imes \gamma_{mb} imes I_{load} imes$	$\langle N_{\gamma} \times s_{\gamma} \times i_{\gamma} =$
			231.7 kN/n	n²			
	Factor of safety		$FoS_{bp} = n_f$	/ max(q _{toe} , q _{hee}	ı) = 3.461		
		PASS - A	llowable bearin	ig pressure ex	ceeds maximui	n applied bea	ring pressure
	Partial factors on actions - Ta	ble A.3 - Comb	oination 2				
	Permanent unfavourable action		γg = 1.00				
	Permanent favourable action		γ _{Gf} = 1.00				
	Variable unfavourable action		γα = 1.30				
	Variable favourable action		$\gamma_{Qf} = 0.00$				
1							

Todds	54 Sumatra road, London, NW6 1PR 1165							
Bini Engineering	Calcs for				Start page no./	Revision		
Unit 415, 241-251 Ferndale Road,		Retaining Wall -		5 P1				
London SW9 8BJ	Calcs by VC	Calcs date 21/10/2018	Checked by	Checked date	Approved by	Approved date		
			_	1		1		
Partial factors for soil paran	neters – Table	A.4 - Combinatio	n 2					
Angle of shearing resistance		$\gamma_{\phi'} = 1.25$						
Effective conesion		$\gamma_{c'} = 1.25$						
		$\gamma_{\gamma} = 1.00$						
Retained soil properties								
Design effective shear resista	nce angle	$\phi' r.d = atan($	tan(φ'r.k) / γ _φ ') =	= 14.6 deg				
Design wall friction angle		$\delta_{r,d} = atan($	tan(ðr.k) / γ _{φ'}) =	7.2 deg				
Base soil properties								
Design effective shear resista	nce angle	∳' _{b.d} = atan	(tan(φ' _{b.k}) / γ _{φ'})	= 17.9 deg				
Design wall friction angle		δb.d = atan(tan(δ _{b.k}) / γ _{φ'}) =	8.8 deg				
Design base friction angle		$\delta_{bb.d} = atan$	(tan(δ _{bb.k}) / γ _{φ'})	= 11.9 deg				
Design effective cohesion		$c'_{b.d} = c'_{b.k} / \gamma_{c'} = 0 \ kN/m^2$						
Using Coulomb theory								
Active pressure coefficient	$K_A = sin(\alpha)$	+ φ'r.d) ² / (sin(o	$(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times \delta_{r.d}$	[1 + √[sin(¢'r.d	+ δr.d) ×			
		sin(φ'r.d - β)	/ (sin(α - δr.d)	$\times \sin(\alpha + \beta))]]^2) =$	0.553			
Passive pressure coefficient		$K_P = sin(90)$) - ¢'₀.d)² / (sin(90 + $\delta_{b.d}$) × [1 - $$	[sin(φ'b.d + δb.d)	$\times sin(\phi'_{b.d})$ /		
		(sin(90 + δ	b.d))]] ²) = 2.340)				
Overturning check								
Vertical forces on wall								
Wall stem		$F_{stem} = \gamma_{Gf}$	< Astem × γstem =	= 6.8 kN/m				
Wall base		$F_{base} = \gamma_{Gf}$	< Abase × γbase =	= 23 kN/m				
Line loads		$F_{P_v} = \gamma_{Gf} \times P_{G1} + \gamma_{Qf} \times P_{Q1} = 67 \text{ kN/m}$						
Total		$F_{total_v} = F_{stem} + F_{base} + F_{P_v} = 96.8 \text{ kN/m}$						
Horizontal forces on wall								
Moist retained soil		$F_{moist_h} = \gamma G$	$\mathbf{s} \times \mathbf{K}_{A} \times \mathbf{cos}(\delta_{r})$	d) $\times \gamma_{mr} \times h_{eff}^2$ / 2	= 7 kN/m			
Base soil		$F_{exc_h} = -\gamma_{Gf} \times K_P \times cos(\delta_{b.d}) \times \gamma_{mb} \times (h_{pass} + h_{base})^2 / 2 = -3.9 \text{ kN/m}$						
Total		$F_{total_h} = F_m$	oist_h + F _{exc_h} =	3.1 kN/m				
Overturning moments on w	all							
Moist retained soil		M _{moist_OT} =	$F_{moist_h} imes \mathbf{x}_{moist_moist}$	_h = 3 kNm/m				
Total		M _{total_OT} = N	M _{moist_OT} = 3 kN	lm/m				
Restoring moments on wall								
Wall stem		$M_{stem_R} = F$	$_{stem} \times x_{stem} = 1$	4.5 kNm/m				
Wall base		$M_{base_R} = F$	$base \times Xbase = 2$	6.4 kNm/m				
Line loads		MP_R = (ab	s(γgf × Pg1 + γα	$q_f \times Pq_1) \times p_1 = 1$	44.1 kNm/m			
Total		$M_{total_R} = M$	stem_R + Mbase_F	R + MP_R = 185 kM	Nm/m			
Check stability against over	turning							
Factor of safety		FoSot = Mtc	atal R / Mtotal OT =	= 61.413				

٢		Job no.					
Tedds		54	Sumatra road,	London, NW6	1PR	11654	
Bini Engineering Unit 415, 241-251 Ferndale Road,	Calcs for	R	etaining Wall - \	Wall WITH NO	. 52	Start page no./R	evision P1
London SW9 8BJ	Calcs by VC		Calcs date 21/10/2018	Checked by	Checked date	Approved by	Approved date
Bearing pressure check							
Vertical forces on wall							
Wall stem			$F_{stem} = \gamma G \times$	Astem $\times \gamma$ stem = 6	6.8 kN/m		
Wall base			$F_{base} = \gamma_G \times$	$A_{base} \times \gamma_{base} = 2$	23 kN/m		
Line loads			$F_{P_v} = \gamma_G \times I$	Pg1 + γq × Pq1 =	= 77.4 kN/m		
Base soil			$F_{pass_v} = \gamma G$	\times Apass \times γ mb =	8.4 kN/m		
Total			Ftotal_v = Fste	em + Fbase + Fpas	s_v + FP_v = 115.6	3 kN/m	
Horizontal forces on wall							
Moist retained soil			$F_{moist_h} = \gamma G$	× $K_A \times cos(\delta_{r.d})$) $\times \gamma_{mr} \times h_{eff}^2 / 2 =$	7 kN/m	
Base soil			F _{pass_h} = ma	$\mathbf{a}\mathbf{x}(-\gamma_{\mathrm{Gf}}\times\mathbf{K}_{\mathrm{P}}\times\mathbf{C})$	$DS(\delta_{b.d}) \times \gamma_{mb} \times (d)$	$_{\rm cover}$ + $h_{\rm base})^2$ / 2	2, -(F _{moist_h})) =
			-7 kN/m				
Total			Ftotal_h = Fmc	oist_h + Fpass_h =	0 kN/m		
Moments on wall							
Wall stem			M _{stem} = F _{ster}	$m \times x_{stem} = 14.5$	kNm/m		
Wall base			Mbase = Fbas	$x \times x_{base} = 26.4$	kNm/m		
Line loads	oads			P _{G1} + γ _Q × P _{Q1})	× p1 = 166.4 kNn	n/m	
Moist retained soil		$M_{moist} = -F_{moist_h} \times x_{moist_h} = -3 \text{ kNm/m}$					
Base soil	$M_{pass} = F_{pass_v} \times x_{pass_v} = 8.4 \text{ kNm/m}$						
Total			Mtotal = Mster	m + Mbase + Mmo	ist + Mpass + MP =	212.8 kNm/m	
Check bearing pressure							
Propping force			$F_{prop_base} = F$	F _{total_h} = 0 kN/m	l		
Distance to reaction			$\overline{\mathbf{x}} = \mathbf{I}_{\text{base}} / 2$	2 = 1150 mm			
Eccentricity of reaction			$e = \bar{x} - I_{base}$	∍ / 2 = 0 mm			
Loaded length of base			lload = Ibase =	2300 mm			
Bearing pressure at toe			$q_{toe} = F_{total_v}$	/ I _{base} = 50.2 k	N/m²		
Bearing pressure at heel			$q_{heel} = F_{total}$	v / Ibase = 50.2	kN/m²		
Effective overburden pressure			$q = (t_{base} + o)$	$d_{cover}) \times \gamma_{mb} = 1$	2.6 kN/m²		
Design effective overburden pre	ssure		$q' = q / \gamma_{\gamma} =$	12.6 kN/m ²			
Bearing resistance factors			$N_q = Exp(\pi$	$\times tan(\phi'_{b.d})) \times (t$	an(45 deg + \phi_b.d	/ 2)) ² = 5.213	
			$N_{c} = (N_{q} - 1)$	$) \times \cot(\phi'_{b.d}) = 1$	3.034		
			$N_{\gamma} = 2 \times (N_{\gamma})$	q - 1) × tan(φ'ь.d) = 2.723		
Foundation shape factors			s _q = 1				
			$s_{\gamma} = 1$				
			sc = 1				
Load inclination factors			$H = F_{moist_h}$	+ Fpass_h - Fprop_	_base = 0 kN/m		
			$V = F_{total_v} =$	= 115.6 kN/m			
			m = 2				
			$I_q = [I - \Pi / I_1]$	$(V + Iload \times C b.d)$	$\times \operatorname{COI}(\psi \operatorname{b.d}))]^{m} = \mathbf{I}$		
			$i_{\gamma} = [1 - H]$	$(V + Iload \times Cb.d$	× COI(φ b.d))] ^(m - 1)	= 1	
Not ultimate because and the			$I_{c} = I_{q} - (1 - 1)$	iq) / (Νc × tan(φ	b.d)) = 1	F	Nue
Net ultimate bearing capacity			n _f = C [·] _{b.d} × N 131.4 kN/m	$\mathbf{v}_{c} \times \mathbf{S}_{c} \times \mathbf{I}_{c} + \mathbf{q}'$	× Nq × Sq × Iq + 0.	$\mathbf{S} \times \gamma_{mb} \times \mathbf{I}_{load} \times \mathbf{S}$	$\mathbf{IN}_{\gamma} \times \mathbf{S}_{\gamma} \times \mathbf{I}_{\gamma} =$

<u></u>	Project Job no.						
Tedds	5	4 Sumatra road,	London, NW6	1PR	11654		
Bini Engineering	Calcs for				Start page no./R	evision	
Unit 415, 241-251 Ferndale Road,		Retaining Wall - V	7 P1				
London SW9 8BJ	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date	
	VC	21/10/2018					
Factor of safety		$FoS_{bp} = n_f / $	max(qtoe, qheel) = 2.616			
	PASS - A	llowable bearin	g pressure ex	cceeds maximur	n applied bea	ring pressure	

Job Ref Project 54 Sumatra road, London, Bini Struct-e **NW6 1PR** 11654 Ltd. Calculations by Checked by Drawing Ref Sheet of Consulting VC MR Structural Date Part of Structure Engineers 10.2018 RETAINING WALL DESIGN - PARTY WALL WITH NO.56. UDL due to reaction from Upl 685 / 6B2 & PARTY WALL WITH CHIMNEY BREASTS. UPL @ DL = (0,215×19+0,2)×9+ [(0,215×19+0.2)×12×3,2]/10×2 +(73,6 x2 + 43,7x2)/10 = 95kN/m. 11=(19,7×2+ 19.2×2)/10 = 7,8 kN/m.

Tedds	Project 54	Sumatra road, I	London, NW6 1I	PR	Job no. 11654		
Bini Engineering Unit 415, 241-251 Ferndale Road,	Calcs for	etaining Wall - V	Vall WITH NO. 5	56	Start page no./Re 1	vision P1	
London SW9 8BJ	Calcs by VC	Calcs date 21/10/2018	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

P_{Q1} = **8** kN/m

Tedds calculation version 2.6.04

Retaining wall details	
Stem type	Cantilever
Stem height	h _{stem} = 2300 mm
Prop height	h _{prop} = 900 mm
Stem thickness	t _{stem} = 300 mm
Angle to rear face of stem	α = 90 deg
Stem density	$\gamma_{stem} = 25 \text{ kN/m}^3$
Toe length	l _{toe} = 2000 mm
Base thickness	t _{base} = 400 mm
Base density	$\gamma_{\text{base}} = 25 \text{ kN/m}^3$
Height of retained soil	h _{ret} = 2100 mm
Angle of soil surface	$\beta = 0 \deg$
Depth of cover	d _{cover} = 200 mm
Depth of excavation	d _{exc} = 200 mm
Retained soil properties	
Soil type	Organic clay
Moist density	$\gamma_{mr} = 15 \text{ kN/m}^3$
Saturated density	$\gamma_{sr} = 15 \text{ kN/m}^3$
Characteristic effective shear resistance angle	φ'r.k = 18 deg
Characteristic wall friction angle	$\delta_{r.k} = 9 \text{ deg}$
Base soil properties	
Soil type	Stiff or hard glacial silty clay
Moist density	$\gamma_{mb} = 21 \text{ kN/m}^3$
Characteristic cohesion	$c'_{b,k} = 0 \ kN/m^2$
Characteristic effective shear resistance angle	φ' _{b.k} = 22 deg
Characteristic wall friction angle	δ _{b.k} = 11 deg
Characteristic base friction angle	$\delta_{bb.k}$ = 14.7 deg
Loading details	
Vertical line load at 2150 mm	P _{G1} = 95 kN/m



Taddai	Project Job no. 54 Sumatra road, London, NW6 1PR 11654										
Rini Engineering	Calcs for				Start page no./Re	evision					
Unit 415, 241-251 Ferndale Road,		Retaining Wall -	Wall WITH NO	. 56	3	P1					
London SW9 8BJ	Calcs by VC	Calcs date 21/10/2018	Checked by	Checked date	Approved by	Approved date					
Effective cohesion											
Weight density		$\gamma c = 1.00$									
		$\gamma\gamma = 1.00$									
Retained soil properties											
Design effective shear resistant	ce angle	φ'r.d = atan($\tan(\phi' r.k) / \gamma_{\phi'}) =$	18 deg							
Design wall friction angle		$\delta_{r,d} = atan(t)$	$an(\delta_{r,k}) / \gamma_{\phi'}) = S$	aeg							
Base soil properties											
Design effective shear resistant	ce angle	φ' _{b.d} = atan(tan(φ' _{b.k}) / γ _{φ'}) =	22 deg							
Design wall friction angle		$\delta_{b.d} = atan($	tan(δ _{b.k}) / γ _{φ'}) =	11 deg							
Design base friction angle		δ _{bb.d} = atan	(tan(δьь.k) / γ _{φ'}) :	= 14.7 deg							
Design effective cohesion		$C'_{b,d} = C'_{b,k} /$	$\gamma_{c'} = 0 \text{ kN/m}^2$								
Using Coulomb theory											
Active pressure coefficient		$K_A = sin(\alpha \cdot$	+ $\phi'_{r.d}$) ² / (sin(α)	$^{2} \times sin(\alpha - \delta_{r.d}) \times [$	[1 + √[sin(¢'r.d +	$\delta_{r.d}$) ×					
		sin(φ'r.d - β)	/ (sin(α - $\delta_{r.d}$) ×	$sin(\alpha + \beta))]]^2) = 0$	0.483						
Passive pressure coefficient	Passive pressure coefficient			$K_{P} = sin(90 - \phi'_{b.d})^{2} / (sin(90 + \delta_{b.d}) \times [1 - \sqrt{sin(\phi'_{b.d} + \delta_{b.d})} \times sin(\phi'_{b.d}) / (sin(\phi'_{b.d} + \delta_{b.d}) / (sin(\phi'_{b.d} + \delta_{b.d})$							
		(sin(90 + δι	o.d))]] ²) = 2.958								
Overturning check											
Vertical forces on wall											
Wall stem		$F_{stem} = \gamma_{Gf} \times$	$A_{stem} \times \gamma_{stem} =$	17.3 kN/m							
Wall base		$F_{base} = \gamma_{Gf} \times$	Abase \times γ base =	23 kN/m							
Line loads		$F_{P_v} = \gamma_{Gf} \times$	$F_{P_v} = \gamma_{Gf} \times P_{G1} + \gamma_{Qf} \times P_{Q1} = 95 \text{ kN/m}$								
Total		$F_{total_v} = F_{st}$	em + Fbase + FP_	v = 135.3 kN/m							
Horizontal forces on wall											
Moist retained soil		$F_{moist_h} = \gamma G$	$\times K_{A} \times cos(\delta_{r.d})$) × γ_{mr} × heff ² / 2 =	35.2 kN/m						
Base soil		$F_{exc_h} = -\gamma_{Gf}$	$\times \text{ K}_{\text{P}} \times \text{ cos}(\delta_{\text{b.d}}$) × γ_{mb} × (h _{pass} + 1	n _{base}) ² / 2 = -4.9	kN/m					
Total		$F_{total_h} = F_m$	oist_h + F _{exc_h} = 3	30.3 kN/m							
Overturning moments on wal	I										
Moist retained soil		M _{moist_OT} =	$-$ moist_h × Xmoist_h	= 31.7 kNm/m							
Total		$M_{total_OT} = N$	moist_OT = 31.7	kNm/m							
Restoring moments on wall											
Wall stem		$M_{stem_R} = F_{stem_R}$	stem × Xstem = 37	.1 kNm/m							
Wall base		$M_{base_R} = F$	$base \times x_{base} = 26$.4 kNm/m							
Line loads		$M_{P_R} = (abs$	s(γgf × Pg1 + γqf	× Pq1)) × p1 = 20	4.3 kNm/m						
Total		$M_{total_R} = M_{total_R}$	stem_R + M base_R	+ M _{P_R} = 267.8 k	Nm/m						
Check stability against overtu	ırning										
Factor of safety		$FoS_{ot} = M_{to}$	tal_R / Mtotal_OT =	8.449							
		PASS - Maximui	n restoring m	oment is greater	r than overtur	ning moment					
Bearing pressure check											
Vertical forces on wall											
Wall stem		$F_{stem} = \gamma_G \times$	$A_{stem} \times \gamma_{stem} = 2$	23.3 kN/m							
Wall base		$F_{base} = \gamma G \times$	Abase $\times \gamma$ base = 3	31.1 kN/m							

Project Job no.						054		
Tedds		54 Sumatra road,	London, NW6	1PR	11	654		
Bini Engineering Unit 415, 241-251 Ferndale Road,	Calcs for	Retaining Wall -	Wall WITH NO	Start page no./R 4	Start page no./Revision 4 P1			
London SW9 8BJ	Calcs by VC	Calcs date 21/10/2018	Checked by	Checked date	Approved by	Approved date		
Line loads		$F_{P_v} = \gamma_G \times$	P _{G1} + γ _Q × P _{Q1}	= 140.3 kN/m				
Base soil		$F_{pass_v} = \gamma G$	\times Apass \times γ mb =	11.3 kN/m				
Total		$F_{total_v} = F_{ster}$	em + Fbase + Fpa	_{ss_v} + F _{P_v} = 205.	9 kN/m			
Horizontal forces on wall								
Moist retained soil		$F_{moist_h} = \gamma_G$	$\times \; \textbf{K}_{\textbf{A}} \times \textbf{cos}(\delta_{r.d}$) $\times \gamma_{mr} \times h_{eff}^2 / 2 =$	= 35.2 kN/m			
Base soil	$F_{pass_h} = -\gamma G$	$s_{f} \times K_{P} \times cos(\delta_{b})$.d) $\times \gamma_{mb} \times (d_{cover} -$	+ h _{base}) ² / 2 = -1	1 kN/m			
Total	$F_{total_h} = F_{mon}$	oist_h + Fpass_h =	24.2 kN/m					
Moments on wall								
Wall stem		Mstem = Fster	$m \times x_{stem} = 50.1$	kNm/m				
Wall base		$M_{base} = F_{bas}$	x = x x base = 35.7	′ kNm/m				
Line loads		$M_P = (\gamma_G \times I)$	P _{G1} + γ _Q × P _{Q1})	× p1 = 301.5 kNr	m/m			
Moist retained soil		$M_{moist} = -F_{m}$	oist_h × Xmoist_h =	-31.7 kNm/m				
Base soil	$M_{pass} = F_{pas}$	$x_{s_v} \times x_{pass_v} = 1$	1.3 kNm/m					
Total	Mtotal = Mstem + Mbase + Mmoist + Mpass + Mp = 367 kNm/m							
Check bearing pressure								
Propping force		$F_{prop_base} =$	F _{total_h} = 24.2 k	N/m				
Distance to reaction	$\overline{\mathbf{x}} = \mathbf{I}_{\text{base}} / 2$	2 = 1150 mm						
Eccentricity of reaction	$e = \bar{x} - I_{bas}$	₀ / 2 = 0 mm						
Loaded length of base		load = base =	= 2300 mm					
Bearing pressure at toe		$q_{toe} = F_{total_v}$	/ I _{base} = 89.5 k	N/m²				
Bearing pressure at heel		$q_{heel} = F_{total}$	v / I _{base} = 89.5	kN/m²				
Effective overburden pressure		$q = (t_{base} + $	$d_{cover}) \times \gamma_{mb} = 1$	2.6 kN/m ²				
Design effective overburden pre	essure	$q' = q / \gamma_{\gamma} =$	12.6 kN/m ²					
Bearing resistance factors		$N_q = Exp(\pi$	$\times \tan(\phi'_{b.d})) \times ($	tan(45 deg + \ _b.c	(2)) ² = 7.821			
		Nc = (Nq - 1	$) \times \cot(\phi'_{b.d}) = f$	16.883				
		$N_{\gamma} = 2 \times (N_{\gamma})$	q - 1) × tan(φ'ь.d) = 5.512				
Foundation shape factors		s _q = 1						
		s _γ = 1						
		sc = 1		0.1.11/				
Load inclination factors		$H = F_{moist_h}$	+ Fpass_h - Fprop - 205 9 kN/m	_base = U KIN/M				
		$v = F total_v = m = 2$	= 203.9 KIN/III					
		ia = [1 - H /	$(V + I_{load} \times C'_{hd})$	$\times \operatorname{cot}(\phi'_{b,d}))^{m} = 1$				
		i _x = [1 - H /	$(V + I_{load} \times C'_{bd})$	$\times \operatorname{cot}(\phi'_{b,d}))^{(m+1)}$	= 1			
		$i_{c} = i_{a} - (1 - 1)$	i_{α}) / (N _c × tan(ϕ	(p, d) = 1	-			
Net ultimate bearing capacity		$n_f = C'_{bd} \times N_{bd}$	$\mathbf{v}_{c} \times \mathbf{s}_{c} \times \mathbf{i}_{c} + \mathbf{a}'$	× Na × Sa × ia + 0	$.5 \times \gamma_{mb} \times I_{load} \times$	$N_{y} \times S_{y} \times i_{y} =$		
5 · · · · · · · · · · · · · · · · · · ·		231.7 kN/m	1 ²		,	1 -1 1		
Factor of safety		$FoS_{bp} = n_f$	max(qtoe, qheel) = 2.587				
	PASS	· Allowable bearin	g pressure ex	ceeds maximu	m applied bea	ring pressure		
Partial factors on actions - Ta	ble A.3 - Co	mbination 2						
Permanent unfavourable action		γg = 1.00						

Tadda	Project	Job no. 1	Job no. 11654					
Bini Engineering	Calcs for				Start page no./	Revision		
Unit 415, 241-251 Ferndale Road,		Retaining Wall -		5 P1				
London SW9 8BJ	Calcs by VC	Calcs date 21/10/2018	Checked by	Checked date	Approved by	Approved date		
Variable unfavourable action		γ Q = 1.30						
Variable favourable action		$\gamma_{Qf} = 0.00$						
Partial factors for soil param	eters – Table	A.4 - Combinatio	n 2					
Angle of shearing resistance		$\gamma_{\phi'} = 1.25$						
Effective cohesion		$\gamma_{c'} = 1.25$						
Weight density		$\gamma_{\gamma} = 1.00$						
Retained soil properties								
Design effective shear resistar	nce angle	∳'r.d = atan	(tan(φ'r.k) / γ _{φ'}) =	= 14.6 deg				
Design wall friction angle		δr.d = atan($tan(\delta_{r.k}) / \gamma_{\phi'}) =$	7.2 deg				
Base soil properties								
Design effective shear resistar	nce angle	₀' _{Ե.d} = atan	(tan(φ'ык) / γω) :	= 17.9 dea				
Design wall friction angle	i i i i i i i gi i	δ _{b.d} = atan($(\tan(\delta_{\rm b,k}) / \gamma_{\rm b}) =$	8.8 dea				
Design base friction angle		$\delta_{bb,d} = \operatorname{atan}(\operatorname{tan}(\delta_{bb,k}) / \gamma_{d}) = 11.9 \operatorname{deg}$						
Design effective cohesion	$c'_{b,d} = c'_{b,k} / \gamma_{c'} = 0 \text{ kN/m}^2$							
Using Coulomb theory								
Active pressure coefficient		$K_{A} = \sin(\alpha)$	+ \(\dots)^2 / (\sin(\alpha))	$(\alpha - \delta_{rd}) \times$	[1 + √[sin(\ _r_d	+δrd) ×		
		sin(\u00f6'r.d - \u00bb)) / (sin(α - δr.d)	$\times \sin(\alpha + \beta))$	0.553			
Passive pressure coefficient		$K_P = \sin(90)$) - φ' _{b.d}) ² / (sin(90 + δ _{b.d}) × [1 - √[sin(φ'ь.d + δь.d)	× sin(o'b.d) /		
		(sin(90 + δ	b.d))]] ²) = 2.340)				
Overturning check								
Vertical forces on wall								
Wall stem		$F_{stem} = \gamma_{Gf}$	× A _{stem} × γ _{stem} =	17.3 kN/m				
Wall base		$F_{base} = \gamma_{Gf}$	× Abase × γbase =	= 23 kN/m				
Line loads		$F_{P_v} = \gamma_{Gf} \times P_{G1} + \gamma_{Qf} \times P_{Q1} = 95 \text{ kN/m}$						
Total		$F_{total_v} = F_{stem} + F_{base} + F_{P_v} = 135.3 \text{ kN/m}$						
Horizontal forces on wall								
Moist retained soil		$F_{moist_h} = \gamma G$	$\mathbf{s} \times \mathbf{K} \mathbf{A} \times \mathbf{cos}(\delta \mathbf{r})$	d) × γ mr × heff ² / 2 =	= 30 kN/m			
Base soil		$F_{exc_h} = -\gamma_{Gf} \times K_P \times cos(\delta_{b.d}) \times \gamma_{mb} \times (h_{pass} + h_{base})^2 \ / \ 2 = -3.9 \ kN/m$						
Total		F _{total_h} = F _m	$poist_h + F_{exc_h} =$	26.1 kN/m				
Overturning moments on wa	ll.							
Moist retained soil		M _{moist_OT} =	$F_{moist_h} \times x_{moist_h}$	h = 27 kNm/m				
Total		Mtotal_OT = N	$M_{moist_OT} = 27 \text{ k}$	Nm/m				
Restoring moments on wall								
Wall stem		$M_{stem_R} = F$	stem \times Xstem = 37	7.1 kNm/m				
Wall base		$M_{base_R} = F$	$base \times x_{base} = 20$	6.4 kNm/m				
		Mp_r = (ab	s(γgf × Pg1 + γg	$p_f \times P_{Q1}) \times p_1 = 2$	04.3 kNm/m			
Line loads								
Line loads Total		$M_{total_R} = M$	stem_R + Mbase_R	R + MP_R = 267.8 I	kNm/m			
Line loads Total Check stability against overt	urning	Mtotal_R = M	stem_R + Mbase_R	α + Mρ_R = 267.8 Ι	kNm/m			

Tedds	Project Job no. 54 Sumatra road, London, NW6 1PR 1165								
Bini Engineering	Calcs for				Start page no./R	evision			
Unit 415, 241-251 Ferndale Road,		Retaining Wall -	Wall WITH NO	. 56	6	5 P1			
London SW9 8BJ	Calcs by VC	Calcs date 21/10/2018	Checked by	Checked date	Approved by	Approved date			
Bearing pressure check									
Vertical forces on wall									
Wall stem		$F_{stem} = \gamma G \times$	Astem $\times \gamma$ stem =	17.3 kN/m					
Wall base		$F_{base} = \gamma_G \times$	$A_{base} \times \gamma_{base} =$	23 kN/m					
Line loads		$F_{P_v} = \gamma_G \times$	P G1 + γα × P α1	= 105.4 kN/m					
Base soil		$F_{pass_v} = \gamma G$	\times A _{pass} \times γ mb =	8.4 kN/m					
Total		Ftotal_v = Fste	em + Fbase + Fpa	ss_v + FP_v = 154.	1 kN/m				
Horizontal forces on wall									
Moist retained soil		$F_{moist} h = v_{G}$	$\times K_A \times \cos(\delta_{rd})$) $\times v_{mr} \times h_{eff}^2 / 2 =$	= 30 kN/m				
Base soil		$F_{\text{noss}} = -\gamma c$		d) X Vmb X (decver :	$+ h_{hagg}^2 / 2 = -8$	7 kN/m			
Total		Ftotal h = Fm	$h + F_{\text{pass}} h =$	21.2 kN/m					
			bist_ii i i pass_ii —						
Moments on wall				1. N. I					
		IVIstem = Fster	$m \times X$ stem = 37.1	KNM/M					
		$\frac{1}{1000} = \frac{1}{1000} = \frac{20.4 \text{ NNIII/III}}{\text{Mp}} = \frac{1}{1000} = \frac{20.4 \text{ NNIII/III}}{\text{Np}} = \frac{20.4 \text{ NNIII/III}}{\text{Np}}$							
Line loads		$M_{P} = (\gamma_{G} \times I_{G})$	PG1 + γα × Pα1)	× p1 = 226.6 KNI	m/m				
Moist retained soil		Mmoist = -Fm	oist_h × Xmoist_h =	-27 kNm/m					
Base soil		$M_{pass} = F_{pas}$	$s_v \times x_{pass_v} = 8$.4 kNm/m					
Total		M _{total} = M _{ster}	m + Mbase + Mmo	oist + Mpass + Mp =	= 271.6 kNm/m				
Check bearing pressure									
Propping force		Fprop_base =	Ftotal_h = 21.2 k	N/m					
Distance to reaction		$\overline{\mathbf{x}} = \mathbf{I}_{\text{base}} / 2$	2 = 1150 mm						
Eccentricity of reaction		$e = \overline{x} - I_{bas}$	_e / 2 = 0 mm						
Loaded length of base		lload = lbase =	2300 mm						
Bearing pressure at toe		$q_{toe} = F_{total_v}$	/ Ibase = 67 kN	/m²					
Bearing pressure at heel		$q_{heel} = F_{total}$	_v / I _{base} = 67 kN	l/m²					
Effective overburden pressure		$q = (t_{base} + $	d_{cover}) × γ_{mb} = 1	2.6 kN/m ²					
Design effective overburden pre	essure	$q' = q / \gamma_{\gamma} =$	12.6 kN/m ²						
Bearing resistance factors		$N_{q} = Exp(\pi \times tan(\phi'_{b.d})) \times (tan(45 \text{ deg} + \phi'_{b.d} / 2))^{2} = 5.213$							
		Nc = (Nq - 1	$) \times \cot(\phi'_{b.d}) = c$	13.034					
		$N_{\gamma} = 2 \times (N_{\gamma})$	գ - 1) × tan(փ'ь.ժ) = 2.723					
Foundation shape factors		s _q = 1							
		$s_{\gamma} = 1$							
		s _c = 1							
Load inclination factors		$H = F_{moist_h}$	+ F _{pass_h} - F _{prop}	_ _{base} = 0 kN/m					
		V = F _{total_v} =	= 154.1 kN/m						
		m = 2							
		iq = [1 - H /	$(V + I_{load} \times C'_{b.d})$	$\times \operatorname{cot}(\phi'_{b.d}))]^m = 1$					
		i _γ = [1 - Η /	$(V + I_{load} \times C'_{b.d})$	$\times \operatorname{cot}(\phi'_{b.d}))]^{(m+1)}$	= 1				
		$i_c = i_q - (1 - $	i_q) / (N _c × tan(ϕ	(b.d)) = 1					
Net ultimate bearing capacity		$n_f = c'_{b.d} \times N_{c}$	$\mathbf{N}_{c} \times \mathbf{S}_{c} \times \mathbf{i}_{c} + \mathbf{q}'$	$\times N_q \times s_q \times i_q + 0$	$.5 imes \gamma_{mb} imes I_{load} imes$	$N_{\gamma} \times S_{\gamma} \times i_{\gamma} =$			
		131.4 kN/m	1 ²						
Factor of safety		$FoS_{bp} = n_f /$	max(q _{toe} , q _{heel}) = 1.963					

Tedds	Project 54	Job no. 11654					
Bini Engineering Unit 415, 241-251 Ferndale Road, London SW9 8BJ	Calcs for R	alcs for Retaining Wall - Wall WITH NO. 56				Start page no./Revision 7 P1	
	Calcs by VC	Calcs date 21/10/2018	Checked by	Checked date	Approved by	Approved date	

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

Bini Struct-e	Project 54 Sumatra road, London, NW6 1PR		Job Ref 11654		
Ltd. Consulting Structural	Drawing Ref	Calculations by BD	Checked by DB	Sheet of	
Engineers	Part of Structure UPLIFT FORCE		Date 09.2018		

MOVEMENT DUE TO REMOVAL OF SOIL : i.e. UPLIFT & MEANE



:. DUE TO WALLS & PLOORS ADDUCE: 73.6 × $(8 \times 2 + 5.2 \times 2) = 1928 \text{ MALLS}$ DUE TO WALLS AT GASEAGENT = 0.3 × 3×24 × $(8 \times 2 + 5.2 \times 2) = 510 \text{ MALLS}$ DUE TO RAFT STABESCREED= 0.475×24×8×5.2 = 474 TO TAL LOAD = 1928 + 570 + 2474 = 2472 \text{ MALLS}

SOIL REMOJAL !. TUTAL UPLIPE FORCE = 18x8xBA × 2.8 + 1.2x8x1.5X18= 1751 KA ... F.O.S = 2972/1701 = 1.7 ... NO UPLIFE. SLAB & HEAVE DESLUP REFER TO FOLLOWING PAOES

Tedds	Project 54 Sumatra road, London, NW6 1PR					Job no. 11654	
Bini Struct-e	Calcs for Basement Slab - HEAVE				Start page no./Revision 1		
	Calcs by DB	Calcs date 21/10/2018	Checked by	Checked date	Approved by	Approved date	

RC SLAB DESIGN

In accordance with EN1992-1-1:2004 incorporating corrigendum January 2008 and the UK national annex

Tedds calculation version 1.0.10



Slab definition

Type of slab	Two way spanning with restrained edges
Overall slab depth	h = 400 mm
Shorter effective span of panel	l _x = 4500 mm
Longer effective span of panel	l _y = 9600 mm
Support conditions	Four edges continuous (interior panel)
Top outer layer of reinforcement	Short span direction
Bottom outer layer of reinforcement	Short span direction
Loading	
Characteristic permanent action	G _k = 54.0 kN/m ²
Characteristic variable action	Q _k = 0.0 kN/m ²
Partial factor for permanent action	γ _G = 1.35
Partial factor for variable action	γ Q = 1.50
Quasi-permanent value of variable action	$\psi_2 = 0.30$
Design ultimate load	$\textbf{q} = \gamma_{G} \times G_k + \gamma_{Q} \times Q_k = \textbf{72.9} \text{ kN/m}^2$
Quasi-permanent load	$q_{\text{SLS}} = 1.0 \times G_k + \psi_2 \times Q_k = \textbf{54.0} \ kN/m^2$
Concrete properties	
Concrete strength class	C35/45
Characteristic cylinder strength	f _{ck} = 35 N/mm ²

Partial factor (Table 2.1N) Compressive strength factor (cl. 3.1.6) Design compressive strength (cl. 3.1.6) Mean axial tensile strength (Table 3.1) Maximum aggregate size

Reinforcement properties

Characteristic yield strength Partial factor (Table 2.1N) Design yield strength (fig. 3.8)

Concrete cover to reinforcement

Nominal cover to outer top reinforcement

 $\begin{aligned} & \zeta_{ck} = \textbf{35} \text{ N/mm}^2 \\ & \gamma_{C} = \textbf{1.50} \\ & \alpha_{cc} = \textbf{0.85} \\ & f_{cd} = \textbf{19.8} \text{ N/mm}^2 \\ & f_{ctm} = 0.30 \text{ N/mm}^2 \times (f_{ck} \ / \ 1 \text{ N/mm}^2)^{2/3} = \textbf{3.2} \text{ N/mm}^2 \\ & d_g = \textbf{20} \text{ mm} \end{aligned}$

 $f_{yk} = 500 \text{ N/mm}^2$ $\gamma s = 1.15$ $f_{yd} = f_{yk} / \gamma s = 434.8 \text{ N/mm}^2$

 $c_{nom_t} = 30 \text{ mm}$

	Project 54	Sumatra road,	London, NW6	Job no. 11654					
Bini Struct-e	Calcs for				Start page no./R	evision			
		Basement S	Slab - HEAVE			2			
	Calcs by DB	Calcs date 21/10/2018	Checked by	Checked date	Approved by	Approved date			
Nominal cover to outer botton	n reinforcement	Cnom_b = 30	mm						
Fire resistance period to top of	of slab	R _{top} = 60 m	in						
Fire resistance period to botto	om of slab	Rbtm = 60 m	nin						
Axia distance to top reinft (Ta	ble 5.8)	a _{fi_t} = 15 m	m						
Axia distance to bottom reinft	(Table 5.8)	afi_b = 15 m	m						
Min. top cover requirement wi	ith regard to bond	Cmin,b_t = 16	mm						
Min. btm cover requirement w	ith regard to bond	Cmin,b_b = 10	mm						
Reinforcement fabrication		Not subjec	t to QA syste	m					
Cover allowance for deviation		$\Delta C_{dev} = 10$ i	mm						
Min. required nominal cover to	o top reinft	Cnom_t_min = 2	26.0 mm						
Min. required nominal cover to	o bottom reinft	Cnom_b_min =	20.0 mm	in aufficient cou	an ta tha tan m				
		r PAS	-ASS - There S - There is si	is sumicient cov ufficient cover to	er to the top r o the bottom r	einforcement einforcement			
Poinforcoment design at mi	idenan in chart a	oon direction (ennoreennem			
Rending moment coefficient	iuspan in short sp		21.0.1) 20						
Design bonding moment		psx_p = 0.04	x = x + 2 = 70	0 kNm/m					
Design bending moment		$IVIx_p = psx_p$	$M_{x_p} = \beta_{sx_p} \times q \times I_{x^2} = 70.9 \text{ kNm/m}$						
		As $= 786 \text{ mm}^2/\text{m}$							
Effective depth to tension rein	oforcement	$d_{x,y} = h_{z,y} \cos(\frac{\pi}{2} - \frac{365}{2} - \frac{365}{2} - \frac{365}{2} - \frac{365}{2} - \frac{365}{2} - \frac{3}{2} - \frac{3}$							
K footor	lioicement	$K = M = /(b \times d^{-2} \times f_{1}) = 0.015$							
K tactor		$\mathbf{K} = IVIx_p / ($	$\mathbf{U} \times \mathbf{U}\mathbf{x}_{p} \times \mathbf{I}\mathbf{c}\mathbf{k}$	= 0.015					
Redistribution ratio		$\delta = 1.0$	S 0 4 0 S ²	0.04 0.000					
K factor		K = 0.598	× 0 - 0.18 × 0-	-0.21 = 0.200	inforcomont is	not required			
		- min(0.0	N < N - (Compression rei		s not required			
Area of reinforcement require	d for bonding	$Z = \min(0.9)$	$(5 \times \text{Ux}_p, \text{Ux}_p)$	x (1 + (1 - 3.33))	() ⁽¹⁾)) = 340.0				
Area or remorcement require		$A_{sx_p} = M_{x_p} / (T_{yd} \times Z) = 4/0 \text{ mm}^2/\text{m}$							
Minimum area or reinforceme	nt required	$Asx_p_min = f$	$A_{sx_p_min} = max(0.26 \times (f_{ctm}/f_{yk}) \times b \times d_{x_p}, 0.0013 \times b \times d_{x_p}) = 609 \text{ mm}^2/\text{m}$						
Area or reinforcement require	G	A _{sx_p_req} = n PASS	<pre>- Area of rein</pre>	x_p_min) = 609 mm forcement provi	ided exceeds	area required			
Check reinforcement spaci	ng								
Reinforcement service stress		$\sigma_{sx_p} = (f_{yk} / $	γs) × min((Asx	_p_m/Asx_p), 1.0) ×	qsls / q = 192. 7	7 N/mm ²			
Maximum allowable spacing ((Table 7.3N)	Smax_x_p = 2	59 mm						
Actual bar spacing		s _{x_p} = 100 r	nm						
			PASS	- The reinforcer	ment spacing	is acceptable			
Reinforcement design at mi	idspan in long sp	an direction (c	l.6.1)						
Bending moment coefficient		βsy_p = 0.02	40						
Design bending moment		My_p = βsy_p	$M_{y_p} = \beta_{sy_p} \times q \times lx^2 = 35.4 \text{ kNm/m}$						
Reinforcement provided		A393 mesh + 10 mm dia. bars at 200 mm centres							
Area provided		A _{sy_p} = 786 mm ² /m							
Effective depth to tension reir	nforcement	$d_{y_p} = h - c_r$	$d_{y_p} = h - c_{nom_b} - \phi_{x_p} - \phi_{y_p} / 2 = 355.0 \text{ mm}$						
K factor		$K = M_{y_p} / ($	$b \times d_{y_p^2} \times f_{ck}$)	= 0.008					
Redistribution ratio		δ = 1.0							
K' factor		K' = 0.598	$\times \delta$ - 0.18 $\times \delta^2$	- 0.21 = 0.208					
			K < K' - (Compression rei	inforcement is	not required			
Lever arm		z = min(0.9	5 × d _{v p} , d _{v p} /2	× (1 + (1 - 3.53×	K) ^{0.5})) = 337.3	mm			
Area of reinforcement require	d for bendina	$A_{\text{SV}, \text{p,m}} = M_{\text{V},\text{p}} / (f_{\text{V}} \times z) = 242 \text{ mm}^2/\text{m}$							
Minimum area of reinforceme	nt required	$A_{sy_p_{min}} = max(0.26 \times (f_{ctm}/f_{yk}) \times b \times d_{y_p}, 0.0013 \times b \times d_{y_p}) = 593 \text{ mm}^2/\text{m}$							

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		Basement S	Slab - HEAVE			3	
C	Calcs by DB	Calcs date 21/10/2018	Checked by	Checked date	Approved by	Approved date	
Area of reinforcement required		A _{sy_p_req} = r	max(A _{sy_p_m} , A _s	_{sy_p_min}) = 593 mm	¹² /m vided exceeds	area required	
Check reinforcement spacing			,	norecinem prot		, al ca i cquil ca	
Reinforcement service stress		$\sigma_{sy_p} = (f_{yk})$	′γs) × min((Asy	m/Asy_p), 1.0) ×	qsls / q = 99.0) N/mm²	
Maximum allowable spacing (Tab	le 7.3N)	Smax_y_p = 3	00 mm				
Actual bar spacing		s _{y_p} = 100	mm				
			PASS	S - The reinforce	ment spacing	y is acceptable	
Reinforcement design at contin	uous supp	ort in short span	direction (cl.	6.1)			
Bending moment coefficient		β _{sx_n} = 0.06	530				
Design bending moment		$M_{x n} = \beta_{sx n}$	$h \times q \times l_x^2 = 93$. 0 kNm/m			
Reinforcement provided		A393 mest	n + 16 mm dia	. bars at 200 mm	centres		
Area provided		A _{sx_n} = 139	8 mm²/m				
Effective depth to tension reinford	ement	d _{x_n} = h - c	nom_t - \$\$_n / 2 =	= 362.0 mm			
K factor		K = M _x n / ($b \times d_{x n^2} \times f_{ck}$	= 0.020			
Redistribution ratio		$\delta = 1.0$					
K' factor		K' = 0.598	$\times \delta = 0.18 \times \delta^2$	- 0 21 = 0 208			
		N = 0.000	K < K' - 1	Compression re	inforcement	is not required	
l ever arm		z = min(0.9)	2, v d v d v d	$2 \times (1 + (1 - 3.53))$	$(K)^{0.5})) - 343 9$) mm	
Area of rainforcement required for banding		2 = mm(0.0	lu = / (fu= × 7) =	$622 \text{ mm}^2/\text{m}$, , , , , , , , , , , , , , , , , , , ,	
Area of remorement required for behaving		$A_{sx_n} = W$	$\max(0.26 \times (f))$		0012 by d)	$-601 \text{ mm}^{2/m}$	
Area of reinforcement required	equirea	$Asx_n_min = I$	$\operatorname{TIaX}(0.20 \times (\operatorname{Ict}))$	$m/Iyk) \times D \times dx_n, U$	$1.0013 \times 0 \times 0 x_n$	= 004 mm/m	
Area of reinforcement required		Asx_n_req = T PASS	- Area of reir	nforcement prov	vided exceeds	s area required	
Check reinforcement spacing							
Reinforcement service stress		$\sigma_{sx_n} = (f_{yk} / \gamma s) \times min((A_{sx_n_m}/A_{sx_n}), 1.0) \times q_{sLs} / q = 143.3 \text{ N/mm}^2$					
Maximum allowable spacing (Tab	le 7.3N)	s _{max_x_n} = 300 mm					
Actual bar spacing		s _{x_n} = 100 mm					
Poinforcoment decign at contin		ort in long open	PASS	S - The reinforce	ment spacing	y is acceptable	
Remorcement design at contin	luous supp	ort in long span \circ -0.03		5.1)			
		psy_n = 0.03	DZU	O Ishina (na			
Design bending moment		$IVIy_n = \beta sy_r$	$M_{y_n} = \beta_{sy_n} \times q \times l_x^2 = 47.2 \text{ kNm/m}$				
Area provided		A393 mesh + 16 mm dia. bars at 200 mm centres A $1200 \text{ mm}^2/\text{m}$					
Effective depth to topology reinford	oment	$A_{sy_n} = 138$		/ 2 246 0 mm			
Enective depth to tension reinford	ement	$a_{y_n} = n - c$	$d_{y_n} = h - c_{nom_t} - \phi_{x_n} - \phi_{y_n} / 2 = 346.0 \text{ mm}$				
		$K = M_{y_n} / (b \times d_{y_n} \times f_{ck}) = 0.011$					
Redistribution ratio		δ = 1.0					
K' tactor		K' = 0.598	$\times \delta$ - 0.18 $\times \delta^2$	- 0.21 = 0.208		_	
			K < K' -	Compression re	inforcement i	is not required	
Lever arm		z = min(0.9	$z = min(0.95 \times d_{y_n}, d_{y_n}/2 \times (1 + (1 - 3.53 \times K)^{0.5})) = 328.7 \text{ mm}$				
Area of reinforcement required fo	r bending	$A_{sy_n_m} = M$	$A_{sy_n_m} = M_{y_n} / (f_{yd} \times z) = 331 \text{ mm}^2/\text{m}$				
Minimum area of reinforcement re	$A_{sy_n_min} = max(0.26 \times (f_{ctm}/f_{yk}) \times b \times d_{y_n}, 0.0013 \times b \times d_{y_n}) = 578 \text{ mm}^2/m^2 \times 10^{-1} \text{ mm}^2/m^2$						
Area of reinforcement required		A _{sy_n_req} = max(A _{sy_n_m} , A _{sy_n_min}) = 578 mm ² /m PASS - Area of reinforcement provided exceeds area req				area requirec	
Check reinforcement spacing							
Reinforcement service stress		σ _{sy_n} = (f _{yk} / γs) × min((A _{sy_n_m} /A _{sy_n}), 1.0) × q _{sLs} / q = 76.1 N/mm ²				I N/mm ²	
Maximum allowable spacing (Tab	s _{max_y_n} = 300 mm						

Todde	Project Job no. 54 Sumatra road, London, NW6 1PR 11654					654	
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	Calcs by DB	Calcs date 21/10/2018	Checked by	Checked date	Approved by	Approved date	
Actual bar spacing		s _{y_n} = 100 r	nm				
			PASS	- The reinforce	ment spacing i	s acceptable	
Shear capacity check at shor	rt span continu	ious support					
Shear force		$V_{x_n} = q \times I_x$	a / 2 = 164.0 kN	N/m			
Effective depth factor (cl. 6.2.2)	k = min(2.0	, 1 + (200 mm	$/ dx_n)^{0.5} = 1.743$	3		
Reinforcement ratio		$\rho_l = \min(0.0)$	02, A _{sx_n} / (b × 0	d _{x_n})) = 0.0039			
Minimum shear resistance (Exp	p. 6.3N)	$V_{Rd,c_min} = 0$.035 N/mm ² ×	$k^{1.5} \times (f_{ck} / 1 N/m)$	$(m^2)^{0.5} \times b \times d_{x_n}$	1	
		$V_{Rd,c_min} = 1$	72.5 kN/m				
Shear resistance (Exp. 6.2a)	$V_{Rd,c_x_n} = max$	((VRd,c_min, (0.18 N	/mm² / γc) × k :	\times (100 \times pl \times (fck/	1 N/mm ²)) ^{0.333} ×	$(\mathbf{b} \times \mathbf{d}_{x_n})$	
		$V_{Rd,c_x_n} = 1$	80.2 kN/m				
				PASS -	Shear capacity	/ is adequate	
Shear capacity check at long	span continu	ous support					
Shear force		$V_{y_n} = q \times I_x$	/ 2 = 164.0 kM	N/m			
Effective depth factor (cl. 6.2.2) $k = min(2.0, 1 + (200 \text{ mm} / d_{y_n})^{0.5}) = 1.760$							
Reinforcement ratio		$\rho_l = \min(0.0)$	02, A _{sy_n} / (b ×)	d _{y_n})) = 0.0040			
Minimum shear resistance (Ex	p. 6.3N)	$V_{Rd,c_min} = 0$.035 N/mm ² ×	$k^{1.5} \times (f_{ck} / 1 N/m)$	$(m^2)^{0.5} \times b \times d_{y_n}$		
		$V_{Rd,c_min} = 1$	67.3 kN/m				
Shear resistance (Exp. 6.2a)	V _{Rd,c_y_n} = max	(VRd,c_min, (0.18 N	/mm² / γc) × k :	× (100 × ρι× (fck /	1 N/mm ²)) ^{0.333} ×	$(\mathbf{b} \times \mathbf{d}_{y_n})$	
		V _{Rd,c_y_n} = 1	76.6 kN/m				
				PASS -	Shear capacity	/ is adequate	
Basic span-to-depth deflection	on ratio check	(cl. 7.4.2)					
Reference reinforcement ratio		$\rho_0 = (f_{ck} / 1 \text{ N/mm}^2)^{0.5} / 1000 = 0.0059$					
Required tension reinforcemen	it ratio	$\rho = \max(0.0)$	$\rho = \max(0.0035, A_{sx p} \text{ reg} / (b \times d_{x p})) = 0.0035$				
Required compression reinforc	$\rho' = A_{SCX} \rho$ re	$\rho' = A_{\text{scx } p \text{ reg}} / (b \times d_{x p}) = 0.0000$					
Stuctural system factor (Table	$(Table 7.4N) K_{\delta} = 1.5$						
asic limit span-to-depth ratio ratio $K_{\delta} \times [11 + 1.5 \times (f_{ck}/1 \text{ N/mm}^2)^{0.5} \times \Omega_0/\Omega + 3.2 \times (f_{ck}/1 \text{ N/mm}^2)^{0.5} \times (\Omega_0/\Omega - 1)^{1.5}]$) ^{1.5}]		
(Exp. 7.16)	ratiolim x bas = 55.29						
Mod span-to-depth ratio limit	ratiolim_x = min	(40 × K _δ , min(1.5,	(500 N/mm ² /f _y	/k)×(Asx_p/Asx_p_m)) \times ratio _{lim_x_bas})	= 60.00	
Actual span-to-eff, depth ratio $ratio_{act x} = lx / dx p = 12.33$							
Actual span-to-eff. depth ratio		ratio _{act_x} = I	« / 0x_p = 12.33				

Reinforcement sketch

The following sketch is indicative only. Note that additional reinforcement may be required in accordance with clauses 9.2.1.2, 9.2.1.4 and 9.2.1.5 of EN 1992-1-1:2004 to meet detailing rules.

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Tedds	S4 Sumara Toad, London, NW6 TPR			Stort page no /Bovision		
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	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	DB	21/10/2018				
			A393+	16mm bars @ 20	0 ctrs T1	
	\					
			A393+	16mm bars @ 20	0 ctrs T1	
	B2 -		5 T2 -			
	0 ctrs 0 ctrs		0 ctrs			
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Engineers	Part of Structure WORIZONIZAL MOVEN TO ERCAVATION &	NENT DUE Installation of NI	Date 09.2018		

HORIFONTAL & VERTICAL MOVEMENT ASSESSMENT TO CIRIA LSOO FUN EMBEDDED RETAILING WALLS.

(ABUE 2.4 CIRIA C530

CATE CORY OF DATLAGE	NORMAL DEGREEE	LIMITING RELE STRAW 90
0	NECLEGBLE	0.00% - 0.05%
	very sucht	0.05% - 0.075%
2	SLIGHT	0. 075% - 0.15%
3	MODERATE	0.15% -0.3%
4 to 5	SE VERE TO VE	et severe 7 0.3%
5	~	

THE HORITONTAL MOVEMENT WILL BE DETERMINED BASED ON ACCOMMULATION OF POTONTIAL MOVEMENT DUE TO WALL EXCANATION & INSTALLATION.



