Our Ref: 15189

March 2016

28 HARLEY ROAD, LONDON NW3

RESPONSE TO QUERIES RAISED IN CAMPBELL REITH'S BASEMENT IMPACT ASSESSMENT AUDIT

INTRODUCTION:

Michael Chester & Partners prepared a structural Basement Impact Assessment (BIA) to accompany a planning application by Construct 360. The application included numerous structural alterations to the super structure of the building plus proposals for a single storey basement across most of the footprint of the existing building.

Campbell Reith act on behalf of London Borough of Camden and have prepared an Audit Report of the BIA. The following addresses the queries raised by Campbell Reith in the Audit Tracker contained within Appendix 2 of their report. The queries are reproduced for ease of reference.

QUERIES RAISED IN AUDIT TRACKER REPORT:

1. Some proof of experience in ground engineering for the author of land stability section of the BIA is required.

The author of the report, Duncan Mercer, has been a chartered member of the Institution of Structural Engineers since 1994 and has worked on many successful basement projects in and around London over the course of the years, including –

53A Elsworthy Road, NW3:	large single storey basement, full footprint of building, combined with substantial alterations and re-modelling of the superstructure.
No.1 Pilgrim's Lane NW3	large single storey basement, full footprint of building, combined with substantial alterations and re-modelling of the superstructure.
Wildwood Road, NW11	large single storey basement on a piled foundation, full footprint of building with minor structural alterations to superstructure.
No.4 Oldbury Place, W1	single storey basement over 2/3 footprint of building with minor alterations to the superstructure.

2. Site Investigation report has to be submitted, including; site walkover study, clarification on the groundwater level with subsequent monitoring, geotechnical model and recommendations on basement/ retaining wall design parameters.

Trial pits were excavated around the property as part of the original BIA to establish the existing foundation regime and underlying ground conditions. The trial pit locations were agreed following a detailed walkover study, site inspection and assessment of the existing superstructure by the author The results were included in the original BIA and confirmed that the house was founded in firm clay and that it had been previously underpinned. Water was found in one trial pit at the front left of the house. It was not considered to be ground water but was thought to be coming from a leaking pipe. This was because the pit was located directly adjacent to both the water meter and the ground floor WC and no water was found in the other trial pits.

Three additional trial pits have now been excavated to 3m depth (locations indicated on appended Architect's drawing number HR28/1001revA) and the results are appended herewith as Appendix A. The additional trial pits found gravelly clayey Made Ground typically to about 0.5m depth (to 2.7m depth in trial pit 1 adjacent to an underpinned foundation) overlying firm, becoming stiff, greyish brown mottled orange and brown clay (London Clay). No water was recorded in these trial pits.

In terms of a geotechnical model, the site is generally level and is overlain by Made Ground to approximately 0.5m deep over London Clay. British Geological Society boreholes to the north, south, east and west of the site prove the London Clay to depths variously between 20m and 30m. London Clay is considered to be in excess of 60m thick in this area of London. No significant water strikes are noted in the borehole logs that I have seen. Deeper areas of Made Ground have been found around the foundations and are consistent with backfilling the working spaces following underpinning. Some locally perched ground water may exist around the existing footings or in the topsoils and/or Made Ground but the presence of water is not generally considered to be a significant issue.

3. The BIA should be updated with address to the Source Protection Zone. See section 4.6.

See Hydrological response by JH Groundwater Ltd.

4. Building damage assessment is rejected on the basis that these are not correct. Calculations to be resubmitted to demonstrate that damage will be less than Category 1, otherwise mitigation measures have to be considered.

Amended drawings have been received from the Architect, copies attached, and these show that the light well has now been omitted from along the left-hand flank wall. At the closest point, the neighbour's building (No.30) is approximately 2.8m from the face of the No.28 Harley Road. The ages of the two buildings are similar so it is reasonable to assume that the foundations (ignoring the underpinning to No.28) are similar. The original foundations to No.28 are 550mm deep below ground level. Excavations for the basement will be approximately 3.4m deep below ground level so approximately 50mm below the 45 degree line of spread from the underside of No.30's footing.

The retaining wall is to be designed for at rest earth pressures (see point 5) with a maximum span to depth ratio of 7 modified as permitted by increasing the percentage of reinforcement. The retaining walls are to be cast in sections not exceeding 1m long in a carefully controlled hit-and-miss sequence. Concrete is to be cast directly against the exposed earth face thus eliminating the risk of voids being left behind the wall. Consequently it is considered that there is no significant risk of long term movement of the ground behind the wall and, therefore, no significant risk of movement in the building beyond.

5. Outline design for floor slab and retaining walls.

Calculations appended and provide designs for maximum dead plus live load and for minimum dead load. At rest pressures have been assumed along with a possible hydrostatic head of three quarters of the height of the wall.

6. The permanent exclusion of the groundwater from the proposed basement should be considered.

Agreed. The reinforced concrete is to be detailed to limit shrinkage cracking and hydrophilic water bars are to be provided at all construction joints. A drained cavity membrane system is to be provided as a secondary means of protection.

APPENDIX A

28 HARLEY ROAD, LONDON NW3

ADDITIONAL SITE INVESTIGATION INFORMATION

OJ Environmental Consultancy Land Quality Assessors and Contaminated Land Specialists

Depth (m)	Description of strata	Sample	Туре	Water	Remarks
0.00-0.10	Concrete Slab	N/A	N/A	Dry	Made Ground.
0.10-2.60	MADE GROUND comprised of existing concrete columns with occasional cross mesh rebar	N/A	N/A	Dry	Made Ground. Organic fragments estimated at <1%.
2.60-2.70	Firm to stiff brown gravelly sandy CLAY with low subangular concrete cobble. Gravel is angular to subangular concrete and brick (MADE GROUND)	N/A	N/A	Dry	Made Ground. Organic fragments estimated at <1%.
2.60-3.00	Firm becoming stiff with depth greyish brown mottled orange and brown CLAY with rare fine and medium gravel sized roots and rootlets. (LONDON CLAY).	N/A	N/A	Dry	London Clay with Organic fragments estimated at <1%.
Trial Pit Length (m): 8	.00 X 7.50 X 3.00				
Groundwater Observ	ation: Dry				
Shoring: None					
Weather: Rain					
Comments: Depths this location. Pits ex	are given from lowest point of surface acavated with JCB 3CX tracked excava	e at trial pit ator with 3	t location: t ft bucket.	he base of the	landscaped bund at
Project	Trial Pit	No	Logger	Date	Job No:
28 Harley Road, Lor	ndon TP01		OJ	05/03/2016	D28H

OJ Environmental Consultancy Land Quality Assessors and Contaminated Land Specialists

Depth (m)	Description of strata	Sample	Туре	Water	Remarks
0.00-0.10	Concrete Slab	N/A	N/A	Dry	Made Ground.
					Grass and roots.
0.10-0.40	Dark brown slightly gravelly	N/A	N/A	Dry	Made Ground.
	sandy clayey SILT with low				Organic
	subangular brick cobble content.				fragments
	Gravel is angular and subangular				
	fine to coarse flint, concrete and				<170.
	brick. Rare fine ash. (MADE				
	GROUND).				
0.40-3.00	Firm becoming stiff with depth	N/A	N/A	Dry	London Clay with
	greyish brown mottled orange and				Organic
	brown CLAY with rare fine and				iragments
	medium gravel sized roots and				
	rootlets. (LONDON CLAY).				<1/0.
Trial Pit Length (m): 2	.00 X 1.50 X 3.00				
Groundwater Observ	ation: Dry				
Shoring: None					
Weather: Rain					
Comments: Depths	are given from lowest point of surface	at trial pit	t location: t	he base of the	e landscaped bund at
this location. Pits ex	acavated with JCB 3CX tracked excava	ator with 3	ft bucket.		_
Project	Trial Pit	No	Logger	Date	Job No:
28 Harley Road, Lon	idon TP02		OJ	05/03/2016	D28H

OJ Environmental Consultancy Land Quality Assessors and Contaminated Land Specialists

Depth (m)	Description of strata	Sample	Туре	Water	Remarks
0.00-0.10	Concrete Slab	N/A	N/A	Dry	Made Ground.
					Grass and roots.
0.10-0.50	Dark brown slightly gravelly	N/A	N/A	Dry	Made Ground.
	sandy clayey SILT with low				Organic
	subangular brick cobble content.				fragments
	Gravel is angular and subangular				
	fine to coarse flint, concrete and				<170.
	CROUND				
	GROUND).				
0.50-3.00	Firm becoming stiff with depth	N/A	N/A	Dry	London Clay with
	greyish brown mottled orange and				Organic
	brown CLAY with rare fine and				estimated at
	medium gravel sized roots and				<1%.
	rootiets. (LONDON CLAT).				
Trial Pit Length (m): 2	.00 X 1.50 X 3.00				
Groundwater Observ	ation: Dry				
Shoring: None					
Weather: Rain					
Comments: Depths	are given from lowest point of surface	at trial pi	t location: t	he base of the	e landscaped bund at
this location. Pits ex	cavated with JCB 3CX tracked excava	ator with 3	ft bucket.		_
Project	Trial Pit	No	Logger	Date	Job No:
28 Harley Road, Lon	idon TP03		OJ	05/03/2016	D28H

APPENDIX B

28 HARLEY ROAD, LONDON NW3

AMENDED ARCHITECTURAL DRAWINGS



Please note that construction must only commence once planning, building control and any other approvals have been received. It is the responsibilitiy of the owner/contractor to commence prior to these approvals.

EXISTING GROUND FLOOR PLAN SCALE 1:100





EXISTING LOFT FLOOR PLAN

	Revision	Date	Description	Paper Size	Scale	Construct 360 Ltd, Trading as:	
	A	18.01.16	Drains Added		1:100		veExtend®
proval,					Revision A	info@construct360.co.uk	Planning Permission Specialist
vings					~	Tel: 0208 206 0011	1
on/s					Oct-15		Existing
					Drawn By/Checked By	28 Harley Road	Plans
ior to					AP/HW	NW/3 3BN	
							11120-1001







EXISTING REAR ELEVATION SCALE 1:100





EXISTING SIDE ELEVATION SCALE 1:100

	Revision	Date	Description	Paper Size	Scale	Construct 360 Ltd, Trading as:	_
				.	1:100		veExtend®
proval,					Revision 1 ct	info@construct360.co.uk	Planning Permission Specialist
vings					151	Tel: 0208 206 0011	,
on/s					Oct-15		Existing
					Drawn By/Checked By	28 Harley Road	Elevations
or to					AP/HW		
					/ /	INVV3 3BIN	HR28-1002



PROPOSED BASEMENT FLOOR PLAN Scale 1:100





PROPOSED FIRST FLOOR PLAN

	Revision	Date	Description	Paper Size	Scale	Construct 360 Ltd, Trading as:	
	A	18.01.16	Drains Added	1.	1:100		veExtend®
pproval,	в	01.02.16	Lightwell Removed		Revision R	info@construct360.co.uk	Planning Permission Specialist
wings	с	01.03.16	Roof Terrace Removed		В	Tel: 0208 206 0011	,
son/s					Oct-15	Site Address	Proposed
					Drawn By/Checked By	28 Harley Road	Plans
rior to					AP/HW	London NW3 3BN	Drawing Number HR28-1003C







PROPOSED FRONT ELEVATION Scale 1:100



PROPOSED REAR ELEVATION SCALE 1:100



PROPOSED SIDE ELEVATION Scale 1:100



PROPOSED SIDE ELEVATION SCALE 1:100

	Revision	Date	Description	Paper Size	Scale	Construct 360 Ltd, Trading as:	
	A	01.02.16	Lightwell Removed	1.	1:100		veExtend®
oroval,	В	01.03.16	Roof Terrace Removed		Revision B	info@construct360.co.uk	Planning Permission Specialists
ngs						Tel: 0208 206 0011 Site Address	Duran a sa d
n/s					Drawn By/Checked By	28 Harley Road	Elevations
or to					AP/HW	London NW3 3BN	Drawing Number HR28-1004R
							111120-1004D





PROPOSED BLOCK PLAN SCALE 1:1250 SHOWING EXTENSIONS AT GROUND FLOOR LEVEL





PROPOSED BLOCK PLAN SCALE 1:1250 SHOWING EXTENSIONS AT BASEMENT LEVEL

		Revision	Date	Description	Paper Size	Scale	Construct 360 Ltd, Trading as:	
	IMPONIANT GENERAL NOTE The execting to be read in conjunction with the plans/section details, and other					1.1250/500		
	associated Structural details as may be provided.					1.1230/300		
	All work is to be carried out to the Local Authority Planning and Building Regulations Approval,] (\ /	Revision		
	and the Codes of Practice and British Standards as necessary.				- V V -	1st	info@construct360.co.uk	Planning Permission Specialists
	All dimensions, levels, sizes, positions and locations of particulars as indicated on drawings						Tel: 0208 206 0011	
	discrepancies must be reported to the Architect/Surveyor/Engineer or responsible person/s					Sep-15	Site Address	Location & Block Plans
	immediately.						28 Harley Road	Ecodion & Biocit hans
	The Contractor is responsible for ensuring compliance with the CDM Regulations, and					Drawn By/Checked By	2011/01/040	
XX	appropriate Health & Safety on site precautions.						London	Drawing Number
	Ine Client/Building Owner must obtain any necessary PARTY WALL AGREEMENTS, prior to engaging in the works on site.				- '	AP/HVV	NW3 3RN	[°] HR28_1005
-	chgaging in the works on site.							111120-1003

APPENDIX C

28 HARLEY ROAD, LONDON NW3

OUTLINE DESIGNS FOR RETAINING WALL AND SLAB

			Date Mar 16	Job No	Sheet	No	
MICHAE		HESIER & PARINERS	Eng DM	15189	1		
Co	nsulting	Civil and Structural Engineers					
8 Hale Lane L	ondon N\	N7 3NX tel 020 8959 9119 fax 020 8959 9662	Project:				
				DAD			
INTRODUCTIO	<u>NO</u>						
PRELIMINARY	DESIG	IN FOR RETAINING WALLS.					
CARRY OUT 1 MINIMUM DEA	TWO DE AD LOAI	SIGNS FOR WALL, ONE WITH FULL DEA	AD AND LIVE LOA	ADS AND	ONE W	ITH	
LOADS TO HE	EAD OF	RETAINING WALL -		Dead	Live		
<u>FULL DEAD P</u>	LUS LIV	<u>′E</u>					
Roof;	Dead;	$w_{dpr} = 0.5 \times 5.7 \text{ m} \times 0.95 \text{ kN/m}^2$	=	2.7		kN/m	I
	Live;	$w_{lpr} = 0.5 \times 5.7 \text{ m} \times 0.75 \text{ kN/m}^2$	=		2.1	kN/m	I
Second Floor;	Dead;	w_{df2} = 0.5 × 5.7 m × 0.65 kN/m ²	=	1.9		kN/m	J
	Live;	$w_{if2} = 0.5 \times 5.7 \text{ m} \times 1.50 \text{ kN/m}^2$	=		4.3	kN/m	I
First Floor;	Dead;	$w_{df1} = 0.5 \times 5.7 \text{ m} \times 0.65 \text{ kN/m}^2$	=	1.9		kN/m	I
	Live;	$w_{if1} = 0.5 \times 5.7 \text{ m} \times 1.50 \text{ kN/m}^2$	=		4.3	kN/m	I
Ground Floor;	Dead;	$w_{dfg} = 0.5 \times 5.7 \text{ m} \times 4.50 \text{ kN/m}^2$	=	12.8		kN/m	I
	Live;	$w_{\text{lfg}} = 0.5 \times 5.7 \text{ m} \times 1.50 \text{ kN/m}^2$	=		4.3	kN/m	I
9" Wall;	Dead;	$w_{dw9} = 3.2 \text{ m} \times 4.9 \text{ kN/m}^2$	=	15.7		kN/m	I
13½" Wall;	Dead;	$w_{dw13} = 3.9 \text{ m} \times 7.6 \text{ kN/m}^2$	=	29.6		kN/m	
Totals;	Dead;	$W_d = W_{dpr} + W_{df2} + W_{df1} + W_{dfg} + W_{dw9} + W_{dw9}$	₁₃ = 64.6 kN/m				
	Live;	$W_{I} = w_{Ipr} + w_{If2} + w_{If1} + w_{Ifg} = 15.0 \text{ kN/m}$					
	<u>\D</u>						
9" Wall;	Dead;	$w_{dw9} = 3.2 \text{ m} \times 4.9 \text{ kN/m}^2$	=	15.7		kN/m	I
13½" Wall;	Dead;	$w_{dw13} = 3.9 \text{ m} \times 7.6 \text{ kN/m}^2$	=	29.6		kN/m	
Less windows	Dead;	w_{wind9} = (9 $m^2 \times 4.9 \text{ kN/m}^2$) / 2.8 m	=	15.8		kN/m	I
	Dead;	w_{wind13} = (13 m ² × 7.9 kN/m ²) / 7.5 m	=	13.7		kN/m	
Totals;	Dead;	W_{d} = w_{dw9} + w_{dw13} - w_{wind9} - w_{wind13} = 15.9 k	kN/m				
<u>RETAINING W</u>	ALL DE	ESIGN CASE 1					
RETAINING W	VALL A	NALYSIS					
In accordanc	e with E	EN1997-1:2004 incorporating Corrigendu	Im dated Februar	y 2009 an	d the L	JK	
National Ann	ex inco	rporating Corrigendum No.1					

Tedds calculation version 2.6.05

Retaining wall details

Stem type;	Cantilever
Stem height;	h _{stem} = 3000 mm

MICHAEL CHES Consulting Civil a	ICHAEL CHESTER & PARTNE Consulting Civil and Structural Engineers		Date Mar 16 Eng DM	Job No 15189	Sheet No 2	
8 Hale Lane London NW7 3N	X tel 020 8959 9119 fax 020 895	9 9662	Project:			1
			28 HARLEY RC LONDON NW3	DAD		
Stem thickness;	t _{stem} = 350 mm		1			
Angle to rear face of stem;	α = 90 deg					
Stem density;	$\gamma_{\text{stem}} = 25 \text{ kN/m}^3$					
Toe length;	l _{toe} = 2500 mm					
Base thickness;	t _{base} = 350 mm					
Base density;	$\gamma_{\text{base}} = 25 \text{ kN/m}^3$					
Height of retained soil;	h _{ret} = 3000 mm;	Angle o	f soil surface;	$\beta = 0 d\mathbf{e}$	eg	
Depth of cover;	$d_{cover} = 0 mm$					
Height of water;	h _{water} = 2200 mm					
Water density;	$\gamma_w = 9.8 \text{ kN/m}^3$					
Retained soil properties						
Soil type;	Firm clay					
Moist density;	$\gamma_{mr} = 18 \text{ kN/m}^3$					
Saturated density;	$\gamma_{sr} = 18 \text{ kN/m}^3$					
Characteristic effective she	ar resistance angle;	φ' _{r.k} = 18	3 deg			
Characteristic wall friction a	angle;	δ _{r.k} = 9 α	deg			
Base soil properties						
Soil type;	Firm clay					
Soil density;	$\gamma_{\rm b}$ = 18 kN/m ³					
Characteristic effective she	ar resistance angle;	φ' _{b.k} = 1 8	8 deg			
Characteristic wall friction a	angle;	$\delta_{b.k} = 9$	deg			
Characteristic base friction	angle;	$\delta_{\text{bb.k}} = 1$	2 deg			
Presumed bearing capacity	$r; P_{\text{bearing}} = 125 \text{ kN/m}^2$					
Loading details						
Variable surcharge load;	Surcharge _Q = 2.5 kN/m ²					
Vertical line load at 2700 m	m;	P _{G1} = 6	5 kN/m			
;		P ₀₁ = 1	5 kN/m			



MICHAEL CHESTER & PARTNERS		Date Mar 16 Eng DM	Job No 15189	Sheet No 4	Rev		
8 Hale Lane London NW7 3NX tel 020 8959 9119 fax 020 8959 9662		Project: 28 HARLEY ROAD LONDON NW3					
Check bearing pressure	2						
Bearing pressure at toe;	$q_{toe} = 17 \text{ kN/m}^2;$	Bearing	pressure at heel;	$q_{heel} = 7$	7 5.1 kN/m²		
Factor of safety;	$FOS_{bp} = 1.664$			maliad be			
PA Desticit factors on actions	Table A 2 Combination	ssure exc	eeus maximum a	ippilea be	aring pres	sure	
Partial factors on actions	- Table A.3 - Combination	1	r.	Dormo	ant four our	oblo	
Permanent unravourable a		$\gamma_{\rm G} = 1.3$	5,	Permai	ient lavour	able	
	$\gamma_{\rm Gf} = 1.00$		0.	Variahl	o for controla		
	on;	$\gamma_Q = 1.5$	U;	variabi	e favourabi	е	
action;	$\gamma_{Qf} = 0.00$	ore for co	il paramotors T	blo A 4 -	Combinat	ion 1	
Angle of cheering registered			n parameters – ra	Effoctiv			
1.00	. с ,	$\gamma_{\phi'} = 1.00$	U,	Enecuv	e conesion	,γ _{c'} =	
Weight density;	$\gamma_{\gamma} = 1.00$						
Water properties	•,						
Design water density;	γ _w ' = 9.8 kN/m ³						
Retained soil properties							
Design moist density;	$\gamma_{mr}' = 18 \text{ kN/m}^3;$	Design	saturated density;	γ _{sr} ' = 18	kN/m ³		
Des.eff.shear resist.angle;	φ' _{r.d} = 18 deg;	Design	wall friction angle;	$\delta_{\text{r.d}} = 9$	deg		
Base soil properties							
Design soil density;	$\gamma_{\rm b}' = 18 {\rm kN/m^3};$	Des.eff.	shear resist.angle;	φ' _{b.d} = 1	8 deg		
Design wall friction angle;	$\delta_{b.d} = 9 \text{ deg};$	Design	base friction angle	$\delta_{bb.d} = 1$	2 deg		
			;Design effective	cohesion;	c' _{b.d} = 0 k	N/m ²	
Overturning check							
Vertical forces on wall							
Total;	F _{total v} = F _{stem} + F _{base} + F _{wate}	r v + F _{P v} :	= 116.2 kN/m				
Horizontal forces on wall							
Total:	$F_{total,h} = F_{sat,h} + F_{moist,h} + F_{sat,h}$	we h + Fwat	er h + Fsur h = 112.7	kN/m			
Overturning moments on	wall	xc_n • • wat					
Total	Must of - Must of + Must of	- - M	or + M., or - 129 0	kNm/m			
Postoring momente en u		i iviwater_	01 1 Wisur_01 - 123.				
Total:		N4 .		m			
	$W_{total_R} = W_{stem_R} + W_{base_R} +$	- IVI _{exc_R} +	$IV_{P_R} = 201.0 KINII/$	111			
Check stability against or	verturning						
Factor of safety;	$FOS_{ot} = 2.168$	oring mo	mont is greater t	on overt	urning mo	mont	
			inent is greater ti	ian over		mem	
Partial factors on actions	- Table A.3 - Combination 2	2	.			- 6 1	
Permanent untavourable a		γ _G = 1.0	U;	Permai	nent favour	adle	
	$\gamma_{\rm Gf} = 1.00$.		- f		
variable unfavourable actio	on;	$\gamma_Q = 1.3$	U;	variabl	e tavourabl	е	
action;	$\gamma_{Qf} = 0.00$	re for as	il paramotoro T		Combinet	ion 2	
;Partial factors for soil parameters – Table A.4 - Combination 2							

MICHAEL CHESTER & PARTNERS Consulting Civil and Structural Engineers		Date Mar 16 Eng DM	Job No 15189	Sheet No	Rev	
8 Hale Lane London NW7 3NX tel 020 8959 9119 fax 020 8959 9662		Project: 28 HARLEY ROAD LONDON NW3				
Angle of shearing resistanc	e;	$\gamma_{\phi'} = 1.25$	5;	Effectiv	e cohesion	;γ _{c'} =
Weight density;	$\gamma_{\gamma} = 1.00$					
	.,			;W	ater prope	rties
Design water density;	$\gamma_{w}' = 9.8 \text{ kN/m}^{3}$					
		Desire	to we to all all a set to a	Retained	soil prope	rties
Design moist density;	$\gamma_{mr} = 18 \text{ KN/m}^{-1};$	Design	saturated density;	$\gamma_{sr} = 18$	a dog	
	$\psi_{r.d} = 14.0 \text{ deg},$	Design	wall metion angle,	$o_{r.d} = r$.	z ueg	
Base soil properties	$u' = 19 \text{ kN/m}^3$	Dec off	aboar ragiat angla	• • • – •		
Design soll defisity,	$\gamma_b = 10 \text{ km/m}$, $\delta_{\text{c}} = 7.2 \text{ deg}$	Des.en.	base friction angle	$\phi_{b,d} = \mathbf{I}$	4.6 uey 7 dea	
Design wan metion angle,	$0_{b,d} = 7.2 000,$	Design	Design effectiv	/e cohesio	n:c' _{b.d} = 0 k	N/m ²
Using Coulomb theory			, <u>.</u>		, e b.u e t	
At rest pressure coefficient;	K ₀ = 0.748 ;	Passive	pressure coefficie	ent; $K_P = 1.9$	965	
Overturning check	Č ,			<i>,</i> .		
Vertical forces on wall						
Total;	F _{total v} = F _{stem} + F _{base} + F _w	_{/aterv} + F _{Pv} =	= 116.2 kN/m			
Horizontal forces on wall						
Total;	$F_{total_h} = F_{sat_h} + F_{moist_h} +$	F _{exc_h} + F _{wat}	_{er_h} + F _{sur_h} = 89.1	kN/m		
Overturning moments on	wall					
Total;	$M_{total_{OT}} = M_{sat_{OT}} + M_{moist}$	_ot + M _{water_}	_{OT} + M _{sur_OT} = 104.	3 kNm/m		
Restoring moments on wa	all					
Total;	$M_{total_R} = M_{stem_R} + M_{base_F}$	$_{R}$ + $M_{exc_{R}}$ +	M _{P_R} = 281.5 kNm	/m		
Check stability against ov	verturning					
Factor of safety;	$FoS_{ot} = 2.7$					
	PASS - Maximum re	storing mo	ment is greater t	han overt	urning mo	ment
RETAINING WALL DESIG	<u>N</u>					
In accordance with EN199	92-1-1:2004 incorporating	Corrigend	um dated Januar	y 2008 an	d the UK	
National Annex incorpora	iting National Amendmen	it NO.1		Tedds calcu	ation version	2.6.05
Concrete details - Table 3	3.1 - Strength and deform	ation chara	cteristics for con	crete		
Concrete strength class;	C30/37					
Char.comp.cylinder strengt	h;	f _{ck} = 30	N/mm²;	Mean a	ixial tensile	
strength;	$f_{ctm} = 2.9 \text{ N/mm}^2$			_		
Secant modulus of elasticity	y;E _{cm} = 32837 N/mm ² ;	Maximu	m aggregate size;	h _{agg} = 2	2 0 mm	
Design comp.concrete strei	ngtn;	t _{cd} = 17 .	0 N/mm ⁻ ;	Partial	ractor; $\gamma_{\rm C} = \gamma_{\rm C}$	1.50
Reinforcement details		N.4. 1 1	f -l('-')	F • •		2
Unaracteristic yield strength	$T_{yk} = 500 \text{ N/mm}^{-};$	Nodulus	s of elasticity;	⊨ _s = 20	0000 N/MM	
Design yield strength;	$r_{yd} = 433 N/11111$;	ranian		γ _S = 1.1	5	

MICHAEL CHESTER & PARTNE		RS	Eng DM	15189	6		
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			LONDON NW3				
Cover to reinforcement							
Front face of stem;	c _{sf} = 40 mm;	Rear fac	ce of stem;	C _{sr} = 50	mm		
Top face of base;	c _{bt} = 50 mm;	Bottom	face of base;	C _{bb} = 75	mm		
Check stem design at ba	se of stem						
Depth of section;	h = 350 mm						
Rectangular section in fl	exure - Section 6.1						
Design bending moment:	M = 93.6 kNm/m	K = 0.03	7:	K' = 0.2	07		
2 co.g.: 2 co.g. ,	•••••	K' > K - N	, lo compression r	einforcen	ent is requ		
Tens.reinforcement require	ed;	A _{sr.reg} = '	, 781 mm²/m				
Tens.reinforcement provid	ed;	20 dia.b	ars @ 200 c/c;	Tens.re	inforcemer		
provided;	A _{sr.prov} = 1571 mm ² /m						
Min.area of reinforcement;	A _{sr.min} = 437 mm ² /m;	Max.are	a of reinforcement	t; A _{sr.max} =	= 14000 mm		
PASS -	Area of reinforcement pro	vided is gr	eater than area o	f reinforc	ement requ		
Crack control - Section 7	'.3						
Limiting crack width;	w _{max} = 0.3 mm;	Maximu	m crack width;	w _k = 0. 1	1 8 mm		
PASS - Maximum crac	k width is less than limiting	g crack wid	dthRectangular s	ection in	shear - Seo		
6.2							
Design shear force;	V = 92.5 kN/m;	Design s	shear resistance;	$V_{Rd.c} =$	161.3 kN/m		
	PASS - E	Design she	ar resistance exc	eeds des	ign shear f		
Horizontal reinforcement	t parallel to face of stem - S	Section 9.6					
Min.area of reinforcement;	A _{sx.req} = 393 mm ² /m;	Max.spa	acing of reinforcem	nent;s _{sx_max}	. = 400 mm		
Trans.reinforcement provid	ded;	10 dia.b	ars @ 200 c/c;	Trans.r	einforceme		
provided;	A _{sx.prov} = 393 mm ² /m						
PASS -	Area of reinforcement prov	vided is gr	eater than area o	f reinforc	ement requ		
	•	0					
Check base design at toe	à	Ū					
Check base design at too Depth of section;	e h = 350 mm	0					
Check base design at too Depth of section; Rectangular section in fl	e h = 350 mm exure - Section 6.1	Ū					
Check base design at too Depth of section; Rectangular section in fl Design bending moment;	e h = 350 mm exure - Section 6.1 M = 107.3 kNm/m;	K = 0.04	9;	K' = 0. 2	07		
Check base design at too Depth of section; Rectangular section in fl Design bending moment;	e h = 350 mm exure - Section 6.1 M = 107.3 kNm/m;	K = 0.04 K' > K - N	9; lo compression r	K' = 0.2 einforcen	07 Dent is requ		
Check base design at too Depth of section; Rectangular section in fl Design bending moment; Tens.reinforcement require	e h = 350 mm exure - Section 6.1 M = 107.3 kNm/m; ∋d;	K = 0.04 <i>K' > K - N</i> A _{bb.req} =	9; <i>lo compression r</i> 966 mm ² /m	K' = 0.2 einforcen	07 Dent is requ		
Check base design at too Depth of section; Rectangular section in fl Design bending moment; Tens.reinforcement require Tens.reinforcement provid	e h = 350 mm exure - Section 6.1 M = 107.3 kNm/m; ed; ed;	K = 0.04 <i>K' > K - N</i> A _{bb.req} = 20 dia.b	9; <i>lo compression r</i> 966 mm²/m ars @ 200 c/c;	K' = 0.2 einforcen Tens.re	07 Itent is requ		
Check base design at too Depth of section; Rectangular section in fl Design bending moment; Tens.reinforcement require Tens.reinforcement provid provided;	e h = 350 mm exure - Section 6.1 M = 107.3 kNm/m; ed; ed; A _{sr.prov} = 1571 mm ² /m	K = 0.04 <i>K' > K - N</i> A _{bb.req} = 20 dia.b	9; <i>lo compression r</i> 966 mm ² /m ars @ 200 c/c;	K' = 0.2 einforcen Tens.re	07 Dent is requ		
Check base design at too Depth of section; Rectangular section in fl Design bending moment; Tens.reinforcement require Tens.reinforcement provid provided; Min.area of reinforcement;	e h = 350 mm exure - Section 6.1 M = 107.3 kNm/m; ed; ed; A _{sr.prov} = 1571 mm ² /m A _{sr.min} = 437 mm ² /m;	K = 0.04 <i>K' > K - N</i> A _{bb.req} = 20 dia.b Max.are	9; <i>lo compression r</i> 966 mm²/m ars @ 200 c/c; a of reinforcement	K' = 0.2 einforcen Tens.re t; A _{sr.max} =	07 Ient is requ inforcemer = 14000 mm		
Check base design at too Depth of section; Rectangular section in fl Design bending moment; Tens.reinforcement require Tens.reinforcement provid provided; Min.area of reinforcement; PASS -	e h = 350 mm exure - Section 6.1 M = 107.3 kNm/m; ed; ed; $A_{sr.prov} = 1571 \text{ mm}^2/\text{m}$ $A_{sr.min} = 437 \text{ mm}^2/\text{m};$ Area of reinforcement prov	K = 0.04 <i>K' > K - N</i> A _{bb.req} = 20 dia.b Max.are <i>vided is gr</i>	9; <i>lo compression r</i> 966 mm ² /m ars @ 200 c/c; a of reinforcement reater than area o	K' = 0.2 einforcen Tens.re t; A _{sr.max} = f reinforc	07 Tent is requ inforcemer = 14000 mm ement requ		
Check base design at too Depth of section; Rectangular section in fl Design bending moment; Tens.reinforcement require Tens.reinforcement provid provided; Min.area of reinforcement; PASS - Design shear force;	e h = 350 mm exure - Section 6.1 M = 107.3 kNm/m; ed; ed; A _{sr.prov} = 1571 mm ² /m A _{sr.min} = 437 mm ² /m; Area of reinforcement prov V = 115.4 kN/m;	K = 0.04 <i>K' > K - N</i> A _{bb.req} = 20 dia.b Max.are <i>vided is gr</i> Design s	9; lo compression ra 966 mm²/m ars @ 200 c/c; a of reinforcement reater than area o shear resistance;	K' = 0.2 einforcen Tens.re t; A _{sr.max} = f reinforc V _{Rd.c} =	07 eent is requ inforcemer = 14000 mm ement requ 131.1 kN/m		
Check base design at too Depth of section; Rectangular section in fl Design bending moment; Tens.reinforcement require Tens.reinforcement provid provided; Min.area of reinforcement; PASS - Design shear force;	e h = 350 mm exure - Section 6.1 M = 107.3 kNm/m; ed; ed; $A_{sr.prov} = 1571 \text{ mm}^2/\text{m}$ $A_{sr.min} = 437 \text{ mm}^2/\text{m};$ Area of reinforcement prov V = 115.4 kN/m; PASS - D	K = 0.04 K' > K - N A _{bb.req} = 20 dia.b Max.are vided is gr Design s	9; lo compression r 966 mm ² /m ars @ 200 c/c; a of reinforcement eater than area o shear resistance; ar resistance exc	K' = 0.2 einforcen Tens.re t; A _{sr.max} = f reinforc V _{Rd.c} = eeds des	07 eent is requ inforcemer = 14000 mm ement requ 131.1 kN/m ign shear f		
Check base design at too Depth of section; Rectangular section in fl Design bending moment; Tens.reinforcement require Tens.reinforcement provid provided; Min.area of reinforcement; PASS - Design shear force; Secondary transverse re	e h = 350 mm exure - Section 6.1 M = 107.3 kNm/m; ed; ed; $A_{sr.prov} = 1571 \text{ mm}^2/\text{m}$ $A_{sr.min} = 437 \text{ mm}^2/\text{m};$ Area of reinforcement prov V = 115.4 kN/m; PASS - D inforcement to base - Sect	K = 0.04 K' > K - N A _{bb.req} = 20 dia.b Max.are vided is gr Design shea ion 9.3	9; lo compression ra 966 mm²/m ars @ 200 c/c; a of reinforcement reater than area o shear resistance; ar resistance exc	K' = 0.2 einforcen Tens.re t; A _{sr.max} = f reinforc V _{Rd.c} = reeds des	07 eent is requ inforcemer = 14000 mm ement requ 131.1 kN/m ign shear f		
Check base design at too Depth of section; Rectangular section in fl Design bending moment; Tens.reinforcement require Tens.reinforcement provid provided; Min.area of reinforcement; PASS - Design shear force; Secondary transverse re Min.area of reinforcement;	e h = 350 mm exure - Section 6.1 M = 107.3 kNm/m; ed; ed; $A_{sr.prov} = 1571 \text{ mm}^2/\text{m}$ $A_{sr.min} = 437 \text{ mm}^2/\text{m};$ Area of reinforcement prov V = 115.4 kN/m; PASS - D inforcement to base - Sect $A_{bx.req} = 113 \text{ mm}^2/\text{m};$	K = 0.04 <i>K' > K - N</i> A _{bb.req} = 20 dia.b Max.are <i>vided is gr</i> Design shead ion 9.3 Max.spa	9; lo compression ra 966 mm ² /m ars @ 200 c/c; a of reinforcement eater than area o shear resistance; ar resistance exc acing of reinforcem	K' = 0.2 einforcen Tens.re t; A _{sr.max} = f reinforc V _{Rd.c} = eeds des	07 eent is requ inforcemer = 14000 mm ement requ 131.1 kN/m ign shear f		
Check base design at too Depth of section; Rectangular section in fl Design bending moment; Tens.reinforcement require Tens.reinforcement provid provided; Min.area of reinforcement; PASS - Design shear force; Secondary transverse re Min.area of reinforcement; Trans.reinforcement provid	e h = 350 mm exure - Section 6.1 M = 107.3 kNm/m; ed; ed; ed; $A_{sr.prov} = 1571 \text{ mm}^2/\text{m}$ $A_{sr.min} = 437 \text{ mm}^2/\text{m};$ <i>Area of reinforcement prov</i> V = 115.4 kN/m; <i>PASS - D</i> inforcement to base - Sect $A_{bx.req} = 113 \text{ mm}^2/\text{m};$ ded; 10 dia.bars @ 200 c/c;	K = 0.04 K' > K - N A _{bb.req} = 20 dia.b Max.are vided is gra Design s Design shea ion 9.3 Max.spa Trans.re	9; lo compression re 966 mm ² /m ars @ 200 c/c; a of reinforcement eater than area o shear resistance; ar resistance exc acing of reinforcem einforcement provis	K' = 0.2 einforcen Tens.re t; A _{sr.max} = f reinforc V _{Rd.c} = eeds des nent;s _{bx_max} ded;A _{bx.prov}	07 eent is requ inforcemer = 14000 mm ement requ 131.1 kN/m ign shear f = 450 mm		

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28 HARLEY ROAD LONDON NW3

Mar 16

DM

Job No

15189

RETAINING WALL DESIGN CASE 2

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 2.6.05

Sheet No

7

Rev

Retaining wall details			
Stem type;	Cantilever		
Stem height;	h _{stem} = 3000 mm		
Stem thickness;	t _{stem} = 350 mm		
Angle to rear face of stem;	$\alpha = 90 \text{ deg}$		
Stem density;	$\gamma_{\text{stem}} = 25 \text{ kN/m}^3$		
Toe length;	l _{toe} = 2500 mm		
Base thickness;	t _{base} = 350 mm		
Base density;	$\gamma_{\text{base}} = 25 \text{ kN/m}^3$		
Height of retained soil;	h _{ret} = 3000 mm;	Angle of soil surface;	$\beta = 0 \deg$
Depth of cover;	$d_{cover} = 0 mm$		
Height of water;	h _{water} = 2200 mm		
Water density;	$\gamma_{\rm w} = 9.8 \ {\rm kN/m}^3$		
Retained soil properties			
Soil type;	Firm clay		
Moist density;	$\gamma_{mr} = 18 \text{ kN/m}^3$		
Saturated density;	$\gamma_{sr} = 18 \text{ kN/m}^3$		
Characteristic effective shea	ar resistance angle;	$\phi'_{r.k} = 18 \text{ deg}$	
Characteristic wall friction a	ngle;	$\delta_{r.k} = 9 \text{ deg}$	
Base soil properties			
Soil type;	Firm clay		
Soil density;	$\gamma_b = 18 \text{ kN/m}^3$		
Characteristic effective shea	ar resistance angle;	$\phi'_{b.k} = 18 \text{ deg}$	
Characteristic wall friction a	ngle;	$\delta_{b.k} = 9 \text{ deg}$	
Characteristic base friction	angle;	$\delta_{bb.k} = 12 \text{ deg}$	
Presumed bearing capacity	; $P_{\text{bearing}} = 125 \text{ kN/m}^2$		
Loading details			
Variable surcharge load;	Surcharge _Q = 2.5 kN/m ²		
Vertical line load at 2700 m	m;	P _{G1} = 16 kN/m	



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		28 HARLEY ROA	AD			
			LONDON NW3			
Check bearing pressure						
Bearing pressure at toe;	q _{toe} = 56.3 kN/m ² ;	Bearing	pressure at heel;	q _{heel} = 0	0 kN/m²	
Factor of safety;	$FoS_{bp} = 2.222$					
PA	SS - Allowable bearing pi	ressure exc	eeds maximum a	pplied be	earing pres	sure
Partial factors on actions	- Table A.3 - Combination	n 1				
Permanent unfavourable ac	ction;	γ _G = 1.3	5;	Permai	nent favour	able
action;	γ _{Gf} = 1.00					
Variable unfavourable actio	n;	γ _Q = 1.5	D;	Variabl	e favourabl	e
action;	$\gamma_{Qf} = 0.00$					
	;Partial fac	tors for so	il parameters – Ta	able A.4 -	Combinat	ion 1
Angle of shearing resistanc	e;	$\gamma_{\phi'} = 1.00$	D ;	Effectiv	e cohesion	ι;γ _{c'} =
1.00						
Weight density;	$\gamma_{\gamma} = 1.00$					
	2			;W	ater prope	erties
Design water density;	$\gamma_{w}' = 9.8 \text{ kN/m}^{3}$					_
			;	Retained	soil prope	rties
Design moist density;	$\gamma_{mr}' = 18 \text{ kN/m}^{3};$	Design	saturated density;	γ _{sr} ' = 18	3 kN/m°	
Des.eff.shear resist.angle;	φ' _{r.d} = 18 deg;	Design	wall friction angle;	$\delta_{r.d} = 9$	deg	
Base soil properties						
Design soil density;	$\gamma_{\rm b}' = 18 \text{ kN/m}^3;$	Des.eff.	shear resist.angle;	$\phi'_{b.d} = 18 \text{ deg}$		
Design wall friction angle;	$\delta_{b.d} = 9 \text{ deg};$	Design	base friction angle	; $\delta_{bb.d} = 12 \text{ deg}$		
			;Design effectiv	e cohesio	on;c' _{b.d} = 0 k	:N/m ²
Using Coulomb theory						
At rest pressure coefficient;	K ₀ = 0.691 ;	Passive	pressure coefficie	nt;K _P = 2. :	359	
Overturning check						
Vertical forces on wall						
Total;	$F_{total v} = F_{stem} + F_{base} + F_{w}$	_{ater v} + F _{P v} =	= 67.2 kN/m			
Horizontal forces on wall						
Total [.]	Frank h = Fast h + Fraint h +	Fava h + Furat	ar h + Faur h = 1127	kN/m		
Overturning memorie on		• exc_n • • wat				
Total:		. M	· M – 120.0	kNm/m		
	$VI_{total}OT = VI_{sat}OT + VI_{moist}$	_OT + IVI water_0	$OT + IVI_{sur_OT} = 129.9$	/ KINI11/111		
Restoring moments on wa	all					
lotal;	$M_{total_R} = M_{stem_R} + M_{base_F}$	$_{R} + M_{exc_{R}} +$	M _{P_R} = 149.3 kNm/	m		
Check stability against ov	verturning					
Factor of safety;	FoS _{ot} = 1.149					
	PASS - Maximum re	storing mo	ment is greater th	an overt	urning mo	ment
Partial factors on actions	- Table A.3 - Combination	n 2				
Permanent unfavourable ac	ction;	$\gamma_{\rm G} = 1.0$	D ;	Permai	nent favour	able
action;	$\gamma_{Gf} = 1.00$					

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		LONDON NW	3				
Variable unfavourable actic	on;	γ _Q = 1.30 ;	Variabl	e favourabl			
action;	$\gamma_{Qf} = 0.00$						
	;Partial fa	ctors for soil parameters -	- Table A.4 -	Combinat			
Angle of shearing resistanc 1.25	e;	$\gamma_{\phi'} =$ 1.25;	Effectiv	e cohesion			
Weight density; ; Water properties	$\gamma_{\gamma} = 1.00$						
Design water density; Retained soil properties	$\gamma_w' = 9.8 \text{ kN/m}^3$						
Design moist density	ν _{mr} ' = 18 kN/m ^{3.}	Design saturated densi	tv: v _{er} ' = 18	3 kN/m ³			
Des.eff.shear resist andle	φ' _{rd} = 14.6 deα	Design wall friction and	$le: \delta_{rd} = 7$	2 dea			
Base soil proportion	Ψ I.u · · · · · · · · · · · · · · · · · · ·		, o _{r.a} – 7	9			
Design soil density:	$w' - 18 k N/m^3$	Des off shear regist on	nlo: 4' - 4				
Design wall friction angle:	$\gamma_{\rm D} = 10$ kivili , $\delta_{\rm bla} = 7.2$ deg.	Design hase friction an	αle: δ0	ucy 7 dea			
Design wan menon angle,	$O_{b.d} = 7.2 \text{ Geg},$;Design effe	ctive cohesic	on;c' _{b.d} = 0 k			
Using Coulomb theory							
At rest pressure coefficient	; K ₀ = 0.748 ;	Passive pressure coeff	cient; $K_P = 1$.	965			
Overturning check							
Vertical forces on wall							
Total;	$F_{total_v} = F_{stem} + F_{base} + F$	_{vater_v} + F _{P_v} = 67.2 kN/m					
Horizontal forces on wall							
Total;	F _{total_h} = F _{sat_h} + F _{moist_h} +	$F_{exc_h} + F_{water_h} + F_{sur_h} = 89$.1 kN/m				
Overturning moments on	wall						
Total;	$M_{total_{OT}} = M_{sat_{OT}} + M_{mois}$	$_{t_{OT}} + M_{water_{OT}} + M_{sur_{OT}} = 10$	04.3 kNm/m				
Restoring moments on w	all						
Total;	$M_{total_R} = M_{stem_R} + M_{base}$	_R + M _{exc_R} + M _{P R} = 149.2 kN	lm/m				
Check stability against ov	/erturnina						
Factor of safety;	FoS _{ot} = 1.431						
-	PASS - Maximum r	estoring moment is greate	r than overt	urning mo			
RETAINING WALL DESIG	N						
In accordance with EN199	92-1-1:2004 incorporatin	g Corrigendum dated Janu	ary 2008 an	d the UK			
	ating National Amendme	nt No.1	- Tedds colou	lation version			
National Annex incorpora			i euus caicu	auon version			
National Annex incorpora	1 - Strength and defer	ation characteristics for a	oncrete				
National Annex incorpora Concrete details - Table 3	3.1 - Strength and deform	ation characteristics for c	oncrete				
National Annex incorpora Concrete details - Table 3 Concrete strength class; Char.comp.cylinder.strengt	8.1 - Strength and deform C30/37 h:	ation characteristics for c $f_{ok} = 30 \text{ N/mm}^{2}$	oncrete Mean a	axial tensile			
National Annex incorpora Concrete details - Table 3 Concrete strength class; Char.comp.cylinder strengt strength;	3.1 - Strength and deform C30/37 h; f _{cim} = 2.9 N/mm ²	ation characteristics for c f _{ck} = 30 N/mm ² ;	oncrete Mean a	axial tensile			
National Annex incorpora Concrete details - Table 3 Concrete strength class; Char.comp.cylinder strengt strength; Secant modulus of elasticit	8.1 - Strength and deform C30/37 h; $f_{ctm} = 2.9 \text{ N/mm}^2$ y; $E_{cm} = 32837 \text{ N/mm}^2$;	ation characteristics for c f _{ck} = 30 N/mm ² ; Maximum aggregate si	oncrete Mean a ze; h _{ann} = 2	axial tensile 2 0 mm			

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			LONDON NW3				
Reinforcement details							
Characteristic yield strength	n; f _{yk} = 500 N/mm ² ;	Modulus	s of elasticity;	E _s = 200000 N/mm ²			
Design yield strength;	f _{yd} = 435 N/mm ² ;	Partial fa	actor;	γ _S = 1.15			
Cover to reinforcement							
Front face of stem;	c _{sf} = 40 mm;	Rear fac	e of stem;	C _{sr} = 50	mm		
Top face of base;	c _{bt} = 50 mm;	Bottom face of base;		C _{bb} = 75	mm		
Check stem design at bas	se of stem						
Depth of section;	h = 350 mm						
Rectangular section in fle	exure - Section 6.1						
Design bending moment;	M = 93.6 kNm/m;	K = 0.03	7;	K' = 0.2	07		
		K' > K - N	o compression re	einforcem	ent is requ		
Tens.reinforcement require	d;	A _{sr.req} =	781 mm ² /m				
Tens.reinforcement provided;		20 dia.b	ars @ 200 c/c;	Tens.re	inforcemer		
provided;	$A_{sr.prov} = 1571 \text{ mm}^2/\text{m}$						
Min.area of reinforcement;	A _{sr.min} = 437 mm ² /m;	Max.are	a of reinforcement	; A _{sr.max} =	= 14000 mm		
PASS - /	Area of reinforcement pr	ovided is gr	eater than area o	f reinforc	ement requ		
Crack control - Section 7.	3						
Crack control - Section 7. Limiting crack width;	3 w _{max} = 0.3 mm;	Maximu	m crack width;	w _k = 0. 1	8 mm		
Crack control - Section 7. Limiting crack width; PASS - Maximum crack	3 w _{max} = 0.3 mm; width is less than limiti	Maximu ng crack wi d	m crack width; dthRectangular se	w _k = 0.1 ection in s	8 mm shear - Seo		
Crack control - Section 7. Limiting crack width; PASS - Maximum crack 6.2	3 w _{max} = 0.3 mm; c width is less than limiti	Maximu ng crack wi d	m crack width; /thRectangular se	w _k = 0.1 ection in s	8 mm shear - Seo		
Crack control - Section 7. Limiting crack width; PASS - Maximum crack 6.2 Design shear force;	3 w _{max} = 0.3 mm; width is less than limiti V = 92.5 kN/m;	Maximu ng crack wi d Design s	m crack width; //thRectangular se shear resistance;	$w_k = 0.1$ ection in s $V_{Rd.c} =$	18 mm shear - Seo 161.3 kN/m		
Crack control - Section 7. Limiting crack width; PASS - Maximum crack 6.2 Design shear force;	3 $w_{max} = 0.3 \text{ mm};$ width is less than limiting V = 92.5 kN/m; PASS -	Maximu ng crack wie Design s Design she	m crack width; dthRectangular se shear resistance; ar resistance exc e	$w_k = 0.1$ ection in s $V_{Rd.c} =$ eeds des	I8 mm shear - Seo 161.3 kN/m ign shear f		
Crack control - Section 7. Limiting crack width; PASS - Maximum crack 6.2 Design shear force; Horizontal reinforcement	3 $w_{max} = 0.3 \text{ mm};$ x width is less than limiting V = 92.5 kN/m; PASS - parallel to face of stem -	Maximu ng crack wid Design s Design she Section 9.6	m crack width; dthRectangular se shear resistance; ar resistance exc e	$W_k = 0.1$ ection in s $V_{Rd.c} =$ eeeds des	18 mm shear - Seo 161.3 kN/m ign shear f		
Crack control - Section 7. Limiting crack width; <i>PASS - Maximum crack</i> 6.2 Design shear force; Horizontal reinforcement; Min.area of reinforcement;	3 w _{max} = 0.3 mm; x width is less than limitian V = 92.5 kN/m; PASS - parallel to face of stem - A _{sx.req} = 393 mm ² /m;	Maximu ng crack wid Design s Design she Section 9.6 Max.spa	m crack width; dthRectangular se shear resistance; ar resistance exc e acing of reinforcem	$w_k = 0.1$ ection in s $V_{Rd.c} =$ eeds des ent; s_{sx_max}	18 mm shear - Sea 161.3 kN/m ign shear f		
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Crack control - Section 7. Limiting crack width; PASS - Maximum crack 6.2 Design shear force; Horizontal reinforcement Min.area of reinforcement; Trans.reinforcement provid provided; PASS - A Check base design at toe	3 $w_{max} = 0.3 \text{ mm};$ x width is less than limitians V = 92.5 kN/m; PASS - parallel to face of stem - $A_{sx,req} = 393 \text{ mm}^2/\text{m};$ ed; $A_{sx,prov} = 393 \text{ mm}^2/\text{m}$ Area of reinforcement pro-	Maximu ng crack wid Design she Design she Section 9.6 Max.spa 10 dia.b	m crack width; dthRectangular se shear resistance; ar resistance exce acing of reinforcem ars @ 200 c/c; eater than area o	$W_k = 0.1$ ection in s $V_{Rd.c} =$ eeds des ent; s_{sx_max} Trans.r	8 mm shear - Seo 161.3 kN/m ign shear f a = 400 mm einforceme ement requ		
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Trans.reinforcement provided; 10 dia.bars @ 200 c/c; Trans.reinforcement provided;A_{bx.prov} = **393** mm²/m **PASS - Area of reinforcement provided is greater than area of reinforcement required**