**Structural Calculations** 

for a proposed new basement at

**10, Downside Crescent** 

Belsize Park, London

NW3

# rodriguesassociates

1 Amwell Street London EC1R 1UL Telephone 020 7837 1133 www.rodriguesassociates.com November 2018 **Structural Calculations** 

for

10, Downside Crescent Belsize Park, London NW3 for

Asif Noor and Sabina Khan 10 Downside Crescent, London NW3 2AP

Job No 1411

Rev	Date	Notes
-	01.05.18	First issue
1	13.09.18	Revision
2	16.11.18	Annex A & B revised

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# **1. CALCULATION PLAN**

This report contains the structural engineering initial calculations for a proposed new basement at No.10 Downside Crescent.

The development consists of a new basement built mostly under an existing semi-detached house and partially under a new rear extension. The extension over the basement will be single storey with flat roof. The access to the new basement and rear extension will be provided creating a new opening in the existing building back wall and a new flight under the main stair at ground floor. At the ground floor of the main building are also proposed internal alteration and demolition of existing partitions.

# **1.1. SUMMARY OF STRUCTURE**

Proposed plan area – extension

Maximum plan dimensions	14.7m by 8.9m, say
Footprint area	114m²
Storeys	Basement, Ground, First & Second floor
Rear extension maximum height	3.6m over ground level
Basement maximum depth	3.5m below ground level

# **1.2. IMPOSED LOADS**

The following imposed loads have been used

Typical imposed loads on pitched roofs	0.75 kN/m <sup>2</sup>
Typical imposed loads on floors	1.50 kN/m <sup>2</sup>
Partitions loads on floors (as imposed loads)	1.00 kN/m <sup>2</sup>
Typical imposed loads on flat roofs allowing for maintenance	1.50 kN/m <sup>2</sup>

# **1.3. REAR EXTENSION AND BASEMENT**

The basement box will be realized with reinforced concrete walls and slabs. Rear extension walls at ground floor walls will be constructed as cavity block wall and the roof will be mainly built in timber elements and steel beams.

# 2. RESOURCES

## 2.1 CODES & REFERENCES

- BS6399 Pt1 Loadings for buildings. Code of practice for dead and imposed loads.
- BS6399 Pt2 Loadings for buildings. Code of practice for wind loads.
- BS6399 Pt3 Loadings for buildings. Code of practice for imposed roof loads.
- BS5269 Pt2 Structural use of Timber. Code of practice for permissible stress design, materials and workmanship.
- BS5628 Pt1 Use of masonry. Structural use of unreinforced masonry.
- BS5950 Pt1 Structural use of steelwork in building. Code of practice for design in simple and continuous construction hot rolled sections.
- BS8110 Pt1 Structural use of concrete

Manual for the design of plain masonry in building structures – The Institution of Structural Engineers. July 1997.

## 2.2 SOFTWARE

Tekla Structural Designer suite of design and analysis tools.

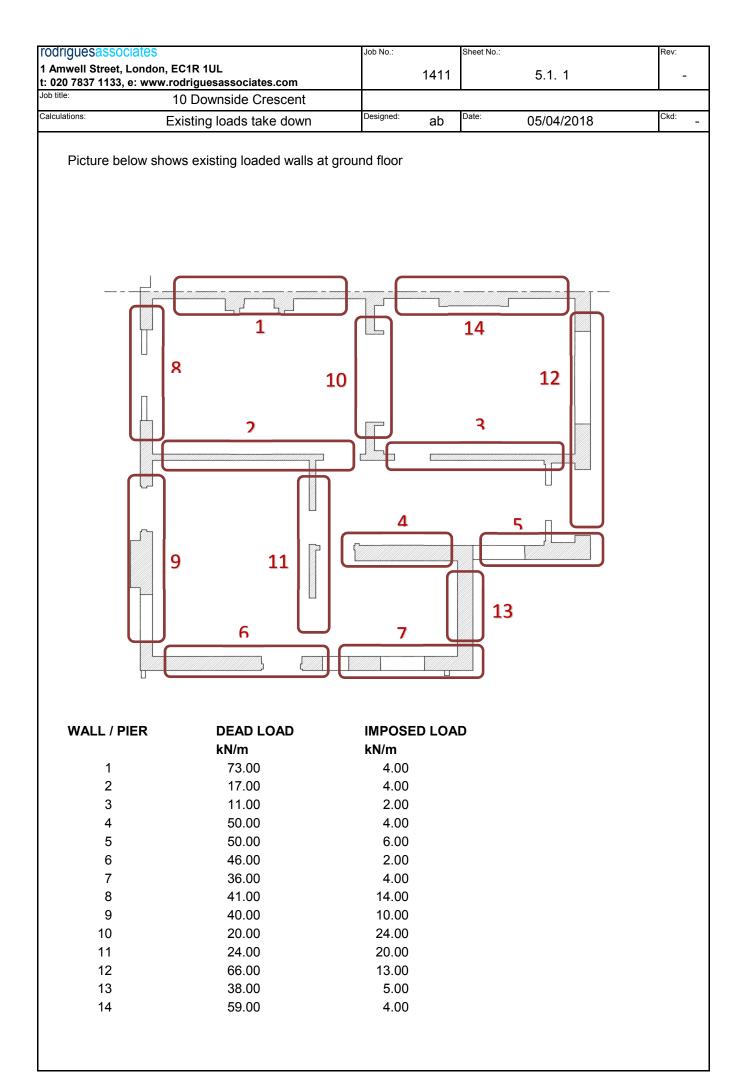
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	10 Downside Crescent			
ions:	Area loads	Designed: ab Date:	05/04/2018	Cł
Existing pitche	ed roof			
Dead	Tiles		0.77 kN/m <sup>2</sup>	
Dodd	Battens and felt		0.05 kN/m <sup>2</sup>	
	Rafters		0.15 kN/m <sup>2</sup>	
	Insulation		0.01 kN/m <sup>2</sup>	
	Services		0.05 kN/m <sup>2</sup>	
	Plasterboard and skim coat		0.15 kN/m <sup>2</sup>	
			1.18 kN/m <sup>2</sup>	
	Roof Angle 51 °		1.88 kN/m <sup>2</sup>	
Impos	ed		0.75 kN/m <sup>2</sup>	
Existing typica	l floor			
			0.15 kN/m <sup>2</sup>	
Dead	Finishes		0.15 kN/m 0.14 kN/m <sup>2</sup>	
	Boarding		0.14 kN/m 0.15 kN/m <sup>2</sup>	
	Joists		0.15 kN/m 0.05 kN/m <sup>2</sup>	
	Insulation			
	Services		0.05 kN/m <sup>2</sup>	
	Lath and plaster		0.25 kN/m <sup>2</sup> 0.79 kN/m <sup>2</sup>	
			0.79 KN/M	
Dead	with tiles as finishes		0.96 kN/m <sup>2</sup>	
Impos	ed		1.50 kN/m <sup>2</sup>	
	Partitions		1.00 kN/m <sup>2</sup>	
			2.50 kN/m <sup>2</sup>	
External brick	wall			
Dead	External render		0.60 kN/m <sup>2</sup>	
	215mm brickwork		4.73 kN/m <sup>2</sup>	
	Plaster		0.25 kN/m <sup>2</sup>	
			5.58 kN/m <sup>2</sup>	
Internal loadbe	earing stud walls			
Dead	Lath and plaster (both sides)		0.50 kN/m <sup>2</sup>	
	Studs and blocking		0.15 kN/m <sup>2</sup>	
			0.65 kN/m <sup>2</sup>	
Internal brick v	valls			
Dead	Lath and plaster (both sides)		0.50 kN/m <sup>2</sup>	
	102.5mm brickwork		2.24 kN/m <sup>2</sup>	
			2.74 kN/m <sup>2</sup>	

		1411	3. 2	
Area loads 10 Downside Crescent 10 Downside Crescent 10 Downside Crescent Area loads roposed ground floor slab Dead Finishes Screed 50mm Insulation 200mm slab Services Allowance for possible dow Patio Stone slab as finishes Imposed Partitions Patio Stone slab as finishes Imposed Partitions Dead Finishes Screed Insulation 400mm slab Services Imposed Partitions roposed flat roof Dead Asphalt Boarding Insulation Joists Services Plasterboard and skim coal Imposed (allowing for maintenance lazing Dead Glazing (Double)				
Area loads         Proposed ground floor slab         Dead       Finishes         Screed 50mm         Insulation         200mm slab         Services         Allowance for possible down         Patio       Stone slab as finishes         Imposed         Partitions         Proposed basement floor slab         Dead       Finishes         Screed         Insulation         400mm slab         Services         Imposed         Partitions         Proposed flat roof         Dead       Asphalt         Boarding         Insulation         Joists         Services         Plasterboard and skim coat         Imposed (allowing for maintenance of the state stat	Designed: ab Date:	05/04/2018	С	
Proposed grou	nd floor slab			
Dead	Finishes		0.30 kN/m <sup>2</sup>	
	Screed 50mm		1.00 kN/m <sup>2</sup>	
	Insulation		0.05 kN/m <sup>2</sup>	
	200mm slab		4.80 kN/m <sup>2</sup>	
	Services		0.15 kN/m <sup>2</sup>	
	Allowance for possible down-s	stand beams	0.50 kN/m <sup>2</sup>	
			6.80 kN/m <sup>2</sup>	
Patio	Stone slab as finishes		7.25 kN/m <sup>2</sup>	
Imnos	ed		1.50 kN/m <sup>2</sup>	
inpos			1.00 kN/m <sup>2</sup>	
			2.50 kN/m <sup>2</sup>	_
Proposed base	ment floor slab			
Dead	Finishes		0.15 kN/m <sup>2</sup>	
Doud			1.80 kN/m <sup>2</sup>	
			0.05 kN/m <sup>2</sup>	
			9.60 kN/m <sup>2</sup>	
			0.15 kN/m <sup>2</sup>	
			11.75 kN/m <sup>2</sup>	
Impos	ed		1.50 kN/m <sup>2</sup>	
			1.00 kN/m <sup>2</sup>	
			2.50 kN/m <sup>2</sup>	
Proposed flat r	oof			
Dead	Asphalt		0.40 kN/m <sup>2</sup>	
	-		0.14 kN/m <sup>2</sup>	
			0.05 kN/m <sup>2</sup>	
			0.15 kN/m <sup>2</sup>	
			0.05 kN/m <sup>2</sup>	
	Plasterboard and skim coat		0.15 kN/m <sup>2</sup> 0.94 kN/m <sup>2</sup>	
Impos	ed (allowing for maintenance of	structure above)	1.50 kN/m <sup>2</sup>	
Glazing				
Dead	Glazing (Double)		0.65 kN/m <sup>2</sup>	
			0.20 kN/m <sup>2</sup>	
			0.85 kN/m <sup>2</sup>	
	ed (for horizontal glazing accour		0.75 kN/m <sup>2</sup>	

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Job title:	10 Downside Crescent				-
Calculations:	Area loads	Designed:	ab	Date: 05/04/2018	Ckd: -
<u>Proposed exter</u> Dead	nal wall External render 100mm blockwork Insulation 100mm block work Plasterboard and skim coat			0.60 kN/ 1.50 kN/ 0.05 kN/ 1.50 kN/ 0.15 kN/ 3.80 kN/	/m <sup>2</sup> /m <sup>2</sup> /m <sup>2</sup>

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ations:		vnside C s on eler			Designed:	ah	Date:	05/04	/2010		Ckd:
	LOad	s on eler	nents			ab		05/04	/2018		
Beam & Load	Span	Area	loads	Width	Loca	ation	U	DL	Point	loads	1
description	mm	DL kN/m²	LL kN/m²	mm	from mm	to mm	DL kN/m	LL kN/m	DL kN	LL kN	
Retaining wall i	in rear e	xtensior	n toward	1 No.12							
Assumed load a	t foundat	tion level	of rear e	 extensior 	n wall at	No.12					
Flat roof/terrace External wall SV TOT	-	0.94 5.58	1.50	2000 3200			1.88 17.86 19.74				
Assuming a dist wall of 2m we ca				surcharg	e at 2.2m	n depth (	refer to	image be		 w retainir	ng
					_L)/(2r	n * 2)=	5.68	kN/m2			
Assumed load a	t foundat	tion level	of party	wall with	<u>1 No.12</u>						
External wall SV	/	4.73		2100			9.93				
Assuming a dist wall of 0.8m we				-						<i>w</i> retainir	ng
			(	DL + LL	)/(0.8r	n * 2)=	6.21	kN/m2			
For the retaining	wall des	sign will b	e consid	dered a s	surcharge	e of 12 k	N/m2.				
	-			800, SA	2m Y 1200, SA	•		P			
		40		↓ 0.	8m	rear at No	extensio p.12	in			
		new ret wall	aining			2m					
	-	1 	ter sa								

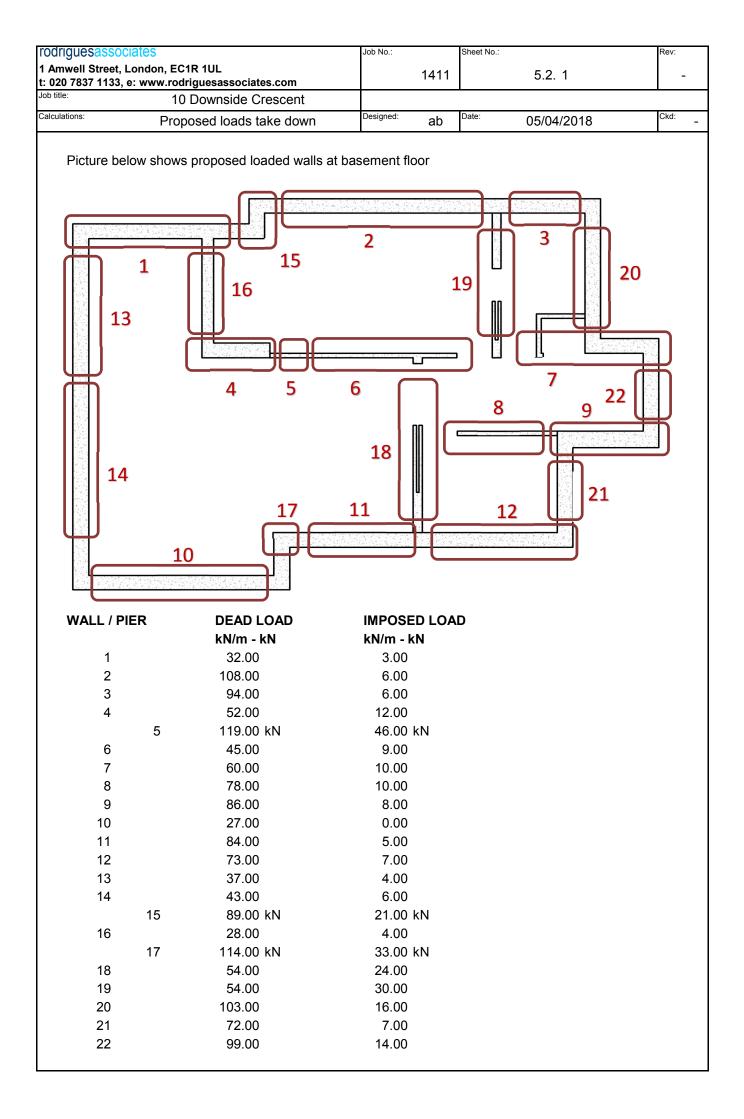
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ations:		s on elen			Designed: ab Date: 05/04/2018						
						ab			2010		
Beam & Load	Span	Area	loads	Width	Loca	ation	UI	DL	Point	loads	
description		DL	LL		from	to	DL	LL	DL	LL	
	mm	kN/m²	kN/m²	mm	mm	mm	kN/m	kN/m	kN	kN	
Retaining wall u	under m	ain build	ling tow	/ard No.	12						
Assumed load a	t foundat	tion level	of exter	nal wall a	at No.12						
no of		1 1 0	0.75	2000			0.00	1 50			
roof		1.18	0.75				2.36				
attic		0.79	2.50				1.58				
wall SW at "f		4.98	0.50	3000			14.94				
2F		0.79	2.50				1.58				
wall SW at 1F		4.98	0 -0	3000			14.94				
1F		0.79	2.50				1.58				
wall SW at GF		7.51		3000			22.53				
тот							59.51	16.50			
Assumed load a	t foundat	tion level	of party		_L)/(2r   <u>1 No.12</u>	ŕ					
External wall SW	/	4.73		2100			9.93				
Assuming a distr wall of 1.3m we For the retaining	can cons	sider the	following (	DL + LL	rge at 1.{ ) / ( 1.3r	5m depth n * 2)=	n ( refer t 3.82	o image kN/m2	below )		ng
				1300, SAY	1100, SAY						
		No10 ext w new wall		2.4m		No12 ex wall m	t				
		-									



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tions:	Existing	loads ta	ke down		Designed:	ab	Date:	05/04/	/2018		Ckd
Beam & Load	Span	Area	loads	Width	Loca	ation	U	DL	Point	loads	
description		DL	LL		from	to	DL	LL	DL	LL	
	mm	kN/m²	kN/m²	mm	mm	mm	kN/m	kN/m	kN	kN	
WALL 1											
( assumed 330 t	l hk partv	wall )									
roof ( both side )	• •	1.88	0.75	2000			3.75	1.50			
2F ( both side )		0.79	2.50	350			0.28	0.88			
1F ( both side )		0.79	2.50	350			0.28	0.88			
party wall SW		7.76		8800			68.29	0.00			
-							72.59	3.25			
WALL 2											
(assumed 103 t	hk brick	·									
roof		1.88	0.75	2250			4.22	1.69			
2F		0.79	2.50	350			0.28	0.88			
1F		0.79	2.50	350			0.28	0.88			
stud wall at 2F		0.65		2700			1.76	0.00			
stud wall at 1F		0.65		2900			1.89	0.00			
wall SW at GF		2.74		3000			8.23	0.00			
							16.64	3.44			
WALL 3											
(assumed 103 t	hk brick	wall)									
roof		1.88	0.75	0			0.00	0.00			
2F		0.79	2.50	350			0.28	0.88			
1F		0.79	2.50	350			0.28	0.88			
stud wall at 2F		0.65		0			0.00	0.00			
stud wall at 1F		0.65		2900			1.89	0.00			
wall SW at GF		2.74		3000			8.23	0.00			
							10.67	1.75			
WALL 4	hk briele										
( assumed 330 t	IIK DEICK	,	0.75	1000			1 00	0.75			
roof		1.88	0.75	1000			1.88	0.75			
2F 1F		0.79	2.50	0 1200			0.00	0.00			
wall SW		0.79 7.76	2.50	1200 6000			0.95	3.00			
		1.10		0000			46.56 49.38	0.00 3.75			
							10.00	0.10			
WALL 5											
(assumed 330 t	hk brick	wall)									
roof		1.88	0.75	1000			1.88	0.75			
2F		0.79	2.50	350			0.28	0.88			
1F		0.79	2.50	1550			1.22	3.88			
wall SW		7.76		6000			46.56	0.00			
							49.94	5.50			1

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tions:	Existing	loads ta	ke down		Designed:	ab	Date:	05/04/	/2018		Ckd:
Beam & Load	Span	Area	loads	Width	Loca	ation	U	DL	Point	loads	
description		DL	LL		from	to	DL	LL	DL	LL	
	mm	kN/m²	kN/m²	mm	mm	mm	kN/m	kN/m	kN	kN	
WALL 6											
( assumed 215 f	I thk brick	wall )									
roof		1.88	0.75	1125			2.11	0.84			
2F		0.79	2.50	175			0.14	0.44			
1F		0.79	2.50	175			0.14	0.44			
wall SW		5.58	2.00	7800			43.52				
		0.00		1000			45.91	1.72			
WALL 7											
(assumed 215 f	thk brick	<i>,</i>									
roof		1.88	0.75	350			0.66	0.26			
2F		0.79	2.50	0			0.00	0.00			
1F		0.79	2.50	1200			0.95	3.00			
wall SW		5.58		6000			33.48	0.00			
							35.08	3.26			
WALL 8											
(assumed 215 f	hk brick										
roof		1.88	0.75	1500			2.81	1.13			
2F		0.79	2.50	2450			1.94	6.13			
2F 1F											
wall SW		0.79 5.58	2.50	2450 6000			1.94 33.48				
		5.56		0000			40.16				
WALL 9	 										
(assumed 215 f			0.75	4500			0.04	4 4 0			
roof 2F		1.88	0.75	1500			2.81	1.13			
2F 1F		0.79	2.50	1750			1.38				
		0.79 5.58	2.50	1750			1.38				
wall SW		5.58		6000			33.48				
							39.06	9.88			
WALL 10											
( assumed 103 1	thk brick	wall)									
roof		1.88	0.75	200			0.38	0.15			
2F		0.79	2.50	4700			3.71	11.75			
1F		0.79	2.50	4700			3.71	11.75			
stud wall at 2F		0.75	2.50	2700			1.76				
stud wall at 2F		0.65		2900			1.89				
wall SW at GF		2.74		3000			8.23	0.00			
waii Svv al Gr		2.14		3000			0.23	23.65			
							19.07	23.03			

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tions:	Existing	loads tal	ke down		Designed:	ab	Date:	05/04	/2018		Ckd
Beam & Load	Span	Area	loads	Width	Loca	ation	U	DL	Point	loads	]
description		DL	LL		from	to	DL	LL	DL	LL	
	mm	kN/m²	kN/m²	mm	mm	mm	kN/m	kN/m	kN	kN	
WALL 11											
( assumed 103 t	hk brick										
roof		1.88	0.75	3500			6.56	2.63			
2F		0.79	2.50	3400			2.69	8.50			
1F		0.79	2.50	3400			2.69	8.50			
stud wall at 2F		0.65		2700			1.76	0.00			
stud wall at 1F		0.65		2900			1.89	0.00			
wall SW at GF		2.74		3000			8.23				1
							23.81	19.63			
WALL 40											
WALL 12	ا المار المراجات										
( assumed 330 t											
roof		1.88	0.75	1000			1.88	0.75			
2F		0.79	2.50	2300			1.82	5.75			
1F		0.79	2.50	2300			1.82	5.75			
wall SW		7.51		8000			60.08				
							65.59	12.25			
WALL 13											
(assumed 330 t	hk brick	wall)									
roof		1.88	0.75	1500			2.81	1.13			
2F		0.79	2.50	1000			0.79				
1F		0.79	2.50	350			0.28				
wall SW		7.51	2.00	4500			33.80				
		7.51		4500			37.67	4.50			
WALL 14											
( assumed 330 t											1
roof ( both side )	)	1.88	0.75	2000			3.75	1.50			
2F ( both side )		0.79	2.50	350			0.28	0.88			
1F ( both side )		0.79	2.50	350			0.28	0.88			
party wall SW		7.76		7000			54.32	0.00			
							58.62	3.25			1
	I										1



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itions:	Proposed			า	Designed:	ab	Date:	05/04/	2018		Ckd:
Beam & Load	Span	Area		Width		ation		DL		loads	]
description	mm	DL kN/m²	LL kN/m²	mm	from mm	to mm	DL kN/m	LL kN/m	DL kN	LL kN	
WALL 1											
( assumed 300 t	hk rc wa	II )									
GF wall SW		6.80 7.50	2.50	825 3500			5.61 26.25	2.06			
		7.50		5500			31.86				
WALL 2											
( assumed 330 t	hk rc wa	II )									
from existing wa GF	ll 1 (see	sheet 5. 6.80	1) 2.50	950			72.59 6.46	3.25 2.38			
wall SW		8.25	2.00	3500			28.88				
							107.93	5.63			
WALL 3											
( assumed 330 t from existing wa			(1)				58.62	3.25			
GF		6.80	2.50	950			6.46	2.38			
wall SW		8.25		3500			28.88 93.96				
							00.00	0.00			
WALL 4 ( assumed 300 t	hk rc wa	)									
new flat roof		0.94	1.50	2250			5.50	8.78			
GF cavity wall at GF	 -	6.80 3.80	2.50	1175 3000			7.99 11.40	2.94			
wall SW		7.50		3500			26.25				
							51.14	11.71			

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itions:	Proposed			n	Designed:	ab	Date:	05/04	/2018	С
							•			
Beam & Load	Span	Area	loads	Width	Loca	ation	U	DL	Point	oads
description	mm	DL kN/m²	LL kN/m²	mm	from mm	to mm	DL kN/m	LL kN/m	DL kN	LL kN
PIER 5									50.04	40.00
from existing wa from existing wa	•								58.24 49.10	19.39 21.73
GF		6.80							10.88	4.00
									118.22	45.12
WALL 6										
( assumed 150 t from existing wa		,	1)				16.64	3.44		
GF		6.80	2.50	2200			14.96	5.50		
wall SW		3.75		3500			13.13			
							44.73	8.94		
WALL 7 ( assumed 330 t from existing wa		,	1)				10.67	1.75		
GF	11 5 (566	6.80	2.50	2950			20.06	7.38		
wall SW		8.25		3500			28.88			
							59.61	9.13		
WALL 8 ( assumed 150 t from existing wa GF				2250			49.38 15.30			
wall SW		3.75		3500			13.13			
							77.81	9.38		
WALL 9 ( assumed 330 t from existing wa		,	1)				49.94	5.50		
GF	11 5 (See	6.80	-	1000			6.80	2.50		
wall SW		8.25	2.00	3500			28.88	2.00		
							85.61	8.00		
WALL 10 ( assumed 300 t	bk ro wo	11 )								
wall SW		7.50		3500			26.25			

Proposed			-						
	d loads ta	ake dowr	า	Designed:	ab	Date:	05/04/	/2018	C
Span			Width	Loca	ation			Point	loads
<b>m</b> m	DL kN/m²	LL kN/m²	<b>m</b> m	from	to	DL kN/m	LL kN/m	DL	LL kN
hk rc wal	II )	1)				45.91 8.50 28.88 83.28	1.72 3.13 4.84	<u>KIN</u>	KIN
		-	1250 3500			35.08 8.50 28.88 72.46	3.26 3.13 6.39		
hk rc wal	ll) 6.80 7.50	2.50	1450 3500			9.86 26.25 36.11	3.63 3.63		
hk rc wa	ll) 6.80 7.50	2.50	2350 3500			15.98 26.25 42.23	5.88 5.88		
ll 8 (see	sheet 5.7 7.50 6.80	1) 2.50	3500					58.24 26.25 4.08 88.57	19.39 <u>1.50</u> 20.89
hk rc wal	ll ) 6.80 5.00	2.50	1450 3500			9.86 17.50 27.36	3.63 3.63		
	mm hk rc wal l 6 (see hk rc wal hk rc wal hk rc wal	DL         mm       DL         kN/m²         hk rc wall )       6.80         16 (see sheet 5.         6.80         8.25         hk rc wall )         17 (see sheet 5.         6.80         8.25         hk rc wall )         6.80         7.50         hk rc wall )         6.80         7.50         6.80         7.50         6.80         7.50         6.80         7.50         6.80         7.50         6.80         7.50         6.80         7.50         6.80         7.50         6.80         7.50         6.80         7.50         6.80         7.50         6.80         7.50         6.80         8.80         8.80         8.80         8.80         8.80         8.80         8.80         9.80         9.80         9.80	DL         LL           mm         DL         LL           kN/m²         kN/m²           hk rc wall )         16 (see sheet 5.1)         6.80         2.50           16 (see sheet 5.1)         6.80         2.50           nk rc wall )         17 (see sheet 5.1)         6.80         2.50           nk rc wall )         2.50         2.50	DL         LL         mm           mm         DL         kN/m²         mm           hk rc wall )         6.80         2.50         1250           16 (see sheet 5.1)         6.80         2.50         1250           nk rc wall )         6.80         2.50         1450           nk rc wall )         6.80         2.50         3500           18 (see sheet 5.1)         7.50         3500         3500           nk rc wall )         6.80         2.50         1450           nk rc wall )         6.80         2.50         1450	DL         LL         from mm           kN/m²         kN/m²         mm         mm           hk rc wall )         16 (see sheet 5.1)         6.80         2.50         1250           hk rc wall )         6.80         2.50         1250         3500           hk rc wall )         17 (see sheet 5.1)         6.80         2.50         1250           hk rc wall )         6.80         2.50         1250         3500           hk rc wall )         6.80         2.50         1450           nk rc wall )         6.80         2.50         3500           hk rc wall )         6.80         2.50         3500           hk rc wall )         6.80         2.50         3500           hk rc wall )         6.80         2.50         3500           18 (see sheet 5.1)         3500         3500           hk rc wall )         6.80         2.50         3500           hk rc wall )         6.80         2.50         1450	DL         LL         from mm         to mm           mm         kN/m²         mm         mm         mm         mm           nk rc wall )         6.80         2.50         1250         3500         1250         3500         1250<	DL         LL         from         to         DL           mm         kN/m²         mm         mm         mm         kN/m           nk rc wall )         6.80         2.50         1250         45.91           16 (see sheet 5.1)         6.80         2.50         1250         8.50           8.25         3500         1250         8.50           nk rc wall )         1         7 (see sheet 5.1)         35.08           6.80         2.50         1250         8.50           8.25         3500         28.88           72.46         8.50           8.25         3500         28.88           72.46         9.86           7.50         3500         26.25           36.11         9.86           7.50         3500         26.25           3500         26.25           3500         42.23           18 (see sheet 5.1)         3500         42.23           18 (see sheet 5.1)         3500         42.23           nk rc wall )         6.80         2.50         3500           6.80         2.50         3500         42.23           18 (see sheet 5.1)         5.00	DL         LL         from         to         DL         LL           mm         kN/m²         mm         mm         mm         mm         kN/m         kN/m           nk rc wall )         16 (see sheet 5.1)         6.80         2.50         1250         8.25         3500         28.88         35.08         3.13           8.25         3500         1250         8.328         4.84         83.28         4.84           nk rc wall )         17 (see sheet 5.1)         6.80         2.50         1250         8.50         3.13           17 (see sheet 5.1)         6.80         2.50         1250         8.50         3.13           nk rc wall )         6.80         2.50         1450         8.50         3.13           nk rc wall )         6.80         2.50         2350         42.23         5.88           18 (see sheet 5.1)         3500         42.23         5.88         26.25           18 (see sheet 5.1)         3500         42.23         5.88           18 (see sheet 5.1)         7.50         3500         42.23         5.88           18 (see sheet 5.1)         7.50         3500         42.23         5.88           18 (see sheet 5.1)	$\begin{array}{c c c c c c c c c c c c c c c c c c c $

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itions:	Proposed	loads ta	ake dowr	1	Designed:	ab	Date:	05/04	/2018		Ckd
Beam & Load	Span	Area	loads	Width	Loca	ation	U	DL	Point I	loads	
description		DL	LL		from	to	DL	LL	DL	LL	
	mm	kN/m²	kN/m²	mm	mm	mm	kN/m	kN/m	kN	kN	1
PIER 17											1
from existing wa	ll 9 @1F								49.10	21.73	1
GF		6.80	2.50						6.80	2.50	1
new flat roof	2350	0.94	1.50	2250					4.97	7.93	1
cavity wall at GF	2350	3.80		3000					26.79		1
pier SW		7.50		3500					26.25	00.40	I
									113.91	32.16	l
WALL 18											1
( assumed 200 t	hk ro wa										i i
from existing wa			sheet 5 1	)			23.81	19.63			1
GF		6.80	2.50	, 1725			11.73	4.31			1
wall SW		5.00	2.00	3500			17.50	1.01			1
		0.00					53.04	23.94			1
( assumed 200 t from existing wa GF wall SW		· ·	sheet 5.1 2.50	) 2400 3500			19.67 16.32 17.50 53.49	23.65 6.00 29.65			
WALL 20 ( assumed 330 t from existing wa GF wall SW		,	sheet 5.1 2.50	-			65.59 7.82 28.88 102.28	12.25 2.88 15.13			
WALL 21 ( assumed 330 t from existing wa GF wall SW		,	sheet 5.1 2.50				37.67 5.44 28.88 71.99	4.50 2.00 6.50			
WALL 22 ( assumed 330 t from existing wa GF wall SW			sheet 5.1 2.50				65.59 3.74 28.88 98.20	12.25 1.38 13.63			

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le:	-	vnside C					I				<u> </u>
ations:		er uplift o			Designed:	ab	Date:	05/04	/2018		Ckd:
							1				<u> </u>
Beam & Load	Span	Area	loads	Width	Loca	ation	U	DL	Point	loads	1
description		DL	LL		from	to	DL	LL	DL	LL	1
	mm	kN/m²	kN/m²	mm	mm	mm	kN/m	kN/m	kN	kN	
Check under m	ain buile	ding									
Water uplift forc	 <u>e</u>										
3m high water table	7600	30.00		9500					2166.0		
Gravitational loa											
roof DL	7600	1.88		9500					135.4		
2F DL	7600	0.79		9500					57.0		
1F ext walls SW			kN/m3	22.06	m3				485.3		
1F DL	7600	0.79		9500					57.0		
GF side&spine v			kN/m3	12.65	m3				278.4		
GF DL	7600	6.80	kNI/mc O	9500	m2				491.0		
BF walls SW BF DL	7600	24.00 11.75	kN/m3	26.79 9500	1113				643.0		
TOT	1000	11.75		9000					848.4 <b>2995.4</b>	PASS	
Check under re	ar exten	sion									
<u>Water uplift forc</u> 3m high water table		30.00		6500					994.5		
Gravitational loa											
roof DL	5100			5300					25.4		
GF walls SW	2800			6900					73.4		
GF DL BF walls SW	5300	6.80 24.00	kN/m3	6200 11.934	m?				223.4 286.4		
BF Walls SVV BF DL	5100		rin/1113	6500	1113				286.4 389.5		
TOT	5100	11.75		0000						PASS	
Check under re	ar court	yard									
Water uplift forc	e e										
3m high water table	5000	30.00		3100					465.0		
<u>Gravitational loa</u> GF DL BF walls SW	3800		kN/m3	3100 10.38	m3				80.1 249.1		
BF DL TOT	5000	11.75		3100					182.1 <b>511.3</b>	PASS	

<b>Tekla</b> Tedds	Project	10 Downsic	Job no. 1411			
RODRIGUES ASSOCIATES 1 AMWELL STREET	Calcs for	GF	slab		Start page no./Revision 6.2. 1	
LONDON EC1R 1UL	Calcs by ab	Calcs date 20/04/2018	Checked by	Checked date	Approved by	Approved date

RC SLAB DESIGN (BS8110:PART1:1997)	TEDDS calculation version 1.0.
TWO WAY SPANNING SLAB DEFINITION – SIMPLY SUPPORTED	
Overall depth of slab $h = 200 \text{ mm}$	
Outer sagging steel	
Cover to outer tension reinforcement resisting sagging $c_{sag} = 25$ mm	
Trial bar diameter D <sub>tryx</sub> = <b>10</b> mm	
Depth to outer tension steel (resisting sagging)	
$d_x = h - c_{sag} - D_{tryx}/2 = 170 \text{ mm}$	
Inner sagging steel	
Trial bar diameter D <sub>tryy</sub> = <b>10</b> mm	
Depth to inner tension steel (resisting sagging)	
$d_y = h - c_{sag} - D_{tryx} - D_{tryy}/2 = 160 \text{ mm}$	
Materials	
Characteristic strength of reinforcement $f_y = 500 \text{ N/mm}^2$	
Characteristic strength of concrete $f_{cu} = 40 \text{ N/mm}^2$	
Asy Nominal 1 m width Asx	
Shorter Span	
h dy	
Asy Nominal 1 m width Asx	
Longer Span	
Two-way spanning slab (simple)	
MAXIMUM DESIGN MOMENTS	
Length of shorter side of slab $I_x = 4.300 \text{ m}$	
Length of longer side of slab $I_y = 4.800 \text{ m}$	
Design ultimate load per unit area $n_s = 13.5 \text{ kN/m}^2$	

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 $\alpha_{sx} = (I_y / I_x)^4 / (8 \times (1 + (I_y / I_x)^4)) = 0.076$ 

 $\alpha_{sy} = (I_y / I_x)^2 / (8 \times (1 + (I_y / I_x)^4)) = 0.061$ 

Maximum moments per unit width - simply supported slabs

 $m_{sx} = \alpha_{sx} \times n_s \times I_x^2 = 19.0 \text{ kNm/m}$ 

 $m_{sy} = \alpha_{sy} \times n_s \times I_x^2 = 15.2 \text{ kNm/m}$ 

#### CONCRETE SLAB DESIGN - SAGGING - OUTER LAYER OF STEEL (CL 3.5.4)

Design sagging moment (per m width of slab) m<sub>sx</sub> = 19.0 kNm/m

Moment Redistribution Factor  $\beta_{bx} = 1.0$ 

#### Area of reinforcement required

 $K_x = abs(m_{sx}) / (d_x^2 \times f_{cu}) = 0.016$ 

K'x = min (0.156 , (0.402 × ( $\beta_{bx}$  - 0.4)) - (0.18 × ( $\beta_{bx}$  - 0.4)<sup>2</sup> )) = 0.156

Outer compression steel not required to resist sagging

#### Slab requiring outer tension steel only - bars (sagging)

 $z_x = min ((0.95 \times d_x), (d_x \times (0.5 + \sqrt{(0.25 - K_x/0.9)}))) = 162 mm$ 

Neutral axis depth  $x_x = (d_x - z_x) / 0.45 = 19 \text{ mm}$ 

Area of tension steel required

 $A_{sx_{req}} = abs(m_{sx}) / (1/\gamma_{ms} \times f_y \times z_x) = 270 \text{ mm}^2/\text{m}$ 

#### **Tension steel**

Provide 10 dia bars @ 200 centres outer tension steel resisting sagging

 $A_{sx_{prov}} = A_{sx} = 393 \text{ mm}^2/\text{m}$ 

Area of outer tension steel provided sufficient to resist sagging

## Concrete Slab Design - Sagging - Inner layer of steel (cl. 3.5.4)

Design sagging moment (per m width of slab) m<sub>sy</sub> = 15.2 kNm/m

Moment Redistribution Factor  $\beta_{by} = 1.0$ 

Area of reinforcement required

 $K_y = abs(m_{sy}) / (d_y^2 \times f_{cu}) = 0.015$ 

K'<sub>y</sub> = min (0.156 , (0.402  $\times$  ( $\beta_{by}$  - 0.4)) - (0.18  $\times$  ( $\beta_{by}$  - 0.4)² )) = 0.156

Inner compression steel not required to resist sagging

Slab requiring inner tension steel only - bars (sagging)

 $z_y = min ((0.95 \times d_y), (d_y \times (0.5 + \sqrt{(0.25 - K_y/0.9)}))) = 152 mm$ 

Neutral axis depth  $x_y = (d_y - z_y) / 0.45 = 18 \text{ mm}$ 

Area of tension steel required

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RODRIGUES ASSOCIATES 1 AMWELL STREET	Calcs for	CE	slab		Start page no./F	Revision .2. 3
LONDON	Oplan hu			Observed data		-
EC1R 1UL	Calcs by ab	Calcs date 20/04/2018	Checked by	Checked date	Approved by	Approved da
$A_{sy_{req}} = abs(m_{sy}) / (1/2)$	$\gamma_{ms} \times f_y \times z_y) = 23$	<b>30</b> mm²/m				
Tension steel						
<u>Provide 10 dia bars @ 200</u>		tension steel res	sisting saggin	ng		
A <sub>sy_prov</sub> = A <sub>sy</sub> = <b>393</b> mr	m²/m					
Check min and may areas	fotool registing		inner tension	steel provided	sufficient to r	esist saggir
<u>Check min and max areas o</u> Total area of concrete $A_c = h$						
Minimum % reinforcer						
A <sub>st_min</sub> = k × A <sub>c</sub> = <b>260</b> r						
- A <sub>st max</sub> = 4 % × A <sub>c</sub> = 80						
Steel defined:						
Outer steel resisting s	agging Asx prov	<b>= 393</b> mm²/m				
C C				Area of outer s	steel provided	(sagging) (
Inner steel resisting s	agging A <sub>sy_prov</sub> =	= <b>393</b> mm²/m				
Inner steel resisting s	agging A <sub>sy_prov</sub> =	= <b>393</b> mm²/m		Area of inner s	teel provided	(sagging) O
Inner steel resisting steel resisting steel resisting steel resistance of co				Area of inner s	teel provided	(sagging) C
	DNCRETE SLAI	BS (CL 3.5.5)		Area of inner s	teel provided	(sagging) C
SHEAR RESISTANCE OF CO	DNCRETE SLAI	BS (CL 3.5.5) ients	mm	Area of inner s	teel provided	(sagging) C
SHEAR RESISTANCE OF CO	DNCRETE SLAI	BS (CL 3.5.5) ients ion face dx = 170			teel provided	(sagging) C
SHEAR RESISTANCE OF CO Outer tension steel resisting Depth to tension steel	DNCRETE SLAI	BS (CL 3.5.5) tents tion face d <sub>x</sub> = 170 ed (per m width of	slab) A <sub>sx_prov</sub> :		teel provided	(sagging) C
SHEAR RESISTANCE OF CO Outer tension steel resisting Depth to tension steel Area of tension reinfo	DNCRETE SLAI g sagging mom l from compress rcement provide	<b>BS (CL 3.5.5)</b> tents tion face $d_x = 170$ and (per m width of dth of slab) $V_x = 3$	slab) A <sub>sx_prov</sub> :		teel provided	(sagging) C
SHEAR RESISTANCE OF CO Outer tension steel resisting Depth to tension steel Area of tension reinfo Design ultimate shear	DNCRETE SLAI g sagging mom l from compress rcement provide	<b>BS (CL 3.5.5)</b> tents tion face $d_x = 170$ and (per m width of dth of slab) $V_x = 3$	slab) A <sub>sx_prov</sub> :		teel provided	(sagging) C
SHEAR RESISTANCE OF CO Outer tension steel resisting Depth to tension steel Area of tension reinfo Design ultimate shear Characteristic strengt	DNCRETE SLAI g sagging mom l from compress rcement provide	<b>BS (CL 3.5.5)</b> tents tion face $d_x = 170$ and (per m width of dth of slab) $V_x = 3$	slab) A <sub>sx_prov</sub> :		teel provided	(sagging) C
SHEAR RESISTANCE OF CO Outer tension steel resisting Depth to tension steel Area of tension reinfo Design ultimate shear Characteristic strengt Applied shear stress	DNCRETE SLAI g sagging mom l from compress rcement provide force (per m wi h of concrete for	<b>BS (CL 3.5.5)</b> tents tion face $d_x = 170$ and (per m width of dth of slab) $V_x = 3$	slab) A <sub>sx_prov</sub> :		teel provided	(sagging) C
SHEAR RESISTANCE OF COOuter tension steel resistingDepth to tension steelArea of tension reinfoDesign ultimate shearCharacteristic strengtApplied shear stress $v_x = V_x / d_x = 0.17 \text{ N/mm}^2$	DNCRETE SLAI g sagging mom l from compress rcement provide force (per m wi h of concrete for h of concrete for	<b>BS (CL 3.5.5)</b> <b>Thents</b> Fion face $d_x = 170$ and (per m width of dth of slab) $V_x = 3$ u = 40 N/mm <sup>2</sup>	slab) A <sub>sx_prov</sub> :		teel provided	(sagging) C
SHEAR RESISTANCE OF COOuter tension steel resistingDepth to tension steelArea of tension reinfoDesign ultimate shearCharacteristic strengtApplied shear stress $v_x = V_x / d_x = 0.17 \text{ N/mm}^2$ Check shear stress to clause	DNCRETE SLAI g sagging mom l from compress rcement provide force (per m wi h of concrete for h of concrete for	<b>BS (CL 3.5.5)</b> <b>Thents</b> Fion face $d_x = 170$ and (per m width of dth of slab) $V_x = 3$ u = 40 N/mm <sup>2</sup>	slab) A <sub>sx_prov</sub> :			
SHEAR RESISTANCE OF COOuter tension steel resistingDepth to tension steelArea of tension reinfoDesign ultimate shearCharacteristic strengtApplied shear stress $v_x = V_x / d_x = 0.17 \text{ N/mm}^2$ Check shear stress to clause	<b>DNCRETE SLAI</b> <b>g sagging mom</b> I from compress reement provide force (per m wi h of concrete $f_{ct}$ <b>h of concrete</b> $f_{ct}$ <b>e 3.5.5.2</b>	<b>BS (CL 3.5.5)</b> <b>Thents</b> Fion face $d_x = 170$ and (per m width of dth of slab) $V_x = 3$ u = 40 N/mm <sup>2</sup>	slab) A <sub>sx_prov</sub> :			
SHEAR RESISTANCE OF COOuter tension steel resistingDepth to tension steelArea of tension reinforDesign ultimate shearCharacteristic strengthApplied shear stress $v_x = V_x / d_x = 0.17 \text{ N/mm}^2$ Check shear stress to claus $v_{allowable} = min ((0.8 N^{1/2}/mm) \times 10^{-1})$	<b>DNCRETE SLAI</b> <b>g sagging mom</b> I from compress reement provide force (per m wi h of concrete $f_{ct}$ <b>be 3.5.5.2</b> $e^{1/2}(f_{cu})$ , 5 N/mm <sup>2</sup> <b>5.5.3</b>	<b>BS (CL 3.5.5)</b> <b>Thents</b> Fion face $d_x = 170$ and (per m width of dth of slab) $V_x = 3$ u = 40 N/mm <sup>2</sup>	slab) A <sub>sx_prov</sub> :			
SHEAR RESISTANCE OF COOuter tension steel resistingDepth to tension steelArea of tension reinfoDesign ultimate shearCharacteristic strengthApplied shear stress $v_x = V_x / d_x = 0.17 \text{ N/mm}^2$ Check shear stress to clausevallowable = min ((0.8 N <sup>1/2</sup> /mm) ×Shear stresses to clause 3.5	<b>DNCRETE SLAI</b> <b>g sagging mom</b> I from compress recement provide force (per m wi h of concrete $f_{cc}$ <b>e 3.5.5.2</b> $e \sqrt{(f_{cu})}$ , 5 N/mm <sup>2</sup> <b>5.5.3</b>	<b>BS (CL 3.5.5)</b> <b>nents</b> ion face $d_x = 170$ ed (per m width of dth of slab) $V_x = 3$ $u = 40 \text{ N/mm}^2$ $f^2 = 5.00 \text{ N/mm}^2$	slab) A <sub>sx_prov</sub> - <b>29</b> kN/m			
SHEAR RESISTANCE OF COOuter tension steel resistingDepth to tension steelArea of tension reinfoDesign ultimate shearCharacteristic strengthApplied shear stress $v_x = V_x / d_x = 0.17 \text{ N/mm}^2$ Check shear stress to clauseVallowable = min ((0.8 N <sup>1/2</sup> /mm) ×Shear stresses to clause 3.8Design shear stress	<b>DNCRETE SLAI</b> <b>g sagging mom</b> I from compress reement provide force (per m wi h of concrete for <b>e 3.5.5.2</b> $e \sqrt{(f_{cu})}$ , 5 N/mm <sup>2</sup> <b>5.5.3</b> mm <sup>2</sup> , 40/25 , f <sub>cu</sub>	<b>BS (CL 3.5.5)</b> <b>nents</b> ion face $d_x = 170$ ed (per m width of dth of slab) $V_x = 32$ $u = 40 \text{ N/mm}^2$ $f^2 = 5.00 \text{ N/mm}^2$	slab) A <sub>sx_prov</sub> - 29 kN/m 600	= <b>393</b> mm²/m	She	
SHEAR RESISTANCE OF COOuter tension steel resistingDepth to tension steelArea of tension reinfoDesign ultimate shearCharacteristic strengthApplied shear stress $v_x = V_x / d_x = 0.17 \text{ N/mm}^2$ Check shear stress to clauseVallowable = min ((0.8 N <sup>1/2</sup> /mm) ×Shear stresses to clause 3.8Design shear stressfcu_ratio = if (fcu > 40 N/r	<b>DNCRETE SLAI</b> <b>g sagging mom</b> I from compress reement provide force (per m wi h of concrete for <b>e 3.5.5.2</b> $e \sqrt{(f_{cu})}$ , 5 N/mm <sup>2</sup> <b>5.5.3</b> mm <sup>2</sup> , 40/25 , f <sub>cu</sub>	<b>BS (CL 3.5.5)</b> <b>nents</b> ion face $d_x = 170$ ed (per m width of dth of slab) $V_x = 32$ $u = 40 \text{ N/mm}^2$ $f^2 = 5.00 \text{ N/mm}^2$	slab) A <sub>sx_prov</sub> - 29 kN/m 600	= <b>393</b> mm²/m	She	
SHEAR RESISTANCE OF COOuter tension steel resistingDepth to tension steelArea of tension reinfoDesign ultimate shearCharacteristic strengthApplied shear stress $v_x = V_x / d_x = 0.17 \text{ N/mm}^2$ Check shear stress to clauseVallowable = min ((0.8 N <sup>1/2</sup> /mm) ×Shear stresses to clause 3.8Design shear stressfcu_ratio = if (fcu > 40 N/r $v_{cx} = 0.79 \text{ N/mm}^2 \times m$	<b>DNCRETE SLAI</b> <b>g sagging mom</b> I from compress reement provide force (per m wi h of concrete for <b>e 3.5.5.2</b> $e \sqrt{(f_{cu})}$ , 5 N/mm <sup>2</sup> <b>5.5.3</b> mm <sup>2</sup> , 40/25 , f <sub>cu</sub>	<b>BS (CL 3.5.5)</b> <b>nents</b> ion face $d_x = 170$ ed (per m width of dth of slab) $V_x = 32$ $u = 40 \text{ N/mm}^2$ $f^2 = 5.00 \text{ N/mm}^2$	slab) A <sub>sx_prov</sub> - 29 kN/m 600	= <b>393</b> mm²/m	She	(sagging) C ar stress - (

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SHEAR RESISTANCE OF CONCRETE SLABS (CL 3.5.5)	
Inner tension steel resisting sagging moments	
Depth to tension steel from compression face $d_y = 160 \text{ mm}$	
Area of tension reinforcement provided (per m width of slab) $A_{sy_prov}$ = 393 mm <sup>2</sup> /m	
Design ultimate shear force (per m width of slab) $V_y = 32 \text{ kN/m}$	
Characteristic strength of concrete $f_{cu} = 40 \text{ N/mm}^2$	
Applied shear stress	
v <sub>y</sub> = V <sub>y</sub> / d <sub>y</sub> = <b>0.20</b> N/mm <sup>2</sup>	
Check shear stress to clause 3.5.5.2	
$v_{allowable}$ = min ((0.8 N <sup>1/2</sup> /mm) × $\sqrt{(f_{cu})}$ , 5 N/mm <sup>2</sup> ) = <b>5.00</b> N/mm <sup>2</sup>	
	Shear stress - OK
Shear stresses to clause 3.5.5.3	
Design shear stress	
$f_{cu_ratio} = if (f_{cu} > 40 \text{ N/mm}^2, 40/25, f_{cu}/(25 \text{ N/mm}^2)) = 1.600$	
$v_{cy} = 0.79 \text{ N/mm}^2 \times \text{min}(3,100 \times A_{sy\_prov} \ / \ d_y)^{1/3} \times \text{max}(0.67,(400 \ \text{mm}) \ / \ d_y)^{1/4} \ / \ 1.25 \times f_{cu\_ratio}^{1/3}$	
v <sub>cy</sub> = <b>0.58</b> N/mm <sup>2</sup>	
Applied shear stress	
v <sub>y</sub> = <b>0.20</b> N/mm <sup>2</sup>	

No shear reinforcement required

CONCRETE SLAB DEFLECTION CHECK (CL 3.5.7) Slab span length Ix = 4.300 m Design ultimate moment in shorter span per m width msx = 19 kNm/m Depth to outer tension steel  $d_x = 170 \text{ mm}$ 

## **Tension steel**

Area of outer tension reinforcement provided Asx\_prov = 393 mm<sup>2</sup>/m

Area of tension reinforcement required Asx\_req = 270 mm<sup>2</sup>/m

Moment Redistribution Factor  $\beta_{bx}$  = 1.00

## **Modification Factors**

Basic span / effective depth ratio (Table 3.9) ratio<sub>span\_depth</sub> = 20

The modification factor for spans in excess of 10m (ref. cl 3.4.6.4) has not been included.

 $f_{s}$  = 2  $\times$   $f_{y} \times$   $A_{sx\_req}$  / (3  $\times$   $A_{sx\_prov}$   $\times$   $\beta_{bx}$  ) = 229.3  $N/mm^{2}$ 

factor\_{tens} = min ( 2 , 0.55 + ( 477 N/mm<sup>2</sup> - f\_s ) / (  $120 \times (0.9 N/mm^2 + m_{sx} / d_x^2)$ )) = 1.876

## **Calculate Maximum Span**

	Project	10 Downsic	le Crescent		Job no. 14	11
RODRIGUES ASSOCIATES 1 AMWELL STREET	Calcs for GF slab				Start page no./Revision 6.2. 5	
LONDON EC1R 1UL	Calcs by ab	Calcs date 20/04/2018	Checked by	Checked date	Approved by	Approved date

This is a simplified approach and further attention should be given where special circumstances exist. Refer to clauses 3.4.6.4 and 3.4.6.7.

Maximum span  $I_{max}$  = ratio<sub>span depth</sub> × factor<sub>tens</sub> × d<sub>x</sub> = 6.38 m

### Check the actual beam span

Actual span/depth ratio  $I_x / d_x = 25.29$ 

Span depth limit  $ratio_{span\_depth} \times factor_{tens} = 37.52$ 

#### Span/Depth ratio check satisfied

## CHECK OF NOMINAL COVER (SAGGING) - (BS8110:PT 1, TABLE 3.4)

Slab thickness h = 200 mm

Effective depth to bottom outer tension reinforcement  $d_x = 170.0 \text{ mm}$ 

Diameter of tension reinforcement  $D_x = 10 \text{ mm}$ 

Diameter of links L<sub>diax</sub> = 0 mm

Cover to outer tension reinforcement

 $c_{tenx} = h - d_x - D_x / 2 = 25.0 \text{ mm}$ 

Nominal cover to links steel

 $c_{nomx} = c_{tenx} - L_{diax} = 25.0 \text{ mm}$ 

Permissable minimum nominal cover to all reinforcement (Table 3.4)

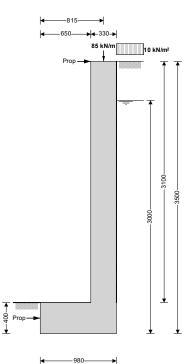
c<sub>min</sub> = 25 mm

Cover over steel resisting sagging OK

	Project	10 Downsid	Job no. 1411			
RODRIGUES ASSOCIATES 1 AMWELL STREET	Calcs for	retaining wall u	under party wa	11	Start page no./R 6.	evision 3. 1
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved date

TEDDS calculation version 1.2.01.06

### RETAINING WALL ANALYSIS (BS 8002:1994)



#### Wall details

Retaining wall type Height of retaining wall stem Thickness of wall stem Length of toe Length of heel Overall length of base Thickness of base Depth of downstand Position of downstand Thickness of downstand Height of retaining wall Depth of cover in front of wall Depth of unplanned excavation Height of ground water behind wall Height of saturated fill above base Density of wall construction Density of base construction Angle of rear face of wall Angle of soil surface behind wall Effective height at virtual back of wall

## **Retained material details**

Mobilisation factor Moist density of retained material

Cantilever propped at both h<sub>stem</sub> = **3100** mm t<sub>wall</sub> = 330 mm I<sub>toe</sub> = **650** mm I<sub>heel</sub> = **0** mm Ibase = Itoe + Iheel + twall = 980 mm t<sub>base</sub> = **400** mm d<sub>ds</sub> = **0** mm l<sub>ds</sub> = **15** mm t<sub>ds</sub> = **400** mm  $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3500 \text{ mm}$ d<sub>cover</sub> = **0** mm d<sub>exc</sub> = **0** mm h<sub>water</sub> = 3000 mm  $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 2600 mm$ γ<sub>wall</sub> = 23.6 kN/m<sup>3</sup> γ<sub>base</sub> = **23.6** kN/m<sup>3</sup> α = **90.0** deg  $\beta = 0.0 \text{ deg}$  $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3500 \text{ mm}$ 

M = **1.5** γ<sub>m</sub> = **18.0** kN/m<sup>3</sup>

	Project	10 Downsie	de Crescent		Job no.	411
RODRIGUES ASSOCIATES	Calcs for	retaining wall u	under party wall		Start page no./R 6.	evision 3. 2
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Approved by	Approved date		
Saturated density of retained m	naterial	γ <sub>s</sub> = <b>21.0</b> kM	N/m <sup>3</sup>			
Design shear strength		φ' = <b>24.2</b> de	eg			
Angle of wall friction		δ = <b>18.6</b> de	g			
Base material details						
Firm clay						
Moist density		γ <sub>mb</sub> = <b>18.0</b> k	κN/m <sup>3</sup>			
Design shear strength		φ'₅ = <b>15.8</b> d	eg			
Design base friction		δ <sub>b</sub> = <b>18.6</b> de	eg			
Allowable bearing pressure		P <sub>bearing</sub> = <b>12</b>	-			
Using Coulomb theory						
Active pressure coefficient for r	etained material					
		$\times \sin(\alpha - \delta) \times [1 + ]$	$\sqrt{(\sin(\phi' + \delta) \times s)}$	in(φ' - β) / (sin(α	$(-\delta) \times \sin(\alpha + \delta)$	β)))] <sup>2</sup> ) = <b>0.369</b>
Passive pressure coefficient fo		、 <i>,</i> <u>-</u>	,		, , ,	. ,,,_ ,
	K <sub>p</sub> = sin(§	90 - φ' <sub>b</sub> )² / (sin(90	) - δ₀) × [1 - √(sin	$(\phi'_{b} + \delta_{b}) \times sin(\phi)$	'₅) / (sin(90 + ð	5b)))] <sup>2</sup> ) = <b>2.740</b>
At-rest pressure						
At-rest pressure for retained ma	aterial	K₀ = 1 – sir	n(φ') = <b>0.590</b>			
		-				
Loading details Surcharge load on plan		Surabarga	= <b>10.0</b> kN/m²			
Applied vertical dead load on w	vall	W <sub>dead</sub> = 79.				
Applied vertical live load on wa		W dead - 79. W live = 5.6				
Position of applied vertical load		l <sub>load</sub> = <b>815</b> n				
Applied horizontal dead load or		F <sub>dead</sub> = <b>0.0</b>				
Applied horizontal live load on		F <sub>live</sub> = <b>0.0</b> k				
Height of applied horizontal loa		$h_{load} = 0 mr$				
0 11		85	Πho			
	Prop	Prop		9.4		
				Loads showr	n in kN/m, pressure	es shown in kN/m²

	Project	10 Downsid	le Crescent		Job no. 1411	
RODRIGUES ASSOCIATES 1 AMWELL STREET	Calcs for retaining wall under party wall				Start page no./Revision 6.3. 3	
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved date

Propping force $F_{prop} = max(F_{total} - F_p - (W_{total} - W_{ive}) \times tan(\delta_b), 0 kN/m)$ $F_{prop} = 42.7 kN/m$ Overturning momentsSurcharge $M_{sur} = F_{sur} \times (heff - 2 \times d_s) / 2 = 21.4 kNm/m$ Moist backfill above water table $M_{m_a} = F_{m_a} \times (heff + 2 \times h_{water} - 3 \times d_s) / 3 = 2.5 kNm/m$ Moist backfill below water table $M_{m_a} = F_{m_a} \times (heff + 2 \times h_{water} - 3 \times d_s) / 3 = 2.5 kNm/m$ Moist backfill below water table $M_{m_a} = F_{m_b} \times (h_{water} - 2 \times d_s) / 2 = 14.2 kNm/m$ Saturated backfill $M_m = F_m \times (h_water - 2 \times d_s) / 3 = 17.6 kNm/m$ $M_m \otimes F_s \times (h_water - 3 \times d_s) / 3 = 17.6 kNm/m$ Water $M_{water} = F_water \times (h_water - 3 \times d_{d_s}) / 3 = 17.6 kNm/m$ $M_{water} \otimes M_{water} = F_water \times (h_water - 3 \times d_{d_s}) / 3 = 44.1 kNm/m$ Water $M_{water} = F_water \times (h_water - 3 \times d_{d_s}) / 3 = 44.1 kNm/m$ $M_{water} \otimes M_{water} = W_{wat} \times (h_{water} - 3 \times d_{d_s}) / 3 = 44.1 kNm/m$ Wall stem $M_{water} = W_{wat} \times (h_{water} + M_{m_a} + M_{m_b} + M_s + M_{water} = 99.9 kNm/m$ Wall stem $M_{wat} = W_{wat} \times (h_{wat} + M_{m_a} + M_{m_b} + M_s + M_{water} = 99.9 kNm/m$ Wall stem $M_{wat} = W_{wat} \times (h_{wat} + M_{m_a} + M_{m_b} + M_s + M_{water} = 99.9 kNm/m$ Design vertical dead load $M_{base} = W_{base} \times h_{base} / 2 = 4.5 kNm/m$ Design vertical dead load $M_{dead} = W_{watl} \times (h_{wat} = 64.4 kNm/m)$ Total vertical reaction $R = W_{total} = 118.0 kN/m$ Distance to reaction $x_{bar} = h_{base} / 2 = 490 mm$ Eccentricity of reaction $e = abs(((h_{base}) - (6 \times R \times e / h_{base}^2) = 120.4 kN/m^2$ Bearing pressure at toe $p_{toe} = (R / h_{base}) + (6 \times R \times e / h_{base}^2) $	Wall base Applied vertical load Total vertical load	$\begin{split} w_{\text{base}} &= I_{\text{base}} \times t_{\text{base}} \times \gamma_{\text{base}} \ = \textbf{9.3 kN/m} \\ W_v &= W_{\text{dead}} + W_{\text{live}} = \textbf{84.6 kN/m} \end{split}$
Applied vertical load $W_v = W_{dest} + W_{live} = 34.6 kN/m$ Total vertical load $W_{total} = w_{wall} + w_{base} + W_v = 118 kN/m$ Horizontal forces on wallSurchargeSurcharge $F_{sur} = K_a \times cos(90 - a + b) \times Surcharge \times herf = 12.2 kN/m$ Moist backfill above water table $F_{m_a} = 0.5 \times K_a \times cos(90 - a + b) \times \gamma m \times (herf - hwater) \times heater = 9.4 kN/m$ Saturated backfill $F_a = 0.5 \times K_a \times cos(90 - a + b) \times (\gamma_a - \gamma_{water}) \times heater = 9.4 kN/m$ Saturated backfill $F_a = 0.5 \times K_a \times cos(90 - a + b) \times (\gamma_a - \gamma_{water}) \times heater = 9.4 kN/m$ VaterFouter = 0.5 $\times h_{baster} 2 \times \gamma_{water} = 44.1 kN/m$ Total horizontal loadFouter = 0.5 $\times K_a \times cos(6b) \times (d_{cover} + h_{baster} + d_{da} - d_{exc})^2 \times \gamma_{mb} = 3.7 kN/m$ Pastive resistance of soil in front of wall $F_p = 0.5 \times K_p \times cos(6b) \times (d_{cover} + h_{baster} + d_{da} - d_{exc})^2 \times \gamma_{mb} = 3.7 kN/m$ Proping force $P_{prop} = max(Ftotal - F_p - (Wotal - W_{live}) \times tan(6b), 0 kN/m)$ Proping force $F_{prop} = max(Ftotal - F_p - (Wotal - W_{live}) \times tan(6b), 0 kN/m)$ Surcharge $M_{aur} = F_{aur} \times (herf - 2 \times d_{ds}) / 2 = 21.4 kNm/m$ Moist backfill above water table $M_{m_a} = F_{m_a} \times (herf - 2 \times d_{ds}) / 3 = 2.5 kNm/m$ Moist backfill below water table $M_m = F_m \times (herf - 3 \times d_{da}) / 3 = 17.6 kN/m$ Moist backfill below water table $M_m = F_m \times (herf - 3 \times d_{da}) / 3 = 17.6 kN/m$ Moist backfill below water table $M_m = F_m \times (herf - 3 \times d_{da}) / 3 = 17.6 kN/m$ Mater $M_{weat} = W_{water} \times M_{water} = 99.9 kN/m$ Total verturning moment $M_{water} = W_{water} \times M_{water} = 24.5 kN/$	Applied vertical load Total vertical load	$W_v = W_{dead} + W_{live} = 84.6 \text{ kN/m}$
Total vertical load $W_{total} = w_{wall} + w_{basen} + W_v = 118 kN/m$ Horizontal forces on wallSurcharge $F_{uur} = K_a \cos(90 - \alpha + \delta) \times Surcharge \times her = 12.2 kN/m$ Moist backfill above water table $F_{m_a} = 0.5 \times K_a \cos(90 - \alpha + \delta) \times \gamma n \times (hert - hwater)^2 = 0.8 kN/m$ Moist backfill below water table $F_{m_b} = K_a \cos(90 - \alpha + \delta) \times \gamma n \times (hert - hwater) \times hwater = 9.4 kN/m$ Saturated backfill $F_e = 0.5 \times K_a \cos(90 - \alpha + \delta) \times (\gamma n \times (hert - hwater) \times hwater = 9.4 kN/m$ Water $F_{vetor} = 0.5 \times hwater^2 \times youter = 44.1 kN/m$ Total horizontal load $F_{total} = F_{aur} + F_{m_a} + F_{m_b} + F_a + F_{water} = 84.2 kN/m$ Calculate total propping force $F_p = 0.5 \times K_p \times \cos(\delta_0) \times (d_{cover} + t_{bases} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 3.7 kN/m$ Propping force $F_p = 0.5 \times K_p \times \cos(\delta_0) \times (d_{cover} + t_{bases} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 3.7 kN/m$ Propping force $F_p = 0.5 \times K_p \times \cos(\delta_0) \times (d_{cover} + t_{bases} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 3.7 kN/m$ Overturning moments $K_{prop} = max(F_{bata} - F_p - (W_{total} - W_{how}) \times tan(\delta_b), 0 kN/m)$ Surcharge $M_{aur} = F_{aux} \times (hert - 2 \times d_{ab}) / 2 = 21.4 kNm/m$ Moist backfill below water table $M_{m_a} = F_{m_a} \times (hert - 3 \times d_{ab}) / 3 = 2.5 kNm/m$ Moist backfill below water table $M_{m_a} = F_{m_a} \times (hert - 3 \times d_{ab}) / 3 = 44.1 kN/m$ Moist backfill below water table $M_{m_a} = F_{m_a} \times (hert - 3 \times d_{ab}) / 3 = 44.1 kNm/m$ Moist backfill below water table $M_{m_a} = F_{m_a} \times (hert - 3 \times d_{ab}) / 3 = 44.1 kNm/m$ Moist backfill below water table $M_{m_a} = F_{m_a} \times (hert - 3 \times d_{ab}) / 3 = 44.1 kNm/m$ Mat	Total vertical load	
Horizontal forces on wallSurcharge $F_{aur} = K_a \times cos(90 - \alpha + \delta) \times Surcharge \times haft = 12.2 kN/mMoist backfill above water tableF_{m,b} = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (hart - hwater)^2 = 0.8 kN/mMoist backfill below water tableF_{m,b} = K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (hart - hwater)^2 = 0.8 kN/mSaturated backfillF_a = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (hart - hwater)^2 = 0.4 kN/mSaturated backfillF_a = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times (\gamma_{ar} \cdot \gamma_{unter}) \times hwater^2 = 17.6 kN/mWaterF_water = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times (\gamma_{ar} \cdot \gamma_{unter}) \times hwater^2 = 17.6 kN/mTotal horizontal loadF_{botal} = F_{out} + F_{m,b} + F_a + F_{woter} = 84.2 kN/mCalculate total propping forceP_{ptop} = max(F_{total} - F_p - (W_{total} - d_{axc})^2 \times \gamma_{mb} = 3.7 kN/mPropping forceF_{ptop} = max(F_{total} - F_p - (W_{total} - W_{hve}) \times tan(\delta_b), 0 kN/m)Propping forceK_{max} = F_{aur} \times (hart - 2 \times d_{ab}) / 2 = 21.4 kNm/mMoist backfill above water tableM_{m,a} = F_{m,a} \times (hart - 2 \times d_{ab}) / 3 = 2.5 kNm/mMoist backfill below water tableM_{m,a} = F_{water} - 3 \times d_{ab} / 3 = 17.6 kNm/mMoist backfill below water tableM_{m,a} = F_{water} \times (harter - 3 \times d_{ab}) / 3 = 44.1 kNm/mTotal overturning momentM_{water} = W_{water} = W_{water} - 3 \times d_{ab} / 3 = 44.1 kNm/mMusterM_{water} = F_{water} \times (haster - 3 \times d_{ab}) / 3 = 44.1 kNm/mTotal overturning momentM_{water} = W_{water} + M_{wabe} / 2 = 45.5 kNm/mWaterM_{water} = W_{water} + M_{wabe} + M_{wabe} / 2 = 45.6 kNm/mDesign vertical dead loadM_{dead} = W_{dead}$		$W_{total} = W_{wall} + W_{base} + W_v = 118 \text{ kN/m}$
Surcharge $F_{aur} = K_a \times cos(90 - \alpha + \delta) \times Surcharge \times hert = 12.2 kN/m$ Moist backfill above water table $F_{m,b} = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (hert - hwater)^2 = 0.8 kN/m$ Moist backfill below water table $F_{m,b} = K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (hert - hwater) \times hwater^2 = 17.6 kN/m$ Saturated backfill $F_a = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times (\gamma_{ter} \cdot \gamma_{water}) \times hwater^2 = 17.6 kN/m$ Water $F_a = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times (\gamma_{ter} \cdot \gamma_{water}) \times hwater^2 = 17.6 kN/m$ Total horizontal load $F_{total} = F_{aur} + F_{m,b} + F_a + F_{water} = 44.1 kN/m$ Calculate total propping forcePassive resistance of soil in front of wall $F_p = 0.5 \times K_p \times cos(\delta_b) \times (d_{cover} + t_{base} + d_{as} - d_{asc})^2 \times \gamma_{mb} = 3.7 kN/m$ Propping force $F_{prop} = max(F_{total} - F_p - (W_{total} - W_{hve}) \times tan(\delta_b), 0 kN/m)$ Propping force $F_{prop} = 42.7 kN/m$ Overturning moments $M_{aur} = F_{aur} \times (hert - 2 \times d_{ds}) / 2 = 21.4 kNm/m$ Moist backfill above water table $M_{m,a} = F_{m,b} \times (hewater - 3 \times d_{ab}) / 3 = 2.5 kNm/m$ Moist backfill below water table $M_{m,a} = F_{m,b} \times (hwater - 3 \times d_{ab}) / 3 = 44.1 kNm/m$ Moist backfill below water table $M_{m,a} = F_{av} N (hwater - 3 \times d_{ab}) / 3 = 44.1 kNm/m$ Moist backfill below water table $M_{aus} = M_{wat} \times (h_{water} - 3 \times d_{ab}) / 3 = 44.1 kNm/m$ Moist backfill below water table $M_{aus} = M_{wat} \times (h_{water} - 3 \times d_{ab}) / 3 = 44.1 kNm/m$ Moist backfill below water table $M_{aus} = M_{wat} \times M_{wat} = M_{wat} / 2) = 19.7 kNm/m$ Water $M_{water} = M_{wat} \times (h_{water} - 3 \times d_{ab}) / 3 = 44.1 kNm/m$	Horizontal forces on wall	
Moist backfill above water table $F_{m,a} = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (herr - hwater)^2 = 0.8 kN/m$ Moist backfill below water table $F_{m,b} = K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (herr - hwater) \times hwater = 9.4 kN/m$ Saturated backfill $F_a = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times (\gamma_a - \gamma_{water}) \times h_{water}^2 = 17.6 kN/m$ Water $F_{water} = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times (\gamma_a - \gamma_{water}) \times h_{water}^2 = 17.6 kN/m$ Total horizontal load $F_{total} = F_{sur} + F_{m,a} + F_{m,b} + F_a + F_{water} = 84.2 kN/m$ Calculate total propping forcePassive resistance of soil in front of wall $F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{da} - d_{ecc})^2 \times \gamma_{mb} = 3.7 kN/n$ Propping forcePassive resistance of soil in front of wall $F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{da} - d_{ecc})^2 \times \gamma_{mb} = 3.7 kN/n$ Propping forcePassive resistance of soil in front of wall $F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{da} - d_{ecc})^2 \times \gamma_{mb} = 3.7 kN/n$ Propping force $F_{prop} = max(F_{total} - F_p - (W_{total} - W_{low}) \times tan(\delta_b), 0 kN/m)$ $F_{prop} = 42.7 kN/m$ Moist backfill above water table $M_{m,p} = F_{m,a} \times (herf - 2 \times d_a) / 2 = 21.4 kNm/m$ Moist backfill below water table $M_{m,p} = F_{m,a} \times (herf - 3 \times d_m) / 3 = 17.6 kNm/m$ MaterMaterSaturated backfill $M_{a,b} = F_{a,c} \times (hwater - 3 \times d_{a,b}) / 3 = 17.6 kNm/m$ WaterMaterMaster = Hwater + M_{m,a} + M_{m,b} + M_{m,b} + M_{water} = 99.9 kNm/mRestoring momentsWall baseMase =		
Moist backfill below water table $F_{m,b} = K_n \times \cos(90 - \alpha + \delta) \times \gamma_m \times (hert - hwater) \times hwater = 9.4 kN/m$ Saturated backfill $F_s = 0.5 \times K_n \times \cos(90 - \alpha + \delta) \times (\gamma_s - \gamma_{outer}) \times h_{water}^2 = 17.6 kN/m$ Water $F_{water} = 0.5 \times K_n \times \cos(90 - \alpha + \delta) \times (\gamma_s - \gamma_{outer}) \times h_{water}^2 = 17.6 kN/m$ Total horizontal load $F_{water} = 0.5 \times K_n \times \cos(90 - \alpha + \delta) \times (\gamma_s - \gamma_{outer}) \times h_{water}^2 = 17.6 kN/m$ Calculate total propping force $F_{suter} = 0.5 \times K_n \times \cos(\delta_n) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 3.7 kN/m$ Passive resistance of soil in front of wall $F_p = 0.5 \times K_p \times \cos(\delta_n) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 3.7 kN/m$ Porpping force $F_{prop} = max(Ftotal - F_p - (W_{total} - W_{lowe}) \times tan(\delta_b), 0 kN/m)$ Propp = 42.7 kN/m $F_{prop} = 42.7 kN/m$ Overturning moments $M_{m,s} = F_{m,s} \times (heff - 2 \times d_{ss}) / 2 = 21.4 kNm/m$ Moist backfill below water table $M_{m,p} = F_{m,p} \times (heff - 2 \times d_{ss}) / 3 = 2.5 kNm/m$ Moist backfill below water table $M_{m,p} = F_{m,p} \times (heff - 2 \times d_{ss}) / 3 = 17.6 kNm/m$ Water $M_{autor} = F_{mutar} \times (heff - 2 \times d_{ss}) / 3 = 17.6 kNm/m$ Water $M_{m,p} \in F_{m,p} \times (hwater - 3 \times d_{ss}) / 3 = 17.6 kNm/m$ Water $M_{m,p} \in F_{mutar} \times (hwater - 3 \times d_{ss}) / 3 = 17.6 kNm/m$ Water $M_{autor} = F_{water} + M_{m,p} + M_{m,p} + M_{m,p} + M_{m,m} + M_{m,m}$ Notal overturning moment $M_{out} + M_{m,n} + M_{m,n}$	Surcharge	$\textbf{F}_{sur} = \textbf{K}_{a} \times \textbf{cos(90 - \alpha + \delta)} \times \textbf{Surcharge} \times \textbf{h}_{eff} = \textbf{12.2 kN/m}$
Saturated backfill $F_s = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times (y_{s-} y_{vater}) \times h_{water}^2 = 17.6 kN/m$ Water $F_{water} = 0.5 \times h_{water}^2 \times y_{vater} = 44.1 kN/m$ Total horizontal load $F_{total} = F_{sur} + F_{m_s} + F_{m_s} + F_s + F_{water} = 84.2 kN/m$ Calculate total propping force $F_p = 0.5 \times K_p \times cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times y_{mb} = 3.7 kN/m$ Propping force $F_{prop} = max(F_{total} - F_p - (W_{total} - W_{bre}) \times tan(\delta_b), 0 kN/m)$ Propping force $F_{prop} = 42.7 kN/m$ Overturning moments $M_{m_a} = F_{m_a} \times (h_{eff} - 2 \times d_{ds}) / 2 = 21.4 kNm/m$ Moist backfill above water table $M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 2.5 kNm/m$ Moist backfill below water table $M_{m_a} = F_m_a \times (h_{eff} - 3 \times d_{ds}) / 3 = 17.6 kNm/m$ Water $M_{m_a} = F_w + (h_{water} - 3 \times d_{ds}) / 3 = 17.6 kNm/m$ Water $M_{max} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 17.6 kNm/m$ Water $M_{max} = F_{wate} \times (h_{water} - 3 \times d_{ds}) / 3 = 17.6 kNm/m$ Water $M_{max} = F_w + M_{m_a} + M_{m_a} + M_{m_a} + M_{water} = 99.9 kNm/m$ Restoring moments $M_{water} = W_{water} + M_{water} = 44.1 kNm/m$ Wall stem $M_{water} = M_{water} + M_{water} + 2 \times k_{water} - 3 \times d_{ds}) / 3 = 17.6 kNm/m$ Wall base $M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 17.6 kNm/m$ Wall stem $M_{water} = M_{water} + M_{water} + M_{water} = 99.9 kNm/m$ Restoring moments $M_{water} = M_{water} + M_{water} + M_{water} = 44.1 kNm/m$ Wall stem $M_{water} = M_{water} + M_{water} + 2 \times k_{water} = 38.6 kNm/m$ Distan	vloist backfill above water table	$F_{m\_a} = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2 = 0.8 \text{ kN/m}$
Water $F_{water} = 0.5 \times h_{water}^2 \times y_{water} = 44.1 kN/m$ Total horizontal load $F_{total} = F_{sur} + F_{m_{a}} + F_{m_{a}} + F_{s} + F_{water} = 84.2 kN/m$ Calculate total propping forcePassive resistance of soil in front of wall $F_p = 0.5 \times K_p \times cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 3.7 kN/m$ Propping force $F_{prop} = max(F_{total} - F_p - (W_{total} - W_{live}) \times tan(\delta_b), 0 kN/m)$ $F_{prop} = 42.7 kN/m$ Overturning moments $M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = 21.4 kNm/m$ $M_{out} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 2.5 kNm/m$ Moist backfill above water table $M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 2.5 kNm/m$ $M_{out} = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 17.6 kNm/m$ Mater $M_{uater} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 41.1 kN/m$ $M_{oit} = M_{sur} + M_{m_a} + M_{m_a} + M_{a_b} / 3 = 41.1 kN/m$ Water $M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 41.1 kNm/m$ $M_{oit} = M_{sur} + M_{m_a} + M_{m_a}$	vloist backfill below water table	$F_{m\_b} = K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = 9.4 \text{ kN/m}$
Total horizontal load $F_{total} = F_{sur} + F_{m_a} + F_{m_b} + F_s + F_{water} = 84.2 kN/m$ Calculate total propping force $F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 3.7 kN/m$ Propping force $F_{prop} = max(F_{total} - F_p - (W_{total} - W_{live}) \times tan(\delta_b), 0 kN/m)$ $F_{prop} = 42.7 kN/m$ Overturning moments $S_{urcharge}$ $M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = 21.4 kNm/m$ Moist backfill above water table $M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{vater} - 3 \times d_{ds}) / 3 = 2.5 kNm/m$ Moist backfill below water table $M_{m_b} = F_{m_b} \times (h_{vater} - 3 \times d_{ds}) / 3 = 2.5 kNm/m$ Moter $M_{water} = F_{water} \times (h_{vater} - 3 \times d_{ds}) / 3 = 17.6 kNm/m$ Water $M_{water} = F_{water} \times (h_{vater} - 3 \times d_{ds}) / 3 = 44.1 kNm/m$ Total overturning moment $M_{outer} = F_{water} \times (h_{vater} - 3 \times d_{ds}) / 3 = 44.1 kNm/m$ Water $M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 44.1 kNm/m$ Water $M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 44.1 kNm/m$ Water $M_{water} = W_{wat} \times (h_{tos} + t_{watl} / 2) = 19.7 kNm/m$ Wall stem $M_{water} = W_{watl} \times (h_{tos} + t_{watl} / 2) = 19.7 kNm/m$ Wall base $M_{base} = W_{base} / 2 = 4.5 kNm/m$ Design vertical dead load $M_{dead} = W_{dead} \times h_{dead} = 88.6 kNm/m$ Check bearing pressure $Reaction acts within middle third of$ Distance to reaction $R_{base} / 2 = 490 mm$ Ceccentricity of reaction $R_{base} / 2 = 490 mm$ Descipn pressure at toe $p_{toe} = (R / h_{base}) - (6 \times R \times e / h_{base}^2) = 120.4 kN/m^2$ Beari	Saturated backfill	$F_s = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times (\gamma_{s} - \gamma_{water}) \times h_{water}^2 = 17.6 \text{ kN/m}$
Calculate total propping force         Passive resistance of soil in front of wall $F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 3.7 \text{ kN/m}$ Propping force $F_{prop} = max(F_{total} - F_p - (W_{total} - W_{live}) \times tan(\delta_b), 0 \text{ kN/m})$ Propping force $F_{prop} = 42.7 \text{ kN/m}$ Overturning moments $W_{tur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = 21.4 \text{ kNm/m}$ Moist backfill above water table $M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 2.5 \text{ kNm/m}$ Moist backfill below water table $M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 12.5 \text{ kNm/m}$ Water $M_{m_a} = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 17.6 \text{ kNm/m}$ Water       Mouter = F_water & (hwater - 3 \times d_{ds}) / 3 = 44.1 \text{ kNm/m}         Total overturning moment $M_{cel} = M_{wat} + M_{m_a} + M_{m_b} + M_{water} = 99.9 \text{ kNm/m}$ Wall stem       Mouter = Wwall × (hoe + twal / 2) = 19.7 \text{ kNm/m}         Wall base $M_{base} = W_{base} / 2 = 4.5 \text{ kNm/m}$ Design vertical dead load $M_{dead} = W_{dead} \times h_{bade} = 88.6 \text{ kNm/m}$ Check bearing pressure       Total vertical reaction $R = W_{total} = 118.0 \text{ kN/m}$ Distance to reaction $x_{base} / 2 = 490 \text{ mm}$ e abs(( $h_{base} / 2) - x_{bas} / 2 = 120.4 \text{ kN/m}^2$ Bearing pressure at toe	Nater	$F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water} = 44.1 \text{ kN/m}$
Passive resistance of soil in front of wall $F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 3.7 kN/m$ Propping force $F_{prop} = max(F_{total} - F_p - (W_{total} - W_{live}) \times tan(\delta_b), 0 kN/m)$ $F_{prop} = 42.7 kN/m$ Overturning moments $M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = 21.4 kNm/m$ Surcharge $M_{sur} = F_{mar} \times (h_{eff} + 2 \times h_{weter} - 3 \times d_{ds}) / 3 = 2.5 kNm/m$ Moist backfill above water table $M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{weter} - 3 \times d_{ds}) / 3 = 2.5 kNm/m$ Moist backfill $M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 17.6 kNm/m$ Saturated backfill $M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 44.1 kNm/m$ Water $M_{water} = F_{wate} \times (h_{water} - 3 \times d_{ds}) / 3 = 44.1 kNm/m$ Total overturning moment $M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 99.9 kNm/m$ Wall stem $M_{wall} = w_{wall} \times (h_{toe} + t_{wall} / 2) = 19.7 kNm/m$ Wall base $M_{base} = W_{base} \times l_{base} / 2 = 4.5 kNm/m$ Design vertical dead load $M_{dead} = W_{dead} \times l_{bade} = 88.6 kNm/m$ Check bearing pressure $R = W_{total} = 118.0 kN/m$ Total vertical reaction $R = W_{total} = 118.0 kN/m$ Distance to reaction $x_{bar} = l_{base} / 2 = 490 mm$ Eccentricity of reaction $e = abs((l_{base}) - (6 \times R \times e / l_{base}^2) = 120.4 kN/m^2$ Bearing pressure at toe $p_{toe} = (R / l_{base}) - (6 \times R \times e / l_{base}^2) = 120.4 kN/m^2$	Fotal horizontal load	F <sub>total</sub> = F <sub>sur</sub> + F <sub>m_a</sub> + F <sub>m_b</sub> + F <sub>s</sub> + F <sub>water</sub> = <b>84.2</b> kN/m
Propping force $F_{prop} = max(F_{total} - F_p - (W_{total} - W_{live}) \times tan(\delta_b), 0 kN/m)$ $F_{prop} = 42.7 kN/m$ Overturning momentsSurcharge $M_{sur} = F_{sur} \times (heff - 2 \times d_{ds}) / 2 = 21.4 kNm/m$ Moist backfill above water table $M_{m_a} = F_{m_a} \times (heff + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 2.5 kNm/m$ Moist backfill below water table $M_{m_b} = F_{m_b} \times (heff + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 2.5 kNm/m$ Saturated backfill $M_{m_b} = F_{m_b} \times (h_{water} - 2 \times d_{ds}) / 2 = 14.2 kNm/m$ Saturated backfill $M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 17.6 kNm/m$ Water $M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 44.1 kNm/m$ Total overturning moment $M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 99.9 kNm/m$ Restoring momentsWall stemWall stem $M_{wall} = w_{wall} \times (hce + t_{wall} / 2) = 19.7 kNm/m$ Wall base $M_{base} = W_{base} / 2 = 4.5 kNm/m$ Design vertical dead load $M_{dead} = W_{dead} \times load = 64.4 kNm/m$ Total restoring moment $M_{rest} = M_{wall} + M_{base} + M_{dead} = 88.6 kNm/m$ Check bearing pressure $R = W_{total} = 118.0 kN/m$ Total vertical reaction $R = W_{total} = 2 = 490 mm$ Eccentricity of reaction $e = abs((l_{base} / 2) - x_{bar}) = 0 mm$ Reaction acts within middle third of ptoe = $(R / l_{base}) - (6 \times R \times e / l_{base}^2) = 120.4 kN/m^2$ Bearing pressure at toe $p_{heel} = (R / l_{base}) + (6 \times R \times e / l_{base}^2) = 120.4 kN/m^2$	Calculate total propping force	
Fprop = 42.7 kN/mOverturning momentsSurcharge $M_{sur} = F_{sur} \times (heff - 2 \times d_{ds}) / 2 = 21.4 kNm/m$ Moist backfill above water table $M_{m_a} = F_{m_a} \times (heff + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 2.5 kNm/m$ Moist backfill below water table $M_{m_b} = F_{m_b} \times (h_{water} - 2 \times d_{ds}) / 2 = 14.2 kNm/m$ Saturated backfill $M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 17.6 kNm/m$ Water $M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 44.1 kNm/m$ Total overturning moment $M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 99.9 kNm/m$ Restoring momentsWall stemWall stem $M_{watll} = w_{wall} \times (hoe + t_{wall} / 2) = 19.7 kNm/m$ Wall base $M_{base} = w_{base} \times b_{ase} / 2 = 4.5 kNm/m$ Design vertical dead load $M_{dead} = W_{dead} \times h_{oad} = 64.4 kNm/m$ Total vertical reaction $R = W_{total} = 118.0 kN/m$ Distance to reaction $R = W_{total} = 118.0 kN/m$ Eccentricity of reaction $e = abs((l_{base} / 2) - t_{bars}) = 0 mm$ Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / l_{base}) - (6 \times R \times e / l_{base}^2) = 120.4 kN/m^2$	Passive resistance of soil in front of wall	$F_{p} = 0.5 \times K_{p} \times cos(\delta_{b}) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^{2} \times \gamma_{mb} = 3.7 \text{ kN/m}$
Overturning momentsSurcharge $M_{sur} = F_{sur} \times (heff - 2 \times d_{ds}) / 2 = 21.4 kNm/m$ Moist backfill above water table $M_{m_a} = F_{m_a} \times (heff + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 2.5 kNm/m$ Moist backfill below water table $M_{m_a} = F_{m_a} \times (heff + 2 \times h_{water} - 3 \times d_{ds}) / 2 = 14.2 kNm/m$ Saturated backfill $M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 17.6 kNm/m$ Water $M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 44.1 kNm/m$ Total overturning moment $M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 99.9 kNm/m$ Restoring momentsWall stemWall stem $M_{wall} = w_{wall} \times (h_{toe} + t_{wall} / 2) = 19.7 kNm/m$ Wall base $M_{base} = w_{base} \times b_{base} / 2 = 4.5 kNm/m$ Design vertical dead load $M_{dead} = W_{dead} \times h_{oad} = 64.4 kNm/m$ Total restoring moment $M_{rest} = M_{wall} + M_{base} + M_{dead} = 88.6 kNm/m$ Check bearing pressureTotal vertical reactionTotal vertical reaction $R = W_{total} = 118.0 kN/m$ Distance to reaction $x_{toar} = l_{base} / 2 = 490 mm$ Eccentricity of reaction $e = abs(((l_{base}) - (6 \times R \times e / l_{base}^2) = 120.4 kN/m^2$ Bearing pressure at toe $p_{heel} = (R / l_{base}) - (6 \times R \times e / l_{base}^2) = 120.4 kN/m^2$	<sup>&gt;</sup> ropping force	$F_{prop} = max(F_{total} - F_{p} - (W_{total} - W_{live}) \times tan(\delta_{b}), 0 \text{ kN/m})$
Surcharge $M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = 21.4 kNm/m$ Moist backfill above water table $M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 2.5 kNm/m$ Moist backfill below water table $M_{m_b} = F_{m_b} \times (h_{water} - 2 \times d_{ds}) / 2 = 14.2 kNm/m$ Saturated backfill $M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 17.6 kNm/m$ Water $M_water = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 44.1 kNm/m$ Total overturning moment $M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 99.9 kNm/m$ Restoring moments $M_{wall} = w_{wall} \times (h_{toe} + t_{wall} / 2) = 19.7 kNm/m$ Wall stem $M_{wall} = w_{wall} \times (h_{toe} + t_{wall} / 2) = 19.7 kNm/m$ Wall base $M_{base} = w_{base} \times l_{base} / 2 = 4.5 kNm/m$ Design vertical dead load $M_{dead} = W_{dead} \times l_{load} = 64.4 kNm/m$ Total restoring moment $M_{rest} = M_{wall} + M_{base} + M_{dead} = 88.6 kNm/m$ Check bearing pressure $T_{otal} = 118.0 kN/m$ Total vertical reaction $R = W_{total} = 118.0 kN/m$ Distance to reaction $k_{bar} = l_{base} / 2 = 490 mm$ Eccentricity of reaction $e = abs(((l_{base} / 2) - x_{bar}) = 0 mm$ Reaction acts within middle third of p_{toe} = (R / l_{base}) - (6 × R × e / l_{base}^2) = 120.4 kN/m^2Bearing pressure at toe $p_{heel} = (R / l_{base}) + (6 × R × e / l_{base}^2) = 120.4 kN/m^2$		F <sub>prop</sub> = <b>42.7</b> kN/m
Moist backfill above water table $M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 2.5 kNm/m$ Moist backfill below water table $M_{m_b} = F_{m_b} \times (h_{water} - 2 \times d_{ds}) / 2 = 14.2 kNm/m$ Saturated backfill $M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 17.6 kNm/m$ Water $M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 44.1 kNm/m$ Total overturning moment $M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 99.9 kNm/m$ <b>Restoring moments</b> Wall stemWall stem $M_{wall} = w_{wall} \times (h_{be} + t_{wall} / 2) = 19.7 kNm/m$ Wall base $M_{base} = w_{base} \times b_{ase} / 2 = 4.5 kNm/m$ Design vertical dead load $M_{dead} = W_{dead} \times h_{oad} = 64.4 kNm/m$ Total vertical reaction $R = W_{total} = 118.0 kN/m$ Distance to reaction $R = W_{total} = 118.0 kN/m$ Eccentricity of reaction $e = abs((base / 2) - x_{bar}) = 0 mm$ Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / base) - (6 \times R \times e / base^2) = 120.4 kN/m^2$	Overturning moments	
Moist backfill below water table $M_{m_b} = F_{m_b} \times (h_{water} - 2 \times d_{ds}) / 2 = 14.2 \text{ kNm/m}$ Saturated backfill $M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 17.6 \text{ kNm/m}$ Water $M_water = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 44.1 \text{ kNm/m}$ Total overturning moment $M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 99.9 \text{ kNm/m}$ Restoring momentsWall stemWall stem $M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = 19.7 \text{ kNm/m}$ Wall base $M_{base} = w_{base} \times l_{base} / 2 = 4.5 \text{ kNm/m}$ Design vertical dead load $M_{dead} = W_{dead} \times I_{load} = 64.4 \text{ kNm/m}$ Total restoring moment $M_{rest} = M_{wall} + M_{base} + M_{dead} = 88.6 \text{ kNm/m}$ Check bearing pressure $R = W_{total} = 118.0 \text{ kN/m}$ Total vertical reaction $R = W_{total} = 118.0 \text{ kN/m}$ Distance to reaction $x_{bar} = l_{base} / 2 = 490 \text{ mm}$ Eccentricity of reaction $e = abs(((l_{base} / 2) - x_{bar}) = 0 \text{ mm}$ Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / l_{base}) + (6 \times R \times e / l_{base}^2) = 120.4 \text{ kN/m}^2$	Surcharge	$M_{sur}$ = $F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2$ = <b>21.4</b> kNm/m
Saturated backfill $M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 17.6 kNm/m$ Water $M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 44.1 kNm/m$ Total overturning moment $M_{ot} = M_{sur} + M_{m_a} + M_m + M_s + M_{water} = 99.9 kNm/m$ Restoring moments $M_{ot} = M_{sur} + M_{m_a} + M_m + M_s + M_{water} = 99.9 kNm/m$ Wall stem $M_{wall} = w_{wall} \times (Itoe + t_{wall} / 2) = 19.7 kNm/m$ Wall base $M_{base} = w_{base} \times I_{base} / 2 = 4.5 kNm/m$ Design vertical dead load $M_{dead} = W_{dead} \times I_{load} = 64.4 kNm/m$ Total restoring moment $M_{rest} = M_{wall} + M_{base} + M_{dead} = 88.6 kNm/m$ Check bearing pressure $T_{total} = 118.0 kN/m$ Total vertical reaction $R = W_{total} = 118.0 kN/m$ Distance to reaction $x_{bar} = I_{base} / 2 = 490 mm$ Eccentricity of reaction $e = abs((I_{base} / 2) - x_{bar}) = 0 mm$ Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 120.4 kN/m^2$	vloist backfill above water table	$M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 2.5 \text{ kNm/m}$
Water $M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 44.1 \text{ kNm/m}$ Total overturning moment $M_{ot} = M_{sur} + M_{m_b} + M_s + M_{water} = 99.9 \text{ kNm/m}$ Restoring moments $M_{wall} = M_{sur} + M_{m_b} + M_s + M_{water} = 99.9 \text{ kNm/m}$ Wall stem $M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = 19.7 \text{ kNm/m}$ Wall base $M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = 19.7 \text{ kNm/m}$ Design vertical dead load $M_{dead} = W_{base} / 2 = 4.5 \text{ kNm/m}$ Total restoring moment $M_{rest} = M_{wall} + M_{base} + M_{dead} = 88.6 \text{ kNm/m}$ Check bearing pressure $R = W_{total} = 118.0 \text{ kN/m}$ Total vertical reaction $R = W_{total} = 118.0 \text{ kN/m}$ Distance to reaction $x_{bar} = I_{base} / 2 = 490 \text{ mm}$ Eccentricity of reaction $e = abs((I_{base} / 2) - x_{bar}) = 0 \text{ mm}$ Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$	vloist backfill below water table	$M_{m_b} = F_{m_b} \times (h_{water} - 2 \times d_{ds}) / 2 = 14.2 \text{ kNm/m}$
Total overturning moment $M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 99.9 \text{ kNm/m}$ Restoring momentsWall stem $M_{wall} = W_{wall} \times (l_{toe} + t_{wall} / 2) = 19.7 \text{ kNm/m}$ Wall base $M_{wall} = W_{wall} \times (l_{toe} + t_{wall} / 2) = 19.7 \text{ kNm/m}$ Design vertical dead load $M_{base} = w_{base} \times l_{base} / 2 = 4.5 \text{ kNm/m}$ Total restoring moment $M_{dead} = W_{dead} \times l_{load} = 64.4 \text{ kNm/m}$ Total restoring moment $M_{rest} = M_{wall} + M_{base} + M_{dead} = 88.6 \text{ kNm/m}$ Check bearing pressureTotal vertical reactionTotal vertical reaction $R = W_{total} = 118.0 \text{ kN/m}$ Distance to reaction $w_{base} / 2 = 490 \text{ mm}$ Eccentricity of reaction $e = abs((l_{base} / 2) - x_{bar}) = 0 \text{ mm}$ Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / l_{base}) - (6 \times R \times e / l_{base}^2) = 120.4 \text{ kN/m}^2$ Bearing pressure at heel $p_{heel} = (R / l_{base}) + (6 \times R \times e / l_{base}^2) = 120.4 \text{ kN/m}^2$	Saturated backfill	$M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 17.6 \text{ kNm/m}$
Restoring momentsWall stem $M_{wall} = W_{wall} \times (l_{toe} + t_{wall} / 2) = 19.7 \text{ kNm/m}$ Wall base $M_{base} = W_{base} \times l_{base} / 2 = 4.5 \text{ kNm/m}$ Design vertical dead load $M_{dead} = W_{dead} \times l_{load} = 64.4 \text{ kNm/m}$ Total restoring moment $M_{rest} = M_{wall} + M_{base} + M_{dead} = 88.6 \text{ kNm/m}$ Check bearing pressureTotal vertical reaction $R = W_{total} = 118.0 \text{ kN/m}$ Distance to reaction $k_{base} / 2 = 490 \text{ mm}$ Eccentricity of reaction $e = abs((l_{base} / 2) - x_{bar}) = 0 \text{ mm}$ Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / l_{base}) - (6 \times R \times e / l_{base}^2) = 120.4 \text{ kN/m}^2$	Nater	$M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 44.1 \text{ kNm/m}$
Wall stem $M_{wall} = w_{wall} \times (l_{toe} + t_{wall} / 2) = 19.7 \text{ kNm/m}$ Wall base $M_{base} = w_{base} \times l_{base} / 2 = 4.5 \text{ kNm/m}$ Design vertical dead load $M_{dead} = W_{dead} \times l_{load} = 64.4 \text{ kNm/m}$ Total restoring moment $M_{rest} = M_{wall} + M_{base} + M_{dead} = 88.6 \text{ kNm/m}$ Check bearing pressureTotal vertical reaction $R = W_{total} = 118.0 \text{ kN/m}$ Distance to reaction $k_{base} / 2 = 490 \text{ mm}$ Eccentricity of reaction $e = abs((l_{base} / 2) - x_{bar}) = 0 \text{ mm}$ Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / l_{base}) - (6 \times R \times e / l_{base}^2) = 120.4 \text{ kN/m}^2$	Fotal overturning moment	$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 99.9 \text{ kNm/m}$
Wall base $M_{base} = w_{base} \times l_{base} / 2 = 4.5 \text{ kNm/m}$ Design vertical dead load $M_{dead} = W_{dead} \times l_{load} = 64.4 \text{ kNm/m}$ Total restoring moment $M_{rest} = M_{wall} + M_{base} + M_{dead} = 88.6 \text{ kNm/m}$ Check bearing pressureTotal vertical reaction $R = W_{total} = 118.0 \text{ kN/m}$ Distance to reaction $x_{bar} = l_{base} / 2 = 490 \text{ mm}$ Eccentricity of reaction $e = abs((l_{base} / 2) - x_{bar}) = 0 \text{ mm}$ Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / l_{base}) - (6 \times R \times e / l_{base}^2) = 120.4 \text{ kN/m}^2$ Bearing pressure at heel $p_{heel} = (R / l_{base}) + (6 \times R \times e / l_{base}^2) = 120.4 \text{ kN/m}^2$	Restoring moments	
Design vertical dead load $M_{dead} = W_{dead} \times I_{load} = 64.4 \text{ kNm/m}$ Total restoring moment $M_{rest} = M_{wall} + M_{base} + M_{dead} = 88.6 \text{ kNm/m}$ Check bearing pressure $R = W_{total} = 118.0 \text{ kN/m}$ Total vertical reaction $R = W_{total} = 118.0 \text{ kN/m}$ Distance to reaction $x_{bar} = I_{base} / 2 = 490 \text{ mm}$ Eccentricity of reaction $e = abs((I_{base} / 2) - x_{bar}) = 0 \text{ mm}$ Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$ Bearing pressure at heel $p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$	Nall stem	$M_{wall}$ = $w_{wall} \times (I_{toe} + t_{wall} / 2)$ = <b>19.7</b> kNm/m
Total restoring moment $M_{rest} = M_{wall} + M_{base} + M_{dead} = 88.6 \text{ kNm/m}$ Check bearing pressure $R = W_{total} = 118.0 \text{ kN/m}$ Total vertical reaction $R = W_{total} = 118.0 \text{ kN/m}$ Distance to reaction $x_{bar} = I_{base} / 2 = 490 \text{ mm}$ Eccentricity of reaction $e = abs((I_{base} / 2) - x_{bar}) = 0 \text{ mm}$ Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$ Bearing pressure at heel $p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$	Nall base	$M_{\text{base}} = w_{\text{base}} \times I_{\text{base}} / 2 = 4.5 \text{ kNm/m}$
Check bearing pressureTotal vertical reaction $R = W_{total} = 118.0 \text{ kN/m}$ Distance to reaction $x_{bar} = I_{base} / 2 = 490 \text{ mm}$ Eccentricity of reaction $e = abs((I_{base} / 2) - x_{bar}) = 0 \text{ mm}$ Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$ Bearing pressure at heel $p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$	Design vertical dead load	M <sub>dead</sub> = W <sub>dead</sub> × I <sub>load</sub> = <b>64.4</b> kNm/m
Total vertical reaction $R = W_{total} = 118.0 \text{ kN/m}$ Distance to reaction $x_{bar} = I_{base} / 2 = 490 \text{ mm}$ Eccentricity of reaction $e = abs((I_{base} / 2) - x_{bar}) = 0 \text{ mm}$ Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$ Bearing pressure at heel $p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$	Fotal restoring moment	M <sub>rest</sub> = M <sub>wall</sub> + M <sub>base</sub> + M <sub>dead</sub> = <b>88.6</b> kNm/m
Distance to reaction $x_{bar} = I_{base} / 2 = 490 \text{ mm}$ Eccentricity of reaction $e = abs((I_{base} / 2) - x_{bar}) = 0 \text{ mm}$ Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$ Bearing pressure at heel $p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$	Check bearing pressure	
Eccentricity of reaction $e = abs(( l_{base} / 2) - x_{bar}) = 0 mm$ Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / l_{base}) - (6 \times R \times e / l_{base}^2) = 120.4 kN/m^2$ Bearing pressure at heel $p_{heel} = (R / l_{base}) + (6 \times R \times e / l_{base}^2) = 120.4 kN/m^2$	Fotal vertical reaction	R = W <sub>total</sub> = <b>118.0</b> kN/m
Reaction acts within middle third ofBearing pressure at toe $p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$ Bearing pressure at heel $p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$	Distance to reaction	x <sub>bar</sub> = I <sub>base</sub> / 2 = <b>490</b> mm
Bearing pressure at toe $p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$ Bearing pressure at heel $p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$	Eccentricity of reaction	e = abs((l <sub>base</sub> / 2) - x <sub>bar</sub> ) = <b>0</b> mm
Bearing pressure at heel $p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$		Reaction acts within middle third of bas
	3earing pressure at toe	$p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 120.4 \text{ kN/m}^2$
	3earing pressure at heel	$p_{heel}$ = (R / I <sub>base</sub> ) + (6 × R × e / I <sub>base</sub> <sup>2</sup> ) = <b>120.4</b> kN/m <sup>2</sup>
PASS - Maximum bearing pressure is less than allowable bearing pres	PASS	- Maximum bearing pressure is less than allowable bearing pressu

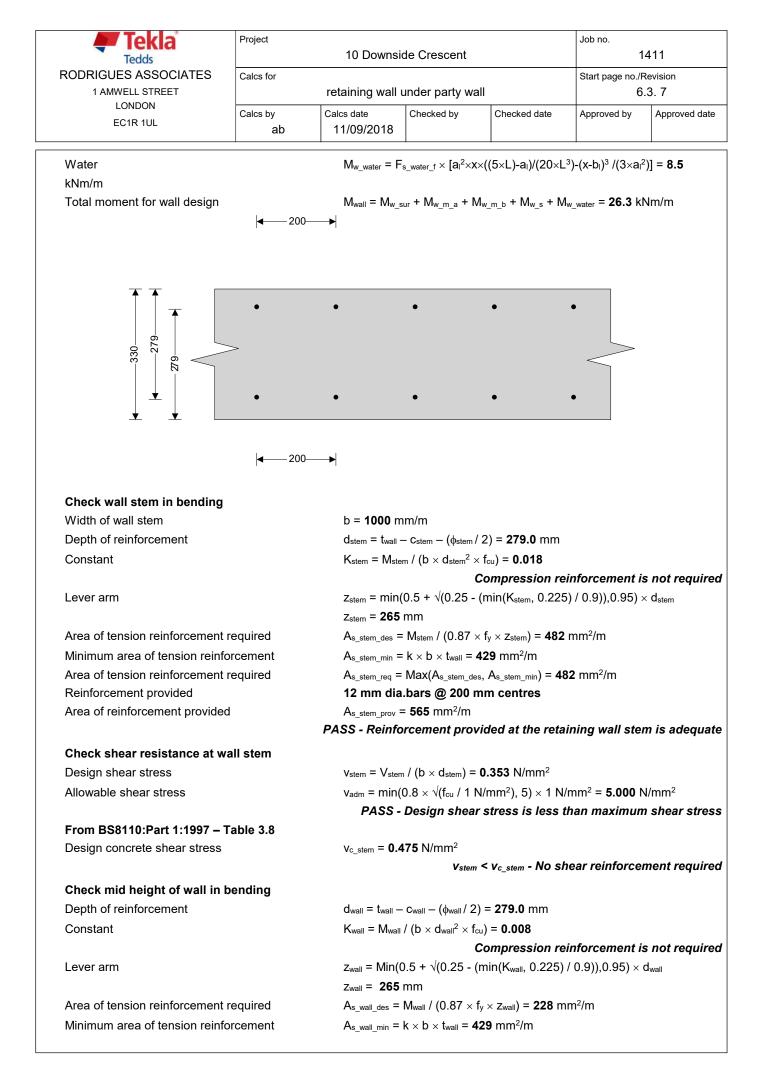
Propping force to base of wall

$$\begin{split} F_{prop\_top} = (M_{ot} - M_{rest} + R \times I_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = \textbf{18.345 kN/m} \\ F_{prop\_base} = F_{prop} - F_{prop\_top} = \textbf{24.330 kN/m} \end{split}$$

	Project	10 Downsi	de Crescent		Job no. 1	411			
RODRIGUES ASSOCIATES	Calcs for				Start page no./Revision				
1 AMWELL STREET LONDON		retaining wall	under party wa	6.3. 4					
EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved da			
RETAINING WALL DESIGN (	BS 8002:1994	)							
		<u>-</u>			TEDDS calculatio	n version 1.2.01			
Ultimate limit state load facto	ors								
Dead load factor		$\gamma_{f_d} = 1.4$							
Live load factor		γ <sub>f_1</sub> = 1.6							
Earth and water pressure facto	br	γ <sub>f_e</sub> = <b>1.4</b>							
Factored vertical forces on v	vall								
Wall stem				γ <sub>wall</sub> = <b>33.8</b> kN/r					
Wall base				<γ <sub>base</sub> = <b>13</b> kN/n					
Applied vertical load			• –	W <sub>live</sub> = <b>119.6</b> kN					
Total vertical load		$W_{total_f} = W_v$	<sub>vall_f</sub> + W <sub>base_f</sub> +	W <sub>v_f</sub> = 166.3 kN/	m				
Factored horizontal at-rest for	orces on wall								
Surcharge				$ge \times h_{eff} = 33 kN_{eff}$					
Moist backfill above water table				m × (h <sub>eff</sub> - h <sub>water</sub> )² :					
Moist backfill below water table	e		$F_{m\_b\_f} = \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = 22.3 \text{ kN/m}$						
Saturated backfill				$\gamma_{water}$ ) × $h_{water}^2$ =					
Water				×γ <sub>water</sub> = <b>61.8</b> k					
Total horizontal load		F <sub>total_f</sub> = F <sub>su</sub>	r_f + Fm_a_f + Fm	n_b_f + Fs_f + Fwate	<sub>r_f</sub> = <b>160.6</b> kN/n	n			
Calculate total propping force									
Passive resistance of soil in fro kN/m	ont of wall	$F_{p_f} = \gamma_{f_e} \times$	$0.5 \times K_p \times cos$	$\mathbf{s}(\delta_{b}) \times (d_{cover} + t_{ball})$	$_{\rm ase}$ + d <sub>ds</sub> - d <sub>exc</sub> ) <sup>2</sup>	× γ <sub>mb</sub> = <b>5.2</b>			
Propping force		F <sub>prop_f</sub> = ma F <sub>prop_f</sub> = <b>10</b> 2		(W <sub>total_f</sub> - $\gamma_{f_i} \times W$	$I_{live})  imes tan(\delta_b), 0$	kN/m)			
Factored overturning mome	nts								
Surcharge		M <sub>sur_f</sub> = F <sub>sur</sub>	_f × (h <sub>eff</sub> - 2 × 0	d <sub>ds</sub> ) / 2 = <b>57.8</b> kN	lm/m				
Moist backfill above water table	е	$M_{m_a_f} = F_m$	_a_f × (h <sub>eff</sub> + 2 ×	< h <sub>water</sub> - 3 × d <sub>ds</sub> ) /	′ 3 = <b>5.9</b> kNm/n	า			
Moist backfill below water table	e	$M_{m_b_f} = F_m$	_b_f × (h <sub>water</sub> - 2	× d <sub>ds</sub> ) / 2 = <b>33.5</b>	kNm/m				
Saturated backfill		$M_{s_f} = F_{s_f}$	$<$ (h <sub>water</sub> - 3 $\times$ d <sub>d</sub>	<sub>is</sub> ) / 3 = <b>41.6</b> kNn	n/m				
Water		$M_{water_f} = F_v$	$_{vater_f} \times (h_{water} - $	$3 \times d_{ds}) / 3 = 61.$	<b>8</b> kNm/m				
Total overturning moment		$M_{ot_f} = M_{sur_f}$	$_{f}$ + M <sub>m_a_f</sub> + M <sub>n</sub>	<sub>m_b_f</sub> + M <sub>s_f</sub> + M <sub>wa</sub>	<sub>ter_f</sub> = <b>200.6</b> kNr	m/m			
Restoring moments									
Wall stem		$M_{wall_f} = w_{wall_f}$	$_{all_f} \times (I_{toe} + t_{wall})$	/ 2) = <b>27.5</b> kNm/	m				
Wall base		$M_{base_f} = w_b$	base_f × Ibase / 2 =	= <b>6.3</b> kNm/m					
Design vertical load		$M_{v_f} = W_{v_f}$	× I <sub>load</sub> = <b>97.4</b> k	Nm/m					
Total restoring moment		$M_{rest_f} = M_w$	<sub>all_f</sub> + M <sub>base_f</sub> + I	M <sub>v_f</sub> = <b>131.3</b> kNn	n/m				
Factored bearing pressure									
Total vertical reaction		$R_f = W_{total_f}$	= <b>166.3</b> kN/m						
Distance to reaction			/ 2 = <b>490</b> mm						
Eccentricity of reaction		$e_f = abs((I_{bs}))$	<sub>ase</sub> / 2) - x <sub>bar_f</sub> ) =						
				Reaction acts		e third of ba			
Bearing pressure at toe				$\times e_f / I_{base}^2$ ) = 169					
Deside a second set of the		/	$p_{\text{heel}_f} = (R_f / I_{\text{base}}) + (6 \times R_f \times e_f / I_{\text{base}}^2) = 169.7 \text{ kN/m}^2$ rate = (p_{\text{toe}_f} - p_{\text{heel}_f}) / I_{\text{base}} = 0.00 \text{ kN/m}^2/\text{m}						
Bearing pressure at heel Rate of change of base reaction			, ,						

	Project	10 Downsi	de Crescent		Job no.	411
RODRIGUES ASSOCIATES 1 AMWELL STREET	Calcs for	Start page no.				Revision .3. 5
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved
Bearing pressure at mid stem		p <sub>stem_mid_f</sub> =	max(p <sub>toe_f</sub> - (ra	ate × ( $I_{toe}$ + $t_{wall}$ / 2	)), 0 kN/m²) =	169.7 kN/ı
Bearing pressure at stem / hee	el	$p_{stem\_heel\_f} =$	max(p <sub>toe_f</sub> - (ra	ate × ( $I_{toe}$ + $t_{wall}$ )),	0 kN/m²) = <b>16</b>	<b>9.7</b> kN/m <sup>2</sup>
Calculate propping forces to Propping force to top of wall	top and base	e of wall				
	$F_{prop\_top\_f}$	= (M <sub>ot_f</sub> - M <sub>rest_f</sub> + R	$\times$ I <sub>base</sub> / 2 - F <sub>pr</sub>	$_{ m rop_f}  imes t_{ m base}$ / 2) / (h	Istem + t <sub>base</sub> / 2)	= 39.469
Propping force to base of wall		F <sub>prop_base_f</sub> =	Fprop_f - Fprop_t	<sub>top_f</sub> = <b>62.951</b> kN/r	m	
Design of reinforced concret	e retaining w	all toe (BS 8002:1	994 <u>)</u>			
Material properties						
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/r	nm²			
Characteristic strength of reinfo	orcement	f <sub>y</sub> = <b>500</b> N/r	mm²			
Base details						
Minimum area of reinforcemen	t	k = <b>0.13</b> %				
Cover to reinforcement in toe		<sub>Ctoe</sub> = <b>45</b> m	m			
Calculate shear for toe desig	n					
Shear from bearing pressure				$_{f}) \times I_{toe} / 2 = 110.$		
Shear from weight of base				$toe \times t_{base} = 8.6 \text{ kN}$	l/m	
Total shear for toe design		$V_{toe} = V_{toe_t}$	ear - V <sub>toe_wt_</sub> base	= <b>101.7</b> kN/m		
Calculate moment for toe de	-				_	
Moment from bearing pressure	;			m_mid_f) × ( $I_{toe}$ + $t_{wa}$		
Moment from weight of base Total moment for toe design				t <sub>base</sub> × (I <sub>toe</sub> + t <sub>wall</sub> / <sub>se</sub> = <b>52</b> kNm/m	$(2)^2 / 2) = 4.4 k$	:Nm/m
400	•	•	•	•	•	
Ľ L	<b>-</b> 200	)				
Check toe in bending						
Width of toe		b = <b>1000</b> m		- 240 0		
Depth of reinforcement			$-c_{toe} - (\phi_{toe}/2)$			
Constant		$\mathbf{r}_{\text{toe}} = \mathbf{IVI}_{\text{toe}}$	$(b \times d_{toe}^2 \times f_{cu})$	) = 0.011 Compression re	inforcement i	s not reau
Lever arm		z <sub>toe</sub> = min(0 z <sub>toe</sub> = <b>332</b> r	.5 + √(0.25 - (	min(K <sub>toe</sub> , 0.225) /		-
	required			<sub>y</sub> × z <sub>toe</sub> ) <b>= 360</b> mn	n²/m	
Area of tension reinforcement	-		$\mathbf{k} \times \mathbf{b} \times \mathbf{t}_{base} = \mathbf{k}$			
Area of tension reinforcement Minimum area of tension reinfo	prcement	<u></u>				
			Max(A <sub>s_toe_des</sub> , ,	A <sub>s_toe_min</sub> ) = <b>520</b> n	nm²/m	
Minimum area of tension reinfo		A <sub>s_toe_req</sub> = I	Max(A <sub>s_toe_des</sub> , . .bars @ 200 r	•	nm²/m	

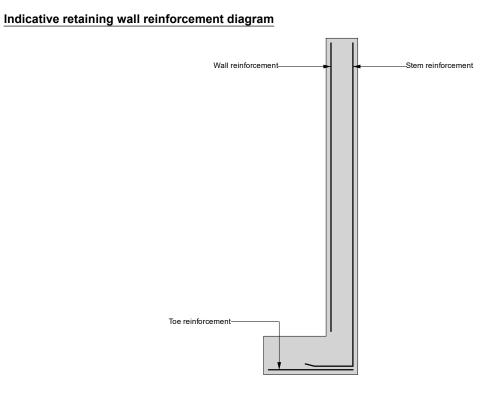
	Project	10 Downsi	de Crescent		Job no. 1	411
RODRIGUES ASSOCIATES	Calcs for		Start page no./F			
1 AMWELL STREET LONDON		retaining wall	6.3. 6			
EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved
	-	PASS - Rein	forcement pr	ovided at the re	taining wall to	e is adeq
Check shear resistance at to	e				-	
Design shear stress		$v_{toe} = V_{toe} /$	$(b \times d_{toe}) = 0.2$	<b>91</b> N/mm²		
Allowable shear stress		v <sub>adm</sub> = min(	0.8 × √(f <sub>cu</sub> / 1 I	N/mm²), 5) × 1 N/	/mm² = <b>5.000</b> N	N/mm <sup>2</sup>
		PASS -	Design shea	r stress is less t	han maximun	n shear st
From BS8110:Part 1:1997 - 1	able 3.8					
Design concrete shear stress		v <sub>c_toe</sub> = <b>0.4</b>	<b>17</b> N/mm²			
			$V_{to}$	<sub>pe</sub> < v <sub>c_toe</sub> - No sł	near reinforce	ment requ
Design of reinforced concret	e retaining w	all stem (BS 8002	:1994)			
Material properties	U	•	<u> </u>			
Characteristic strength of conc	rata	f <sub>cu</sub> = <b>40</b> N/r	nm <sup>2</sup>			
Characteristic strength of reinfo		$f_v = 500 \text{ N/}$				
C C		ly coorti,				
Wall details		k - <b>0 42</b> 0/				
Minimum area of reinforcement Cover to reinforcement in stem		k = 0.13 %				
Cover to reinforcement in sterr	I	C <sub>stem</sub> = <b>45</b> r				
		c <sub>wall</sub> = <b>45</b> m				
Factored horizontal at-rest fo	orces on stem			<i>"</i> .		.,
Surcharge				$arge \times (h_{eff} - t_{base})$		
Moist backfill above water table				$\gamma_m \times (h_{eff} - t_{base} - t_{base})$		
Moist backfill below water table	9			h <sub>eff</sub> - t <sub>base</sub> - d <sub>ds</sub> - h		<b>3</b> kN/m
Saturated backfill				$_{\rm s}$ - $\gamma_{\rm water}$ ) × $h_{\rm sat}^2$ = 3		
Water		$F_{s_water_f} = 0$	$0.5  imes \gamma_{f_e}  imes \gamma_{wate}$	<sub>r</sub> × h <sub>sat</sub> ² <b>= 46.4</b> k№	N/m	
Calculate shear for stem des	ign					
Surcharge		$V_{s\_sur\_f} = 5$	$\times F_{s\_sur\_f} / 8 = r$	<b>18.3</b> kN/m		
Moist backfill above water table	e	$V_{s_m_a_f} = F$	$s_{m_a_f} \times b_I \times (($	$5 \times L^2$ ) - $b_1^2$ ) / (5 >	< L <sup>3</sup> ) = <b>0.3</b> kN/n	n
Moist backfill below water table	9	$V_{s_m_b_f} = F$	s_m_b_f × (8 - (n	<sup>2</sup> × (4 - n))) / 8 =	<b>13.8</b> kN/m	
Saturated backfill		$V_{s_s_f} = F_{s_s}$	$s_f \times (1 - (a_1^2 \times ($	$(5 \times L) - a_i) / (20$	× L <sup>3</sup> ))) = <b>26.6</b> k	kN/m
Water		V <sub>s_water_f</sub> =	Fs_water_f × (1 - (	$a_1^2 \times ((5 \times L) - a_1)$	/ (20 × $L^3$ ))) =	<b>39.5</b> kN/m
Total shear for stem design		$V_{stem} = V_{s_s}$	$sur_f + V_{s_m_a_f} +$	$V_{s_m_b_f} + V_{s_s_f} +$	+ V <sub>s_water_f</sub> = <b>98.</b>	<b>5</b> kN/m
Calculate moment for stem of	lesign					
Surcharge		$M_{s_{sur}} = F_{s_{sur}}$	surf × L / 8 = <b>1</b>	<b>2.1</b> kNm/m		
Moist backfill above water table	Э	M <sub>s_m_a</sub> = F <sub>s</sub>	_m_a_f × b <sub>l</sub> × ((5	imes L <sup>2</sup> ) - (3 $ imes$ bl <sup>2</sup> ))	(15 × L <sup>2</sup> ) = <b>0.</b> 3	<b>3</b> kNm/m
Moist backfill below water table	9	$M_{s_m_b} = F_s$	$\_m\_b_f \times a_I \times (2$	- n)² / 8 = <b>9</b> kNm	/m	
Saturated backfill		$M_{s\_s} = F_{s\_s}$	_f ×a⊧×((3×a⊧²)-(	15×aı×L)+(20×L²)	))/(60×L²) = <b>13</b> .	<b>8</b> kNm/m
Water			, .	<a⊧²)-(15×a⊧×l)+(2< td=""><td></td><td></td></a⊧²)-(15×a⊧×l)+(2<>		
kNm/m					,	
Total moment for stem design		M <sub>stem</sub> = M <sub>s</sub> _	<sub>_sur</sub> + M <sub>s_m_a</sub> + M	M <sub>s_m_b</sub> + M <sub>s_s</sub> + M	s_water <b>= 55.5</b> kN	lm/m
Calculate moment for wall de	esign					
Surcharge	-	M <sub>w_sur</sub> = 9 >	$\langle F_{s\_sur\_f} \times L / 1$	28 = <b>6.8</b> kNm/m		
Moist backfill above water table	9	-		kbi×[(bi³+5×ai×L²)	/(5×L <sup>3</sup> )-0.577 <sup>2</sup> /3	3] = <b>0.4</b>
kNm/m				/	. , .	-
Moist backfill below water table	9	$M_{w_m b} = F_s$	s_m_b_f × <b>a</b> l × [((6	8-n²×(4-n))² /16)-	4+n×(4-n)]/8 =	<b>4.9</b> kNm/r



Tekla Tedds	Project	10 Downsic	Project 10 Downside Crescent				
RODRIGUES ASSOCIATES 1 AMWELL STREET	Calcs for	retaining wall u	inder party wall		Start page no./Re 6.3	vision 8. 8	
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved date	

Area of tension reinforcement required	A <sub>s_wall_req</sub> = Max(A <sub>s_wall_des</sub> , A <sub>s_wall_min</sub> ) = <b>429</b> mm <sup>2</sup> /m
Reinforcement provided	12 mm dia.bars @ 200 mm centres
Area of reinforcement provided	A <sub>s_wall_prov</sub> = <b>565</b> mm <sup>2</sup> /m
PASS - Rei	nforcement provided to the retaining wall at mid height is adequate
Check retaining wall deflection	
Basic span/effective depth ratio	ratio <sub>bas</sub> = <b>20</b>
Design service stress	$f_s = 2 \times f_y \times A_{s\_stem\_req} / (3 \times A_{s\_stem\_prov}) = 283.9 \text{ N/mm}^2$
Modification factor factor <sub>tens</sub> = min(0.55	$5 + (477 \text{ N/mm}^2 - f_s)/(120 \times (0.9 \text{ N/mm}^2 + (M_{\text{stem}}/(b \times d_{\text{stem}}^2)))),2) = 1.55$
Maximum span/effective depth ratio	ratio <sub>max</sub> = ratio <sub>bas</sub> × factor <sub>tens</sub> = <b>30.94</b>
Actual span/effective depth ratio	ratio <sub>act</sub> = h <sub>stem</sub> / d <sub>stem</sub> = <b>11.11</b>
	PASS - Span to depth ratio is acceptable

Tekla Tedds	Project	10 Downsi	de Crescent		Job no. 14	411
RODRIGUES ASSOCIATES	Calcs for	retaining wall u	under party wa	II	Start page no./R 6.	evision 3. 9
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved date

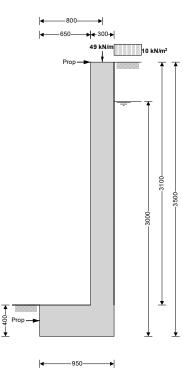


Toe bars - 12 mm dia.@ 200 mm centres - (565 mm<sup>2</sup>/m) Wall bars - 12 mm dia.@ 200 mm centres - (565 mm<sup>2</sup>/m) Stem bars - 12 mm dia.@ 200 mm centres - (565 mm<sup>2</sup>/m)

	Project	10 Downsid	de Crescent		Job no. 14	411
RODRIGUES ASSOCIATES 1 AMWELL STREET	Calcs for rea	r retaining wall ι	inder rear exte	ension	Start page no./R 6.	evision 4. 1
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved date

TEDDS calculation version 1.2.01.06

#### RETAINING WALL ANALYSIS (BS 8002:1994)



#### Wall details

Retaining wall type Height of retaining wall stem Thickness of wall stem Length of toe Length of heel Overall length of base Thickness of base Depth of downstand Position of downstand Thickness of downstand Height of retaining wall Depth of cover in front of wall Depth of unplanned excavation Height of ground water behind wall Height of saturated fill above base Density of wall construction Density of base construction Angle of rear face of wall Angle of soil surface behind wall Effective height at virtual back of wall **Retained material details** 

Mobilisation factor Moist density of retained material

Cantilever propped at both h<sub>stem</sub> = **3100** mm t<sub>wall</sub> = 300 mm I<sub>toe</sub> = **650** mm I<sub>heel</sub> = **0** mm Ibase = Itoe + Iheel + twall = 950 mm t<sub>base</sub> = **400** mm d<sub>ds</sub> = **0** mm l<sub>ds</sub> = **15** mm t<sub>ds</sub> = **400** mm  $h_{wall}$  =  $h_{stem}$  +  $t_{base}$  +  $d_{ds}$  = **3500** mm d<sub>cover</sub> = **0** mm  $d_{exc} = 0 mm$ h<sub>water</sub> = 3000 mm  $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 2600 mm$ γ<sub>wall</sub> = 23.6 kN/m<sup>3</sup> γ<sub>base</sub> = 23.6 kN/m<sup>3</sup> α = **90.0** deg  $\beta = 0.0 \deg$  $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3500 \text{ mm}$ 

M = **1.5** γ<sub>m</sub> = **18.0** kN/m<sup>3</sup>

Tedds	Project 10 Downside Crescent Calcs for rear retaining wall under rear extension				Job no. 1411 Start page no./Revision 6.4. 2	
RODRIGUES ASSOCIATES						
1 AMWELL STREET						
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved da
Saturated density of retained r	material	γ <sub>s</sub> = <b>20.0</b> k				
Design shear strength		φ' = <b>18.6</b> d	-			
Angle of wall friction		δ = <b>0.0</b> deg	]			
Base material details						
Firm clay						
Moist density		γ <sub>mb</sub> = <b>18.0</b>	kN/m³			
Design shear strength		φ'ь = <b>15.8</b> α	leg			
Design base friction		δ <sub>b</sub> = <b>18.6</b> d	eg			
Allowable bearing pressure		P <sub>bearing</sub> = 12	25 kN/m²			
Using Coulomb theory						
Active pressure coefficient for	retained materi	al				
K <sub>a</sub> = sin(e	$(\alpha + \phi')^2 / (\sin(\alpha)^2)$	$^2  imes sin(lpha$ - $\delta)  imes$ [1 -	- √(sin(φ' + δ) ×	sin(φ' - β) / (sin(	$\alpha$ - $\delta$ ) × sin( $\alpha$ +	β)))]²) = <b>0.</b> ξ
Passive pressure coefficient for	or base materia	l				
	K <sub>p</sub> = sin	n(90 - φ' <sub>b</sub> )² / (sin(90	) - δ₀) × [1 - √(s	$\sin(\phi_{P} + \delta_{P}) \times \sin(\phi_{P})$	φ' <sub>b</sub> ) / (sin(90 +	δ <sub>b</sub> )))] <sup>2</sup> ) = <b>2.</b>
At-rest pressure						
At-rest pressure for retained m	naterial	K <sub>0</sub> = 1 – si	n(φ') = <b>0.681</b>			
Surcharge load on plan Applied vertical dead load on v Applied vertical live load on va Position of applied vertical load Applied horizontal dead load on Applied horizontal live load on	all d on wall on wall	Surcharge $W_{dead} = 43$ $W_{live} = 6.0$ $I_{load} = 800$ $F_{dead} = 0.0$ $F_{live} = 0.0$	kN/m nm kN/m			
Height of applied horizontal loa	ad on wall	$h_{load} = 0 m$	n			
Height of applied horizontal lo	ad on wall	49 ↓1				
Height of applied horizontal lo	ad on wall $ \int_{18.7}^{Prop} \Phi_{4.1} $	49		29.4		
Height of applied horizontal lo	Prop		0	29.4		

	Project	10 Downsi	de Crescent		Job no.	411
RODRIGUES ASSOCIATES	Calcs for rea	r retaining wall	under rear exte	ension	Start page no./R 6.	evision 4. 3
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved date
Vertical forces on wall						

Vertical forces on wall	
Wall stem	$w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall} = \textbf{21.9 kN/m}$
Wall base	$w_{base} = I_{base} \times t_{base} \times \gamma_{base} = 9 \text{ kN/m}$
Applied vertical load	$W_v = W_{dead} + W_{live} = 49 \text{ kN/m}$
Total vertical load	$W_{total} = W_{wall} + W_{base} + W_v = 79.9 \text{ kN/m}$
Horizontal forces on wall	
Surcharge	$F_{sur} = K_a \times Surcharge \times h_{eff} = 18.1 \text{ kN/m}$
Moist backfill above water table	$F_{m_a}$ = 0.5 × K <sub>a</sub> × $\gamma_m$ × (h <sub>eff</sub> - h <sub>water</sub> ) <sup>2</sup> = <b>1.2</b> kN/m
Moist backfill below water table	$F_{m_{-}b} = K_a \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = 13.9 \text{ kN/m}$
Saturated backfill	$F_s = 0.5 \times K_a \times (\gamma_{s-} \gamma_{water}) \times h_{water}^2 = 23.7 \text{ kN/m}$
Water	$F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water} = 44.1 \text{ kN/m}$
Total horizontal load	$F_{total} = F_{sur} + F_{m_a} + F_{m_b} + F_s + F_{water} = 101 \text{ kN/m}$
Calculate total propping force	
Passive resistance of soil in front of wall	$F_{p} = 0.5 \times K_{p} \times cos(\delta_{b}) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^{2} \times \gamma_{mb} = 3.7 \text{ kN/m}$
Propping force	$F_{prop}$ = max( $F_{total}$ - $F_{p}$ - ( $W_{total}$ - $W_{live}$ ) × tan( $\delta_{b}$ ), 0 kN/m)
	F <sub>prop</sub> = <b>72.4</b> kN/m
Overturning moments	
Surcharge	$M_{sur}$ = $F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = 31.6 \text{ kNm/m}$
Moist backfill above water table	$M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 3.7 \text{ kNm/m}$
Moist backfill below water table	$M_{m_{-}b} = F_{m_{-}b} \times (h_{water} - 2 \times d_{ds}) / 2 = 20.9 \text{ kNm/m}$
Saturated backfill	$M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 23.7 \text{ kNm/m}$
Water	$M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 44.1 \text{ kNm/m}$
Total overturning moment	$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 124 \text{ kNm/m}$
Restoring moments	
Wall stem	$M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = 17.6 \text{ kNm/m}$
Wall base	M <sub>base</sub> = w <sub>base</sub> × I <sub>base</sub> / 2 = <b>4.3</b> kNm/m
Design vertical dead load	$M_{dead} = W_{dead} \times I_{load} = 34.4 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_{dead} = 56.2 \text{ kNm/m}$
Check bearing pressure	
Total vertical reaction	R = W <sub>total</sub> = <b>79.9</b> kN/m
Distance to reaction	x <sub>bar</sub> = I <sub>base</sub> / 2 = <b>475</b> mm
Eccentricity of reaction	$e = abs((I_{base} / 2) - x_{bar}) = 0 mm$
	Reaction acts within middle third of bas
Bearing pressure at toe	$p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 84.1 \text{ kN/m}^2$
Bearing pressure at heel	$p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 84.1 \text{ kN/m}^2$
_	ASS - Maximum bearing pressure is less than allowable bearing pressure

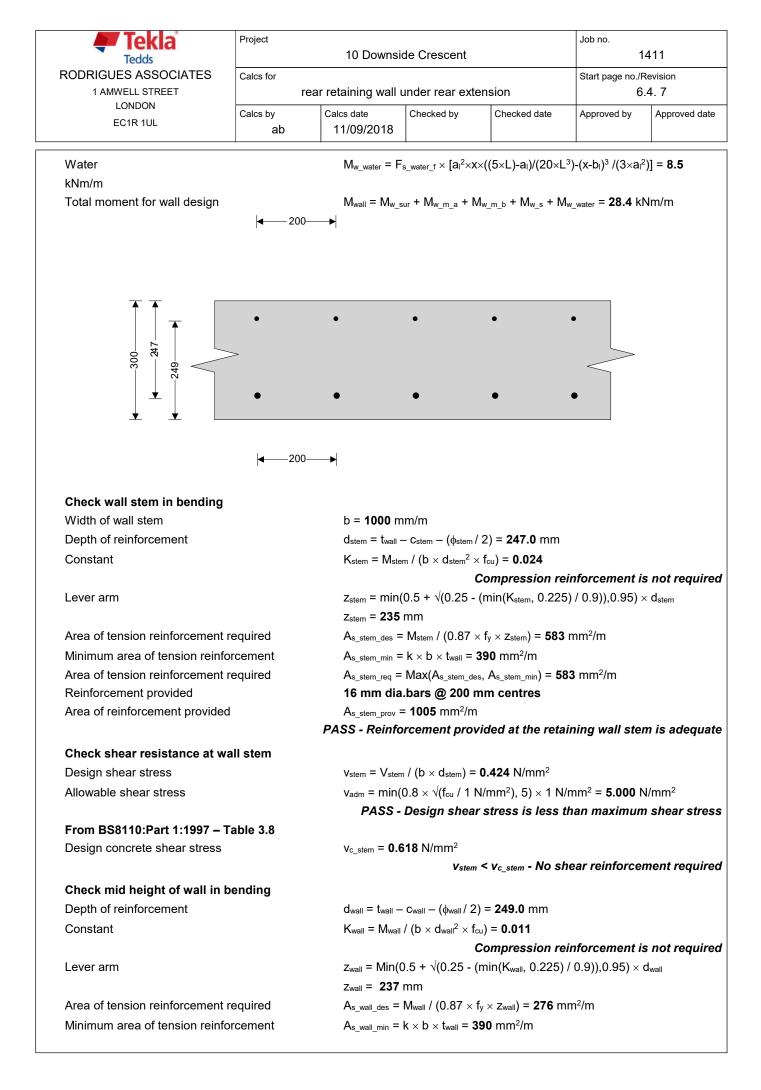
Propping force to base of wall

$$\begin{split} F_{prop\_top} = (M_{ot} - M_{rest} + R \times I_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = \textbf{27.668 kN/m} \\ F_{prop\_base} = F_{prop} - F_{prop\_top} = \textbf{44.715 kN/m} \end{split}$$

	Project Job no. 10 Downside Crescent			Job no. ent 1411				
RODRIGUES ASSOCIATES	Calcs for				Start page no./F	Revision		
1 AMWELL STREET	r	ear retaining wall	under rear ext	ension	6	.4. 4		
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved da		
RETAINING WALL DESIGN (F	35 8002-1994		1	I		1		
	<u></u>	<u>_</u>			TEDDS calculatio	n version 1.2.01		
Ultimate limit state load facto	ors							
Dead load factor		γ <sub>f_d</sub> = <b>1.4</b>						
Live load factor		γ <sub>f_l</sub> = <b>1.6</b>						
Earth and water pressure facto	r	γ <sub>f_e</sub> = <b>1.4</b>						
Factored vertical forces on w	vall							
Wall stem		$W_{wall_f} = \gamma_{f_c}$	$1  imes h_{\text{stem}}  imes t_{\text{wall}}  imes$	$\gamma_{\text{wall}}$ = 30.7 kN/r	n			
Wall base		$W_{base_f} = \gamma_{f_}$	$d \times I_{base} \times t_{base}$	× γ <sub>base</sub> = <b>12.6</b> kN	/m			
Applied vertical load		$W_{v\_f} = \gamma_{f\_d}$	$ imes$ W dead + $\gamma_{f_l}$ $ imes$	W <sub>live</sub> = 69.8 kN/r	n			
Total vertical load		$W_{total_f} = w$	wall_f + W <sub>base_f</sub> +	W <sub>v_f</sub> = <b>113.1</b> kN/	'n			
Factored horizontal at-rest for	orces on wall							
Surcharge		$F_{sur_f} = \gamma_{f_i}$	$\times$ K <sub>0</sub> $\times$ Surchar	ge × h <sub>eff</sub> = <b>38.1</b> k	N/m			
Moist backfill above water table	9	$F_{m_a_f} = \gamma_{f_a}$	$_{\text{B}}  imes 0.5  imes K_0  imes \gamma$	$_{\rm m}  imes (h_{\rm eff} - h_{\rm water})^2 \approx$	= <b>2.1</b> kN/m			
Moist backfill below water table	;	$F_{m_b_f} = \gamma_{f_0}$	$F_{m\_b\_f} = \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = 25.7 \text{ kN/m}$					
Saturated backfill		$F_{s_f} = \gamma_{f_e} \times 0.5 \times K_0 \times (\gamma_{s^*} \gamma_{water}) \times h_{water}^2 = 43.7 \text{ kN/m}$						
Water		$F_{water_f} = \gamma_{f_e} \times 0.5 \times h_{water}^2 \times \gamma_{water} = 61.8 \text{ kN/m}$						
Total horizontal load		F <sub>total_f</sub> = F <sub>sur_f</sub> + F <sub>m_a_f</sub> + F <sub>m_b_f</sub> + F <sub>s_f</sub> + F <sub>water_f</sub> = <b>171.6</b> kN/m						
Calculate total propping forc	e							
Passive resistance of soil in fro	ont of wall	$F_{p_f} = \gamma_{f_e}$	$\times 0.5 \times K_p \times cos$	$\mathbf{s}(\delta_{b}) \times (d_{cover} + t_{base})$	$a_{se} + d_{ds} - d_{exc})^2$	× γ <sub>mb</sub> = <b>5.2</b>		
Propping force		F <sub>prop_f</sub> = ma F <sub>prop_f</sub> = <b>13</b>		• (W <sub>total_f</sub> - $\gamma_{f_l} \times W$	$V_{\sf live})  imes tan(\delta_{\sf b}), 0$	kN/m)		
<b>F</b> 4 4 1		Fprop_t – IS	1.3 KIN/III					
Factored overturning momer Surcharge	its	М. – Е		d <sub>ds</sub> ) / 2 = <b>66.7</b> kN	lm/m			
Moist backfill above water table	<b>`</b>					2		
Moist backfill below water table	-		M <sub>m_a_f</sub> = F <sub>m_a_f</sub> × (h <sub>eff</sub> + 2 × h <sub>water</sub> - 3 × d <sub>ds</sub> ) / 3 = <b>6.8</b> kNm/m M <sub>m b f</sub> = F <sub>m b f</sub> × (h <sub>water</sub> - 2 × d <sub>ds</sub> ) / 2 = <b>38.6</b> kNm/m					
Saturated backfill	i							
Water			$M_{s_f} = F_{s_f} \times (h_{water} - 3 \times d_{ds}) / 3 = 43.7 \text{ kNm/m}$					
Total overturning moment			M <sub>water_f</sub> = F <sub>water_f</sub> × (h <sub>water</sub> - 3 × d <sub>ds</sub> ) / 3 = <b>61.8</b> kNm/m M <sub>ot f</sub> = M <sub>sur f</sub> + M <sub>m a f</sub> + M <sub>m b f</sub> + M <sub>s f</sub> + M <sub>water f</sub> = <b>217.7</b> kNm/m					
Restoring moments			<u>a_</u> i · Wi	• ••••wa				
Wall stem		$\mathbf{M}_{Molet} \mathbf{f} = \mathbf{M}.$	all f X (Iton + two!	/ 2) = <b>24.6</b> kNm/	m			
Wall base								
Design vertical load			$M_{base_f} = W_{base_f} \times I_{base} / 2 = 6 \text{ kNm/m}$ $M_{v_f} = W_{v_f} \times I_{load} = 55.8 \text{ kNm/m}$					
Total restoring moment			$M_{\text{rest}_f} = M_{\text{wall}_f} + M_{\text{base}_f} + M_{\text{v}_f} = 86.4 \text{ kNm/m}$					
Factored bearing pressure								
Total vertical reaction		R <sub>f</sub> = W <sub>total</sub>	<sub>f</sub> = <b>113.1</b> kN/m					
Distance to reaction		_	/ 2 = <b>475</b> mm					
Eccentricity of reaction			base / 2) - Xbar_f)	= <b>0</b> mm				
			•		within middle	e third of ba		
Bearing pressure at toe		$p_{toe_f} = (R_f)$	/ I <sub>base</sub> ) - (6 $ imes$ R <sub>f</sub>	$\times e_f / I_{base}^2$ ) = 11	<b>9</b> kN/m²			
Bearing pressure at heel		$p_{heel_f} = (R_f)$	$p_{heel_f} = (R_f / I_{base}) + (6 \times R_f \times e_f / I_{base}^2) = 119 \text{ kN/m}^2$					
Rate of change of base reaction	n	rate = (p <sub>toe</sub>	rate = (p <sub>toe_f</sub> - p <sub>heel_f</sub> ) / I <sub>base</sub> = <b>0.00</b> kN/m <sup>2</sup> /m					
Bearing pressure at stem / toe	D-4 4 =	$p_{\text{stem_toe_f}} = \max(p_{\text{toe_f}} - (\text{rate} \times I_{\text{toe}}), 0 \text{ kN/m}^2) = 119 \text{ kN/m}^2$						

Tedds	Project	10 Downsi	de Crescent		Job no. 1	411
RODRIGUES ASSOCIATES 1 AMWELL STREET	Calcs for	ear retaining wall u	under rear exte	ension	Start page no./F	Revision .4. 5
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved
Bearing pressure at mid stem		p <sub>stem_mid_f</sub> =	max(p <sub>toe_f</sub> - (ra	$te \times (I_{toe} + t_{wall} / 2)$	)), 0 kN/m²) = ′	<b>119</b> kN/m <sup>2</sup>
Bearing pressure at stem / hee		$p_{stem\_heel\_f} =$	max(p <sub>toe_f</sub> - (ra	ate × ( $I_{toe}$ + $t_{wall}$ )),	0 kN/m²) = <b>11</b> 9	kN/m²
Calculate propping forces to Propping force to top of wall	top and base	of wall				
	F <sub>prop_top_f</sub> :	= (M <sub>ot_f</sub> - M <sub>rest_f</sub> + R	$\times$ I <sub>base</sub> / 2 - F <sub>pr</sub>	$_{ m op_f}  imes t_{ m base}$ / 2) / (h	Istem + t <sub>base</sub> / 2) :	= 48.092
Propping force to base of wall		F <sub>prop_base_f</sub> =	F <sub>prop_f</sub> - F <sub>prop_t</sub>	<sub>op_f</sub> = <b>83.398</b> kN/ı	n	
Design of reinforced concret	e retaining w	all toe (BS 8002:1	994 <u>)</u>			
Material properties						
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/n	1m²			
Characteristic strength of reinfo	orcement	f <sub>y</sub> = <b>500</b> N/r	nm²			
Base details						
Minimum area of reinforcemen	t	k = <b>0.13</b> %				
Cover to reinforcement in toe		c <sub>toe</sub> = <b>45</b> m	n			
Calculate shear for toe desig	n					
Shear from bearing pressure		V <sub>toe_bear</sub> = (	o <sub>toe_f</sub> + p <sub>stem_toe_</sub>	_f) × I <sub>toe</sub> / 2 = <b>77.4</b>	kN/m	
Shear from weight of base		V <sub>toe_wt_base</sub> =	$\gamma_{f_d} \times \gamma_{base} \times I_t$	$_{oe} \times t_{base}$ = 8.6 kN	l/m	
Total shear for toe design		V <sub>toe</sub> = V <sub>toe_bear</sub> - V <sub>toe_wt_base</sub> = <b>68.8</b> kN/m				
Calculate moment for toe de	sign					
Moment from bearing pressure	:	M <sub>toe_bear</sub> = (	$2 \times p_{toe_f} + p_{ster}$	m_mid_f) × (I <sub>toe</sub> + t <sub>wa</sub>	u / 2)² / 6 <b>= 38.</b>	<b>1</b> kNm/m
Moment from weight of base		M <sub>toe_wt_base</sub> :	= ( $\gamma_{f_d} \times \gamma_{base} \times$	$t_{base}  imes (I_{toe} + t_{wall} /$	2) <sup>2</sup> /2) = <b>4.2</b> k	Nm/m
Total moment for toe design		$M_{toe} = M_{toe}$	<sub>bear</sub> - M <sub>toe_wt_bas</sub>	<sub>e</sub> = <b>33.9</b> kNm/m		
400	•	•	•	•	•	
400	•	•	•	•	•	
Check toe in bending	->   <b>∢</b> 200	•	•	•	•	
Check toe in bending Width of toe	►   <b>4</b> 200	b = <b>1000</b> m		•	•	
Check toe in bending Width of toe Depth of reinforcement	►   <del></del> 200	b = <b>1000</b> m d <sub>toe</sub> = t <sub>base</sub> -	· c <sub>toe</sub> – ( <sub>\$toe</sub> / 2)		•	
Check toe in bending Width of toe	►   <b>4</b> 200	b = <b>1000</b> m d <sub>toe</sub> = t <sub>base</sub> -	$c_{toe} - (\phi_{toe} / 2)$ (b × d <sub>toe</sub> <sup>2</sup> × f <sub>cu</sub>	) = 0.007	•	
Check toe in bending Width of toe Depth of reinforcement Constant	►   <del></del> 200	b = <b>1000</b> m d <sub>toe</sub> = t <sub>base</sub> - K <sub>toe</sub> = M <sub>toe</sub> /	$c_{toe} - (\phi_{toe} / 2)$ (b × d <sub>toe</sub> <sup>2</sup> × f <sub>cu</sub>	) = 0.007 Compression re		-
Check toe in bending Width of toe Depth of reinforcement	►   <b>4</b> 200	$b = 1000 m$ $d_{toe} = t_{base} - K_{toe} = M_{toe} / Z_{toe} = min(0)$	$c_{\text{toe}} - (\phi_{\text{toe}} / 2)$ (b × d <sub>toe</sub> <sup>2</sup> × f <sub>cu</sub> (b) .5 + $\sqrt{0.25}$ - (b)	) = 0.007		-
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm		$b = 1000 \text{ m}$ $d_{toe} = t_{base} - K_{toe} = M_{toe} / Z_{toe} = min(C_{z_{toe}} = 332 \text{ m})$	$c_{toe} - (\phi_{toe} / 2)$ (b × d <sub>toe</sub> <sup>2</sup> × f <sub>cu</sub> (b × d <sub>toe</sub> <sup>2</sup> × f <sub>cu</sub> ) (b × d <sub>toe</sub> <sup>2</sup> × f <sub>cu</sub> )	) = <b>0.007</b> Compression re min(K <sub>toe</sub> , 0.225) /	0.9)),0.95) × d	-
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement	required	$b = 1000 \text{ m}$ $d_{toe} = t_{base} - K_{toe} = M_{toe} / Z_{toe} = min(C_{toe} = 332 \text{ m})$ $A_{s\_toe\_des} = min(C_{toe} = 332 \text{ m})$	$c_{toe} - (\phi_{toe} / 2) \\ (b \times d_{toe}^2 \times f_{cu}) \\ (b \times d_{toe}^2 - (0) \\ (b \times d_{toe}^$	) = <b>0.007</b> Compression re min(K <sub>toe</sub> , 0.225) / , × z <sub>toe</sub> ) = <b>235</b> mn	0.9)),0.95) × d	-
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement Minimum area of tension reinforcement	required	$b = 1000 \text{ m}$ $d_{toe} = t_{base} - t_{toe} = t_{toe} - t_{toe}$ $Z_{toe} = min(0)$ $Z_{toe} = 332 \text{ m}$ $A_{s\_toe\_des} = t_{toe}$ $A_{s\_toe\_min} = t_{toe}$	$\begin{array}{l} c_{\text{toe}} - (\phi_{\text{toe}} / 2) \\ (b \times d_{\text{toe}}^2 \times f_{\text{cu}} \\ (b \times d_{\text{toe}}^2 - f_{\text{cu}} \\ c_{\text{toe}} / (0.25 - (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (0.87 \times f_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{t$	) = <b>0.007</b> Compression re min(K <sub>toe</sub> , 0.225) / , × z <sub>toe</sub> ) = <b>235</b> mn 5 <b>20</b> mm <sup>2</sup> /m	0.9)),0.95) × d n²/m	-
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement	required	$b = 1000 \text{ m}$ $d_{toe} = t_{base} - K_{toe} = M_{toe} / L_{toe} = M_{toe} / L_{toe} = 332 \text{ m}$ $A_{s\_toe\_des} = M_{s\_toe\_min} = L_{s\_toe\_req} = L_{s\_toe\_req} = L_{toe}$	$\begin{array}{l} c_{\text{toe}} - (\phi_{\text{toe}} / 2) \\ (b \times d_{\text{toe}}^2 \times f_{\text{cu}} \\ (b \times d_{\text{toe}}^2 - f_{\text{cu}} \\ c_{\text{toe}} / (0.25 - (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (0.87 \times f_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} / (c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} - c_{\text{toe}} \\ c_{t$	) = <b>0.007</b> Compression re min(K <sub>toe</sub> , 0.225) / , × z <sub>toe</sub> ) = <b>235</b> mn 520 mm <sup>2</sup> /m A <sub>s_toe_min</sub> ) = <b>520</b> n	0.9)),0.95) × d n²/m	-

Tedds		10 Downs	10 Downside Crescent			1411	
RODRIGUES ASSOCIATES	Calcs for		_		Start page no./F		
1 AMWELL STREET LONDON	1	rear retaining wall	ar retaining wall under rear extension			6.4. 6	
EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved	
		PASS - Reir	nforcement pr	ovided at the re	taining wall to	oe is adeq	
Check shear resistance at to	e						
Design shear stress		$v_{toe} = V_{toe} /$	$(b \times d_{toe}) = 0.1$	<b>97</b> N/mm <sup>2</sup>			
Allowable shear stress		v <sub>adm</sub> = min	0.8 × √(f <sub>cu</sub> / 1 ľ	N/mm²), 5) × 1 N/	/mm² = <b>5.000</b> M	N/mm <sup>2</sup>	
		PASS -	Design shea	r stress is less t	han maximun	n shear st	
From BS8110:Part 1:1997 - 1	able 3.8						
Design concrete shear stress		v <sub>c_toe</sub> = <b>0.4</b>	<b>17</b> N/mm²				
			V <sub>to</sub>	<sub>be</sub> < v <sub>c_toe</sub> - No sł	near reinforce	ment requ	
Design of reinforced concret	e retaining w	all stem (BS 8002	2:1994)				
			<u> </u>				
Material properties Characteristic strength of conc	roto	f <sub>cu</sub> = <b>40</b> N/r	$mm^2$				
Characteristic strength of reinfo		f <sub>v</sub> = <b>500</b> N/					
-	orocinent	ly – 666 l.V.					
Wall details							
Minimum area of reinforcemen		k = 0.13 %					
Cover to reinforcement in stem	1	$C_{\text{stem}} = 45 \text{ r}$					
Cover to reinforcement in wall		c <sub>wall</sub> = <b>45</b> mm					
Factored horizontal at-rest for	orces on stem						
Surcharge				$arge \times (h_{eff} - t_{base})$			
Moist backfill above water table	Э	$F_{s_m_a_f} = 0$	$F_{s_ma_f} = 0.5 \times \gamma_{f_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat})^2 = 2.1 \text{ kN/m}$				
Moist backfill below water table	9	$F_{s\_m\_b\_f} = \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat}) \times h_{sat} = 22.3 \text{ kN/m}$					
Saturated backfill		$F_{s\_s\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times (\gamma_{s-} \gamma_{water}) \times h_{sat}^2 = 32.8 \text{ kN/m}$					
Water		$F_{s_water_f} = 0$	$0.5  imes \gamma_{f_e}  imes \gamma_{wate}$	<sub>er</sub> × h <sub>sat</sub> ² = <b>46.4</b> k№	N/m		
Calculate shear for stem des	ign						
Surcharge		$V_{s\_sur_f} = 5$	$\times F_{s_{s_{s_{r_{f}}}}} / 8 = 2$	21.1 kN/m			
Moist backfill above water table	e	$V_{s_m_a_f} = F$	$s_{m_a_f} \times b_I \times ((s_{m_a}))$	$5  imes L^2$ ) - $b_1^2$ ) / (5 >	< L <sup>3</sup> ) = <b>0.3</b> kN/r	n	
Moist backfill below water table	9	$V_{s_m_b_f} = F_{s_m_b_f} \times (8 - (n^2 \times (4 - n))) / 8 = 16 \text{ kN/m}$					
Saturated backfill		$V_{s\_s\_f} = F_{s\_f}$	$s_f \times (1 - (a_l^2 \times ($	((5 × L) - a <sub>l</sub> ) / (20	× L <sup>3</sup> ))) = <b>27.9</b>	۸/m	
Water		$V_{s\_water_f} = F_{s\_water_f} \times (1 - (a_1^2 \times ((5 \times L) - a_1) / (20 \times L^3))) = 39.5 \text{ kN/m}$					
Total shear for stem design		V <sub>stem</sub> = V <sub>s_s</sub>	<sub>sur_f</sub> + V <sub>s_m_a_f</sub> +	$V_{s_m_b_f} + V_{s_s_f} +$	+ V <sub>s_water_f</sub> = 104	<b>4.8</b> kN/m	
Calculate moment for stem of	lesign						
Surcharge	U	Ms sur = Fs	sur f × L / 8 = <b>1</b>	<b>3.9</b> kNm/m			
Moist backfill above water table	e		$M_{s m a} = F_{s m a f} \times b_{1} \times ((5 \times L^{2}) - (3 \times b_{1}^{2})) / (15 \times L^{2}) = 0.4 \text{ kNm}/$				
Moist backfill below water table	9	$M_{s m b} = F_{s m b f} \times a_{l} \times ((3 \times 2)^{-} (3 \times b_{l}))) / (13 \times 2)^{-} 0.4 \text{ kNm}/m$					
Saturated backfill		$M_{s_s} = F_{s_s_f} \times a_1 \times ((3 \times a_1^2) - (15 \times a_1 \times L) + (20 \times L^2))/(60 \times L^2) = 14.5 \text{ kNm/m}$					
Water			$M_{s\_water} = F_{s\_water_f} \times ai \times ((3 \times ai^2) - (15 \times ai \times L) + (20 \times L^2))/(60 \times L^2) = 14.3 \text{ km/r/m}$ $M_{s\_water} = F_{s\_water_f} \times ai \times ((3 \times ai^2) - (15 \times ai \times L) + (20 \times L^2))/(60 \times L^2) = 20.4$				
kNm/m				· / ( · · · · · · · · / · ( ·			
Total moment for stem design		M <sub>stem</sub> = M <sub>s</sub>	<sub>sur</sub> + M <sub>s m a</sub> + N	И <sub>s_m_b</sub> + M <sub>s_s</sub> + М	s water = <b>59.5</b> kN	lm/m	
Calculate moment for wall de	esian	-			-		
Surcharge			≺Fs sur f x I / 1	28 = <b>7.8</b> kNm/m			
Moist backfill above water table	2	-		×bi×[(bi <sup>3</sup> +5×ai×L <sup>2</sup> )/	/(5×1 <sup>3</sup> )_0 5772/	31 = 0 5	
kNm/m	-	iviw_m_a = 1	<u></u> ^ U.UI / ^			-j <b>v.v</b>	
		M - F	- / /	$D = \frac{2}{4} \frac{4}{4} = \frac{2}{4} \frac{2}{4} \frac{1}{4} \frac{1}{4$	4+n×(4-n)]/8 =		
Moist backfill below water table	2		2 m h f X <b>A</b> I X I ( )	5-n-x(4-n n- / in-	$4 + 1 \times 4 + 1 \times 6 = 1$	5.7 KINM/h	



	Project	10 Downsio	de Crescent		Job no. 14	11
RODRIGUES ASSOCIATES	Calcs for real	r retaining wall ι	under rear exte	nsion	Start page no./R	evision 4. 8
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved date

Area of tension reinforcement required	A <sub>s_wall_req</sub> = Max(A <sub>s_wall_des</sub> , A <sub>s_wall_min</sub> ) = <b>390</b> mm²/m
Reinforcement provided	12 mm dia.bars @ 200 mm centres
Area of reinforcement provided	A <sub>s_wall_prov</sub> = <b>565</b> mm <sup>2</sup> /m
PASS	- Reinforcement provided to the retaining wall at mid height is adequate
Check retaining wall deflection	
Basic span/effective depth ratio	ratio <sub>bas</sub> = <b>20</b>
Design service stress	$f_s = 2 \times f_y \times A_{s\_stem\_req} / (3 \times A_{s\_stem\_prov}) = 193.4 \text{ N/mm}^2$
Modification factor factor <sub>tens</sub> = mir	$n(0.55 + (477 \text{ N/mm}^2 - f_s)/(120 \times (0.9 \text{ N/mm}^2 + (M_{\text{stem}}/(b \times d_{\text{stem}}^2)))),2) = 1.81$
Maximum span/effective depth ratio	ratio <sub>max</sub> = ratio <sub>bas</sub> × factor <sub>tens</sub> = <b>36.20</b>
Actual span/effective depth ratio	ratio <sub>act</sub> = h <sub>stem</sub> / d <sub>stem</sub> = <b>12.55</b>
	PASS - Span to depth ratio is acceptable

🐙 Tekla	Project		de Oreccent		Job no.	444	
Tedds		10 Downsi	de Crescent		1	411	
RODRIGUES ASSOCIATES	Calcs for	Calcs for		Calcs for Start page no./Re		Revision	
1 AMWELL STREET		rear retaining wall	under rear exte	extension 6.4. 9		4.9	
	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved dat	
EC1R 1UL	ab forcement dia	11/09/2018					
Indicative retaining wall rein							

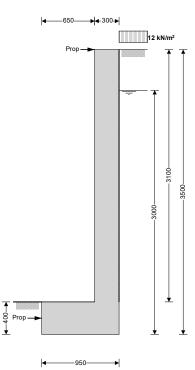
Toe bars - 12 mm dia.@ 200 mm centres - (565 mm²/m) Wall bars - 12 mm dia.@ 200 mm centres - (565 mm²/m) Stem bars - 16 mm dia.@ 200 mm centres - (1005 mm²/m)

Toe reinforcement-

	Project	10 Downsid	de Crescent		Job no. 14	411
RODRIGUES ASSOCIATES 1 AMWELL STREET	Calcs for side	cs for side retaining wall under rear extension			Start page no./Revision 6.5. 1	
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved date

TEDDS calculation version 1.2.01.06

#### RETAINING WALL ANALYSIS (BS 8002:1994)



Wall details

Retaining wall type Height of retaining wall stem Thickness of wall stem Length of toe Length of heel Overall length of base Thickness of base Depth of downstand Position of downstand Thickness of downstand Height of retaining wall Depth of cover in front of wall Depth of unplanned excavation Height of ground water behind wall Height of saturated fill above base Density of wall construction Density of base construction Angle of rear face of wall Angle of soil surface behind wall Effective height at virtual back of wall **Retained material details** 

Mobilisation factor Moist density of retained material

Cantilever propped at both h<sub>stem</sub> = **3100** mm t<sub>wall</sub> = 300 mm I<sub>toe</sub> = **650** mm I<sub>heel</sub> = **0** mm Ibase = Itoe + Iheel + twall = 950 mm t<sub>base</sub> = **400** mm d<sub>ds</sub> = **0** mm l<sub>ds</sub> = **15** mm t<sub>ds</sub> = **400** mm  $h_{wall}$  =  $h_{stem}$  +  $t_{base}$  +  $d_{ds}$  = **3500** mm d<sub>cover</sub> = **0** mm  $d_{exc} = 0 mm$ h<sub>water</sub> = 3000 mm  $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 2600 mm$ γ<sub>wall</sub> = 23.6 kN/m<sup>3</sup> γ<sub>base</sub> = 23.6 kN/m<sup>3</sup> α = **90.0** deg  $\beta = 0.0 \deg$  $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3500 \text{ mm}$ 

M = **1.5** γ<sub>m</sub> = **18.0** kN/m<sup>3</sup>

	Project	10 Downsi	de Crescent		Job no. 1	411
RODRIGUES ASSOCIATES 1 AMWELL STREET	Calcs for	side retaining wall ι	under rear exte	ension	Start page no./F 6	Revision .5. 2
LONDON EC1R 1UL	Calcs by ab	Calcs by Calcs date Checked by Checked date				Approved date
Saturated density of retained r	material	γ <sub>s</sub> = <b>20.0</b> kt				
Design shear strength		∳' = <b>18.6</b> de	-			
Angle of wall friction		δ <b>= 0.0</b> deg	l			
Base material details						
Firm clay						
Moist density		γ <sub>mb</sub> = <b>18.0</b> k				
Design shear strength		φ' <sub>b</sub> = <b>15.8</b> d	-			
Design base friction		δ <sub>b</sub> = <b>18.6</b> de	-			
Allowable bearing pressure		P <sub>bearing</sub> = 12	2 <b>5</b> kN/m²			
Using Coulomb theory						
Active pressure coefficient for			1			
		$)^2  imes \sin(\alpha - \delta)  imes [1 + c]$	· √(sin(φ' + δ) ×	$\sin(\phi' - \beta) / (\sin(\phi'))$	$(\alpha - \delta) \times \sin(\alpha + \delta)$	$(\beta)))]^2) = 0.5$
Passive pressure coefficient for						<pre></pre>
	K <sub>p</sub> = SI	n(90 - ¢'₅)² / (sin(90	) - ð⊳) × [1 - ∿(S	$\ln(\phi_{\rm b} + \delta_{\rm b}) \times \sin(\phi_{\rm b})$	ф <sup>ъ</sup> ) / (sin(90 +	ðь)))]²) = <b>2.7</b>
At-rest pressure						
At-rest pressure for retained m	naterial	K₀ = 1 – sir	n(φ') = <b>0.681</b>			
Loading details						
Surcharge load on plan		-	= <b>12.0</b> kN/m <sup>2</sup>			
Applied vertical dead load on v		W <sub>dead</sub> = <b>0.0</b>				
Applied vertical live load on wa		W <sub>live</sub> = <b>0.0</b>				
Position of applied vertical loa Applied horizontal dead load of		l <sub>load</sub> = <b>0</b> mm F <sub>dead</sub> = <b>0.0</b>				
Applied horizontal live load on		F <sub>live</sub> = <b>0.0</b> k				
Height of applied horizontal loa		h <sub>load</sub> = <b>0</b> mr				
		11	2			
	Prop → 18.7 32.5	Prop		29.4		
				Loads show	vn in kN/m, pressu	na ahaum in KN

<b>Tekla</b> Tedds	Project Job no. 10 Downside Crescent 141		10 Downside Crescent			411
RODRIGUES ASSOCIATES	Calcs for	Calcs for side retaining wall under rear extension				Revision .5. 3
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved date
Vertical forces on wall						
Wall stem		$w_{wall} = h_{stem}$	$\times t_{wall} \times \gamma_{wall} =$	<b>21.9</b> kN/m		
Wall base		$w_{\text{base}} = I_{\text{base}} \times t_{\text{base}} \times \gamma_{\text{base}} = 9 \text{ kN/m}$				
Total vertical load		W <sub>total</sub> = w <sub>wa</sub>	# + Wbase = <b>30</b> .	<b>9</b> kN/m		

F<sub>prop</sub> = **90.5** kN/m

Horizontal forces on wall	
Surcharge	$F_{sur}$ = K <sub>a</sub> × Surcharge × h <sub>eff</sub> = <b>21.7</b> kN/m
Moist backfill above water table	$F_{m_a}$ = 0.5 × K <sub>a</sub> × $\gamma_m$ × (h <sub>eff</sub> - h <sub>water</sub> ) <sup>2</sup> = <b>1.2</b> kN/m
Moist backfill below water table	$F_{m\_b} = K_a \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = \textbf{13.9} \text{ kN/m}$
Saturated backfill	$F_s = 0.5 \times K_a \times (\gamma_{s} - \gamma_{water}) \times h_{water}^2 = 23.7 \text{ kN/m}$
Water	$F_{water}$ = 0.5 × $h_{water}^2$ × $\gamma_{water}$ = 44.1 kN/m
Total horizontal load	$F_{total} = F_{sur} + F_{m_a} + F_{m_b} + F_s + F_{water} = 104.6 \text{ kN/m}$

#### Calculate total propping force

Passive resistance of soil in front of wall Propping force

#### **Overturning moments**

Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment

# Restoring moments Wall stem

Wall base Total restoring moment

Check bearing pressure Total vertical reaction Distance to reaction Eccentricity of reaction

Bearing pressure at toe Bearing pressure at heel 
$$\begin{split} M_{m_a} &= F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = \textbf{3.7 kNm/m} \\ M_{m_b} &= F_{m_b} \times (h_{water} - 2 \times d_{ds}) / 2 = \textbf{20.9 kNm/m} \\ M_s &= F_s \times (h_{water} - 3 \times d_{ds}) / 3 = \textbf{23.7 kNm/m} \\ M_{water} &= F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = \textbf{44.1 kNm/m} \\ M_{ot} &= M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = \textbf{130.4 kNm/m} \end{split}$$

 $F_{prop} = max(F_{total} - F_p - (W_{total}) \times tan(\delta_b), 0 \text{ kN/m})$ 

 $M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = 38 \text{ kNm/m}$ 

 $F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 3.7 \text{ kN/m}$ 

$$\begin{split} M_{wall} &= w_{wall} \times (I_{toe} + t_{wall} / 2) = \textbf{17.6 kNm/m} \\ M_{base} &= w_{base} \times I_{base} / 2 = \textbf{4.3 kNm/m} \\ M_{rest} &= M_{wall} + M_{base} = \textbf{21.8 kNm/m} \end{split}$$

 $\begin{aligned} R &= W_{total} = \textbf{30.9 kN/m} \\ x_{bar} &= I_{base} / 2 = \textbf{475 mm} \\ e &= abs((I_{base} / 2) - x_{bar}) = \textbf{0 mm} \\ \hline \textbf{Reaction acts within middle third of base} \\ p_{toe} &= (R / I_{base}) - (6 \times R \times e / I_{base}^2) = \textbf{32.5 kN/m}^2 \\ p_{heel} &= (R / I_{base}) + (6 \times R \times e / I_{base}^2) = \textbf{32.5 kN/m}^2 \end{aligned}$ 

### PASS - Maximum bearing pressure is less than allowable bearing pressure

#### Calculate propping forces to top and base of wall

Propping force to top of wall

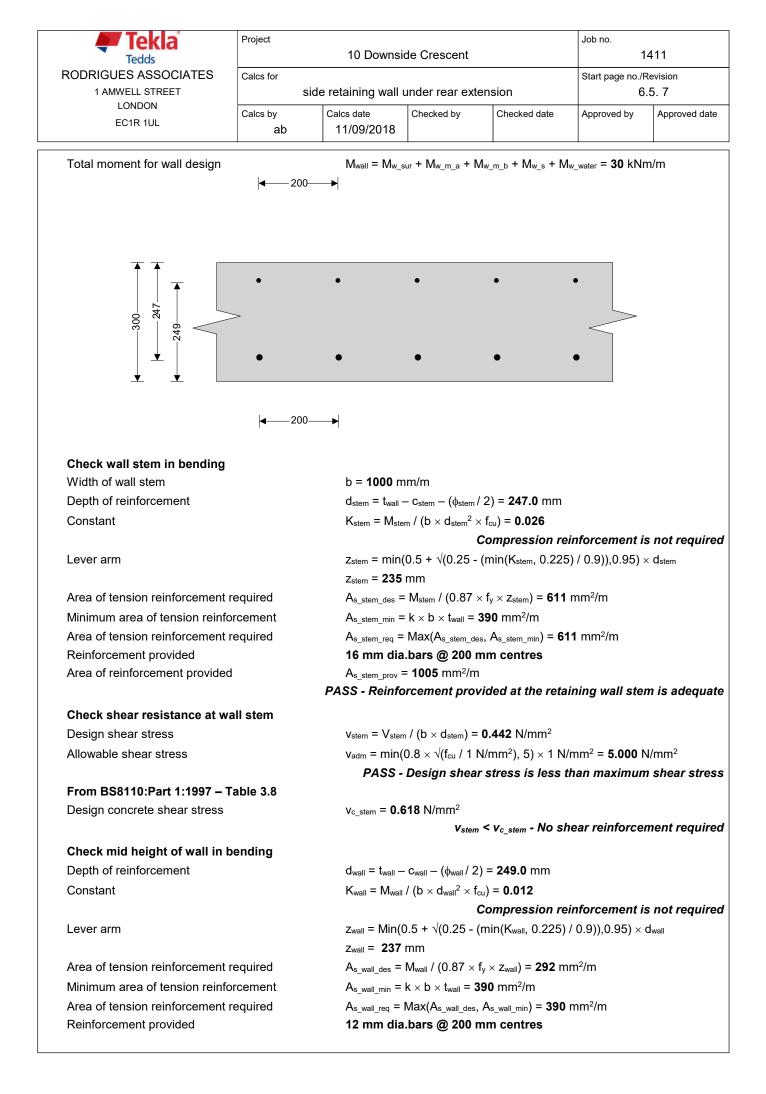
Propping force to base of wall

$$\begin{split} F_{prop\_top} &= (M_{ot} - M_{rest} + R \times I_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = \textbf{31.860 kN/m} \\ F_{prop\_base} &= F_{prop} - F_{prop\_top} = \textbf{58.608 kN/m} \end{split}$$

	Project	10 Downsi	e Crescent Job no. 1411				
RODRIGUES ASSOCIATES	Calcs for		Start page no./F	Revision			
1 AMWELL STREET	5	ide retaining wall	6.5. 4				
LONDON EC1R 1UL	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved da	
	ab	11/09/2018					
RETAINING WALL DESIGN (I	3S 8002:1994	<u>)</u>					
					TEDDS calculatio	n version 1.2.0	
Ultimate limit state load factor	ors						
Live load factor		γ <sub>f_d</sub> = <b>1.4</b>					
Earth and water pressure factor	r	γ <sub>f_l</sub> = 1.6 γ <sub>f_e</sub> = 1.4					
·		γt_e - 1.4					
Factored vertical forces on w	all			00 <b>-</b> 1 N/			
Wall stem				γ <sub>wall</sub> = <b>30.7</b> kN/r			
Wall base				$\times \gamma_{\text{base}} = 12.6 \text{ kN}$	/m		
Total vertical load		$W_{total_f} = W_v$	$wall_f + W_{base_f} =$	<b>43.3</b> kN/m			
Factored horizontal at-rest for	orces on wall						
Surcharge		$F_{sur_f} = \gamma_{f_i}$	$\times$ K <sub>0</sub> $\times$ Surchar	ge × h <sub>eff</sub> = <b>45.8</b> k	N/m		
Moist backfill above water table	e	$F_{m_a_f} = \gamma_{f_e}$	$_{e} \times 0.5 \times K_{0}  imes \gamma$	$m \times (h_{eff} - h_{water})^2 =$	= <b>2.1</b> kN/m		
Moist backfill below water table	)	$F_{m_b_f} = \gamma_{f_e}$	$e \times K_0 \times \gamma_m \times (h)$	<sub>eff</sub> - $h_{water}$ ) × $h_{water}$	= <b>25.7</b> kN/m		
Saturated backfill		$F_{s_f} = \gamma_{f_e} \times$	$0.5  imes K_0  imes$ ( $\gamma_s$ -	$\gamma_{water}$ ) × h <sub>water</sub> <sup>2</sup> =	<b>43.7</b> kN/m		
Water		$F_{water_f} = \gamma_{f}$	$_{e} \times 0.5 \times h_{water}$	$^{2} \times \gamma_{water}$ = 61.8 k	:N/m		
Total horizontal load		F <sub>total_f</sub> = F <sub>su</sub>	ır_f + F <sub>m_a_f</sub> + Fı	<sub>m_b_f</sub> + F <sub>s_f</sub> + F <sub>wate</sub>	<sub>r_f</sub> = <b>179.2</b> kN/n	n	
Calculate total propping force	e						
Passive resistance of soil in fro	ont of wall	$F_{p_f} = \gamma_{f_e} \times$	$0.5 \times K_p \times cos$	$\mathbf{s}(\delta_{b})  imes (d_{cover} + t_{ball})$	<sub>ase</sub> + d <sub>ds</sub> - d <sub>exc</sub> ) <sup>2</sup>	$\times \gamma_{mb} = 5.2$	
kN/m							
Propping force		F <sub>prop_f</sub> = ma	ax(F <sub>total_f</sub> - F <sub>p_f</sub> ⋅	- (W <sub>total_f</sub> ) × tan( $\delta_t$	₀), 0 kN/m)		
		F <sub>prop_f</sub> = <b>15</b>	<b>9.4</b> kN/m				
Factored overturning moment	nts						
Surcharge		$M_{sur_f} = F_{su}$	$r_f \times (h_{eff} - 2 \times$	d <sub>ds</sub> ) / 2 <b>= 80.1</b> kN	lm/m		
Moist backfill above water table	9	$M_{m_a_f} = F_m$	n_a_f × (h <sub>eff</sub> + 2 :	$\times$ h <sub>water</sub> - 3 $\times$ d <sub>ds</sub> ) /	/ 3 = <b>6.8</b> kNm/n	n	
Moist backfill below water table	;	$M_{m_b_f} = F_m$	n_b_f × (h <sub>water</sub> - 2	2 × d <sub>ds</sub> ) / 2 = <b>38.6</b>	kNm/m		
Saturated backfill		$M_{s_f} = F_{s_f}$	× (h <sub>water</sub> - 3 × d	<sub>ds</sub> ) / 3 = <b>43.7</b> kNr	n/m		
Water		$M_{water_f} = F_{v}$	$M_{water_f}$ = $F_{water_f} \times (h_{water} - 3 \times d_{ds}) / 3 = 61.8 \text{ kNm/m}$				
Total overturning moment		$M_{ot_f} = M_{sur}$	f + M <sub>m_a_f</sub> + M	<sub>m_b_f</sub> + M <sub>s_f</sub> + M <sub>wa</sub>	<sub>ter_f</sub> = <b>231</b> kNm/	′m	
Restoring moments							
Wall stem		$M_{wall_f} = w_w$	$_{\text{rall}_{f}} \times (I_{\text{toe}} + t_{\text{wall}})$	/ 2) = <b>24.6</b> kNm/	'n		
Wall base			base_f × Ibase / 2				
Total restoring moment							
Factored bearing pressure							
Total vertical reaction		R <sub>f</sub> = W <sub>total</sub>	f = <b>43.3</b> kN/m				
Distance to reaction		-	/ 2 = <b>475</b> mm				
Eccentricity of reaction			ase / 2) - Xbar_f)				
			,		s within middle	e third of b	
Bearing pressure at toe		$p_{toe_f} = (R_f)$	/ I <sub>base</sub> ) - (6 $ imes$ R <sub>f</sub>	$\times$ e <sub>f</sub> / I <sub>base</sub> <sup>2</sup> ) = 45.	.6 kN/m²		
Bearing pressure at heel		$p_{\text{heel}_f} = (R_f)$	/ $I_{base}$ ) + (6 × F	$R_f \times e_f / I_{base}^2$ ) = 4	<b>5.6</b> kN/m²		
Rate of change of base reaction	n	rate = (p <sub>toe</sub>	_f - p <sub>heel_f</sub> ) / I <sub>base</sub>	∍ <b>= 0.00</b> kN/m²/m			
Bearing pressure at stem / toe		p <sub>stem_toe_f</sub> =	max(p <sub>toe_f</sub> - (ra	ate × I <sub>toe</sub> ), 0 kN/m	²) = <b>45.6</b> kN/m²	2	
Bearing pressure at mid stem		p <sub>stem_mid_f</sub> =	max(p <sub>toe_f</sub> - (ra	ate $\times$ (I <sub>toe</sub> + t <sub>wall</sub> / 2	2)), 0 kN/m²) =	<b>45.6</b> kN/m²	
	9				0 kN/m <sup>2</sup> ) = <b>45</b> .		

Tedds	Project	10 Downs	ide Crescent		Job no. 1411		
RODRIGUES ASSOCIATES	Calcs for		Start page no./Revision				
1 AMWELL STREET LONDON	s	ide retaining wall	under rear ext	ension	6.5. 5		
EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved of	
Calculate propping forces to	top and base	of wall					
Propping force to top of wall							
	Fprop_top_f =	= (M <sub>ot_f</sub> - M <sub>rest_f</sub> + R	$R_{\rm f}  imes I_{\rm base} / 2 - F_{\rm p}$	$_{rop_f}  imes t_{base} / 2) / (t$	n <sub>stem</sub> + t <sub>base</sub> / 2)	= <b>57.321</b> k	
Propping force to base of wall		F <sub>prop_base_f</sub> =	= F <sub>prop_f</sub> - F <sub>prop_</sub>	<sub>top_f</sub> = <b>102.056</b> kN	l/m		
Design of reinforced concret	e retaining wa	all toe (BS 8002:1	994)				
Material properties	jj		<u> </u>				
Characteristic strength of conc	ete	f <sub>cu</sub> = <b>40</b> N/ı	mm²				
Characteristic strength of reinfo		$f_y = 500 \text{ N/}$					
Base details		,					
Minimum area of reinforcement	ł	k = 0.13 %					
Cover to reinforcement in toe		c <sub>toe</sub> = <b>45</b> m					
Calculate shear for toe desig	n						
Shear from bearing pressure		Vtee beer = (	Dtoo f + Dotom too	_f) × I <sub>toe</sub> / 2 = <b>29.6</b>	kN/m		
Shear from weight of base				$t_{toe} \times t_{base} = 8.6 \text{ kN}$			
Total shear for toe design			bear - Vtoe_wt_base				
Calculate moment for toe des	lan						
Moment from bearing pressure	-	M	$2 \times n_{\rm max} + n_{\rm max}$	$m_{m_{d_f}} \times (I_{toe} + t_{wa})$	$(2)^2/6 = 14$	<b>6</b> kNm/m	
Moment from weight of base				$t_{base} \times (I_{toe} + t_{wall})$			
Total moment for toe design				<sub>se</sub> = <b>10.4</b> kNm/m	2) / 2) = 4.2		
349	>						
400	•	•	•	•	•		
	•   <del>4</del> 200	•	•	•	•		
Check toe in bending	•   <del>4</del> 200	•	•	•	•		
¥ ↓	•   <b>4</b> 200	• • b = <b>1000</b> n	• nm/m	•	•		
Check toe in bending	•  4200	b = <b>1000</b> n	• nm/m – c <sub>toe</sub> – (φ <sub>toe</sub> / 2	• ) = <b>349.0</b> mm	•		
Check toe in bending Width of toe	•   <b>∢</b> 200	b = <b>1000</b> n d <sub>toe</sub> = t <sub>base</sub> -			•		
Check toe in bending Width of toe Depth of reinforcement	•  4200	b = <b>1000</b> n d <sub>toe</sub> = t <sub>base</sub> - K <sub>toe</sub> = M <sub>toe</sub>	- $c_{toe}$ - ( $\phi_{toe}$ / 2 / (b × d <sub>toe</sub> <sup>2</sup> × f <sub>ct</sub>	) = 0.002 Compression re		-	
Check toe in bending Width of toe Depth of reinforcement	•   <b>∢</b> 200	$b = 1000 \text{ n}$ $d_{\text{toe}} = t_{\text{base}} \cdot$ $K_{\text{toe}} = M_{\text{toe}}$ $z_{\text{toe}} = \min(0)$	$- c_{toe} - (\phi_{toe} / 2)$ / (b × d <sub>toe</sub> <sup>2</sup> × f <sub>ct</sub> ) 0.5 + $\sqrt{0.25}$ - (	a) = <b>0.002</b>		-	
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm		$b = 1000 \text{ m}$ $d_{toe} = t_{base} \cdot$ $K_{toe} = M_{toe}$ $z_{toe} = min(t_{toe})$	$- c_{toe} - (\phi_{toe} / 2)$ / (b × d <sub>toe</sub> <sup>2</sup> × f <sub>ct</sub> ) 0.5 + $\sqrt{0.25}$ - (mm	,) = <b>0.002</b> Compression re (min(K <sub>toe</sub> , 0.225) /	/ 0.9)),0.95) × c	-	
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement r	equired	$b = 1000 \text{ m}$ $d_{\text{toe}} = t_{\text{base}} - t_{\text{toe}} -$	$-c_{toe} - (\phi_{toe} / 2) / (b \times d_{toe}^2 \times f_{ct})$ $0.5 + \sqrt{0.25 - (0.25 - (0.25 - 0.25))}$ $M_{toe} / (0.87 \times f_{ct})$	n) = <b>0.002</b> <i>Compression re</i> (min(K <sub>toe</sub> , 0.225)) y × z <sub>toe</sub> ) = <b>72</b> mm	/ 0.9)),0.95) × c	-	
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement r Minimum area of tension reinforcement	equired	$b = 1000 \text{ m}$ $d_{toe} = t_{base} + t_{toe}$ $K_{toe} = M_{toe}$ $z_{toe} = min(t_{toe} = 332 \text{ m})$ $A_{s\_toe\_des} = A_{s\_toe\_min} = t_{toe}$	$-c_{toe} - (\phi_{toe} / 2)$ $/ (b \times d_{toe}^2 \times f_{ct})$ $0.5 + \sqrt{0.25 - (mm)}$ $M_{toe} / (0.87 \times f_{base} = 1)$	,) = <b>0.002</b> <i>Compression re</i> (min(K <sub>toe</sub> , 0.225)) (y × z <sub>toe</sub> ) = <b>72</b> mm <sup>2</sup> <b>520</b> mm <sup>2</sup> /m	′ 0.9)),0.95) × c ²/m	-	
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement r Minimum area of tension reinfor Area of tension reinforcement r	equired	$b = 1000 \text{ m}$ $d_{toe} = t_{base} \cdot$ $K_{toe} = M_{toe}$ $z_{toe} = M_{toe}$ $z_{toe} = 332 \text{ m}$ $A_{s\_toe\_des} =$ $A_{s\_toe\_min} =$ $A_{s\_toe\_min} =$	$-c_{toe} - (\phi_{toe} / 2)$ $/ (b \times d_{toe}^{2} \times f_{ct})$ $0.5 + \sqrt{0.25 - (mm)}$ $M_{toe} / (0.87 \times f_{base} = 1)$ $M_{x}(A_{s_toe_des}, -1)$	,) = <b>0.002</b> <i>Compression re</i> (min(K <sub>toe</sub> , 0.225)) <sup>(7</sup> <sub>y</sub> × z <sub>toe</sub> ) = <b>72</b> mm <b>520</b> mm <sup>2</sup> /m A <sub>s_toe_min</sub> ) = <b>520</b> r	′ 0.9)),0.95) × c ²/m	-	
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement r Minimum area of tension reinforcement	equired rcement equired	$b = 1000 \text{ m}$ $d_{toe} = t_{base} - t_{toe} = M_{toe}$ $Z_{toe} = M_{toe}$ $Z_{toe} = 332 \text{ m}$ $A_{s\_toe\_des} = A_{s\_toe\_des} = A_{s\_toe\_req} = 12 \text{ mm dia}$	$-c_{toe} - (\phi_{toe} / 2)$ $/ (b \times d_{toe}^2 \times f_{ct})$ $0.5 + \sqrt{0.25 - (mm)}$ $M_{toe} / (0.87 \times f_{base} = 1)$	,) = <b>0.002</b> <i>Compression re</i> (min(K <sub>toe</sub> , 0.225)) <sup>(7</sup> <sub>y</sub> × z <sub>toe</sub> ) = <b>72</b> mm <b>520</b> mm <sup>2</sup> /m A <sub>s_toe_min</sub> ) = <b>520</b> r	′ 0.9)),0.95) × c ²/m	-	

Tedds	10 Downside Crescent					411
RODRIGUES ASSOCIATES 1 AMWELL STREET	Calcs for	side retaining wall	under rear ext	ension	Start page no./Revision 6.5. 6	
LONDON EC1R 1UL	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved
	ab	11/09/2018				
Check shear resistance at to	e					
Design shear stress		$v_{toe} = V_{toe} /$	$(b \times d_{toe}) = 0.0$	<b>160</b> N/mm <sup>2</sup>		
Allowable shear stress		v <sub>adm</sub> = min(	0.8 × √(f <sub>cu</sub> / 1 I	N/mm²), 5) × 1 N/	/mm² = <b>5.000</b> N	N/mm <sup>2</sup>
		PASS -	Design shea	r stress is less t	han maximun	n shear st
From BS8110:Part 1:1997 – 1	Table 3.8		_			
Design concrete shear stress		v <sub>c_toe</sub> = <b>0.4</b> ′				
			Vte	oe < Vc_toe - No sł	near reinforce	ment requ
Design of reinforced concret	e retaining wa	all stem (BS 8002	:1994 <u>)</u>			
Material properties						
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/r	nm²			
Characteristic strength of reinf	orcement	f <sub>y</sub> = <b>500</b> N/	mm²			
Wall details						
Minimum area of reinforcemen	t	k = <b>0.13</b> %				
Cover to reinforcement in stem	ı	c <sub>stem</sub> = <b>45</b> r	nm			
Cover to reinforcement in wall		c <sub>wall</sub> = <b>45</b> m	im			
Factored horizontal at-rest fe	orces on stem	I				
Surcharge		$F_{s\_sur\_f} = \gamma_{f\_}$	$1 \times K_0 \times Surcha$	$arge \times (h_{eff} - t_{base})$	- d <sub>ds</sub> ) = <b>40.5</b> kN	l/m
Moist backfill above water table	е	F <sub>s_m_a_f</sub> = 0	$.5  imes \gamma_{f_e}  imes K_0  imes$	$\gamma_{m}  imes$ (h <sub>eff</sub> - t <sub>base</sub> -	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>2.1</b>	l kN/m
Moist backfill below water table	9	$F_{s_m_b_f} = \gamma_f$	_e × $K_0 \times \gamma_m \times ($	h <sub>eff</sub> - t <sub>base</sub> - d <sub>ds</sub> - h	lsat) × h <sub>sat</sub> = <b>22.</b>	<b>3</b> kN/m
Saturated backfill		F <sub>s_s_f</sub> = 0.5	$\times \gamma_{f_e} \times K_0 \times (\gamma$	s-γ <sub>water</sub> ) × h <sub>sat</sub> ² = 3	<b>32.8</b> kN/m	
Water		F <sub>s_water_f</sub> = (	$0.5  imes \gamma_{f_e}  imes \gamma_{wate}$	er × h <sub>sat</sub> ² <b>= 46.4</b> kN	N/m	
Calculate shear for stem des	ian					
Surcharge	U	V <sub>s sur f</sub> = 5	$\times F_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_$	<b>25.3</b> kN/m		
Moist backfill above water table	9			5 × L²) - bı²) / (5 >	< L <sup>3</sup> ) = <b>0.3</b> kN/n	n
Moist backfill below water table	9			$^{2} \times (4 - n))) / 8 =$		
Saturated backfill			` `	((5 × L) - a <sub>l</sub> ) / (20		κN/m
Water		V <sub>s water f</sub> = I	= =s water f × (1 - (	(al² × ((5 × L) - al)	/ (20 × L <sup>3</sup> ))) =	<b>39.5</b> kN/m
Total shear for stem design		V <sub>stem</sub> = V <sub>s_s</sub>	<sub>ur_f</sub> + V <sub>s_m_a_f</sub> +	$V_{s_m_b_f} + V_{s_s_f} +$	+ V <sub>s_water_f</sub> = 109	<b>9.1</b> kN/m
Calculate moment for stem of	lesign					
Surcharge	- 0 -	Ms sur = Fs	<sub>sur f</sub> × L / 8 = <b>1</b>	<b>6.7</b> kNm/m		
Moist backfill above water table	9		_	$\times$ L <sup>2</sup> ) - (3 $\times$ b <sup>2</sup> ))	/ (15 × L <sup>2</sup> ) = <b>0.4</b>	<b>4</b> kNm/m
Moist backfill below water table				- n) <sup>2</sup> / 8 = <b>10.4</b> ki	, ,	
Saturated backfill			·	15×aı×L)+(20×L <sup>2</sup> )		. <b>5</b> kNm/m
Water				×ai²)-(15×ai×L)+(2	, , ,	
kNm/m			((-	,,,,,,,	// \ /	
Total moment for stem design		M <sub>stem</sub> = M <sub>s</sub> _	<sub>sur</sub> + M <sub>s_m_a</sub> + N	Ms_m_b + Ms_s + M	s_water <b>= 62.3</b> kN	lm/m
Calculate moment for wall de	esign					
Surcharge	-	$M_{w_sur} = 9$	$F_{s_{sur_f} \times L / 1}$	28 = <b>9.4</b> kNm/m		
Moist backfill above water table	Э			⟨b <sub>l</sub> ×[(b <sub>l</sub> ³+5×a <sub>l</sub> ×L²)/	/(5×L <sup>3</sup> )-0.577 <sup>2</sup> /3	3] = <b>0.5</b>
kNm/m				,		
Moist backfill below water table	9	$M_{w_m_b} = F_s$	s_m_b_f × <b>a</b> l × [((6	8-n²×(4-n))² /16)-	4+n×(4-n)]/8 =	5.7 kNm/r
Saturated backfill				L)-aı)/(20×L³)-(x-l	. ,-	
Water		M <sub>w_water</sub> = F	s_water_f × <b>[a</b> l <sup>2</sup> × <b>x</b>	.×((5×L)-a⊨)/(20×L	. <sup>3</sup> )-(x-b <sub>i</sub> ) <sup>3</sup> /(3×ai <sup>2</sup>	<sup>2</sup> )] = <b>8.5</b>
kNm/m		-	- •			



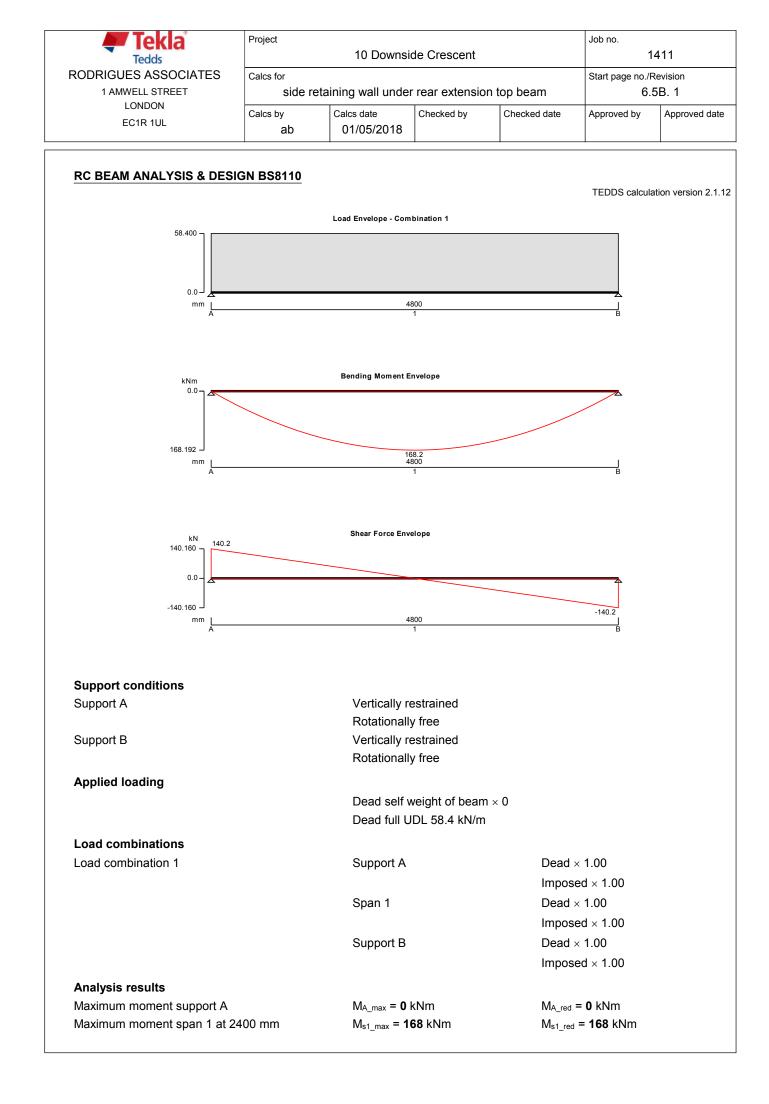
두 Tekla	Project		Job no.			
Tedds		10 Downsi	1411			
RODRIGUES ASSOCIATES	Calcs for				Start page no./R	evision
1 AMWELL STREET	side retaining wall under rear extension				6.5. 8	
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved date
Area of reinforcement provideo	1	As_wall_prov =	<b>565</b> mm²/m			

	PASS - Reinforcement provided to the retaining wall at mid height is adequate
Check retaining wall deflect	n
Basic span/effective depth ra	ratio <sub>bas</sub> = <b>20</b>
Design service stress	$f_s = 2 \times f_y \times A_{s\_stem\_req} / (3 \times A_{s\_stem\_prov}) = 202.4 \text{ N/mm}^2$
Modification factor	factor <sub>tens</sub> = min(0.55 + (477 N/mm <sup>2</sup> - f <sub>s</sub> )/(120 × (0.9 N/mm <sup>2</sup> + (M <sub>stem</sub> /(b × d <sub>stem</sub> <sup>2</sup> )))),2) = 1.74
Maximum span/effective dept	ratio ratio <sub>max</sub> = ratio <sub>bas</sub> $\times$ factor <sub>tens</sub> = <b>34.82</b>
Actual span/effective depth ra	ratio <sub>act</sub> = h <sub>stem</sub> / d <sub>stem</sub> = <b>12.55</b>
	PASS - Span to depth ratio is acceptable

Tedds	Project 10 Downside Crescent Calcs for side retaining wall under rear extension				Job no. 1411 Start page no./Revision 6.5. 9	
RODRIGUES ASSOCIATES 1 AMWELL STREET						
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved date
	Wall rein	nforcement-	Stem	reinforcement		

Toe bars - 12 mm dia.@ 200 mm centres - (565 mm²/m) Wall bars - 12 mm dia.@ 200 mm centres - (565 mm²/m) Stem bars - 16 mm dia.@ 200 mm centres - (1005 mm²/m)

Toe reinforcement-



	Project	10 Downsi		Job no. 1411		
RODRIGUES ASSOCIATES 1 AMWELL STREET	Calcs for side ref	Start page no./	Revision 5B. 2			
LONDON EC1R 1UL	Calcs by ab	Calcs date 01/05/2018	Checked by	Checked date	Approved by	Approved da
Maximum moment support B Maximum shear support A		M <sub>B_max</sub> = 0 V <sub>A_max</sub> = 14	<b>10</b> kN	V <sub>A_red</sub> =	= <b>0</b> kNm = <b>140</b> kN	
Maximum shear support A span Maximum shear support B Maximum shear support B span Maximum reaction at support A Unfactored dead load reaction at Maximum reaction at support B Unfactored dead load reaction at	1 at 4507 mm t support A	$V_{A_s1_max} = V_{B_max} = -1$ $V_{B_s1_max} = -1$ $R_A = 140 k$ $R_{A_Dead} = 1$ $R_B = 140 k$ $R_{B_Dead} = 1$	40 kN -124 kN N 40 kN N	V <sub>B_red</sub> =	ed = 124 kN = -140 kN ed = -124 kN	
Rectangular section details Section width Section depth		b = <b>300</b> mr h = <b>350</b> mr				
<b>Concrete details</b> Concrete strength class Characteristic compressive cube			00►			
Modulus of elasticity of concrete Maximum aggregate size			$mm^2$ + 200 × f	<sub>cu</sub> = <b>28000</b> N/mm <sup>2</sup>	2	
<b>Reinforcement details</b> Characteristic yield strength of re Characteristic yield strength of s		fy = <b>500</b> N/				
Nominal cover to reinforceme Nominal cover to top reinforcem Nominal cover to bottom reinforce Nominal cover to side reinforce	<b>nt</b> ent cement	C <sub>nom_t</sub> = 35 C <sub>nom_b</sub> = 35 C <sub>nom_s</sub> = 35	mm mm			
Support A						
9 EU			$3  imes 12_{\varphi}$ bars $2  imes 10_{\varphi}$ shear l $4  imes 25_{\varphi}$ bars	egs at 200 c/c		
2						

🚝 Tekla	Project				Job no.	
Tedds	10 Downside Crescent				1411	
RODRIGUES ASSOCIATES	Calcs for				Start page no./Re	evision
1 AMWELL STREET LONDON	side reta	ining wall under	rear extensior	n top beam	6.5B. 3	
EC1R 1UL	Calcs by ab	Calcs date 01/05/2018	Checked by	Checked date	Approved by	Approved date

Rectangular	section i	n shear
-------------	-----------	---------

Design shear force span 1 at 293 mm Design shear stress Design concrete shear stress (min(f<sub>cu</sub>, 40) / 25)<sup>1/3</sup> /  $\gamma_m$ 

Allowable design shear stress

Value of v from Table 3.7 Design shear resistance required Area of shear reinforcement required Shear reinforcement provided Area of shear reinforcement provided  $V = \max(V_{A_s1_max}, V_{A_s1_red}) = 124 \text{ kN}$   $v = V / (b \times d) = 1.409 \text{ N/mm}^2$   $v_c = 0.79 \times \min(3, [100 \times A_{s, prov} / (b \times d)]^{1/3}) \times \max(1, (400 / d)^{1/4}) \times$   $v_c = 1.046 \text{ N/mm}^2$   $v_{max} = \min(0.8 \text{ N/mm}^2 \times (f_{cu}/1 \text{ N/mm}^2)^{0.5}, 5 \text{ N/mm}^2) = 5.000 \text{ N/mm}^2$  PASS - Design shear stress is less than maximum allowable  $0.5 \times v_c < v < (v_c + 0.4 \text{ N/mm}^2)$   $v_s = \max(v - v_c, 0.4 \text{ N/mm}^2) = 0.400 \text{ N/mm}^2$ 

 $A_{sv,req} = v_s \times b / (0.87 \times f_{yv}) = 276 \text{ mm}^2/\text{m}$ 

 $2\times10\varphi$  legs at 200 c/c

 $s_{vl,max} = 0.75 \times d = 219 \text{ mm}$ 

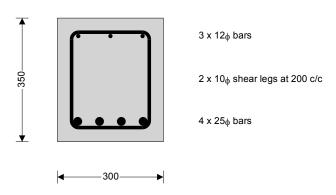
A<sub>sv,prov</sub> = **785** mm<sup>2</sup>/m

PASS - Area of shear reinforcement provided exceeds minimum required

Maximum longitudinal spacing

PASS - Longitudinal spacing of shear reinforcement provided is less than maximum

Mid span 1



Design moment resistand	o of roctangular costion	(a 2 4 4)	Positivo moment
Design moment resistant	e of rectangular section	(CI. 3.4.4)	- Positive moment

Design bending moment	M = abs(M <sub>s1_red</sub> ) = <b>168</b> kNm
Depth to tension reinforcement	$d = h - c_{nom_b} - \phi_v - \phi_{bot} / 2 = 293 \text{ mm}$
Redistribution ratio	$\beta_{b} = min(1 - m_{rs1}, 1) = 1.000$
	$K = M / (b \times d^2 \times f_{cu}) = 0.164$
	K' = 0.156
	K > K' - Compression reinforcement is required
Lever arm	z = d × (0.5 + (0.25 - K' / 0.9) <sup>0.5</sup> ) = <b>227</b> mm
Depth of neutral axis	x = (d - z) / 0.45 = <b>145</b> mm
Depth of compression reinforcement	$d_2 = c_{nom_t} + \phi_v + \phi_{top} / 2 = 51 mm$
Area of compression reinforcement required	$A_{s2,req} = (K - K') \times f_{cu} \times b \times d^2 / (0.87 \times f_y \times (d - d_2)) = 76 \text{ mm}^2$
Compression reinforcement provided	$3 \times 12\phi$ bars
Area of compression reinforcement provided	A <sub>s2,prov</sub> = <b>339</b> mm <sup>2</sup>
Maximum area of reinforcement (cl.9.2.1.1(3))	$A_{s,max} = 0.04 \times b \times h = 4200 \text{ mm}^2$
PASS - Area of r	einforcement provided is greater than area of reinforcement required
Area of tension reinforcement required	$A_{s,req} = K' \times f_{cu} \times b \times d^2 / (0.87 \times f_y \times z) + A_{s2,req} = 1697 \text{ mm}^2$
Tension reinforcement provided	$4 \times 25\phi$ bars
Area of tension reinforcement provided	A <sub>s,prov</sub> = <b>1963</b> mm <sup>2</sup>

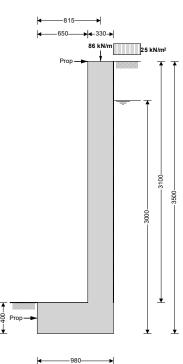
ning wall unde			Start page no./F		
ning wan unue	Calcs for side retaining wall under rear extension top beam				
<b>A</b> 1 1 1				5B. 4	
Calcs date 01/05/2018	Checked by	Checked date	Approved by	Approved of	
- /	$013 \times b \times h = 1$				
reinforcemen	t provided is g	reater than are	a of reinforce	nent requ	
$2 \times 10\phi$ leg	gs at 200 c/c				
$A_{sv,prov} = 78$	<b>35</b> mm²/m				
) $A_{sv,min} = 0.4$	4N/mm² × b / (0	$0.87 \times f_{yv}) = 276$	mm²/m		
SS - Area of s	hear reinforce	ment provided	exceeds minii	num requ	
$s_{vl,max} = 0.7$	′5 × d <b>= 219</b> mi	n			
udinal spacing	g of shear rein	forcement prov	vided is less th	nan maxim	
v <sub>c</sub> = 0.79N	/mm <sup>2</sup> × min(3,[	$100  imes A_{s,prov}$ / (b	× d)] <sup>1/3</sup> ) × max( <sup>-</sup>	1, (400mm	
/d) <sup>1/4</sup> ) × (m	in(f <sub>cu</sub> , 40N/mm <sup>2</sup>	<sup>2</sup> ) / 25N/mm <sup>2</sup> ) <sup>1/3</sup> /	′ γ <sub>m</sub> = <b>1.046</b> N/r	nm²	
	-	/ b = <b>1.139</b> N/m	-		
	<sub>ov</sub> + v <sub>c</sub> = <b>2.184</b>				
	$a \times (b \times d) = 19$				
		m with tension	reinforcemen	t of 1963 r	
"					
s = (b - 2 ×	$(C_{nom_s} + \phi_v + \phi_v)$	0bot/2)) /(Nbot - 1)	- φ <sub>bot</sub> = <b>37</b> mm		
:  3.12.11.1)					
s <sub>min</sub> = h <sub>agg</sub>	+ 5 mm <b>= 25</b> m	m			
	PAS	SS - Satisfies th	e minimum sp	acing crit	
cl 3.12.11.2)					
$f_s = (2 \times f_y)$	imes A <sub>s,req</sub> ) / (3 $ imes$ A	$(s, prov \times \beta_b) = 288.$	. <b>0</b> N/mm <sup>2</sup>		
s <sub>max</sub> = min(	(47000 N/mm /	f <sub>s</sub> , 300 mm) = <b>1</b>	<b>63</b> mm		
	PAS	S - Satisfies the	e maximum sp	acing crit	
span to d	epth <sub>basic</sub> = 20.0				
		<sub>s,prov</sub> × β <sub>b</sub> ) = <b>288.</b> 0	0 N/mm²		
		· · · /			
in(2.0, 0.55 + (	(477N/mm <sup>2</sup> - fs)	/ (120 × (0.9N/n	$nm^2$ + (M / (b ×	d <sup>2</sup> ))))) = <b>0</b> .	
( ) ,				- ///// -	
= min(1.5, 1 + (	$100 \times A_{s2 prov} / 0$	(b × d)) / (3 + (10	$00 \times A_{s2,prov}$ / (b	× d)))) = <b>1</b> .	
$f_{long} = 1.00$					
•		_to_depth <sub>basic</sub> ×	f <sub>tens ×</sub> f <sub>comp</sub> = 17	.0	
	$epth_{actual} = L_{s1}$				
		n to depth ratio	is within the a	llowable l	
7700					

	Project	10 Downside Crescent 1411						
RODRIGUES ASSOCIATES 1 AMWELL STREET	Calcs for side r	etaining wall unde	Start page no./Revision 6.5B. 5					
LONDON EC1R 1UL	Calcs by ab	Calcs date 01/05/2018	Checked by	Checked date	Approved by	Approved date		
Support B								
		)	$3 \text{ x} 12_{\phi} \text{ bars}$					
	-350		$2  ext{ x } 10_{\varphi}  ext{ shear } \phi$	egs at 200 c/c				
		•••	4 x 25 $_{\varphi}$ bars					
	4	300►						
Rectangular section in shea	r							
Design shear force span 1 at		V = abs(mi	n(V <sub>B_s1_max</sub> , V <sub>B</sub>	_s1_red)) = <b>124</b> kN				
Design shear stress		v = V / (b ×	v = V / (b × d) = <b>1.409</b> N/mm <sup>2</sup>					
Design concrete shear stress		$v_c$ = 0.79 $\times$	$v_{c}$ = 0.79 × min(3,[100 × A_{s,prov} / (b × d)]^{1/3}) × max(1, (400 / d)^{1/4}) ×					
(min(f <sub>cu</sub> , 40) / 25) <sup>1/3</sup> / γ <sub>m</sub>								
		v <sub>c</sub> = <b>1.046</b>	N/mm²					
Allowable design shear stress		$v_{max}$ = min(0.8 N/mm <sup>2</sup> × (f <sub>cu</sub> /1 N/mm <sup>2</sup> ) <sup>0.5</sup> , 5 N/mm <sup>2</sup> ) = 5.000 N/mm <sup>2</sup>						
		PAS	S - Design sh	ear stress is le	ss than maxin	num allowal		
Value of v from Table 3.7		$0.5 \times v_c < v_c$	v < (v <sub>c</sub> + 0.4 N/	mm²)				
Design shear resistance requi	v <sub>s</sub> = max(v - v <sub>c</sub> , 0.4 N/mm <sup>2</sup> ) = <b>0.400</b> N/mm <sup>2</sup>							
Area of shear reinforcement re	$A_{sv,req} = v_s \times b / (0.87 \times f_{yv}) = 276 \text{ mm}^2/\text{m}$							
Shear reinforcement provided	$2 \times 10\phi \log$	s at 200 c/c						
Area of shear reinforcement p		A <sub>sv,prov</sub> = 78 PASS - Area of sl		ement provided	exceeds mini	mum requir		
Maximum longitudinal spacing			5 × d <b>= 219</b> m			-		
		gitudinal spacing						

Tekla Tedds	Project 10 Downside Crescent				Job no. 1411	
RODRIGUES ASSOCIATES	Calcs for retain	ing wall under r	nain building s	side wall	Start page no./R 6.	evision 6. 1
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TEDDS calculation version 1.2.01.06

#### RETAINING WALL ANALYSIS (BS 8002:1994)



#### Wall details

Retaining wall type Height of retaining wall stem Thickness of wall stem Length of toe Length of heel Overall length of base Thickness of base Depth of downstand Position of downstand Thickness of downstand Height of retaining wall Depth of cover in front of wall Depth of unplanned excavation Height of ground water behind wall Height of saturated fill above base Density of wall construction Density of base construction Angle of rear face of wall Angle of soil surface behind wall Effective height at virtual back of wall

### **Retained material details**

Mobilisation factor Moist density of retained material

Cantilever propped at both h<sub>stem</sub> = **3100** mm t<sub>wall</sub> = 330 mm I<sub>toe</sub> = **650** mm I<sub>heel</sub> = **0** mm Ibase = Itoe + Iheel + twall = 980 mm t<sub>base</sub> = **400** mm d<sub>ds</sub> = **0** mm l<sub>ds</sub> = **15** mm t<sub>ds</sub> = **400** mm  $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3500 \text{ mm}$ d<sub>cover</sub> = **0** mm d<sub>exc</sub> = **0** mm h<sub>water</sub> = 3000 mm  $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 2600 mm$ γ<sub>wall</sub> = 23.6 kN/m<sup>3</sup> γ<sub>base</sub> = **23.6** kN/m<sup>3</sup> α = **90.0** deg  $\beta = 0.0 \text{ deg}$  $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3500 \text{ mm}$ 

M = **1.5** γ<sub>m</sub> = **18.0** kN/m<sup>3</sup>

RODENQUESA ASSOCIATES 1 AMMELL STREET 1 CONDON EGIR 10. 2 Galac by EGIR 10. 2 Galac by EGIR 10. 2 Galac by EGIR 10. 2 Galac by 2 Galac by	Tekla Project Tedds 10 Dow			ide Crescent		Job no. 1	411	
LONDON ECIR TUL Calles by Calles data Calles data Calles data Constructed density of retained material Design shear strength Age of wall friction Age of wall friction Age of wall friction Age of wall friction Calles day Design shear strength $\psi = 18.6 \ deg$ Base material details Firm day Moist density Design shear strength $\psi_{z} = 15.8 \ deg$ Design base friction $\lambda_{0} = 18.6 \ deg$ Calles day Moist density $K_{z} = \sin(\alpha + \theta)^{2} / (\sin(\alpha)^{2} \sin(\alpha - \theta) \times [1 + \sqrt{(\sin((\alpha' + \theta) \times \sin((\alpha' - \theta) \times \sin(\alpha' + \beta)))]^{2})} = 0.4$ Passive pressure coefficient for retained material $K_{z} = \sin(\alpha + \theta)^{2} / (\sin(\alpha)^{2} \sin(\alpha - \theta) \times [1 + \sqrt{(\sin((\alpha' + \theta) \times \sin((\alpha' - \theta) \times \sin(\alpha' + \beta)))]^{2})} = 0.4$ Passive pressure coefficient for retained material $K_{z} = \sin(\alpha + \theta)^{2} / (\sin(\alpha)^{2} \sin(\alpha - \theta) \times [1 - \sqrt{(\sin((\alpha' + \theta) \times \sin((\alpha' + \theta) \times \sin((\alpha' + \beta)))]^{2})} = 0.4$ Passive pressure coefficient for retained material $K_{z} = \sin(\alpha + \theta)^{2} / (\sin(\alpha - \theta) \times [1 - \sqrt{(\sin((\alpha' + \theta) \times \sin((\alpha' + \theta) \times \sin((\alpha' + \beta)))]^{2})} = 0.4$ At-rest pressure At-rest pressure At-rest pressure Caterest pressure for retained material $K_{z} = 1 - \sin((\theta)^{2} = 0.681$ Loading details Surcharge load on plan Applied vertical dead load on wall Applied vertical dead load on wall Applied vertical dead load on wall $K_{z} = 0.0 \ KN/m$ Applied horizontal load on wall $K_{z} = 0.0 \ KN/m$ $K_{z} = 0.0 \ KN/m$	RODRIGUES ASSOCIATES	Calcs for						
ECR 1ULCalculate abCalculate 1109/2018Checked by Checked byChecked date Approved by Approved by  Approved by Approved by<		ret	retaining wall under main building side wall			6.6. 2		
Design shear strength $\phi' = 18.6 \text{ deg}$ Angle of wall friction $\delta = 0.0 \text{ deg}$ Base material details Firm day Moist density $y_{\text{res}} = 18.0 \text{ kN/m}^3$ Design shear strength $\phi_1 = 15.8 \text{ deg}$ Allowable bearing pressure $p_{\text{starting}} = 125 \text{ kN/m}^2$ Difg Coulomb theory Active pressure coefficient for trained material $K_{\sigma} = \sin(\alpha + \phi')^2 (\sin(\alpha') \times \sin(\alpha \cdot \delta) \times  1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))}^2) = 0.1$ Passive pressure coefficient for base material $K_{\sigma} = \sin(\alpha + \phi')^2 (\sin(\alpha + \delta) \times \sin(\alpha - \delta) \times (1 - \sqrt{(\sin(\phi_b + \delta_b) \times \sin(\phi_b) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))}^2) = 2.7$ At-rest pressure At-rest pressure for retained material $K_{\phi} = \sin(\alpha + \phi_{\phi})^2 (\sin(\alpha + \delta) \times (1 - \sqrt{(\sin(\phi_b + \delta_b) \times \sin(\phi_b) / (\sin(\alpha + \delta) \times \sin(\alpha + \beta)))}^2) = 2.7$ At-rest pressure for retained material $K_{\phi} = \sin(\alpha + \phi_{\phi})^2 (\sin(\alpha + \delta) \times (1 - \sqrt{(\sin(\phi_b + \delta_b) \times \sin(\phi_b) / (\sin(\alpha + \delta) \times \sin(\alpha + \beta)))}^2) = 2.7$ At-rest pressure for retained material $K_{\phi} = \sin(\alpha + \phi_{\phi})^2 (\sin(\alpha + \delta) \times (1 - (\sin(\phi_b + \delta_b) \times \sin(\phi_b) / (\sin(\alpha + \delta) \times \sin(\phi_b)))^2) = 2.7$ At-rest pressure for retained material $K_{\phi} = \sin(\alpha + \phi_{\phi})^2 (\sin(\alpha + \delta) \times (1 - (\sin(\phi_b + \delta_b) \times \sin(\phi_b) / (\sin(\alpha + \delta) \times \sin(\phi_b)))^2) = 2.7$ At-rest pressure for retained material $K_{\phi} = \sin(\alpha + \phi_{\phi})^2 (\sin(\alpha + \delta) \times (1 - (\sin(\phi_b + \delta_b) \times \sin(\phi_b) / (\sin(\alpha + \delta) \times \sin(\phi_b + \delta_b)))^2) = 2.7$ At-rest pressure for retained material $K_{\phi} = \sin(\alpha + \phi_{\phi})^2 (\sin(\alpha + \delta) \times (1 - (\sin(\phi_b + \delta_b) \times \sin(\phi_b) / (\sin(\alpha + \delta) \times \sin(\phi_b + \delta_b)))^2) = 2.7$ At-rest pressure for retained material $K_{\phi} = \sin(\beta + \delta_{\phi}) = 0.681$ Description of applied vertical level to a on wall $K_{\phi} = 0.0 \text{ KN/m}$ Applied horizontal ive load on wall $K_{\phi} = 0.0 \text{ KN/m}$ Applied horizontal level to a on wall $K_{\phi} = 0.0 \text{ KN/m}$ $K_{\phi} = 0.0 \text{ KN/m}$				Checked by	Checked date	Approved by	Approved d	
Angle of wall friction $\delta = 0.0 \text{ deg}$ <b>Base material details</b> Firm day Moist density $y_{ma} = 18.0 \text{ kN/m}^3$ Design shear strength $\phi_b = 15.8 \text{ deg}$ Allowable bearing pressure $P_{\text{starreg}} = 125 \text{ kN/m}^2$ <b>Using Coulomb theory</b> Active pressure coefficient for retained material $K_{\pi} = \sin(q + \phi_{\pi}^2) / (\sin(q^2 \times \sin(q - \delta) \times [1 + v](\sin(\phi^2 + \delta) \times \sin(\phi^2 - \beta) / (\sin(q - \delta) \times \sin(q + \beta)))]^2) = 0.1$ Passive pressure coefficient for base material $K_{\pi} = \sin(q - \phi_{\pi})^2 / (\sin(q) - \delta_{\pi}) \times [1 - v](\sin(\phi_{\pi} + \delta_{\pi}) \times \sin(\phi_{\pi}) / (\sin(q) - \delta_{\pi})))]^2) = 2.1$ <b>At-rest pressure</b> At-rest pressure for retained material $K_{0} = 1 - \sin(\phi) = 0.681$ <b>Loging dotains</b> Surcharge beat on plan $Surcharge = 25.0 \text{ kN/m}^2$ Applied vertical deal do and wall $W_{\text{tow}} = 8.0.7 \text{ kN/m}$ Applied vertical deal do and on wall $W_{\text{tow}} = 3.0 \text{ kN/m}$ Position of applied vertical and on wall $W_{\text{tow}} = 0.0 \text{ kN/m}$ Applied horizontal load on wall $F_{\text{tow}} = 0.0 \text{ kN/m}$ Applied horizontal load on wall $F_{\text{tow}} = 0.0 \text{ kN/m}$ Applied horizontal load on wall $F_{\text{tow}} = 0.0 \text{ kN/m}$ Applied horizontal load on wall $F_{\text{tow}} = 0 \text{ m}$ $W_{\text{tow}} = 0 \text{ m}$		naterial						
Base material details Firm lay Moist density Design share strength $\psi_{a} = 15.8 \text{ deg}$ Design base friction $\delta_{b} = 18.6 \text{ deg}$ Allowable bearing pressure $H_{a} = \sin(\alpha + q)^{a} / (\sin(\alpha)^{2} \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi^{1} + \delta) \times \sin(\phi^{1} - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))]^{2}) = 0.$ Passive pressure coefficient for retained material $K_{a} = \sin(90 - \phi_{b})^{2} / (\sin(90 - \delta_{b}) \times [1 - \sqrt{(\sin(\phi^{b} + \delta_{b}) \times \sin(\phi^{b}) / (\sin(90 + \delta_{b})))]^{2}) = 2.$ At-rest pressure At-rest pressure for retained material Loading details Surcharge load on pain Applied vertical load on wall Applied horizontal load on wall Applied horizontal load on wall Applied horizontal load on wall Height of applied horizontal load on wall $F_{rese} = 0.0 \text{ kN/m}$ $F_{rese} = 0.0  kN$	Design shear strength		∳' = <b>18.6</b> de	eg				
Firm clay Most density Design shear strength Design shear strength Design base friction Allowable bearing pressure Design base friction $\delta_0 = 13.6 \text{ deg}$ Allowable bearing pressure Design base friction $K_0 = \sin(\alpha + \varphi)^2 / (\sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\varphi^1 - \delta) \times \sin(\varphi^1 - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))^2}) = 0.1$ Passive pressure coefficient for base material $K_0 = \sin(\alpha + \varphi)^2 / (\sin(\Theta - \delta_0) \times [1 - \sqrt{(\sin(\varphi^1 - \delta) \times \sin(\varphi^1 - \beta) / (\sin(\Theta + \delta_0)))^2}) = 0.1$ Passive pressure coefficient for base material $K_0 = 1 - \sin(\varphi^1) = 0.681$ Loading details Surcharge = 25.0 kN/m <sup>2</sup> Applied vertical load on wall Applied vertical load on wall Huest = 80.7 kN/m Position of applied vertical load on wall Height of applied horizontal load on wall Height of applied horizontal load on wall $K_{0000} = 0$ kN/m Height of applied horizontal load on wall $K_{00000} = 0$ kN/m $K_{000000000000000000000000000000000000$	Angle of wall friction		δ = <b>0.0</b> deg	9				
Moist density $y_{\text{the}} = 18.0 \text{ kN/m}^3$ Design shear strength $\phi_z = 15.8 \text{ deg}$ Design base friction $\delta_0 = 18.6 \text{ deg}$ Allowable bearing pressure $p_{\text{bearing}} = 125 \text{ kN/m}^3$ <b>Using Coulomb theory</b> Active pressure coefficient for retained material $\kappa_z = \sin(\alpha + \phi)^2 / (\sin(\alpha)^2 \sin(\alpha \cdot \delta) \times [1 + \sqrt{(\sin(\phi^2 + \delta) \times \sin(\phi^2 - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))^2}) = 0.2$ Passive pressure coefficient for base material $\kappa_z = \sin(90 - \phi_z)^2 / (\sin(90 - \delta_z) \times [1 - \sqrt{(\sin(\phi^2 + \delta_z) \times \sin(\phi^2 + \beta) / (\sin(90 + \delta_z))))^2}) = 2.2$ <b>At-rest pressure</b> <b>At-rest pressure</b> <b>Cating details</b> Surcharge load on plan Surcharge = 25.0 kN/m <sup>2</sup> Applied vertical dead load on wall Wawe = 4.8 kN/m Position of applied vertical load on wall Fases = 0.0 kN/m Applied horizontal live load on wall Fases = 0.0 kN/m theight of applied horizontal load on wall Fases = 0.0 kN/m $f_{\text{the other position}} = 0 \text{ the other position}$ $f_{\text{the other position}} = 0 \text{ the other position} = 0 \text{ the other position} = 0 \text{ the other position} = 0  the$	Base material details							
Design shear strength $\psi_{1} = 15.8 \text{ deg}$ Design base friction $\delta_{0} = 18.6 \text{ deg}$ Altowable bearing pressure $P_{nowing} = 125 \text{ kN/m}^{2}$ Difing Coulomb theory Active pressure coefficient for retained material $K_{0} = \sin(\alpha + q)^{2} / (\sin(\alpha)^{2} \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi^{1} + \delta) \times \sin(\phi^{1} - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))]^{2}}) = 0.$ Passive pressure coefficient for base material $K_{0} = \sin(90 - \phi_{0})^{2} / (\sin(90 - \delta_{0}) \times [1 - \sqrt{(\sin(\phi^{1} + \delta_{0}) \times \sin(\phi^{1} - \beta) / (\sin(90 + \delta_{0})))]^{2}}) = 2.$ Actrest pressure Actrest pressure for retained material $K_{0} = 1 - \sin(\phi^{1}) = 0.681$ Loading details Surcharge load on plan Applied vertical load on wall Applied vertical load on wall Applied vertical load on wall Applied horizontal load do on wall $F_{twe} = 0.0 \text{ kN/m}$ Applied horizontal load on wall $F_{twe} = 0.0 \text{ kN/m}$ Height of applied horizontal load on wall $F_{twe} = 0.0 \text{ kN/m}$ $Height of applied horizontal load on wall F_{twe} = 0.0 \text{ kN/m}F_{twe} = 0.0 \text{ kN/m}F_{twe$	Firm clay							
Design base friction $b_0 = 18.6 \text{ deg}$ Allowable bearing pressure $P_{\text{bearing}} = 125 \text{ kN/m}^2$ <b>Using Coulomb theory</b> Active pressure coefficient for teatained material $k_0 = \sin(\alpha + \phi)^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))]^2}) = 0.$ Passive pressure coefficient for base material $k_0 = \sin(90 - \phi_0)^2 / (\sin(90 - \delta_0) \times [1 - \sqrt{(\sin(\phi_0 + \delta_0) \times \sin(\phi_0) / (\sin(90 + \delta_0)))]^2}) = 2.$ <b>Arrest pressure</b> Art-rest pressure foretained material $k_0 = 1 - \sin(\phi') = 0.681$ <b>Loading details</b> Surcharge load on plan Applied vertical load on wall Applied vertical load on wall Applied horizontal deal load on wall Applied horizontal load on wall $F_{1000} = 0.0 \text{ kN/m}$ Height of applied horizontal load on wall $F_{1000} = 0.0 \text{ kN/m}$ Height of applied horizontal load on wall $F_{1000} = 0.0 \text{ kN/m}$ $F_{1000} = 0.0  k$	Moist density		γ <sub>mb</sub> = <b>18.0</b>	kN/m³				
Allowable bearing pressure $P_{earry} = 125 \text{ kN/m}^2$ <b>Using Coulomb theory</b> Active pressure coefficient for retained material $k_a = \sin(\alpha + \phi)^2 / (\sin(\alpha)^2 \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))]^2}) = 0.$ Pasive pressure coefficient for base material $k_a = \sin(\theta - \phi_b)^2 / (\sin(\theta - \delta_b) \times [1 - \sqrt{(\sin(\phi' + \delta_b) \times \sin(\phi_b) / (\sin(\theta - \delta_b)))]^2}) = 2.$ <b>Arrest pressure</b> <b>Arrest pressure</b> <b>Arrest pressure for retained material</b> <b>Burcharge load on plan</b> Applied vertical dead load on wall Applied vertical dead load on wall Applied horizontal load on wall Applied horizontal load on wall Height of applied horizontal load on wall $F_{iosel} = 0.0 \text{ kN/m}$ $P_{iosel} = 0 \text{ mm}$ $P_{iosel} = 0 \text{ mm}$ $P_{iosel} = 0 \text{ mm}$ $P_{iosel} = 0 \text{ mm}$	Design shear strength		φ' <sub>b</sub> = <b>15.8</b> c	deg				
Using Coulomb theory Active pressure coefficient for retained material $K_{a} = \sin(\alpha + \beta)^{2} / (\sin(\alpha)^{2} \times \sin(\alpha + \delta) \times [1 + \sqrt{(\sin((\psi + \delta) \times \sin((\psi - \beta)) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))]^{2}} = 0.$ Passive pressure coefficient for base material $K_{b} = \sin(90 - \phi_{b})^{2} / (\sin(90 - \delta_{b}) \times [1 - \sqrt{(\sin(\psi_{b} + \delta_{b}) \times \sin(\psi_{b}) / (\sin(90 + \delta_{b})))]^{2}} = 2.$ At-rest pressure At-rest pressure for retained material $K_{b} = 1 - \sin(\psi) = 0.681$ Surcharge = 25.0 kN/m <sup>2</sup> Applied vertical live load on wall Applied horizontal lead load on wall Applied horizontal lead on wall Applied horizontal load on wall Applied horizontal load on wall $K_{b} = 0 \text{ mm}$ $f_{basd} = 0 \text{ mm}$ $f_{basd} = 0 \text{ mm}$	Design base friction		δ <sub>b</sub> = <b>18.6</b> d	leg				
Active pressure coefficient for retained material $\begin{aligned} & \kappa_{a} = \sin(\alpha + \phi)^{2} / (\sin(\alpha)^{2} \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))]^{2}} = 0. \end{aligned}$ Passive pressure coefficient for base material $\begin{aligned} & \kappa_{b} = \sin(0 - \phi_{b})^{2} / (\sin(00 - \delta_{b}) \times [1 - \sqrt{(\sin(\phi_{b} + \delta_{b}) \times \sin(\phi_{b}) / (\sin(90 + \delta_{b})))]^{2}} = 2. \end{aligned}$ Act-rest pressure Act-rest pressure for retained material $\begin{aligned} & \kappa_{0} = 1 - \sin(\phi) = 0.681 \end{aligned}$ Coding details Surcharge load on plan Applied vertical dead load on wall Applied vertical live load on wall Applied horizontal dead load on wall Applied horizontal load on wall Height of applied horizontal load on wall $\begin{aligned} & \kappa_{0} = 1 - \sin(\phi) = 0.681 \end{aligned}$ $\begin{aligned} & W_{0sed} = 8.07 \text{ K/lm} \\ & W_{0sed} = 6.01 \text{ K/l/m} \\ & H_{0sed} = 0.01 \text{ K/l/m} \\ & H_{0sed} = 0.01 \text{ K/l/m} \\ & H_{0sed} = 0 \text{ mm} \end{aligned}$	Allowable bearing pressure		P <sub>bearing</sub> = 12	<b>25</b> kN/m²				
Active pressure coefficient for retained material $\begin{aligned} & \kappa_{a} = \sin(\alpha + \phi)^{2} / (\sin(\alpha)^{2} \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))]^{2}} = 0. \end{aligned}$ Passive pressure coefficient for base material $\begin{aligned} & \kappa_{b} = \sin(0 - \phi_{b})^{2} / (\sin(90 - \delta_{b}) \times [1 - \sqrt{(\sin(\phi_{b} + \delta_{b}) \times \sin(\phi_{b}) / (\sin(90 + \delta_{b})))]^{2}} = 2. \end{aligned}$ Actrest pressure Actrest pressure for retained material $\begin{aligned} & \kappa_{b} = 1 - \sin(\phi) = 0.681 \end{aligned}$ Cading details Surcharge load on plan $\begin{aligned} & Surcharge = 25.0 \text{ kN/m}^{2} \\ \text{Applied vertical live load on wall} \\ \text{Applied vertical live load on wall} \\ \text{Applied horizontal lead load on wall} \\ \text{Applied horizontal live load on wall} \\ \text{Applied horizontal load on wall} \\ Appli$	Using Coulomb theory							
Passive pressure coefficient for base material $\begin{aligned}                                    $		retained mater	ial					
$ k_p = \sin(90 - \phi_b)^2 / (\sin(90 - \delta_b) \times [1 - \sqrt{(\sin(\phi_b + \delta_b) \times \sin(\phi_b) / (\sin(90 + \delta_b)))]^2}) = 2. $	K <sub>a</sub> = sin(c	$(\alpha + \phi')^2 / (\sin(\alpha))$	$)^2 \times \sin(\alpha - \delta) \times [1 + \delta]$	+ √(sin(φ' + δ) :	× sin(φ' - β) / (sin(	$(\alpha - \delta) \times \sin(\alpha + \delta)$	· β)))]²) = <b>0</b> .	
Atrest pressure Atrest pressure for retained material Loading details Surcharge load on plan Applied vertical dead load on wall Applied horizontal load on wall Applied horizontal load on wall Height of applied horizontal height				. ,			-	
At-rest pressure At-rest pressure for retained material Loading details Surcharge load on plan Applied vertical load on wall Applied horizontal load on wall Applied horizontal load on wall Height of applied vertical load on wall Height of applied horizontal height of a		K <sub>p</sub> = sir	n(90 - ø'₅)² / (sin(90	Ο - δ <sub>b</sub> ) × [1 - √(	$\sin(\phi_{P} + \delta_{P}) \times \sin(\phi_{P})$	(փ'♭) / (sin(90 +	δ <sub>b</sub> )))] <sup>2</sup> ) = <b>2</b> .	
At-rest pressure for retained material $K_0 = 1 - \sin(\phi') = 0.681$ Loading details Surcharge load on plan Applied vertical dead load on wall Applied horizontal dead on wall Applied horizontal load on wall Height of applied horizontal load on wall $M_{exc} = 0.0 \ KN/m$ $H_{ince} = 0.0 \ KN/m$ $H_{ince} = 0.0 \ KN/m$ $H_{ince} = 0 \ m$ $f_{ince} = 0 \ m$	At-rest pressure							
Loading details Surcharge load on plan Applied vertical dead load on wall Applied vertical load on wall Applied horizontal load on wall Applied horizontal load on wall Height of applied horizontal load on wall Height of applied horizontal load on wall $\int_{\text{Height}} \frac{1}{10000000000000000000000000000000000$	-	aterial	K₀ = 1 – sir	n(oʻ) = <b>0.681</b>				
Surcharge load on plan Applied vertical dead load on wall Applied vertical load on wall Applied horizontal dead load on wall Applied horizontal live load on wall Applied horizontal live load on wall Height of applied horizontal load on wall Height of applied horizontal load on wall fried = 0.0  kN/m $Fried = 0.0  kN/m$								
Applied vertical load on wall Applied vertical load on wall Applied horizontal dead load on wall Applied horizontal load on wall Height of applied horizontal load on wall Height of applied horizontal load on wall $Height of applied horizontal load on wallHeight of applied horizon$	-		Surcharge	$= 25.0 \text{ kN}/\text{m}^2$				
Applied vertical live load on wall Applied horizontal dead load on wall Applied horizontal live load on wall Height of applied horizontal load on wall	•	vall	-					
Position of applied vertical load on wall Applied horizontal live load on wall Height of applied horizontal load o								
Applied horizontal load on wall Applied horizontal load on wall Height of applied horizontal load on wall $F_{ibve} = 0.0  kN/m$ $h_{ibcad} = 0  mm$								
Height of applied horizontal load on wall Height of applied horizontal load on wall Five = 0.0 kN/m head = 0 mm five = 0.0 kN/m head = 0 mm								
Height of applied horizontal load on wall $h_{oud} = 0$ mm								
	••							
			86 1 25					
		18.7	Prop	12.9 4.6 15.8	29.4			
Loads shown in kN/m, pressures shown in kI					Loads sho	wn in kN/m, pressu	res shown in kl	

<b>Tekla</b> Tedds	Project	Job no. 1411				
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Vertical forces on wall						

Vertical forces on wall	
Wall stem	$w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall} = 24.1 \text{ kN/m}$
Wall base	$w_{\text{base}} = I_{\text{base}} \times t_{\text{base}} \times \gamma_{\text{base}} = \textbf{9.3 kN/m}$
Applied vertical load	$W_v = W_{dead} + W_{live} = 85.5 \text{ kN/m}$
Total vertical load	$W_{total} = W_{wall} + W_{base} + W_v = 118.9 \text{ kN/m}$
Horizontal forces on wall	
Surcharge	$F_{sur} = K_a \times Surcharge \times h_{eff} = 45.2 \text{ kN/m}$
Moist backfill above water table	$F_{m_a} = 0.5 \times K_a \times \gamma_m \times (h_{eff} - h_{water})^2 = 1.2 \text{ kN/m}$
Moist backfill below water table	$F_{m_b} = K_a \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = 13.9 \text{ kN/m}$
Saturated backfill	$F_s = 0.5 \times K_a \times (\gamma_{s} - \gamma_{water}) \times h_{water}^2 = 23.7 \text{ kN/m}$
Water	$F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water} = 44.1 \text{ kN/m}$
Total horizontal load	F <sub>total</sub> = F <sub>sur</sub> + F <sub>m_a</sub> + F <sub>m_b</sub> + F <sub>s</sub> + F <sub>water</sub> = <b>128.1</b> kN/m
Calculate total propping force	
Passive resistance of soil in front of wall	$F_{p} = 0.5 \times K_{p} \times \text{cos}(\delta_{b}) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = \textbf{3.7 kN/m}$
Propping force	$F_{prop} = max(F_{total} - F_p - (W_{total} - W_{live}) \times tan(\delta_b), 0 \text{ kN/m})$
	F <sub>prop</sub> = <b>86.0</b> kN/m
Overturning moments	
Surcharge	$M_{sur}$ = $F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2$ = <b>79.1</b> kNm/m
Moist backfill above water table	$M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 3.7 \text{ kNm/m}$
Moist backfill below water table	$M_{m_b} = F_{m_b} \times (h_{water} - 2 \times d_{ds}) / 2 = 20.9 \text{ kNm/m}$
Saturated backfill	$M_{s} = F_{s} \times (h_{water} - 3 \times d_{ds}) / 3 = 23.7 \text{ kNm/m}$
Water	$M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 44.1 \text{ kNm/m}$
Total overturning moment	$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 171.5 \text{ kNm/m}$
Restoring moments	
Wall stem	$M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = 19.7 \text{ kNm/m}$
Wall base	$M_{\text{base}} = w_{\text{base}} \times I_{\text{base}} / 2 = 4.5 \text{ kNm/m}$
Design vertical dead load	$M_{dead} = W_{dead} \times I_{load} = 65.8 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_{dead} = 90 \text{ kNm/m}$
Check bearing pressure	
Total vertical reaction	R = W <sub>total</sub> = <b>118.9</b> kN/m
Distance to reaction	x <sub>bar</sub> = I <sub>base</sub> / 2 = <b>490</b> mm
Eccentricity of reaction	$e = abs((I_{base} / 2) - x_{bar}) = 0 mm$
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 121.3 \text{ kN/m}^2$
Bearing pressure at heel	$p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 121.3 \text{ kN/m}^2$
D/	ASS - Maximum bearing pressure is less than allowable bearing pressure

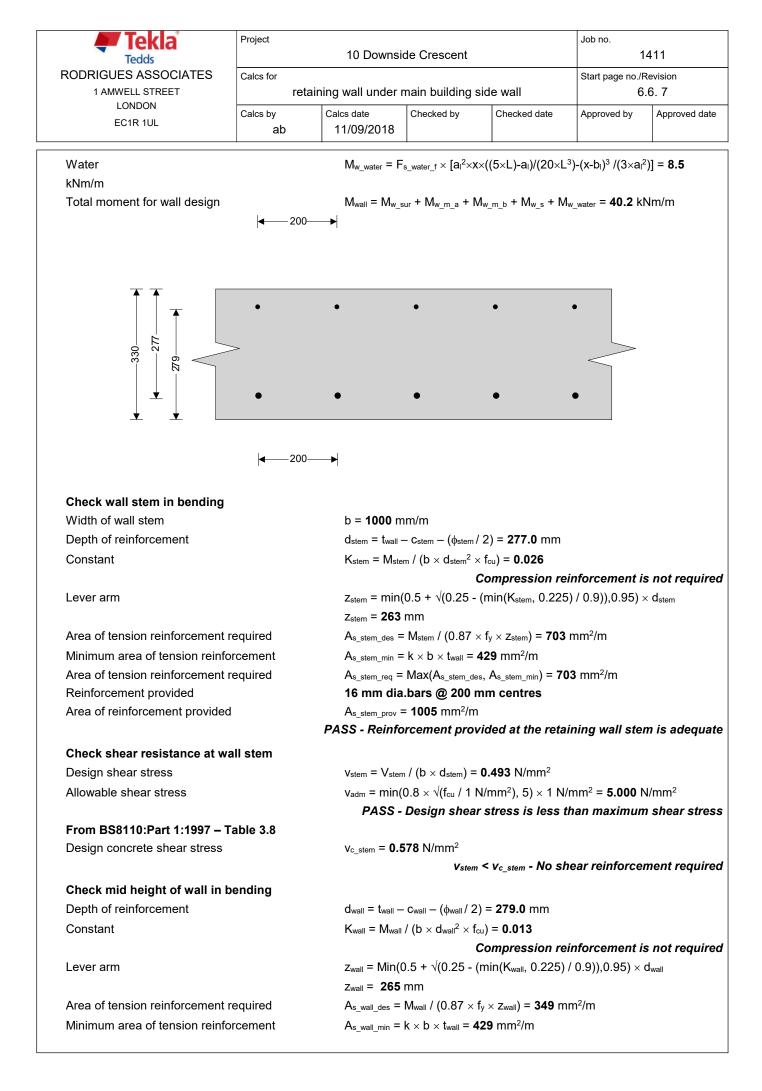
Propping force to base of wall

$$\begin{split} F_{prop\_top} = (M_{ot} - M_{rest} + R \times I_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = \textbf{37.140} \text{ kN/m} \\ F_{prop\_base} = F_{prop} - F_{prop\_top} = \textbf{48.829} \text{ kN/m} \end{split}$$

	Project	10 Downsi	de Crescent		Job no. 1	411			
RODRIGUES ASSOCIATES 1 AMWELL STREET	Calcs for	taining wall under r	main building s	side wall	Start page no./F	Revision .6. 4			
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved da			
RETAINING WALL DESIGN (I	3S 8002:1994	)			TEDDS calculatio	n version 1.2.0 <sup>4</sup>			
Ultimate limit state load facto	ors								
Dead load factor		γ <sub>f_d</sub> = <b>1.4</b>							
Live load factor		γ <sub>f_1</sub> = <b>1.6</b>							
Earth and water pressure facto	r	γ <sub>f_e</sub> = <b>1.4</b>							
Factored vertical forces on w	/all								
Wall stem		$W_{wall_f} = \gamma_{f_d}$	$\times \; h_{\text{stem}} \times t_{\text{wall}} \times$	$\gamma_{\text{wall}}$ = 33.8 kN/r	n				
Wall base		$W_{base_f} = \gamma_{f_c}$	$1  imes I_{base}  imes t_{base}$	× γ <sub>base</sub> = <b>13</b> kN/n	า				
Applied vertical load		$W_{v_f} = \gamma_{f_d}$	${}^{\scriptstyle <}$ W <sub>dead</sub> + ${}^{\scriptstyle \gamma f\_l}$ ${}^{\scriptstyle \times}$	W <sub>live</sub> = <b>120.7</b> kN	/m				
Total vertical load		$W_{total_f} = w_w$	<sub>vall_f</sub> + W <sub>base_f</sub> +	W <sub>v_f</sub> = <b>167.4</b> kN/	′m				
Factored horizontal at-rest for	orces on wall								
Surcharge		$F_{sur_f} = \gamma_{f_l} >$	Ko × Surchar	ge × h <sub>eff</sub> = <b>95.3</b> k	N/m				
Moist backfill above water table	e	F <sub>m_a_f</sub> = γ <sub>f_e</sub>	$\times \ 0.5 \times K_0 \times \gamma_1$	m × (h <sub>eff</sub> - h <sub>water</sub> ) <sup>2</sup> :	= <b>2.1</b> kN/m				
Moist backfill below water table	;	$F_{m_b_f} = \gamma_{f_e}$	$F_{m\_b\_f} = \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = 25.7 \text{ kN/m}$						
Saturated backfill		$F_{s_{1}} = \gamma_{f_{e}} \times 0.5 \times K_{0} \times (\gamma_{s} - \gamma_{water}) \times h_{water}^{2} = 43.7 \text{ kN/m}$							
Water		$F_{water_f} = \gamma_{f_e} \times 0.5 \times h_{water}^2 \times \gamma_{water} = 61.8 \text{ kN/m}$							
Total horizontal load				' n_b_f + Fs_f + Fwate		n			
Calculate total propping forc	۵	_			-				
Passive resistance of soil in fro		$F_{p,f} = \gamma_{f,q,X}$	$0.5 \times K_{\rm e} \times \cos$	$\mathbf{s}(\delta_{b})  imes (d_{cover} + t_{ball})$	$d_{da} = d_{da}$	x Vmb = 52			
kN/m		· p_i /i_e ^	0.0 / 14 / 000						
Propping force		Fprop f = ma	X(Ftotal f - Fp f -	• ( $W_{total_f}$ - $\gamma_{f_l} \times W$	$I_{\rm live}$ ) × tan( $\delta_{\rm b}$ ). 0	kN/m)			
11 5		F <sub>prop_f</sub> = 169		(					
Factored overturning momer	nts								
Surcharge		Msur f = Fsur	$f \times (h_{eff} - 2 \times 0)$	d <sub>ds</sub> ) / 2 = <b>166.9</b> k	Nm/m				
Moist backfill above water table	9			× h <sub>water</sub> - 3 × d <sub>ds</sub> ) /		n			
Moist backfill below water table			$M_{m\_b\_f} = F_{m\_b\_f} \times (h_{water} - 2 \times d_{ds}) / 2 = 38.6 \text{ kNm/m}$						
Saturated backfill		$M_{s f} = F_{s f} \times (h_{water} - 3 \times d_{ds}) / 3 = 43.7 \text{ kNm/m}$							
Water			$M_{water_f} = F_{water_f} \times (h_{water} - 3 \times d_{ds}) / 3 = 61.8 \text{ kNm/m}$						
Total overturning moment		$M_{ot_f} = M_{sur_f} + M_{m_a_f} + M_{m_b_f} + M_{s_f} + M_{water_f} = 317.8 \text{ kNm/m}$							
Restoring moments		orsui_	<u>a_</u> i · wi	<u>-</u>					
Wall stem		M		(2) - <b>27 5</b> kNm/	m				
Wall base			$M_{\text{wall}f} = W_{\text{wall}f} \times (I_{\text{toe}} + t_{\text{wall}} / 2) = 27.5 \text{ kNm/m}$						
			$M_{base_f} = W_{base_f} \times I_{base} / 2 = 6.3 \text{ kNm/m}$						
Design vertical load Total restoring moment		$M_{v_f} = W_{v_f} \times I_{load} = 98.3 \text{ kNm/m}$ $M_{rest_f} = M_{wall_f} + M_{base_f} + M_{v_f} = 132.2 \text{ kNm/m}$							
-		ivirest_t – iViwa	an_t ' IVIbase_t + I	$v_1 - 132.2 \text{ KINII}$	1/111				
Factored bearing pressure									
Total vertical reaction		-	= <b>167.4</b> kN/m						
Distance to reaction		-	/ 2 = <b>490</b> mm	- 0 mm					
Eccentricity of reaction		ef – abs((lba	ase / 2) - X <sub>bar_f</sub> ) :		s within middle	third of h			
Bearing pressure at toe		$n_{\rm max} = (P_{\rm c})$	(6 v P						
Bearing pressure at heel		$p_{toe_f} = (R_f / I_{base}) - (6 \times R_f \times e_f / I_{base}^2) = 170.8 \text{ kN/m}^2$ $p_{toe_f} = (R_f / I_{base}) + (6 \times R_f \times e_f / I_{base}^2) = 170.8 \text{ kN/m}^2$							
	$p_{heel_f} = (R_f / I_{base}) + (6 \times R_f \times e_f / I_{base}^2) = 170.8 \text{ kN/m}^2$ rate = ( $p_{track} \in p_{heal}$ () ( $h_{hase} = 0.00 \text{ kN/m}^2/m$								
Rate of change of base reaction		rate = (p <sub>toe_f</sub> - p <sub>heel_f</sub> ) / I <sub>base</sub> = <b>0.00</b> kN/m²/m p <sub>stem_toe_f</sub> = max(p <sub>toe_f</sub> - (rate × I <sub>toe</sub> ), 0 kN/m²) = <b>170.8</b> kN/m²							

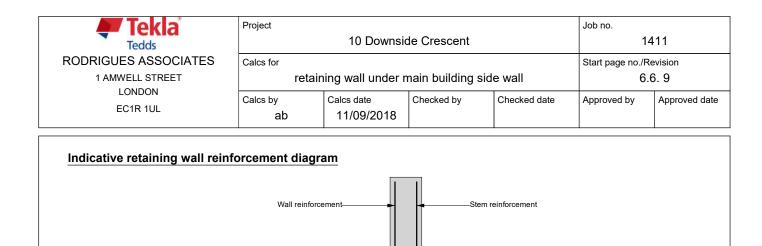
Tedds	Project	10 Downsi	de Crescent		Job no.	411		
RODRIGUES ASSOCIATES	Calcs for ret	aining wall under i	ning wall under main building side wall 6.6. 5					
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved		
Bearing pressure at mid stem		p <sub>stem_mid_f</sub> =	max(p <sub>toe_f</sub> - (ra	$te \times (I_{toe} + t_{wall} / 2)$	)), 0 kN/m²) = ′	170.8 kN/		
Bearing pressure at stem / hee	1	$p_{stem\_heel\_f} =$	max(p <sub>toe_f</sub> - (ra	ate × ( $I_{toe}$ + $t_{wall}$ )),	0 kN/m²) = <b>17(</b>	<b>).8</b> kN/m <sup>2</sup>		
Calculate propping forces to Propping force to top of wall	top and base	of wall						
	F <sub>prop_top_f</sub> =	= (M <sub>ot_f</sub> - M <sub>rest_f</sub> + R	$_{\rm f}  imes$ I <sub>base</sub> / 2 - F <sub>pr</sub>	$_{ m op_f}  imes t_{ m base}$ / 2) / (h	Istem + t <sub>base</sub> / 2)	= 70.798		
Propping force to base of wall		F <sub>prop_base_f</sub> =	Fprop_f - Fprop_t	<sub>op_f</sub> = <b>98.969</b> kN/i	n			
Design of reinforced concret	e retaining wa	all toe (BS 8002:1	994 <u>)</u>					
Material properties								
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/r	nm²					
Characteristic strength of reinfo	prcement	f <sub>y</sub> = <b>500</b> N/r	mm²					
Base details								
Minimum area of reinforcemen	t	k = <b>0.13</b> %						
Cover to reinforcement in toe		c <sub>toe</sub> = <b>45</b> m	m					
Calculate shear for toe desig	n							
Shear from bearing pressure				$_{f}) \times I_{toe} / 2 = 111$				
Shear from weight of base			$V_{toe_wt_base} = \gamma_{f_d} \times \gamma_{base} \times I_{toe} \times t_{base} = 8.6 \text{ kN/m}$					
Total shear for toe design		V <sub>toe</sub> = V <sub>toe_bear</sub> - V <sub>toe_wt_base</sub> = <b>102.4</b> kN/m						
Calculate moment for toe de	-							
Moment from bearing pressure		_ 、	$\begin{split} M_{toe\_bear} &= (2 \times p_{toe\_f} + p_{stem\_mid\_f}) \times (I_{toe} + t_{wall} / 2)^2 / 6 = \textbf{56.7 kNm/m} \\ M_{toe\_wt\_base} &= (\gamma_{f\_d} \times \gamma_{base} \times t_{base} \times (I_{toe} + t_{wall} / 2)^2 / 2) = \textbf{4.4 kNm/m} \end{split}$					
Moment from weight of base Total moment for toe design				t <sub>base</sub> × (I <sub>toe</sub> + t <sub>wall</sub> / <sub>e</sub> = <b>52.3</b> kNm/m	2) <sup>2</sup> / 2) = <b>4.4</b> k	Nm/m		
400	•	•	•	•	•			
400	->   <b>4</b> 200	•	•	•	•			
Check toe in bending	->   <b>←</b> 200	•	•	·	•			
Check toe in bending Width of toe	►   <b>4</b> 200	b = <b>1000</b> m		•	•			
Check toe in bending Width of toe Depth of reinforcement	->   <b>←</b> 200	b = <b>1000</b> m d <sub>toe</sub> = t <sub>base</sub> -	- c <sub>toe</sub> – ( <sub>\$toe</sub> / 2)		•			
Check toe in bending Width of toe	->   <b>∢</b> 200	b = <b>1000</b> m d <sub>toe</sub> = t <sub>base</sub> -	$- c_{toe} - (\phi_{toe} / 2)$ $f'(b \times d_{toe}^2 \times f_{cu})$	) = 0.011	•			
Check toe in bending Width of toe Depth of reinforcement Constant	->   <b>←</b> 200	b = <b>1000</b> m d <sub>toe</sub> = t <sub>base</sub> - K <sub>toe</sub> = M <sub>toe</sub> /	$- c_{toe} - (\phi_{toe} / 2)$ $f'(b \times d_{toe}^2 \times f_{cu})$	) = 0.011 Compression re		-		
Check toe in bending Width of toe Depth of reinforcement	->   <b>∢</b> 200	$b = 1000 m$ $d_{toe} = t_{base} - K_{toe} = M_{toe} / Z_{toe} = min(0)$	$-c_{toe} - (\phi_{toe} / 2)$ $/ (b \times d_{toe}^2 \times f_{cu})$ $0.5 + \sqrt{(0.25 - (b^2)^2)}$	) = 0.011		-		
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm		$b = 1000 \text{ m}$ $d_{toe} = t_{base} - K_{toe} = M_{toe} / Z_{toe} = min(C_{z_{toe}} = 332 \text{ m})$	- c <sub>toe</sub> - ( $\phi_{toe}$ / 2) / (b × d <sub>toe</sub> <sup>2</sup> × f <sub>cu</sub> 0.5 + √(0.25 - ( nm	) = <b>0.011</b> Compression re min(K <sub>toe</sub> , 0.225) /	0.9)),0.95) × d	-		
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement	required	$b = 1000 \text{ m}$ $d_{toe} = t_{base} - K_{toe} = M_{toe} / Z_{toe} = min(C_{toe} = 332 \text{ m})$ $A_{s_toe_des} = min(C_{toe} = 322 \text{ m})$	$c_{\text{toe}} - (\phi_{\text{toe}} / 2) / (b \times d_{\text{toe}}^2 \times f_{\text{cu}}) / (b \times d_{\text{toe}}^2 \times f_{\text{cu}}) / (0.25 + \sqrt{(0.25 - (m_{\text{nm}}))} / (0.87 \times f_{\text{su}}) / ($	) = <b>0.011</b> Compression re min(K <sub>toe</sub> , 0.225) / , × z <sub>toe</sub> ) = <b>363</b> mn	0.9)),0.95) × d	-		
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement Minimum area of tension reinforcement	required	$b = 1000 \text{ m}$ $d_{toe} = t_{base} - K_{toe} = M_{toe} / K_{toe} = M_{toe} / K_{toe} = M_{toe} / K_{toe} = 332 \text{ m}$ $A_{s\_toe\_des} = A_{s\_toe\_des} = A_{s\_toe\_min} = K_{s\_toe\_min} = K_{s$	$\begin{aligned} -c_{toe} - (\phi_{toe} / 2) \\ (b \times d_{toe}^2 \times f_{cu}) \\ 0.5 + \sqrt{(0.25 - (mmm))} \\ M_{toe} / (0.87 \times f_y) \\ k \times b \times t_{base} = \xi \end{aligned}$	) = <b>0.011</b> Compression re min(K <sub>toe</sub> , 0.225) / , × z <sub>toe</sub> ) = <b>363</b> mn 520 mm <sup>2</sup> /m	0.9)),0.95) × d n²/m	-		
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement	required	$b = 1000 \text{ m}$ $d_{toe} = t_{base} - K_{toe} = M_{toe} / K_{toe} = M_{toe} / K_{toe} = M_{toe} / K_{toe} = 332 \text{ m}$ $A_{s_toe_des} = A_{s_toe_des} = A_{s_toe_min} = A_{s_toe_req} = 1$	$\begin{aligned} -c_{toe} - (\phi_{toe} / 2) \\ (b \times d_{toe}^2 \times f_{cu}) \\ 0.5 + \sqrt{(0.25 - (mmm))} \\ M_{toe} / (0.87 \times f_y) \\ k \times b \times t_{base} = \xi \end{aligned}$	) = <b>0.011</b> Compression re min(K <sub>toe</sub> , 0.225) / , × z <sub>toe</sub> ) = <b>363</b> mn 520 mm <sup>2</sup> /m A <sub>s_toe_min</sub> ) = <b>520</b> n	0.9)),0.95) × d n²/m	-		

	Project	10 Downs	de Crescent		Job no. 1	411			
RODRIGUES ASSOCIATES	Calcs for		Start page no./Revision						
1 AMWELL STREET	ret	taining wall under	aining wall under main building side wall			6.6. 6			
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved of			
		PASS - Reir	oforcement pr	ovided at the re	taining wall to	ne is adequ			
Check shear resistance at to	Δ								
Design shear stress	C .	Vtoe = Vtoe /	(b × d <sub>toe</sub> ) = 0.2	2 <b>94</b> N/mm <sup>2</sup>					
Allowable shear stress				N/mm²), 5) × 1 N	/mm <sup>2</sup> = <b>5.000</b> N	N/mm <sup>2</sup>			
				r stress is less t					
From BS8110:Part 1:1997 - 1	able 3.8		g.						
Design concrete shear stress		v <sub>c_toe</sub> = <b>0.4</b>	<b>17</b> N/mm²						
			Vt	<sub>pe</sub> < v <sub>c_toe</sub> - No sl	hear reinforce	ment requ			
Design of reinforced concret	e retaining w	all stem (BS 8002	.1994)						
	o rotannig w								
Material properties Characteristic strength of conc	roto	f <sub>cu</sub> = <b>40</b> N/r	mm <sup>2</sup>						
Characteristic strength of reinfo		$f_v = 500 \text{ N/}$							
-	oroement	ly = 000 llv							
Wall details	4	k = 0.42.0/							
Minimum area of reinforcement Cover to reinforcement in stem		k = 0.13 %							
Cover to reinforcement in wall	I		c <sub>stem</sub> = <b>45</b> mm c <sub>wall</sub> = <b>45</b> mm						
-									
Factored horizontal at-rest fo	orces on stem			and the t		1/100			
Surcharge	_			$arge \times (h_{eff} - t_{base})$					
Moist backfill above water table				$\gamma_m \times (h_{eff} - t_{base} - t_{base})$	-				
Moist backfill below water table	9			h <sub>eff</sub> - t <sub>base</sub> - d <sub>ds</sub> - h		3 KN/M			
Saturated backfill			$F_{s\_s\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times (\gamma_{s-} \gamma_{water}) \times h_{sat}^2 = 32.8 \text{ kN/m}$ $F_{s\_water\_f} = 0.5 \times \gamma_{f\_e} \times \gamma_{water} \times h_{sat}^2 = 46.4 \text{ kN/m}$						
Water		Fs_water_f = (	$0.5  imes \gamma_{f_e}  imes \gamma_{wate}$	<sub>er</sub> × h <sub>sat</sub> ² = <b>46.4</b> kľ	N/m				
Calculate shear for stem des	ign								
Surcharge			$\times F_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_$						
Moist backfill above water table			~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	$5 \times L^2$ ) - $b_1^2$ ) / (5 >	,	n			
Moist backfill below water table	9		$V_{s_m_b_f} = F_{s_m_b_f} \times (8 - (n^2 \times (4 - n))) / 8 = 16 \text{ kN/m}$						
Saturated backfill			$V_{s_s_f} = F_{s_s_f} \times (1 - (a_i^2 \times ((5 \times L) - a_i) / (20 \times L^3))) = 27.9 \text{ kN/m}$						
Water			$V_{s\_water_f} = F_{s\_water_f} \times (1 - (a_i^2 \times ((5 \times L) - a_i) / (20 \times L^3))) = 39.5 \text{ kN/m}$						
Total shear for stem design		$V_{stem} = V_{s_s}$	$sur_f + V_{s_m_a_f} +$	$V_{s_m_b_f} + V_{s_s_f}$	+ V <sub>s_water_f</sub> = <b>13</b> 0	6.5 kN/m			
Calculate moment for stem of	lesign								
Surcharge		$M_{s\_sur} = F_{s\_}$	_sur_f × L / 8 <b>= 3</b>	<b>4.8</b> kNm/m					
Moist backfill above water table	е	$M_{s_m_a} = F_s$	$M_{s\_m\_a} = F_{s\_m\_a\_f} \times b_I \times ((5 \times L^2) - (3 \times b_I^2)) / (15 \times L^2) = 0.4 \text{ kNm/m}$						
Moist backfill below water table	9	$M_{s_m_b} = F_{s_m_b_f} \times a_I \times (2 - n)^2 / 8 = 10.4 \text{ kNm/m}$							
Saturated backfill		$M_{s_s} = F_{s_s_f} \times a_{l} \times ((3 \times a_{l}^2) - (15 \times a_{l} \times L) + (20 \times L^2))/(60 \times L^2) = 14.5 \text{ kNm/m}$							
Water		$M_{s_water} = F$	$M_{s\_water} = F_{s\_water_f} \times a_l \times ((3 \times a_l^2) - (15 \times a_l \times L) + (20 \times L^2))/(60 \times L^2) = 20.4$						
kNm/m									
Total moment for stem design		M <sub>stem</sub> = M <sub>s</sub> _	<sub>_sur</sub> + M <sub>s_m_a</sub> + N	$M_{s_m_b} + M_{s_s} + M_{s_s}$	s_water <b>= 80.4</b> kN	Nm/m			
Calculate moment for wall de	esign								
Surcharge		M <sub>w_sur</sub> = 9 :	$\times F_{s\_sur\_f} \times L / 1$	28 = <b>19.6</b> kNm/n	n				
Moist backfill above water table	Э	$M_{w_m_a} = F_{e}$	s_m_a_f × 0.577>	 ⟨bı×[(bı³+5×aı×L²),	/(5×L <sup>3</sup> )-0.577 <sup>2</sup> /	3] = <b>0.5</b>			
kNm/m									
Moist backfill below water table	e	$M_{w_m_b} = F_{e}$	$s_m_b_f \times a_l \times [((a_l))]$	8-n²×(4-n))² /16)-	4+n×(4-n)]/8 =	5.7 kNm/m			
Saturated backfill		M - E	··· [0.2.vv///5.v	L)-a <sub>l</sub> )/(20×L <sup>3</sup> )-(x-l	$h_{1}^{3}/(3 \times a^{2}) = 6$	kNm/m			



	Project 10 Downside Crescent					Job no. 1411	
RODRIGUES ASSOCIATES	Calcs for reta	aining wall under	main building s	side wall	Start page no./l 6	Revision .6. 8	
LONDON EC1R 1UL	Calcs by ab	Calcs date 11/09/2018	Checked by	Checked date	Approved by	Approved date	
Area of tension reinforcement	required	A <sub>s_wall_req</sub> =	Max(As_wall_des,	, A <sub>s_wall_min</sub> ) = <b>429</b>	mm²/m		

Reinforcement provided	12 mm dia.bars @ 200 mm centres
Area of reinforcement provided	A <sub>s_wall_prov</sub> = <b>565</b> mm <sup>2</sup> /m
	PASS - Reinforcement provided to the retaining wall at mid height is adequate
Check retaining wall deflection	
Basic span/effective depth ratio	ratio <sub>bas</sub> = <b>20</b>
Design service stress	$f_s = 2 \times f_y \times A_{s\_stem\_req} / (3 \times A_{s\_stem\_prov}) = 233.0 \text{ N/mm}^2$
Modification factor fac	$tor_{tens} = min(0.55 + (477 \text{ N/mm}^2 - f_s)/(120 \times (0.9 \text{ N/mm}^2 + (M_{stem}/(b \times d_{stem}^2)))),2) = 1.59$
Maximum span/effective depth rati	io ratio <sub>max</sub> = ratio <sub>bas</sub> × factor <sub>tens</sub> = <b>31.88</b>
Actual span/effective depth ratio	ratio <sub>act</sub> = h <sub>stem</sub> / d <sub>stem</sub> = <b>11.19</b>
	PASS - Span to depth ratio is acceptable



Toe bars - 12 mm dia.@ 200 mm centres - (565 mm<sup>2</sup>/m) Wall bars - 12 mm dia.@ 200 mm centres - (565 mm<sup>2</sup>/m) Stem bars - 16 mm dia.@ 200 mm centres - (1005 mm<sup>2</sup>/m)

Toe reinforcement-

# Annex A - Structural methodology

# Introduction

This document sets out the structural methodology for the construction of the basement at 10, Downside Crescent.

# **Details of the stages**

This methodology refers to the drawings 1411-31 and 32, which are included in the drawings package. Reference should also be made to the other drawings in the contract.

### **PRE SITE START**

1. Install monitoring positions on walls and do baseline survey. Monitoring to be carried out in accordance with movement monitoring specification thereafter, during structural works.

#### UNDERPINNING OF MAIN BUILDING PARTY AND PERIMETER WALLS

- 2. Saw cut any existing ground floor screed, where it is present, to its full depth parallel to the party wall with No.8 as close to it as feasible and remove the portion against the party wall to limit vibration born noise through the party wall during demolition.
- 3. Demolish side infill with party wall toward No.12, observing the main house walls for any movement as demolition proceeds.
- 4. Install underpinning to the party wall with No.8 and under main building walls where indicated on plan, in an agreed sequence.
- 5. Only ASUC registered underpinning specialists to be used to carry out the work.
- 6. Excavate for the pin, each excavation to be no more than 1 m wide. Excavations to be temporarily shored as they progress down in accordance with good practice. The line of the rear face of the excavation under the party wall is to be carefully set out to be at the face of the adjoining owner's wall above (allowing for the corbel to overhang). The rear face is to be shored with sacrificial cement board shutters. A lean mix cementitious grout is to be poured down the back of these boards as they are placed to fill any voids.
- 7. Carefully remove any existing mass concrete footing if present, clean off the underside of the existing original footing and repair any damaged brickwork.
- 8. Clean and blind the base of the excavation, put in the reinforcement and cast the toe and kicker of the pin with continuity reinforcement pushed into the surrounding soil to give the required lap for the next pins or using couplers.
- 9. To allow for continuity of the reinforced concrete in the wall and suspended slab, carefully saw cut a section of the brickwork vertically on the line of the party wall boundary at the centre of the wall. The use of percussion tools to remove the brickwork will not be permitted.
- 10. Reinforce the pin and cast the wall up to 75mm below the footing level or underside of prepared brickwork, with continuity reinforcement or couplers as for its toe.
- 11. Dry pack the back half of the pin to the underside of the brickwork.
- 12. Cast the small remaining section of the front half of the pin.
- 13. Dry pack the front half of the pin to the underside of the cut brickwork.

14. Leave excavation to pin fully shored and proceed with the next pin in the sequence.

### CONSTRUCTION OF REAR EXTENSION BASEMENT WALLS

- 15. Where rear extension basement external walls will be constructed insert steel trench sheeting into ground as excavation moves down maintaining sheeting fully propped with wailers and adjustable steel jacks in accordance with good practice.
- 16. Clean and blind the base of the excavation, put in the reinforcement and cast the toe and kicker of the rear basement external walls with continuity reinforcement for basement slab provided by couplers.
- 17. When the concrete has gained enough strength place reinforcements and cast external walls in sequence up to the underside of the future ground floor slab. Timbering and propping of trenches will be moved to suit the pouring sequence.

#### **EXCAVATION AND COMPLETION OF BASEMENT**

- 18. Install temporary needles and steelwork to support back and internal walls of the main building prior to commencing excavation of basement area. Dig local pit or trenches if necessary to allow construction of temporary pad or strip foundation at basement level to support temporary props. Excavations to be temporarily shored as they progress down in accordance with good practice.
- 19. Excavate to 1000mm below existing ground floor level removing the top level of shoring to the underpinning and main retaining walls.
- 20. Install the high level propping and waling below the underside of the proposed concrete ground floor slab. Resin anchor wailing beams to retaining walls using threaded bars to secure positioning. NOTE Contractor to set out and split the beams, providing robust end plate and bolted splice connections to suit their manual handling requirements.
- 21. Reduce excavation to 1000mm above proposed basement slab removing the inner shoring down to the level of the excavation only and keeping the bottom shoring in place.
- 22. Locally excavate trenches max 400mm wide to the top of basement slab level across the central mound. Put low level of propping against main building and rear extension perimeter walls, just above the proposed slab level. NOTE Contractor to set out and split the beams, providing robust end plate and bolted splice connections to suit their manual handling requirements.
- 23. Complete excavation inside to basement slab formation level.
- 24. Lay blinding concrete, place reinforcement, and wall starter bars.
- 25. Cast basement slab with any drainage channels if necessary.
- 26. When basement slab concrete has reached strength, remove the low level propping and waling beams.
- 27. Place reinforcement, formwork and cast any internal reinforced concrete wall.
- 28. Place soffit formwork, reinforcement and cast ground floor slab, with boxouts for any temporary work.
- 29. When the concrete reaches strength remove high level propping in basement.
- 30. Dry-pack to the underside of the existing walls and over the new concrete basement structure where necessary.

- 31. Remove temporary needles and steel work supporting structure; fill in any boxout.
- 32. Install drained cavity.
- 33. Construct rear extension superstructure.
- 34. Complete the construction and fitting out.

# Removal of water during excavation for rear extension basement

The Basement Impact Assessment Report shows that significant groundwater inflows should not be encountered on this site, however perched water inflows may be encountered from the made ground and underlying Head Deposits.

Arup's Subterranean Development Scoping Study (para 5.1) June 2008, notes that the impact of subterranean development on groundwater flows is negligible as groundwater flows will find an alternative route if blocked by a subterranean structure.

If ground water is encountered during the course of excavation a localised excavated sump pit is to be formed in the trench at a lower level than the progressive base of excavation being carried out.

A timber perforated plywood shell is to be constructed to support the perimeter of the temporary working sump and placed within the excavated zone.

Any ground water which is present will naturally pull within the sump area and at this point a 50mm dia semi-trash water pump unit is to be introduced with a 50mm dia discharge hose.

Once located adjacent to the excavation level sump, the solids pump hose is to be routed to the nearest adjacent manhole for discharge.

To avoid excessive loss of fines in the adjacent ground and other destabilizing effects on soil, the project engineer will be informed if pumping is required for more than a day after rain fall.

# Annex B – Movement monitoring specification

# 1. Introduction

The purpose of this specification is to outline the requirements for a movement monitoring system that will measure movements during underpinning and basement excavation works. Movements of the owners' property and the neighbouring property, No.8 Downside Crescent and No.12 Downside Crescent will be monitored.

# 2. Installation

### 2.1. Control

Monitoring control stations are to be established around the site perimeter from which the monitoring targets can be surveyed. Additional control survey targets are to be placed outside the site's zone of influence and accurately fixed in 3 dimensions. These targets will be used to establish station coordinates prior to each survey.

### 2.2. Reflective targets

Monitoring points are to be installed as per the attached sketches. Exact locations are to be adjusted to ensure line of sight from survey stations. Targets are to be attached to walls using epoxy adhesive.

### 2.3. Tilt meters

Wireless high precision tilt sensors transmit data to the monitoring provider's office over an internet connection and can be published to a web portal with automatic alerts to the contractor at trigger levels. No tilt meters on party walls are suggested.

### 2.4. Precise levels

Precise level monitoring points are to be installed below each tilt-meter to monitor precise vertical movement. These are to be done head ball studs resin anchored into the wall.

# 3. Monitoring

### 3.1. Reflective Targets

These are to be surveyed using two rounds of angles for each survey point and recorded. Any large deviations are to be immediately reported to the contractor.

### **3.2. Precise levels**

Precise levelling points are to be levelled based on benchmarks and levelling runs should be based on closed loops. Any closures greater than 1mm will require measurements to be repeated.

# 4. Monitoring frequency

Monitoring is to commence during site establishment. The initial set of baseline readings should be taken minimum 1 month before commencement of any significant structural works and then a first set of readings should be taken immediately prior to the start of any groundworks.

Thereafter monitoring should be carried out weekly during underpinning, excavation, temporary shoring, and concrete basement box construction. Once basement works are complete including the removal of all temporary works a set of readings should be taken followed by 3 more sets at intervals of 1 month.

# 5. Trigger values

Trigger levels for neighbouring property and party wall monitoring are set as follows;

#### Vertical settlement

Threshold value is 75% of trigger value – Report to all parties. Contractor to check walls in the vicinity of the monitoring point and report any new cracking. If cracks are evident, then crack monitors are to be installed and reported on weekly. Engineer to check relative settlement from neighbouring monitoring points and determine if any further action is required.

Action values are reported in the attached plan – Stop work and report to all parties. Contractor to check walls in the vicinity of the monitoring point and report on any cracking. Engineer to check relative settlement from neighbouring monitoring points and determine what action is required.

#### Tilt

Threshold alert value 1/500 – Automatic alert issued to contractor who is to alert all parties. Contractor to check party wall for any visible defects. Engineer to determine if any further action is required.

Threshold alert value 1/350 – Automatic alert issued to contractor who is to alert all parties and stop work. Contractor to check party wall for any visible defects. Engineer to determine what further action is required.

Trigger levels for areas other than the neighbouring property and party wall are set as follows;

#### Vertical settlement

Threshold value 3mm – Report to all parties. Contractor to check walls in the vicinity of the monitoring point and report any new cracking. If cracks are evident, then crack monitors are to be installed and reported on weekly. Engineer to check relative settlement from neighbouring monitoring points and determine if any further action is required.

Action value 4mm – Stop work and report to all parties. Contractor to check walls in the vicinity of the monitoring point and report on any cracking. Engineer to check relative settlement from neighbouring monitoring points and determine what action is required.

#### Horizontal movement

Threshold value 4mm – Report to all parties. Contractor to check walls in the vicinity of the monitoring point and report any new cracking. If cracks are evident, then crack monitors are to be installed and reported on weekly. Engineer to check relative movement from neighbouring monitoring points and determine if any further action is required.

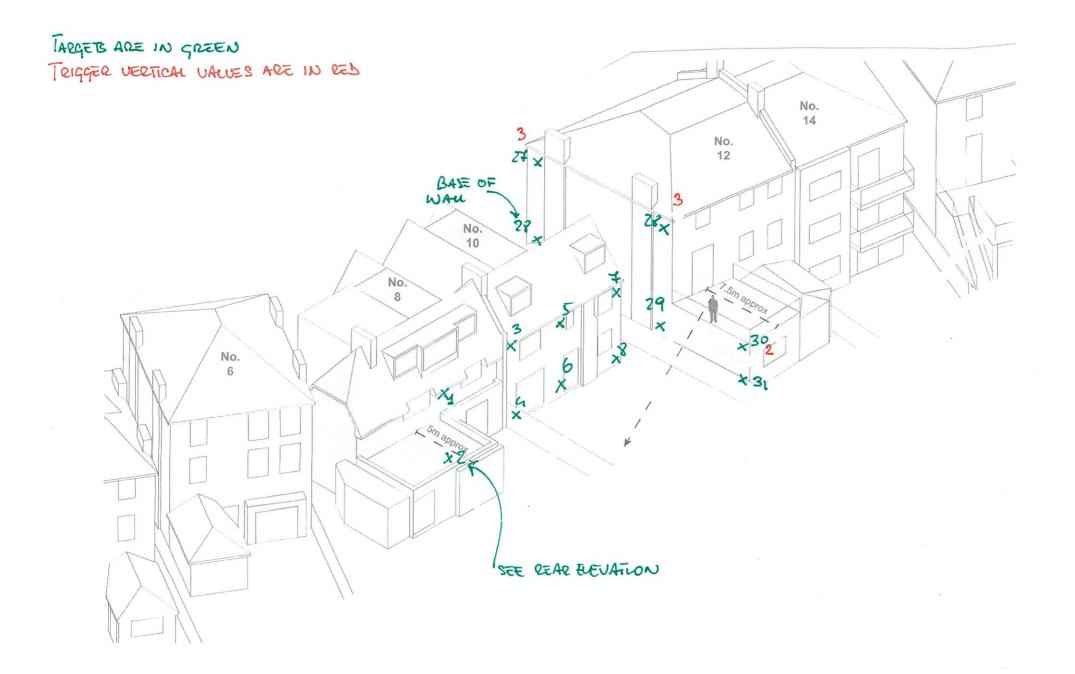
Action value 6mm – Stop work and report to all parties. Contractor to check walls in the vicinity of the monitoring point and report on any cracking. Engineer to check relative movement from neighbouring monitoring points and determine what action is required.

# 6. Reporting

The reporting will be provided in PDF format.

Each report will contain the following information:

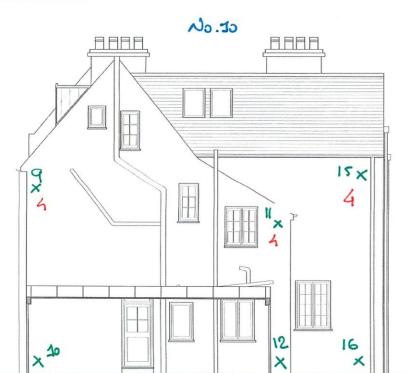
- Executive Summary
- Date of survey,
- Weather conditions during survey,
- Surveyor responsible for the survey.
- Applicable notes and accuracies
- Tabular data highlighting exceeding specified trigger limits.
- Graphs showing vertical and horizontal movements with time.
- Location plans



# TARGETS ARE IN GREEN

TRIGGER USRIICH VALUES ARE IN AED





NI.

Existing Rear Elevation

EXISTING Side Elevation SCALE 1:100@A3 EX-02

