# wsp

# 4 DELIVERY OPENING STEELWORK

# 4.1 LOAD TAKEDOWN OF EXISTING COLUMNS

A full load takedown check has been completed in order to determine the axial load in the existing columns which are to be removed to allow for the MRI scanner delivery entrance, this has been based on existing structural information and drawings.





## **SECTION BETWEEN GRIDLINE 8&9**

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Project Bir	kbeck Unive	rsity - MRI	Status INFORMATION		\\\\)	
Date 9 By PG Checked N	/01/18  P	Job no. 70038590	Section	Sheet no.	Rev 01	
Rev	Date Details	-d Tukedou	mn Analy	2553		Tel Fax
Part	Removal og	2 Colum	ins dor	MRI	nst-lla	tion

REF		OUTPUT
	7 Floors above, plus roug level	
(PL +)	Road DL= 7.0 KN/m2 SDL=0.35 KN/m2 11= 500 KN/m2	
FI LANDI		
(ogrice)	Lv5 DL= 8.4 k N/m SDL=0.85 k N/m LL= 3.5 k N/m	
(	$h_{\rm H} = 0.570  {\rm km/m^2}  {\rm Sp}_{\rm H} = 0.85  {\rm km/m^2}  {\rm M} = 0.5  {\rm km/m^2}$	
(sffice)	LV4 DESTROMMENTA SPECOSSENTA ELSISENTA	
(oggice)	LV3 DL= 7.0 KN/m2 SDL= 035 KN/m2 LL= 3.3 KN/m	
(assisted)	$1 - 2 \text{ D} + 70 \text{ b} M/a^2 = 50 + 205 \text{ b} N/2 = 1 + 25 \text{ b} M/2^2$	
( aggice)	EV2 DECTORING SOLE GASSINNA LESSINNA	
(bygice)	Lr1 DL= 7.0 kN/m SDL= 0.85 kN/m LL= 3.5 kN/m	
C	GE NI= 70 KN (m2 SDL= 235 KN (m2 11-251)/2	
(office)	GF LL: NO MAIN 2000 0. SO MITH LL: SO KNIM	
(Library)	) LG DL= 8.4 LN/nº SDL= 0-85 KN/nº LL= 5.0 KN/nº	
	$0 > 1 \leq c > 1 > 1 > 0 \leq b > 1/2$	
	Contract Load = 2.5 RN/M	
	Lightwordt Plant Land & 500 KN /M	
	Services & Finishes = 0.85 kN/m2	
	Demountuble Partitions = 1.0 kN /n (All except Rood	)
	0.35m thh SLab: 0.35x24 = 8.4 KN/M2	
ŀ	Hollow Pot Floor Construction = $0.35 \times 20$ kN/m <sup>3</sup> = 7 kN/m <sup>2</sup>	
	1 ributary Area = 4.0 m x 1.19m = 4.76m (co	nsidered Area
	$\sim 42$	er Column)
	Dend Load = [2 x (8.4 + 0.85) x 4.8] + [6 x (7.0 + 0.85) x 4.8]	
	- 314.8 KN (	
	= ST4.0 KIN (Unjactored)	
	41.33 = 425.1 KN (jactored)	
	Live Loud = 2(5.0 x 4.8) + 6(3.5 x 4.8)	
	= 148.8  kN (unjuctored)	
	S/W of Column = 0.457 x 0.230 x 24m High x 25kN/m <sup>2</sup> - 65 kN (1 Infaction	tored)
	x 1.35 = 90kN (Factor	ed)
	". Total = 542 kN (ungactored) => 550 k	N
	(Per Column) $= 739 \text{ kN}$ (Sector 1) $\Rightarrow 750 \text{ k}$	N
	( galactored) => 130 K	

Project	roject UCLH, Birbeck University - MRI		Status Information		116	)	
Date By Checked	09/01/2018 NP MB	Job no. 70038590	Section	Sheet no. 1 Of 1	Rev 01		
Rev 01	Date 09/01/2018	Details	<u> </u>				
Part Del	ivery Openi	ing Concrete to Stee	el Through Bolts				

#### REF

OUTPUT

4No. Through Bolts are required for connection of the cut concrete columns to the steel PFC's. A total design load of 750kN per column is required to be resisted by the through bolts. As a conservative approach, it is considered that 2 x 4No. anchor bolts in each side of the column are taking 375kN each in single shear.

From the Hilti load table below, for a HIT-V-5.8 with HIT-RE 500-SD in C20/25 Concrete the design shear resistance is 112 kN per anchor.

							Hilti Hi	vith HIT	-V roc
Basic loading data (fo	r a sin	gle and	chor)		S. O. eren		20601	abnem	
All data in this section applie Correct setting (See setting No edge distance and space	es to instructions ing influe	on) ence			Fo	or details s	ee Simpli	fied desig	n metho
Steel failure Base material thickness, as	specifie	d in the ta	able						
One anchor material, as sp	ecified in	the table	es						
Temperate range I	25 N/mm	Je.							
(min. base material temper	ature -40	C, max.	long ter m	/short terr	m base m	aterial tem	nperature	+24°C/40	°C)
Installation temperature ran	nge +5°C	to +40°C							
Embedment depth <sup>a)</sup> an Mean ultimate resistand loads.	d base ce, cha	materi racteris	al thick stic resi	ness fo stance,	r the ba design	sic load resistar	ling dat nce, rec	a. commen	ded
Anchor size	newp or	M8	M10	M12	M16	M20	M24	M27	M30
Typical embedment depth [m	im]	80	90	110	125	170	210	240	270
Base material thickness [mm]	]	110	120	140	165	220	270	300	340
Mean ultimate resistan	ce: con	icrete C	20/25	- f <sub>ck,cub</sub>	e = 25 N	Vmm², a	nchor h	HIT-V 5.8	3
Mean ultimate resistan	ce: con	M8	20/25 Data	- f <sub>ck,cub</sub> accordin M12	e = 25 N g ETA-07 M16	Vmm², a //0260, iss M20	nchor H sue 2009- M24	HIT-V 5.8 01-12 M27	M30
Mean ultimate resistant Anchor size Non cracked concrete	ce: con	M8	20/25 Data M10	- f <sub>ck,cub</sub> accordin M12	e = 25 N g ETA-07 M16	Vmm², a 7/0260, iss M20	nchor H sue 2009- M24	HT-V 5.8 01-12 M27	M30
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Rum</sub> HIT-V 5.8	ce: con	M8 18,9	20/25 Data M10 30,5	- f <sub>ck,cub</sub> accordin M12 44,1	e = 25 N g ETA-07 M16 83,0	Vmm², a 7/0260, iss M20 129,2	185,9	HIT-V 5.8 01-12 M27 241,5	M30
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Rum</sub> HIT-V 5.8 Shear V <sub>Rum</sub> HIT-V 5.8	[kN]	M8 18,9 9,5	20/25 Data M10 30,5 15,8	- f <sub>ck,cub</sub> accordin M12 44,1 22,1	e = 25 N g ETA-07 M16 83,0 41,0	Vmm², a 7/0260, iss M20 129,2 64,1	185,9 92,4	HIT-V 5.8 01-12 M27 241,5 120,8	M30 295,1 147,0
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Cracked concrete	[kN]	M8 18,9 9,5	20/25 Data M10 30,5 15,8	- f <sub>ck,cub</sub> accordin M12 44,1 22,1	e = 25 N g ETA-07 M16 83,0 41,0	Vmm², a 7/0260, iss M20 129,2 64,1	185,9 92,4	HT-V 5.8 01-12 M27 241,5 120,8	M30 295,1 147,0
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Ru.m</sub> HIT-V 5.8 Shear V <sub>Ru.m</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Ru.m</sub> HIT-V 5.8	[kN] [kN]	M8 18,9 9,5 18,9	20/25 Data M10 30,5 15,8 30,5	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 44,1	e = 25 N g ETA-07 M16 83,0 41,0	Vmm², a 7/0260, iss M20 129,2 64,1 110,8	185,9 92,4 146,1	HT-V 5.8 01-12 M27 241,5 120,8 196,0	M30 295,1 147,0 226,2
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8	[kN] [kN] [kN] [kN]	M8 18,9 9,5 18,9 9,5	20/25 Data M10 30,5 15,8 30,5 15,8	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 44,1 22,1	e = 25 N g ETA-07 M16 83,0 41,0 65,2 41,0	Vmm², a 70260, iss M20 129,2 64,1 110,8 64,1	185,9 92,4 146,1 92,4	HT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8	M30 295,1 147,0 226,2 147,0
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Characteristic resistan	[kN] [kN] [kN] [kN] [kN] [ce: cor	M8 18,9 9,5 18,9 9,5 ncrete C	20/25 Data M10 30,5 15,8 30,5 15,8 20/25	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 44,1 22,1 - f <sub>ck,cub</sub>	e = 25 N g ETA-07 M16 83,0 41,0 65,2 41,0 e = 25 N	Vmm², a 70260, iss M20 129,2 64,1 110,8 64,1 Vmm², a	185,9 92,4 146,1 92,4	HIT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HIT-V 5.8	M30 295,1 147,0 226,2 147,0
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Characteristic resistan	(kN) [kN] [kN] [kN] [kN] (ce: cor	M8 18,9 9,5 18,9 9,5 ncrete C	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 44,1 22,1 - f <sub>ck,cub</sub>	be         = 25 N           g         ETA-07           M16         83,0           41,0         65,2           41,0	V/mm <sup>2</sup> , a //0260, iss M20 129,2 64,1 110,8 64,1 V/mm <sup>2</sup> , a //0260, iss	185,9 92,4 146,1 92,4 nchor H sue 2009	HIT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HIT-V 5.8 01-12	M30 295,1 147,0 226,2 147,0 3
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Characteristic resistan Anchor size	[kN] [kN] [kN] [kN] [kN] [kN]	M8 18,9 9,5 18,9 9,5 ncrete C M8	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data M10	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 44,1 22,1 - f <sub>ck,cub</sub> accordin M12	be         = 25 N           g         ETA-07           M16         83,0           41,0         65,2           41,0         65,2           41,0         65,2           9         ETA-07           M16         M16	V/mm <sup>2</sup> , a 7/0260, iss M20 129,2 64,1 110,8 64,1 V/mm <sup>2</sup> , a 7/0260, iss M20	Inchor H           sue 2009-           M24           185,9           92,4           146,1           92,4           inchor H           sue 2009-           M24	HIT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HIT-V 5.8 01-12 M27	M30 295,1 147,0 226,2 147,0 3 M30
Mean ultimate resistant Anchor size Tensile N <sub>Ru.m</sub> HIT-V 5.8 Shear V <sub>Ru.m</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Ru.m</sub> HIT-V 5.8 Shear V <sub>Ru.m</sub> HIT-V 5.8 Characteristic resistant Anchor size Non cracked concrete	[kN] [kN] [kN] [kN] [kN] [kN]	M8 18,9 9,5 18,9 9,5 ncrete C M8	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data M10	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 44,1 22,1 - f <sub>ck,cub</sub> accordin M12	be         = 25 N           g         ETA-07           M16         83,0           41,0         65,2           41,0         65,2           41,0         65,2           41,0         65,2           41,0         65,2           41,0         65,2           41,0         65,2           41,0         70,0	V/mm <sup>2</sup> , a 7/0260, iss M20 129,2 64,1 110,8 64,1 V/mm <sup>2</sup> , a 7/0260, iss M20	Inchor H           sue 2009-           M24           185,9           92,4           146,1           92,4           inchor H           sue 2009-           M24	HIT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HIT-V 5.8 01-12 M27	M30 295,1 147,0 226,2 147,0 3 M30
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Characteristic resistan Anchor size Non cracked concrete Tensile N <sub>Rk</sub> HIT-V 5.8	[kN] [kN] [kN] [kN] [kN] [kN]	M8 18,9 9,5 18,9 9,5 norrete C M8 18,0 0,0	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data M10 29,0 45,5	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 44,1 22,1 - f <sub>ck,cub</sub> accordin M12 42,0 24,0	be         = 25 N           g ETA-07         M16           83,0         41,0           65,2         41,0           be         = 25 N           op         = 25 N           og ETA-07         M16           70,6         200	Vmm², a V0260, iss M20 129,2 64,1 110,8 64,1 Vmm², a V0260, iss M20 111,9 010	185,9 92,4 146,1 146,1 92,4 146,1 146,	HIT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HIT-V 5.8 01-12 M27 187,8	M30 295,1 147,0 226,2 147,0 3 M30 224,0
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Characteristic resistan Anchor size Non cracked concrete Tensile N <sub>Ru</sub> HIT-V 5.8 Shear V <sub>Ru</sub> , HIT-V 5.8	[kN] [kN] [kN] [kN] [kN] [kN] [kN] [kN]	M8 18,9 9,5 18,9 9,5 ncrete C M8 18,0 9,0	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data M10 29,0 15,0	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 - f <sub>ck,cub</sub> accordin M12 42,0 21,0	be         = 25 N           g ETA-07         M16           83,0         41,0           65,2         41,0           65,2         41,0           be         = 25 N           op         = 25 N           m16         70,6           39,0         39,0	Vmm², a 7/0260, iss M20 129,2 64,1 110,8 64,1 V/mm², a 7/0260, iss M20 111,9 61,0	Inchor H           sue 2009-           M24           185,9           92,4           146,1           92,4           inchor H           sue 2009-           M24           153,7           88,0	HT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HT-V 5.8 01-12 M27 187,8 115,0	M30 295,1 147,0 226,2 147,0 3 M30 224,0 140,0
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Rum</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Rum</sub> HIT-V 5.8 Characteristic resistan Anchor size Non cracked concrete Tensile N <sub>Rk</sub> HIT-V 5.8 Shear V <sub>Rk</sub> HIT-V 5.8	[kN] [kN] [kN] [kN] [kN] [kN] [kN] [kN]	M8 18,9 9,5 18,9 9,5 ncrete C M8 18,0 9,0 16,1	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data M10 29,0 15,0	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 44,1 22,1 - f <sub>ck,cub</sub> accordin M12 42,0 21,0	we         = 25 N           g ETA-07         M16           83,0         41,0           65,2         41,0           65,2         41,0           we         = 25 N           wg ETA-07         M16           70,6         39,0           44.0         44.0	Vmm², a 7/0260, iss M20 129,2 64,1 110,8 64,1 V/mm², a 7/0260, iss M20 111,9 61,0 74,8	Inchor H           Sue 2009-           M24           185,9           92,4           146,1           92,4           Inchor H           Sue 2009-           M24           153,7           88,0           109,6	HT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HT-V 5.8 01-12 M27 187,8 115,0	M30 295,1 147,0 226,2 147,0 3 M30 224,0 140,0
Mean ultimate resistand Anchor size Non cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Characteristic resistan Anchor size Non cracked concrete Tensile N <sub>Rk</sub> HIT-V 5.8 Shear V <sub>Rk</sub> HIT-V 5.8 Shear V <sub>Rk</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Rk</sub> HIT-V 5.8	[kN] [kN] [kN] [kN] [kN] [kN] [kN] [kN]	M8 18,9 9,5 18,9 9,5 18,9 9,5 norrete C M8 18,0 9,0 16,1 9,0	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data M10 29,0 15,0 22,6 15,0	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 44,1 22,1 - f <sub>ck,cub</sub> accordin M12 42,0 21,0 31,1 21,0	be         = 25 N           g ETA-07         M16           83,0         41,0           65,2         41,0           65,2         41,0           be         = 25 N           op         = 25 N           og         ETA-07           M16         70,6           39,0         44,0           39,0         29,0	Vmm², a 7/0260, iss 129,2 64,1 110,8 64,1 Vmm², a 7/0260, iss 111,9 61,0 74,8 61,0	Inchor H           Sue 2009-           M24           185,9           92,4           146,1           92,4           Inchor H           Sue 2009-           M24           153,7           88,0           109,6	HT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HT-V 5.8 01-12 M27 187,8 115,0 132,3 115,0	M30 295,1 147,0 226,2 147,0 3 M30 224,0 140,0 152,7
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Characteristic resistan Anchor size Non cracked concrete Tensile N <sub>Rk</sub> HIT-V 5.8 Shear V <sub>Rk</sub> HIT-V 5.8	[kN] [kN] [kN] [kN] [kN] [kN] [kN] [kN]	M8 18,9 9,5 18,9 9,5 ncrete C M8 18,0 9,0 16,1 9,0	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data M10 29,0 15,0 22,6 15,0	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 44,1 22,1 - f <sub>ck,cub</sub> accordin M12 42,0 21,0 31,1 21,0	be         = 25 N           g ETA-07         M16           83,0         41,0           65,2         41,0           65,2         41,0           9e         = 25 N           og ETA-07         M16           70,6         39,0           44,0         39,0	Vmm², a 7/0260, iss M20 129,2 64,1 110,8 64,1 V/mm², a 7/0260, iss M20 111,9 61,0 74,8 61,0	Inchor H           Sue 2009-           M24           185,9           92,4           146,1           92,4           Inchor H           sue 2009-           M24           153,7           88,0           109,6           88,0	HT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HT-V 5.8 01-12 M27 187,8 115,0 132,3 115,0	M30 295,1 147,0 226,2 147,0 3 M30 224,0 140,0 152,7 140,0
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Characteristic resistan Anchor size Non cracked concrete Tensile N <sub>Rk</sub> HIT-V 5.8 Shear V <sub>Rk</sub> HIT-V 5.8	[kN] [kN] [kN] [kN] [kN] [kN] [kN] [kN]	M8 18,9 9,5 18,9 9,5 18,9 9,5 norrete C M8 18,0 9,0 16,1 9,0 20/25	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data M10 29,0 15,0 22,6 15,0 - fck,cu	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 - f <sub>ck,cub</sub> accordin M12 42,0 21,0 31,1 21,0 be = 25 I	we         = 25 N           g ETA-07         M16           83,0         41,0           65,2         41,0           65,2         41,0           we         = 25 N           wg ETA-07         M16           70,6         39,0           44,0         39,0           Vmm²,         Wm²,	Vmm², a 7/0260, iss M20 129,2 64,1 110,8 64,1 V/mm², a 7/0260, iss M20 111,9 61,0 74,8 61,0 anchor	Inchor H           sue 2009           M24           185,9           92,4           146,1           92,4           inchor H           sue 2009           M24           153,7           88,0           109,6           88,0           HIT-V 5	HT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HT-V 5.8 01-12 M27 187,8 115,0 132,3 115,0 8	M30 295, 1 147, 0 226, 2 147, 0 226, 2 3 M30 224, 0 140, 0 152, 7 140, 0
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Rum</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Rum</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Characteristic resistan Anchor size Non cracked concrete Tensile N <sub>Rk</sub> HIT-V 5.8 Shear V <sub>Rk</sub> HIT-V 5.8 Chasing resistance: con	[kN] [kN] [kN] [kN] [kN] [kN] [kN] [kN]	M8 18,9 9,5 18,9 9,5 18,9 9,5 norrete C M8 18,0 9,0 16,1 9,0 20/25	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data M10 29,0 15,0 22,6 15,0 - f <sub>ck,cu</sub>	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 44,1 22,1 - f <sub>ck,cub</sub> accordin M12 42,0 21,0 31,1 21,0 be = 25 I accordin	we = 25 N           g ETA-07           M16           83,0           41,0           65,2           41,0           65,2           41,0           se = 25 N           m16           70,6           39,0           44,0           39,0           Vmm², ig ETA-07	Vmm², a 70260, iss M20 129,2 64,1 110,8 64,1 Vmm², a 70260, iss M20 111,9 61,0 74,8 61,0 anchor f 70260, iss	Inchor H           sue 2009-           M24           185,9           92,4           146,1           92,4           inchor H           sue 2009-           M24           153,7           88,0           109,6           88,0           HIT-V 5           sue 2004	HT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HT-V 5.8 01-12 M27 187,8 115,0 132,3 115,0 .8 8 01-12	3 M30 295, 147, 0 226, 2, 2 147, 0 226, 2, 2 147, 0 147, 0 152, 7 140, 0 152, 7 152, 7 152, 7 152, 7 152, 7 154, 7 154
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Characteristic resistan Anchor size Non cracked concrete Tensile N <sub>Rk</sub> HIT-V 5.8 Shear V <sub>Rk</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Rk</sub> HIT-V 5.8 Characteristance: cor	(kN) (kN) (kN) (kN) (kN) (kN) (kN) (kN)	M8 18,9 9,5 18,9 9,5 18,9 9,5 norrete C M8 18,0 9,0 16,1 9,0 20/25 M8	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data M10 22,6 15,0 22,6 15,0 - f <sub>ck,cu</sub> Data M10	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 - f <sub>ck,cub</sub> accordin M12 42,0 21,0 31,1 21,0 be = 25 I accordin M12	be         = 25 N           g ETA-07         M16           83,0         41,0           65,2         41,0           65,2         41,0           be         = 25 N           op         = 25 N           op         = 25 N           op         = 25 N           op         = 70,6           39,0         44,0           Vmm², i         op           op         ETA-07           M16         100	Vmm², a 7/0260, iss 129,2 64,1 110,8 64,1 Vmm², a 7/0260, iss 111,9 61,0 74,8 61,0 anchor 7/0260, iss 112,9 111,9 112,2 111,9 111,9 111,9 111,9 111,9 111,9 111,9 111,9 111,9 111,9 111,9 111,9 111,0 111,9 111,0 111,9	Inchor H           Sue 2009-           M24           185,9           92,4           146,1           92,4           Inchor H           sue 2009-           M24           153,7           88,0           109,6           88,0           HIT-V 5           sue 2009-           M24	HT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HT-V 5.8 01-12 M27 187,8 115,0 132,3 115,0 8 -01-12 M27	3 M30 295, 1 147, c 226, 2 47, c 147, c 3 M30 224, c 140, c 152, 7, 140, c M30 M30
Mean ultimate resistant         Anchor size         Non cracked concrete         Tensile $N_{Ru,m}$ HIT-V 5.8         Shear $V_{Ru,m}$ HIT-V 5.8         Cracked concrete         Tensile $N_{Ru,m}$ HIT-V 5.8         Shear $V_{Ru,m}$ HIT-V 5.8         Characteristic resistant         Anchor size         Non cracked concrete         Tensile $N_{Ru,m}$ HIT-V 5.8         Characteristic resistant         Anchor size         Non cracked concrete         Tensile $N_{Ru}$ HIT-V 5.8         Shear $V_{Ru}$ HIT-V 5.8         Shear $V_{Ru}$ HIT-V 5.8         Cracked concrete         Tensile $N_{Ru}$ HIT-V 5.8         Design resistance: con         Design resistance: con         Anchor size         Non cracked concrete         Tensile N_{Ru} HIT-V 5.8         Design resistance: con	(kN) (kN) (kN) (kN) (kN) (kN) (kN) (kN)	M8 18,9 9,5 18,9 9,5 norrete C M8 18,0 9,0 16,1 9,0 20/25 M8 12,0	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data M10 29,0 15,0 22,6 15,0 - f <sub>ck,cu</sub> Data M10	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 - f <sub>ck,cub</sub> accordin M12 42,0 21,0 31,1 21,0 be = 25 I accordin M12	be         = 25 N           g ETA-07         M16           83,0         41,0           65,2         41,0           65,2         41,0           9         = 25 N           g ETA-07         M16           70,6         39,0           44,0         39,0           Vmm², ing ETA-07         M16           22,6         M16	Vmm², a V0260, iss M20 129,2 64,1 110,8 64,1 Vmm², a V0260, iss M20 111,9 61,0 74,8 61,0 74,8 61,0 anchor M20 52,2	Inchor H           sue 2009           M24           185,9           92,4           146,1           92,4           inchor H           sue 2009           M24           153,7           88,0           109,6           88,0           HIT-V 5           sue 2009           M24	HT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HT-V 5.8 01-12 M27 187,8 115,0 132,3 115,0 .8 01-12 M27 89,4	3 M30 295, 1 147, 0 226, 2 147, 0 3 M30 224, 0 152, 7 140, 0 M30 102, 5 M30 102, 5 147, 0 147, 0 140, 0 140, 0 152, 7 140, 0 152, 7 154,
Mean ultimate resistant         Anchor size         Non cracked concrete         Tensile $N_{Ru,m}$ HIT-V 5.8         Shear $V_{Ru,m}$ HIT-V 5.8         Cracked concrete         Tensile $N_{Ru,m}$ HIT-V 5.8         Shear $V_{Ru,m}$ HIT-V 5.8         Characteristic resistan         Anchor size         Non cracked concrete         Tensile $N_{Ru}$ HIT-V 5.8         Shear $V_{Ru,m}$ HIT-V 5.8         Shear V <sub>Ru</sub> HIT-V 5.8         Design resistance: con         Anchor size         Non cracked concrete         Tensile N <sub>Ru</sub> HIT-V 5.8         Design resistance: con         Anchor size         Non cracked concrete         Tensile N <sub>Ru</sub> HIT-V 5.8	(kN) (kN) (kN) (kN) (kN) (kN) (kN) (kN)	M8           18,9           9,5           18,9           9,5           ncrete C           M8           18,0           9,0           16,1           9,0           16,1           9,0           16,1           9,0           16,1           9,0           12,0           7,2	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data M10 22,6 15,0 - f <sub>ck,cu</sub> Data M10	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 - f <sub>ck,cub</sub> accordin M12 42,0 21,0 31,1 21,0 be = 25 I accordin M12 28,0 16 °	be         = 25 N           g ETA-07         M16           83,0         41,0           65,2         41,0           65,2         41,0           be         = 25 N           g ETA-07         M16           70,6         39,0           44,0         39,0           V/mm², i         g ETA-07           M16         33,6	Vmm², a V0260, iss M20 129,2 64,1 110,8 64,1 Vmm², a V0260, iss M20 111,9 61,0 74,8 61,0 anchor 70260, iss M20 53,3 4º º	Inchor H           sue 2009           M24           185,9           92,4           146,1           92,4           inchor H           sue 2009           M24           153,7           88,0           109,6           88,0           HIT-V 5           sue 2009           M24	HT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HT-V 5.8 01-12 187,8 115,0 132,3 115,0 .8 01-12 M27 89,4 92,0	3 M30 295, 1 147, 0 226, 2 147, 0 3 M30 224, 0 140, 0 152, 7 140, 0 M30 106, 3 102, 6 112, 0 112, 0 112, 0 112, 0 112, 0 114, 0 1
Mean ultimate resistant Anchor size Non cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Cracked concrete Tensile N <sub>Ru,m</sub> HIT-V 5.8 Shear V <sub>Ru,m</sub> HIT-V 5.8 Characteristic resistan Anchor size Non cracked concrete Tensile N <sub>Rk</sub> HIT-V 5.8 Shear V <sub>Rk</sub> HIT-V 5.8	[kN] [kN] [kN] [kN] [kN] [kN] [kN] [kN]	M8           18,9           9,5           18,9           9,5           ncrete C           M8           18,0           9,0           16,1           9,0           16,2           20/25           M8           12,0           7,2	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data M10 29,0 15,0 22,6 15,0 - f <sub>ck,cu</sub> Data M10 19,3 12,0	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 - f <sub>ck,cub</sub> accordin M12 42,0 21,0 31,1 21,0 be = 25 I accordin M12 28,0 16,8	be         = 25 N           g ETA-07         M16           83,0         41,0           65,2         41,0           65,2         41,0           be         = 25 N           g ETA-07         M16           70,6         39,0           44,0         39,0           Vmm², i         sg ETA-07           M16         33,6           31,2         31,2	Vmm², a 7/0260, iss M20 129,2 64,1 110,8 64,1 Vmm², a 7/0260, iss M20 111,9 61,0 74,8 61,0 74,8 61,0 3,3 48,8	Inchor H           sue 2009           M24           185,9           92,4           146,1           92,4           inchor H           sue 2009           M24           153,7           88,0           109,6           88,0           HIT-V 5           sue 2009           M24           73,2           70,4	HT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HT-V 5.8 01-12 M27 187,8 115,0 132,3 115,0 8 8 -01-12 M27 89,4 92,0	3 M30 295, 1 147, 0 226, 2 147, 0 3 M30 224, 0, 1 152, 7 140, 0 152, 1 140, 0 106, 7, 140, 0 106, 12, 0 112, 0 112, 0 112, 0 112, 0 112, 0 114, 0 1140, 0 112, 0 114,
Mean ultimate resistant Anchor size Non cracked concrete Tensile $N_{Ru,m}$ HIT-V 5.8 Shear $V_{Ru,m}$ HIT-V 5.8 Cracked concrete Tensile $N_{Ru,m}$ HIT-V 5.8 Shear $V_{Ru,m}$ HIT-V 5.8 Characteristic resistan Anchor size Non cracked concrete Tensile $N_{Rk}$ HIT-V 5.8 Shear $V_{Rk}$ HIT-V 5.8 Cracked concrete Tensile $N_{Rk}$ HIT-V 5.8 Characteristic correte Tensile $N_{Rk}$ HIT-V 5.8 Characted concrete Tensile $N_{Rk}$ HIT-V 5.8 Cracked concrete Tensile $N_{Rk}$ HIT-V 5.8 Shear $V_{Rk}$ HIT-V 5.8 Shear $V_{Rk}$ HIT-V 5.8 Shear $V_{Rk}$ HIT-V 5.8 Cracked concrete Tensile $N_{Rk}$ HIT-V 5.8	[kN] [kN] [kN] [kN] [kN] [kN] [kN] [kN]	M8 18,9 9,5 18,9 9,5 18,9 9,5 morete C M8 18,0 9,0 16,1 9,0 20/25 M8 12,0 7,2 8,9	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data M10 29,0 15,0 22,6 15,0 - f <sub>ck,cu</sub> Data M10 19,3 12,0 12,6	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 - f <sub>ck,cub</sub> accordin M12 42,0 21,0 31,1 21,0 be = 25 I accordin M12 28,0 16,8 17,3	be         = 25 N           g ETA-07         M16           83,0         41,0           65,2         41,0           65,2         41,0           65,2         41,0           9         ETA-07           M16         70,6           39,0         44,0           44,0         39,0           Vmm², ing ETA-07         M16           33,6         31,2           20,9         20,9	Vmm², a 70260, iss M20 129,2 64,1 110,8 64,1 Vmm², a 70260, iss M20 111,9 61,0 74,8 67,0 anchor 70260, iss M20 53,3 48,8 35,6	Inchor H           sue 2009           M24           185,9           92,4           146,1           92,4           inchor H           sue 2009           M24           153,7           88,0           109,6           88,0           HIT-V 5           sue 2009           M24           73,2           70,4           52,2	HT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 HT-V 5.8 01-12 M27 187,8 115,0 132,3 115,0 8 8 01-12 M27 89,4 92,0 63,0	3 M30 295, 1 147, 0 226, 2 147, 0 3 M30 152, 7 140, 0 106, 7 112, 0 72, 7 7, 72, 7
Mean ultimate resistant         Anchor size         Non cracked concrete         Tensile N <sub>Ru,m</sub> HIT-V 5.8         Shear V <sub>Ru,m</sub> HIT-V 5.8         Cracked concrete         Tensile N <sub>Ru,m</sub> HIT-V 5.8         Shear V <sub>Ru,m</sub> HIT-V 5.8         Characteristic resistan         Anchor size         Non cracked concrete         Tensile N <sub>Rk</sub> HIT-V 5.8         Shear V <sub>Rk</sub> HIT-V 5.8         Cracked concrete         Tensile N <sub>Rk</sub> HIT-V 5.8         Shear V <sub>Rk</sub> HIT-V 5.8         Design resistance: cor         Anchor size         Non cracked concrete         Tensile N <sub>Rk</sub> HIT-V 5.8         Design resistance: cor         Anchor size         Non cracked concrete         Tensile N <sub>Rd</sub> HIT-V 5.8         Shear V <sub>Rd</sub> HIT-V 5.8	(kN) (kN) (kN) (kN) (kN) (kN) (kN) (kN)	M8           18,9           9,5           18,9           9,5           ncrete C           M8           18,0           9,0           16,1           9,0           16,1           9,0           16,1           9,0           12,0           7,2           8,9	20/25 Data M10 30,5 15,8 30,5 15,8 20/25 Data M10 29,0 15,0 22,6 15,0 - f <sub>ck,cu</sub> Data M10 19,3 12,0 19,3	- f <sub>ck,cub</sub> accordin M12 44,1 22,1 - f <sub>ck,cub</sub> accordin M12 42,0 21,0 31,1 21,0 be = 25 I accordin M12 28,0 16,8	be         = 25 N           g ETA-07         M16           83,0         41,0           65,2         41,0           65,2         41,0           9         = 25 N           g ETA-07         M16           70,6         39,0           44,0         39,0           Vmm², ig         ETA-07           M16         33,6           31,2         20,9	Vmm², a V0260, iss M20 129,2 64,1 110,8 64,1 Vmm², a V0260, iss M20 111,9 61,0 74,8 61,0 74,8 61,0 74,8 61,0 53,3 48,8 35,6 10,0 10,6 10,0	Inchor H           sue 2009           M24           185,9           92,4           146,1           92,4           inchor H           sue 2009           M24           153,7           88,0           109,6           88,0           HIT-V 5           sue 2009           M24           73,2           70,4           52,2           20,4	HT-V 5.8 01-12 M27 241,5 120,8 196,0 120,8 196,0 120,8 HT-V 5.8 01-12 M27 187,8 115,0 132,3 115,0 132,3 115,0 8 8 01-12 M27 89,4 92,0 63,0 20,6	M30 295, 1 147, 0 226, 2 147, 0 3 M30 224, 0 147, 0 147, 0 147, 0 3 M30 224, 0 140, 0 140, 0 106, 7 112, 0 72, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7, 7,

As 8 x 112 = 896 kN > 750 kN therefore OKAY Provide M30 (8.8) HIT-V Threaded rod with HIT-RE 500-SD

Project L	UCLH, Birbeck University - MRI		Status Information		<b>NS</b>		
Date	09/01/2018	Job no.	Section	Sheet no.	Rev		
By Checked	NP MB	70038590		1 of 1	01		
Rev	Date	Details					
01	09/01/2018						
Part Deli	very Openi	ng Concrete to Stee	I Through Bolts				

OUTPUT

Installation of the through bolts and resin should be as follows: RC Column PFC PFC

- Drill hole through RC Column.

REF

- Clean Bore hole as per manufactures requirements

- Install road with Hilti filling washer set on each side.
  Dispense HIT-RE 500 Resin through hole until entire cavity is filled.
- Tighten nut to required torque setting.

wsp	Project	UCLH, Birkbeck	Job no. 70038590			
WSP One Queens Drive	Calcs for	Delivery Oper	ning Steelwork		Start page no./Re p 1	vision 01
Birmingham B5 4PJ	Calcs by PG	Calcs date 09/02/2018	Checked by NP	Checked date 09/01/2018	Approved by MB	Approved date 09/01/2018

#### STEEL BEAM ANALYSIS & DESIGN (EN1993-1-1:2005)

In accordance with EN1993-1-1:2005 incorporating Corrigenda February 2006 and April 2009 and the UK national annex



<b>\\SD</b>	Project Job no.					
		UCLH, BIRKDECI	IRI	700	38590	
WSP	Calcs for	Delivery Ope	:	Start page no./F	Revision 2 01	
Birmingham	Calcs by Calcs date Checked by Checked date			Checked date	Approved by	Approved date
B5 4PJ	PG	09/02/2018	NP	09/01/2018	MB	09/01/2018
Analysis results						
Maximum moment		M <sub>max</sub> = 394	. <b>6</b> kNm	M <sub>min</sub> = <b>0</b>	kNm	
Maximum shear		V <sub>max</sub> = 376	kN	V <sub>min</sub> = -3	876 kN	
Deflection		δ <sub>max</sub> = 10.1	mm	$\delta_{\min} = 0$	mm	
Maximum reaction at support A	tion of ournort	$R_{A_{max}} = 37$	6 KN - 276 kN	R <sub>A_min</sub> =	376 KN	
Maximum reaction at support B	ction at support	A RA_Permanent	- 370 KIN	Provide -	376 kN	
Unfactored permanent load read	ction at support	B RB Permanent	= 376 kN	I KB_min —	JIO KIN	
Section details						
Section type		LIKPEC 43	0v100v64 (Tat	a Steel Advance		
Steel grade		S355				
EN 10025-2:2004 - Hot rolled p	products of stru	ictural steels				
Nominal thickness of element		t = max(t <sub>f</sub> ,	t <sub>w</sub> ) = <b>19.0</b> mm			
Nominal yield strength		f <sub>y</sub> = <b>345</b> N/	mm²			
Nominal ultimate tensile strengt	า	f <sub>u</sub> = <b>470</b> N/	mm <sup>2</sup>			
Modulus of elasticity		E = 21000	<b>0</b> N/mm <sup>2</sup>			
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		<u>6</u>				
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	_	<b>↑</b>				
		◀100				
Partial factors - Section 6.1						
Resistance of cross-sections		γ <sub>M0</sub> = <b>1.00</b>				
Resistance of members to insta	bility	γ <sub>M1</sub> = <b>1.00</b>				
Resistance of tensile members	o fracture	γ <sub>M2</sub> = 1.10				
Lateral restraint						
		Span 1 has	s full lateral res	traint		
Effective length factors						
Effective length factor in major a	ixis	K <sub>y</sub> = <b>1.000</b>				
Effective length factor in minor a	ixis	K <sub>z</sub> = 1.000				
Effective length factor for torsion	ı	K <sub>LT.A</sub> = 1.00	00			
		K <sub>LT.B</sub> = 1.00	00			
Classification of cross section	ns - Section 5.5					
		ε = √[235 Ν	N/mm² / f <sub>y</sub> ] = <b>0.8</b>	33		
Internal compression parts su	bject to bendir	ng - Table 5.2 (	sheet 1 of 3)			
Width of section	-	c = d = 362	2 mm			
L						

1150	Project	UCLH, Birkbeck	CUniversity - N	1RI	Job no. 7003	38590		
WSP	Calcs for		Start page no./Re	evision				
One Queens Drive	One Queens Drive			Delivery Opening Steelwork				
Birmingham	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date		
B5 4PJ	PG	09/02/2018	NP	09/01/2018	MB	09/01/2018		
		c / t <sub>w</sub> = 39.9	9×ε <= 72×ε	Class 1				
Outstand flanges - Table	5.2 (sheet 2 of 3)							
Width of section		c = b - t <sub>w</sub> - i	r <sub>1</sub> = <b>74</b> mm					
		c / t <sub>f</sub> = 4.7 >	< ε <= 9 × ε	Class 1				
					Sect	ion is class 1		
Check shear - Section 6.2	2.6							
Height of web		$h_w = h - 2 \times$	: t <sub>f</sub> = <b>392</b> mm					
Shear area factor		η = <b>1.000</b>						
		h <sub>w</sub> / t <sub>w</sub> < 72	×ε/η					
			·	Shear buckling	resistance ca	n be ignored		
Design shear force		V <sub>Ed</sub> = max(	abs(V <sub>max</sub> ), abs	(V <sub>min</sub> )) = <b>376</b> kN				
Shear area - cl 6.2.6(3)		A <sub>v</sub> = A - 2 >	$\times$ b $\times$ t <sub>f</sub> + (t <sub>w</sub> + r	1) × t <sub>f</sub> = <b>4903</b> mm²				
Design shear resistance - o	cl 6.2.6(2)	$V_{c,Rd} = V_{pl,R}$	$_{\rm d}$ = A <sub>v</sub> × (f <sub>y</sub> / $\sqrt{[3]}$	3]) / γ <sub>M0</sub> = <b>976.5</b> kt	N			
		PAS	S - Design sh	ear resistance ex	ceeds desig	n shear force		
Check bending moment r	major (y-y) axis - Se	ection 6.2.5						
Design bending moment		M <sub>Ed</sub> = max(	abs(M <sub>s1_max</sub> ), a	abs(M <sub>s1_min</sub> )) = <b>394</b>	. <b>6</b> kNm			
Design bending resistance	moment - eq 6.13	$M_{c,Rd} = M_{pl,l}$	$R_{d} = W_{pl.y} \times f_y / f_y$	γ <sub>M0</sub> = <b>421.6</b> kNm				
	PASS	- Design bendi	ng resistance	moment exceed	s design ben	ding moment		
Check vertical deflection	- Section 7.2.1							
Consider deflection due to	permanent and varia	able loads						
Limiting deflection		$\delta_{\text{lim}} = L_{s1} / 2$	250 = <b>13.2</b> mm					
Maximum deflection span 1	1	$\delta$ = max(ab	s( $\delta_{max}$ ), abs( $\delta_{max}$	<sub>nin</sub> )) = <b>10.085</b> mm				
		PAS	S - Maximum	deflection does I	not exceed de	eflection limit		

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### BOLT GROUP ANALYSIS

Tedds calculation version 1.0.02



## Geometry of bolt group

Number of rows	R = 3
Number of columns	C = 2
Pitch distance	S <sub>x</sub> = <b>100</b> mm
Gauge distance	S <sub>y</sub> = <b>300</b> mm
Edge distance in vertical direction	d <sub>y</sub> = <b>50</b> mm
Edge distance in horizontal direction	d <sub>x</sub> = <b>50</b> mm
Load data	
Vertical load applied on bolt group	P <sub>y</sub> = -375.000 kN
Horizontal load applied on bolt group	P <sub>x</sub> = 0.000 kN
X coordinate of vertical force	X = <b>100</b> mm
Y coordinate of horizontal force	Y = <b>0</b> mm
Center of gravity of bolt group	
X distance of center of bolt group	$X_c = ((C - 1) \times S_x) / 2 + d_x = 100 \text{ mm}$
Y distance of center of bolt group	$Y_c = ((R - 1) \times S_y) / 2 + d_y = 350 \text{ mm}$
Load eccentricity from center of gravity of bolt	group

Eccentricity of vertical load from C.G.	$e_x = abs(X - X_c) = 0 mm$
Eccentricity of horizontal load from C.G.	$e_y = abs(Y - Y_c) = 350 mm$
Moment about center of gravity	$M = P_x \times (Y - Y_c) - P_y \times (X - X_c) = 0.000 \text{ kNm}$

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Bolt number	Bolt distance from centre of gravity		Direct shear		Torsio	Torsional shear	
	X <sub>i</sub> (mm)	Y <sub>i</sub> (mm)	P <sub>dx</sub> (kN)	P <sub>dy</sub> (kN)	P <sub>tx</sub> (kN)	P <sub>ty</sub> (kN)	(kN)
1	-50	-300	0.0	62.5	0.0	0.0	62.5
2	50	-300	0.0	62.5	0.0	0.0	62.5
3	-50	0	0.0	62.5	0.0	0.0	62.5
4	50	0	0.0	62.5	0.0	0.0	62.5
5	-50	300	0.0	62.5	0.0	0.0	62.5
6	50	300	0.0	62.5	0.0	0.0	62.5

	Tanaila atraca area	Tanaian maintanan	Shear resistance			
Diameter of bolt	Tensile suess area	rension resistance	Single shear	Double shear		
d	As	FtRd	F <sub>v,Rd</sub>	$2 \times F_{v,Rd}$		
mm	mm <sup>2</sup>	kN	kN	kN		
12	84.3	48.6	32.4	64.7		
16	157	90.4	60.3	121		
20	245	141	94.1	188		
24	353	203	136	271		
30	561	323	215	431		

Extract from TATA Steel Blue Book

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#### STEEL COLUMN DESIGN (EN 1993-1-1)

In accordance with EN1993-1-1:2005 incorporating Corrigenda February 2006 and April 2009 and the UK national

annex TEDDS calculation version 1.0.12 -94 209.6-**→** 14.2 NB. In order to accommodate the width of the removed columns, 205.8two UC sections will be provided See UCL-WSP-00-GF-DR-S-200104. Column and loading details **Column details** Column section UKC 203x203x60 L<sub>v</sub> = 3000 mm System length for buckling about y axis System length for buckling about z axis L<sub>z</sub> = 3000 mm Sway The column is not part of a sway frame in the direction of the z axis The column is not part of a sway frame in the direction of the y axis **Column loading** Axial load N<sub>Ed</sub> = 375 kN (Compression) Moment about y axis at end 1  $M_{y,Ed1} = 0.0 \text{ kNm}$ Moment about y axis at end 2 My,Ed2 = 0.0 kNm Moment about z axis at end 1 M<sub>z,Ed1</sub> = 0.0 kNm Moment about z axis at end 2 Mz.Ed2 = 0.0 kNm Shear force parallel to z axis  $V_{z,Ed} = 0 kN$ Shear force parallel to y axis  $V_{y,Ed} = 0 kN$ Material details S355 Steel grade Yield strength f<sub>v</sub> = 355 N/mm<sup>2</sup> f<sub>u</sub> = **470** N/mm<sup>2</sup> Ultimate strength Modulus of elasticity E = 210 kN/mm<sup>2</sup> Poisson's ratio v = 0.3 Shear modulus G = E /  $[2 \times (1 + v)]$  = 80.8 kN/mm<sup>2</sup> Buckling length for flexural buckling about y axis End restraint factor K<sub>y</sub> = 1.000  $L_{cr_y} = L_y \times K_y = 3000 \text{ mm}$ **Buckling length** Buckling length for flexural buckling about z axis End restraint factor K<sub>z</sub> = 1.000  $L_{cr} = L_z \times K_z = 3000 \text{ mm}$ **Buckling length** 

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D0 4F0	PG	09/02/2018	NP	09/01/2018	IVIB	09/01/2018		
Section classification								
<u>Section classification</u>								
Web section classification (	Table 5.2)		$1/m_{2}m_{2}^{2}/(f_{1}) = 0.04$					
Coefficient depending on ly		ε = ∿(235 N	$(f_{1} + r_{1}) = 0.8^{\circ}$	14				
Depth between lillets		$C_w = n - 2 \times ratio = 0$	$c_w = h - 2 \times (t_f + r) = 160.8 \text{ mm}$					
Ralio of c/l	ood	$fallo_w = C_w / $	$u_w = 17.11$					
Eerigin of web taken by axian	Vau	$I_W = IIIIII(IN_E)$	$d / (I_y \times I_w), C_w) =$	112.4				
For class 1 & 2 proportion in o	compression	$\alpha = (C_w/2 + 1)$	$I_w/2$ ) / $C_w = 0.84$	4) - 22.00				
Limit for class 1 web		$Limit_{1w} = (3)$	96×ε) / (13×α	-1) = 32.08	The	uch is close 1		
					The	web is class i		
Flange section classificatio	n (Table 5.2)							
Outstand length		$c_f = (b - t_w)$	/2-r= 88.0 m	m				
Ratio of c/t		$ratio_f = C_f / 1$	lf = 6.20					
Limit for class 1 flange		Limit <sub>1f</sub> = 9 >	<ε <b>= 7.32</b>					
Limit for class 2 flange		$Limit_{2f} = 10$	×ε <b>= 8.14</b>					
Limit for class 3 flange		Limit <sub>3f</sub> = 14	$\text{Limit}_{3\text{f}} = 14 \times \varepsilon = 11.39$					
					The fla	nge is class 1		
Overall section classification	n							
					The sec	tion is class 1		
Posistance of cross section	(c   6 2)							
	(01. 0.2)							
Dosign force		N 275 k	-NI					
Design resistance			$A = \Delta \times f_v / 2000 =$	2711 kN				
Design resistance		PASS - The c	ompression de	sian resistance	exceeds the	e desian force		
Suckling resistance (cl. 6.3)	istance	f 355 N/r	mm <sup>2</sup>					
	·	ly - 355 M/I						
Flexural buckling about y as	(IS	$N = -2 \times$		4404 KNI				
Elastic critical buckling force		$N_{cr,y} = \pi^2 \times$	$E \times Iy / L_{cr}y^2 = 14$	4104 KIN				
Non-dimensional sienderness	i	$\lambda_y = \sqrt{A \times A}$	$T_y / N_{cr,y} = 0.438$	5				
Buckling curve (Table 6.2)	<b>`</b>	D ~ = 0.24						
	)	$\alpha_y = 0.34$	$\frac{1}{2}$	$21 + \frac{1}{2} 21 - 0.62$	7			
Parameter $\Phi$		$\Phi_{\rm y} = 0.5 \times [$	$\Phi_{y} = 0.5 \times [1 + \alpha_{y} \times (\lambda_{y} - 0.2) + \lambda_{y}^{2}] = 0.037$					
		$\chi_y = \min(1.0)$	$\chi_y = \min(1.0, 1/[\Phi_y + \sqrt{\Phi_y^2 - \lambda_y^2}]) = 0.911$					
Design buckling resistance	BASS The fle	$N_{b,y,Rd} = \chi_y$	$\times A \times f_y / \gamma_{M1} = 2$	2468.7 KN	ands the des	ian axial load		
	PASS - The he	xurai buckiing re	esistance about	t the y axis exc	eeus ine ues	ligii axiai loau		
Flexural buckling about z a	cis							
		$N_{cr,z} = \pi^2 \times$	$N_{cr,z} = \pi^2 \times E \times I_z / L_{cr_z}^2 = 4/55 \text{ KN}$					
Non-almensional sienderness		$\lambda_z = \sqrt{A \times A}$	$\lambda_z = \sqrt{(A \times f_y / N_{cr,z})} = 0.755$					
Buckling curve (Table 6.2)		C	c					
Imperfection factor (Table 6.1)		$\alpha_z = 0.49$						
Parameter Φ		$\Phi_{z} = 0.5 \times [1 + \alpha_{z} \times (\lambda_{z} - 0.2) + \lambda_{z}^{2}] = 0.921$						
Reduction factor		$\chi_z = \min(1.0)$	$\chi_z = \min(1.0, 1 / [\Phi_z + \sqrt{(\Phi_z^2 - \lambda_z^2)}]) = 0.690$					
Design buckling resistance	$N_{b,z,Rd} = \chi_z$	$N_{b,z,Rd} = \chi_z \times A \times f_y / \gamma_{M1} = 1871.6 \text{ kN}$						
	PASS - The fle	xural buckling re	esistance abou	t the z axis exc	eeds the des	ign axial load		

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B5 4PJ	PG	09/02/2018	NP	09/01/2018	MB	09/01/2018			
Torsional and torsional-fle	exural buckling (c	1.6.3.1.4)							
Torsional buckling length fac	ctor	Kτ <b>= 1.00</b>							
Effective buckling length		$L_{cr_T} = K_T \times$	$max(L_y, L_z) =$	<b>3000</b> mm					
Distance from shear ctr to c	Distance from shear ctr to centroid along y axis		y <sub>0</sub> = <b>0.0</b> mm						
Distance from shear ctr to centroid along z axis		$z_0 = 0.0 \text{ mm}$	$z_0 = 0.0 \text{ mm}$						
		$i_0 = \sqrt{(i_y^2 + i_y^2)}$	$z^2 + y_0^2 + z_0^2$ ):	= <b>103.5</b> mm					
		$\beta_{T} = 1 - (y_{0}$	/ i <sub>0</sub> ) <sup>2</sup> = <b>1.000</b>						
Elastic critical torsional buck	$N_{cr,T} = 1 / i_0$	$N_{cr,T} = 1 / i_0^2 \times (G \times I_t + \pi^2 \times E \times I_w / L_{cr_T^2}) = 7790 \text{ kN}$							
Elastic critical torsional-flexural buckling force		$N_{cr,TF} = N_{cr,}$	$N_{cr,TF} = N_{cr,y}/(2 \times \beta_T) \times [1 + N_{cr,T}/N_{cr,y} - \sqrt{[(1 - N_{cr,T}/N_{cr,y})^2 + 4 \times (y_0/i_0)^2 \times N_{cr,T}/N_{cr,y}]}]$						
		N <sub>cr,TF</sub> = 779	90 kN						
Non-dimensional slendernes	$\overline{\lambda}_{T} = \sqrt{A \times A}$	$\overline{\lambda}_{T} = \sqrt{(A \times f_{y} / min(N_{cr,T}, N_{cr,TF}))} = 0.590$							
Buckling curve (Table 6.2)		С	c						
Imperfection factor (Table 6.	α <sub>T</sub> = <b>0.49</b>	α <sub>T</sub> = <b>0.49</b>							
Parameter $\Phi$	$\Phi_{ extsf{T}}$ = 0.5 $ imes$	$\Phi_{T} = 0.5 \times [1 + \alpha_{T} \times (\overline{\lambda}_{T} - 0.2) + \overline{\lambda}_{T}^{2}] = 0.770$							
Reduction factor	χ⊤ = min(1.	$\chi_{T} = min(1.0, 1 / [\Phi_{T} + \sqrt{(\Phi_{T}^{2} - \overline{\lambda}_{T}^{2})}]) = 0.791$							
Design buckling resistance	$N_{b,T,Rd}$ = $\chi_T \times A \times f_y / \gamma_{M1}$ = <b>2145.5</b> kN								
	PASS - The torsio	nal/torsional-fle	exural bucklin	ng resistance exc	eeds the des	ign axial load			
Minimum buckling resista	nce								
•									

Minimum buckling resistance

 $N_{b,Rd} = min(N_{b,y,Rd}, N_{b,z,Rd}, N_{b,T,Rd}) = 1871.6 \ kN$ PASS - The axial load buckling resistance exceeds the design axial load

It is considered that the ground floor slab is suspended. Therefore, to transfer the large vertical loads from the delivery opening columns to the lower ground level, additional 450x300 RC columns will be provided with reinforcement details equivalent to that of the RC stub columns detailed in section 2.2. For additional information see UCL-WSP-00-GF-DR-S-200102.