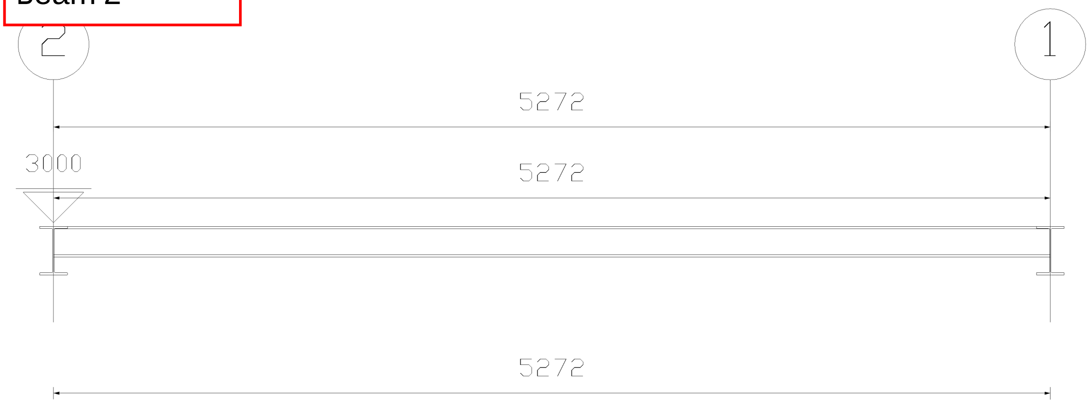
Design Condition	#	Design Value	Design Capacity	Units	U.R.	Status
Shear Minor	-	No	Forces	kN	-	Not required
Buckling Shear Web	-	37.175	58.580	-	-	Pass
Moment Major	1	3.1	171.5	kNm	0.018	Pass
Moment Minor	-	No	Forces	kNm	-	Not required
Axial	-	No	Forces	kN	-	Not required
Axial Bending Combined	-	No	Forces	-	-	Not required
Buckling Lateral Torsional	-	No	Forces	-	-	Not required
Buckling Compression	-	No	Forces	-	-	Not required
Buckling Combined	-	No	Forces	-	-	Not required
Deflection Self weight	1	0.0	-	mm	-	-
Deflection Slab	-	No	Loads	mm	-	Not required
Deflection Dead	1	0.1	3.8	mm	0.016	Pass
Deflection Imposed	-	No	Loads	mm	-	Not required
Deflection Total	1	0.1	9.4	mm	0.010	Pass

WSP One Queens drive Birmingham B5 4PJ	Project UCLH, Birkbeck University - MRI				Job Ref. 70038590	
	Structure Internal Shielding Support Frame				Sheet no. Page 1/1	
	Calc. by Patrick Gittings	Date 23/01/2018	Chk'd by Nathan Pentelow	Date 23/01/2018	App'd by Mark Bundy	Date 23/01/2018

Beam 2



St. 1 (1): SB 1/2/#19-1/1/#20
UC 152x152x37 S355

Restraints

Source	Distance / Length [m]	LTB Top / Sub-Beam	LTB Top Factor	LTB Btm / Sub-Beam	LTB Btm Factor	Strut Major / Sub-Beam	Strut Major Factor	Strut Minor / Sub-Beam	Strut Minor Factor
support	0.000	•		•		•		•	
sub-beam	5.272		1.000		1.000		1.000		1.000
support	5.272	•		•		•		•	

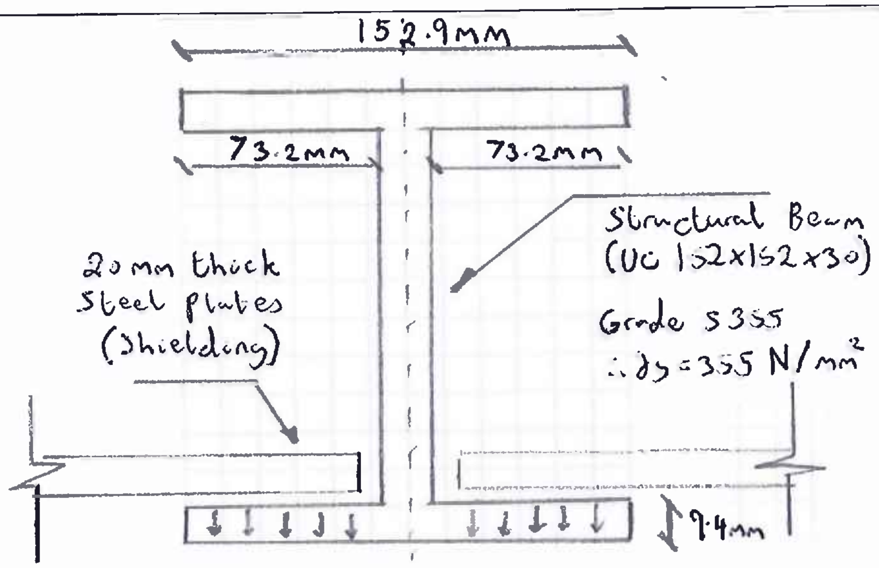
Static

Summary UC 152x152x37(S355)

Design Condition	#	Design Value	Design Capacity	Units	U.R.	Status
Classification	1	Class 1	-	-	-	Pass
Shear Major	1	4.6	292.4	kN	0.016	Pass
Shear Minor	-	No	Forces	kN	-	Not required
Buckling Shear Web	-	17.350	58.580	-	-	Pass
Moment Major	1	6.1	109.6	kNm	0.056	Pass
Moment Minor	-	No	Forces	kNm	-	Not required
Axial	-	No	Forces	kN	-	Not required
Axial Bending Combined	-	No	Forces	-	-	Not required
Buckling Lateral Torsional	1	6.1	79.4	kNm	0.077	Pass
Buckling Compression	-	No	Forces	-	-	Not required
Buckling Combined	-	No	Forces	-	-	Not required
Deflection Self weight	1	0.8	-	mm	-	-
Deflection Slab	-	No	Loads	mm	-	Not required
Deflection Dead	1	2.1	10.5	mm	0.196	Pass
Deflection Imposed	-	No	Loads	mm	-	Not required
Deflection Total	1	2.9	26.4	mm	0.109	Pass

Project: UCLH, Birkbeck University MRI			Status: INFORMATION	
Date: 23/01/18 By: PG Checked: MB	Job no.: 70038590	Section: 01	Sheet no.: 01	Rev: 01
Rev: 01	Date: 23/01/18	Details: Internal Shielding Support Frame	Tel Fax	
Part: Flange Bending Check				

REF | OUTPUT



Max Beam Spacing = 625mm

Considering a 1m strip:

Shielding S.W = 1.5 kN/m²

312.5 m width shielding spanning onto each flange, say 325 mm

∴ UDL = 0.325 x 1.5 = 0.4875 kN/m

UDL SLS = 0.5 kN/m

UDL ULS = 0.65 kN/m

$Z = \frac{bh^2}{6} = \frac{1000 \times 9.4^2}{6} = 14726.7\ mm^3$

$e = \frac{73.2}{2} = 36.6mm$

$M_{Ed} = UDL_{(ULS)} \times e = 0.66 \times 0.0366 = 0.0242$ kNm/m length

$M_{Rd} = \frac{f_y Z}{\gamma_{M0}} = \frac{355 \times 14726.7}{1.0} = 5.23$ kNm/m length

∴ Flange ok in bending.

Project				Status
UCLH - Birkbeck University MRI				INFORMATION

Date 23/01/18 By PG Checked MB	Job no. 70038590	Section 01	Sheet no. 02	Rev 01

Rev	Date	Details	Tel / Fax
01	23/01/18	Internal Shielding Support Frame	

Part: Flange Shear Check

REF | OUTPUT

$A_v = bt = 1000 \times 9.4 = 9400\,mm^2$

$V_{Ed} = 0.66\,kN$ /metre length

$V_{Rd} = \frac{f_y A_v}{\sqrt{3}\,\gamma_{M0}} = \frac{355 \times 9400}{\sqrt{3} \times 1.0} = 1926\,kN$ / metre length

∴ Flange ok in shear.

3.2.2 STEEL COLUMNS

The full design outputs for selected steel columns are shown below:

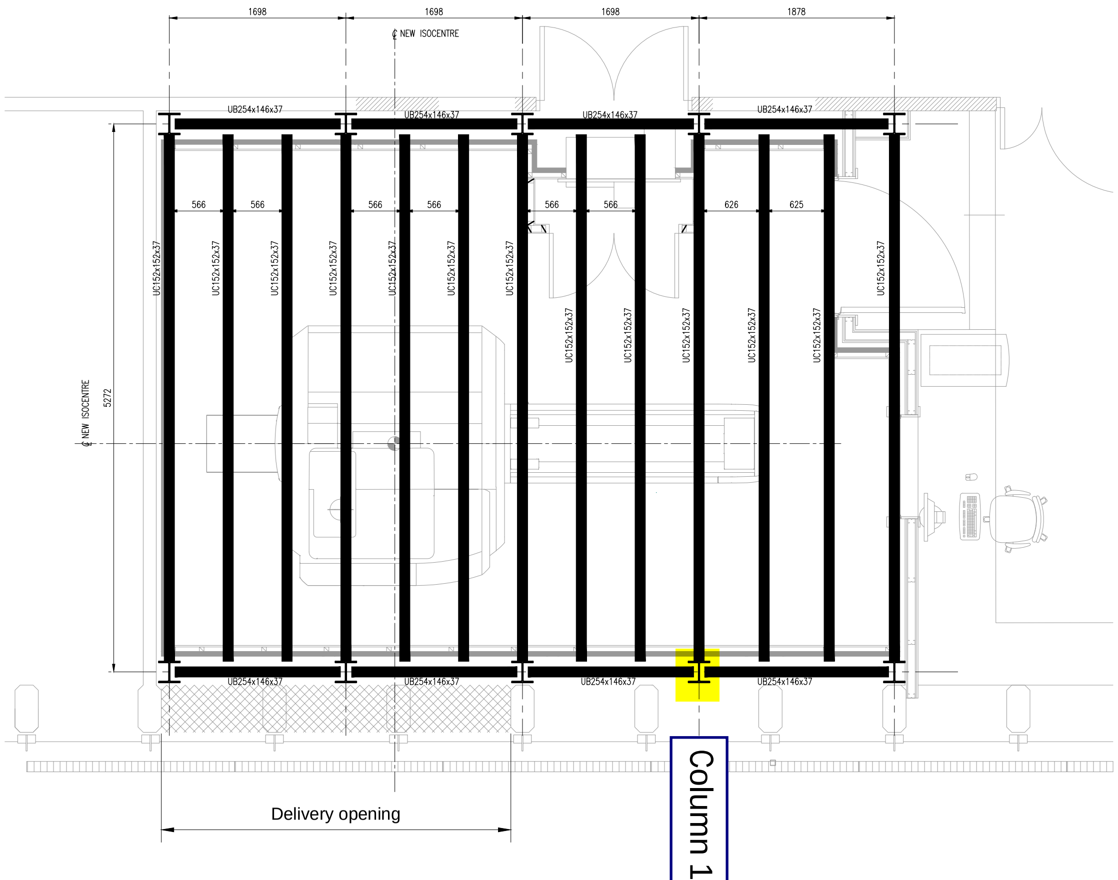
DO NOT SCALE

GENERAL NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH CSM ARCHITECTS DRAWING 4443/15.
2. ALL STRUCTURAL STEELWORK TO COMPLY WITH BS.EN.1993
3. ALL STRUCTURAL STEELWORK TO BE GRADE S355 (U.N.O.) BRITISH MILD STEEL TO BS EN 10056–1:1999, BS.4–1:1993, BS EN 10210–2:1997 AND BS EN 10219–2:1997.
4. ALL STRUCTURAL STEELWORK TO BE BLAST CLEAN TO BS EN ISO 8501–1:2001, GRADE SA 2.5, FOLLOWED BY A HIGH BUILD ZINC PHOSPHATE PRIMER. TO 75 MICRON DRY FILM THICKNESS.
5. ALL BOLTS TO BE GRADE 8.8 ZINC PLATED
6. THE CONTRACTOR SHALL BE RESPONSIBLE FOR FOR ANY TEMPORARY BRACING DURING ERECTION, AND ALL SHOP DETAILS FABRICATION DRAWINGS. THE FABRICATION DRAWINGS SHALL BE SUBMITTED.
7. THE CONTRACTOR SHALL ALLOW FOR ANY AMENDMENTS OF FABRICATION DETAILS ARISING FROM ENGINEERS COMMENTS
8. DIMENSION LINES ARE NOT TO BE SCALED FORM THIS DRAWING
9. THE CONTRACTOR SHALL COMPLY WITH THE HEALTH AND SAFETY REQUIREMENTS AS SET BY THE CDM REGULATIONS, THE HEALTH AND SAFETY EXECUTIVE.
10. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE EXECUTION OF THE WORKS IN ACCORDANCE WITH THE DRAWINGS AND THE SPECIFICATION AND FOR THE ACCURACY OF ALL THE DIMENSIONS AND SETTING OUT ON SITE
11. UNLESS STATED CONNECTIONS SHOULD BE DESIGNED FOR 100KN (ULS) SHEAR LOADING.
12. FOR BUILDERS WORK FOR INCOMING SERVICES REFER TO ARCHITECT'S DRAWING FOR SETTING OUT.

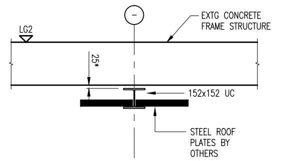
KEY TO HEALTH & SAFETY SYMBOLS

- WARNING RISK — INDICATES A RESIDUAL RISK AS A WARNING.
- COMPULSORY RISK — INDICATES A RESIDUAL RISK REQUIRING A COMPULSORY ACTION.
- PROHIBITIVE RISK — INDICATES A RESIDUAL RISK REQUIRING A PROHIBITIVE ACTION.
- INFORMATION RISK — INDICATES A RESIDUAL RISK FOR INFORMATION.



MRI CEILING PLAN

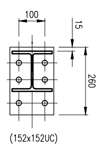
1:25



* DENOTES DIMENSION TBC ON SITE TO ENSURE NO OBSTRUCTIONS TO PROPOSED STEELWORK

MRI CEILING SUPPORT BEAM DETAIL

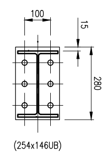
1:20



170x260x12 THK END PLATE 6No. M20 (8.8) BOLTS 8mm FW

BEAM CONNECTION DETAIL 1

1:10



170x280x12 THK END PLATE 6No. M20 (8.8) BOLTS 8mm FW

BEAM CONNECTION DETAIL 2

1:10

SITE MEASUREMENTS REQUIRED TO CONFIRM SETTING OUT OF EXISTING STRUCTURE

EXISTING STRUCTURAL DETAILS/CONSTRUCTION TO BE CONFIRMED ON SITE PRIOR TO COMMENCING WORKS

REV	DATE	BY	DESCRIPTION	CHK	APP
01	18–01–18	NP	ISSUED FOR INFORMATION	NP	MRB

DRAWING STATUS: INFORMATION

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wsp.com

CLIENT: DD PORTER / SIEMENS

ARCHITECT: CSM ARCHITECTS LTD

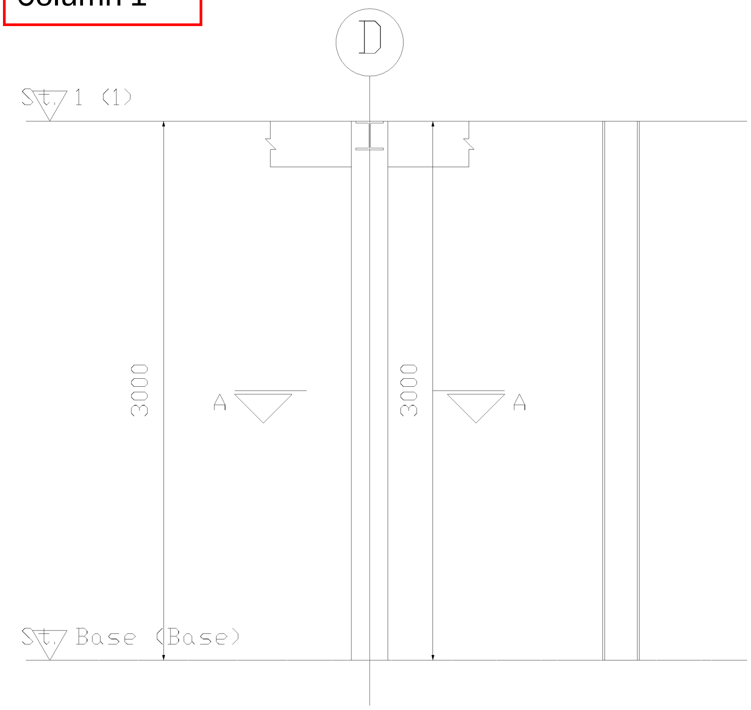
SITE/PROJECT: UCLH, BIRKBECK UNIVERSITY MRI

TITLE: STRUCTURAL MRI FRAME STEELWORK SECTION AND DETAILS

SCALE @ A1: 1:25	CHECKED: MRB		APPROVED: MRB
PROJECT NO: 70038590	DESIGNED: NP	DRAWN: HD	DATE: JAN 2018
DRAWING No: UCL-WSP-00-GF-DR-S-200103			REV: 01

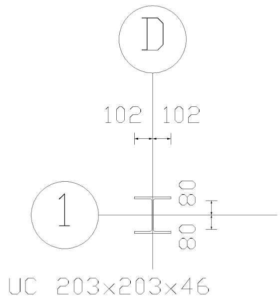
WSP One Queens drive Birmingham B5 4PJ	Project: UCLH, Birkbeck University - MRI				Job Ref.: 70038590	
	Structure: Internal Shielding Support Frame				Sheet no.: Page 1/2	
	Calc. by: Patrick Gittings	Date: 23/01/2018	Chk'd by: Nathan Pentelow	Date: 23/01/2018	App'd by: Mark Bundy	Date: 23/01/2018

Column 1



SC D/1

SC D/1 A-A



Lateral Restraints

Level	Source	Distance / Length	Face A restrained / Sub-stack continuous	Face A factor	Face C restrained/ Sub-stack continuous	Face C factor
2	floor	3.000	Yes		Yes	
	sub-beam	3.000	No	1.000	No	1.000
1	floor	0.000	Yes		Yes	

Strut Restraints

Level	Source	Distance / Length	Major restrained / Sub-stack continuous	Major factor	Minor restrained / Sub-stack continuous	Minor factor
2	floor	3.000	Yes		Yes	
	sub-beam	3.000	No	1.000	No	1.000
1	floor	0.000	Yes		Yes	

Static

Summary UC 203x203x46(S355)

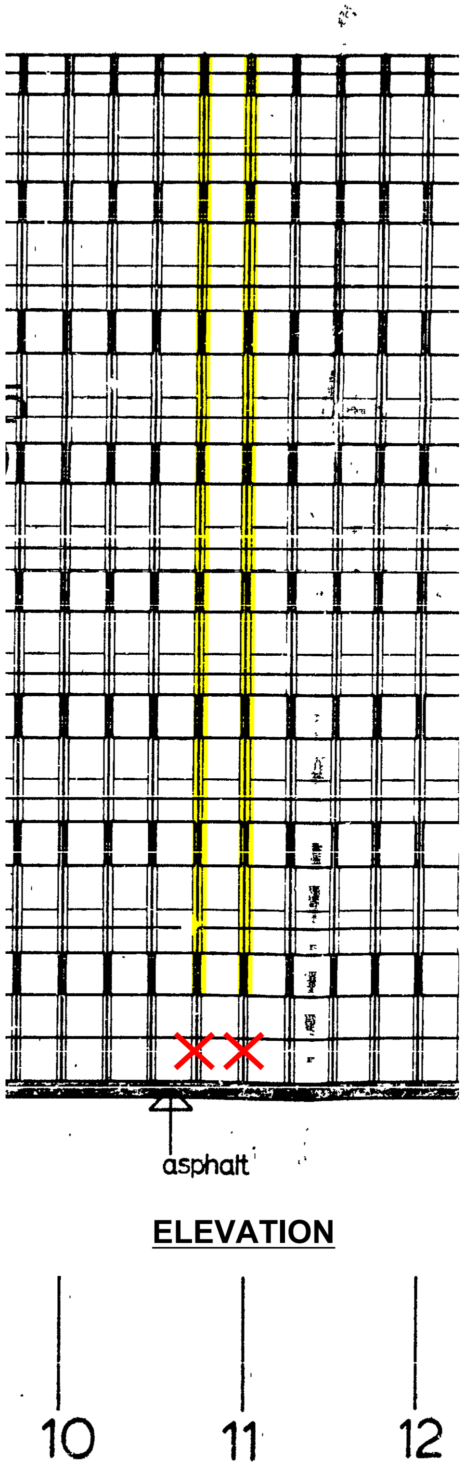
Design Condition	Combination Name	Design Value	Design Capacity	Units	U.R.	Status
Classification	1	Class 2	-	-	-	Pass
Shear Major	No	Significant	Forces	kN	-	Not required
Shear Minor	No	Significant	Forces	kN	-	Not required
Buckling Shear Web	-	25.17	58.58	-	-	Pass
Moment Major	1	-0.9	176.6	kNm	0.005	Pass
Moment Minor	No	Significant	Forces	kNm	-	Not required

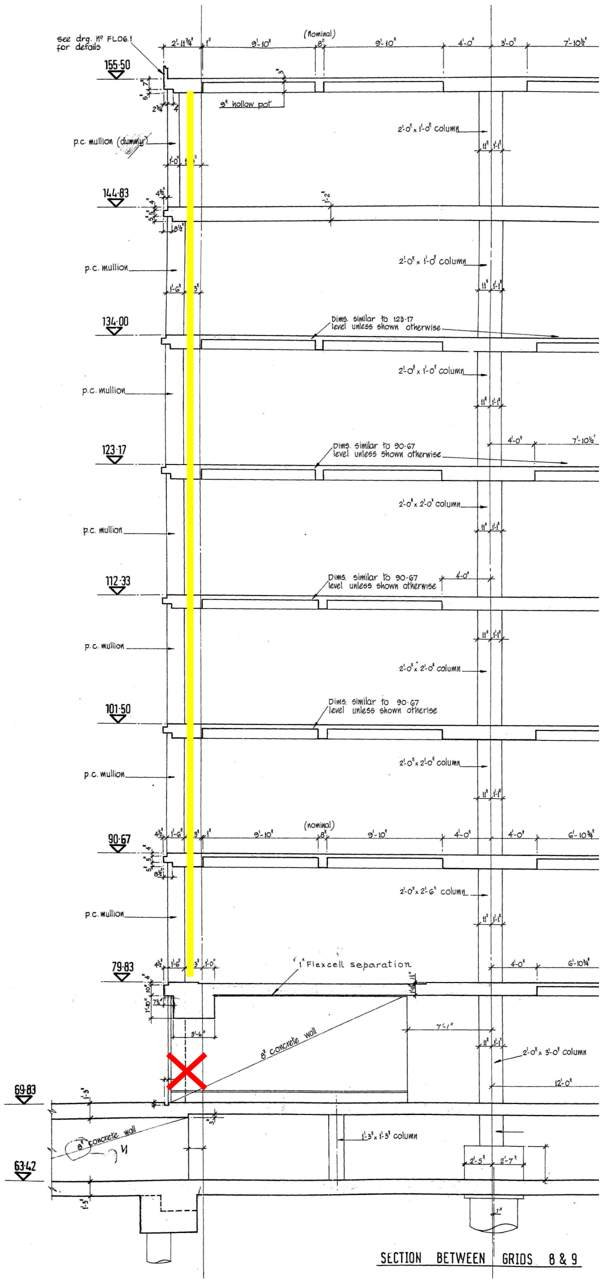
Design Condition	Combination Name	Design Value	Design Capacity	Units	U.R.	Status
Axial	1	16.1	2085.0	kN	0.008	Pass
Axial Bending Combined	1	-	-	-	0.000	Pass
Buckling Lateral Torsional	1	-0.9	171.0	kNm	0.005	Pass
Buckling Compression	1	16.1	1426.8	kN	0.011	Pass
Buckling Combined	1	-	-	-	0.017	Pass

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

Project	Status
Birkbeck University - MRI	INFORMATION

wsp

Date 09/01/18 By PG Checked NP	Job no.	Section	Sheet no.	Rev
	70038590	01	01	01

Rev	Date	Details	Tel / Fax
01	09/01/18	Load Takedown Analysis	

Part: Removal of 2 Columns for MRI installation

REF | OUTPUT

7 Floors above, plus roof level

(Plant) Roof DL: 7.0 kN/m² SDL = 0.85 kN/m² LL = 5.0 kN/m²

(office) Lv5 DL = 8.4 kN/m² SDL = 0.85 kN/m² LL = 3.5 kN/m²

(office) Lv4 DL = 7.0 kN/m² SDL = 0.85 kN/m² LL = 3.5 kN/m²

(office) Lv3 DL = 7.0 kN/m² SDL = 0.85 kN/m² LL = 3.5 kN/m²

(office) Lv2 DL = 7.0 kN/m² SDL = 0.85 kN/m² LL = 3.5 kN/m²

(office) Lv1 DL = 7.0 kN/m² SDL = 0.85 kN/m² LL = 3.5 kN/m²

(office) GF DL = 7.0 kN/m² SDL = 0.85 kN/m² LL = 3.5 kN/m²

(Library) LG DL = 8.4 kN/m² SDL = 0.85 kN/m² LL = 5.0 kN/m²

Office Imposed Load = 2.5 kN/m²
Library Imposed Load = 4.0 kN/m²
Lightweight Plant Load = 5.0 kN/m²
Services & Finishes = 0.85 kN/m²
Demountable Partitions = 1.0 kN/m² (All except Roof)
0.35m thk Slab = 0.35 x 24 = 8.4 kN/m²
Hollow Pot Floor Construction = 0.35 x 20kN/m³ = 7 kN/m²

Tributary Area = 4.0 m x 1.19m = 4.76m² (Considered Area per Column)
≈ 4.8m²

Dead Load = [2 x (8.4 + 0.85) x 4.8] + [6 x (7.0 + 0.85) x 4.8]

= 314.8 kN (unfactored)
x1.35 = 425.1 kN (factored)

Live Load = 2(5.0 x 4.8) + 6(3.5 x 4.8)

= 148.8 kN (unfactored)
x1.5 = 223.2 kN (factored)

S/W of Column = 0.457 x 0.230 x 24m High x 25kN/m² = 65 kN (Unfactored)
x 1.35 = 90kN (Factored)

∴ Total (Per Column) = 542 kN (unfactored) ⇒ 550 kN

= 739 kN (factored) ⇒ 750 kN

Project		Status	
UCLH, Birbeck University - MRI		Information	
Date 09/01/2018 By NP Checked MB	Job no. 70038590	Section	Sheet no. 1 of 1	Rev 01

Rev	Date	Details
01	09/01/2018	

Part

Delivery Opening Concrete to Steel 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 — Hilti HIT-RE 500-SD with HIT-V rod

Basic loading data (for a single anchor)

All data in this section applies to

For details see Simplified design method

- Correct setting (See setting instruction)
- No edge distance and spacing influence
- *Steel* failure
- Base material thickness, as specified in the table
- One typical embedment depth, as specified in the table
- One anchor material, as specified in the tables
- Concrete C 20/25, $f_{ck,cube}$ = 25 N/mm²
- Temperate range I (min. base material temperature -40℃, max. long term/short term base material temperature: +24℃/40℃)
- Installation temperature range +5℃ to +40℃

Embedment depth [a] and base material thickness for the basic loading data. Mean ultimate resistance, characteristic resistance, design resistance, recommended loads.

Anchor size	M8	M10	M12	M16	M20	M24	M27	M30
Typical embedment depth [mm]	80	90	110	125	170	210	240	270
Base material thickness [mm]	110	120	140	165	220	270	300	340

a) The allowed range of embedment depth is shown in the setting details. The corresponding load values can be calculated according to the simplified design method.

Mean ultimate resistance: concrete C 20/25 – $f_{ck,cube}$ = 25 N/mm², anchor HIT-V 5.8

			Data according ETA-07/0260, issue 2009-01-12							
Anchor size			M8	M10	M12	M16	M20	M24	M27	M30
Non cracked concrete										
Tensile $N_{Ru,m}$	HIT-V 5.8	[kN]	*18,9*	*30,5*	*44,1*	*83,0*	*129,2*	*185,9*	*241,5*	*295,1*
Shear $V_{Ru,m}$	HIT-V 5.8	[kN]	*9,5*	*15,8*	*22,1*	*41,0*	*64,1*	*92,4*	*120,8*	*147,0*
Cracked concrete										
Tensile $N_{Ru,m}$	HIT-V 5.8	[kN]	*18,9*	*30,5*	*44,1*	65,2	110,8	146,1	196,0	226,2
Shear $V_{Ru,m}$	HIT-V 5.8	[kN]	*9,5*	*15,8*	*22,1*	*41,0*	*64,1*	*92,4*	*120,8*	*147,0*

Characteristic resistance: concrete C 20/25 – $f_{ck,cube}$ = 25 N/mm², anchor HIT-V 5.8

			Data according ETA-07/0260, issue 2009-01-12							
Anchor size			M8	M10	M12	M16	M20	M24	M27	M30
Non cracked concrete										
Tensile N_{Rk}	HIT-V 5.8	[kN]	*18,0*	*29,0*	*42,0*	70,6	111,9	153,7	187,8	224,0
Shear V_{Rk}	HIT-V 5.8	[kN]	*9,0*	*15,0*	*21,0*	*39,0*	*61,0*	*88,0*	*115,0*	*140,0*
Cracked concrete										
Tensile N_{Rk}	HIT-V 5.8	[kN]	*16,1*	*22,6*	*31,1*	44,0	74,8	109,6	132,3	152,7
Shear V_{Rk}	HIT-V 5.8	[kN]	*9,0*	*15,0*	*21,0*	*39,0*	*61,0*	*88,0*	*115,0*	*140,0*

Design resistance: concrete C 20/25 – $f_{ck,cube}$ = 25 N/mm², anchor HIT-V 5.8

			Data according ETA-07/0260, issue 2009-01-12							
Anchor size			M8	M10	M12	M16	M20	M24	M27	M30
Non cracked concrete										
Tensile N_{Rd}	HIT-V 5.8	[kN]	12,0	19,3	28,0	33,6	53,3	73,2	89,4	106,7
Shear V_{Rd}	HIT-V 5.8	[kN]	7,2	12,0	16,8	31,2	48,8	70,4	92,0	112,0
Cracked concrete										
Tensile N_{Rd}	HIT-V 5.8	[kN]	8,9	12,6	17,3	20,9	35,6	52,2	63,0	72,7
Shear V_{Rd}	HIT-V 5.8	[kN]	7,2	12,0	16,8	31,2	48,8	70,4	92,0	112,0

As 8 x 112 = 896 kN > 750 kN therefore OKAY

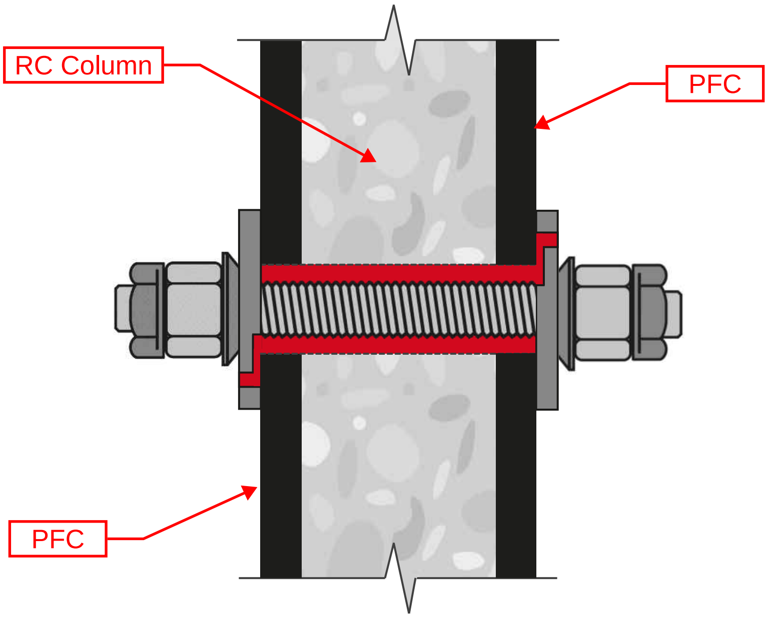
Provide M30 (8.8) HIT-V Threaded rod with HIT-RE 500-SD

Project			Status		
UCLH, Birbeck University - MRI			Information		
Date 09/01/2018 By NP Checked MB	Job no. 70038590	Section	Sheet no. 1 of 1	Rev 01	
Rev 01	Date 09/01/2018	Details			

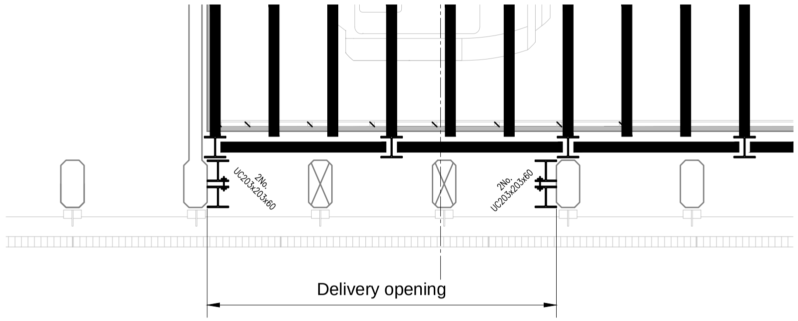
Part
Delivery Opening Concrete to Steel Through Bolts

REF | OUTPUT

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

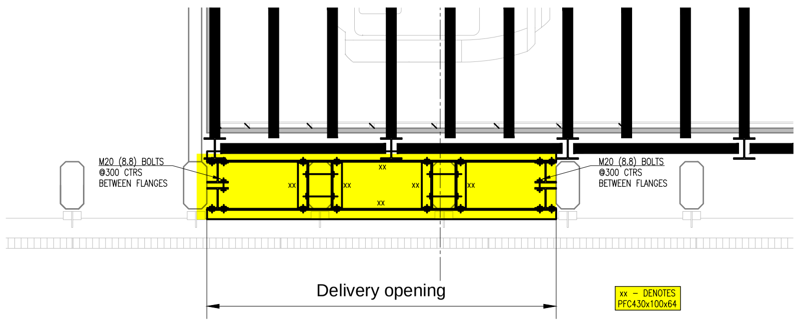


- Drill hole through RC Column.
- Clean Bore hole as per manufactures requirements
- Install road with Hilti filling washer set on each side.
- Dispense HIT-RE 500 Resin through hole until entire cavity is filled.
- Tighten nut to required torque setting.



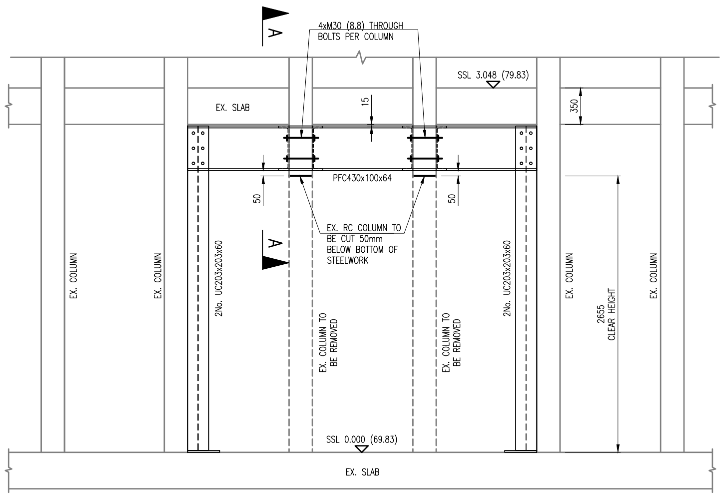
DELIVERY OPENING LOW LEVEL

1:25



DELIVERY OPENING HIGH LEVEL

1:25



DELIVERY OPENING ELEVATION

1:25

DO NOT SCALE

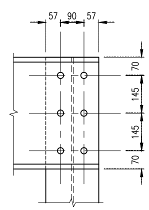
GENERAL NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH CSM ARCHITECTS DRAWING 4443/15.
2. ALL STRUCTURAL STEELWORK TO COMPLY WITH BS.EN.1993
3. ALL STRUCTURAL STEELWORK TO BE GRADE S355 (U.N.O.) BRITISH MILD STEEL TO BS EN 10056-1:1999, BS.4-1:1993, BS EN 10210-2:1997 AND BS EN 10219-2:1997.
4. ALL STRUCTURAL STEELWORK TO BE BLAST CLEAN TO BS EN ISO 8501-1:2001, GRADE SA 2.5, FOLLOWED BY A HIGH BUILD ZINC PHOSPHATE PRIMER. TO 75 MICRON DRY FILM THICKNESS.
5. ALL BOLTS TO BE GRADE 8.8 ZINC PLATED
6. THE CONTRACTOR SHALL BE RESPONSIBLE FOR FOR ANY TEMPORARY BRACING DURING ERECTION, AND ALL SHOP DETAILS FABRICATION DRAWINGS. THE FABRICATION DRAWINGS SHALL BE SUBMITTED.
7. THE CONTRACTOR SHALL ALLOW FOR ANY AMENDMENTS OF FABRICATION DETAILS ARISING FROM ENGINEERS COMMENTS
8. DIMENSION LINES ARE NOT TO BE SCALED FORM THIS DRAWING
9. THE CONTRACTOR SHALL COMPLY WITH THE HEALTH AND SAFETY REQUIREMENTS AS SET BY THE CDM REGULATIONS, THE HEALTH AND SAFETY EXECUTIVE.
10. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE EXECUTION OF THE WORKS IN ACCORDANCE WITH THE DRAWINGS AND THE SPECIFICATION AND FOR THE ACCURACY OF ALL THE DIMENSIONS AND SETTING OUT ON SITE
11. BEAM TO BEAM END CONNECTIONS:
    - 6No. M24 (8.8) BOLTS
    - 12mm THK END PLATES (AS APPLICABLE)
    - 6mm FILLET WELD

KEY TO HEALTH & SAFETY SYMBOLS

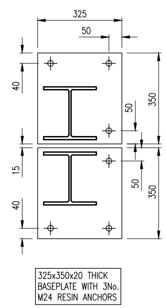
- WARNING RISK – INDICATES A RESIDUAL RISK AS A WARNING.
- COMPULSORY RISK – INDICATES A RESIDUAL RISK REQUIRING A COMPULSORY ACTION.
- PROHIBITIVE RISK – INDICATES A RESIDUAL RISK REQUIRING A PROHIBITIVE ACTION.
- INFORMATION RISK – INDICATES A RESIDUAL RISK FOR INFORMATION.

1. INSTALL STEELWORK AS PER DRAWING.
2. FOR THE COLUMNS TO BE REMOVED INSTALL M30 THROUGH BOLTS WITH INJECTION MORTAR TO FILL ENTIRE HOLE DRILLED THROUGH COLUMN.
3. INSTALL HILTI DYNAMIC SET AS PER GUIDLINES TO ENSURE BOLT IS IN FULL CONTACT WITH PFC.
4. ONCE STEELWORK IS COMPLETE CUT RC COLUMNS 50mm BELOW ANY STEELWORK.



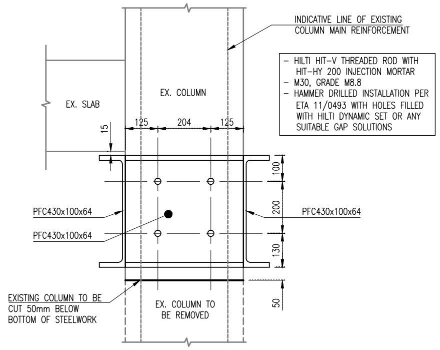
PFC TO COLUMN CONNECTION

1:10



203x203UC BASEPLATE

1:10



DETAIL A–A

1:10

SITE MEASUREMENTS REQUIRED TO CONFIRM SETTING OUT OF EXISTING STRUCTURE

EXISTING STRUCTURAL DETAILS/CONSTRUCTION TO BE CONFIRMED ON SITE PRIOR TO COMMENCING WORKS

REV	DATE	BY	DESCRIPTION	CHK	APP
02	07-02-18	NP	ISSUED FOR INFORMATION	NP	MRB
01	18-01-18	NP	ISSUED FOR INFORMATION	NP	MRB

DRAWING STATUS: INFORMATION

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ARCHITECT: CSM ARCHITECTS LTD

SITE/PROJECT: UCLH, BIRKBECK UNIVERSITY MRI

TITLE: STRUCTURAL
MRI DELIVERY OPENING STEELWORK
SECTION AND DETAILS

SCALE @ A1: 1:25	CHECKED: MRB		APPROVED: MRB
PROJECT NO: 70038590	DESIGNED: NP	DRAWN: HD	DATE: JAN 2018

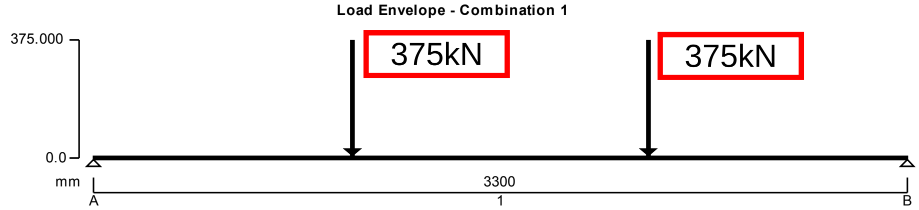
DRAWING No: UCL-WSP-00-GF-DR-S-200104 REV: 02

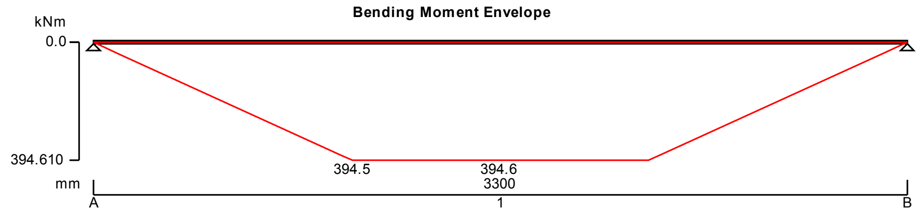
STEEL BEAM ANALYSIS & DESIGN (EN1993-1-1:2005)

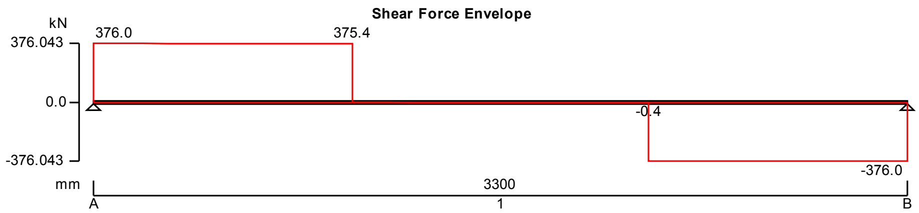
In accordance with EN1993-1-1:2005 incorporating Corrigenda February 2006 and April 2009 and the UK national annex

TEDDS calculation version 3.0.13

NB: Two PFC sections to be used (one either side of the column ot be removed columns). Therefore half the total load per column (750kN factored) will be used in the design of the PFC.







Support conditions

Support A	Vertically restrained
	Rotationally free
Support B	Vertically restrained
	Rotationally free

Applied loading

Beam loads	Permanent point load 375 kN at 1050 mm	Factored Loads
	Permanent point load 375 kN at 2250 mm	
	Permanent self weight of beam × 1	

Load combinations

Load combination 1	Support A	Permanent × 1.00
		Variable × 1.00
	Span 1	Permanent × 1.00
		Variable × 1.00
	Support B	Permanent × 1.00
		Variable × 1.00

Analysis results

Maximum moment	M_{max} = **394.6** kNm	M_{min} = **0** kNm
Maximum shear	V_{max} = **376** kN	V_{min} = **-376** kN
Deflection	δ_{max} = **10.1** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **376** kN	R_{A_min} = **376** kN
Unfactored permanent load reaction at support A	$R_{A\_Permanent}$ = **376** kN	
Maximum reaction at support B	R_{B_max} = **376** kN	R_{B_min} = **376** kN
Unfactored permanent load reaction at support B	$R_{B\_Permanent}$ = **376** kN	

Section details

Section type **UKPFC 430x100x64 (Tata Steel Advance)**

Steel grade **S355**

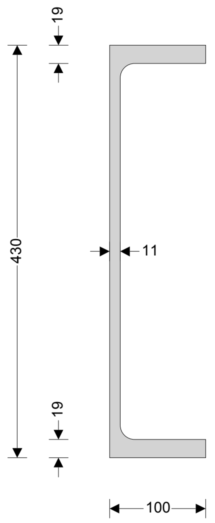
EN 10025-2:2004 - Hot rolled products of structural steels

Nominal thickness of element $t = max(t_f, t_w)$ = **19.0** mm

Nominal yield strength f_y = **345** N/mm^2

Nominal ultimate tensile strength f_u = **470** N/mm^2

Modulus of elasticity E = **210000** N/mm^2



Partial factors - Section 6.1

Resistance of cross-sections γ_{M0} = **1.00**

Resistance of members to instability γ_{M1} = **1.00**

Resistance of tensile members to fracture γ_{M2} = **1.10**

Lateral restraint

Span 1 has full lateral restraint

Effective length factors

Effective length factor in major axis K_y = **1.000**

Effective length factor in minor axis K_z = **1.000**

Effective length factor for torsion $K_{LT.A}$ = **1.000**

$K_{LT.B}$ = **1.000**

Classification of cross sections - Section 5.5

$\varepsilon = \sqrt{[235 \text{ N/mm}^2 / f_y]}$ = **0.83**

Internal compression parts subject to bending - Table 5.2 (sheet 1 of 3)

Width of section c = d = **362** mm

$c / t_w = 39.9 \times \varepsilon <= 72 \times \varepsilon$ Class 1

Outstand flanges - Table 5.2 (sheet 2 of 3)

Width of section $c = b - t_w - r_1 = \mathbf{74}$ mm

$c / t_f = 4.7 \times \varepsilon <= 9 \times \varepsilon$ Class 1

Section is class 1

Check shear - Section 6.2.6

Height of web $h_w = h - 2 \times t_f = \mathbf{392}$ mm

Shear area factor $\eta = \mathbf{1.000}$

$h_w / t_w < 72 \times \varepsilon / \eta$

Shear buckling resistance can be ignored

Design shear force $V_{Ed} = max(abs(V_{max}), abs(V_{min})) = \mathbf{376}$ kN

Shear area - cl 6.2.6(3) $A_v = A - 2 \times b \times t_f + (t_w + r_1) \times t_f = \mathbf{4903}$ mm^2

Design shear resistance - cl 6.2.6(2) $V_{c,Rd} = V_{pl,Rd} = A_v \times (f_y / \sqrt{[3]}) / \gamma_{M0} = \mathbf{976.5}$ kN

PASS - Design shear resistance exceeds design shear force

Check bending moment major (y-y) axis - Section 6.2.5

Design bending moment $M_{Ed} = max(abs(M_{s1\_max}), abs(M_{s1\_min})) = \mathbf{394.6}$ kNm

Design bending resistance moment - eq 6.13 $M_{c,Rd} = M_{pl,Rd} = W_{pl.y} \times f_y / \gamma_{M0} = \mathbf{421.6}$ kNm

PASS - Design bending resistance moment exceeds design bending moment

Check vertical deflection - Section 7.2.1

Consider deflection due to permanent and variable loads

Limiting deflection $\delta_{lim} = L_{s1} / 250 = \mathbf{13.2}$ mm

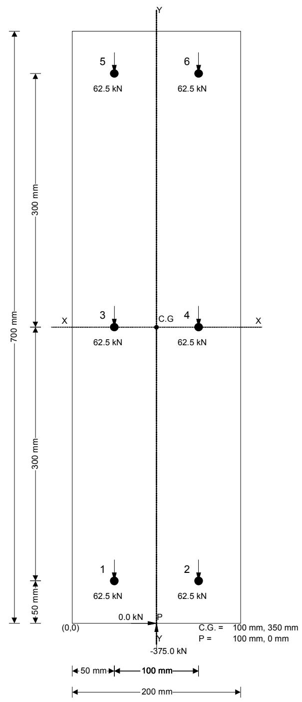
Maximum deflection span 1 $\delta = max(abs(\delta_{max}), abs(\delta_{min})) = \mathbf{10.085}$ mm

PASS - Maximum deflection does not exceed deflection limit

WSP One Queens Drive Birmingham B5 4PJ	Project UCLH, Birkbeck University - MRI				Job no. 70038590	
	Calcs for Delivery Opening Steelwork				Start page no./Revision p 1 01	
	Calcs by PG	Calcs date 09/01/2018	Checked by NP	Checked date 09/01/2018	Approved by MB	Approved date 09/01/2018

BOLT GROUP ANALYSIS

Tedds calculation version 1.0.02



Geometry of bolt group

Number of rows $R = \mathbf{3}$

Number of columns $C = \mathbf{2}$

Pitch distance $S_x = \mathbf{100}$ mm

Gauge distance $S_y = \mathbf{300}$ mm

Edge distance in vertical direction $d_y = \mathbf{50}$ mm

Edge distance in horizontal direction $d_x = \mathbf{50}$ mm

Load data

Vertical load applied on bolt group $P_y = \mathbf{-375.000}$ kN

Horizontal load applied on bolt group $P_x = \mathbf{0.000}$ kN

X coordinate of vertical force $X = \mathbf{100}$ mm

Y coordinate of horizontal force $Y = \mathbf{0}$ mm

Center of gravity of bolt group

X distance of center of bolt group $X_c = ((C - 1) \times S_x) / 2 + d_x = \mathbf{100}$ mm

Y distance of center of bolt group $Y_c = ((R - 1) \times S_y) / 2 + d_y = \mathbf{350}$ mm

Load eccentricity from center of gravity of bolt group

Eccentricity of vertical load from C.G. $e_x = abs(X - X_c) = \mathbf{0}$ mm

Eccentricity of horizontal load from C.G. $e_y = abs(Y - Y_c) = \mathbf{350}$ mm

Moment about center of gravity $M = P_x \times (Y - Y_c) - P_y \times (X - X_c) = \mathbf{0.000}$ kNm

Bolt number	Bolt distance from centre of gravity		Direct shear		Torsional shear		Total force
	X_i (mm)	Y_i (mm)	P_{dx} (kN)	P_{dy} (kN)	P_{tx} (kN)	P_{ty} (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

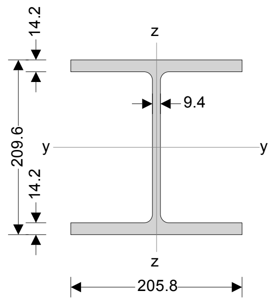
Diameter of bolt	Tensile stress area	Tension resistance	Shear resistance	
			Single shear	Double shear
d mm	A_s mm²	$F_{t,Rd}$ kN	$F_{v,Rd}$ kN	2 x $F_{v,Rd}$ kN
12	84.3	48.6	32.4	64.7
16	157	90.4	60.3	121
20	245	141	94.1	188
24	353	203	136	271
30	561	323	215	431

Extract from TATA Steel Blue Book

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



NB. In order to accommodate the width of the removed columns, two UC sections will be provided See UCL-WSP-00-GF-DR-S-200104.

Column and loading details

Column details

Column section **UKC 203x203x60**

System length for buckling about y axis L_y = **3000** mm

System length for buckling about z axis L_z = **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_{Ed} = **375** kN (Compression)

Moment about y axis at end 1 $M_{y,Ed1}$ = **0.0** kNm

Moment about y axis at end 2 $M_{y,Ed2}$ = **0.0** kNm

Moment about z axis at end 1 $M_{z,Ed1}$ = **0.0** kNm

Moment about z axis at end 2 $M_{z,Ed2}$ = **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

Steel grade **S355**

Yield strength f_y = **355** N/mm^2

Ultimate strength f_u = **470** N/mm^2

Modulus of elasticity E = **210** kN/mm^2

Poisson's ratio ν = **0.3**

Shear modulus $G = E / [2 \times (1 + \nu)]$ = **80.8** kN/mm^2

Buckling length for flexural buckling about y axis

End restraint factor K_y = **1.000**

Buckling length $L_{cr\_y} = L_y \times K_y$ = **3000** mm

Buckling length for flexural buckling about z axis

End restraint factor K_z = **1.000**

Buckling length $L_{cr\_z} = L_z \times K_z$ = **3000** mm

Section classification

Web section classification (Table 5.2)

Coefficient depending on f_y — $\varepsilon = \sqrt{(235 \text{ N/mm}^2 / f_y)}$ = **0.814**

Depth between fillets — $c_w = h - 2 \times (t_f + r)$ = **160.8** mm

Ratio of c/t — $ratio_w = c_w / t_w$ = **17.11**

Length of web taken by axial load — $l_w = \min(N_{Ed} / (f_y \times t_w), c_w)$ =**112.4** mm

For class 1 & 2 proportion in compression — $\alpha = (c_w/2 + l_w/2) / c_w$ = **0.849**

Limit for class 1 web — $Limit_{1w} = (396 \times \varepsilon) / (13 \times \alpha - 1)$ = **32.08**

The web is class 1

Flange section classification (Table 5.2)

Outstand length — $c_f = (b - t_w) / 2 - r$ = **88.0** mm

Ratio of c/t — $ratio_f = c_f / t_f$ = **6.20**

Limit for class 1 flange — $Limit_{1f} = 9 \times \varepsilon$ = **7.32**

Limit for class 2 flange — $Limit_{2f} = 10 \times \varepsilon$ = **8.14**

Limit for class 3 flange — $Limit_{3f} = 14 \times \varepsilon$ = **11.39**

The flange is class 1

Overall section classification

The section is class 1

Resistance of cross section (cl. 6.2)

Compression (cl. 6.2.4)

Design force — N_{Ed} = **375** kN

Design resistance — $N_{c,Rd} = N_{pl,Rd} = A \times f_y / \gamma_{M0}$ = **2711** kN

PASS - The compression design resistance exceeds the design force

Buckling resistance (cl. 6.3)

Yield strength for buckling resistance — f_y = **355** N/mm^2

Flexural buckling about y axis

Elastic critical buckling force — $N_{cr,y} = \pi^2 \times E \times I_y / L_{cr\_y}^2$ = **14104** kN

Non-dimensional slenderness — $\bar{\lambda}_y = \sqrt{(A \times f_y / N_{cr,y})}$ = **0.438**

Buckling curve (Table 6.2) — **b**

Imperfection factor (Table 6.1) — α_y = **0.34**

Parameter Φ — $\Phi_y = 0.5 \times [1 + \alpha_y \times (\bar{\lambda}_y - 0.2) + \bar{\lambda}_y^2]$ = **0.637**

Reduction factor — $\chi_y = \min(1.0, 1 / [\Phi_y + \sqrt{(\Phi_y^2 - \bar{\lambda}_y^2)}])$ = **0.911**

Design buckling resistance — $N_{b,y,Rd} = \chi_y \times A \times f_y / \gamma_{M1}$ = **2468.7** kN

PASS - The flexural buckling resistance about the y axis exceeds the design axial load

Flexural buckling about z axis

Elastic critical buckling force — $N_{cr,z} = \pi^2 \times E \times I_z / L_{cr\_z}^2$ = **4755** kN

Non-dimensional slenderness — $\bar{\lambda}_z = \sqrt{(A \times f_y / N_{cr,z})}$ = **0.755**

Buckling curve (Table 6.2) — **c**

Imperfection factor (Table 6.1) — α_z = **0.49**

Parameter Φ — $\Phi_z = 0.5 \times [1 + \alpha_z \times (\bar{\lambda}_z - 0.2) + \bar{\lambda}_z^2]$ = **0.921**

Reduction factor — $\chi_z = \min(1.0, 1 / [\Phi_z + \sqrt{(\Phi_z^2 - \bar{\lambda}_z^2)}])$ = **0.690**

Design buckling resistance — $N_{b,z,Rd} = \chi_z \times A \times f_y / \gamma_{M1}$ = **1871.6** kN

PASS - The flexural buckling resistance about the z axis exceeds the design axial load

Torsional and torsional-flexural buckling (cl. 6.3.1.4)

Torsional buckling length factor — K_T = **1.00**

Effective buckling length — $L_{cr\_T} = K_T \times \max(L_y, L_z)$ = **3000** mm

Distance from shear ctr to centroid along y axis — y_0 = **0.0** mm

Distance from shear ctr to centroid along z axis — z_0 = **0.0** mm

$i_0 = \sqrt{(i_y^2 + i_z^2 + y_0^2 + z_0^2)}$ = **103.5** mm

$\beta_T = 1 - (y_0 / i_0)^2$ = **1.000**

Elastic critical torsional buckling force — $N_{cr,T} = 1 / i_0^2 \times (G \times I_t + \pi^2 \times E \times I_w / L_{cr\_T}^2)$ = **7790** kN

Elastic critical torsional-flexural buckling force — $N_{cr,TF} = N_{cr,y}/(2\times\beta_T)\times[1+N_{cr,T}/N_{cr,y}-\sqrt{[(1-N_{cr,T}/N_{cr,y})^2 + 4\times(y_0/i_0)^2\times N_{cr,T}/N_{cr,y}]}]$

$N_{cr,TF}$ = **7790** kN

Non-dimensional slenderness — $\bar{\lambda}_T = \sqrt{(A \times f_y / \min(N_{cr,T}, N_{cr,TF}))}$ = **0.590**

Buckling curve (Table 6.2) — **c**

Imperfection factor (Table 6.1) — α_T = **0.49**

Parameter Φ — $\Phi_T = 0.5 \times [1 + \alpha_T \times (\bar{\lambda}_T - 0.2) + \bar{\lambda}_T^2]$ = **0.770**

Reduction factor — $\chi_T = \min(1.0, 1 / [\Phi_T + \sqrt{(\Phi_T^2 - \bar{\lambda}_T^2)}])$ = **0.791**

Design buckling resistance — $N_{b,T,Rd} = \chi_T \times A \times f_y / \gamma_{M1}$ = **2145.5** kN

PASS - The torsional/torsional-flexural buckling resistance exceeds the design axial load

Minimum buckling resistance

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.

5 STRUCTURAL DRAWINGS

All WSP structural drawings are shown below: