



Revision History

[illegible]

 GODSELL • ARNOLD PARTNERSHIP LTD	Project Bellinger House, Havant				Job Ref. 19483	
	Section Balconies				Sheet no./rev. P01	
	Calc. by MC	Date Mar '20	Chck'd by TR	Date Mar '20	App'd by	Date

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1 Design Statement

It is proposed to replace the existing timber framed balconies with steel framed balconies following our site inspection and report 19483 Bellinger House - site inspection no 1 draft. It is proposed to construct new steel balconies with cold formed steel joists flooring system. The balustrade and handrail will be steel construction to comply with the NHBC guidelines.

1.1 Calculation Reference

These calculations are for balconies as per drawings in Annex A:

- 2-storey height: Balcony F-E, Balcony B-A, Balcony H-G
- 3-storey height: Balcony D-C, Balcony P-N, Balcony M-L, Balcony K-J

1.2 Components Covered

The components included in these calculations include the following;

- Balcony frame
- Handrail/Balustrade
- Connections
- Foundation check

2 Design Codes

2.1 Eurocodes

The component design will be carried out to the relevant and current design codes with reference to the National Annex where applicable.

BS EN 1991-1-1	Eurocode 1	Actions on Structures
BS EN 1992-1-1	Eurocode 2	Design of Concrete Structures
BS EN 1993-1-1	Eurocode 3	Design of Steel Structures
BS EN 1993-1-8	Eurocode 3	Design of Joints

2.2 British standards

BS 6180	Barriers in and about buildings
BS 6688	Recommendations for the design of structures to EC1

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3 Materials

3.1 Plate

The steel grade used for plate will be structural grade S355 with the yield stress taken as 355N/mm².

3.2 Sections

The steel grade used for rolled sections shall be structural grade S355 (minimum) with the yield stress taken as 355N/mm².

4 Disproportionate Collapse

To prevent the disproportionate collapse of the balcony structure the lower column shall be protected from any form of impact load from vehicles.

5 Fixings

Steel columns will be fixed down to concrete foundations. An option will be provided to accommodate splicing of the columns due to delivery restrictions on site. Connection details between steels is part of this package

6 Loading

The loading applied to the stair are:

6.1 Dead Loads

The self-weight of the components will be calculated in the design model.

The assumed self-weight of the aluminium deck with bearers, sheet metal soffit lining and drainage is taken conservatively as:

Dead Load	1.0kN/m ²
Roof Dead Load	1.0kN/m ²

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6.2 Imposed Loads

Floor

The balconies are Category A, BS EN 1991-1-1 (2002) and therefore the imposed loads are;

Imposed Floor UDL 2.5kN/m²

Imposed Point Load 2.0kN

Roof

Imposed Roof UDL 0.6kN/m²

Imposed Roof Point Load 0.9kN

Balustrades

Under the BS6180 (2011) classification system, residential external balconies are classified as Class ii and therefore the loads are;

Horizontal UDL – Applied to top rail 0.74kN/m

Vertical UDL/PL – Applied to top rail 0.60kN/m or 1kN

Infill UDL/PL 1.0kN/m² or 0.5kN

The UDL the top rail and infill loads are not additive and will be considered as separate load cases.

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7 Design:

The design will be split into 2-storey typical and 3 -storey typical design.

7.1 Analysis Model: 3-storey

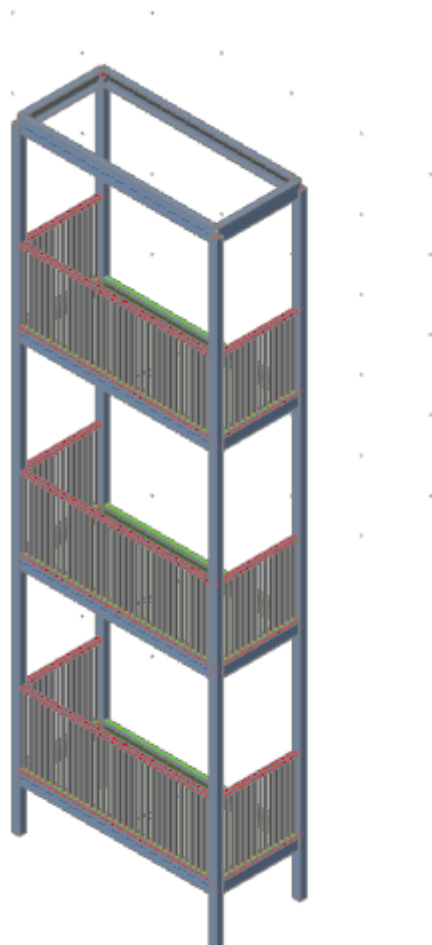


Figure 1 3-storey balcony model

Section Sizes

Column	100x100x6.3 SHS
Balcony Frame	230x90 PFC
Floor Beam	Metsec 142.M.13 inset with 4mm THK cleat
Baluster Post	40 x 10 Flat plate at 80mm c/c
Handrail	60SHS 6.3

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7.2 Dead Load

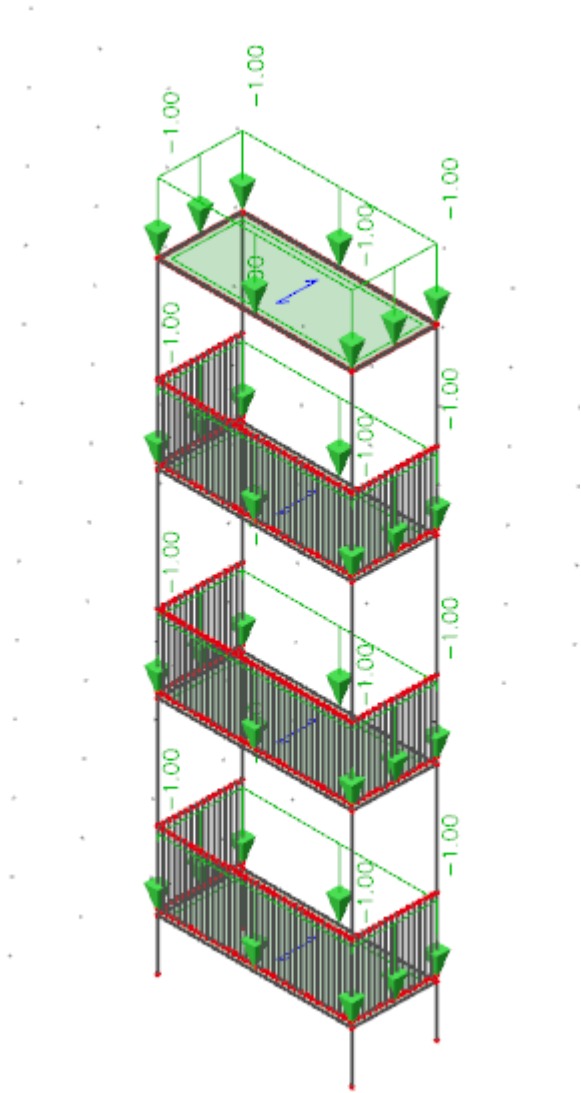
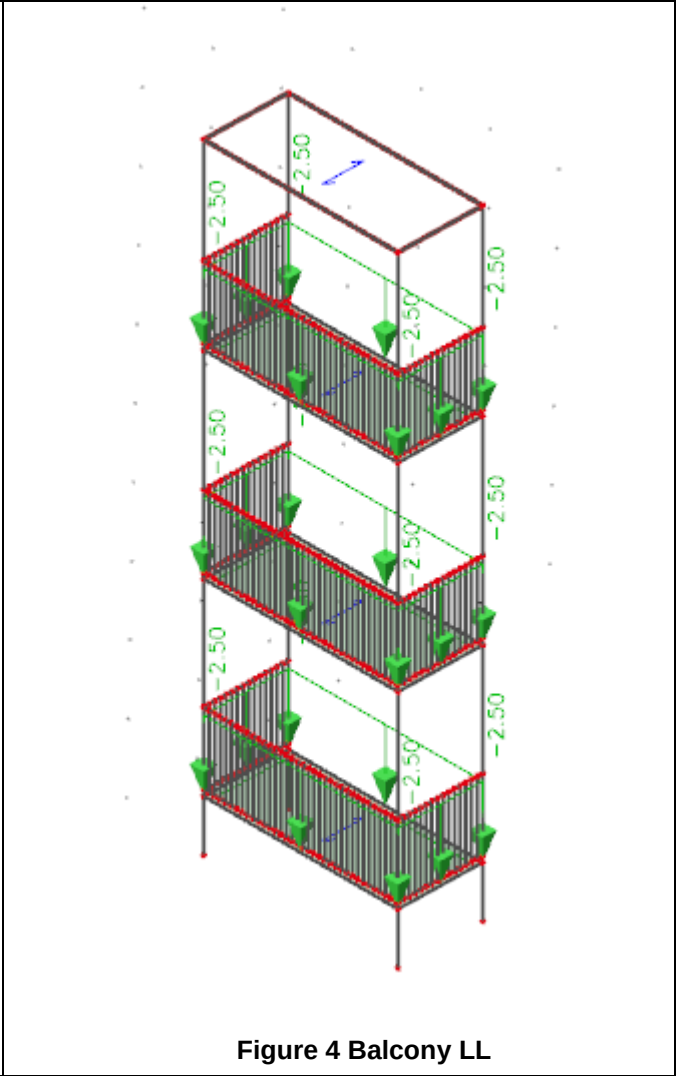
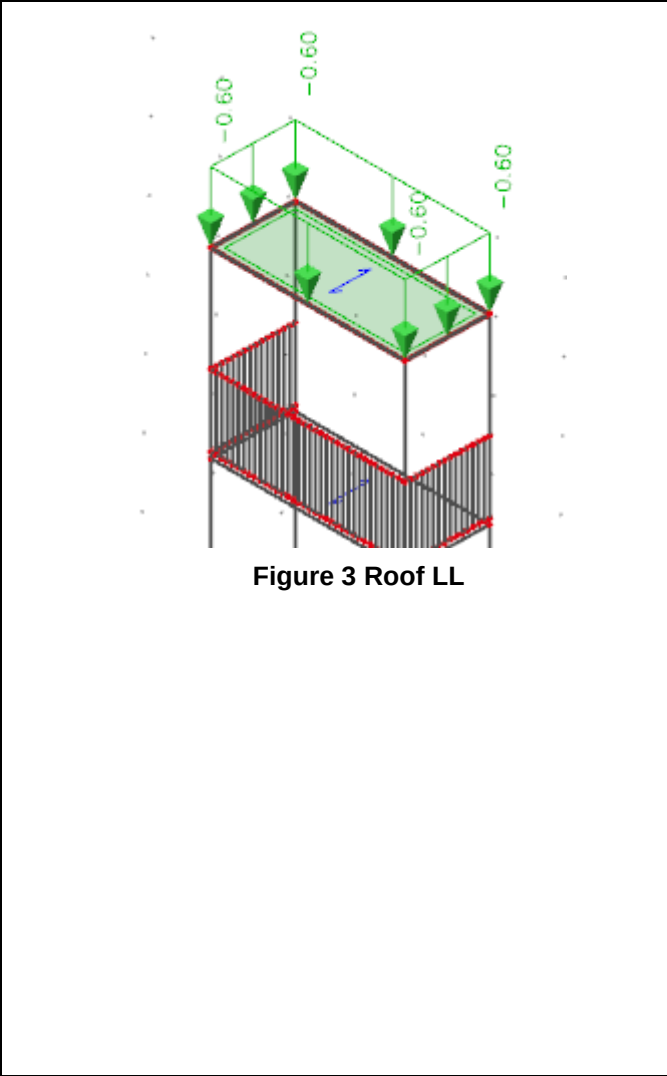


Figure 2 DL

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7.3 Live Load



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7.3.1 Handrail Horizontal

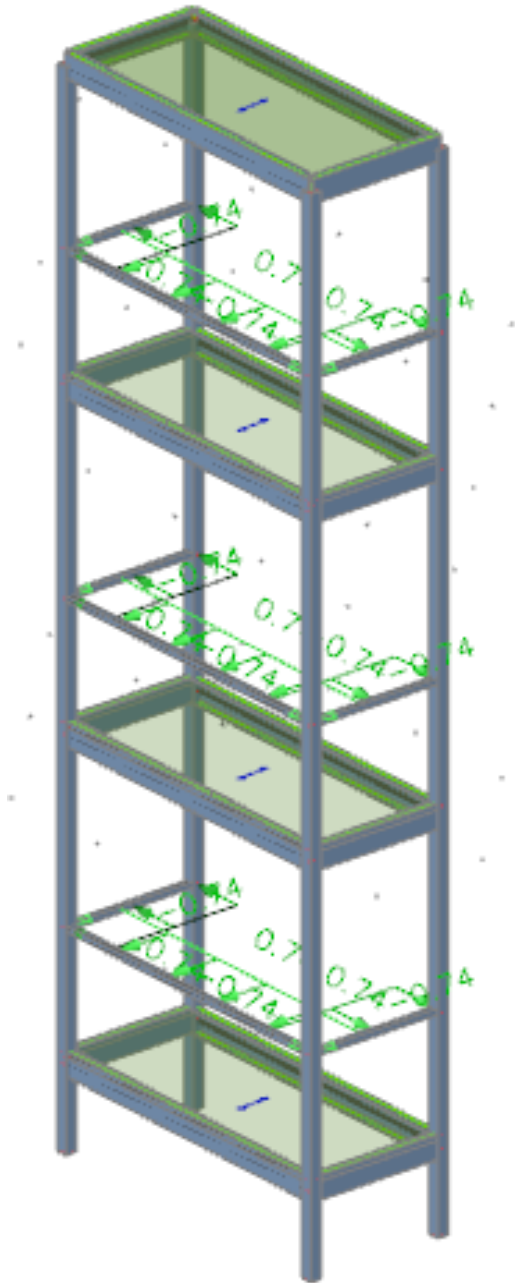


Figure 5 Horizontal load

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7.3.2 Handrail Vertical

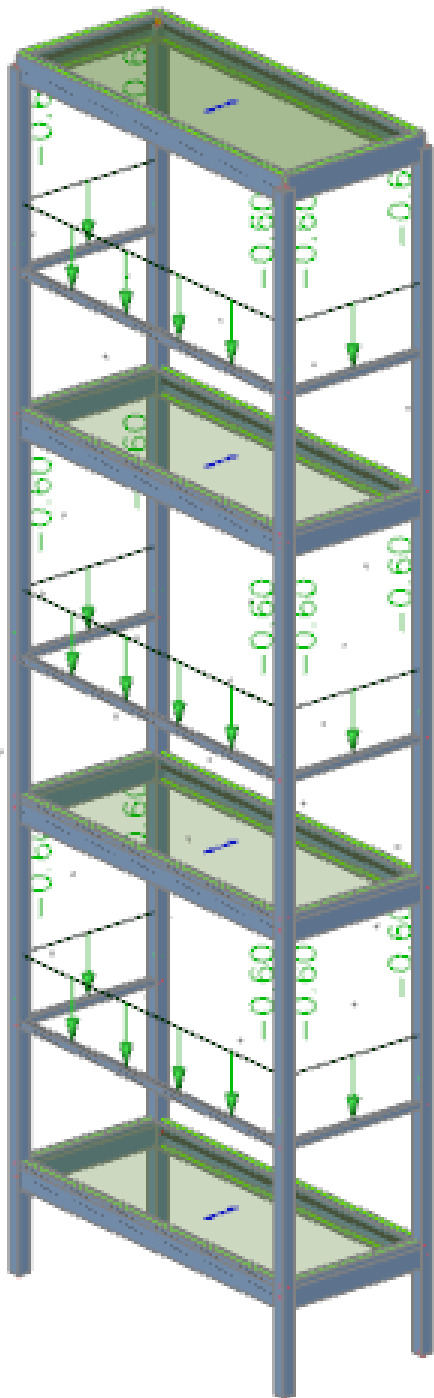


Figure 6 Handrail UDL

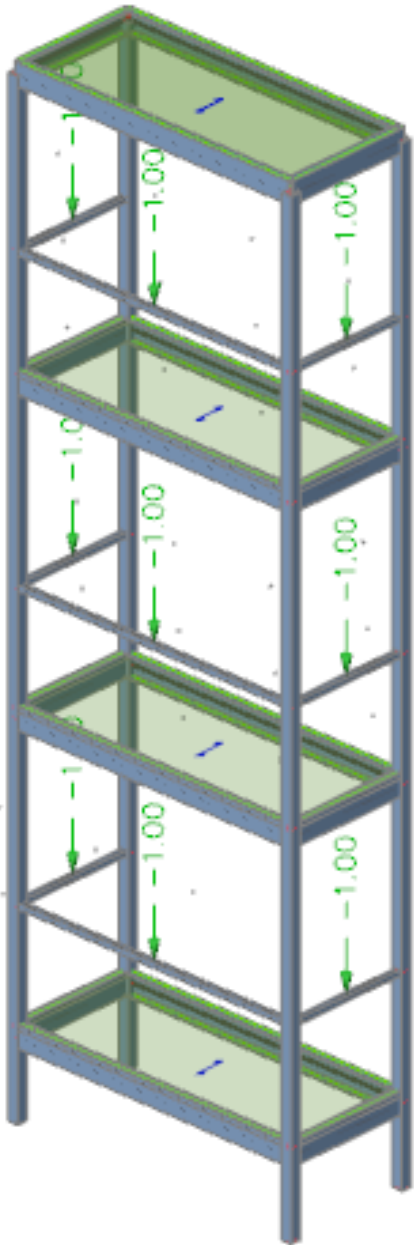


Figure 7 Handrail Point

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7.3.3 Infill UDL

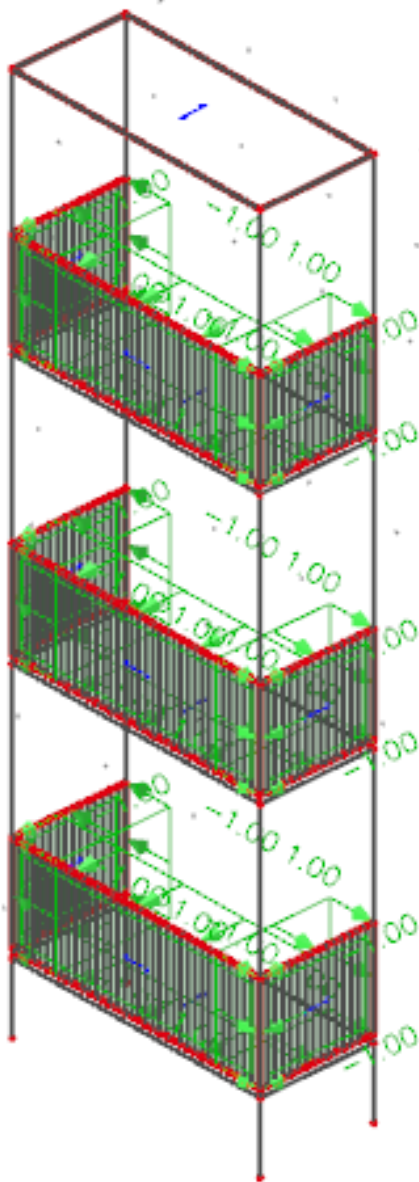


Figure 8 Infill UDL

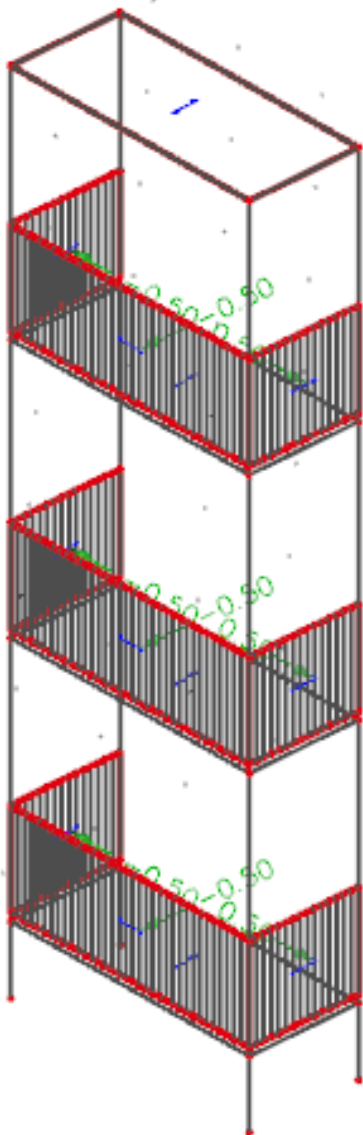


Figure 9 Infill Point Load

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7.3.4 Wind Loads

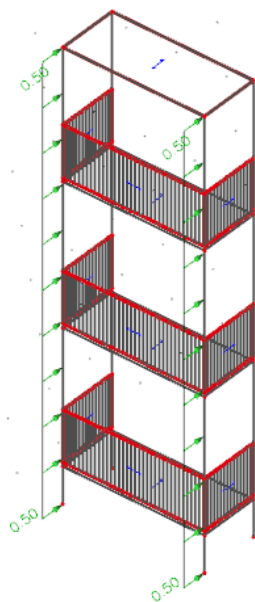


Figure 10 Wind 0

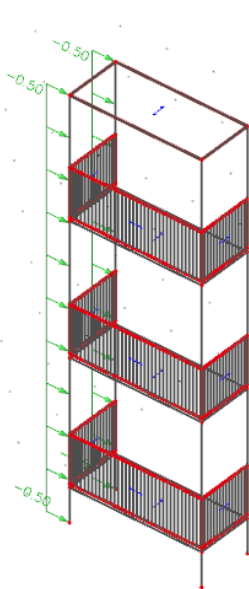


Figure 11 Wind 90

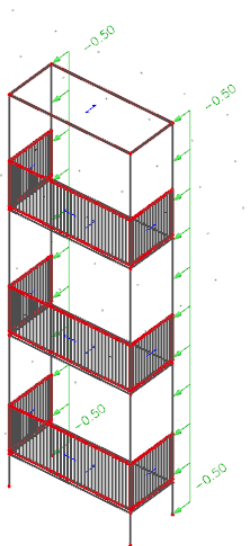


Figure 12 Wind 180

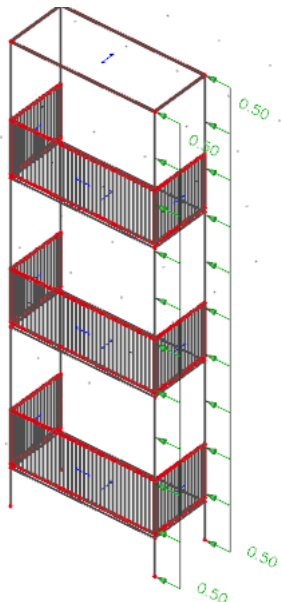


Figure 13 Wind 270

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7.4 Restraints

The main column is taken to be pinned at the base. The balcony is being designed as independent balcony but a location fixing points back to the existing masonry is to be provided. Refer to GAP Ltd drawings.

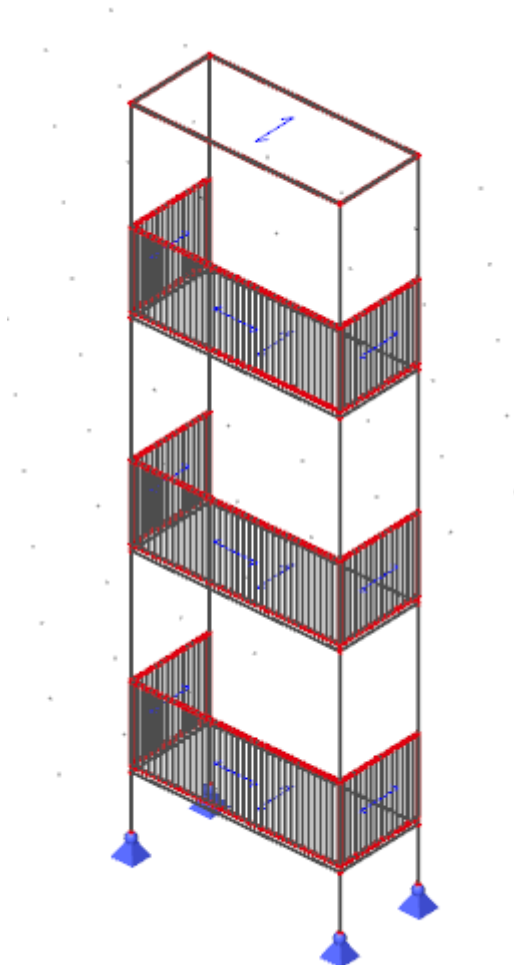


Figure 14 Supports

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7.5 Deflection

7.5.1 Handrail Horizontal

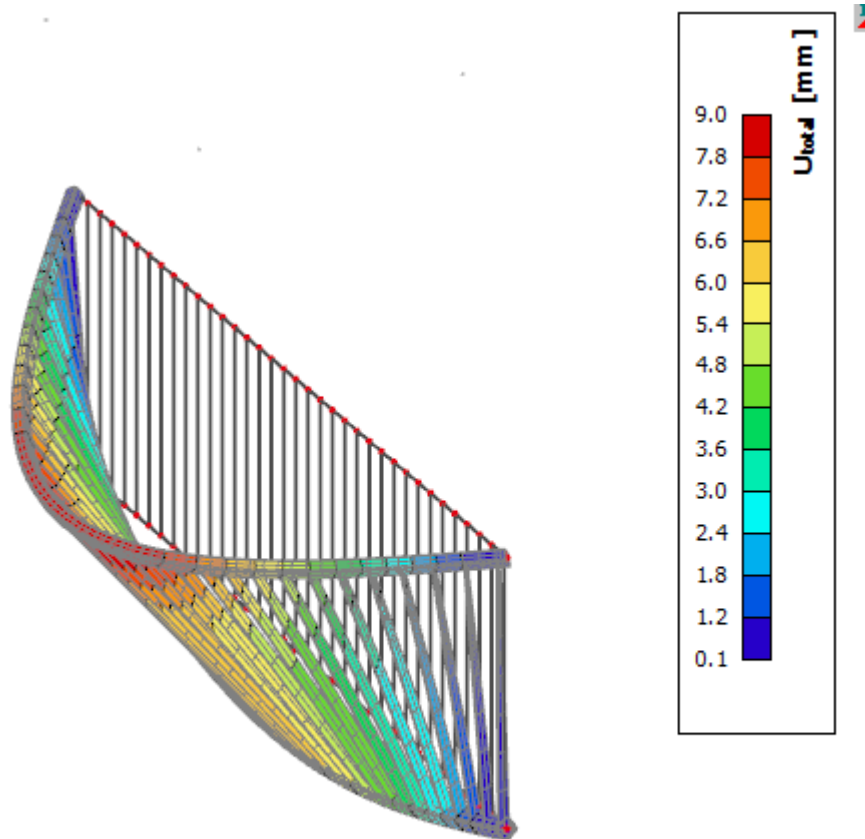


Figure 15 Handrail Horizontal Deflection

Maximum deflection = 9.0mm
Allowable deflection = 25mm
Therefore, deflection is acceptable.

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7.5.2 Balcony Vertical Deflection

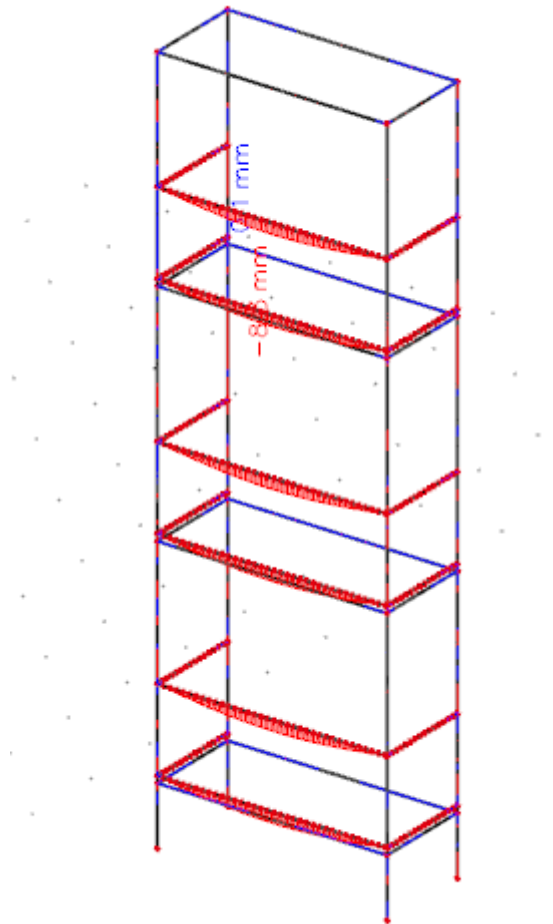


Figure 16 Maximum Vertical Deflection Balcony

Maximum deflection = 8.3mm
Allowable deflection = $L/200$ (SLS)= 14mm
Therefore, deflection is acceptable.

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7.5.3 Maximum Sway Deflection

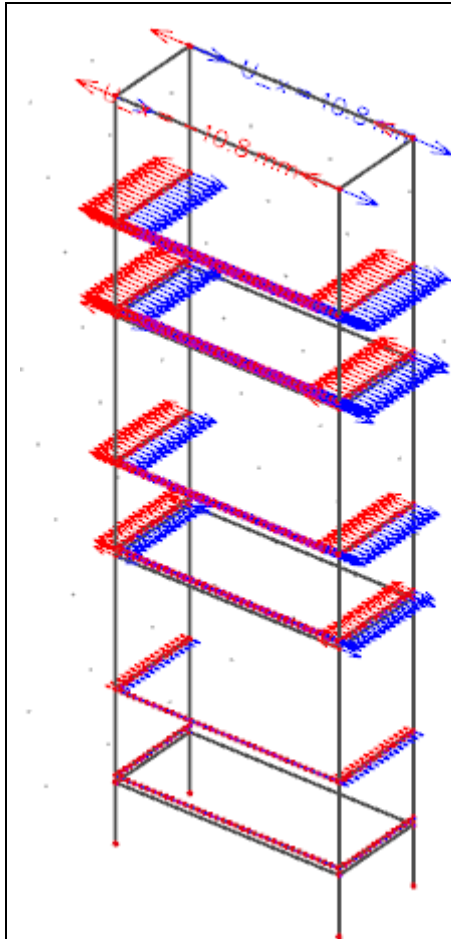


Figure 17 Maximum sway in longer direction

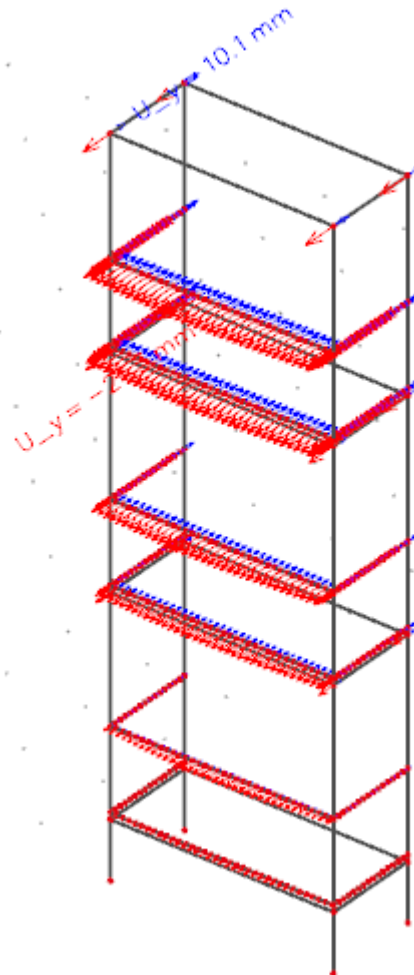
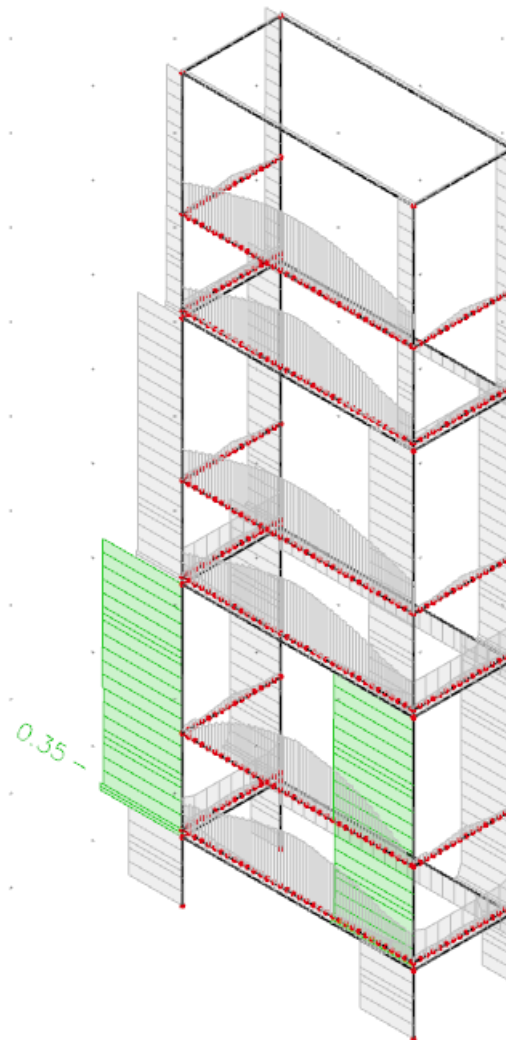


Figure 18 Maximum sway in shorter direction

Maximum deflection = 11.0mm
Allowable deflection = $L/300$ (Live Only) 29 mm
Therefore, deflection is acceptable.

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7.6 Section Design



Maximum UF = 0.35

Therefore, section sizes and grades are acceptable and only critical section detailed output is shown.

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EC-EN 1993 Steel check ULS

Linear calculation
Combination: ULS-Set B (auto)
Coordinate system: Principal
Extreme 1D: Global
Selection: All

EN 1993-1-1 Code Check

National annex: British BS-EN NA

Member B430	0.000 / 2.680 m	SHS100/100/6.3	S 355	ULS-Set B (auto)	0.35 -
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Combination key

ULS-Set B (auto) / 1.35*SW + 1.35*DL + 1.50*LL1 + 1.50*LL5 + 1.50*Wind 180

Partial safety factors

γ_{M0} for resistance of cross-sections	1.00
γ_{M1} for resistance to instability	1.00
γ_{M2} for resistance of net sections	1.10

Material

Yield strength	f_y	355.0	MPa
Ultimate strength	f_u	490.0	MPa
Fabrication		Rolled	

.....SECTION CHECK:.....

The critical check is on position 0.000 m

Internal forces		Calculated	Unit
Normal force	N_{Ed}	-50.66	kN
Shear force	$V_{y,Ed}$	6.52	kN
Shear force	$V_{z,Ed}$	-2.27	kN
Torsion	T_{Ed}	0.00	kNm
Bending moment	$M_{y,Ed}$	0.49	kNm
Bending moment	$M_{z,Ed}$	-7.09	kNm

Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

Id	Type	c [mm]	t [mm]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	Ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	81	6	1.006e+05	-7.066e+04	-0.70		0.59	12.87	45.95	53.94	75.54	1
3	I	81	6	-8.303e+04	-7.113e+04								
5	I	81	6	-5.690e+04	1.144e+05	-0.50		0.67	12.87	38.36	45.52	64.37	1
7	I	81	6	1.267e+05	1.148e+05	0.91		1.00	12.87	22.78	27.66	31.96	1

Note: The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

Compression check

According to EN 1993-1-1 article 6.2.4 and formula (6.9)

Cross-section area	A	2.3200e-03	m ²
Compression resistance	$N_{c,Rd}$	823.60	kN
Unity check		0.06	-

Bending moment check for M_y

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According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

Plastic section modulus	$W_{pl,y}$	8.0900e-05	m ³
Plastic bending moment	$M_{pl,y,Rd}$	28.72	kNm
Unity check		0.02	-

Bending moment check for M_z

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

Plastic section modulus	$W_{pl,z}$	8.0900e-05	m ³
Plastic bending moment	$M_{pl,z,Rd}$	28.72	kNm
Unity check		0.25	-

Shear check for V_y

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Shear correction factor	η	1.00	
Shear area	A_v	1.1600e-03	m ²
Plastic shear resistance for V_y	$V_{pl,y,Rd}$	237.75	kN
Unity check		0.03	-

Shear check for V_z

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Shear correction factor	η	1.00	
Shear area	A_v	1.1600e-03	m ²
Plastic shear resistance for V_z	$V_{pl,z,Rd}$	237.75	kN
Unity check		0.01	-

Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

Index of fibre	Fibre	1	
Total torsional moment	T_{Ed}	0.0	MPa
Elastic shear resistance	T_{Rd}	205.0	MPa
Unity check		0.00	-

Note: The unity check for torsion is lower than the limit value of 0.05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

Combined bending, axial force and shear force check

According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

Design plastic moment resistance reduced due to N_{Ed}	$M_{N,y,Rd}$	28.72	kNm
Exponent of bending ratio y	α	1.67	
Design plastic moment resistance reduced due to N_{Ed}	$M_{N,z,Rd}$	28.72	kNm
Exponent of bending ratio z	β	1.67	

Unity check (6.41) = 0.00 + 0.10 = 0.10 -

Note: Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

.....**STABILITY CHECK**.....

Classification for member buckling design

Decisive position for stability classification: 0.000 m

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Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

Id	Type	c [mm]	t [mm]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	Ψ [-]	k_α [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	81	6	1.006e+05	-7.066e+04	-0.70		0.59	12.87	45.95	53.94	75.54	1
3	I	81	6	-8.303e+04	-7.113e+04								
5	I	81	6	-5.690e+04	1.144e+05	-0.50		0.67	12.87	38.36	45.52	64.37	1
7	I	81	6	1.267e+05	1.148e+05	0.91		1.00	12.87	22.78	27.66	31.96	1

Note: The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

Flexural Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Buckling parameters		yy	zz	
Sway type		sway	sway	
System length	L	2.680	2.680	m
Buckling factor	k	1.13	1.09	
Buckling length	l_{cr}	3.027	2.925	m
Critical Euler load	N_{cr}	759.89	813.99	kN
Slenderness	λ	79.55	76.86	
Relative slenderness	λ_{rel}	1.04	1.01	
Limit slenderness	$\lambda_{rel,0}$	0.20	0.20	
Buckling curve	a	a	a	
Imperfection	α	0.21	0.21	
Reduction factor	χ	0.64	0.66	
Buckling resistance	$N_{b,Rd}$	524.51	544.80	kN

Flexural Buckling verification

Cross-section area	A	2.3200e-03	m ²
Buckling resistance	$N_{b,Rd}$	524.51	kN
Unity check		0.10	-

Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Note: The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1

Note: The cross-section concerns an RHS section with ' $h / b < 10 / \lambda_{rel,z}$ '.

This section is thus not susceptible to Lateral Torsional Buckling.

Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters			
Interaction method		alternative method 1	
Cross-section area	A	2.3200e-03	m ²
Plastic section modulus	$W_{pl,y}$	8.0900e-05	m ³
Plastic section modulus	$W_{pl,z}$	8.0900e-05	m ³
Design compression force	N_{Ed}	50.66	kN
Design bending moment (maximum)	$M_{y,Ed}$	0.49	kNm
Design bending moment (maximum)	$M_{z,Ed}$	-7.09	kNm
Characteristic compression resistance	N_{Rk}	823.60	kN
Characteristic moment resistance	$M_{y,Rk}$	28.72	kNm
Characteristic moment resistance	$M_{z,Rk}$	28.72	kNm
Reduction factor	χ_Y	0.64	

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Bending and axial compression check parameters

Reduction factor	χ_z	0.66	
Modified reduction factor	$\chi_{LT,mod}$	1.00	
Interaction factor	k_{yy}	0.99	
Interaction factor	k_{yz}	0.62	
Interaction factor	k_{zy}	0.62	
Interaction factor	k_{zz}	0.99	

Maximum moment $M_{y,Ed}$ is derived from beam B430 position 0.000 m.

Maximum moment $M_{z,Ed}$ is derived from beam B430 position 0.000 m.

Interaction method 1 parameters

Critical Euler load	$N_{cr,y}$	759.89	kN
Critical Euler load	$N_{cr,z}$	813.99	kN
Elastic critical load	$N_{cr,T}$	149426.88	kN
Plastic section modulus	$W_{pl,y}$	8.0900e-05	m ³
Elastic section modulus	$W_{el,y}$	6.7100e-05	m ³
Plastic section modulus	$W_{pl,z}$	8.0900e-05	m ³
Elastic section modulus	$W_{el,z}$	6.7100e-05	m ³
Second moment of area	I_y	3.3600e-06	m ⁴
Second moment of area	I_z	3.3600e-06	m ⁴
Torsional constant	I_t	5.3400e-06	m ⁴
Method for equivalent moment factor $C_{my,0}$		Table A.2 Line 2 (General)	
Design bending moment (maximum)	$M_{y,Ed}$	0.49	kNm
Maximum relative deflection	δ_z	0.1	mm
Equivalent moment factor	$C_{my,0}$	0.94	
Method for equivalent moment factor $C_{mz,0}$		Table A.2 Line 2 (General)	
Design bending moment (maximum)	$M_{z,Ed}$	-7.09	kNm
Maximum relative deflection	δ_y	-1.1	mm
Equivalent moment factor	$C_{mz,0}$	0.95	
Factor	μ_y	0.97	
Factor	μ_z	0.98	
Factor	ϵ_y	0.34	
Factor	a_{LT}	0.00	
Critical moment for uniform bending	$M_{cr,0}$	647.81	kNm
Relative slenderness	$\lambda_{rel,0}$	0.21	
Limit relative slenderness	$\lambda_{rel,0,lim}$	0.34	
Equivalent moment factor	C_{my}	0.94	
Equivalent moment factor	C_{mz}	0.95	
Equivalent moment factor	C_{mLT}	1.00	
Factor	b_{LT}	0.00	
Factor	c_{LT}	0.00	
Factor	d_{LT}	0.00	
Factor	e_{LT}	0.00	
Factor	w_y	1.21	
Factor	w_z	1.21	
Factor	η_{pl}	0.06	
Maximum relative slenderness	$\lambda_{rel,max}$	1.04	
Factor	C_{yy}	0.99	
Factor	C_{yz}	0.96	
Factor	C_{zy}	0.96	
Factor	C_{zz}	0.99	

Unity check (6.61) = 0.10 + 0.02 + 0.15 = 0.27 -

Unity check (6.62) = 0.09 + 0.01 + 0.25 = 0.35 -

The member satisfies the stability check.

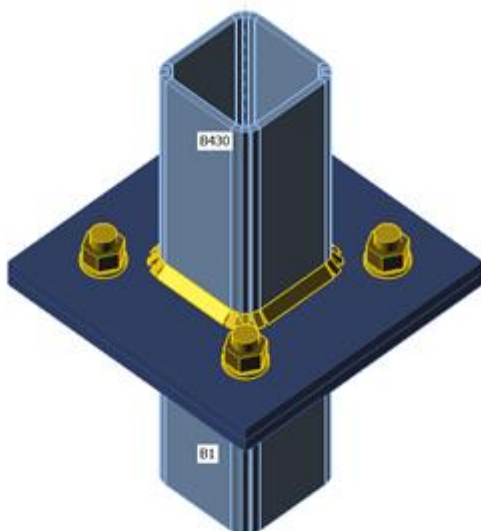
	Project Bellinger House, Havant				Job Ref. 19483	
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7.7 Connections

7.7.1 PFC Splice TBC

Beams and columns

Name	Cross-section	β - Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]	Forces in
B1	1 - SHS100/100/6.3	0.0	90.0	0.0	0	0	0	Position
B430	1 - SHS100/100/6.3	0.0	-90.0	0.0	0	0	0	Position



Cross-sections

Name	Material
1 - SHS100/100/6.3	S 355

Bolts

Name	Bolt assembly	Diameter [mm]	f_u [MPa]	Gross area [mm ²]
M20 8.8	M20 8.8	20	800.0	314

Load effects (forces in equilibrium)

Name	Member	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
ULS-Set(1)	B1	-4.4	-0.9	0.2	0.0	-0.1	-0.7
	B430	-6.2	0.9	0.5	0.0	-0.1	1.1

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ULS-Set(2)	B1	-58.0	4.2	0.7	0.0	-0.5	3.1
	B430	-41.5	-4.5	2.1	0.0	-0.5	-4.6
ULS-Set(3)	B1	-26.4	2.4	-0.7	0.0	0.6	1.7
	B430	-19.0	-2.4	-0.4	0.0	1.0	-2.8
ULS-Set(4)	B1	-53.8	3.3	1.6	0.0	-1.2	2.4
	B430	-39.0	-3.6	3.0	0.0	-1.6	-3.5
ULS-Set(5)	B1	-15.8	0.0	0.2	0.0	-0.2	0.0
	B430	-14.2	-0.1	0.7	0.0	-0.1	0.0
ULS-Set(6)	B1	-8.6	0.0	-0.7	0.0	0.6	0.0
	B430	-8.7	0.0	-0.4	0.0	1.0	0.0
ULS-Set(7)	B1	-30.8	3.3	-0.6	0.0	0.5	2.4
	B430	-21.1	-3.6	-0.1	0.0	0.9	-3.5
ULS-Set(8)	B1	-37.0	0.0	1.6	0.0	-1.1	0.0
	B430	-32.0	-0.1	2.6	0.0	-1.5	0.0
ULS-Set(9)	B1	-37.0	3.3	1.2	0.0	-0.9	2.4
	B430	-24.7	-3.6	1.7	0.0	-1.3	-3.5
ULS-Set(10)	B1	-53.6	3.3	0.6	0.0	-0.4	2.4
	B430	-39.4	-3.3	1.7	0.0	-0.4	-3.9
ULS-Set(11)	B1	-30.8	0.0	-0.3	0.0	0.2	0.0
	B430	-28.3	-0.1	0.8	0.0	0.7	0.0
ULS-Set(12)	B1	-45.3	4.2	0.3	0.0	-0.2	3.1
	B430	-30.9	-4.5	1.0	0.0	-0.3	-4.6
ULS-Set(13)	B1	-21.6	-0.9	0.5	0.0	-0.4	-0.7
	B430	-21.3	0.9	1.5	0.0	-0.3	1.1
ULS-Set(14)	B1	-35.2	0.5	1.6	0.0	-1.2	0.4
	B430	-28.6	-0.6	2.7	0.0	-1.5	-0.6
ULS-Set(15)	B1	-14.0	0.0	-0.7	0.0	0.6	0.0
	B430	-14.1	0.0	-0.4	0.0	1.0	0.0
ULS-Set(16)	B1	-43.2	2.4	-0.3	0.0	0.2	1.7
	B430	-33.2	-2.4	0.8	0.0	0.7	-2.8
ULS-Set(17)	B1	-49.5	2.4	1.6	0.0	-1.1	1.7
	B430	-36.9	-2.4	2.6	0.0	-1.5	-2.8
ULS-Set(18)	B1	-22.2	1.5	0.2	0.0	-0.1	1.0
	B430	-16.5	-1.5	0.5	0.0	-0.1	-1.7
ULS-Set(19)	B1	-36.8	3.3	0.2	0.0	-0.1	2.4
	B430	-25.2	-3.3	0.5	0.0	-0.1	-3.9
ULS-Set(20)	B1	-41.2	4.2	0.2	0.0	-0.2	3.1
	B430	-27.2	-4.5	0.9	0.0	-0.2	-4.6
ULS-Set(21)	B1	-26.6	-0.9	0.6	0.0	-0.4	-0.7
	B430	-25.9	0.9	1.7	0.0	-0.4	1.1
ULS-Set(22)	B1	-32.7	2.4	1.1	0.0	-0.8	1.7
	B430	-22.7	-2.4	1.4	0.0	-1.2	-2.8

Check

Summary

Name	Value	Status
Analysis	100.0%	OK

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Plates	0.0 < 5%	OK
Bolts	17.8 < 100%	OK
Welds	44.9 < 100%	OK
Buckling	47.77	
GMNA	Calculated	

Plates

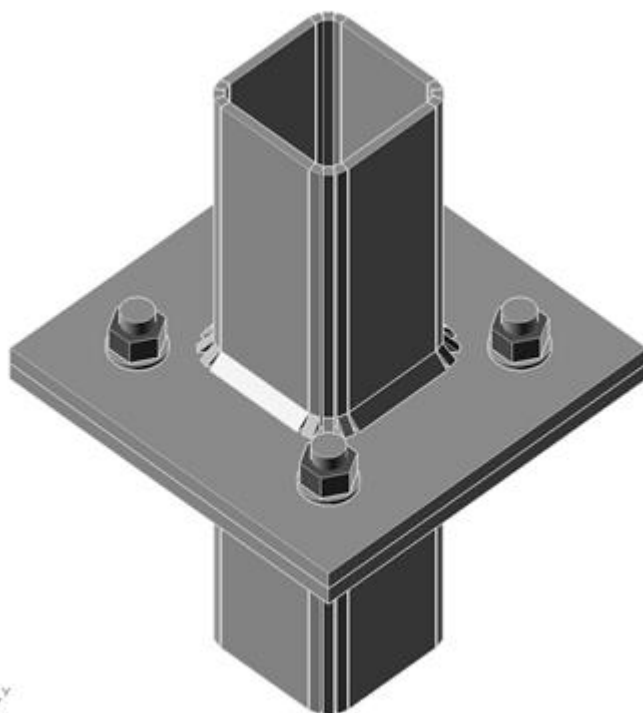
Name	Thickness [mm]	Loads	σ_{Ed} [MPa]	ϵ_{Pl} [%]	Status
B1	6.3	ULS-Set(4)	156.1	0.0	OK
B430	6.3	ULS-Set(4)	153.5	0.0	OK
PP1a	12.0	ULS-Set(20)	119.2	0.0	OK
PP1b	12.0	ULS-Set(20)	115.2	0.0	OK

Design data

Material	f_y [MPa]	ϵ_{lim} [%]
S 355	355.0	5.0

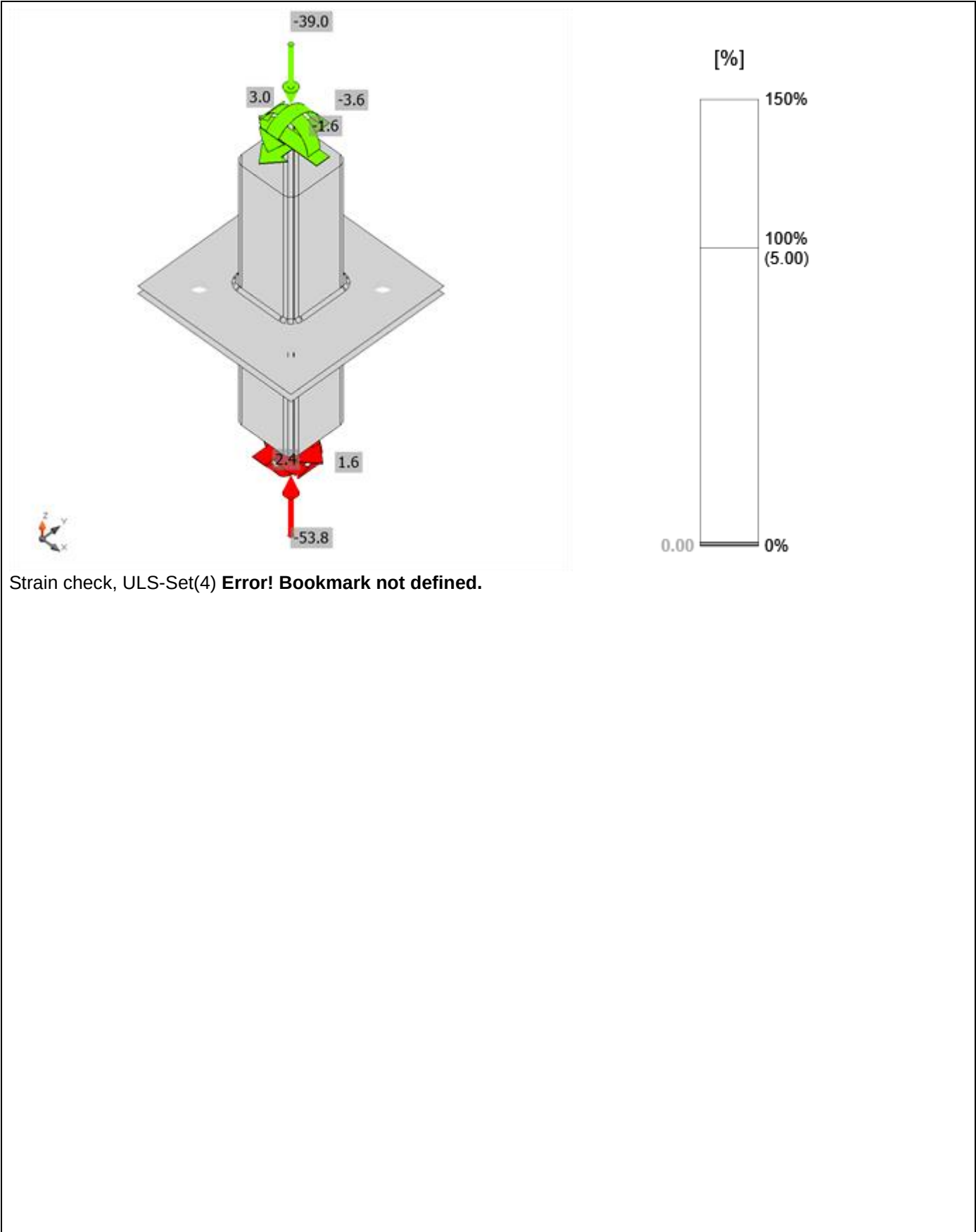
Symbol explanation

ϵ_{Pl} Strain
 σ_{Ed} Eq. stress
 f_y Yield strength
 ϵ_{lim} Limit of plastic strain



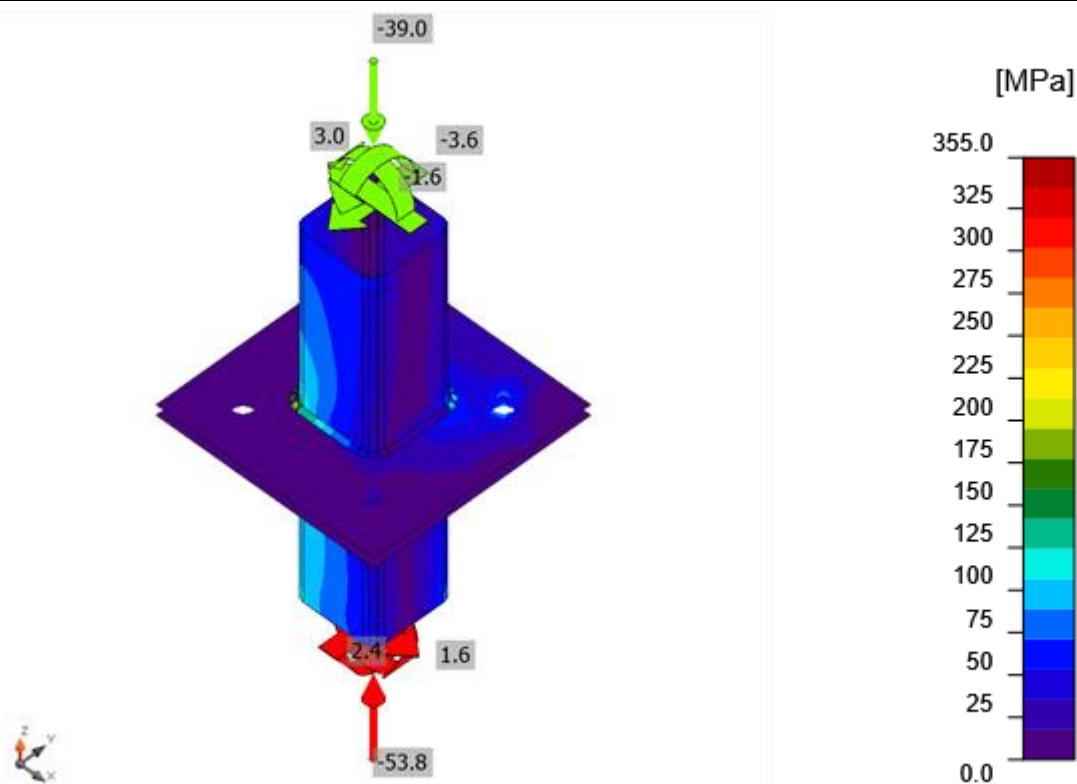
Overall check, ULS-Set(4) **Error! Bookmark not defined.**

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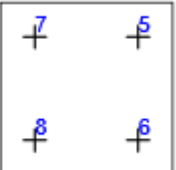
Strain check, ULS-Set(4) **Error! Bookmark not defined.**

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Equivalent stress, ULS-Set(4) **Error! Bookmark not defined.**

Bolts

	Name	Loads	$F_{t,Ed}$ [kN]	V [kN]	U_t [%]	$F_{b,Rd}$ [kN]	U_s [%]	U_{ts} [%]	Status
	B5	ULS-Set(20)	25.2	1.1	17.8	180.5	1.2	13.9	OK
	B6	ULS-Set(20)	23.8	1.1	16.9	182.3	1.2	13.3	OK
	B7	ULS-Set(1)	6.3	0.2	4.5	201.8	0.3	3.5	OK
	B8	ULS-Set(1)	5.6	0.3	4.0	205.9	0.3	3.1	OK

Design data

Name	$F_{t,Rd}$ [kN]	$B_{p,Rd}$ [kN]	$F_{v,Rd}$ [kN]
M20 8.8 - 1	141.1	279.3	94.1

Symbol explanation

$F_{t,Rd}$	Bolt tension resistance EN 1993-1-8 tab. 3.4
$F_{t,Ed}$	Tension force
$B_{p,Rd}$	Punching shear resistance
V	Resultant of shear forces V_y , V_z in bolt
$F_{v,Rd}$	Bolt shear resistance EN 1993-1-8 table 3.4
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 tab. 3.4
U_t	Utilization in tension
U_s	Utilization in shear

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U_{ts} Utilization in tension and shear EN 1993-1-8 table 3.4

Welds (Plastic redistribution)

Item	Edge	Throat th. [mm]	Length [mm]	Loads	$\sigma_{w,Ed}$ [MPa]	ϵ_{PI} [%]	$\sigma_{\perp}$ [MPa]	$\tau_{ }$ [MPa]	$\tau_{\perp}$ [MPa]	Ut [%]	U _t _c [%]	Status
PP1a	B1	▲6.3	352	ULS-Set(2)	195.6	0.0	-118.5	1.3	89.8	44.9	18.2	OK
PP1b	B430	▲6.3	352	ULS-Set(2)	191.9	0.0	-116.9	0.6	87.9	44.1	16.9	OK

Design data

	β_w [-]	$\sigma_{w,Rd}$ [MPa]	0.9 σ [MPa]
S 355	0.90	435.6	352.8

Symbol explanation

ϵ_{PI} Strain
 $\sigma_{w,Ed}$ Equivalent stress
 $\sigma_{w,Rd}$ Equivalent stress resistance
 $\sigma_{\perp}$ Perpendicular stress
 $\tau_{||}$ Shear stress parallel to weld axis
 $\tau_{\perp}$ Shear stress perpendicular to weld axis
0.9 σ Perpendicular stress resistance - 0.9*fu/γM2
 β_w Corelation factor EN 1993-1-8 tab. 4.1
U_t Utilization
U_t_c Weld capacity utilization

Buckling

Loads	Shape	Factor [-]
ULS-Set(1)	1	218.90
	2	233.55
	3	256.77
	4	290.25
	5	298.85
	6	339.60
ULS-Set(2)	1	47.77
	2	51.35
	3	55.57
	4	63.13
	5	65.62
	6	74.95
ULS-Set(3)	1	82.47
	2	88.20
	3	95.24
	4	108.72
	5	110.40
	6	126.54
ULS-Set(4)	1	59.01
	2	64.12
	3	67.06

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	4	77.61
	5	79.80
	6	92.28
ULS-Set(5)	1	455.70
	2	501.64
	3	517.56
	4	617.83
	5	620.40
	6	736.41
ULS-Set(6)	1	227.84
	2	235.26
	3	273.12
	4	294.44
	5	309.28
	6	334.41
ULS-Set(7)	1	67.38
	2	72.99
	3	77.79
	4	88.34
	5	93.28
	6	106.65
ULS-Set(8)	1	115.75
	2	128.88
	3	129.44
	4	149.87
	5	161.76
	6	188.62
ULS-Set(9)	1	65.46
	2	71.20
	3	74.72
	4	85.61
	5	89.70
	6	103.09
ULS-Set(10)	1	54.98
	2	58.46
	3	64.30
	4	73.11
	5	73.97
	6	84.48
ULS-Set(11)	1	184.08
	2	193.99
	3	209.64
	4	231.76
	5	246.73
	6	273.13

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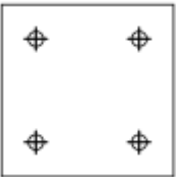
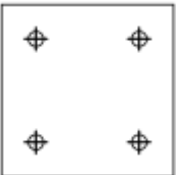
ULS-Set(12)	1	50.55
	2	54.49
	3	58.88
	4	66.64
	5	70.15
	6	79.93
ULS-Set(13)	1	163.81
	2	174.53
	3	187.06
	4	212.99
	5	217.72
	6	246.64
ULS-Set(14)	1	115.36
	2	128.76
	3	129.73
	4	149.91
	5	163.48
	6	190.50
ULS-Set(15)	1	204.31
	2	210.54
	3	241.31
	4	257.87
	5	275.89
	6	295.33
ULS-Set(16)	1	73.51
	2	77.88
	3	85.49
	4	97.04
	5	97.69
	6	111.46
ULS-Set(17)	1	69.99
	2	75.19
	3	79.70
	4	92.20
	5	92.82
	6	107.03
ULS-Set(18)	1	126.63
	2	134.69
	3	148.32
	4	168.43
	5	170.95
	6	195.08
ULS-Set(19)	1	60.07
	2	64.10
	3	70.43

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	4	79.65
	5	81.97
	6	93.24
ULS-Set(20)	1	51.64
	2	55.74
	3	60.13
	4	67.99
	5	71.86
	6	81.83
ULS-Set(21)	1	152.44
	2	162.54
	3	173.27
	4	196.27
	5	203.24
	6	228.58
ULS-Set(22)	1	79.59
	2	85.39
	3	91.13
	4	104.84
	5	105.80
	6	121.84

Bill of material

Manufacturing operations

Name	Plates [mm]	Shape	Nr.	Welds [mm]	Length [mm]	Bolts	Nr.
PP1	P12.0x250.0-250.0 (S 355)		1	Fillet: a = 6.3	704.5	M20 8.8	4
	P12.0x250.0-250.0 (S 355)		1				

Welds

Type	Material	Throat thickness [mm]	Leg size [mm]	Length [mm]
Fillet	S 355	6.3	8.9	704.5

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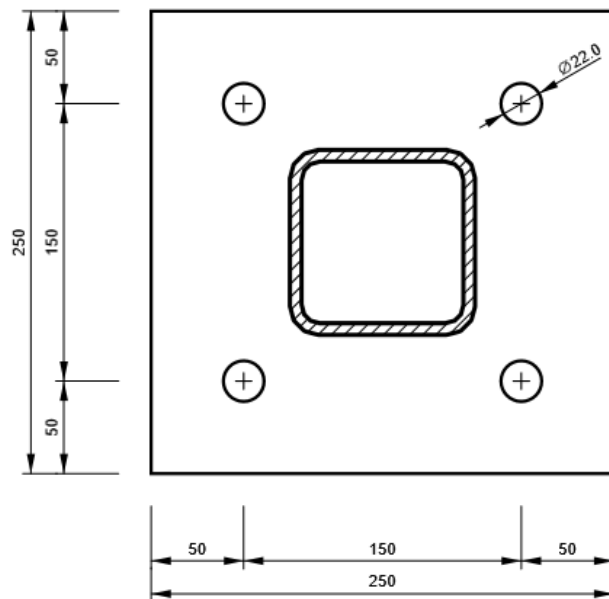
Bolts

Name	Grip length [mm]	Count
M20 8.8	24	4

Drawing

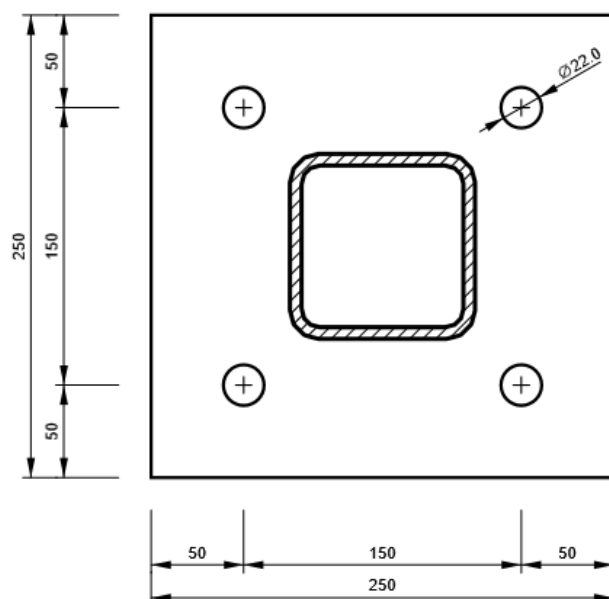
PP1 - PP1a

P12.0x250-250 (S 355)



PP1 - PP1b

P12.0x250-250 (S 355)



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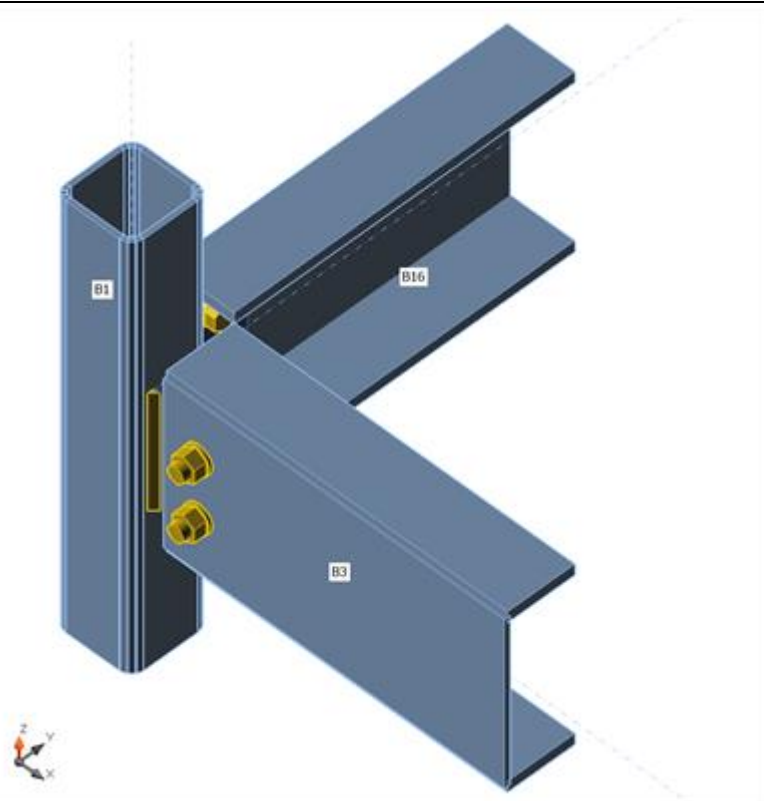
Code settings

Item	Value	Unit	Reference
γ_{M0}	1.00	-	EN 1993-1-1: 6.1
γ_{M1}	1.00	-	EN 1993-1-1: 6.1
γ_{M2}	1.25	-	EN 1993-1-1: 6.1
γ_{M3}	1.25	-	EN 1993-1-8: 2.2
γ_c	1.50	-	EN 1992-1-1: 2.4.2.4
γ_{Inst}	1.20	-	ETAG 001-C: 3.2.1
Joint coefficient β_j	0.67	-	EN 1993-1-8: 6.2.5
Effective area - influence of mesh size	0.10	-	
Friction coefficient - concrete	0.25	-	EN 1993-1-8
Friction coefficient in slip-resistance	0.30	-	EN 1993-1-8 tab 3.7
Limit plastic strain	0.05	-	EN 1993-1-5
Weld stress evaluation	Plastic redistribution		
Detailing	No		
Distance between bolts [d]	2.20	-	EN 1993-1-8: tab 3.3
Distance between bolts and edge [d]	1.20	-	EN 1993-1-8: tab 3.3
Concrete breakout resistance	Yes		ETAG 001-C
Use calculated a_b in bearing check.	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		
Local deformation check	No		
Local deformation limit	0.03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Large deformations for hollow sections

7.7.2 Fin Plate Connection

Name	Cross-section	β – Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]	Forces in
B1	1 - SHS100/100/6.3	0.0	90.0	0.0	0	0	0	Position
B3	2 - U230	0.0	0.0	0.0	0	0	0	Position
B16	2 - U230	90.0	0.0	180.0	0	0	0	Position

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Cross-sections

Name	Material
1 - SHS100/100/6.3	S 355
2 - U230	S 355

Bolts

Name	Bolt assembly	Diameter [mm]	fu [MPa]	Gross area [mm²]
M20 8.8	M20 8.8	20	800.0	314

Load effects (forces in equilibrium)

Name	Member	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
ULS(1)	B1	-4.4	-0.9	0.2	0.0	-0.1	-0.7
	B3	0.3	0.0	-1.0	0.0	0.2	0.0
	B16	0.0	0.0	-2.8	0.0	1.8	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0
ULS(2)	B1	-35.8	1.0	0.6	0.0	-0.4	0.7
	B3	1.1	0.0	-3.5	0.0	0.8	0.0
	B16	0.0	0.0	3.2	0.0	-1.8	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0
ULS(3)	B1	-8.6	0.0	-0.7	0.0	0.6	0.0
	B3	0.2	0.0	0.2	0.0	-1.5	0.0
	B16	0.0	0.0	0.2	0.0	0.0	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0
ULS(4)	B1	-31.6	0.0	1.6	0.0	-1.1	0.0

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	B3	1.0	0.0	-4.7	0.0	2.6	0.0
	B16	0.0	0.0	0.3	0.0	0.0	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0
ULS(5)	B1	-15.8	0.0	0.2	0.0	-0.2	0.0
	B3	0.4	0.0	-1.4	0.0	0.3	0.0
	B16	0.0	0.0	0.3	0.0	0.0	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0
ULS(6)	B1	-14.8	0.0	1.1	0.0	-0.8	0.0
	B3	0.2	0.0	-2.3	0.0	2.0	0.0
	B16	0.0	0.0	0.2	0.0	0.0	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0
ULS(7)	B1	-25.4	0.0	-0.3	0.0	0.2	0.0
	B3	1.0	0.0	-2.2	0.0	-1.0	0.0
	B16	0.0	0.0	0.3	0.0	0.0	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0
ULS(8)	B1	-28.5	0.0	0.6	0.0	-0.4	0.0
	B3	1.1	0.0	-3.5	0.0	0.8	0.0
	B16	0.0	0.0	0.3	0.0	0.0	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0
ULS(9)	B1	-11.7	0.0	0.2	0.0	-0.1	0.0
	B3	0.3	0.0	-1.0	0.0	0.2	0.0
	B16	0.0	0.0	0.2	0.0	0.0	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0
ULS(10)	B1	-29.3	0.0	0.6	0.0	-0.4	0.0
	B3	1.1	0.0	-3.5	0.0	0.8	0.0
	B16	0.0	0.0	0.3	0.0	0.0	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0
ULS(11)	B1	-18.9	0.0	1.2	0.0	-0.9	0.0
	B3	0.4	0.0	-2.6	0.0	2.1	0.0
	B16	0.0	0.0	0.3	0.0	0.0	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0
ULS(12)	B1	-17.1	-0.9	0.5	0.0	-0.4	-0.7
	B3	1.0	0.0	-3.1	0.0	0.7	0.0
	B16	0.0	0.0	-2.8	0.0	1.8	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0
ULS(13)	B1	-8.5	-0.9	0.2	0.0	-0.2	-0.7
	B3	0.4	0.0	-1.4	0.0	0.3	0.0
	B16	0.0	0.0	-2.7	0.0	1.8	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0
ULS(14)	B1	-31.7	1.0	0.5	0.0	-0.4	0.7
	B3	1.0	0.0	-3.1	0.0	0.7	0.0
	B16	0.0	0.0	3.2	0.0	-1.8	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0
ULS(15)	B1	-19.0	1.0	0.2	0.0	-0.1	0.7
	B3	0.3	0.0	-1.0	0.0	0.2	0.0

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	B16	0.0	0.0	3.2	0.0	-1.8	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0
ULS(16)	B1	-21.2	-0.9	0.6	0.0	-0.4	-0.7
	B3	1.1	0.0	-3.5	0.0	0.8	0.0
	B16	0.0	0.0	-2.7	0.0	1.8	0.0
	B1	0.0	0.0	0.0	0.0	0.0	0.0

Check

Summary

Name	Value	Status
Analysis	100.0%	OK
Plates	0.0 < 5%	OK
Bolts	31.4 < 100%	OK
Welds	62.2 < 100%	OK
Buckling	117.44	
GMNA	Calculated	

Plates

Name	Thickness [mm]	Loads	σ_{Ed} [MPa]	ϵ_{Pl} [%]	Status
B1	6.3	ULS(4)	355.1	0.0	OK
B3-bfl 1	14.0	ULS(7)	15.3	0.0	OK
B3-tfl 1	14.0	ULS(4)	16.3	0.0	OK
B3-w 1	7.5	ULS(4)	169.5	0.0	OK
B16-bfl 1	14.0	ULS(1)	10.4	0.0	OK
B16-tfl 1	14.0	ULS(2)	10.7	0.0	OK
B16-w 1	7.5	ULS(2)	120.8	0.0	OK
FP1	10.0	ULS(4)	183.2	0.0	OK
FP2	10.0	ULS(16)	133.0	0.0	OK

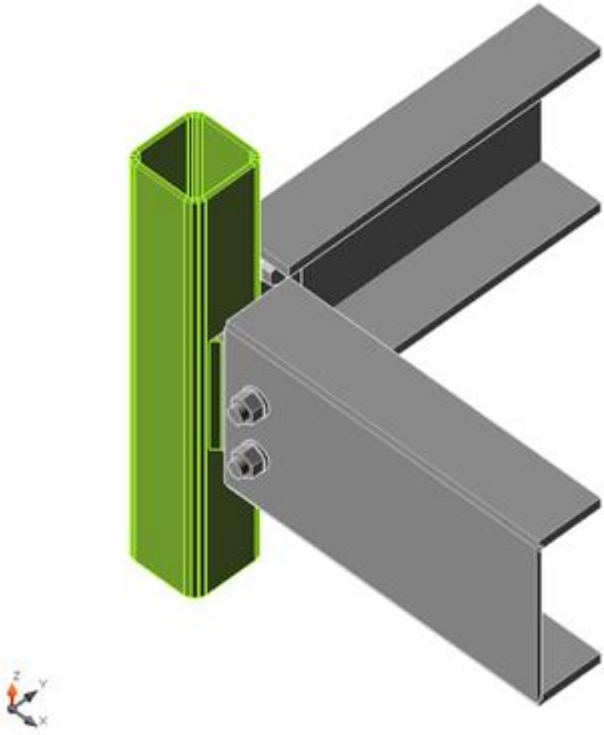
Design data

Material	f_y [MPa]	ϵ_{lim} [%]
S 355	355.0	5.0

Symbol explanation

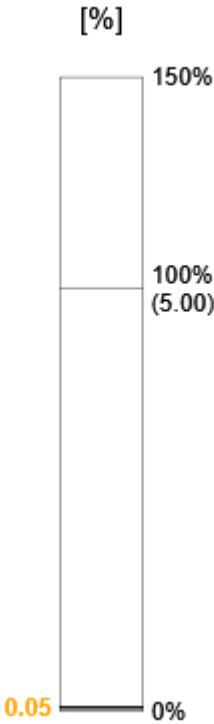
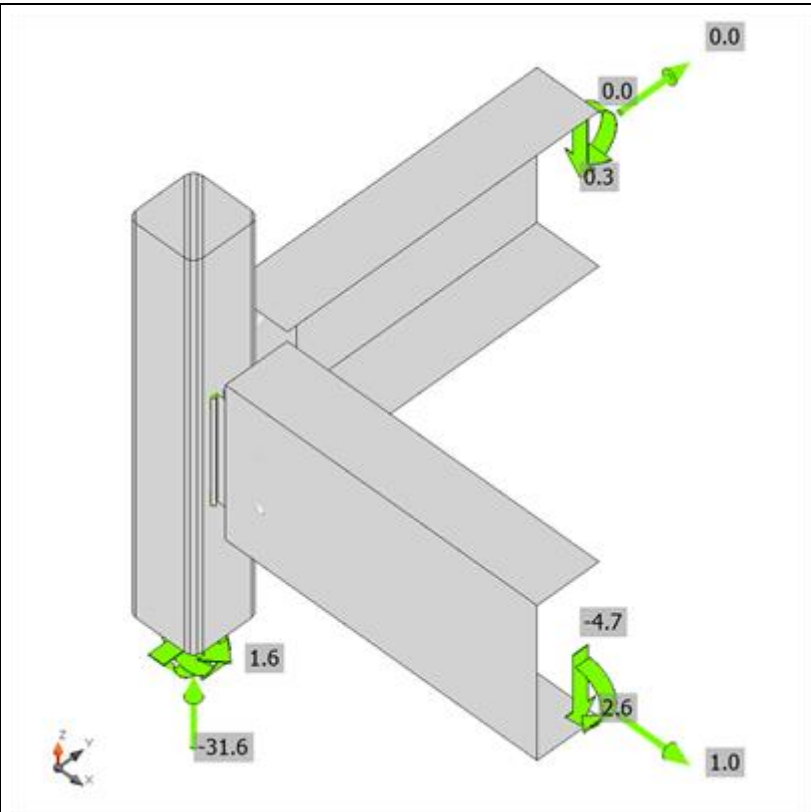
ϵ_{Pl} Strain
 σ_{Ed} Eq. stress
 f_y Yield strength
 ϵ_{lim} Limit of plastic strain

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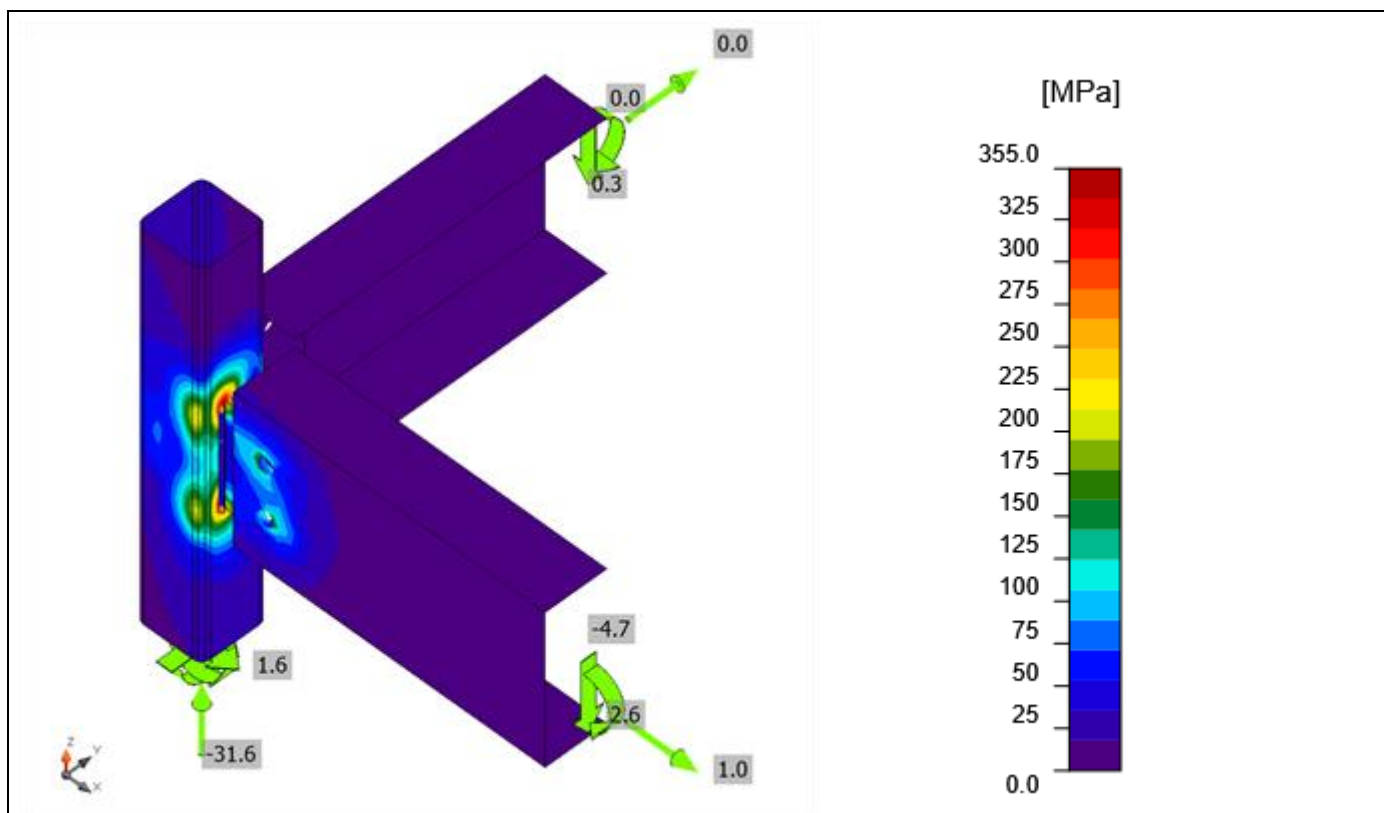
Overall check, ULS(4) **Error! Bookmark not defined.**

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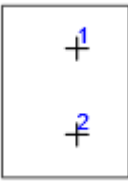
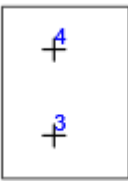
Strain check, ULS(4) **Error! Bookmark not defined.**

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Equivalent stress, ULS(4) **Error! Bookmark not defined.**

Bolts

	Name	Loads	$F_{t,Ed}$ [kN]	V [kN]	U_{t1} [%]	$F_{b,Rd}$ [kN]	U_{ts} [%]	U_{ts1} [%]	Status
	B1	ULS(4)	3.2	28.0	2.3	100.6	29.8	31.4	OK
	B2	ULS(4)	3.4	27.0	2.4	147.0	28.7	30.4	OK
	B3	ULS(14)	2.5	19.3	1.8	147.0	20.5	21.8	OK
	B4	ULS(13)	2.4	19.4	1.7	147.0	20.6	21.8	OK

Design data

Name	$F_{t,Rd}$ [kN]	$B_{p,Rd}$ [kN]	$F_{v,Rd}$ [kN]
M20 8.8 - 1	141.1	174.6	94.1

Symbol explanation

$F_{t,Rd}$ Bolt tension resistance EN 1993-1-8 tab. 3.4
 $F_{t,Ed}$ Tension force
 $B_{p,Rd}$ Punching shear resistance

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V Resultant of shear forces V_y , V_z in bolt
 $F_{v,Rd}$ Bolt shear resistance EN_1993-1-8 table 3.4
 $F_{b,Rd}$ Plate bearing resistance EN 1993-1-8 tab. 3.4
 U_t Utilization in tension
 U_s Utilization in shear
 U_{ts} Utilization in tension and shear EN 1993-1-8 table 3.4

Welds (Plastic redistribution)

Item	Edge	Throat th. [mm]	Length [mm]	Loads	$\sigma_{w,Ed}$ [MPa]	ϵ_{Pl} [%]	$\sigma_{\perp}$ [MPa]	$\tau_{\parallel}$ [MPa]	$\tau_{\perp}$ [MPa]	U_t [%]	U_{tc} [%]	Status
B1-w 3	FP1	▲5.6▲	150	ULS(4)	195.8	0.0	72.3	60.2	-86.0	44.9	14.5	OK
		▲5.6▲	150	ULS(4)	270.8	0.0	-119.2	-91.2	-106.7	62.2	14.5	OK
B1-w 2	FP2	▲5.6▲	150	ULS(2)	137.7	0.0	-49.1	-48.7	56.1	31.6	9.6	OK
		▲5.6▲	150	ULS(16)	187.4	0.0	-80.1	-66.9	-71.3	43.0	10.0	OK

Design data

	β_w [-]	$\sigma_{w,Rd}$ [MPa]	0.9σ [MPa]
S 355	0.90	435.6	352.8

Symbol explanation

ϵ_{Pl} Strain
 $\sigma_{w,Ed}$ Equivalent stress
 $\sigma_{w,Rd}$ Equivalent stress resistance
 $\sigma_{\perp}$ Perpendicular stress
 $\tau_{\parallel}$ Shear stress parallel to weld axis
 $\tau_{\perp}$ Shear stress perpendicular to weld axis
 0.9σ Perpendicular stress resistance - $0.9 \cdot f_u / \gamma_{M2}$
 β_w Corelation factor EN 1993-1-8 tab. 4.1
 U_t Utilization
 U_{tc} Weld capacity utilization

Buckling

Loads	Shape	Factor [-]
ULS(1)	1	166.33
	2	200.96
	3	226.60
	4	247.30
	5	278.01
	6	286.24
ULS(2)	1	165.21
	2	179.37
	3	182.71
	4	188.35
	5	193.89
	6	202.42
ULS(3)	1	158.10
	2	190.73
	3	202.24

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	4	261.97
	5	284.12
	6	294.60
ULS(4)	1	117.44
	2	140.19
	3	162.89
	4	163.02
	5	172.46
	6	177.32
ULS(5)	1	497.66
	2	523.68
	3	585.54
	4	610.45
	5	654.98
	6	691.14
ULS(6)	1	138.59
	2	163.31
	3	178.59
	4	214.20
	5	240.48
	6	250.81
ULS(7)	1	197.21
	2	222.33
	3	227.03
	4	253.83
	5	276.04
	6	287.28
ULS(8)	1	259.99
	2	271.93
	3	327.17
	4	338.71
	5	340.27
	6	356.87
ULS(9)	1	671.85
	2	706.97
	3	790.48
	4	824.11
	5	884.23
	6	933.04
ULS(10)	1	254.62
	2	266.44
	3	318.32
	4	329.73
	5	333.41
	6	349.92

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ULS(11)	1	135.33
	2	159.39
	3	174.68
	4	205.68
	5	225.80
	6	228.97
ULS(12)	1	166.51
	2	201.46
	3	221.50
	4	226.54
	5	227.29
	6	261.62
ULS(13)	1	166.13
	2	200.63
	3	226.25
	4	241.50
	5	262.70
	6	270.58
ULS(14)	1	165.79
	2	192.21
	3	195.67
	4	202.18
	5	205.66
	6	208.45
ULS(15)	1	167.53
	2	202.88
	3	232.34
	4	241.09
	5	245.08
	6	246.11
ULS(16)	1	166.17
	2	201.12
	3	209.85
	4	210.96
	5	226.87
	6	248.57

Code settings

Item	Value	Unit	Reference
Y _{M0}	1.00	-	EN 1993-1-1: 6.1
Y _{M1}	1.00	-	EN 1993-1-1: 6.1
Y _{M2}	1.25	-	EN 1993-1-1: 6.1
Y _{M3}	1.25	-	EN 1993-1-8: 2.2

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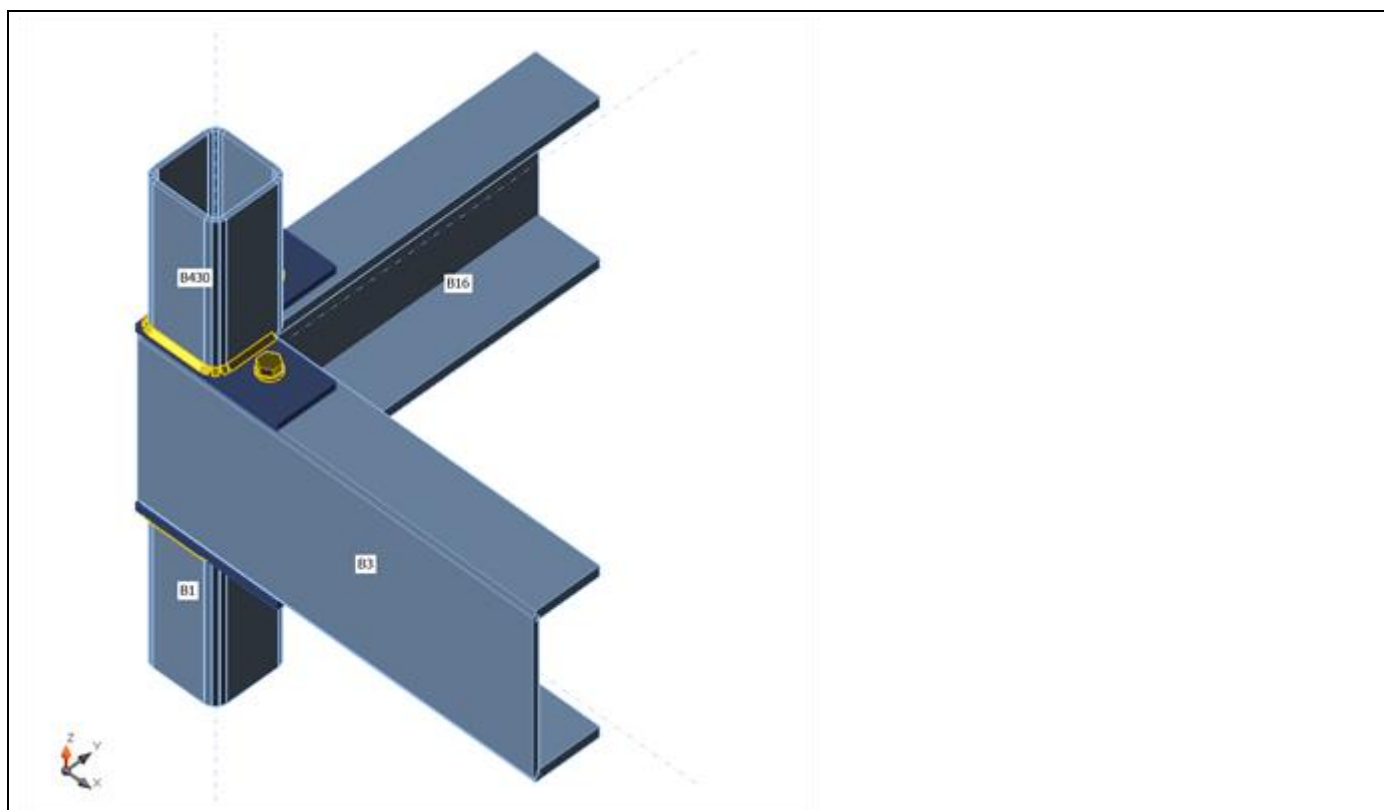
Yc	1.50	-	EN 1992-1-1: 2.4.2.4
Y _{Inst}	1.20	-	ETAG 001-C: 3.2.1
Joint coefficient β _j	0.67	-	EN 1993-1-8: 6.2.5
Effective area - influence of mesh size	0.10	-	
Friction coefficient - concrete	0.25	-	EN 1993-1-8
Friction coefficient in slip-resistance	0.30	-	EN 1993-1-8 tab 3.7
Limit plastic strain	0.05	-	EN 1993-1-5
Weld stress evaluation	Plastic redistribution		
Detailing	No		
Distance between bolts [d]	2.20	-	EN 1993-1-8: tab 3.3
Distance between bolts and edge [d]	1.20	-	EN 1993-1-8: tab 3.3
Concrete breakout resistance	Yes		ETAG 001-C
Use calculated a _b in bearing check.	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		
Local deformation check	No		
Local deformation limit	0.03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Large deformations for hollow sections

7.7.3 Typical Connection Option 2

Beams and columns

Name	Cross-section	β – Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]	Forces in
B1	1 - SHS100/100/6.3	0.0	90.0	0.0	0	0	0	Position
B3	4 - UKPFC230/90/32	0.0	0.0	0.0	-50	-25	0	Position
B16	4 - UKPFC230/90/32	90.0	0.0	180.0	0	-25	0	Position
B430	1 - SHS100/100/6.3	0.0	-90.0	0.0	0	0	0	Position

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Cross-sections

Name	Material
1 - SHS100/100/6.3	S 355
4 - UKPFC230/90/32	S 355

Bolts

Name	Bolt assembly	Diameter [mm]	fu [MPa]	Gross area [mm²]
M16 8.8	M16 8.8	16	800.0	201

Load effects (forces in equilibrium)

Name	Member	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
ULS-Set(1)	B1	-3.7	-0.9	0.2	0.0	-0.1	-0.7
	B3	0.3	0.0	-0.9	0.0	0.3	0.0
	B16	0.0	0.0	-2.8	0.0	1.8	0.0
	B430	-5.7	0.9	0.5	0.0	-0.1	1.1
ULS-Set(2)	B1	-57.1	4.2	0.8	0.0	-0.6	3.1
	B3	1.5	0.0	-3.4	0.0	1.1	0.0
	B16	0.2	0.0	12.9	0.0	-7.6	0.0
	B430	-40.8	-4.4	2.3	0.0	-0.6	-4.6
ULS-Set(3)	B1	-25.8	2.4	-0.7	0.0	0.5	1.7
	B3	0.3	0.0	0.4	0.0	-1.5	0.0
	B16	0.0	0.0	7.6	0.0	-4.5	0.0
	B430	-18.5	-2.4	-0.4	0.0	1.0	-2.8
ULS-Set(4)	B1	-52.9	3.3	1.8	0.0	-1.3	2.4

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	B3	1.4	0.0	-4.7	0.0	2.9	0.0
	B16	0.3	0.0	9.9	0.0	-5.9	0.0
	B430	-38.3	-3.5	3.2	0.0	-1.6	-3.5
ULS-Set(5)	B1	-14.9	0.0	0.3	0.0	-0.2	0.0
	B3	0.5	0.0	-1.2	0.0	0.4	0.0
	B16	0.0	0.0	0.2	0.0	0.0	0.0
	B430	-13.5	-0.1	0.7	0.0	-0.2	0.0
ULS-Set(6)	B1	-7.9	0.0	-0.7	0.0	0.5	0.0
	B3	0.3	0.0	0.4	0.0	-1.5	0.0
	B16	0.0	0.0	0.1	0.0	0.0	0.0
	B430	-8.1	0.0	-0.4	0.0	1.0	0.0
ULS-Set(7)	B1	-30.1	3.3	-0.6	0.0	0.5	2.4
	B3	0.5	0.0	0.3	0.0	-1.4	0.0
	B16	0.3	0.0	9.8	0.0	-5.8	0.0
	B430	-20.5	-3.5	-0.1	0.0	0.9	-3.5
ULS-Set(8)	B1	-36.1	0.0	1.7	0.0	-1.2	0.0
	B3	1.2	0.0	-4.6	0.0	2.8	0.0
	B16	0.0	0.0	0.2	0.0	0.0	0.0
	B430	-31.3	-0.1	2.9	0.0	-1.5	0.0
ULS-Set(9)	B1	-36.3	3.3	1.2	0.0	-0.9	2.4
	B3	0.5	0.0	-2.2	0.0	2.2	0.0
	B16	0.3	0.0	9.8	0.0	-5.8	0.0
	B430	-24.2	-3.5	1.8	0.0	-1.3	-3.5
ULS-Set(10)	B1	-52.7	3.3	0.7	0.0	-0.5	2.4
	B3	1.2	0.0	-3.3	0.0	1.0	0.0
	B16	0.0	0.0	10.7	0.0	-6.3	0.0
	B430	-38.7	-3.3	2.0	0.0	-0.5	-3.9
ULS-Set(11)	B1	-29.9	0.0	-0.1	0.0	0.1	0.0
	B3	1.2	0.0	-2.1	0.0	-0.8	0.0
	B16	0.0	0.0	0.2	0.0	0.0	0.0
	B430	-27.6	-0.1	1.1	0.0	0.6	0.0
ULS-Set(12)	B1	-49.8	3.3	0.8	0.0	-0.6	2.4
	B3	1.5	0.0	-3.4	0.0	1.1	0.0
	B16	0.3	0.0	9.9	0.0	-5.9	0.0
	B430	-36.5	-3.5	2.3	0.0	-0.6	-3.5
ULS-Set(13)	B1	-42.3	2.4	-0.1	0.0	0.1	1.7
	B3	1.2	0.0	-2.1	0.0	-0.8	0.0
	B16	0.0	0.0	7.7	0.0	-4.5	0.0
	B430	-32.5	-2.4	1.1	0.0	0.6	-2.8
ULS-Set(14)	B1	-13.4	0.0	-0.7	0.0	0.5	0.0
	B3	0.3	0.0	0.4	0.0	-1.5	0.0
	B16	0.0	0.0	0.1	0.0	0.0	0.0
	B430	-13.6	0.0	-0.4	0.0	1.0	0.0
ULS-Set(15)	B1	-24.5	0.0	-0.1	0.0	0.1	0.0
	B3	1.2	0.0	-2.1	0.0	-0.8	0.0

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	B16	0.0	0.0	0.2	0.0	0.0	0.0
	B430	-22.2	-0.1	1.1	0.0	0.6	0.0
ULS-Set(16)	B1	-34.3	0.5	1.8	0.0	-1.3	0.4
	B3	1.3	0.0	-4.6	0.0	2.9	0.0
	B16	0.1	0.0	1.7	0.0	-1.0	0.0
	B430	-27.9	-0.6	3.0	0.0	-1.6	-0.6
ULS-Set(17)	B1	-33.2	3.3	0.3	0.0	-0.2	2.4
	B3	0.6	0.0	-1.0	0.0	0.4	0.0
	B16	0.3	0.0	9.8	0.0	-5.8	0.0
	B430	-22.4	-3.5	0.9	0.0	-0.2	-3.5
ULS-Set(18)	B1	-50.5	3.3	0.8	0.0	-0.6	2.4
	B3	1.5	0.0	-3.4	0.0	1.1	0.0
	B16	0.3	0.0	9.9	0.0	-5.9	0.0
	B430	-37.2	-3.5	2.3	0.0	-0.6	-3.5
ULS-Set(19)	B1	-30.7	0.0	1.7	0.0	-1.2	0.0
	B3	1.2	0.0	-4.6	0.0	2.8	0.0
	B16	0.0	0.0	0.2	0.0	0.0	0.0
	B430	-25.9	-0.1	2.9	0.0	-1.5	0.0
ULS-Set(20)	B1	-40.2	3.3	1.3	0.0	-0.9	2.4
	B3	0.6	0.0	-2.6	0.0	2.3	0.0
	B16	0.3	0.0	9.9	0.0	-5.8	0.0
	B430	-27.7	-3.5	1.9	0.0	-1.3	-3.5
ULS-Set(21)	B1	-34.3	1.5	0.7	0.0	-0.5	1.0
	B3	1.1	0.0	-3.0	0.0	0.9	0.0
	B16	0.0	0.0	4.7	0.0	-2.7	0.0
	B430	-26.6	-1.5	1.8	0.0	-0.4	-1.7
ULS-Set(22)	B1	-7.6	-0.8	0.3	0.0	-0.2	-0.7
	B3	0.5	0.0	-1.2	0.0	0.4	0.0
	B16	0.0	0.0	-2.8	0.0	1.8	0.0
	B430	-9.2	0.9	0.7	0.0	-0.2	1.1
ULS-Set(23)	B1	-53.2	4.2	0.7	0.0	-0.5	3.1
	B3	1.4	0.0	-3.1	0.0	1.1	0.0
	B16	0.2	0.0	12.8	0.0	-7.6	0.0
	B430	-37.3	-4.4	2.1	0.0	-0.5	-4.6
ULS-Set(24)	B1	-40.5	4.2	0.3	0.0	-0.2	3.1
	B3	0.6	0.0	-1.0	0.0	0.4	0.0
	B16	0.2	0.0	12.8	0.0	-7.6	0.0
	B430	-26.7	-4.4	0.9	0.0	-0.2	-4.6
ULS-Set(25)	B1	-32.8	0.0	0.8	0.0	-0.5	0.0
	B3	1.2	0.0	-3.3	0.0	1.0	0.0
	B16	0.0	0.0	0.2	0.0	0.0	0.0
	B430	-29.3	-0.1	2.0	0.0	-0.5	0.0
ULS-Set(26)	B1	-24.8	-0.8	0.8	0.0	-0.5	-0.7
	B3	1.2	0.0	-3.3	0.0	1.0	0.0
	B16	0.0	0.0	-2.8	0.0	1.8	0.0

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	B430	-24.2	0.9	2.0	0.0	-0.5	1.1
ULS-Set(27)	B1	-36.2	3.3	0.2	0.0	-0.1	2.4
	B3	0.3	0.0	-0.9	0.0	0.3	0.0
	B16	0.0	0.0	10.6	0.0	-6.3	0.0
	B430	-24.6	-3.3	0.5	0.0	-0.1	-3.9
ULS-Set(28)	B1	-44.4	4.2	0.3	0.0	-0.2	3.1
	B3	0.7	0.0	-1.3	0.0	0.5	0.0
	B16	0.2	0.0	12.9	0.0	-7.6	0.0
	B430	-30.2	-4.4	1.0	0.0	-0.3	-4.6
ULS-Set(29)	B1	-20.9	-0.9	0.7	0.0	-0.5	-0.7
	B3	1.1	0.0	-3.0	0.0	0.9	0.0
	B16	0.0	0.0	-2.8	0.0	1.8	0.0
	B430	-20.7	0.9	1.8	0.0	-0.4	1.1
ULS-Set(30)	B1	-48.5	2.4	1.7	0.0	-1.2	1.7
	B3	1.2	0.0	-4.6	0.0	2.8	0.0
	B16	0.0	0.0	7.7	0.0	-4.5	0.0
	B430	-36.2	-2.4	2.9	0.0	-1.5	-2.8
ULS-Set(31)	B1	-21.6	1.5	0.2	0.0	-0.1	1.0
	B3	0.3	0.0	-0.9	0.0	0.3	0.0
	B16	0.0	0.0	4.7	0.0	-2.7	0.0
	B430	-16.0	-1.5	0.5	0.0	-0.1	-1.7
ULS-Set(32)	B1	-25.7	-0.8	0.8	0.0	-0.5	-0.7
	B3	1.2	0.0	-3.3	0.0	1.0	0.0
	B16	0.0	0.0	-2.8	0.0	1.8	0.0
	B430	-25.2	0.9	2.0	0.0	-0.5	1.1
ULS-Set(33)	B1	-21.9	-0.9	0.7	0.0	-0.5	-0.7
	B3	1.1	0.0	-3.0	0.0	0.9	0.0
	B16	0.0	0.0	-2.8	0.0	1.8	0.0
	B430	-21.7	0.9	1.8	0.0	-0.4	1.1

Check

Summary

Name	Value	Status
Analysis	100.0%	OK
Plates	0.0 < 5%	OK
Bolts	35.2 < 100%	OK
Welds	98.1 < 100%	OK
Buckling	58.50	
GMNA	Calculated	

Plates

Name	Thickness [mm]	Loads	σ_{Ed} [MPa]	ϵ_{Pl} [%]	Status
B1	6.3	ULS-Set(2)	228.7	0.0	OK
B3-bfl 1	14.0	ULS-Set(4)	232.9	0.0	OK
B3-tfl 1	14.0	ULS-Set(6)	107.9	0.0	OK
B3-w 1	7.5	ULS-Set(4)	164.5	0.0	OK

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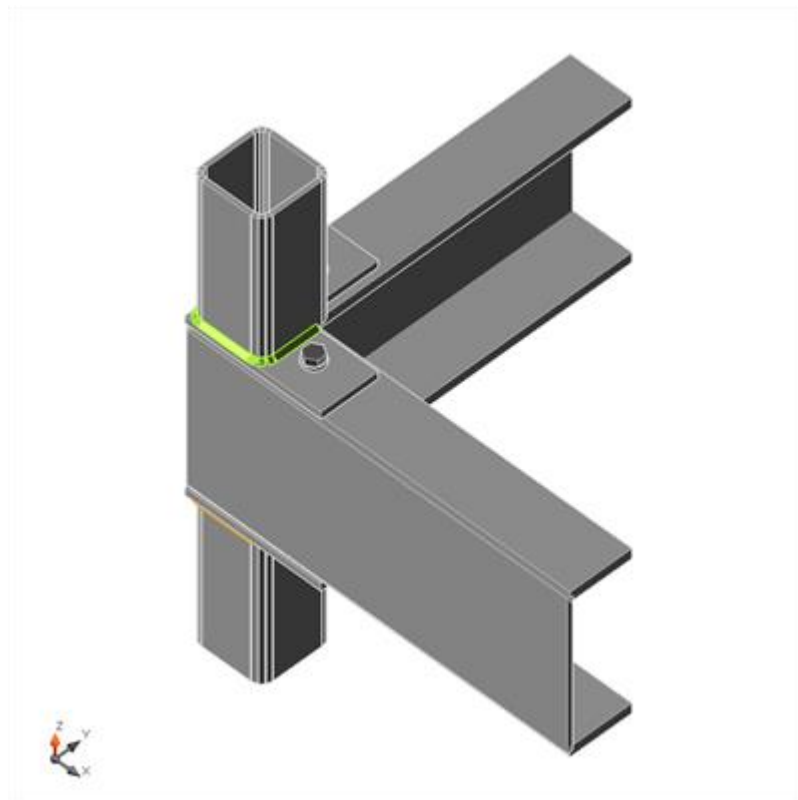
B16-bfl 1	14.0	ULS-Set(24)	220.4	0.0	OK
B16-tfl 1	14.0	ULS-Set(2)	260.3	0.0	OK
B16-w 1	7.5	ULS-Set(2)	209.3	0.0	OK
B430	6.3	ULS-Set(20)	170.7	0.0	OK
SP1	10.0	ULS-Set(24)	289.3	0.0	OK
SP2	10.0	ULS-Set(24)	331.7	0.0	OK

Design data

Material	f_y [MPa]	ϵ_{lim} [%]
S 355	355.0	5.0

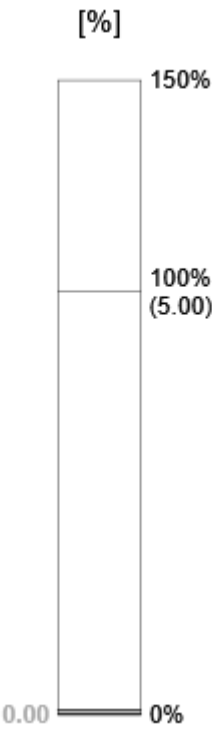
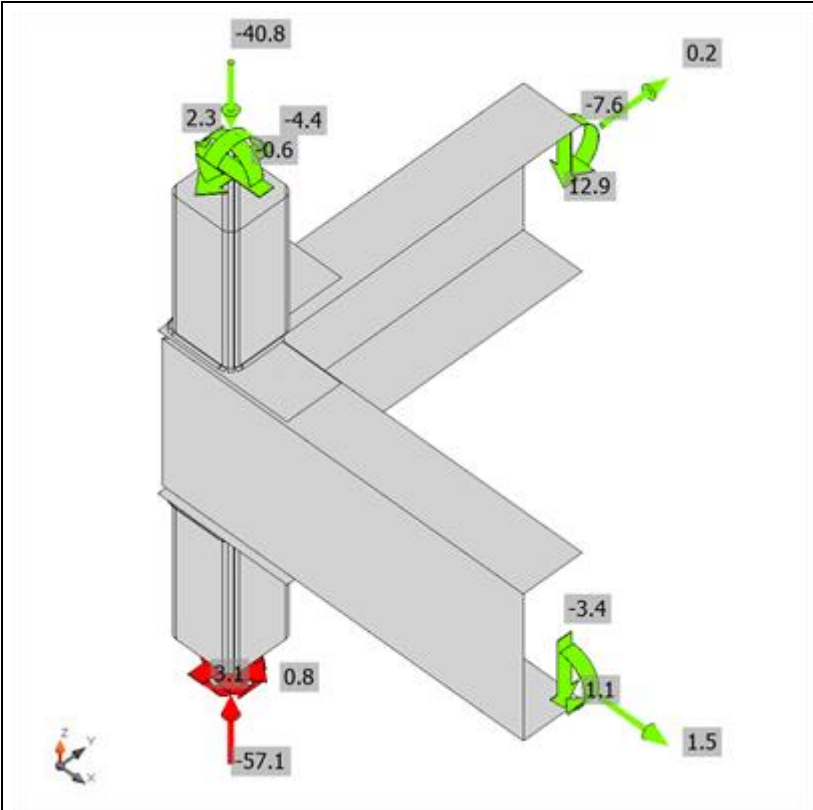
Symbol explanation

ϵ_{Pl} Strain
 σ_{Ed} Eq. stress
 f_y Yield strength
 ϵ_{lim} Limit of plastic strain



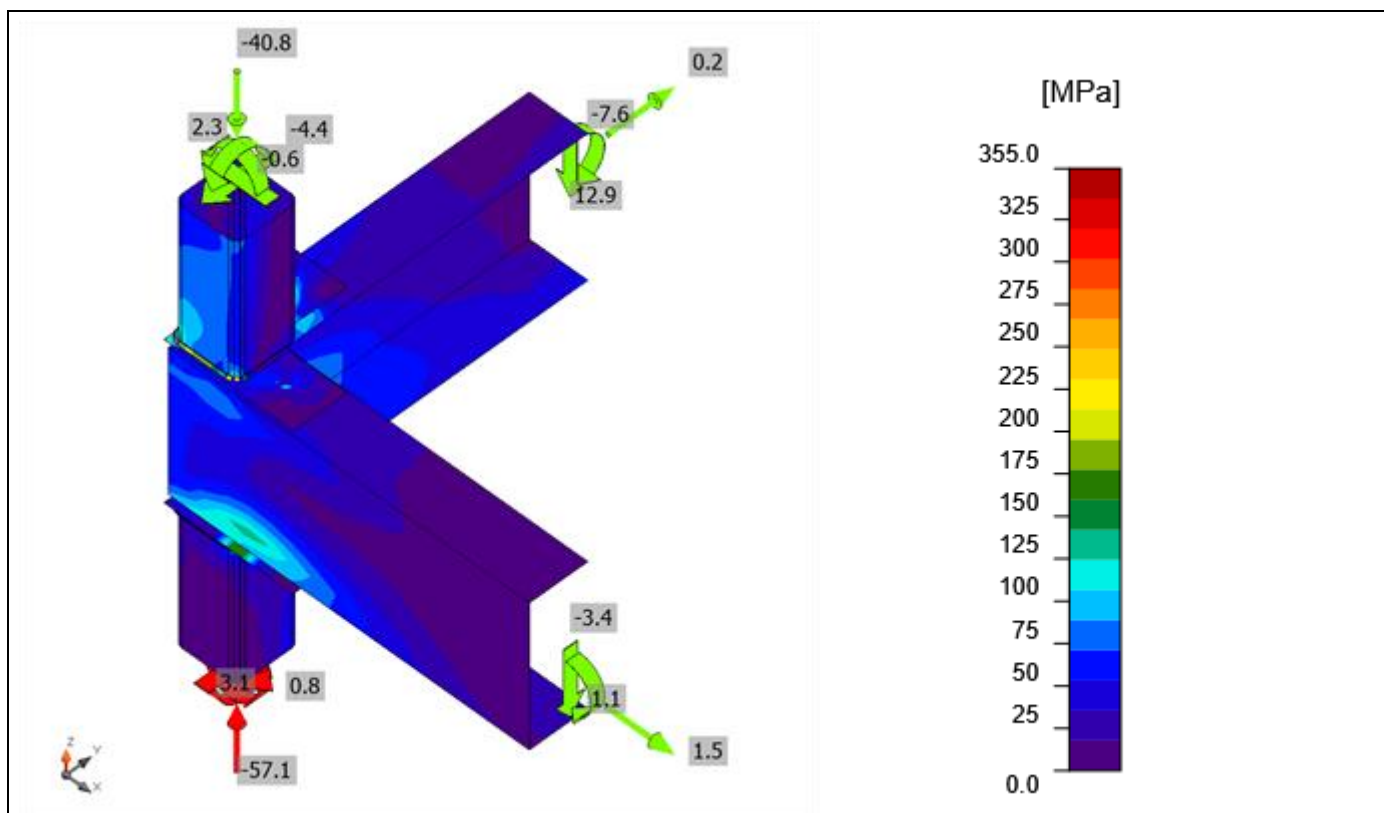
Overall check, ULS-Set(2) **Error! Bookmark not defined.**

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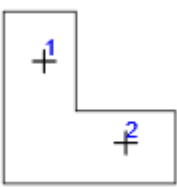
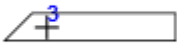
Strain check, ULS-Set(2) **Error! Bookmark not defined.**

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Equivalent stress, ULS-Set(2) **Error! Bookmark not defined.**

Bolts

	Name	Loads	$F_{t,Ed}$ [kN]	V [kN]	U_{t_i} [%]	$F_{b,Rd}$ [kN]	U_{t_s} [%]	$U_{t_{ts}}$ [%]	Status
	B1	ULS-Set(24)	31.8	4.3	35.2	156.8	7.1	32.2	OK
	B2	ULS-Set(1)	15.4	0.8	17.0	110.9	1.3	13.5	OK
	B3	ULS-Set(2)	0.8	5.7	0.8	156.8	9.4	10.0	OK
	B4	ULS-Set(24)	8.0	1.9	8.9	156.8	3.1	9.5	OK

Design data

Name	$F_{t,Rd}$	$B_{p,Rd}$	$F_{v,Rd}$
------	------------	------------	------------

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	[kN]	[kN]	[kN]
M16 8.8 - 1	90.4	184.7	60.3

Symbol explanation

$F_{t,Rd}$ Bolt tension resistance EN 1993-1-8 tab. 3.4
 $F_{t,Ed}$ Tension force
 $B_{p,Rd}$ Punching shear resistance
 V Resultant of shear forces V_y , V_z in bolt
 $F_{v,Rd}$ Bolt shear resistance EN 1993-1-8 table 3.4
 $F_{b,Rd}$ Plate bearing resistance EN 1993-1-8 tab. 3.4
 U_t Utilization in tension
 U_s Utilization in shear
 U_{ts} Utilization in tension and shear EN 1993-1-8 table 3.4

Welds (Plastic redistribution)

Item	Edge	Throat th. [mm]	Length [mm]	Loads	$\sigma_{w,Ed}$ [MPa]	ϵ_{pl} [%]	$\sigma_{\perp}$ [MPa]	$\tau_{\parallel}$ [MPa]	$\tau_{\perp}$ [MPa]	U_t [%]	U_{tc} [%]	Status
B16-bfl 1	B3-tfl 1	14.0	122	ULS-Set(1)								OK
B16-tfl 1	B3-bfl 1	14.0	122	ULS-Set(1)								OK
B16-w 1	B3-w 1	7.5	216	ULS-Set(1)								OK
SP1	B430	▲4.2	317	ULS-Set(20)	375.5	0.0	-242.6	-21.6	164.1	86.2	21.6	OK
SP2	B1	▲4.2	317	ULS-Set(2)	427.2	0.2	-304.9	12.5	172.3	98.1	24.1	OK

Design data

	β_w [-]	$\sigma_{w,Rd}$ [MPa]	0.9σ [MPa]
S 355	0.90	435.6	352.8

Symbol explanation

ϵ_{pl} Strain
 $\sigma_{w,Ed}$ Equivalent stress
 $\sigma_{w,Rd}$ Equivalent stress resistance
 $\sigma_{\perp}$ Perpendicular stress
 $\tau_{\parallel}$ Shear stress parallel to weld axis
 $\tau_{\perp}$ Shear stress perpendicular to weld axis
 0.9σ Perpendicular stress resistance - $0.9 \cdot f_u / \gamma_{M2}$
 β_w Correlation factor EN 1993-1-8 tab. 4.1
 U_t Utilization
 U_{tc} Weld capacity utilization

Buckling

Loads	Shape	Factor [-]
ULS-Set(1)	1	172.99
	2	289.79
	3	335.44
	4	402.02

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	5	440.37
	6	453.56
ULS-Set(2)	1	58.50
	2	66.06
	3	73.01
	4	74.75
	5	82.82
	6	84.10
ULS-Set(3)	1	105.72
	2	123.81
	3	123.86
	4	125.42
	5	145.07
	6	146.48
ULS-Set(4)	1	69.89
	2	79.19
	3	85.49
	4	87.36
	5	99.10
	6	101.47
ULS-Set(5)	1	266.11
	2	319.39
	3	416.07
	4	439.87
	5	471.20
	6	541.86
ULS-Set(6)	1	181.80
	2	286.87
	3	325.78
	4	333.48
	5	396.92
	6	448.95
ULS-Set(7)	1	88.74
	2	89.58
	3	107.19
	4	114.89
	5	121.96
	6	124.09
ULS-Set(8)	1	114.44
	2	132.24
	3	149.74
	4	152.09
	5	179.87
	6	180.87
ULS-Set(9)	1	77.68

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	2	85.09
	3	98.45
	4	113.69
	5	118.61
	6	123.19
ULS-Set(10)	1	65.24
	2	79.64
	3	80.83
	4	82.10
	5	89.17
	6	93.05
ULS-Set(11)	1	122.00
	2	157.81
	3	170.46
	4	188.90
	5	195.81
	6	225.25
ULS-Set(12)	1	73.43
	2	82.20
	3	87.09
	4	91.93
	5	96.64
	6	106.11
ULS-Set(13)	1	88.44
	2	90.31
	3	104.14
	4	105.50
	5	109.50
	6	123.28
ULS-Set(14)	1	181.42
	2	233.03
	3	258.37
	4	292.86
	5	336.78
	6	362.11
ULS-Set(15)	1	146.82
	2	187.74
	3	195.65
	4	218.98
	5	228.05
	6	249.69
ULS-Set(16)	1	127.70
	2	148.99
	3	152.61
	4	152.88

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	5	190.92
	6	191.50
ULS-Set(17)	1	84.60
	2	87.43
	3	105.62
	4	120.78
	5	121.48
	6	124.80
ULS-Set(18)	1	73.00
	2	81.70
	3	85.78
	4	91.34
	5	95.18
	6	105.46
ULS-Set(19)	1	135.89
	2	155.43
	3	164.97
	4	165.70
	5	202.22
	6	205.70
ULS-Set(20)	1	75.35
	2	84.79
	3	95.41
	4	108.53
	5	110.27
	6	118.93
ULS-Set(21)	1	127.07
	2	130.59
	3	146.36
	4	156.58
	5	158.40
	6	184.12
ULS-Set(22)	1	169.79
	2	271.90
	3	313.29
	4	329.04
	5	382.43
	6	383.25
ULS-Set(23)	1	60.02
	2	67.17
	3	74.88
	4	79.37
	5	86.19
	6	88.34
ULS-Set(24)	1	65.44

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	2	67.49
	3	81.38
	4	93.49
	5	97.53
	6	97.94
ULS-Set(25)	1	121.28
	2	146.07
	3	188.79
	4	202.30
	5	206.80
	6	238.59
ULS-Set(26)	1	144.51
	2	163.35
	3	169.15
	4	202.66
	5	206.46
	6	233.03
ULS-Set(27)	1	74.00
	2	85.85
	3	91.20
	4	104.67
	5	112.03
	6	119.48
ULS-Set(28)	1	63.63
	2	67.47
	3	79.19
	4	90.87
	5	91.05
	6	95.34
ULS-Set(29)	1	166.90
	2	170.18
	3	197.12
	4	217.69
	5	230.37
	6	249.17
ULS-Set(30)	1	80.45
	2	94.39
	3	98.08
	4	99.04
	5	107.57
	6	115.35
ULS-Set(31)	1	152.26
	2	188.37
	3	190.82
	4	197.87

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	5	213.58
	6	216.84
ULS-Set(32)	1	139.76
	2	161.26
	3	163.57
	4	199.07
	5	201.78
	6	227.78
ULS-Set(33)	1	160.71
	2	168.71
	3	189.61
	4	213.86
	5	224.63
	6	245.06

Code settings

Item	Value	Unit	Reference
γ_{M0}	1.00	-	EN 1993-1-1: 6.1
γ_{M1}	1.00	-	EN 1993-1-1: 6.1
γ_{M2}	1.25	-	EN 1993-1-1: 6.1
γ_{M3}	1.25	-	EN 1993-1-8: 2.2
γ_c	1.50	-	EN 1992-1-1: 2.4.2.4
γ_{Inst}	1.20	-	ETAG 001-C: 3.2.1
Joint coefficient β_j	0.67	-	EN 1993-1-8: 6.2.5
Effective area - influence of mesh size	0.10	-	
Friction coefficient - concrete	0.25	-	EN 1993-1-8
Friction coefficient in slip-resistance	0.30	-	EN 1993-1-8 tab 3.7
Limit plastic strain	0.05	-	EN 1993-1-5
Weld stress evaluation	Plastic redistribution		
Detailing	No		
Distance between bolts [d]	2.20	-	EN 1993-1-8: tab 3.3
Distance between bolts and edge [d]	1.20	-	EN 1993-1-8: tab 3.3
Concrete breakout resistance	Yes		ETAG 001-C
Use calculated a_b in bearing check.	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		
Local deformation check	No		
Local deformation limit	0.03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Large deformations for hollow sections

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7.7.4 Column Base



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Date
18/03/2020

fischer 
innovative solutions

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Wallingford; Oxfordshire; OX10 9AT
Phone: 44-(0)-1491 827900
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technical@fischer.co.uk
www.fischer.co.uk

Design Specifications

Anchor

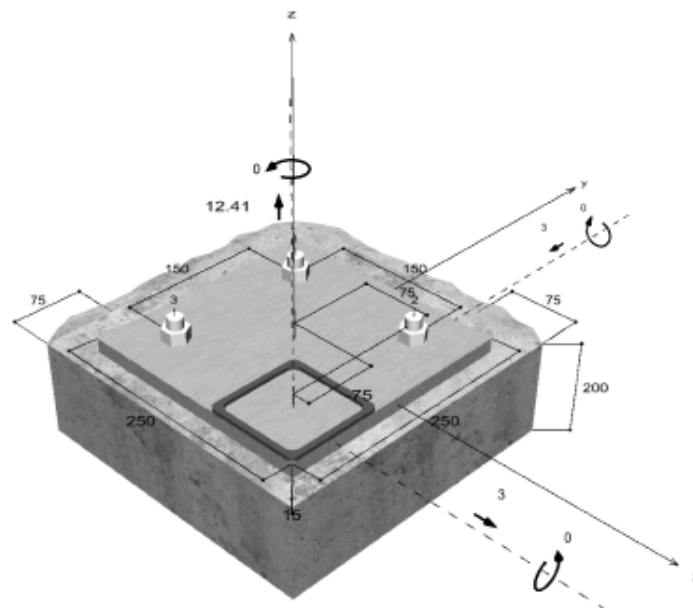
Anchor system	fischer Highbond-System FHB II
Resin capsule	1 x FHB II - P 16x145 or 1 x FHB II - PF 16x145
Fixing element	Coned rod FHB II-A L M16 x 145/30 A4, stainless steel, property class A4-80
Anchorage depth	145 mm
Design Data	Specification by manufacturer



Geometry / Loads / Scale units

mm, kN, kNm

Value of design actions (including
partial safety factor for the load)



Not drawn to scale

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Input data

Design method	Design method ENSO Mechanical
Base material	Normal weight concrete, C20/25, EN 206
Concrete condition	Cracked, dry hole
Temperature range	24 °C long term temperature, 40 °C short term temperature
Reinforcement	No or standard reinforcement. No edge reinforcement. With reinforcement against splitting
Drilling method	hammer drilling
Installation type	Pre-positioned installation
Annular gap	Annular gap not filled
Type of loading	Static or quasi-static
Base plate location	Base plate flush installed on base material
Base plate geometry	250 mm x 250 mm x 15 mm
Profile type	Square tube hot formed (QSH 100x6,3)

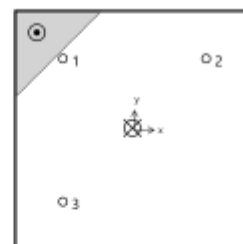
Design actions ^{*)}

#	N _{sd} kN	V _{sd,x} kN	V _{sd,y} kN	M _{sd,x} kNm	M _{sd,y} kNm	M _{t,sd} kNm	Type of loading
1	12.41	3.00	-3.00	0.00	0.00	0.00	Static or quasi-static

^{*)} The required partial safety factors for actions are included

Resulting anchor forces

Anchor no.	Tensile action kN	Shear Action kN	Shear Action x kN	Shear Action y kN
1	0.64	1.41	1.00	-1.00
2	10.66	1.41	1.00	-1.00
3	10.66	1.41	1.00	-1.00



max. concrete compressive strain : 0.23 ‰
max. concrete compressive stress : 7.0 N/mm²
Resulting tensile actions : 21.97 kN, X/Y position (-2 / 2)
Resulting compression actions : 9.56 kN, X/Y position (-102 / 102)

Resistance to tension loads

Proof	Action kN	Capacity kN	Utilisation β _N %
Steel failure *	10.66	64.40	16.6
Concrete cone failure	21.97	28.53	77.0

* Most unfavourable anchor

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Steel failure

$$N_{Sd} \leq \frac{N_{Rk,s}}{\gamma_{Ms}} \quad (N_{Rd,s})$$



$N_{Rk,s}$ kN	γ_{Ms}	$N_{Rd,s}$ kN	N_{Sd} kN	$\beta_{N,s}$ %
96.80	1.50	64.40	10.86	16.6

Anchor no.	$\beta_{N,s}$ %	Group N°	Decisive Beta
1	1.0	1	$\beta_{N,s1}$
2	16.6	2	$\beta_{N,s2}$
3	16.6	3	$\beta_{N,s3}$

Concrete cone failure

$$N_{Sd} \leq \frac{N_{Rk,c}}{\gamma_{Mc}} \quad (N_{Rd,c})$$



$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \Psi_{s,N} \cdot \Psi_{re,N} \cdot \Psi_{ec,N} \quad \text{Eq. (5.2)}$$

$$N_{Rk,c} = 62.86 \text{ kN} \cdot \frac{195,750 \text{ mm}^2}{189,225 \text{ mm}^2} \cdot 0.803 \cdot 1.000 \cdot 0.819 = 42.80 \text{ kN}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} = 7.2 \cdot \sqrt{25.0 \text{ N/mm}^2} \cdot (145 \text{ mm})^{1.5} = 62.86 \text{ kN} \quad \text{Eq. (5.2a)}$$

$$\Psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} = 0.7 + 0.3 \cdot \frac{75 \text{ mm}}{218 \text{ mm}} = 0.803 \leq 1 \quad \text{Eq. (5.2c)}$$

$$\Psi_{re,N} = 1.000 \quad \text{Eq. (5.2d)}$$

$$\Psi_{ec,N} = \frac{1}{1 + \frac{2e_{N,N}}{d_{cr,N}}} \Rightarrow \Psi_{ec,Nx} \cdot \Psi_{ec,Ny} = 0.905 \cdot 0.905 = 0.819 \leq 1 \quad \text{Eq. (5.2e)}$$

$$\Psi_{ec,Nx} = \frac{1}{1 + \frac{2 \cdot 23 \text{ mm}}{435 \text{ mm}}} = 0.905 \leq 1 \quad \Psi_{ec,Ny} = \frac{1}{1 + \frac{2 \cdot 23 \text{ mm}}{435 \text{ mm}}} = 0.905 \leq 1$$

$N_{Rk,c}$ kN	γ_{Mc}	$N_{Rd,c}$ kN	N_{Sd} kN	$\beta_{N,c}$ %
42.80	1.50	28.53	21.97	77.0

Anchor no.	$\beta_{N,c}$ %	Group N°	Decisive Beta
1, 2, 3	77.0	1	$\beta_{N,c1}$

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Resistance to shear loads

Proof	Action kN	Capacity kN	Utilisation β_v %
Steel failure without lever arm *	1.41	50.16	2.8
Concrete pry-out failure	4.24	69.66	6.1
Concrete edge failure	3.16	8.34	37.9

* Most unfavourable anchor

Steel failure without lever arm

$$V_{Sd} \leq \frac{V_{Rk,s}}{\gamma_{Ms}} \quad (V_{Rd,s})$$



$V_{Rk,s}$ kN	γ_{Ms}	$V_{Rd,s}$ kN	V_{Sd} kN	β_{vs} %
62.70	1.25	50.16	1.41	2.8

Anchor no.	β_{vs} %	Group N°	Decisive Beta
1	2.8	1	$\beta_{vs,1}$
2	2.8	2	$\beta_{vs,2}$
3	2.8	3	$\beta_{vs,3}$

Concrete pry-out failure

$$V_{Sd} \leq \frac{V_{Rk,cp}}{\gamma_{Mcp}} \quad (V_{Rd,cp})$$



$$V_{Rk,cp} = k \cdot N_{Rk,c} = 2 \cdot 52.24 \text{ kN} = 104.49 \text{ kN} \quad \text{Eq. (5.8)}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \Psi_{s,N} \cdot \Psi_{re,N} \cdot \Psi_{ec,N} \quad \text{Eq. (5.2)}$$

$$N_{Rk,c} = 62.86 \text{ kN} \cdot \frac{195,750 \text{ mm}^2}{189,225 \text{ mm}^2} \cdot 0.803 \cdot 1.000 \cdot 1.000 = 52.24 \text{ kN}$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} = 7.2 \cdot \sqrt{25.0 \text{ N/mm}^2} \cdot (145 \text{ mm})^{1.5} = 62.86 \text{ kN} \quad \text{Eq. (5.2a)}$$

$$\Psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} = 0.7 + 0.3 \cdot \frac{75 \text{ mm}}{218 \text{ mm}} = 0.803 \leq 1 \quad \text{Eq. (5.2c)}$$

$$\Psi_{re,N} = 1.000 \quad \text{Eq. (5.2d)}$$

$$\Psi_{ec,N} = \frac{1}{1 + \frac{2e_N}{d_{cr,N}}} \Rightarrow \Psi_{ec,Nx} \cdot \Psi_{ec,Ny} = 1.000 \cdot 1.000 = 1.000 \leq 1 \quad \text{Eq. (5.2e)}$$

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$V_{Rk,op}$ kN	γ_{Me}	$V_{Rd,op}$ kN	V_{sd} kN	$\beta_{V,op}$ %
104.49	1.50	69.66	4.24	6.1

Anchor no.	$\beta_{V,op}$ %	Group N°	Decisive Beta
1, 2, 3	6.1	1	$\beta_{V,op1}$

Concrete edge failure

$$V_{Sd} \leq \frac{V_{Rk,c}}{\gamma_{Mc}} \quad (V_{Rd,e})$$



$$V_{Rk,c} = V_{Rk,e}^0 \cdot \frac{A_{c,V}}{A_{c,V}^0} \cdot \Psi_{s,V} \cdot \Psi_{h,V} \cdot \Psi_{\alpha,V} \cdot \Psi_{ec,V} \cdot \Psi_{re,V} \quad \text{Eq. (5.7)}$$

$$V_{Rk,c} = 11.98kN \cdot \frac{25,313mm^2}{25,313mm^2} \cdot 1.000 \cdot 1.000 \cdot 1.045 \cdot 1.000 \cdot 1.000 = 12.52kN$$

$$V_{Rk,e}^0 = k_1 \cdot d_{nom}^{\alpha} \cdot h_{ef}^{\beta} \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1.5} \quad \text{Eq. (5.7a)}$$

$$V_{Rk,e}^0 = 1.7 \cdot (18mm)^{0.139} \cdot (145mm)^{0.075} \cdot \sqrt{25.0N/mm^2} \cdot (75mm)^{1.5} = 11.98kN$$

$$\alpha = 0.1 \cdot \sqrt{\frac{l_f}{c_1}} = 0.1 \cdot \sqrt{\frac{144mm}{75mm}} = 0.139 \quad \beta = 0.1 \cdot \left(\frac{d_{nom}}{c_1}\right)^{0.2} = 0.1 \cdot \left(\frac{18mm}{75mm}\right)^{0.2} = 0.075 \quad \text{Eq. (5.7b)}$$

$$\Psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5c_1} = 0.7 + 0.3 \cdot \frac{113mm}{1.5 \cdot 75mm} = 1.000 \leq 1 \quad \text{Eq. (5.7c)}$$

$$\Psi_{h,V} = \max\left(1; \sqrt{\frac{1.5c_1}{h}}\right) = \max\left(1; \sqrt{\frac{1.5 \cdot 75mm}{200mm}}\right) = 1.000 \geq 1 \quad \text{Eq. (5.7d)}$$

$$\Psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} = \sqrt{\frac{1}{(\cos 18.4)^2 + \left(\frac{\sin 18.4}{2.5}\right)^2}} = 1.045 \geq 1 \quad \text{Eq. (5.7e)}$$

$$\Psi_{ec,V} = \frac{1}{1 + \frac{2 \cdot e_x}{3 \cdot c_1}} = \frac{1}{1 + \frac{2 \cdot 0mm}{3 \cdot 75mm}} = 1.000 \leq 1 \quad \text{Eq. (5.7f)}$$

$$\Psi_{re,V} = 1.000$$

$V_{Rk,e}$ kN	γ_{Me}	$V_{Rd,e}$ kN	V_{sd} kN	$\beta_{V,e}$ %
1252	1.50	8.34	3.16	37.9

Anchor no.	$\beta_{V,e}$ %	Group N°	Decisive Beta
1, 2	20.6	1	$\beta_{V,e1}$
3	37.9	2	$\beta_{V,e2}$

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Utilization of tension and shear loads

Tension loads	Utilisation β_N %	Shear Loads	Utilisation β_V %
Steel failure *	16.6	Steel failure without lever arm *	2.8
Concrete cone failure	77.0	Concrete pry-out failure	6.1
		Concrete edge failure	37.9

* Most unfavourable anchor

Resistance to combined tensile and shear loads

Utilisation steel

$$\beta_{N,s} = \beta_{N,s3} = 0.17 \leq 1 \quad \text{Eq. (5.8a)}$$

$$\beta_{V,s} = \beta_{V,s1} = 0.03 \leq 1 \quad \text{Eq. (5.8b)}$$

$$\beta_N^2 + \beta_V^2 = \beta_{N,s3}^2 + \beta_{V,s1}^2 = 0.03 \leq 1 \quad \text{Eq. (5.9)}$$

Utilisation concrete

$$\beta_{N,c} = \beta_{N,c1} = 0.77 \leq 1 \quad \text{Eq. (5.8a)}$$

$$\beta_{V,c} = \beta_{V,c2} = 0.38 \leq 1 \quad \text{Eq. (5.8b)}$$

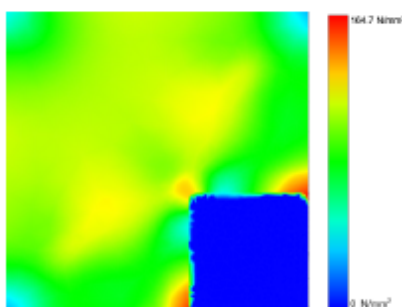
$$\beta_N^{1.5} + \beta_V^{1.5} = \beta_{N,c1}^{1.5} + \beta_{V,c2}^{1.5} = 0.91 \leq 1 \quad \text{Eq. (5.9)}$$



Proof successful

Base plate thickness

Stress distribution pattern within the anchor plate



Base plate details

Anchor plate thickness	t =	15 mm
Base plate material		S 275
E-modulus	E =	210,000 N/mm²
Yield strength	$R_{p0.2}$ =	275 N/mm²
Safety factor	γ_M =	1.1
Poisson's ratio	ν =	0.3
Utilisation	η =	66 %
Profile type	Square tube hot formed (QSH 100x6,3)	

Technical remarks

All data and information in the software is based on fischer products and common engineering knowledge. Please check all the proof results against local valid standards and approvals.

As fischer is not the design office, the attached is no guarantee for incorrect input or assumptions. Any recommendations have to be approved by the building-authority or project engineer. Results are valid only for anchor system calculated in the attached. If any part of the system is changed, it will invalidate this report and new calculations would be required. The calculation was done under the assumption that a sufficient splitting reinforcement is available. In this case the splitting failure can be omitted.

The transmission of the anchor loads to the supports of the concrete member shall be shown for the ultimate limit state and the serviceability limit state; for this purpose, the normal verifications shall be carried out under due consideration of the actions introduced by the anchors. For these verifications the additional provisions given in the current design method shall be taken into account.

As a pre-condition the anchor plate is assumed to be flat when subjected to the actions. Therefore, the plate must be

The input values and the design results should be checked against local valid standards and approvals. Please respect the disclaimer of warranty in

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Installation data

Anchor

Anchor system fischer Highbond-System FHB II
Resin capsule 1 x FHB II - P 16x145 or
1 x FHB II - PF 16x145
Fixing element Coned rod
FHB II-A L M16 x 145/30 A4,
stainless steel, property class A4-80

Art.-No. 507924
Art.-No. 508002
Art.-No. 506914

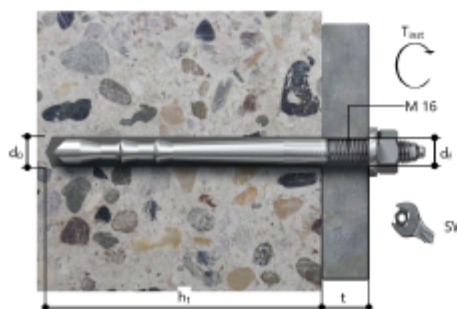


Accessories Machine setting tool RA-SDS
Hammer drill bit SDS Plus IV
18/200/250

Art.-No. 62420
Art.-No. 504162

Installation details

Thread diameter M 16
Drill hole diameter $d_0 = 18$ mm
Drill hole depth $h_1 = 160$ mm
Anchorage depth $h_{ef} = 145$ mm
Drilling method hammer drilling
Drill hole cleaning No cleaning necessary
Installation type Pre-positioned installation
Annular gap Annular gap not filled
Installation torque $T_{inst} = 60.0$ Nm
Socket size 24 mm
Base plate thickness $t = 15$ mm
Total fixing thickness $t_{fix} = 15$ mm
Tfix,max $t_{fix,max} = 30$ mm



Base plate details

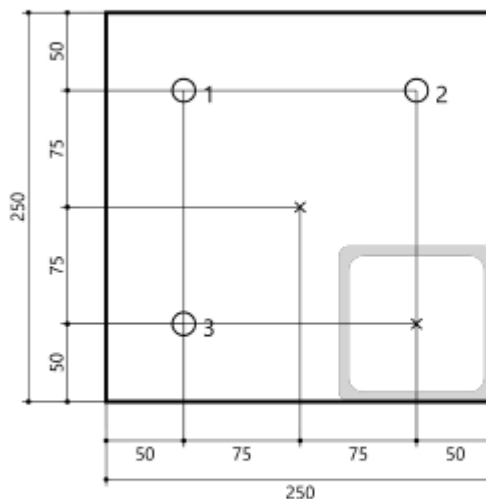
Base plate material S 275
Base plate thickness $t = 15$ mm
Clearance hole in base plate $d_0 = 18$ mm

Attachment

Profile type Square tube hot formed
(QSH 100x6,3)

Anchor coordinates

Anchor no.	x mm	y mm
1	-75	75
2	75	75
3	-75	-75



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8 Reactions

The SLS reactions are shown below;

8.1 Column Base

Reactions

Linear calculation
 Combination: SLS-Char (auto)
 System: Global
 Extreme: Global
 Selection: All

Nodal reactions

Name	Case	R _x [kN]	R _y [kN]	R _z [kN]	M _x [kNm]	M _y [kNm]	M _z [kNm]	e _x [mm]	e _y [mm]
Sn4/ N13	SLS-Char (auto)/1	-1.22	-0.01	14.90	0.00	0.00	0.00	0.0	0.0
Sn2/ N11	SLS-Char (auto)/2	1.22	-0.01	13.29	0.00	0.00	0.00	0.0	0.0
Sn3/ N3	SLS-Char (auto)/3	-0.52	-0.67	17.72	0.00	0.00	0.00	0.0	0.0
Sn4/ N13	SLS-Char (auto)/4	-0.16	2.84	-12.35	0.00	0.00	0.00	0.0	0.0
Sn2/ N11	SLS-Char (auto)/4	0.13	2.84	-12.41	0.00	0.00	0.00	0.0	0.0
Sn3/ N3	SLS-Char (auto)/5	-0.50	2.81	39.03	0.00	0.00	0.00	0.0	0.0

Name	Combination key
SLS-Char (auto)/1	SW + DL + LL1 + LL4 + Wind 90
SLS-Char (auto)/2	SW + DL + LL1 + Wind 270
SLS-Char (auto)/3	SW + DL + LL1 + LL4 + Wind 0
SLS-Char (auto)/4	SW + DL + LL5 + Wind 180
SLS-Char (auto)/5	SW + DL + LL1 + LL5 + Wind 180

Maximum tension is 12.41kN and compression 39.03kN. Both tension and compression to be supported by mass concrete foundations.

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9 Foundations

9.1 Existing Foundation Check

Existing foundation is 700mm. Conservatively assume that it is corner and spreads at 45 degrees therefore take 700mm spread only.

The maximum compression is 39.03kN therefore maximum bearing pressure = $39.03\text{kN}/0.7\text{m} = 55.75\text{kN/m}$.

According to Geological map the ground is Lambeth Group- Clay, Silt and Sand. It is conservatively assumed that the SFB= 100kN/m^2 .

The minimum width= 600W TBC on site

Tension is to be resisted by SW of concrete= $2 \times 0.7 \times 0.6 \times 0.7 \times 25\text{kN/m}^3 = 14.7\text{kN} > 12.41\text{kN}$

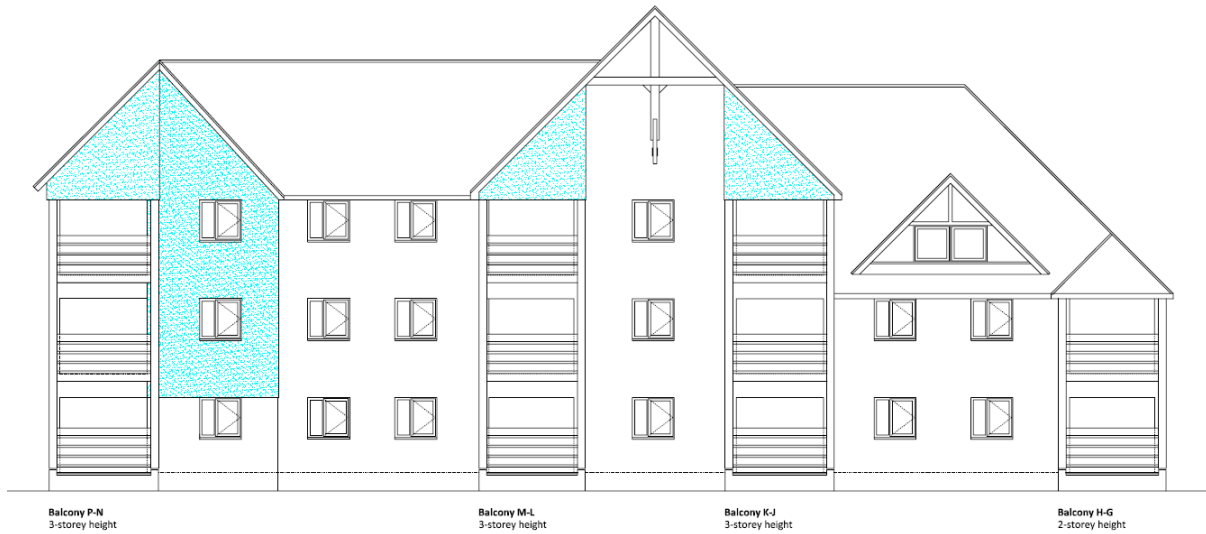
There will be a nominal fix to existing masonry therefore uplift not critical.

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Annex A



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Existing South 'Rear' Elevation
Scale 1:50 @ A1