

εργοδότης :

ΙΕΡΑ ΜΗΤΡΟΠΟΛΗ ΠΕΤΡΑΣ ΚΑΙ ΧΕΡΡΟΝΗΣΟΥ

έργο :

ΣΤΕΓΑΣΤΡΟ ΓΗΠΕΔΟΥ ΝΕΑΠΟΛΗΣ ΛΑΣΙΘΙΟΥ

θέση :

ΓΗΠΕΔΟ ΝΕΑΠΟΛΗΣ ΛΑΣΙΘΙΟΥ

μελετητής :

ΦΡΙΓΚΑ ΑΛΕΞΑΝΔΡΑ

είδος μελέτης : Στατικά  
στάδιο μελέτης : Οριστική Μελέτη  
χρόνος μελέτης : 2021

αριθμός τεύχους :

**Σ.3/4**

θέμα τεύχους : Συνδέσεις μεταλλικού στεγάστρου

σφραγίδα & υπογραφή μελετητή :

## 1 Περιεχόμενα

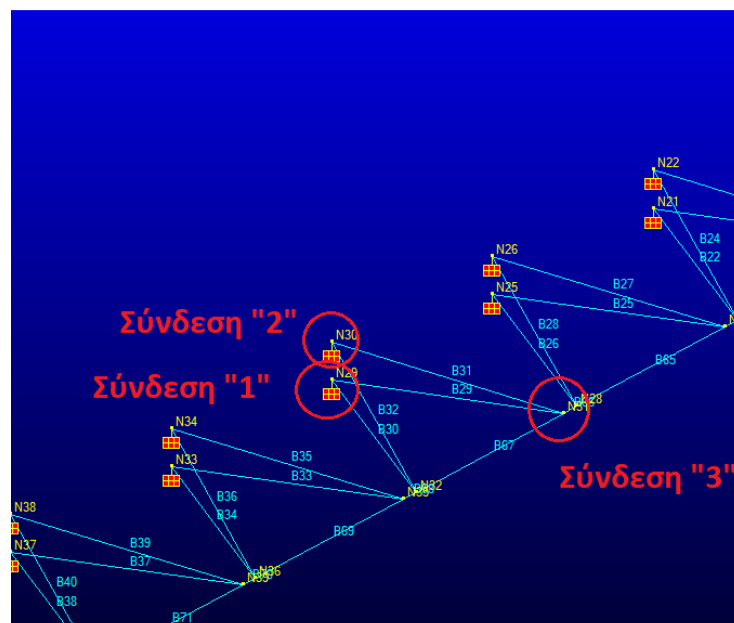
1	Περιεχόμενα .....	2
2	Τεχνική έκθεση .....	3
3	Ζυγώματα επί υποστυλώματος .....	5
3.1	Γεωμετρία.....	5
3.2	Αποτελέσματα ανάλυσης & διαστασιολόγησης – Ενδεικτικά σχέδια επιμέρους στοιχείων .....	7
4	Αντηρίδες επί υποστυλώματος .....	18
4.1	Γεωμετρία.....	18
4.2	Αποτελέσματα ανάλυσης & διαστασιολόγησης – Ενδεικτικά σχέδια επιμέρους στοιχείων .....	20
5	Αντηρίδα επί ζυγώματος.....	33
5.1	Γεωμετρία.....	33
5.2	Αποτελέσματα ανάλυσης & διαστασιολόγησης – Ενδεικτικά σχέδια επιμέρους στοιχείων .....	34

## 2 Τεχνική έκθεση

Η παρούσα τεχνική έκθεση αφορά την ανάλυση και διαστασιολόγηση των συνδέσεων μεταλλικού στεγάστρου το οποίο στηρίζεται σε υποστυλώμα κυκλικής διατομής οπλισμένου σκυροδέματος. Οι συνδέσεις οποίες διαστασιολογήθηκαν είναι οι παρακάτω:

- Σύνδεση ζυγωμάτων επί μεταλλικού κυκλικού δακτυλίου τοποθετούμενο σε υποστυλώμα Ο/Σ
- Σύνδεση αντηρίδας επί μεταλλικού κυκλικού δακτυλίου τοποθετούμενο σε υποστυλώμα Ο/Σ
- Σύνδεση αντηρίδας επί ζυγώματος

Παρακάτω εμφανίζονται οι θέσεις των συνδέσεων επί του μαθηματικού προσομοιώματος.



Οι εν λόγω συνδέσεις δεν μπορούν να διαστασιολογηθούν με συνήθη εργαλεία. Η ιδιαιτερότητα των συνδέσεων εντοπίζεται στο γεγονός ότι υπάρχει συνδυαστική καταπόνηση (παραπάνω από ένα στοιχεία) σε μεταλλικό δακτύλιο. Η ένταση του μεταλλικού δακτυλίου δεν μπορεί να προσεγγιστεί με την θεωρία του βραχέως «ταυ» όπως αυτή περιγράφεται στον EN1993-1-8. Ως εκ τούτου, κρίνεται σκόπιμη η διαστασιολόγηση των συνδέσεων με πεπερασμένα στοιχεία. Συντηρητικώς, στην διαστασιολόγηση έχουν αγνοηθεί οι παρακάτω ευνοϊκοί μηχανισμοί:

- Οι δυνάμεις διεπιφάνειας/αντίστασης του σκυροδέματος
- Οι αντίσταση των διατμητικών ήλων που εξασφαλίζουν την μεταφορά των διατμητικών δυνάμεων από το μεταλλικό δακτυλίδι στο υποστυλώμα Ο/Σ.

Τα εντατικά μεγέθη διαστασιολόγησης κατά απόλυτη τιμή είναι τα παρακάτω:

### **ΑΝΤΗΡΙΑ**

Αξονική  $\approx 170$  kN

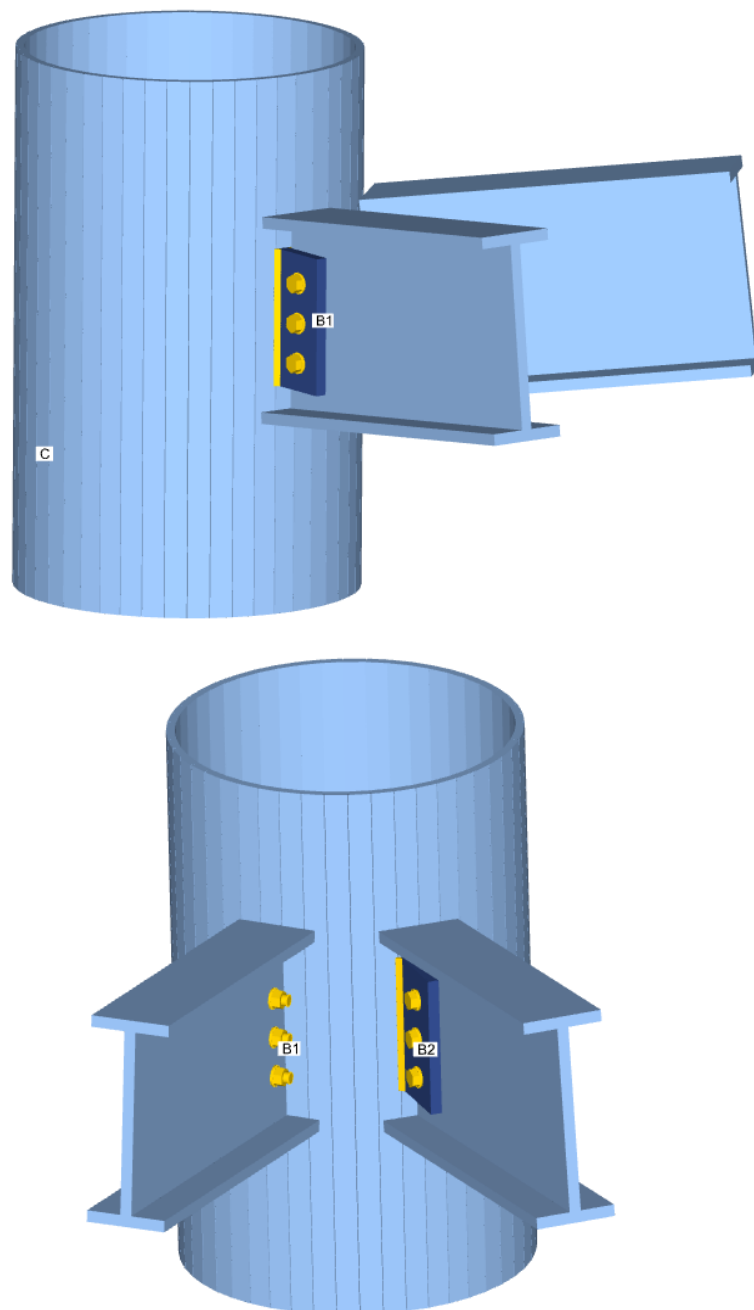
### **ΖΥΓΩΜΑΤΑ**

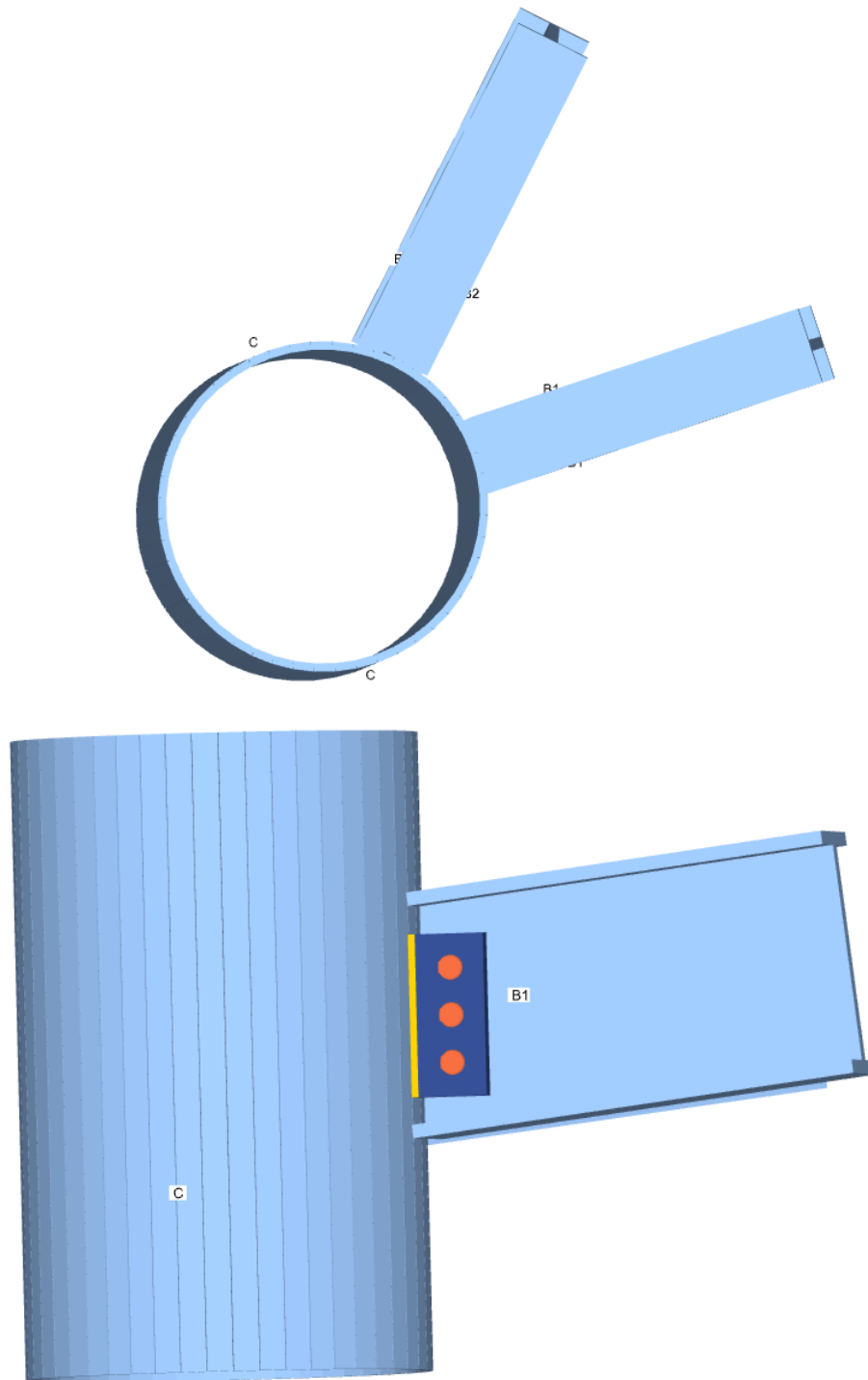
Αξονική  $\approx 170$  kN

Διάτμηση  $\approx 30$  kN

### 3 Ζυγώματα επί υποστυλώματος

#### 3.1 Γεωμετρία





### 3.2 Αποτελέσματα ανάλυσης & διαστασιολόγησης – Ενδεικτικά σχέδια επιμέρους στοιχείων

## Project data

Project name  
Project number  
Author  
Description  
Date 5/9/2016  
Design code EN

## Material

Steel S 235  
Concrete C25/30

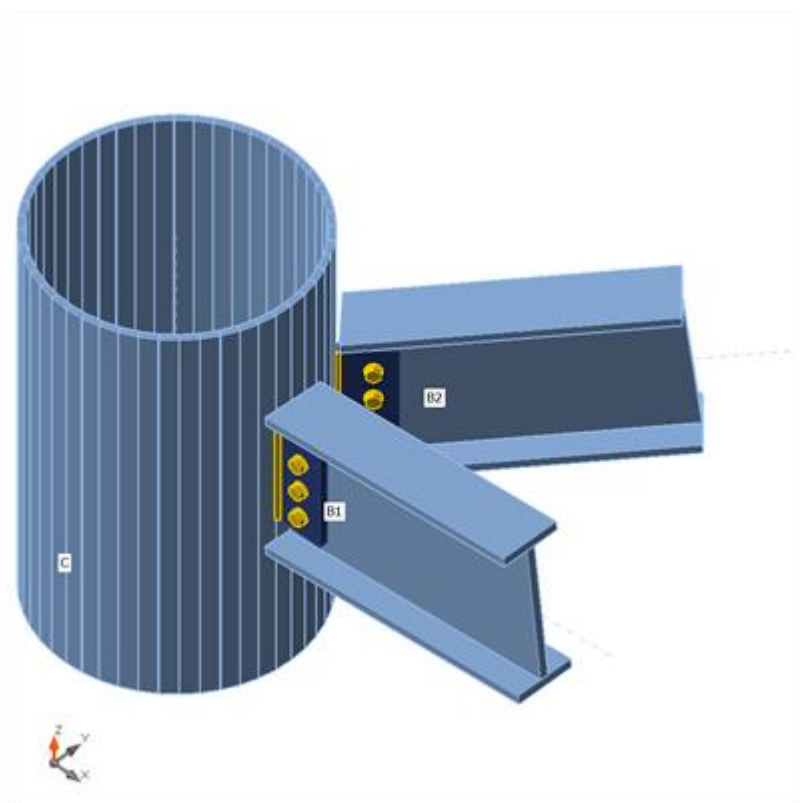
## Project item Connecting plates2

### Design

Name Connecting plates2  
Description  
Analysis Stress, strain/ simplified loading

### Beams and columns

Name	Cross-section	$\beta$ – Direction [°]	$\gamma$ - Pitch [°]	$\alpha$ - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]	Forces in	X [mm]
C	32 - CHS600,15	1.0	-90.0	0.0	0	0	0	Position	0
B1	33 - Iw360x140	0.0	-6.5	0.0	0	0	15	Bolts	363
B2	33 - Iw360x140	45.0	-6.5	0.0	0	0	10	Bolts	373



### Cross-sections

Name	Material
32 - CHS600,15	S 235
33 - Iw360x140	S 235

### Cross-sections

Name	Material	Drawing
32 - CHS600,15	S 235	



33 - lw360x140	S 235	
----------------	-------	--

## Bolts

Name	Bolt assembly	Diameter [mm]	$f_u$ [MPa]	Gross area [mm <sup>2</sup> ]
M20 8.8	M20 8.8	20	800.0	314

## Load effects (equilibrium not required)

Name	Member	N [kN]	V <sub>y</sub> [kN]	V <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]
LE1	B1	170.0	0.0	-30.0	0.0	0.0	0.0
	B2	170.0	0.0	-30.0	0.0	0.0	0.0

## Check

## Summary

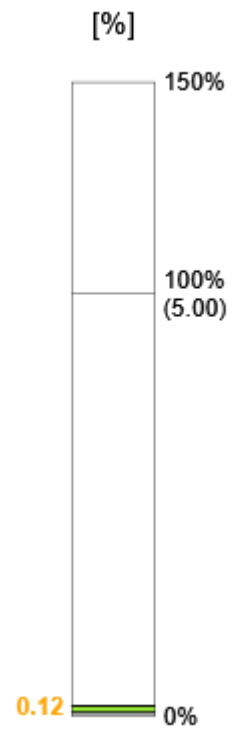
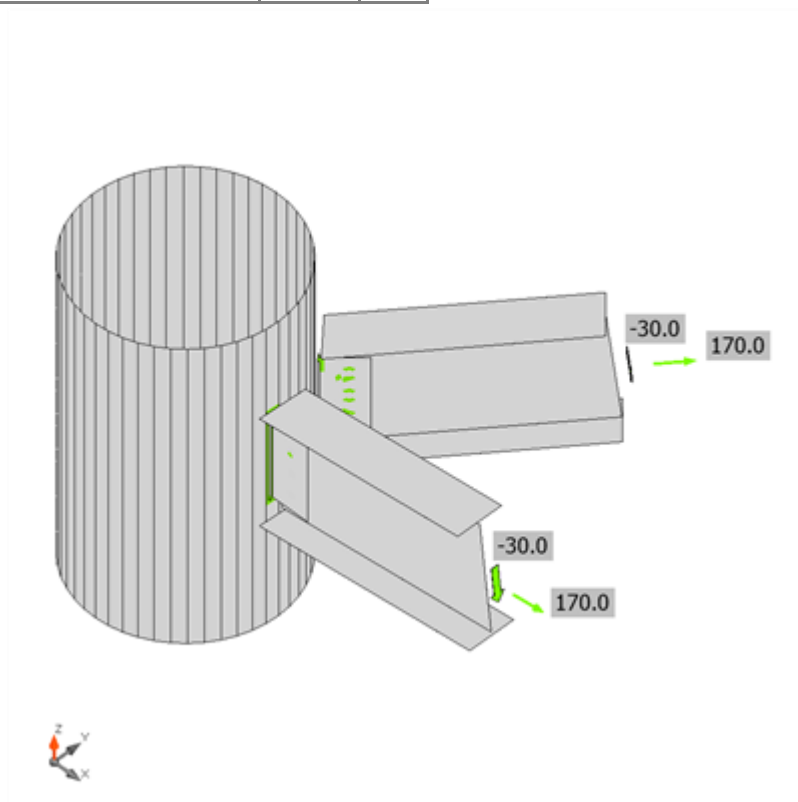
Name	Value	Status
Analysis	100.0%	OK
Plates	0.1 < 5.0%	OK
Bolts	71.4 < 100%	OK
Welds	98.3 < 100%	OK
Buckling	Not calculated	
GMNA	Calculated	

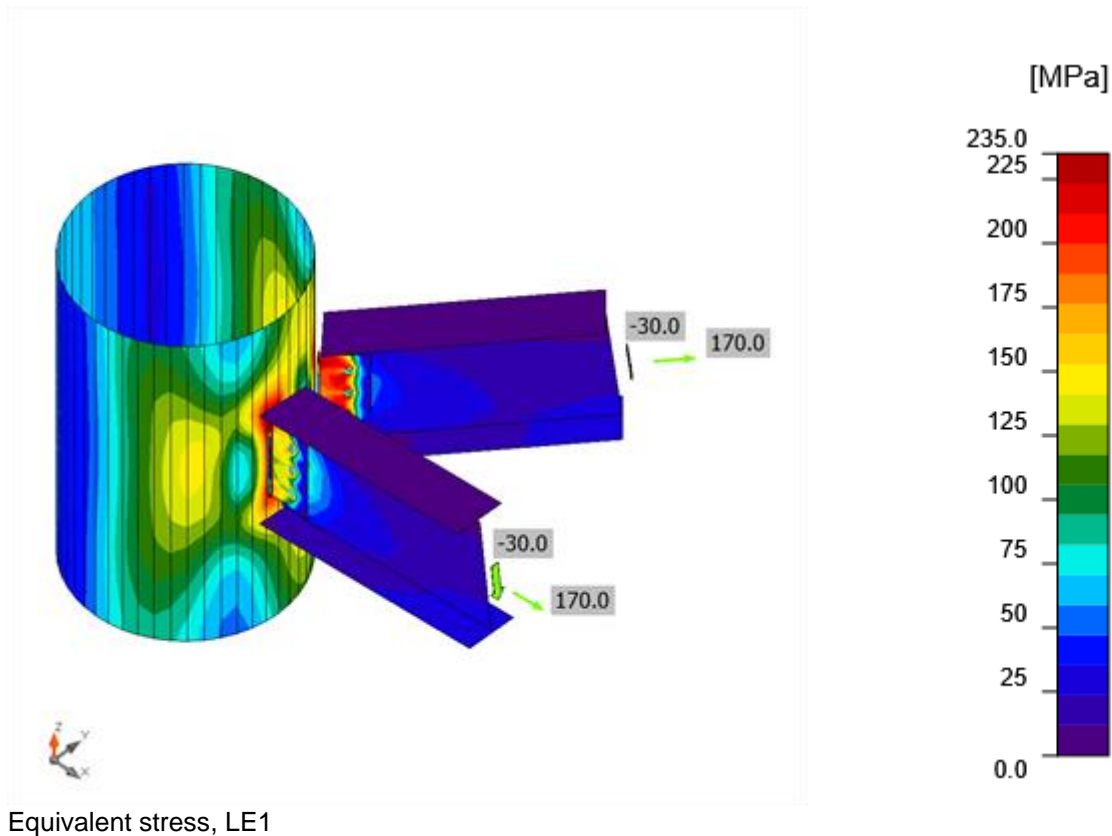
## Plates

Name	Thickness [mm]	Loads	$\sigma_{Ed}$ [MPa]	$\epsilon_{pl}$ [%]	$\sigma_{CEd}$ [MPa]	Status
C	15.0	LE1	235.3	0.1	0.0	OK
B1-tfl 1	20.0	LE1	10.7	0.0	0.0	OK
B1-bfl 1	20.0	LE1	28.7	0.0	0.0	OK
B1-w 1	20.0	LE1	143.9	0.0	6.2	OK
B2-tfl 1	20.0	LE1	7.5	0.0	0.0	OK
B2-bfl 1	20.0	LE1	28.8	0.0	0.0	OK
B2-w 1	20.0	LE1	133.2	0.0	7.6	OK
SP1	20.0	LE1	206.8	0.0	7.4	OK
SP2	20.0	LE1	235.1	0.0	20.7	OK

**Design data**

Material	$f_y$ [MPa]	$\epsilon_{lim}$ [%]
S 235	235.0	5.0





## Bolts

	Name	Loads	$F_{t,Ed}$ [kN]	V [kN]	$U_{t_t}$ [%]	$F_{b,Rd}$ [kN]	$U_{t_s}$ [%]	$U_{t_{ts}}$ [%]	Status
	B1	LE1	4.9	51.7	3.4	218.2	54.9	57.4	OK
	B2	LE1	7.5	56.8	5.3	218.2	60.4	64.2	OK
	B3	LE1	6.4	64.1	4.5	218.2	68.2	71.4	OK
	B4	LE1	13.8	55.6	9.8	218.2	59.1	66.1	OK
	B5	LE1	14.7	57.1	10.4	218.2	60.7	68.2	OK
	B6	LE1	15.1	59.9	10.7	218.2	63.7	71.3	OK

## Design data

Name	$F_{t,Rd}$ [kN]	$B_{p,Rd}$ [kN]	$F_{v,Rd}$ [kN]
M20 8.8 - 1	141.1	342.0	94.1

## Detailed result for B3

Tension resistance check (EN 1993-1-8 tab 3.4)

$$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} = 141.1 \text{ kN} \geq F_t = 6.4 \text{ kN}$$

where:

$$\begin{aligned} k_2 &= 0.90 && \text{– Factor} \\ f_{ub} &= 800.0 \text{ MPa} && \text{– Ultimate tensile strength of the bolt} \\ A_s &= 245 \text{ mm}^2 && \text{– Tensile stress area of the bolt} \\ \gamma_{M2} &= 1.25 && \text{– Safety factor} \end{aligned}$$

Punching resistance check (EN 1993-1-8 tab 3.4)

$$B_{p,Rd} = \frac{0.6\pi d_m t_p f_u}{\gamma_{M2}} = 342.0 \text{ kN} \geq F_t = 6.4 \text{ kN}$$

where:

$$\begin{aligned} d_m &= 32 \text{ mm} && \text{– The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller} \\ t_p &= 20 \text{ mm} && \text{– Thickness} \\ f_u &= 360.0 \text{ MPa} && \text{– Ultimate strength} \\ \gamma_{M2} &= 1.25 && \text{– Safety factor} \end{aligned}$$

Shear resistance check (EN 1993-1-8 tab 3.4)

$$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} = 94.1 \text{ kN} \geq V = 64.1 \text{ kN}$$

where:

$$\begin{aligned} \beta_p &= 1.00 && \text{– Reducing factor} \\ \alpha_v &= 0.60 && \text{– Reducing factor} \\ f_{ub} &= 800.0 \text{ MPa} && \text{– Ultimate tensile strength of the bolt} \\ A &= 245 \text{ mm}^2 && \text{– Tensile stress area of the bolt} \\ \gamma_{M2} &= 1.25 && \text{– Safety factor} \end{aligned}$$

Bearing resistance check (EN 1993-1-8 tab 3.4)

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u d t}{\gamma_{M2}} = 218.2 \text{ kN} \geq V = 64.1 \text{ kN}$$

where:

$$\begin{aligned} k_1 &= \min(2.8 \frac{e_2}{d_0} - 1.7, 1.4 \frac{p_2}{d_0} - 1.7, 2.5) = 2.50 && \text{– Factor for edge distance and bolt spacing perpendicular to the direction of load transfer} \\ \alpha_b &= \min(\frac{e_1}{3d_0}, \frac{p_1}{3d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1) = 0.76 && \text{– Factor for end distance and bolt spacing in direction of load transfer} \\ e_2 &= 50 \text{ mm} && \text{– Distance to the plate edge perpendicular to the shear force} \\ p_2 &= 70 \text{ mm} && \text{– Distance between bolts perpendicular to the shear force} \\ d_0 &= 22 \text{ mm} && \text{– Bolt hole diameter} \\ e_1 &= 50 \text{ mm} && \text{– Distance to the plate edge in the direction of the shear force} \\ p_1 &= \infty \text{ mm} && \text{– Distance between bolts in the direction of the shear force} \\ f_{ub} &= 800.0 \text{ MPa} && \text{– Ultimate tensile strength of the bolt} \\ f_u &= 360.0 \text{ MPa} && \text{– Ultimate strength} \\ d &= 20 \text{ mm} && \text{– Nominal diameter of the fastener} \end{aligned}$$

$$t = 20 \text{ mm}$$

– Thickness of the plate

$$\gamma_{M2} = 1.25$$

– Safety factor

Interaction of tension and shear (EN 1993-1-8 tab 3.4)

$$U_{ts} = \frac{F_{t,Ed}}{F_{t,Rd}} + \frac{F_{v,Ed}}{1.4F_{v,Rd}} = 71.4 \%$$

Utilization in tension

$$U_{tt} = \frac{F_{t,Ed}}{\min(F_{t,Rd}; B_{p,Rd})} = 4.5 \%$$

Utilization in shear

$$U_{ts} = \frac{V_{Ed}}{\min(F_{v,Rd}; F_{s,Rd})} = 68.2 \%$$

## Welds (Plastic redistribution)

Item	Edge	Throat th. [mm]	Length [mm]	Loads	$\sigma_{w,Ed}$ [MPa]	$\epsilon_{Pl}$ [%]	$\sigma_{\perp}$ [MPa]	$\tau_{\parallel}$ [MPa]	$\tau_{\perp}$ [MPa]	Ut [%]	Ut <sub>c</sub> [%]	Status
C-arc 36	SP1	▲5.5▲	240	LE1	352.9	0.1	94.8	-185.9	63.1	98.0	28.1	OK
		▲5.5▲	240	LE1	353.6	0.6	144.1	-109.4	-151.0	98.2	57.4	OK
C-arc 42	SP2	▲6.0▲	240	LE1	352.8	0.0	62.1	-199.2	22.5	98.0	31.8	OK
		▲6.0▲	240	LE1	353.7	0.6	148.5	-109.5	-149.5	98.3	65.9	OK

## Design data

	$\beta_w$ [-]	$\sigma_{w,Rd}$ [MPa]	$0.9 \sigma$ [MPa]
S 235	0.80	360.0	259.2

## Detailed result for C-arc 42 SP2

Weld resistance check (EN 1993-1-8 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360.0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 353.7 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0.9 f_u / \gamma_{M2} = 259.2 \text{ MPa} \geq |\sigma_{\perp}| = 148.5 \text{ MPa}$$

where:

$$f_u = 360.0 \text{ MPa} \quad \text{– Ultimate strength}$$

$$\beta_w = 0.80 \quad \text{– appropriate correlation factor taken from Table 4.1}$$

$$\gamma_{M2} = 1.25 \quad \text{– Safety factor}$$

Stress utilization

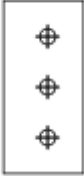

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 98.3 \%$$

## Buckling

Buckling analysis was not calculated.

## Bill of material

### Manufacturing operations

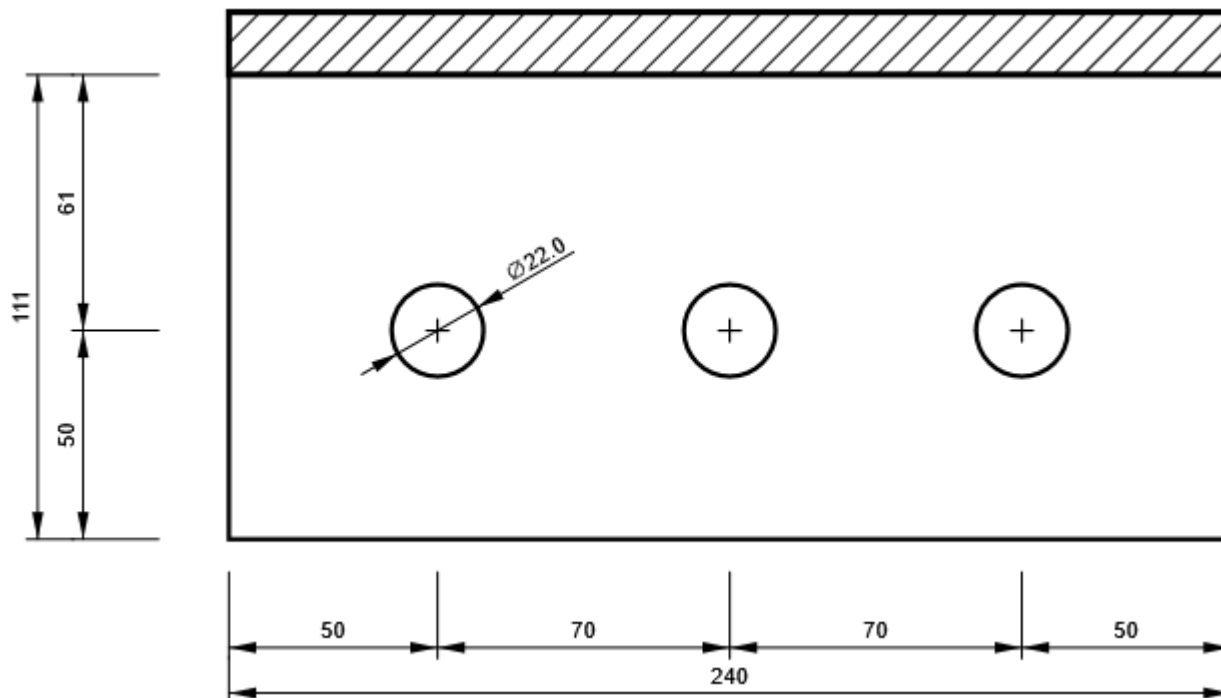
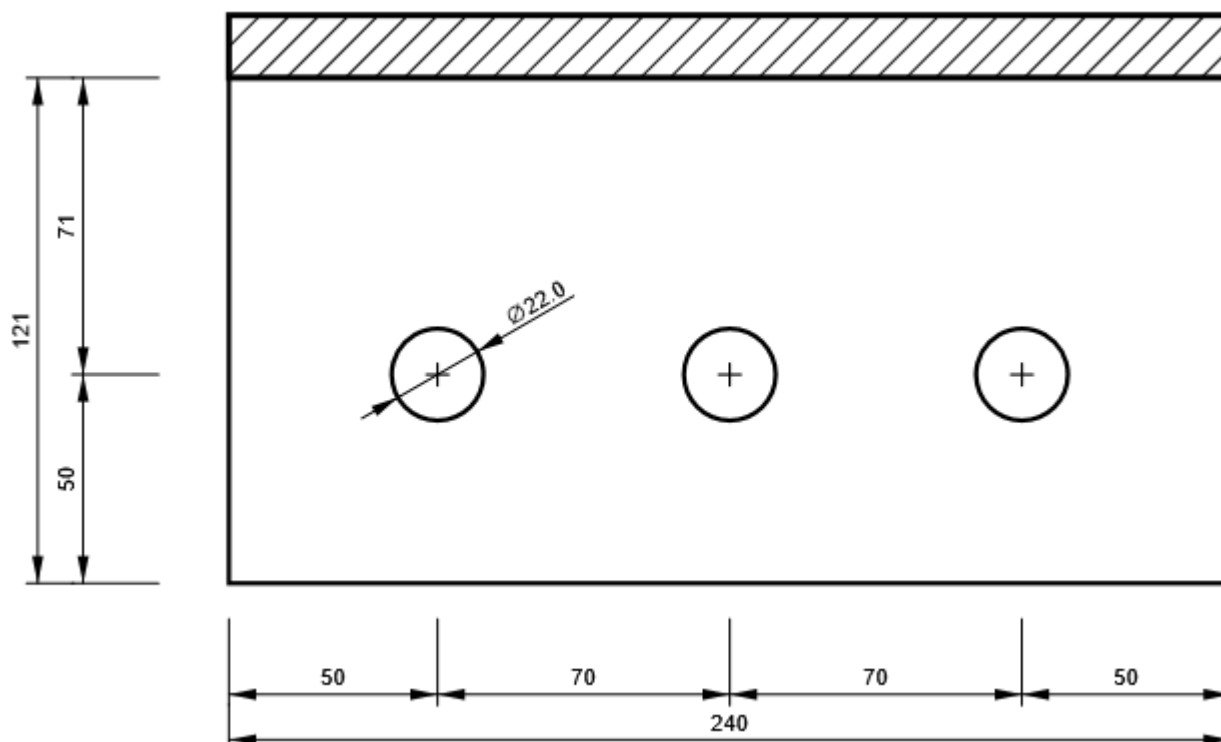
Name	Plates [mm]	Shape	Nr.	Welds [mm]	Length [mm]	Bolts	Nr.
SP1	P20.0x111.2-240.0 (S 235)		1			M20 8.8	3
SP2	P20.0x121.0-240.0 (S 235)		1			M20 8.8	3
CUT1							
CUT2							

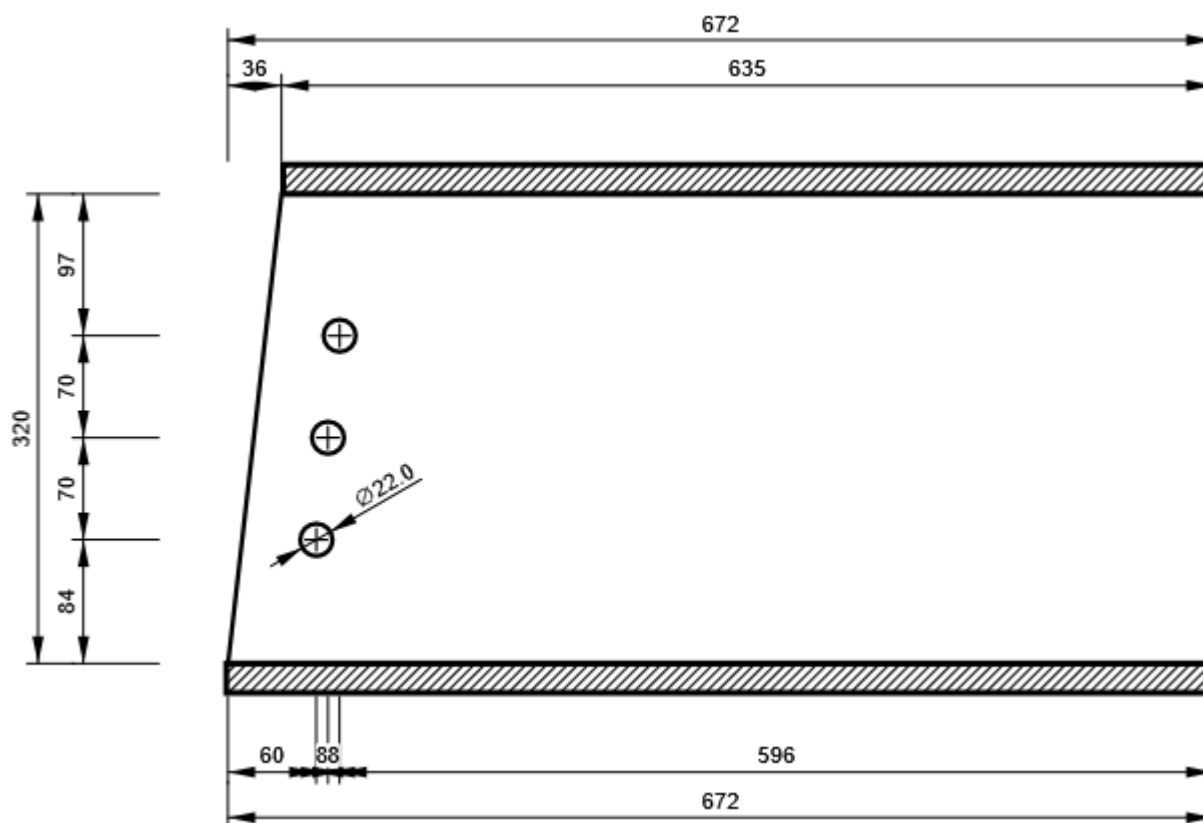
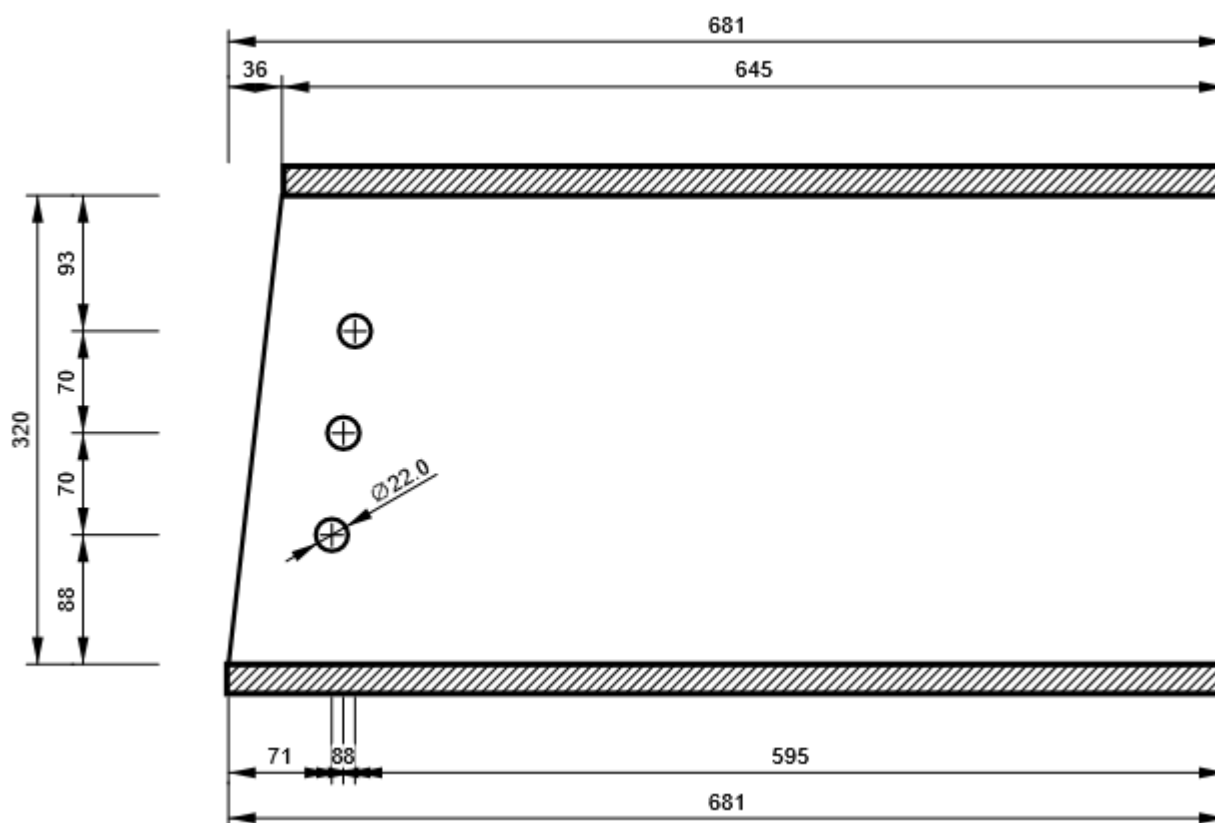
### Welds

Type	Material	Throat thickness [mm]	Leg size [mm]	Length [mm]
Double fillet	S 235	5.5	7.8	240.0
Double fillet	S 235	6.0	8.5	240.0

### Bolts

Name	Grip length [mm]	Count
M20 8.8	40	6

**Drawing****SP1****P20.0x240-111 (S 235)****SP2****P20.0x240-121 (S 235)**

**B1, Iw360x140 - Web 1:****B2, Iw360x140 - Web 1:**

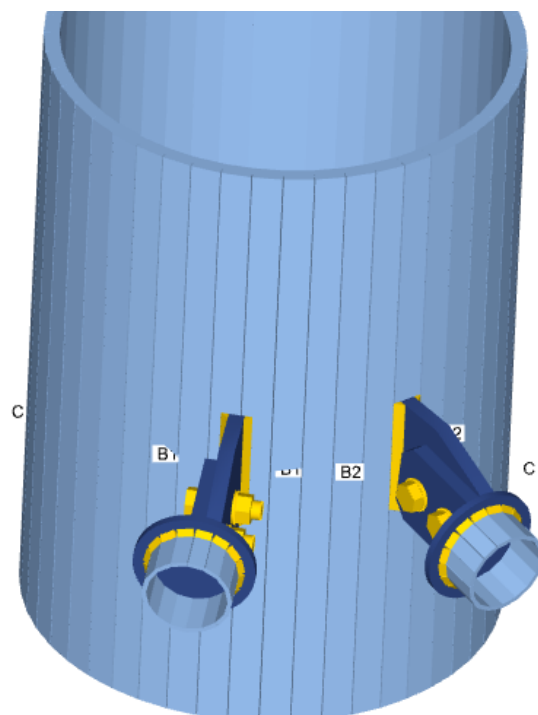
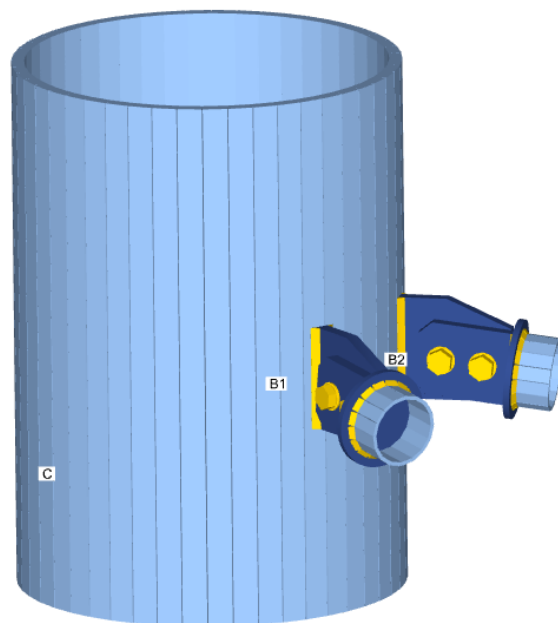


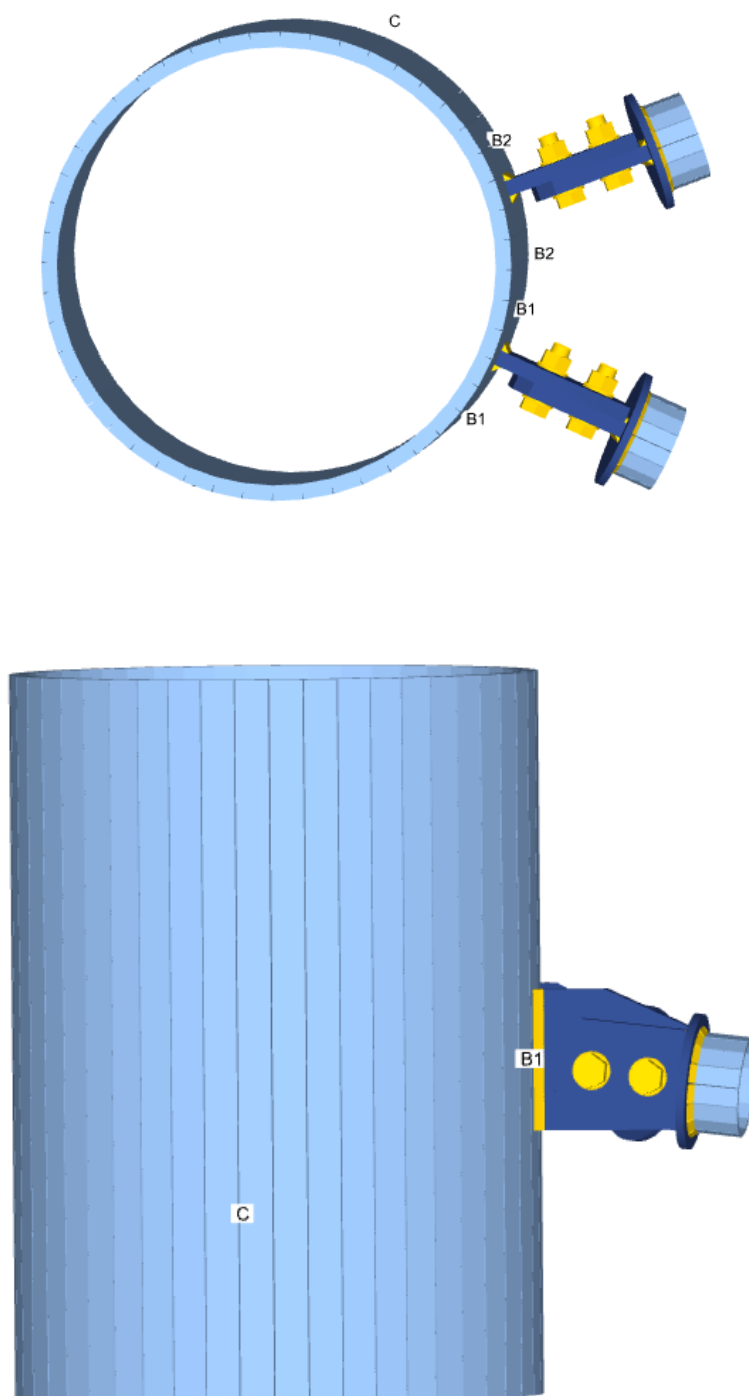
## Code settings

Item	Value	Unit	Reference
$\gamma_{M0}$	1.00	-	EN 1993-1-1: 6.1
$\gamma_{M1}$	1.00	-	EN 1993-1-1: 6.1
$\gamma_{M2}$	1.25	-	EN 1993-1-1: 6.1
$\gamma_{M3}$	1.25	-	EN 1993-1-8: 2.2
$\gamma_C$	1.50	-	EN 1992-1-1: 2.4.2.4
$\gamma_{Inst}$	1.20	-	EN 1992-4: Table 4.1
Joint coefficient $\beta_j$	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 check	Both		EN 1992-4: 7.2.1.4 and 7.2.2.5
Use calculated $\alpha_b$ in bearing check.	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		EN 1992-4
Local deformation check	No		CIDECT DG 1, 3 - 1.1
Local deformation limit	0.03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Analysis with large deformations for hollow section joints
Braced system	No		EN 1993-1-8: 5.2.2.5

## 4 Αντηρίδες επί υποστυλώματος

### 4.1 Γεωμετρία





## 4.2 Αποτελέσματα ανάλυσης & διαστασιολόγησης – Ενδεικτικά σχέδια επιμέρους στοιχείων

# Project data

Project name  
Project number  
Author  
Description  
Date 5/9/2016  
Design code EN

# Material

Steel S 235  
Concrete C25/30

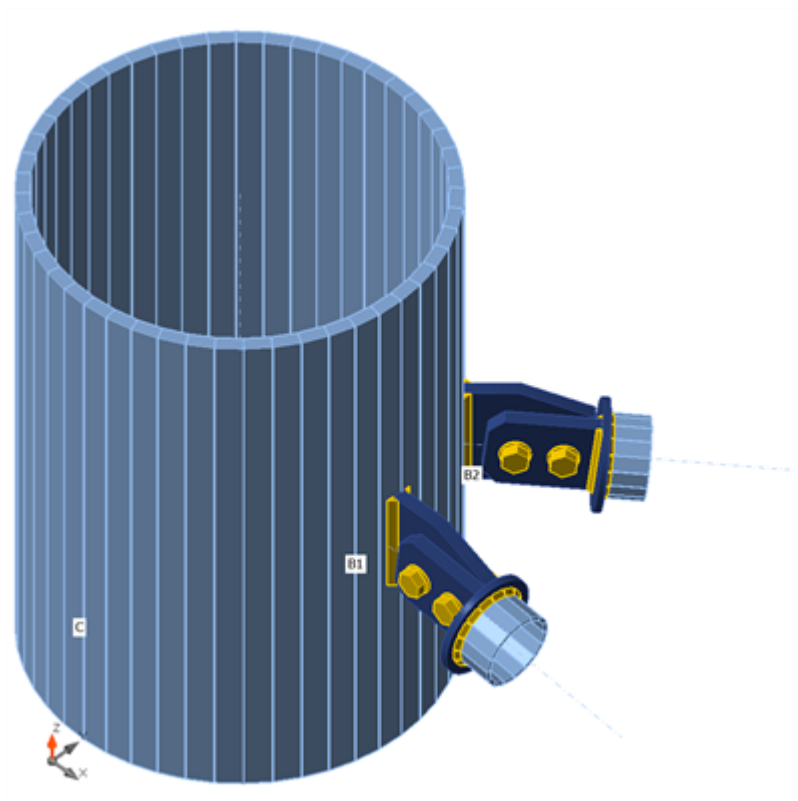
# Project item Connecting plates2

## Design

Name Connecting plates2  
Description  
Analysis Stress, strain/ simplified loading

## Beams and columns

Name	Cross-section	$\beta$ – Direction [°]	$\gamma$ - Pitch [°]	$\alpha$ - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]	Forces in
C	32 - CHS600,20	1.0	-90.0	0.0	0	0	0	Position
B1	31 - CHS(cf)114.3/6.0	0.0	6.5	0.0	0	0	0	Position
B2	31 - CHS(cf)114.3/6.0	45.0	6.5	0.0	0	0	0	Position

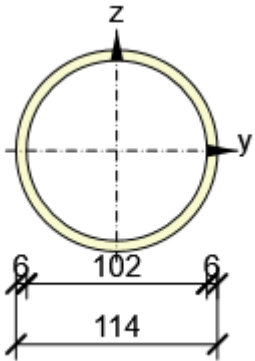


### Cross-sections

Name	Material
32 - CHS600,20	S 235
31 - CHS(cf)114.3/6.0	S 235

### Cross-sections

Name	Material	Drawing
32 - CHS600,20	S 235	

31 - CHS(cf)114.3/6.0	S 235	
-----------------------	-------	---

## Bolts

Name	Bolt assembly	Diameter [mm]	$f_u$ [MPa]	Gross area [mm <sup>2</sup> ]
M24 8.8	M24 8.8	24	800.0	452

## Load effects (equilibrium not required)

Name	Member	N [kN]	V <sub>y</sub> [kN]	V <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]
LE1	B1	170.0	0.0	0.0	0.0	0.0	0.0
	B2	170.0	0.0	0.0	0.0	0.0	0.0

## Check

## Summary

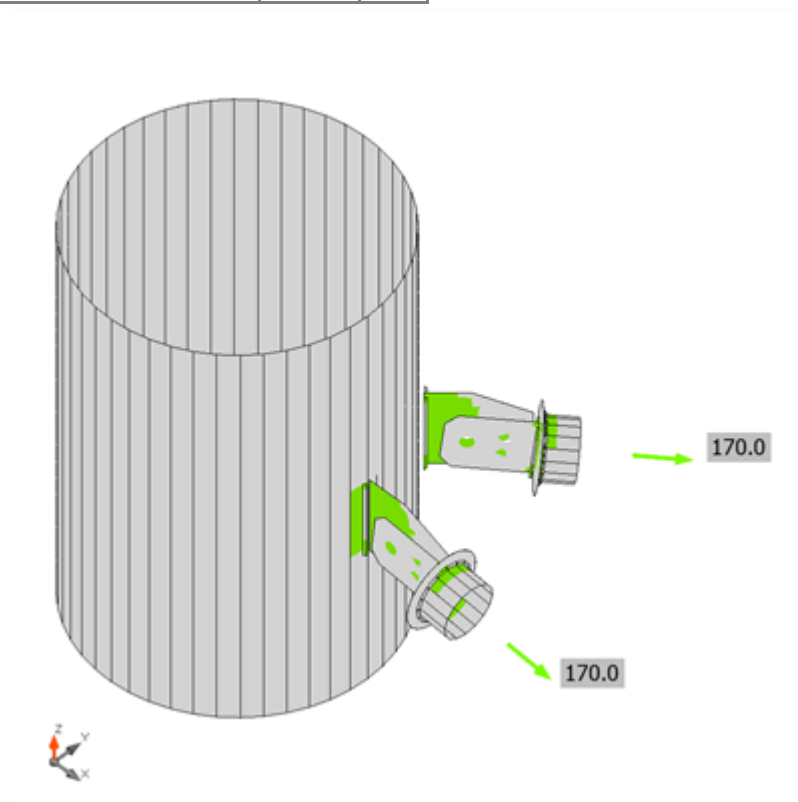
Name	Value	Status
Analysis	100.0%	OK
Plates	0.3 < 5.0%	OK
Bolts	78.4 < 100%	OK
Welds	99.0 < 100%	OK
Buckling	Not calculated	
GMNA	Calculated	

## Plates

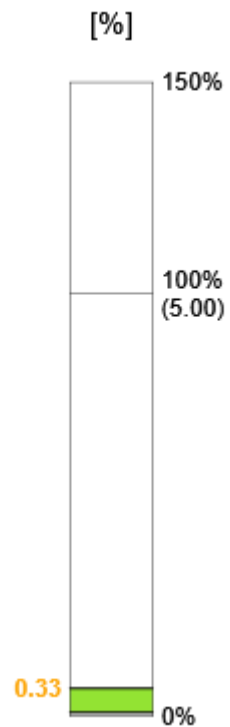
Name	Thickness [mm]	Loads	$\sigma_{Ed}$ [MPa]	$\epsilon_{pl}$ [%]	$\sigma_{CEd}$ [MPa]	Status
C	20.0	LE1	231.9	0.0	0.0	OK
B1	6.0	LE1	235.3	0.1	0.0	OK
B2	6.0	LE1	235.3	0.1	0.0	OK
SP1	20.0	LE1	235.7	0.3	24.4	OK
CPL3a	10.0	LE1	235.2	0.1	0.0	OK
CPL3b	20.0	LE1	205.1	0.0	24.9	OK
SP2	20.0	LE1	235.5	0.3	22.7	OK
CPL2a	10.0	LE1	235.2	0.1	0.0	OK
CPL2b	20.0	LE1	196.6	0.0	23.1	OK

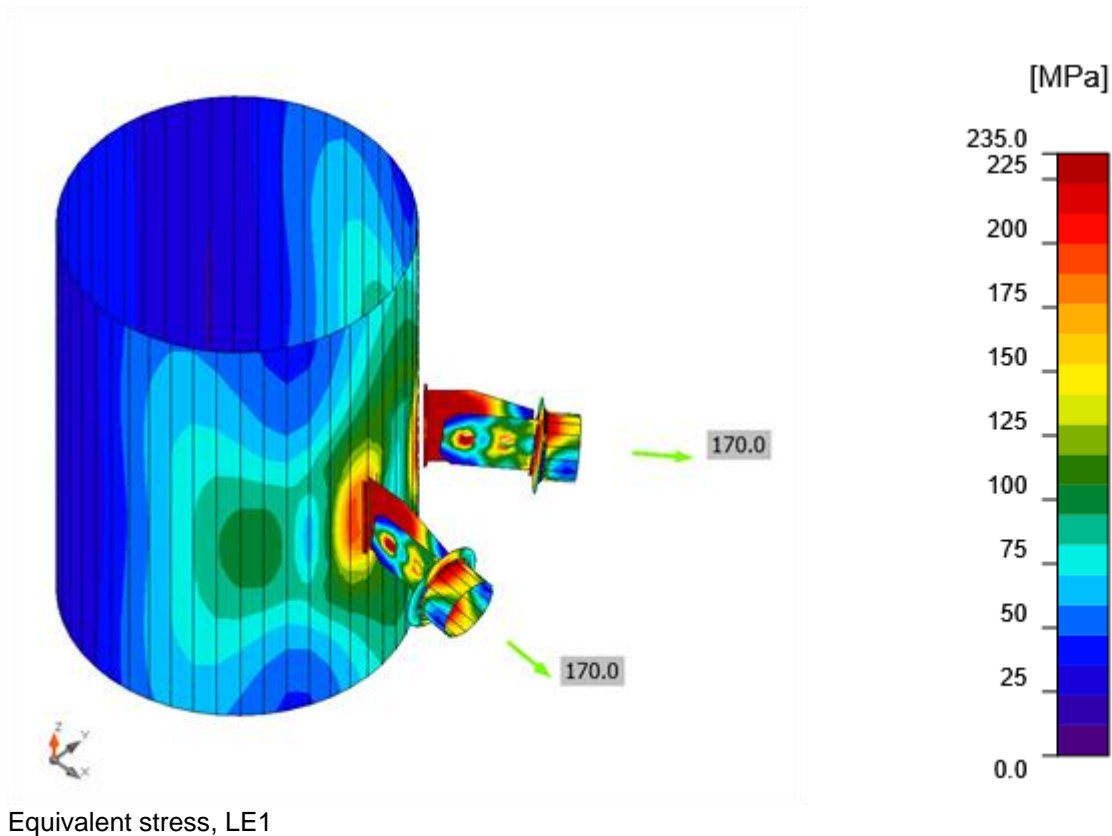
**Design data**

Material	$f_y$ [MPa]	$\epsilon_{lim}$ [%]
S 235	235.0	5.0



Strain check, LE1





## Bolts

	Name	Loads	$F_{t,Ed}$ [kN]	V [kN]	$U_{t_i}$ [%]	$F_{b,Rd}$ [kN]	$U_{t_s}$ [%]	$U_{t_{ts}}$ [%]	Status
	B1	LE1	39.7	87.4	19.5	177.2	64.5	78.4	OK
	B2	LE1	3.3	82.6	1.6	192.4	60.9	62.1	OK
	B3	LE1	36.7	87.2	18.0	177.2	64.3	77.2	OK
	B4	LE1	4.7	82.8	2.3	166.9	61.1	62.8	OK

## Design data

Name	$F_{t,Rd}$ [kN]	$B_{p,Rd}$ [kN]	$F_{v,Rd}$ [kN]
M24 8.8 - 1	203.3	412.6	135.6

## Detailed result for B1

Tension resistance check (EN 1993-1-8 tab 3.4)



$$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} = 203.3 \text{ kN} \geq F_t = 39.7 \text{ kN}$$

where:

$$\begin{aligned} k_2 &= 0.90 && \text{– Factor} \\ f_{ub} &= 800.0 \text{ MPa} && \text{– Ultimate tensile strength of the bolt} \\ A_s &= 353 \text{ mm}^2 && \text{– Tensile stress area of the bolt} \\ \gamma_{M2} &= 1.25 && \text{– Safety factor} \end{aligned}$$

Punching resistance check (EN 1993-1-8 tab 3.4)

$$B_{p,Rd} = \frac{0.6 \pi d_m t_p f_u}{\gamma_{M2}} = 412.6 \text{ kN} \geq F_t = 39.7 \text{ kN}$$

where:

$$\begin{aligned} d_m &= 38 \text{ mm} && \text{– The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller} \\ t_p &= 20 \text{ mm} && \text{– Thickness} \\ f_u &= 360.0 \text{ MPa} && \text{– Ultimate strength} \\ \gamma_{M2} &= 1.25 && \text{– Safety factor} \end{aligned}$$

Shear resistance check (EN 1993-1-8 tab 3.4)

$$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} = 135.6 \text{ kN} \geq V = 87.4 \text{ kN}$$

where:

$$\begin{aligned} \beta_p &= 1.00 && \text{– Reducing factor} \\ \alpha_v &= 0.60 && \text{– Reducing factor} \\ f_{ub} &= 800.0 \text{ MPa} && \text{– Ultimate tensile strength of the bolt} \\ A &= 353 \text{ mm}^2 && \text{– Tensile stress area of the bolt} \\ \gamma_{M2} &= 1.25 && \text{– Safety factor} \end{aligned}$$

Bearing resistance check (EN 1993-1-8 tab 3.4)

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u d t}{\gamma_{M2}} = 177.2 \text{ kN} \geq V = 87.4 \text{ kN}$$

where:

$$\begin{aligned} k_1 &= \min(2.8 \frac{e_2}{d_0} - 1.7, 1.4 \frac{p_2}{d_0} - 1.7, 2.5) = 2.50 && \text{– Factor for edge distance and bolt spacing perpendicular to the direction of load transfer} \\ \alpha_b &= \min(\frac{e_1}{3d_0}, \frac{p_1}{3d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1) = 0.51 && \text{– Factor for end distance and bolt spacing in direction of load transfer} \\ e_2 &= 55 \text{ mm} && \text{– Distance to the plate edge perpendicular to the shear force} \\ p_2 &= \infty \text{ mm} && \text{– Distance between bolts perpendicular to the shear force} \\ d_0 &= 26 \text{ mm} && \text{– Bolt hole diameter} \\ e_1 &= 40 \text{ mm} && \text{– Distance to the plate edge in the direction of the shear force} \\ p_1 &= \infty \text{ mm} && \text{– Distance between bolts in the direction of the shear force} \\ f_{ub} &= 800.0 \text{ MPa} && \text{– Ultimate tensile strength of the bolt} \\ f_u &= 360.0 \text{ MPa} && \text{– Ultimate strength} \\ d &= 24 \text{ mm} && \text{– Nominal diameter of the fastener} \end{aligned}$$

$$t = 20 \text{ mm}$$

– Thickness of the plate

$$\gamma_{M2} = 1.25$$

– Safety factor

Interaction of tension and shear (EN 1993-1-8 tab 3.4)

$$U_{ts} = \frac{F_{t,Ed}}{F_{t,Rd}} + \frac{F_{v,Ed}}{1.4F_{v,Rd}} = 78.4 \%$$

Utilization in tension

$$U_{tt} = \frac{F_{t,Ed}}{\min(F_{t,Rd}; B_{p,Rd})} = 19.5 \%$$

Utilization in shear

$$U_{ts} = \frac{V_{Ed}}{\min(F_{v,Rd}; F_{s,Rd})} = 64.5 \%$$

## Welds (Plastic redistribution)

Item	Edge	Throat th. [mm]	Length [mm]	Loads	$\sigma_{w,Ed}$ [MPa]	$\epsilon_{Pl}$ [%]	$\sigma_{\perp}$ [MPa]	$\tau_{\parallel}$ [MPa]	$\tau_{\perp}$ [MPa]	Ut [%]	Ut <sub>c</sub> [%]	Status
CPL3a	B1	▲5.0	338	LE1	352.8	0.0	141.1	41.1	-182.1	98.0	45.6	OK
CPL2a	B2	▲5.0	338	LE1	352.8	0.0	141.3	42.3	-181.8	98.0	45.6	OK
C-arc 36	SP1	▲7.0▲	160	LE1	353.3	0.3	119.6	141.2	130.0	98.1	77.5	OK
		▲7.0▲	160	LE1	230.1	0.0	53.1	-125.2	-32.0	63.9	29.6	OK
CPL3a	CPL3b	▲5.0▲	114	LE1	356.1	2.3	167.8	-58.8	171.5	98.9	76.2	OK
		▲5.0▲	114	LE1	356.4	2.5	182.9	48.6	-169.8	99.0	77.1	OK
C-arc 42	SP2	▲7.0▲	160	LE1	353.2	0.3	114.0	144.2	128.3	98.1	73.2	OK
		▲7.0▲	160	LE1	244.2	0.0	75.0	-127.6	-41.6	67.8	29.1	OK
CPL2a	CPL2b	▲5.0▲	114	LE1	356.0	2.2	170.4	-59.3	170.5	98.9	75.6	OK
		▲5.0▲	114	LE1	356.6	2.6	180.6	48.3	-170.8	99.0	76.9	OK

## Design data

	$\beta_w$ [-]	$\sigma_{w,Rd}$ [MPa]	$0.9 \sigma$ [MPa]
S 235	0.80	360.0	259.2

## Detailed result for CPL2a CPL2b

Weld resistance check (EN 1993-1-8 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360.0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 356.6 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0.9 f_u / \gamma_{M2} = 259.2 \text{ MPa} \geq |\sigma_{\perp}| = 180.6 \text{ MPa}$$

where:

$$f_u = 360.0 \text{ MPa} \quad \text{– Ultimate strength}$$

$$\beta_w = 0.80 \quad \text{– appropriate correlation factor taken from Table 4.1}$$

$$\gamma_{M2} = 1.25 \quad - \text{Safety factor}$$

Stress utilization

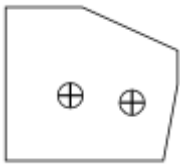
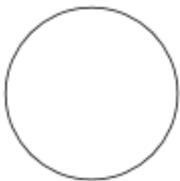


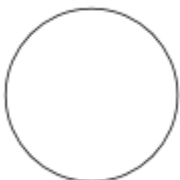

$$U_t = \max\left(\frac{\sigma_{xx,Ed}}{\sigma_{xx,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 99.0 \quad \%$$

## Buckling

**Buckling analysis was not calculated.**

## Bill of material

### Manufacturing operations

Name	Plates [mm]	Shape	Nr.	Welds [mm]	Length [mm]	Bolts	Nr.
SP1	P20.0x180.3-160.0 (S 235)		1			M24 8.8	2
CPL3	P10.0x154.3-0.0 (S 235)		1	Double fillet: a = 5.0 Fillet: a = 5.0	114.4 338.1	M24 8.8	2
	P20.0x150.0-114.4 (S 235)		1				
SP2	P20.0x175.1-160.0 (S 235)		1			M24 8.8	2
CPL2	P10.0x154.3-0.0 (S 235)		1	Double fillet: a = 5.0 Fillet: a = 5.0	114.4 338.1	M24 8.8	2
	P20.0x150.0-114.4 (S 235)		1				

## Welds

Type	Material	Throat thickness [mm]	Leg size [mm]	Length [mm]
Double fillet	S 235	7.0	9.9	320.0
Double fillet	S 235	5.0	7.1	228.8
Fillet	S 235	5.0	7.1	676.1

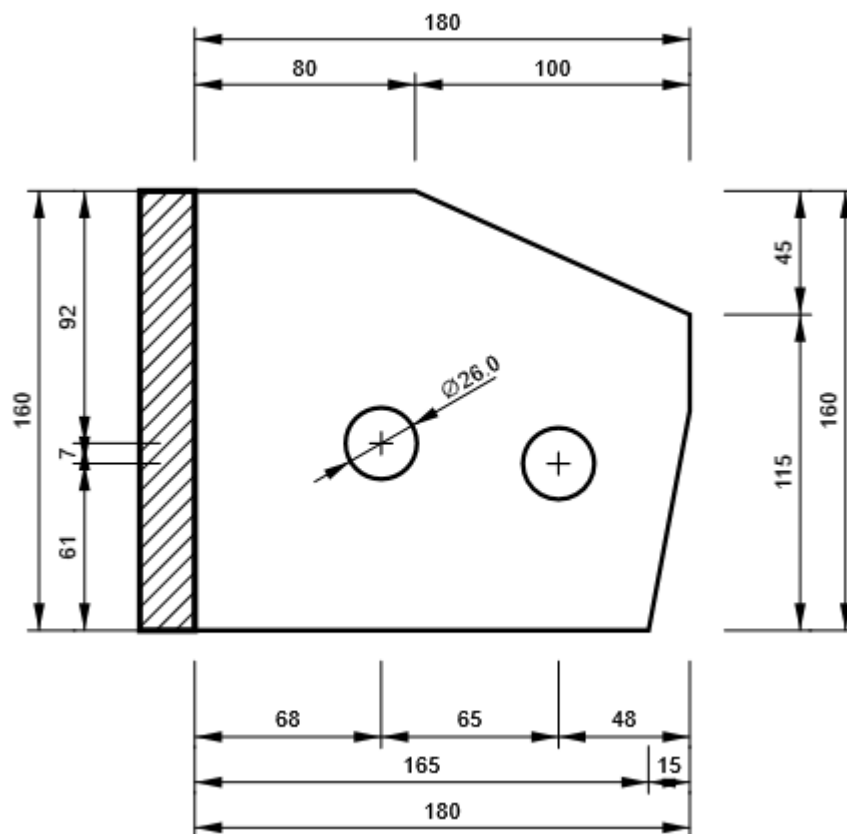
## Bolts

Name	Grip length [mm]	Count
M24 8.8	40	4

## Drawing

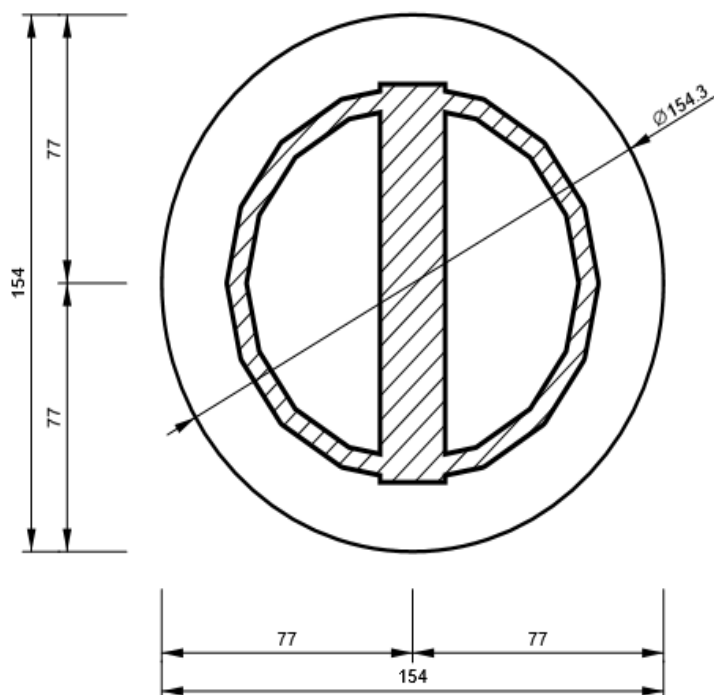
### SP1

### P20.0x160-180 (S 235)



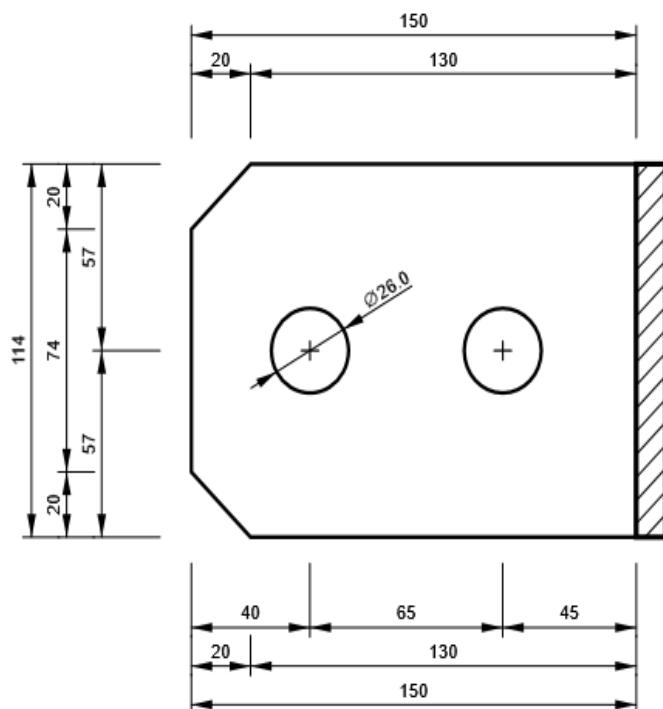
### CPL3 - CPL3a

P10.0x154-154 (S 235)



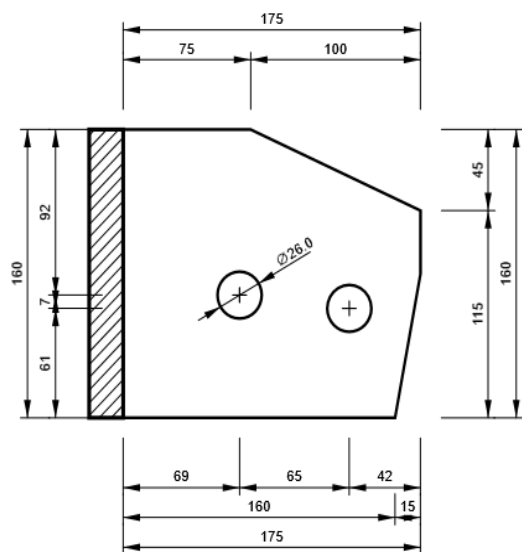
### CPL3 - CPL3b

P20.0x114-150 (S 235)



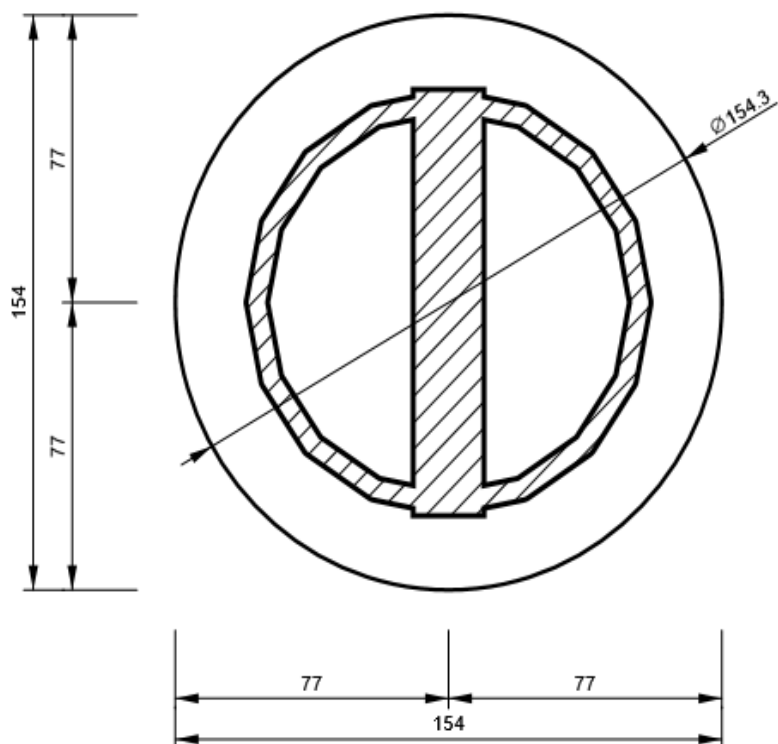
## SP2

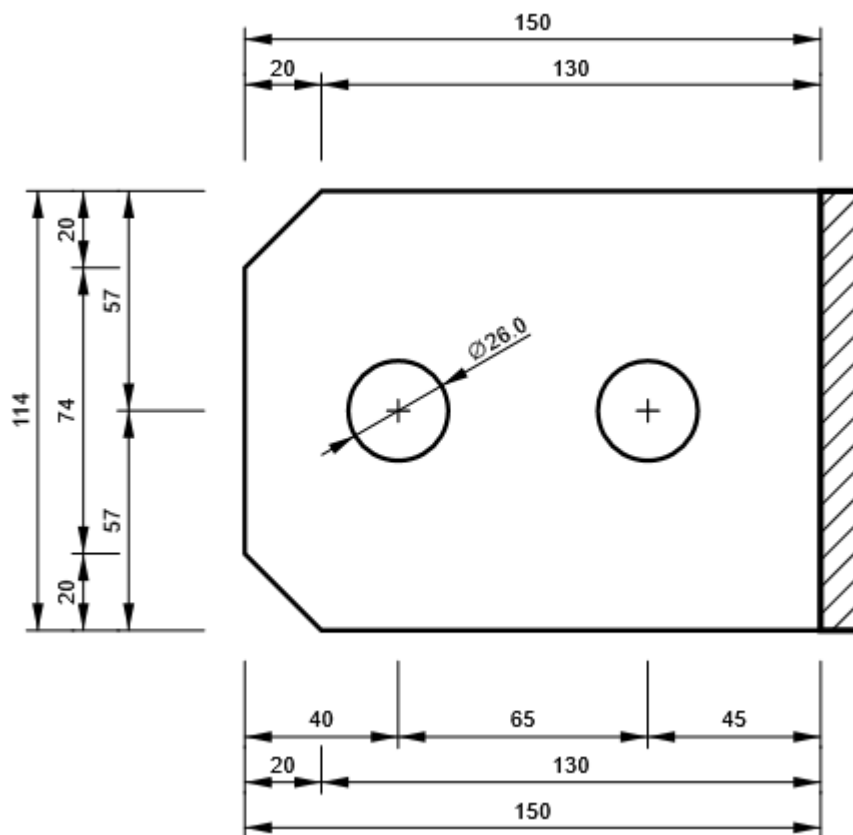
### P20.0x160-175 (S 235)



## CPL2 - CPL2a

### P10.0x154-154 (S 235)



**CPL2 - CPL2b****P20.0x114-150 (S 235)****Code settings**

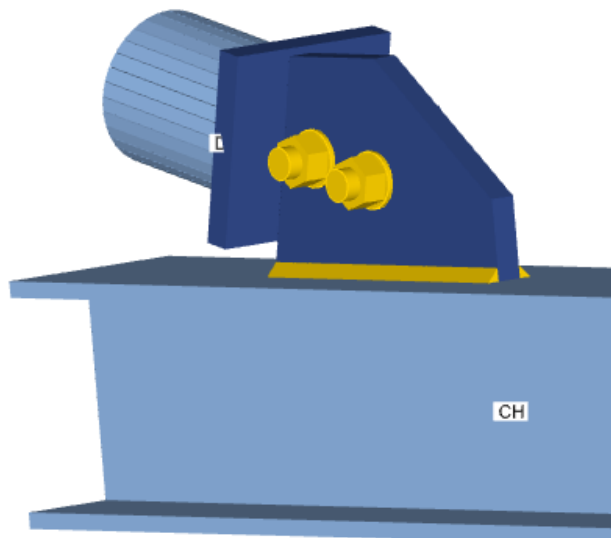
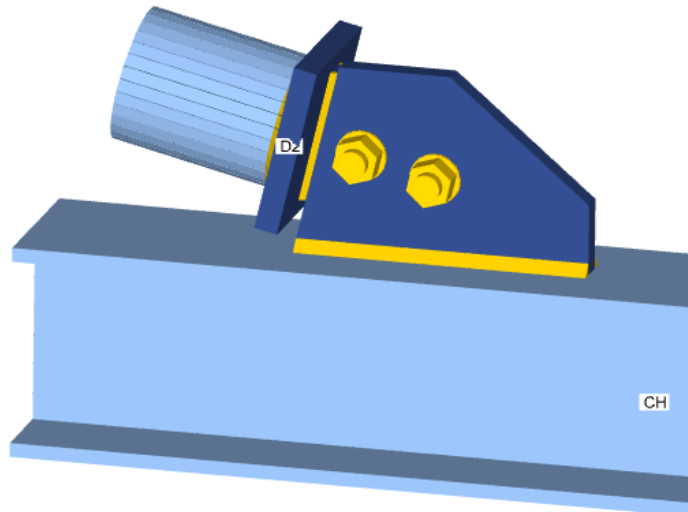
Item	Value	Unit	Reference
$\gamma_{M0}$	1.00	-	EN 1993-1-1: 6.1
$\gamma_{M1}$	1.00	-	EN 1993-1-1: 6.1
$\gamma_{M2}$	1.25	-	EN 1993-1-1: 6.1
$\gamma_{M3}$	1.25	-	EN 1993-1-8: 2.2
$\gamma_c$	1.50	-	EN 1992-1-1: 2.4.2.4
$\gamma_{Inst}$	1.20	-	EN 1992-4: Table 4.1
Joint coefficient $\beta_j$	0.67	-	EN 1993-1-8: 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 check	Both		EN 1992-4: 7.2.1.4 and 7.2.2.5
Use calculated $\alpha_b$ in bearing check.	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		EN 1992-4
Local deformation check	No		CIDECT DG 1, 3 - 1.1
Local deformation limit	0.03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Analysis with large deformations for hollow section joints
Braced system	No		EN 1993-1-8: 5.2.2.5



## 5 Αντηρίδα επί ζυγώματος

### 5.1 Γεωμετρία



## 5.2 Αποτελέσματα ανάλυσης & διαστασιολόγησης – Ενδεικτικά σχέδια επιμέρους στοιχείων

### Project data

Project name  
Project number  
Author  
Description  
Date 11/14/2021  
Design code EN

### Material

Steel S 235

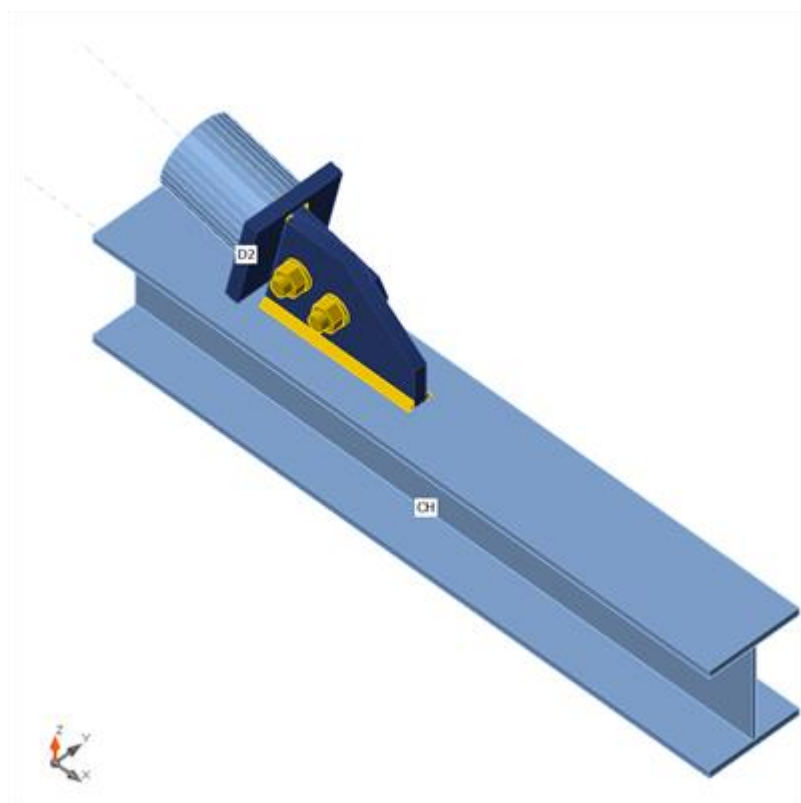
### Project item CON1

#### Design

Name CON1  
Description  
Analysis Stress, strain/ simplified loading

#### Beams and columns

Name	Cross-section	$\beta$ – Direction [°]	$\gamma$ - Pitch [°]	$\alpha$ - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]	Forces in
CH	3 - Iwn180x(150/150)	180.0	0.0	0.0	0	0	0	Node
D2	4 - CHS(cf)114.3/6.3	180.0	-13.0	0.0	600	0	0	Node



## Cross-sections

Name	Material
3 - Iwn180x(150/150)	S 235
4 - CHS(cf)114.3/6.3	S 235

## Bolts

Name	Bolt assembly	Diameter [mm]	fu [MPa]	Gross area [mm <sup>2</sup> ]
M24 8.8	M24 8.8	24	800.0	452

## Load effects (equilibrium not required)

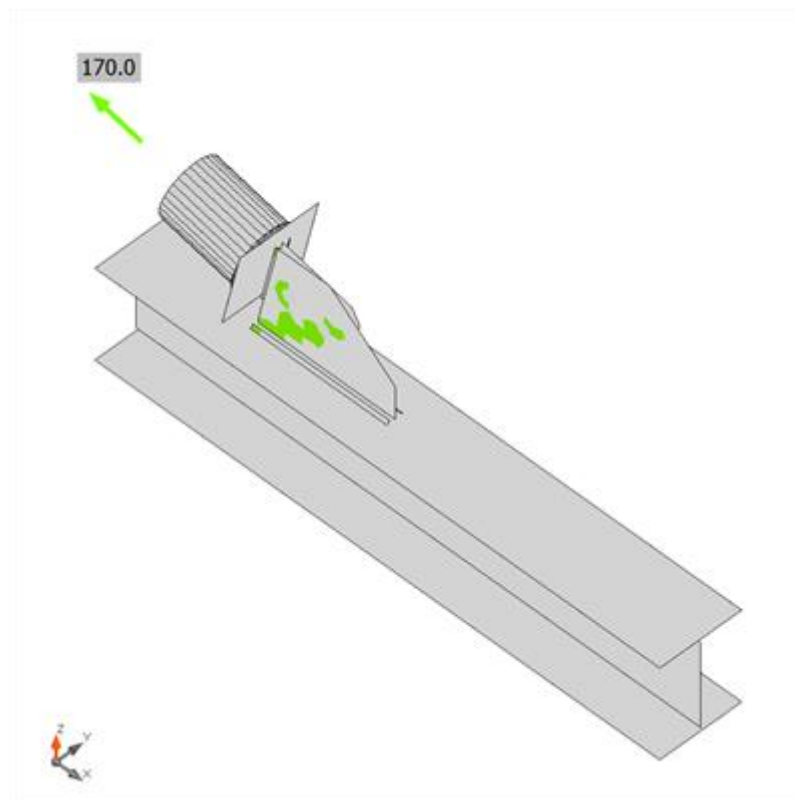
Name	Member	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	D2	170.0	0.0	0.0	0.0	0.0	0.0

## Check

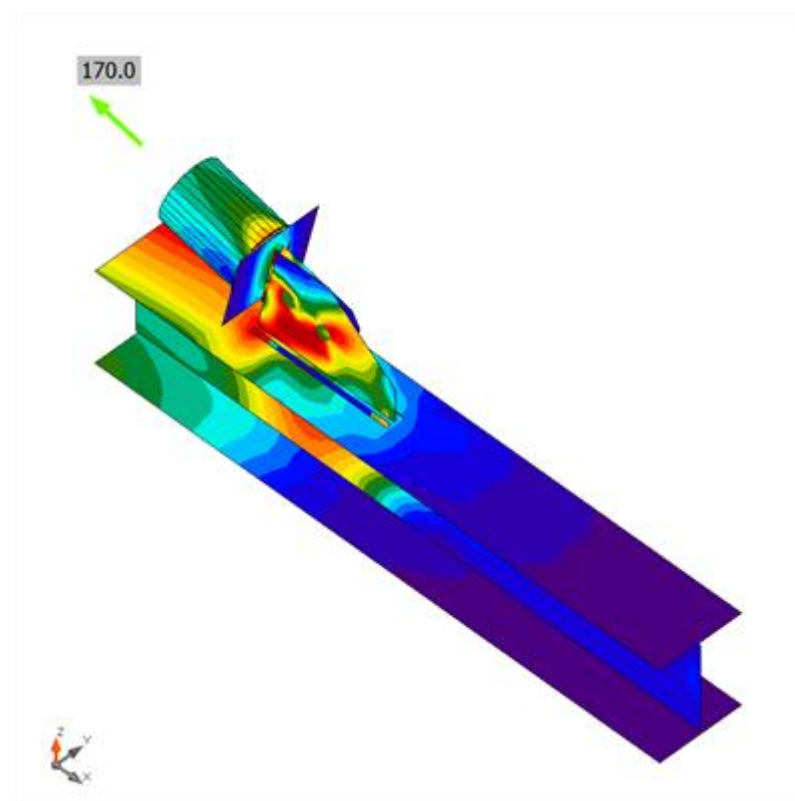
## Summary

Name	Value	Status
Analysis	100.0%	OK
Plates	0.1 < 5.0%	OK
Bolts	74.2 < 100%	OK
Welds	98.0 < 100%	OK



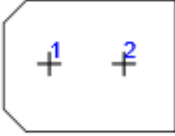


Strain check, LE1



Equivalent stress, LE1

**Bolts**

	Name	Loads	$F_{t,Ed}$ [kN]	V [kN]	$U_{t_t}$ [%]	$F_{b,Rd}$ [kN]	$U_{t_s}$ [%]	$U_{t_{ts}}$ [%]	Status
	B1	LE1	31.1	85.7	15.3	177.2	63.3	74.2	OK
	B2	LE1	4.5	84.6	2.2	161.9	62.4	64.0	OK

**Design data**

Name	$F_{t,Rd}$ [kN]	$B_{p,Rd}$ [kN]	$F_{v,Rd}$ [kN]
M24 8.8 - 1	203.3	412.6	135.6

**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
$U_{t_t}$	Utilization in tension
$U_{t_s}$	Utilization in shear

**Welds (Plastic redistribution)**

Item	Edge	Throat th. [mm]	Length [mm]	Loads	$\sigma_{w,Ed}$ [MPa]	$\epsilon_{PI}$ [%]	$\sigma_{\perp}$ [MPa]	$\tau_{\parallel}$ [MPa]	$\tau_{\perp}$ [MPa]	$U_t$ [%]	$U_{t_c}$ [%]	Status
CPL1a	D2	5.0	339	LE1	267.3	0.0	115.8	-50.5	129.6	74.3	41.8	OK
CH-tfl 1	SP1	7.0	250	LE1	297.5	0.0	21.7	154.8	73.2	82.6	45.3	OK
		7.0	250	LE1	352.9	0.1	188.5	120.5	123.1	98.0	22.0	OK
CPL1a	CPL1b	5.0	114	LE1	352.9	0.1	142.0	76.5	170.1	98.0	65.5	OK
		5.0	114	LE1	352.9	0.1	189.1	40.1	167.3	98.0	61.1	OK

**Design data**

	$\beta_w$ [-]	$\sigma_{w,Rd}$ [MPa]	$0.9 \sigma$ [MPa]
S 235	0.80	360.0	259.2

**Symbol explanation**

$\epsilon_{PI}$	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
$0.9 \sigma$	Perpendicular stress resistance - $0.9 \cdot f_u / \gamma_{M2}$
$\beta_w$	Corelation factor EN 1993-1-8 tab. 4.1
Ut	Utilization
Utc	Weld capacity utilization

## Buckling

**Buckling analysis was not calculated.**

## Code settings

Item	Value	Unit	Reference
$\gamma_{M0}$	1.00	-	EN 1993-1-1: 6.1
$\gamma_{M1}$	1.00	-	EN 1993-1-1: 6.1
$\gamma_{M2}$	1.25	-	EN 1993-1-1: 6.1
$\gamma_{M3}$	1.25	-	EN 1993-1-8: 2.2
$\gamma_C$	1.50	-	EN 1992-1-1: 2.4.2.4
$\gamma_{Inst}$	1.20	-	EN 1992-4: Table 4.1
Joint coefficient $\beta_j$	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 check	Both		EN 1992-4: 7.2.1.4 and 7.2.2.5
Use calculated $\alpha_b$ in bearing check.	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		EN 1992-4
Local deformation check	No		CIDECT DG 1, 3 - 1.1
Local deformation limit	0.00	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	No		Analysis with large deformations for hollow section joints
Braced system	No		EN 1993-1-8: 5.2.2.5