Project data

Project name	DG-29
Project number	Ex 6.1a
Author	IDEA StatiCa
Description	
Date	10/9/2023
Code	AISC/ACI

Material

Steel	A992, A572 Gr.50, A500. Gr. C

Project item EX 6.1a

Design

Name	EX 6.1a
Description	
Analysis	Stress, strain/ simplified loading
Design code	AISC - LRFD (2022)

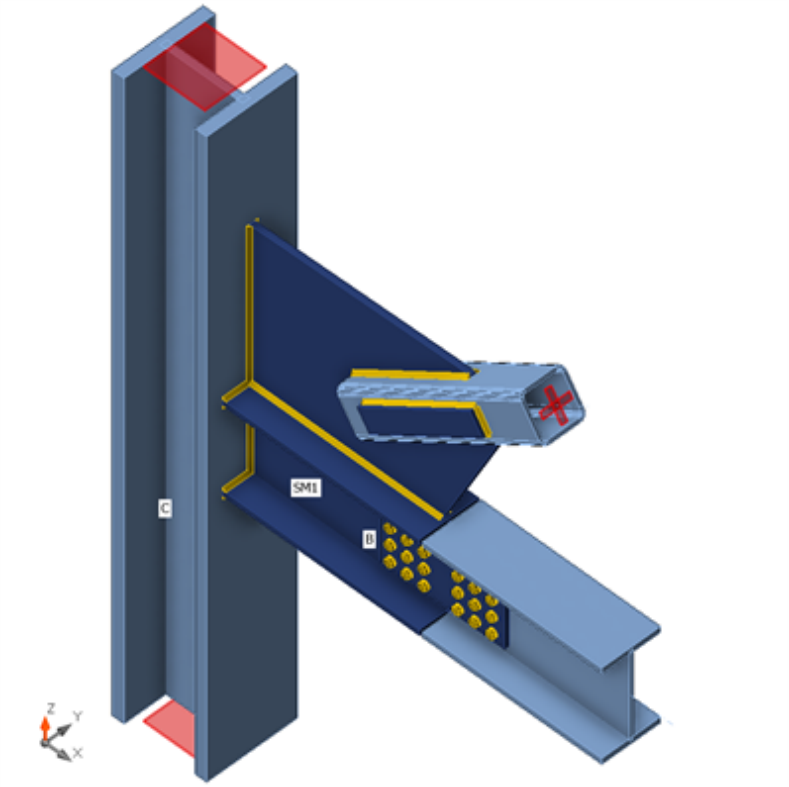
Members

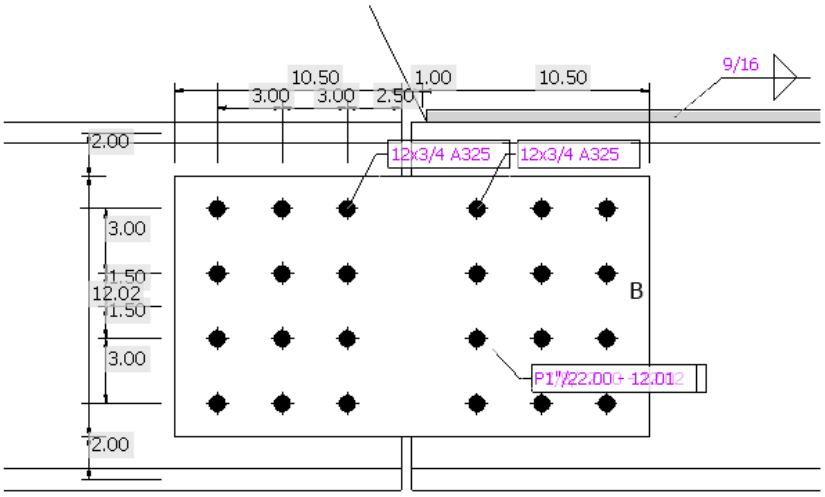
Geometry

Name	Cross-section	β – Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [in]	Offset ey [in]	Offset ez [in]
C	1 - CON1(W14X283)	0.0	90.0	0.0	0.00	0.00	0.00
B	2 - CON1(W16X100)	0.0	0.0	0.0	0.00	0.00	0.00
M3	3 - HSS8X8X.625	0.0	34.0	0.0	35.25	0.00	0.00

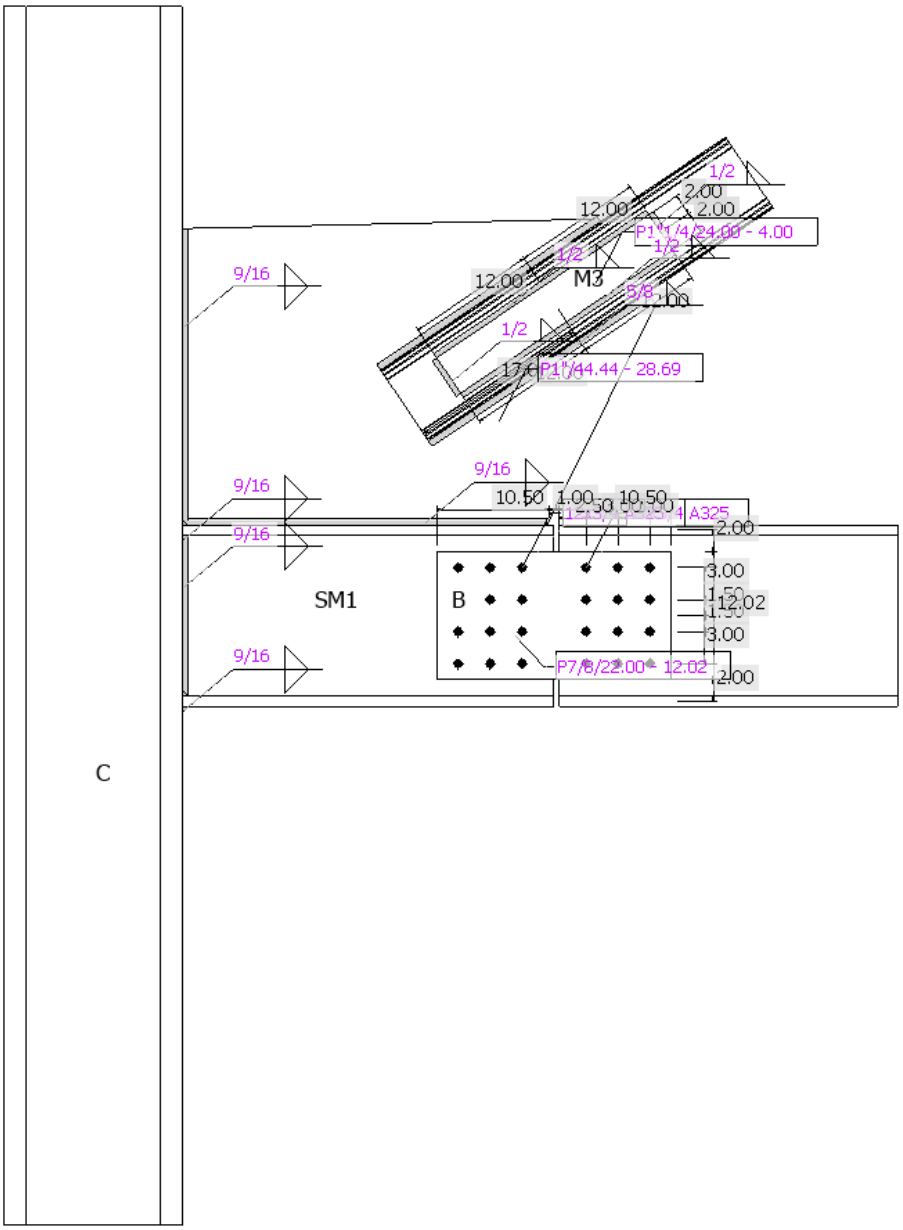
Supports and forces

Name	Support	Forces in	X [in]
C / begin	N-Vy-Vz-Mx-My-Mz	Node	0.00
C / end	N-Vy-Vz-Mx-My-Mz	Node	0.00
B / end		Bolts	49.25
M3 / end	Mx-My-Mz	Node	0.00





Splice (SPL1a)



Generally located plate (SP1)

Cross-sections

Name	Material
1 - CON1(W14X283)	A992
2 - CON1(W16X100)	A992
3 - HSS8X8X.625	A500. Gr. C

Bolts

Name	Bolt assembly	Diameter [in]	f_u [ksi]	Gross area [in^2]
3/4 A325	3/4 A325	0.75	120.0	0.44

Load effects (Equilibrium not required)

Name	Member	N [kip]	Vy [kip]	Vz [kip]	Mx [kip.ft]	My [kip.ft]	Mz [kip.ft]
LE1	B / End	0.00	0.00	-70.00	0.00	0.00	0.00
	M3 / End	300.00	0.00	0.00	0.00	0.00	0.00
LE2	B / End	0.00	0.00	-70.00	0.00	0.00	0.00
	M3 / End	-300.00	0.00	0.00	0.00	0.00	0.00

Check

Summary

Name	Value	Check status
Analysis	100.0%	OK
Plates	0.3 < 5.0%	OK
Bolts	75.2 < 100%	OK
Welds	76.6 < 100%	OK
Buckling	12.17	

Plates

Name	Material	t_p [in]	Loads	σ_{Ed} [ksi]	ε_{Pl} [%]	$\sigma_{c,Ed}$ [ksi]	Status
C-bfl 1	A992	2"1/16	LE2	34.1	0.0	0.0	OK
C-tfl 1	A992	2"1/16	LE2	18.2	0.0	0.0	OK
C-w 1	A992	1"5/16	LE2	22.8	0.0	0.0	OK
B-bfl 1	A992	1"	LE2	10.3	0.0	0.0	OK
B-tfl 1	A992	1"	LE2	10.3	0.0	0.0	OK
B-w 1	A992	9/16	LE1	22.8	0.0	0.3	OK
M3	A500. Gr. C	9/16	LE2	42.2	0.0	0.0	OK
SM1-bfl 1	A992	1"	LE2	40.7	0.0	0.0	OK
SM1-tfl 1	A992	1"	LE1	10.6	0.0	0.0	OK
SM1-w 1	A992	9/16	LE1	45.1	0.3	0.9	OK
SPL1a	A572 Gr.50	7/8	LE1	29.3	0.0	0.9	OK
SPL1b	A572 Gr.50	1"	LE1	25.5	0.0	0.7	OK
SP1	A572 Gr.50	1"	LE1	26.4	0.0	0.0	OK
SP2	A992	1"1/4	LE2	11.5	0.0	0.3	OK
SP3	A992	1"1/4	LE2	11.5	0.0	0.3	OK

Design data

Material	F_y [ksi]	ε_{lim} [%]
A992	50.0	5.0
A500. Gr. C	50.0	5.0
A572 Gr.50	50.0	5.0

Symbol explanation

t_p	Plate thickness
σ_{Ed}	Equivalent stress
ε_{Pl}	Plastic strain
$\sigma_{c,Ed}$	Contact stress
F_y	Yield strength
ε_{lim}	Limit of plastic strain

Detailed result for SM1-w 1

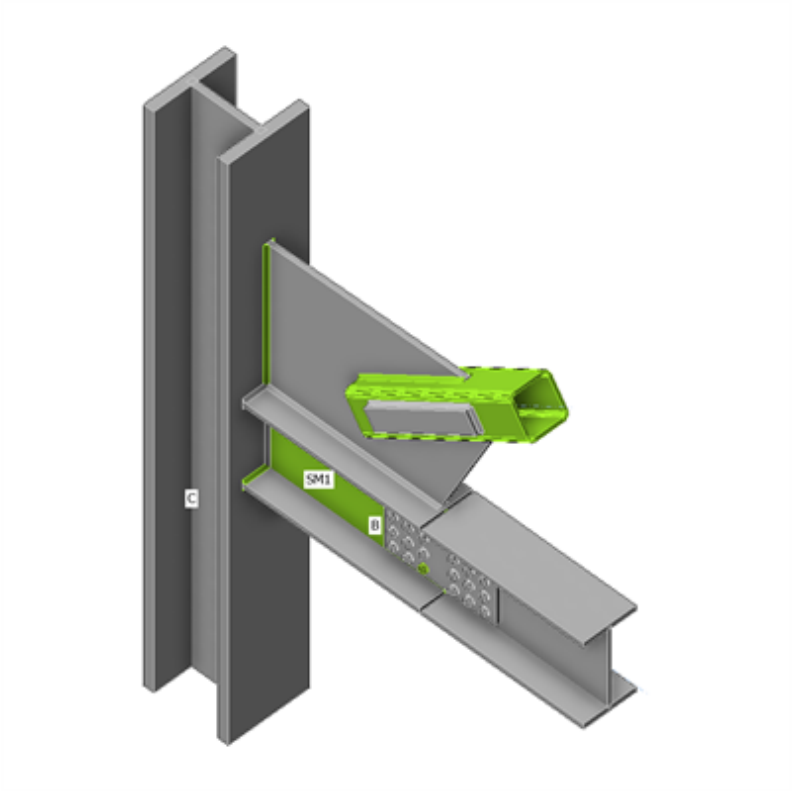
Design values used in the analysis

$\phi F_y =$ 45.0 ksi

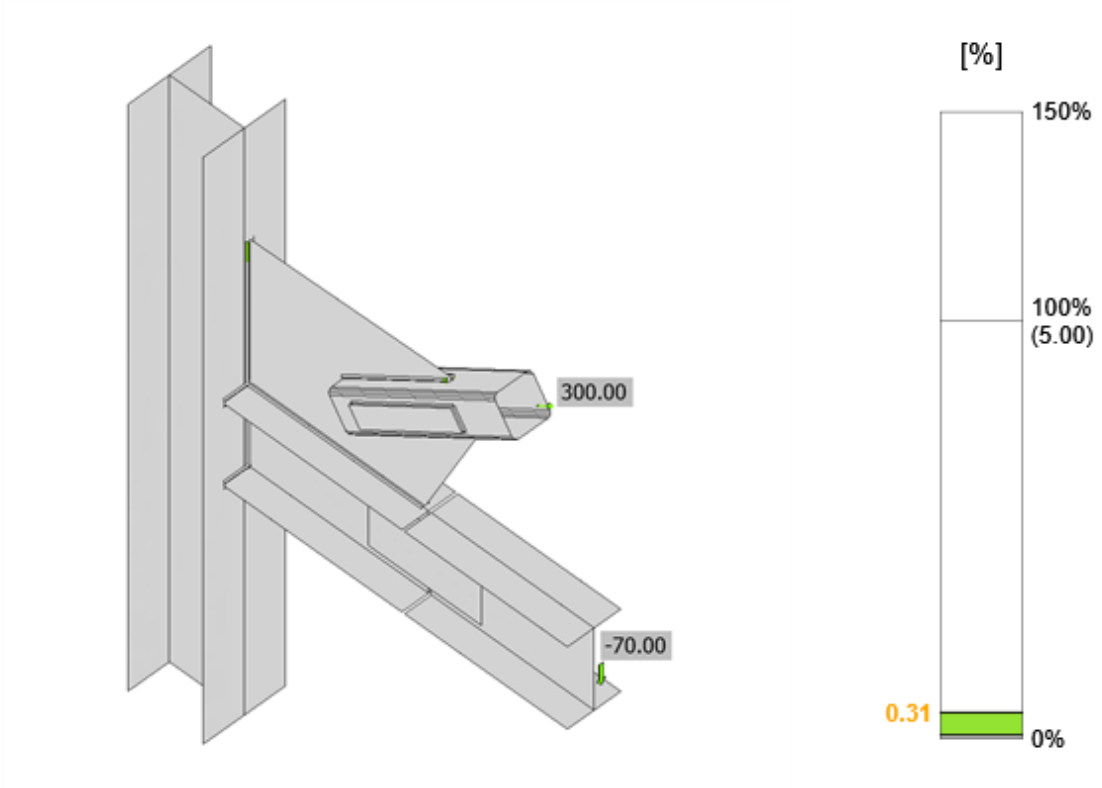
Where:

$F_y = 50.0$ ksi – characteristic yield strength

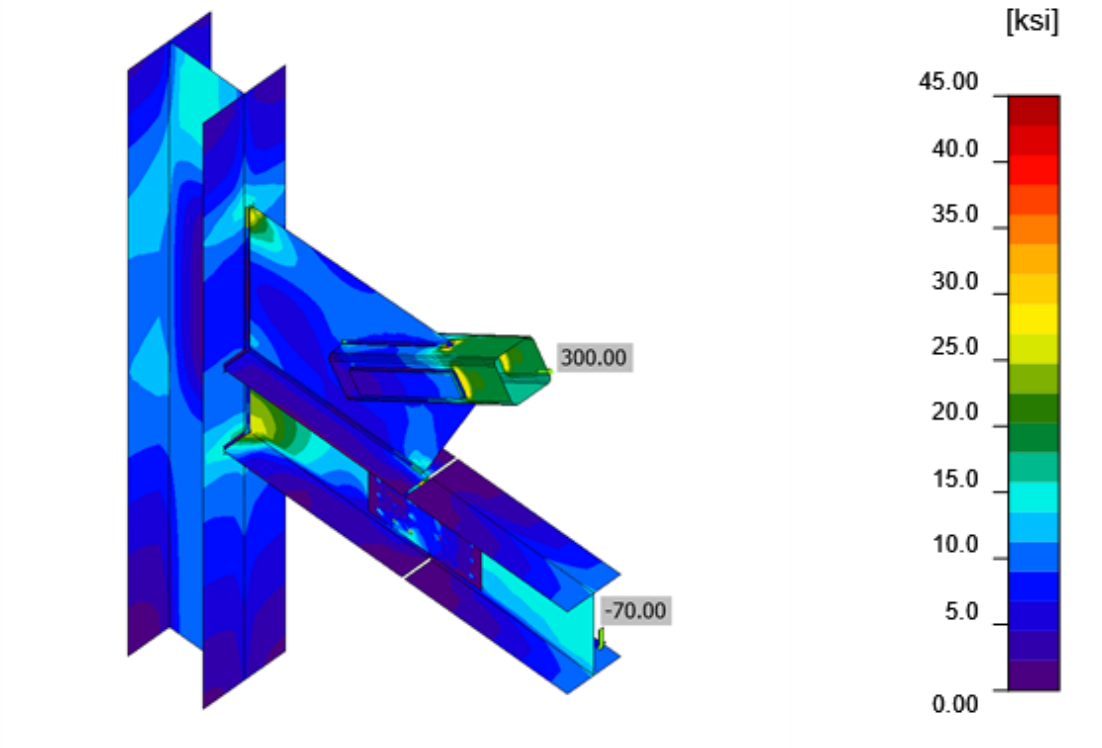
$\phi = 0.90$ – resistance factor for steel material AISC 360-22 – B3.1



Overall check, LE1

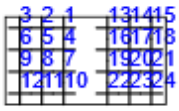


Strain check, LE1



Equivalent stress, LE1

Bolts

Shape	Item	Grade	Loads	F_t [kip]	V [kip]	$\phi R_{n,bearing}$ [kip]	Ut_t [%]	Ut_s [%]	Ut_{ts} [%]	Detailing	Status
	B1	3/4 A325 - 1	LE2	0.07	2.84	51.33	0.2	15.9	-	OK	OK
	B2	3/4 A325 - 1	LE2	0.10	2.80	51.33	0.3	15.6	-	OK	OK
	B3	3/4 A325 - 1	LE1	0.09	3.17	51.33	0.3	17.7	-	OK	OK
	B4	3/4 A325 - 1	LE2	0.08	2.85	51.33	0.3	16.0	-	OK	OK
	B5	3/4 A325 - 1	LE2	0.09	2.79	51.33	0.3	15.6	-	OK	OK
	B6	3/4 A325 - 1	LE1	0.10	3.17	51.33	0.3	17.7	-	OK	OK
	B7	3/4 A325 - 1	LE1	0.14	2.87	51.33	0.5	16.0	-	OK	OK
	B8	3/4 A325 - 1	LE1	0.03	2.79	51.33	0.1	15.6	-	OK	OK
	B9	3/4 A325 - 1	LE1	0.05	3.17	51.33	0.2	17.7	-	OK	OK
	B10	3/4 A325 - 1	LE1	0.68	2.86	51.33	2.3	16.0	-	OK	OK
	B11	3/4 A325 - 1	LE1	0.50	2.79	51.33	1.7	15.6	-	OK	OK
	B12	3/4 A325 - 1	LE1	0.55	3.16	51.33	1.9	17.7	-	OK	OK
	B13	3/4 A325 - 1	LE1	0.89	13.44	51.33	3.0	75.2	-	OK	OK
	B14	3/4 A325 - 1	LE2	0.47	9.84	51.33	1.6	55.0	-	OK	OK
	B15	3/4 A325 - 1	LE2	1.09	9.87	51.33	3.7	55.2	-	OK	OK
	B16	3/4 A325 - 1	LE1	0.18	9.71	51.33	0.6	54.3	-	OK	OK
	B17	3/4 A325 - 1	LE1	0.03	4.14	51.33	0.1	23.2	-	OK	OK
	B18	3/4 A325 - 1	LE1	0.49	4.22	51.33	1.7	23.6	-	OK	OK
	B19	3/4 A325 - 1	LE1	0.46	9.34	51.33	1.5	52.3	-	OK	OK
	B20	3/4 A325 - 1	LE2	0.14	4.08	51.33	0.5	22.8	-	OK	OK
	B21	3/4 A325 - 1	LE1	0.09	4.48	51.33	0.3	25.1	-	OK	OK
	B22	3/4 A325 - 1	LE2	0.67	12.93	51.33	2.3	72.3	-	OK	OK
	B23	3/4 A325 - 1	LE2	0.23	9.73	51.33	0.8	54.4	-	OK	OK
	B24	3/4 A325 - 1	LE1	0.34	9.84	51.33	1.1	55.1	-	OK	OK

Design data

Grade	$\phi R_{n,tension}$ [kip]	$\phi R_{n,shear}$ [kip]
3/4 A325 - 1	29.79	17.88

Symbol explanation

F_t	Tension force
V	Resultant of bolt shear forces Vy and Vz in shear planes
$\phi R_{n,bearing}$	Bolt bearing resistance
Ut_t	Utilization in tension
Ut_s	Utilization in shear
Ut_{ts}	Utilization in tension and shear
$\phi R_{n,tension}$	Bolt tension resistance - AISC 360-22 – J3.7
$\phi R_{n,shear}$	Bolt shear resistance - AISC 360-22 – J3.7

Detailed result for B13

Tension resistance check (AISC 360-22 – J3-1)

$$\phi R_n = \phi \cdot F_{nt} \cdot A_b = \quad 29.79 \quad \text{kip} \quad \geq \quad F_t = \quad 0.89 \quad \text{kip}$$

Where:

$F_{nt} =$ 89.9 ksi – nominal tensile stress AISC 360-22 – Table J3.2

$A_b =$ 0.44 in^2 – gross bolt cross-sectional area

$\phi =$ 0.75 – resistance factor

Shear resistance check (AISC 360-22 – J3-1)

$$\phi R_n = \phi \cdot F_{nv} \cdot A_b = \quad 17.88 \quad \text{kip} \quad \geq \quad V = \quad 13.44 \quad \text{kip}$$

Where:

$F_{nv} =$ 54.0 ksi – nominal shear stress AISC 360-22 – Table J3.2

$A_b =$ 0.44 in^2 – gross bolt cross-sectional area

$\phi =$ 0.75 – resistance factor

Bearing resistance check (AISC 360-22 – J3-6)

$$R_n = 1.20 \cdot l_c \cdot t \cdot F_u \quad \leq \quad 2.40 \cdot d \cdot t \cdot F_u$$

$$\phi R_n = \quad 51.33 \quad \text{kip} \quad \geq \quad V = \quad 26.79 \quad \text{kip}$$

Where:

$l_c =$ 3.93 in – clear distance, in the direction of the force, between the edge of the hole and the edge of the adjacent hole or edge of the material

$t =$ 0.59 in – thickness of the plate

$d =$ 0.75 in – diameter of a bolt

$F_u =$ 65.0 ksi – tensile strength of the connected material

$\phi =$ 0.75 – resistance factor for bearing at bolt holes

Interaction of tension and shear check (AISC 360-22 – J3-2)

The required stress, in either shear or tension, is less than or equal to 30% of the corresponding available stress and the effects of combined stresses need not to be investigated.

Welds

Item	Edge	Xu	t_w [in]	w [in]	L [in]	L_c [in]	Loads	F_n [kip]	ϕR_n [kip]	Ut [%]	Detailing	Status
C-bfl 1	SM1-bfl 1	E70xx	◢ 3/8 ◣	◢ 9/16 ◣	10.38	2.08	LE2	29.40	39.02	75.4	OK	OK
		E70xx	◢ 3/8 ◣	◢ 9/16 ◣	10.38	2.08	LE2	29.88	39.02	76.6	OK	OK
C-bfl 1	SM1-tfl 1	E70xx	◢ 3/8 ◣	◢ 9/16 ◣	10.39	2.08	LE2	3.90	34.69	11.2	OK	OK
		E70xx	◢ 3/8 ◣	◢ 9/16 ◣	10.38	2.08	LE2	5.41	39.02	13.9	OK	OK
C-bfl 1	SM1-w 1	E70xx	◢ 3/8 ◣	◢ 9/16 ◣	16.00	2.00	LE2	26.29	35.03	75.1	OK	OK
		E70xx	◢ 3/8 ◣	◢ 9/16 ◣	16.00	2.00	LE2	26.29	35.03	75.1	OK	OK
C-bfl 1	SP1	E70xx	◢ 3/8 ◣	◢ 9/16 ◣	27.73	1.98	LE1	27.50	36.60	75.1	OK	OK
		E70xx	◢ 3/8 ◣	◢ 9/16 ◣	27.73	1.98	LE1	27.50	36.60	75.1	OK	OK
SM1-tfl 1	SP1	E70xx	◢ 3/8 ◣	◢ 9/16 ◣	34.19	2.01	LE1	18.91	37.71	50.1	OK	OK
		E70xx	◢ 3/8 ◣	◢ 9/16 ◣	34.19	2.01	LE1	18.96	37.70	50.3	OK	OK
SP1	M3-w 1	E70xx	◢ 7/16	◢ 5/8	24.74	0.49	LE1	5.21	6.89	75.7	OK	OK
SP1	M3-w 1	E70xx	◢ 7/16	◢ 5/8	24.74	0.49	LE1	5.21	6.89	75.7	OK	OK
SP1	M3-w 3	E70xx	◢ 7/16	◢ 5/8	24.77	0.50	LE2	5.23	6.90	75.9	OK	OK
SP1	M3-w 3	E70xx	◢ 7/16	◢ 5/8	24.77	0.50	LE2	5.23	6.90	75.9	OK	OK
M3-w 4	SP2	E70xx	◢ 3/8	◢ 1/2	23.91	0.50	LE1	2.35	7.02	33.5	OK	OK
M3-w 4	SP2	E70xx	◢ 3/8	◢ 1/2	23.91	0.50	LE2	2.58	6.92	37.3	OK	OK
M3-w 2	SP3	E70xx	◢ 3/8	◢ 1/2	23.91	0.50	LE2	2.58	6.92	37.3	OK	OK
M3-w 2	SP3	E70xx	◢ 3/8	◢ 1/2	23.91	0.50	LE1	2.34	7.03	33.3	OK	OK
M3-w 4	M3	E70xx	◢ 3/8	◢ 1/2	7.95	0.50	LE2	2.14	8.29	25.9	OK	OK
M3-w 2	M3	E70xx	◢ 3/8	◢ 1/2	7.95	0.50	LE2	2.14	8.29	25.9	OK	OK

Design data

Material	F_{exx} [ksi]
E70xx	70.0

Symbol explanation

t_w	Throat thickness of weld
w	Leg size of weld
L	Length of weld
L_c	Length of weld critical element
F_n	Force in weld critical element
ϕR_n	Weld resistance - AISC 360-22 – J2-4
Ut	Utilization
◢	Fillet weld
F_{exx}	Ultimate strength as rated by electrode classification number

Detailed result for C-bfl 1 / SM1-bfl 1

Weld resistance check (AISC 360-22 – J2-4)

$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} =$ 39.02 kip ≥ $F_n =$ 29.88 kip

Where:

$F_{nw} =$ 63.0 ksi – nominal stress of weld material:

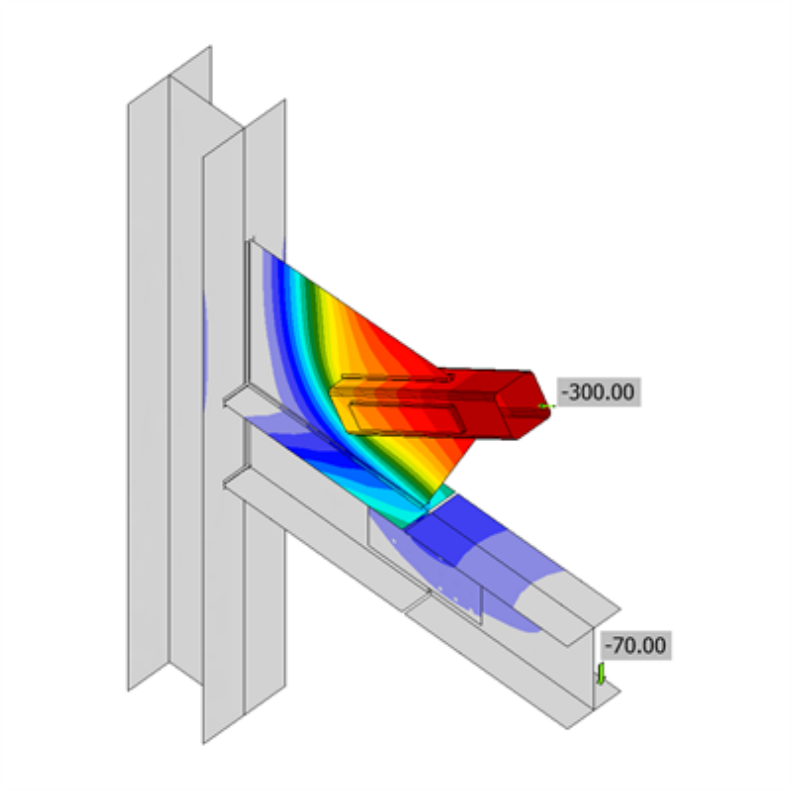
- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 70.0 ksi – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 90.0° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 0.83 in^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Buckling

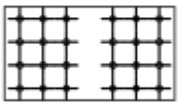
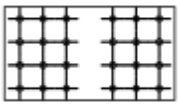
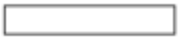
Loads	Shape	Factor [-]
LE1	1	40.14
	2	43.32
	3	54.42
	4	61.01
	5	69.29
	6	84.85
LE2	1	12.17
	2	19.58
	3	22.98
	4	23.75
	5	29.54
	6	35.95



First buckling mode shape, LE2

Bill of material

Manufacturing operations

Name	Plates [in]	Shape	Nr.	Welds [in]	Length [in]	Bolts	Nr.
SM1		CON1(W16X100)			43.25		
CUT1				Double fillet: a = 3/8	36.8		
CUT2							
SPL1	P7/8x22.0-12.0 (A572 Gr.50)		1			3/4 A325	24
	P1"x22.0-12.0 (A572 Gr.50)		1				
SP1	P1"x44.4-28.7 (A572 Gr.50)		1				
CUT3				Fillet: a = 7/16	99.4		
SP2	P1"1/4x24.0-4.0 (A992)		1	Fillet: a = 3/8	56.0		
SP3	P1"1/4x24.0-4.0 (A992)		1	Fillet: a = 3/8	56.0		

Welds

Type	Material	Throat thickness [in]	Leg size [in]	Length [in]
Double fillet	E70xx	3/8	9/16	98.8
Fillet	E70xx	7/16	5/8	99.4
Fillet	E70xx	3/8	1/2	112.0

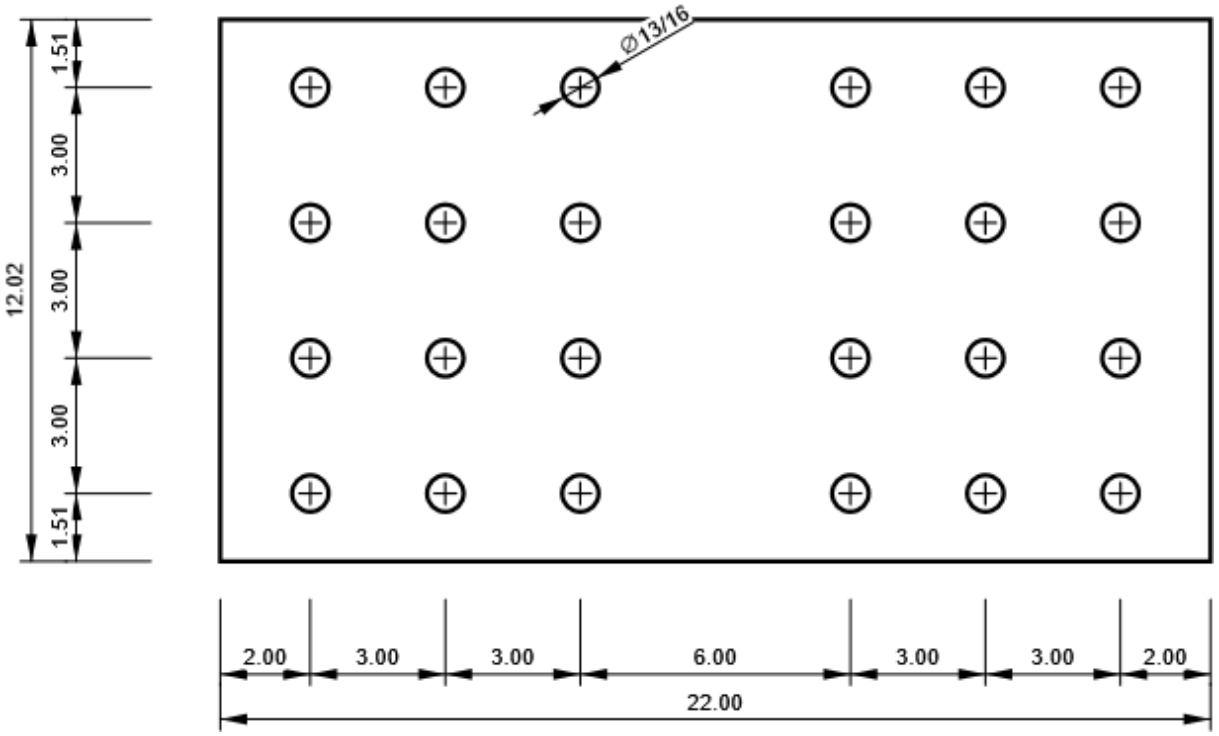
Bolts

Name	Grip length [in]	Count
3/4 A325	2.48	24

Drawing

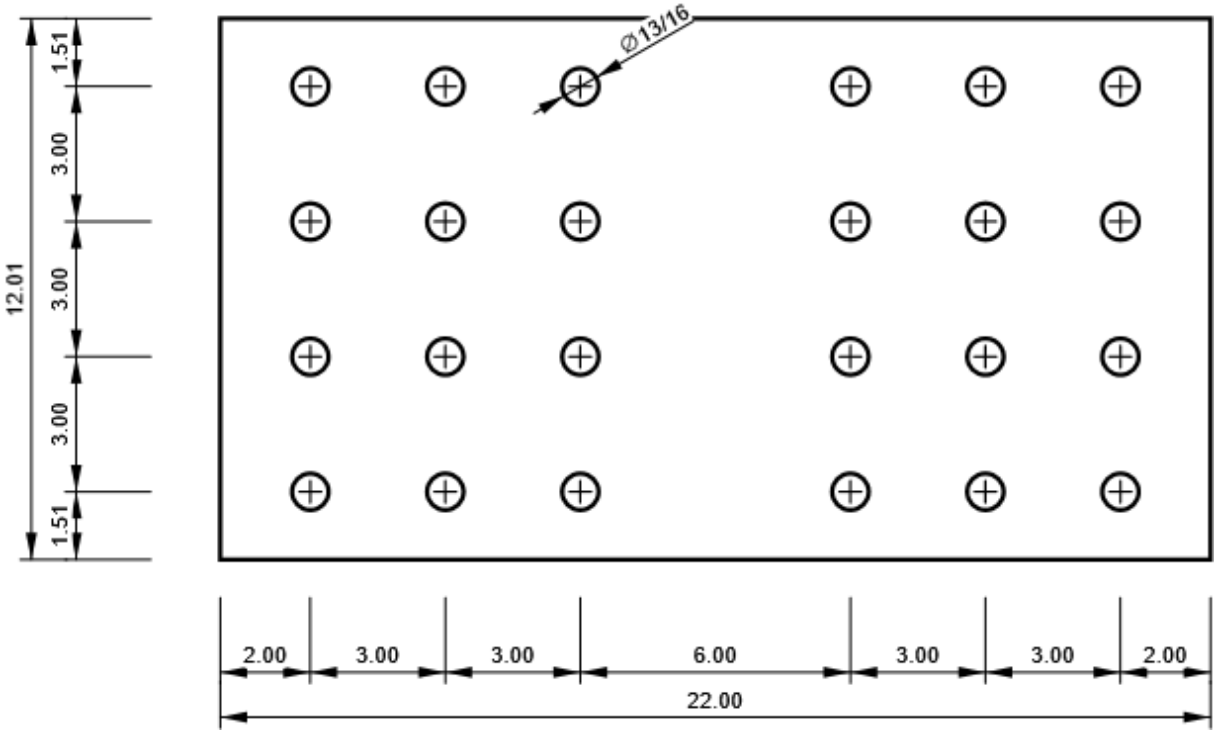
SPL1 - SPL1a

P7/8x12.02-22.00 (A572 Gr.50)



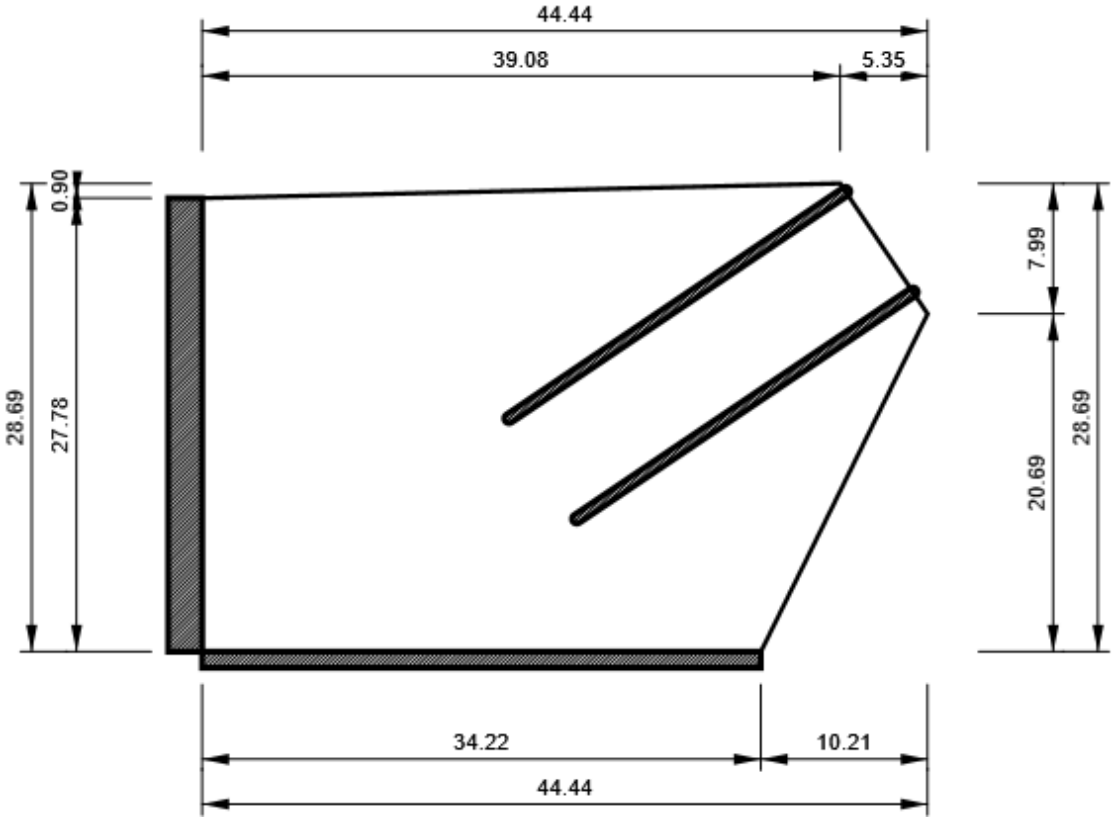
SPL1 - SPL1b

P1"x12.01-22.00 (A572 Gr.50)



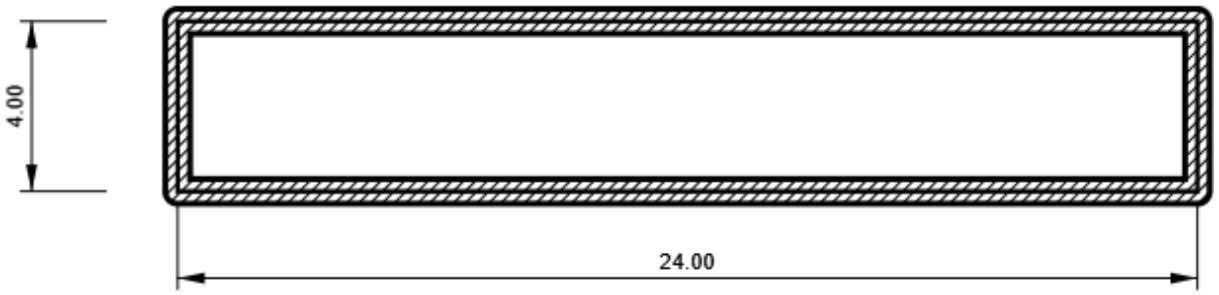
SP1

P1"x28.69-44.44 (A572 Gr.50)



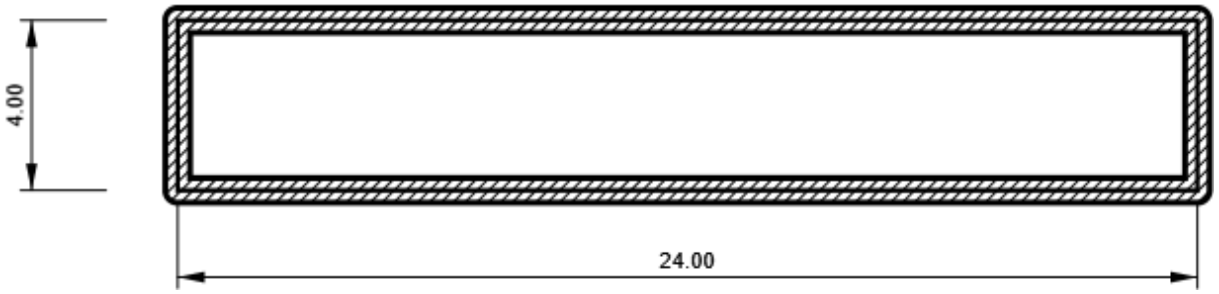
SP2

P1"1/4x4.00-24.00 (A992)

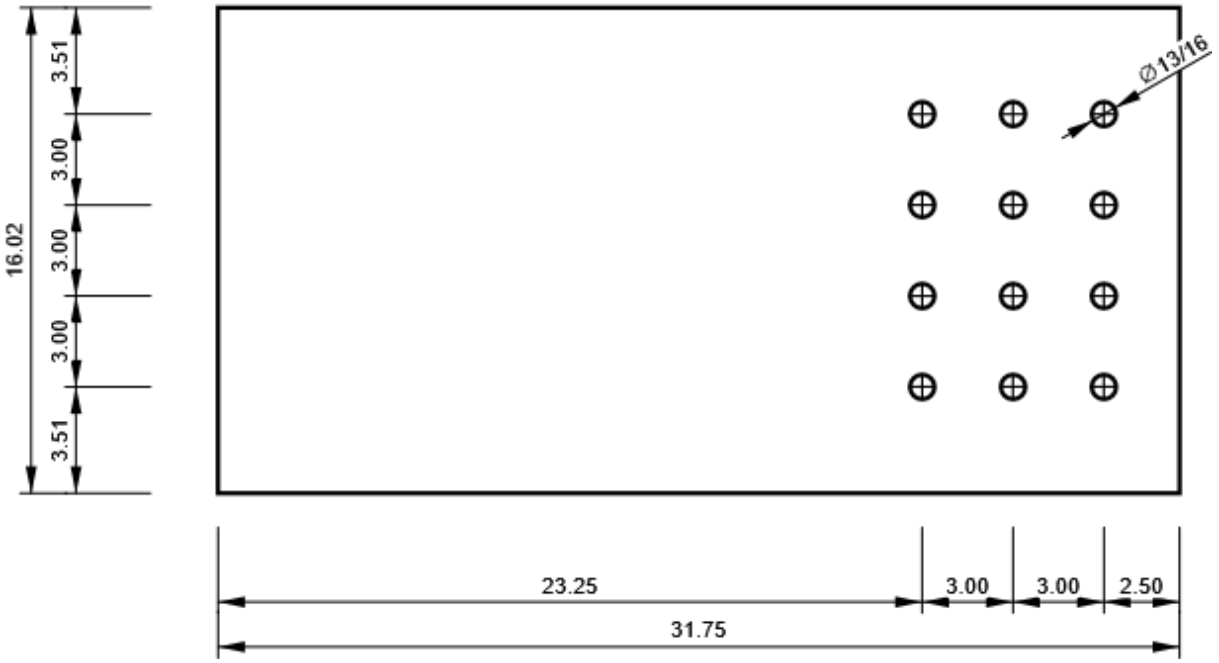


SP3

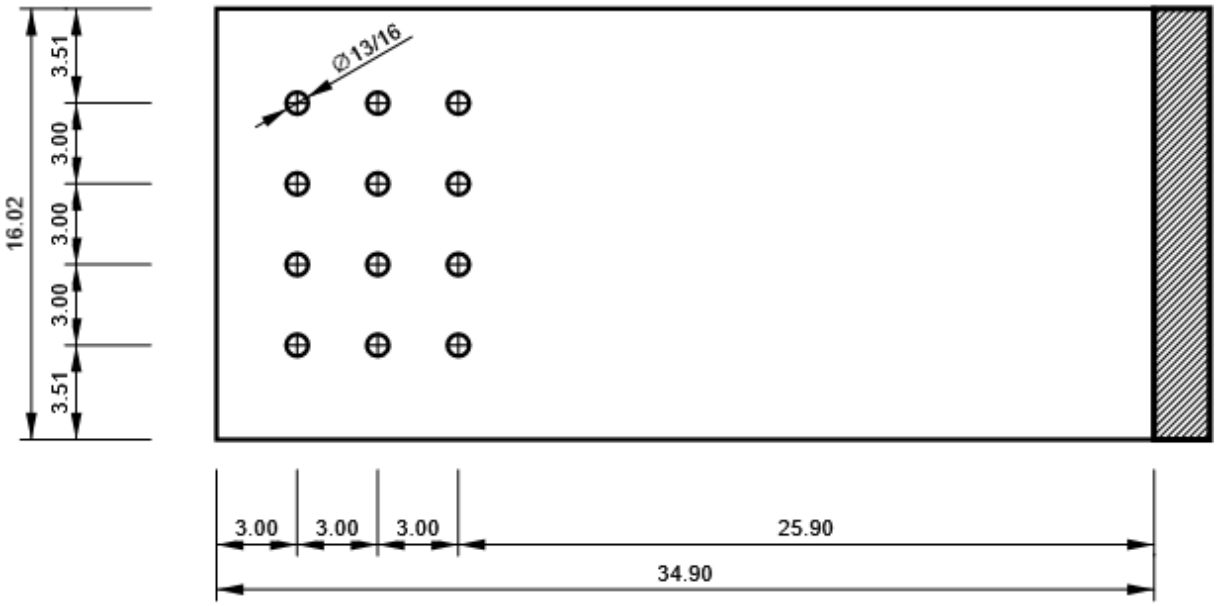
P1"1/4x4.00-24.00 (A992)



B, CON1(W16X100) - Web 1:



SM1, CON1(W16X100) - Web 1:



Code settings

Item	Value	Unit	Reference
Friction coefficient - concrete	0.40	-	ACI 349-01 – B.6.1.4
Friction coefficient in slip-resistance	0.30	-	AISC 360-22 – J3.9
Limit plastic strain	0.05	-	
Detailing	Yes		
Distance between bolts [d]	2.66	-	AISC 360-22 – J3.4
Distance between bolts and edge [d]	1.25	-	AISC 360-22 – J.3.5
Concrete breakout resistance check	Both		
Base metal capacity check at weld fusion face	No		AISC 360-22 – J2-2
Deformation at bolt hole at service load is design consideration	Yes		AISC 360-22 – J3.11
Cracked concrete	Yes		ACI 318-14 – 17
Local deformation check	No		
Local deformation limit	0.03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Analysis with large deformations for hollow section joints

Software info

Application	IDEA StatiCa Connection
Version	23.1.1.1138
Developed by	IDEA StatiCa