Verification example – Welded splice connection

Type of connection: Splice connection of plates

Unit system: Metric

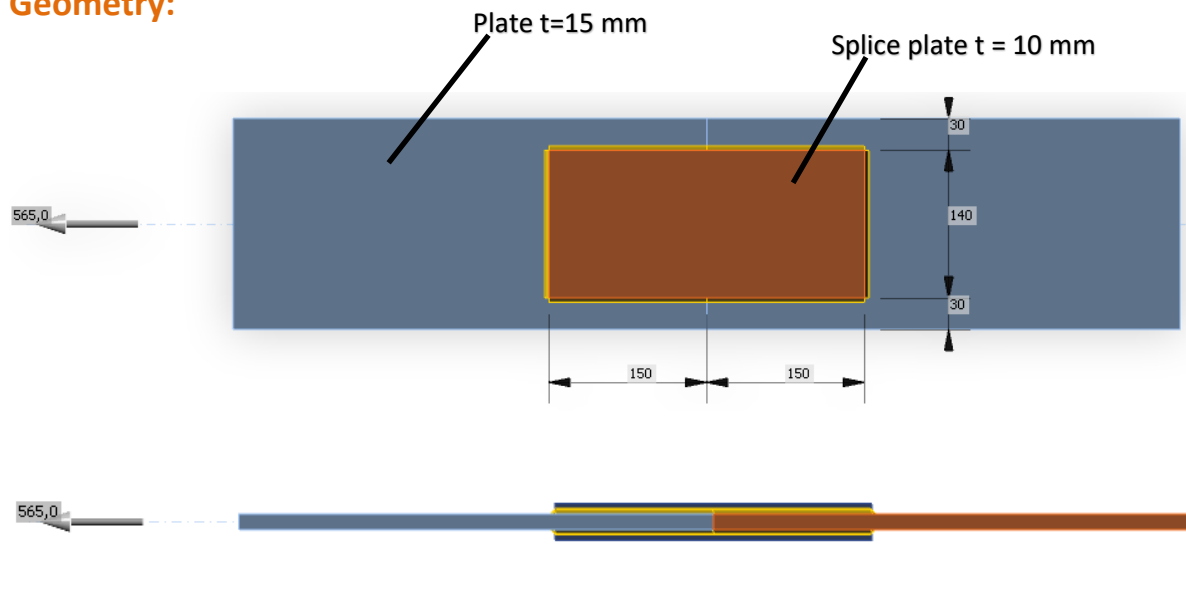Designed acc. to: CSA S14-16

Investigated: Welds, base material,

Plate Materials: Steel grade 350W,

Welds: Leg size = 4 mm, electrode E49XX

Geometry:

Applied forces:

N = 565 kN

V = 0 kN
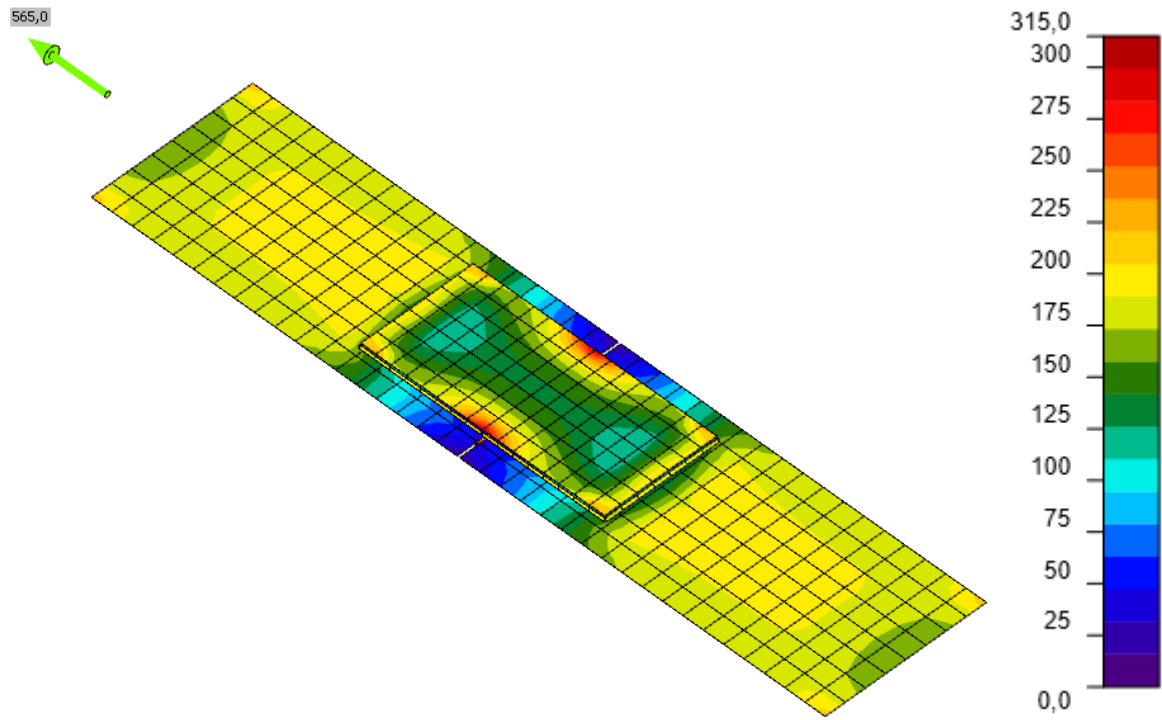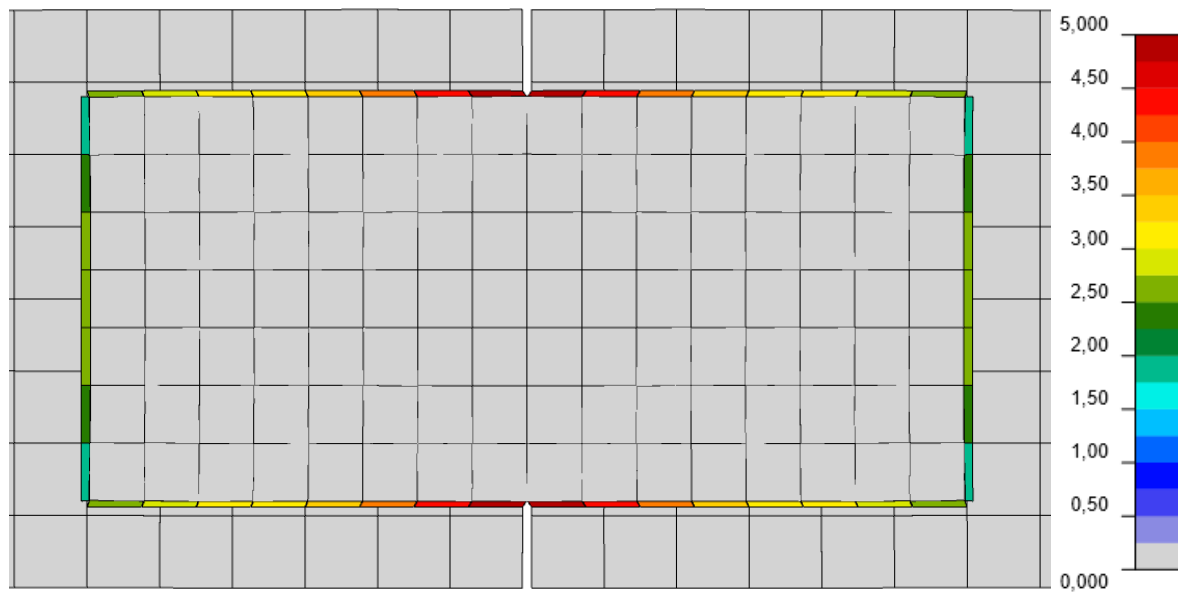
M = 0 kNm

Procedure:

Canadian code CSA S16 uses a strength reduction factor for multi-orientation fillet welds, M_w. This factor is determined automatically by finite element analysis in IDEA StatiCa Connection by plastic redistribution of forces in fillet welds.

IDEA StatiCa Connection

Von Mises stress [MPa]

Plastic strain [%]

Weld utilization – the first four welds are transverse, the others are longitudinal welds.

Check of welds for extreme load effect (Plastic redistribution)

		Status	Item	Edge	Th [mm]	Ls [mm]	L [mm]	Lc [mm]	Loads	Fw [kN]	Vr [kN]	Ut [%]
>	+	✓	B1-bfl 1	SPL1	◢2,8	◢4,0	139	20	LE1	16,3	18,6	87,9
	+	✓	B2-bfl 1	SPL1	◢2,8	◢4,0	139	20	LE1	16,3	18,6	87,9
	+	✓	B1-bfl 1	SPL3	◢2,8	◢4,0	139	20	LE1	16,3	18,6	87,9
	+	✓	B2-bfl 1	SPL3	◢2,8	◢4,0	139	20	LE1	16,3	18,6	87,9
	+	✓	B1-bfl 1	SPL1	◢2,8	◢4,0	150	19	LE1	11,6	11,7	99,8
	+	✓	B1-bfl 1	SPL1	◢2,8	◢4,0	150	19	LE1	11,6	11,7	99,8
	+	✓	B2-bfl 1	SPL1	◢2,8	◢4,0	150	19	LE1	11,6	11,7	99,8
	+	✓	B2-bfl 1	SPL1	◢2,8	◢4,0	150	19	LE1	11,6	11,7	99,8
	+	✓	B1-bfl 1	SPL3	◢2,8	◢4,0	150	19	LE1	11,6	11,7	99,8
	+	✓	B1-bfl 1	SPL3	◢2,8	◢4,0	150	19	LE1	11,6	11,7	99,8
	+	✓	B2-bfl 1	SPL3	◢2,8	◢4,0	150	19	LE1	11,6	11,7	99,8
	+	✓	B2-bfl 1	SPL3	◢2,8	◢4,0	150	19	LE1	11,6	11,7	99,8

Welded Connection

Material:
$$X_u := 490 \text{ MPa}$$
$$F_u := 450 \text{ MPa}$$
$$F_y := 350 \text{ MPa}$$

Resistance factor for welds: $\phi_w := 0.67$

Resistance factor for steel: $\phi := 0.9$

Geometrical parameters:
$$L_{wl} := 150 \text{ mm}$$
$$L_{wt} := 140 \text{ mm}$$
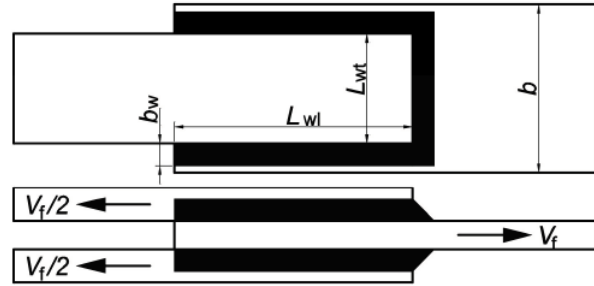$$b_w := 4 \text{ mm} \qquad t_p := 15 \text{ mm}$$
$$\theta_l := 0 \text{ °} \qquad t_s := 10 \text{ mm}$$
$$\theta_t := 90 \text{ °} \qquad b := L_{wt} + 60 \text{ mm} = 200 \text{ mm}$$

Longitudinal weld

Longitudinal weld area:
$$A_{wl} := 2 \cdot L_{wl} \cdot \frac{\sqrt{2}}{2} \cdot b_w = 849 \text{ mm}^2$$

Strength reduction factor for multi-orientation fillet welds:
$$M_w := \frac{0.85 + \dfrac{\theta_l}{600 \text{ °}}}{0.85 + \dfrac{\theta_t}{600 \text{ °}}} = 0.85$$

Lungitudinal weld:
$$V_{rlw} := 0.67 \cdot \phi_w \cdot A_{wl} \cdot X_u \cdot \left(1 + 0.5 \cdot \sin\left(\theta_l\right)^{1.5}\right) \cdot M_w = 158.6 \text{ kN}$$

Area of fusion face:
$$A_m := 2 \cdot L_{wl} \cdot b_w = 1200 \text{ mm}^2$$

Base metal:
$$V_{rlb} := 0.67 \cdot \phi_w \cdot A_m \cdot F_u = 242.4 \text{ kN}$$

Transverse weld

Transverse weld area:
$$A_{wt} := L_{wt} \cdot \frac{\sqrt{2}}{2} \cdot b_w = 396 \text{ mm}^2$$

Strength reduction factor for multi-orientation fillet welds:
$$M_w := \frac{0.85 + \dfrac{\theta_t}{600 \text{ °}}}{0.85 + \dfrac{\theta_t}{600 \text{ °}}} = 1$$

Transverse weld:
$$V_{rtw} := 0.67 \cdot \phi_w \cdot A_{wt} \cdot X_u \cdot \left(1 + 0.5 \cdot \sin\left(\theta_t\right)^{1.5}\right) \cdot M_w = 130.7 \text{ kN}$$

Area of fusion face:
$$A_m := L_{wt} \cdot b_w = 560 \text{ mm}^2$$

Base metal:
$$V_{rtb} := 0.67 \cdot \phi_w \cdot A_m \cdot F_u = 113.1 \text{ kN}$$

No base metal check:
$$V_r := 2 \cdot V_{rlw} + 2 \cdot V_{rtw} = 578.6 \text{ kN}$$

Base metal check:
$$V_r := 2 \cdot \left(\min\left(V_{rlw}, V_{rlb}\right) + \min\left(V_{rtw}, V_{rtb}\right)\right) = 543.5 \text{ kN}$$

Base metal yielding:

$$V_r := 2 \cdot 0.67 \cdot \phi_w \cdot A_m \cdot F_u = 226.2 \text{ kN}$$

$$A := min\left(2 \cdot L_{wt} \cdot t_s, b \cdot t_p\right) = 2800 \text{ mm}^2$$

$$V_r := \phi \cdot A \cdot F_y = 882 \text{ kN}$$

The resistance of the welded splice connection determined according to CSA – S16 is 579 kN considering matching electrodes and 544 kN considering base metal resistance at the fusion face. The decisive are the welds, yielding of steel members has higher resistance. The CISC steel handbook allows for the use of the Instantaneous centre of rotation procedure which also produces similar results in this scenario.

Comparison:

The results of both IDEA StatiCa Connection design and manual computation according to CSA 16-14 give nearly identical values: 565 kN in IDEA, 579 kN in manual computation (2% difference). If the base metal resistance at the fusion face is also taken into account, the resistances are 544 kN in both IDEA and manual calculation. The assessment in IDEA slightly depends on the stiffness (thickness) of connected plates.