

Verification example – Welded beam to column moment connection

Type of connection: Welded beam to column moment connection

Unit system: Metric

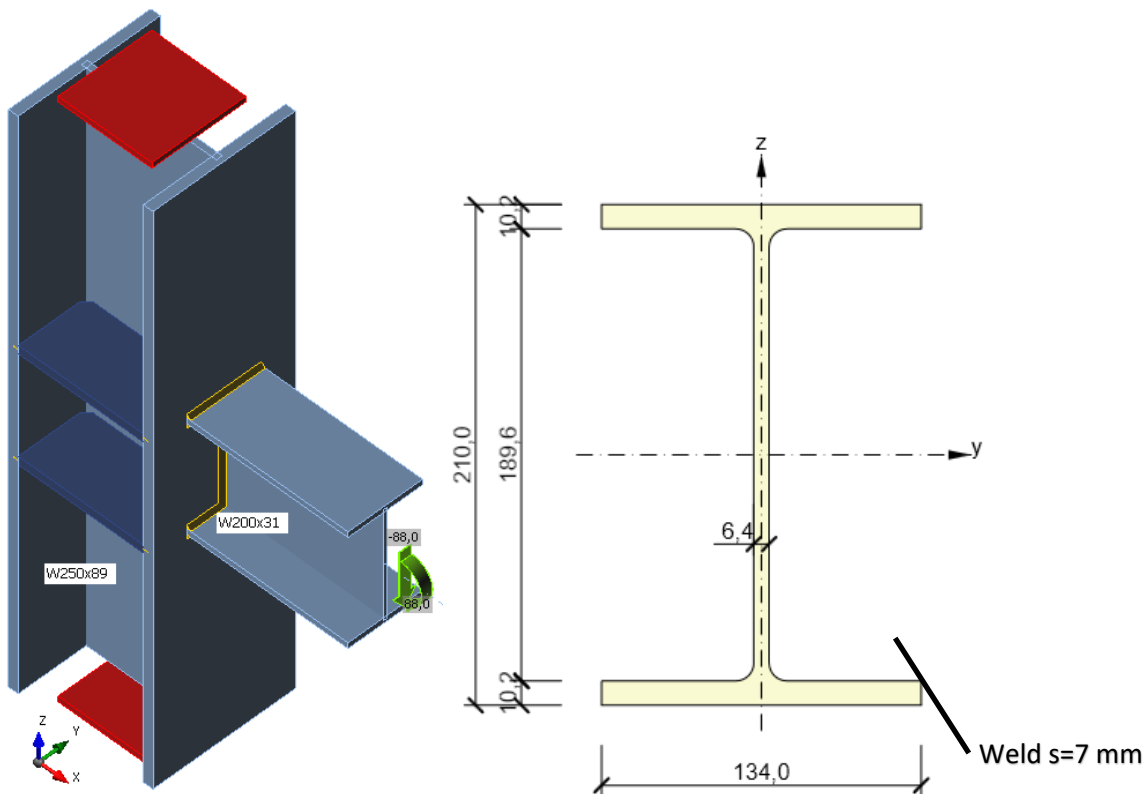
Designed acc. to: CSA S14-16

Investigated: Welds, base material,

Plate Materials: Steel grade 350W,

Welds: leg size $s = 7$ mm, electrode E70XX (equivalent of E49XX)

Geometry:



Applied forces:

$N = 0$ kN

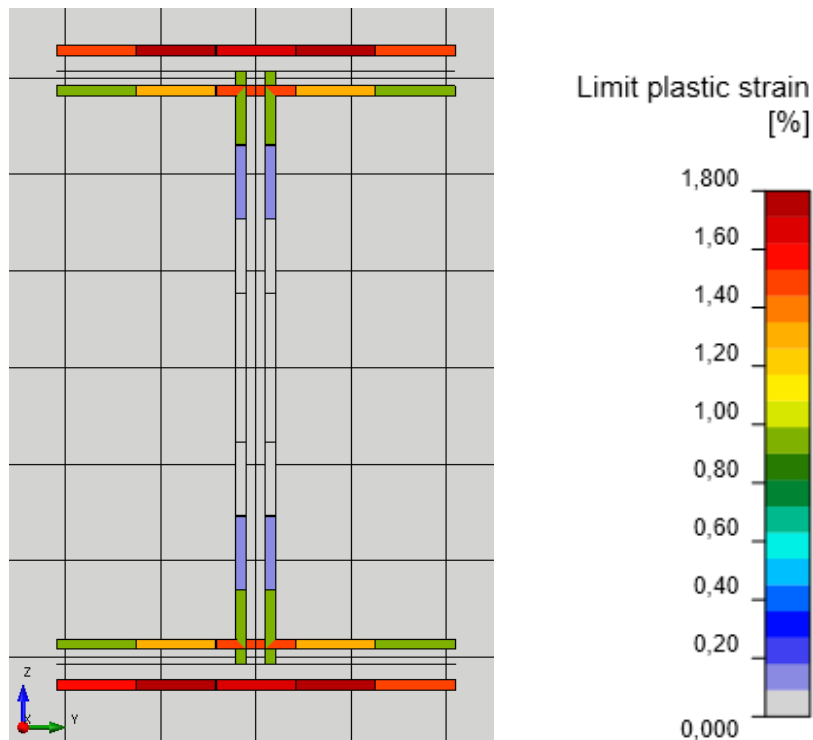
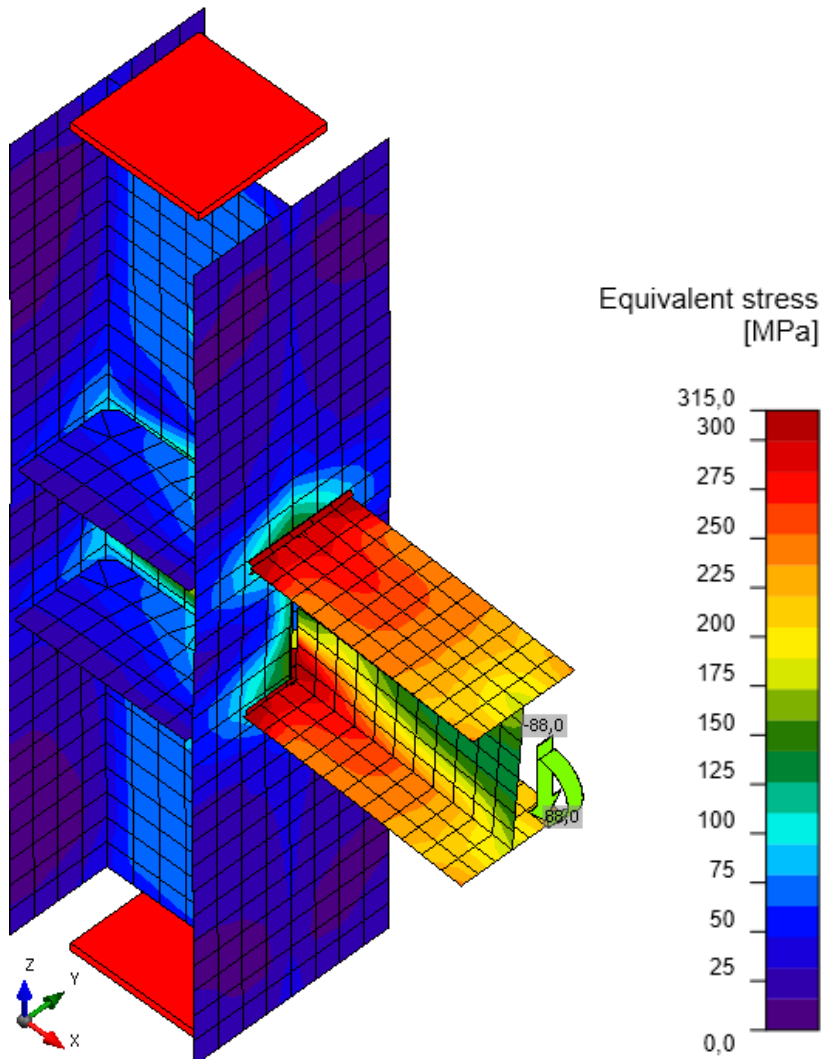
$V = 88$ kN

$M = 88$ kNm

Procedure:

In manual calculations, the fillet welds at flanges transfer bending moment and are loaded transverse to the weld. The shear force is assumed to be transferred by fillet welds at the web and these are loaded parallel to the force. IDEA StatiCa Connection solves all forces in interaction and the moment is transferred partly also by the weld at the web. The magnitude of shear force was chosen the same as the bending moment which corresponds to the uniformly loaded beam with the length of 6 m, which is fixed on both ends.

IDEA StatiCa Connection



Check of welds for extreme load effect (Plastic redistribution)

	Item	Edge	Th [mm]	Ls [mm]	L [mm]	Lc [mm]	Loads	Fw [kN]	Vr [kN]	Ut [%]	Status
>	⊕ W250x89-bfl 1	W200x31-bfl 1	4,9	7,0	133,5	26,7	LE1	32,5	37,7	86,2	✓
	⊕		4,9	7,0	133,5	26,7	LE1	37,5	37,7	99,4	✓
	⊕ W250x89-bfl 1	W200x31-tfl 1	4,9	7,0	133,5	26,7	LE1	37,5	37,7	99,4	✓
	⊕		4,9	7,0	133,5	26,7	LE1	32,5	37,7	86,2	✓
	⊕ W250x89-bfl 1	W200x31-w 1	4,9	7,0	199,4	24,9	LE1	30,0	35,2	85,1	✓
	⊕		4,9	7,0	199,4	24,9	LE1	30,0	35,2	85,1	✓

There is still a reserve for the shear force, although the shear force slightly reduces the bending moment resistance.

Manual assessment

IDEA StatiCa Connection

CISC Verification study

Welded Connection

Material:

$$X_u := 482.6 \text{ MPa}$$

$$F_u := 450 \text{ MPa}$$

$$F_y := 350 \text{ MPa}$$

Resistance factor for welds:

$$\phi_w := 0.67$$

Resistance factor for steel:

$$\phi := 0.9$$

Geometrical parameters:

Beam height:

$$h := 210 \text{ mm}$$

Beam width:

$$b := 134 \text{ mm}$$

Flange thickness:

$$t_f := 10.2 \text{ mm}$$

Web thickness:

$$t_w := 6.4 \text{ mm}$$

Length of the web weld:

$$L_w := h - 2 \cdot t_f = 189.6 \text{ mm}$$

Length of the flange weld:

$$L_f := b = 134 \text{ mm}$$

Weld leg size:

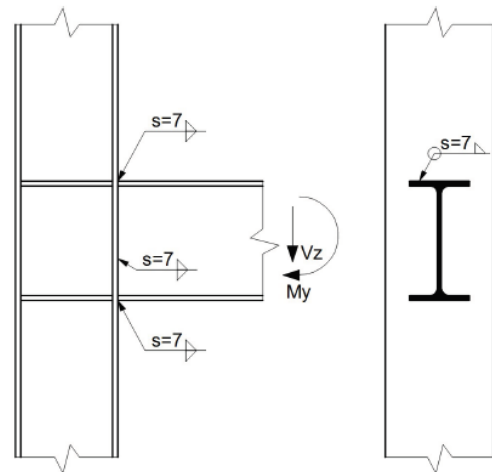
$$s := 7 \text{ mm}$$

Angle of axis of flange weld:

$$\theta_f := 90^\circ$$

Angle of axis of web weld:

$$\theta_w := 0^\circ$$



Web weld area:

$$A_{ww} := 2 \cdot L_w \cdot \frac{s}{\sqrt{2}} = 1877 \text{ mm}^2$$

Flange weld area:

$$A_{wf} := 2 \cdot L_f \cdot \frac{s}{\sqrt{2}} = 1327 \text{ mm}^2$$

Strength reduction factor for multi-orientation fillet welds:

$$M_w := 1$$

It is assumed that the web weld transfers shear force and flange welds transfer bending moment.

Web weld: $V_{rw} := 0.67 \cdot \phi_w \cdot A_{ww} \cdot X_u \cdot \left(1 + 0.5 \cdot \sin(\theta_w)^{1.5}\right) \cdot M_w = 407 \text{ kN}$

Base metal - web:

Area of fusion face: $A_m := (2 \cdot L_w) \cdot s = 2654 \text{ mm}^2$

Base metal resistance: $V_{rb} := 0.67 \cdot \phi_w \cdot A_m \cdot F_u = 536 \text{ kN}$

Web weld resistance: $V_r := \min(V_{rw}, V_{rb}) = 407 \text{ kN}$

Shear resistance: $V_{zR} := V_r = 407 \text{ kN}$

Flange weld: $V_{rw} := 0.67 \cdot \phi_w \cdot A_{wf} \cdot X_u \cdot \left(1 + 0.5 \cdot \sin(\theta_f)^{1.5}\right) \cdot M_w = 431 \text{ kN}$

Base metal - flange:

Area of fusion face: $A_m := (2 \cdot L_f) \cdot s = 1876 \text{ mm}^2$

Base metal resistance: $V_{rb} := 0.67 \cdot \phi_w \cdot A_m \cdot F_u = 379 \text{ kN}$

Flange weld resistance: $V_r := \min(V_{rw}, V_{rb}) = 379 \text{ kN}$

Moment lever arm: $r := h - t_f = 199.8 \text{ mm}$

Moment resistance: $M_{yR} := V_r \cdot r = 75.7 \text{ kN} \cdot \text{m}$

The assumption that the bending moment is transferred only via flange welds is very conservative. Using elastic section modulus of fillet welds and thus assigning part of the bending moment to the welds at the web, the moment resistance is 86 kNm. Another way to increase the moment resistance in hand calculation is neglecting the base metal resistance because a matching electrodes were used (moment resistance 98 kNm). IDEA always determines the base metal resistance due to possible use of a material edited by user.

Comparison:

The results of both IDEA StatiCa Connection design and manual computation according to CSA 16-14 gives similar values: moment resistance was determined as 75.7 kNm using manual computation with standard conservative assumptions and 86 kNm using elastic section modulus of the fillet welds. The moment resistance determined by IDEA software is 88 kNm, which overestimates the more precise manual approach by 2 %. The software allows yielding of welds.