5. SHS KT-joint (K)

The design of axial resistance of the SHS KT-joint is performed according to prEN 1993-1-8(2021), see Figure 5.1. The exact description and material properties of each member are given. The classification of hollow section truss-type joints as T, Y, X or K gap joints (which includes N-type joints) should be based on the method of force transfer in a joint but not on its physical appearance. Since there is no internal force in member 3, the KT joint considers as the K-joint.

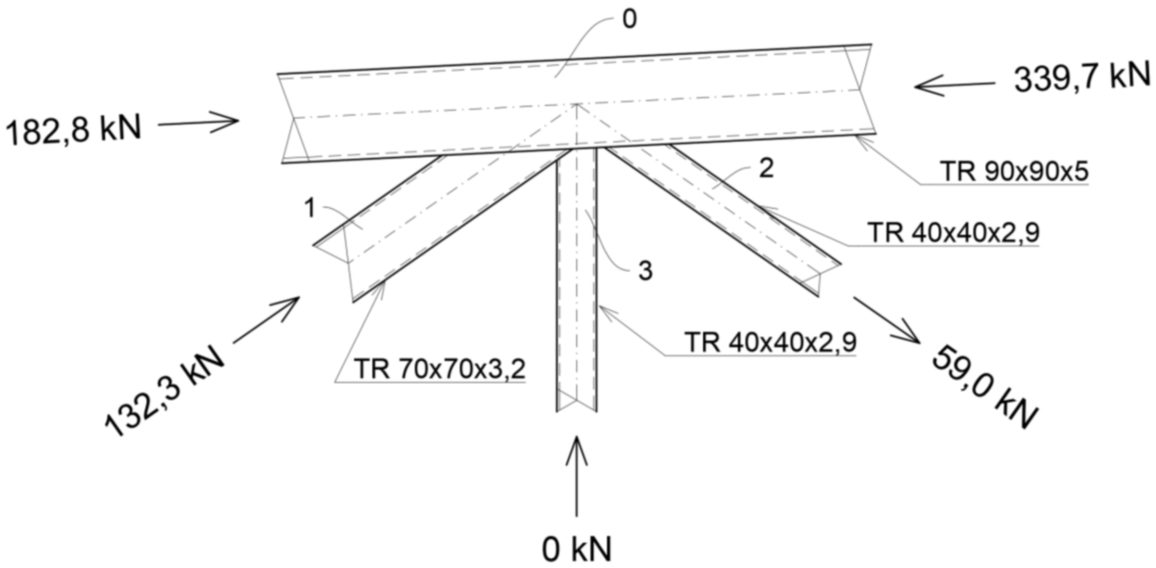

Figure 5.1: Joint geometry, internal forces

5.1. Symbols

b_i	overall out-of-plane width of RHS member i (i=0,1,2 or 3)
h_i	overall in-plane depth of the cross-section of member i (i=0,1,2 or 3)
e	eccentricity of a joint
$f_{y,i}$	yield strength of member i (i=0,1,2 or 3)
A_i	cross sectional area of member i (i=0,1,2 or 3)
$W_{el,i}$	elastic section modulus of member i (i=0,1,2 or 3)
θ_i	included angle between brace member i and the chord (i=1,2 or 3)
β	is the ratio of the mean diameter or width of the brace members, to that of the chord

γ	is the ratio of the chord width or diameter to twice its wall thickness
Q_f	chord stress factor
n	chord stress parameter
C_f	material factor
η	is the ratio of the brace member depth to the chord diameter or width
$M_{ip,i,Ed}$	design in-plane internal moment in member i (i=0,1,2 or 3)
$M_{op,i,Ed}$	design out-of-plane internal moment in member i (i = 0, 1, 2 or 3)
$N_{i,Ed}$	design internal axial force in member i (i=0,1,2 or 3);
$N_{i,Rd}$	design resistance of the joint, expressed in terms of the internal axial force in member i (i = 0, 1, 2 or 3)

5.2. Design forces

$N_{0,Ed} = -339\ 700\ N$

$M_{ip,0,Ed} = 0{,}0\ Nmm$

$M_{op,0,Ed} = 0{,}0\ Nmm$

$N_{1,Ed} = -132\ 300\ N$

$M_{ip,1,Ed} = 0{,}0\ Nmm$

$M_{op,1,Ed} = 0{,}0\ Nmm$

$N_{2,Ed} = 59\ 000\ N$

$M_{ip,2,Ed} = 0{,}0\ Nmm$

$M_{op,2,Ed} = 0{,}0\ Nmm$

$N_{3,Ed} = 0{,}0\ N$

$M_{ip,3,Ed} = 0{,}0\ Nmm$

$M_{op,3,Ed} = 0{,}0\ Nmm$

5.3. Material

$f_{y,0} = 355{,}0\ MPa$ $f_{y,1} = 355{,}0\ MPa$ $f_{y,2} = 355{,}0\ MPa$

5.4. Geometry of sections

$A_0 = 1\ 670\ mm^2$

$W_{el,0} = 44{,}4 * 10^3 mm^3$

5.5. Range of validity

$$0{,}1 + 0{,}01 * \frac{b_o}{t_0} = 0{,}1 + 0{,}01 * \frac{90{,}0}{5{,}0} = 0{,}28 \leq \frac{b_1}{b_0} = \frac{70{,}0}{90{,}0} = 0{,}77$$

$$0{,}1 + 0{,}01 * \frac{b_o}{t_0} = 0{,}1 + 0{,}01 * \frac{90{,}0}{5{,}0} = 0{,}28 \leq \frac{b_2}{b_0} = \frac{40{,}0}{90{,}0} = 0{,}44$$

$$0{,}1 + 0{,}01 * \frac{b_o}{t_0} = 0{,}1 + 0{,}01 * \frac{90{,}0}{5{,}0} = 0{,}28 \leq \frac{b_3}{b_0} = \frac{40{,}0}{90{,}0} = 0{,}44$$

$$0{,}25 \leq \frac{b_1}{b_0} = \frac{70{,}0}{90{,}0} = 0{,}77$$

$$0{,}25 \leq \frac{b_2}{b_0} = \frac{40{,}0}{90{,}0} = 0{,}44$$

$$0{,}25 \leq \frac{b_3}{b_0} = \frac{40{,}0}{90{,}0} = 0{,}44$$

$$0{,}5 \leq \frac{h_1}{b_1} = \frac{70{,}0}{70{,}0} = 1{,}00 \leq 2{,}0$$

$$0{,}5 \leq \frac{h_2}{b_2} = \frac{40{,}0}{40{,}0} = 1{,}00 \leq 2{,}0$$

$$0{,}5 \leq \frac{h_3}{b_3} = \frac{40{,}0}{40{,}0} = 1{,}00 \leq 2{,}0$$

$$\frac{b_o}{t_0} = \frac{90{,}0}{5{,}0} = 18{,}00 \leq 35$$

$$\frac{h_o}{t_0} = \frac{90{,}0}{5{,}0} = 18{,}00 \leq 35$$

$$\frac{b_1}{t_1} = \frac{70{,}0}{3{,}2} = 21{,}87 \leq 35$$

$$\frac{b_2}{t_2} = \frac{40{,}0}{2{,}9} = 13{,}79 \leq 35$$

$$\frac{b_3}{t_3} = \frac{40{,}0}{2{,}9} = 13{,}79 \leq 35$$

$$\frac{h_1}{t_1} = \frac{70{,}0}{3{,}2} = 21{,}87 \leq 35$$

$$\frac{h_2}{t_2} = \frac{40{,}0}{2{,}9} = 13{,}79 \leq 35$$

$$\frac{h_3}{t_3} = \frac{40{,}0}{2{,}9} = 13{,}79 \leq 35$$

$t_1 = 3{,}2\ \text{mm} \leq t_0 = 5{,}0\ \text{mm}$

$t_2 = 2{,}9\ \text{mm} \leq t_0 = 5{,}0\ \text{mm}$

$t_3 = 2{,}9\ \text{mm} \leq t_0 = 5{,}0\ \text{mm}$

$\theta_1 = 32{,}1° \geq 30°$

$\theta_2 = 37{,}9° \geq 30°$

$\theta_3 = 87{,}1° \geq 30°$

$$0{,}5 * (1 - \beta) = 0{,}5 * (1 - 0{,}61) = 0{,}20 \leq \frac{g}{b_0} = \frac{31{,}2}{90{,}0} = 0{,}34 \leq 1{,}5 * (1 - \beta) = 1{,}5 * (1 - 0{,}61) = 0{,}58$$

$$g = 31{,}2\ mm \geq t_1 + t_2 = 3{,}2 + 2{,}9 = 6{,}1\ mm$$

5.6. Geometric ratios

$$\gamma = \frac{b_0}{2 * t_0} = \frac{90{,}0}{2 * 5{,}0} = 9{,}00$$

$$\beta = \frac{b_1 + b_2 + h_1 + h_2}{4 * b_0} = \frac{70{,}0 + 40{,}0 + 70{,}0 + 40{,}0}{4 * 90{,}0} = 0{,}61$$

5.7. Design of axial resistance of the joint

$$n = \frac{N_{o,Ed}}{A_0 * f_{y,o}} + \frac{M_{ip,0,Ed}}{W_{el,0} * f_{y,o}} + \frac{M_{op,0,Ed}}{W_{el,0} * f_{y,o}} = \frac{-339\ 700}{1\ 670 * 355{,}00} + \frac{0{,}0}{44{,}4 * 10^3 * 355{,}00} + \frac{0{,}0}{44{,}4 * 10^3 * 355{,}00} = -0{,}57$$

C_1	
$\mathbf{n} < 0$ (compression)	$n \geq 0$ (tension)
$\mathbf{C_1 = 0,50 - 0,50 * \beta}$ **ale** $\mathbf{C_1 = \geq 0,10}$	$C_1 = 0{,}10$

Tab. 5.1 – Exponent for a chord stress factor

$$C_1 = 0{,}50 - 0{,}50 * \beta = 0{,}50 - 0{,}50 * 0{,}61 = 0{,}19 \geq 0{,}10$$

$$Q_f = (1 - |n|)^{C_1} = (1 - |-0{,}57|)^{0{,}19} = 0{,}85$$

C_f	
$\mathbf{f_y \leq 355\ MPa}$	$C_f = 1{,}0$
$\mathbf{355\ MPa < f_y \leq 460\ MPa}$	$C_f = 0{,}9$
$\mathbf{460\ MPa < f_y \leq 700\ MPa}$	$C_f = 0{,}8$

Tab. 5.2 – Material factors to resistance

$C_f = 1{,}0$

$\beta = 0{,}61 \leq 0{,}85$

$$0{,}6 \leq \frac{b_1 + b_2}{2 * b_1} = \frac{70{,}0 + 40{,}0}{2 * 70{,}0} = 0{,}79 \leq 1{,}3$$

5.7.1. Chord face failure

$$N_{1,Rd} = \frac{8{,}9 * C_f * \beta * \gamma^{0{,}5} * \frac{f_{yo} * t_0^2}{\sin\theta_1} * Q_f}{\gamma_{M5}} = \frac{8{,}9 * 1{,}0 * 0{,}61 * 9{,}0^{0{,}5} * \frac{355{,}0 * 5{,}0^2}{\sin 32{,}1} * 0{,}85}{1{,}25}$$

$$= \frac{231\ 210}{1{,}25} = 184\ 968\ N$$

$$N_{2,Rd} = \frac{8{,}9 * C_f * \beta * \gamma^{0{,}5} * \frac{f_{yo} * t_0^2}{\sin\theta_2} * Q_f}{\gamma_{M5}} = \frac{8{,}9 * 1{,}0 * 0{,}61 * 9{,}0^{0{,}5} * \frac{355{,}0 * 5{,}0^2}{\sin 37{,}9} * 0{,}85}{1{,}25}$$

$$= \frac{200\ 013}{1{,}25} = 160\ 010\ N$$

5.8. Design check

$$\frac{N_{1,Ed}}{N_{1,Rd}} = \frac{132\ 300}{184\ 968} = 0{,}72 \leq 1{,}0$$

$$\frac{N_{2,Ed}}{N_{2,Rd}} = \frac{59\ 000}{160\ 010} = 0{,}37 \leq 1{,}0$$

It is satisfied.