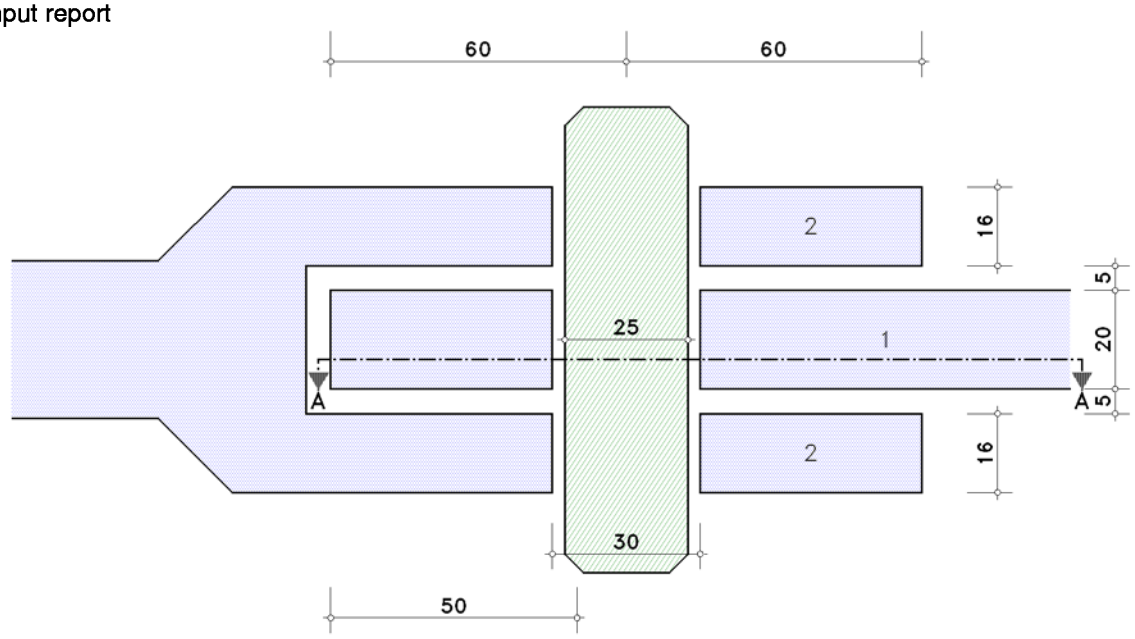
4H-EC3BV version: 1/2012-4k

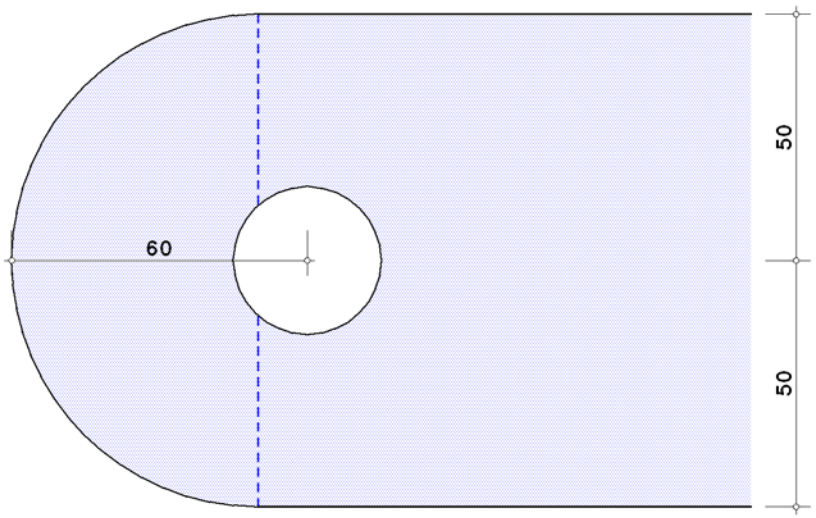
1. Connections made with pins

EC 3-1-8 (04.25), NA: Deutschland

1.1. input report



section A-A



connection device

pin: material of pin: S235J2 + C450
diameter of the pin d = 25.0 mm
diameter of the pin hole d_0 = 30.0 mm

connection plates

pin ended member 1 with thickness t_1 = 20.0 mm
pin ended member 2 with thickness t_2 = 16.0 mm
steel grade S235
Bending: clearance between the pin ended member Δt = 5.0 mm
geometry: distance of pin axis to the tensional edge e_1 = 60.0 mm
geometry: distance of pin axis to the lateral edge e_2 = 50.0 mm

verifications

design value of the applied tensile force in the plate per pin F_{Ed} = 85.0 kN
geometrical requirements for pin ended members with type A: given thickness and hole diameter

partial safety factors for material

resistance of cross-sections γ_{M0} = 1.00
resistance of bolts, welds, plates in bearing γ_{M2} = 1.25
resistance of pins in SLS $\gamma_{M6,ser}$ = 1.00

1.2. resistance

geometrical requirements

pin ended member 1

type A: given $t = t_1 = 20.0$ mm, $d_0 = 30.0$ mm, $F_{Ed} = 85.00$ kN

minimum edge distance in direction of load transfer $a_{min} = (F_{Ed} \cdot \gamma_{M0})/(2 \cdot t \cdot f_y) + 2/3 \cdot d_0 = 29.0$ mm

$a = e_1 - 0.5 \cdot d_0 = 45.0$ mm $>$ $a_{min} = 29.0$ mm ok

minimum edge distance across to direction of load transfer $c_{min} = (F_{Ed} \cdot \gamma_{M0})/(2 \cdot t \cdot f_y) + d_0/3 = 19.0$ mm

$c = e_2 - 0.5 \cdot d_0 = 35.0$ mm $>$ $c_{min} = 19.0$ mm ok

pin ended member 2

type A: given $t = t_2 = 16.0$ mm, $d_0 = 30.0$ mm, $F_{Ed}/2 = 42.5$ kN

minimum edge distance in direction of load transfer $a_{min} = (F_{Ed} \cdot \gamma_{M0})/(2 \cdot t \cdot f_y) + 2/3 \cdot d_0 = 25.7$ mm

$a = e_1 - 0.5 \cdot d_0 = 45.0$ mm $>$ $a_{min} = 25.7$ mm ok

minimum edge distance across to direction of load transfer $c_{min} = (F_{Ed} \cdot \gamma_{M0})/(2 \cdot t \cdot f_y) + d_0/3 = 15.7$ mm

$c = e_2 - 0.5 \cdot d_0 = 35.0$ mm $>$ $c_{min} = 15.7$ mm ok

1: symmetrical situation - maximum internal moment

shear

shear force: $F_{v,Ed} = 0$

shear force: $F_{v,Ed} = 0$

bearing resistance

pin ended member 1 and pins

shear force: $F_{b,Ed} = F_{Ed} = 85.00$ kN

bearing resistance: $F_{b,Rd} = (1.5 \cdot f_{y,min} \cdot d \cdot t) / \gamma_{M0} = 176.25$ kN, $f_{y,min} = 235.0$ N/mm², $t = 20.0$ mm

$F_{b,Ed} = 85.0$ kN $<$ $F_{b,Rd} = 176.25$ kN $\Rightarrow$ $U = 0.482 < 1$ ok

pin ended member 2 and pins

shear force: $F_{b,Ed} = 0.609 \cdot F_{Ed} = 51.74$ kN

bearing resistance: $F_{b,Rd} = (1.5 \cdot f_{y,min} \cdot d \cdot t) / \gamma_{M0} = 141.00$ kN, $f_{y,min} = 235.0$ N/mm², $t = 16.0$ mm

$F_{b,Ed} = 51.7$ kN $<$ $F_{b,Rd} = 141.00$ kN $\Rightarrow$ $U = 0.367 < 1$ ok

bending

internal moment: $M_{Ed} = F_{Ed} \cdot (t_1 + 4 \cdot \Delta t + 2 \cdot t_2)/8 = 0.77$ kNm, $t_1 = 20.0$ mm, $t_2 = 16.0$ mm, $\Delta t = 5.0$ mm

section modulus of the pin: $W_{el} = \pi \cdot d^3/32 = 1.53$ cm³

bending resistance: $M_{Rd} = (1.5 \cdot f_{yp} \cdot W_{el}) / \gamma_{M0} = 0.805$ kNm, $f_{yp} = 350.0$ N/mm²

$M_{Ed} = 0.77$ kNm $<$ $M_{Rd} = 0.805$ kNm $\Rightarrow$ $U = 0.950 < 1$ ok

tension

$F_{t,Rd} = 0$ $\Rightarrow$ no verification !!

2: symmetrical situation - maximum shear force and associated internal moment

shear

shear force: $F_{v,Ed} = F_{Ed}/2 = 42.50$ kN

cross-sectional area of the pin: $A = \pi \cdot d^2/4 = 4.91$ cm²

shear resistance per shear plane: $F_{v,Rd} = (0.6 \cdot f_{up} \cdot A) / \gamma_{M2} = 106.03$ kN, $f_{up} = 450.0$ N/mm²

$F_{v,Ed} = 21.3$ kN $<$ $F_{v,Rd} = 106.03$ kN $\Rightarrow$ $U = 0.200 < 1$ ok

bearing resistance

pin ended member 1 and pins

shear force: $F_{b,Ed} = F_{Ed} = 85.00$ kN

bearing resistance: $F_{b,Rd} = (1.5 \cdot f_{y,min} \cdot d \cdot t) / \gamma_{M0} = 176.25$ kN, $f_{y,min} = 235.0$ N/mm², $t = 20.0$ mm

$F_{b,Ed} = 85.0$ kN $<$ $F_{b,Rd} = 176.25$ kN $\Rightarrow$ $U = 0.482 < 1$ ok

pin ended member 2 and pins

shear force: $F_{b,Ed} = 0.609 \cdot F_{Ed} = 51.74$ kN

bearing resistance: $F_{b,Rd} = (1.5 \cdot f_{y,min} \cdot d \cdot t) / \gamma_{M0} = 141.00$ kN, $f_{y,min} = 235.0$ N/mm², $t = 16.0$ mm

$F_{b,Ed} = 51.7$ kN $<$ $F_{b,Rd} = 141.00$ kN $\Rightarrow$ $U = 0.367 < 1$ ok

bending

internal moment: $M_{Ed} = F_{Ed} \cdot 2 \cdot \Delta t + t_2)/4 = 0.55$ kNm, $t_2 = 16.0$ mm, $\Delta t = 5.0$ mm

section modulus of the pin: $W_{el} = \pi \cdot d^3/32 = 1.53$ cm³

bending resistance: $M_{Rd} = (1.5 \cdot f_{yp} \cdot W_{el}) / \gamma_{M0} = 0.805$ kNm, $f_{yp} = 350.0$ N/mm²

$M_{Ed} = 0.55$ kNm $<$ $M_{Rd} = 0.805$ kNm $\Rightarrow$ $U = 0.686 < 1$ ok

tension

$F_{t,Rd} = 0$ $\Rightarrow$ no verification !!

combination of shear and bending

$(F_{v,Ed}/F_{v,Rd})^2 + (M_{Ed}/M_{Rd})^2 = 0.511 < 1$ ok

3: asymmetrical situation - maximum shear force and associated internal moment

shear

shear force: $F_{v,Ed} = \alpha F_{Ed} = 0.00$ kN, $\alpha = 0.609$

cross-sectional area of the pin: $A = \pi \cdot d^2/4 = 4.91$ cm²

shear resistance per shear plane: $F_{v,Rd} = (0.6 \cdot f_{up} \cdot A) / \gamma_{M2} = 106.03$ kN, $f_{up} = 450.0$ N/mm²

$F_{v,Ed} = 25.9$ kN $<$ $F_{v,Rd} = 106.03$ kN $\Rightarrow$ $U = 0.244 < 1$ ok

bearing resistance

pin ended member 1 and pins

shear force: $F_{b,Ed} = F_{Ed} = 85.00$ kN

bearing resistance: $F_{b,Rd} = (1.5 \cdot f_{y,min} \cdot d \cdot t) / \gamma_{M0} = 176.25$ kN, $f_{y,min} = 235.0$ N/mm², $t = 20.0$ mm

$F_{b,Ed} = 85.0$ kN $<$ $F_{b,Rd} = 176.25$ kN $\Rightarrow$ $U = 0.482 < 1$ ok

pin ended member 2 and pins

shear force: $F_{b,Ed} = 0.609 \cdot F_{Ed} = 51.74$ kN

bearing resistance: $F_{b,Rd} = (1.5 \cdot f_{y,min} \cdot d \cdot t) / \gamma_{M0} = 141.00$ kN, $f_{y,min} = 235.0$ N/mm², $t = 16.0$ mm
$F_{b,Ed} = 51.7$ kN $<$ $F_{b,Rd} = 141.00$ kN $\Rightarrow$ $U = 0.367 < 1$ ok

bending

internal moment: $M_{Ed} = \alpha F_{Ed} \cdot t_2/2 = 0.41$ kNm, $\alpha = 0.609$, $t_2 = 16.0$ mm
section modulus of the pin: $W_{el} = \pi \cdot d^3/32 = 1.53$ cm³
bending resistance: $M_{Rd} = (1.5 \cdot f_{yp} \cdot W_{el}) / \gamma_{M0} = 0.805$ kNm, $f_{yp} = 350.0$ N/mm²
$M_{Ed} = 0.41$ kNm $<$ $M_{Rd} = 0.805$ kNm $\Rightarrow$ $U = 0.514 < 1$ ok

tension

$F_{t,Rd} = 0$ $\Rightarrow$ no verification !!

combination of shear and bending

$(F_{v,Ed}/F_{v,Rd})^2 + (M_{Ed}/M_{Rd})^2 = 0.324 < 1$ ok

4: asymmetrical situation - high shear force and associated high internal moment

shear

shear force: $F_{v,Ed} = (1-\alpha) \cdot F_{Ed} = 33.26$ kN, $\alpha = 0.609$
cross-sectional area of the pin: $A = \pi \cdot d^2/4 = 4.91$ cm²
shear resistance per shear plane: $F_{v,Rd} = (0.6 \cdot f_{up} \cdot A) / \gamma_{M2} = 106.03$ kN, $f_{up} = 450.0$ N/mm²
$F_{v,Ed} = 16.6$ kN $<$ $F_{v,Rd} = 106.03$ kN $\Rightarrow$ $U = 0.157 < 1$ ok

bearing resistance

pin ended member 1 and pins

shear force: $F_{b,Ed} = F_{Ed} = 85.00$ kN
bearing resistance: $F_{b,Rd} = (1.5 \cdot f_{y,min} \cdot d \cdot t) / \gamma_{M0} = 176.25$ kN, $f_{y,min} = 235.0$ N/mm², $t = 20.0$ mm
$F_{b,Ed} = 85.0$ kN $<$ $F_{b,Rd} = 176.25$ kN $\Rightarrow$ $U = 0.482 < 1$ ok

pin ended member 2 and pins

shear force: $F_{b,Ed} = 0.609 \cdot F_{Ed} = 51.74$ kN
bearing resistance: $F_{b,Rd} = (1.5 \cdot f_{y,min} \cdot d \cdot t) / \gamma_{M0} = 141.00$ kN, $f_{y,min} = 235.0$ N/mm², $t = 16.0$ mm
$F_{b,Ed} = 51.7$ kN $<$ $F_{b,Rd} = 141.00$ kN $\Rightarrow$ $U = 0.367 < 1$ ok

bending

internal moment: $M_{Ed} = (1-\alpha) \cdot F_{Ed} \cdot (t_2+4 \cdot \Delta t)/2 = 0.60$ kNm, $\alpha = 0.609$, $t_2 = 16.0$ mm
section modulus of the pin: $W_{el} = \pi \cdot d^3/32 = 1.53$ cm³
bending resistance: $M_{Rd} = (1.5 \cdot f_{yp} \cdot W_{el}) / \gamma_{M0} = 0.805$ kNm, $f_{yp} = 350.0$ N/mm²
$M_{Ed} = 0.60$ kNm $<$ $M_{Rd} = 0.805$ kNm $\Rightarrow$ $U = 0.743 < 1$ ok

tension

$F_{t,Rd} = 0$ $\Rightarrow$ no verification !!

combination of shear and bending

$(F_{v,Ed}/F_{v,Rd})^2 + (M_{Ed}/M_{Rd})^2 = 0.577 < 1$ ok

maximum utilization $U_{max} = 0.950 < 1$ ok

verification succeeded

2. Regulations

EN 1990, Eurocode 0: Grundlagen der Tragwerksplanung;
Deutsche Fassung EN 1990:2002 + A1:2005 + A1:2005/AC:2010, Ausgabe Dezember 2010
EN 1990/NA, Nationaler Anhang zur EN 1990, Ausgabe Dezember 2010

EN 1993-1-1, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau;
Deutsche Fassung EN 1993-1-1:2022, Ausgabe April 2025
EN 1993-1-1/A1, Ergänzungen zur EN 1993-1-1, Ausgabe Juli 2014
EN 1993-1-1/NA, Nationaler Anhang zur EN 1993-1-1, Ausgabe Oktober 2022

EN 1993-1-8, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-8: Bemessung von Anschlüssen;
Deutsche Fassung EN 1993-1-8:2024, Ausgabe April 2025
EN 1993-1-8/NA, Nationaler Anhang zur EN 1993-1-8, Ausgabe November 2020