VALLOUREC & MANNESMANN TUBES

Design-support for MSH sections

according to Eurocode 3,
DIN EN 1993-1-1: 2005
and
DIN EN 1993-1-8: 2005

Design-Support for MSH sections according to Eurocode 3, DIN EN 1993-1-1: 2005 and DIN EN 1993-1-8: 2005

in cooperation with
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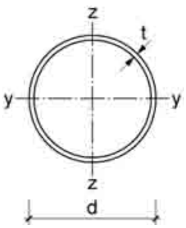
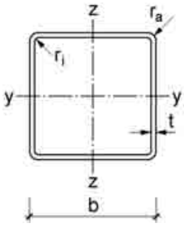
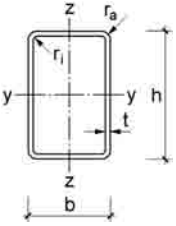
VALLOUREC & MANNESMANN TUBES is world market leader in the manufacture of seamless hot rolled steel tubes for all applications. The company operates 11 state-of-the-art pipe mills worldwide, eight located in Europe (four plants at three locations in Germany and four plants in France), two at a facility in Brazil and one in the USA. With an annual output of up to three million tonnes the world's largest and most comprehensive range of seamless steel tubes is supplied.

Hot rolled circular, square and rectangular **M**annesmann **S**tructural **H**ollow Sections of VALLOUREC & MANNESMANN TUBES have been used successfully for several decades. Modern steel architecture, with its elegant and transparent forms, would be practically impossible to create without them.

1 Descriptions and basic informations

Table 1 Descriptions and available dimensions

	circular (CHS)	square (SHS)	rectangular (RHS)
Cross section			
Outer measurement d, b or h	21.3 mm to 711 mm	40 x 40 mm to 400 x 400 mm	50 x 30 mm to 500 x 300 mm
Wall thickness t	2.3 mm to 100 mm	maximum 20 mm	
Available lengths	up to 16 m; standard up to 12 m		

This brochure for the design only covers **hot-rolled** MSH sections (according to DIN EN 10210).
Due to production differences they provide more favourable characteristics than cold formed profiles:

- higher load-carrying capacity for columns and members in compression
- larger cross section areas as a result of smaller corner radiuses
- substantially better suitability for welding
- in comparison to cold formed hollow profiles according to DIN EN 10219 there are no restrictions for the ability of welding (DIN EN 1993-1-8:2005)

Table 2 Materials: Yield strength f_y, tensile strength f_u, impact energy KV and carbon equivalent CEV

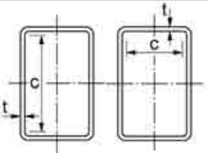
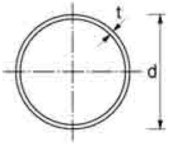
	Steel designation DIN EN 10 027 / EN 10 210-1	old	f_y in N/mm^2	f_u in N/mm^2	KV* in J at test temp.	CEV* in % for $t \leq 16$ mm	$16 < t \leq 40$ mm
			n. EN 1993 for $t \leq 40$ mm				
Structural steels	S 355 J0H 1.0547	St 52-3U	355	510	0 °C: 27	0.45	0.47
	S 355 J2H 1.0576	St 52-3N	**355**	**510**	**-20 °C: 27**	**0.45**	**0.47**
	S 355 K2H 1.0512		355	510	-20 °C: 40	0.45	0.47
Normalised fine grain structual steels	S 355 NH 1.0539	StE 355 N	355	490	-20 °C: 40	0.43	0.45
	S 355 NLH 1.0549	TStE 355 N	355	490	-50 °C: 27	0.43	0.45
	S 460 NH 1.8953	StE 460 N	460	560	-20 °C: 40	0.53	0.55
	S 460 NLH 1.8956	TStE 460 N	460	560	-50 °C: 27	0.53	0.55
	S 690 approval in each individual case				* according to DIN EN 10210-1		

According to DIN EN 1993-1-1 the yield and tensile strengths f_y and f_u are either to be taken out of the product standard (DIN EN 10210-1) or simplified from DIN EN 1993-1-1. The values in table 2 correspond to the simplified specifications according to DIN EN 1993-1-1 for $t \leq 40$ mm. The DIN EN 10210-1 demands a reduction of the yield strength for wall thicknesses > 16 mm already as well as different tensile strengths. The yield strength according to EC 3 specifies a nominal value for calculations, not the actual minimum value of the material.
Detailed information and brochures are available at: www.vmtubes.com

2 Classification of hollow cross sections

By the classification of the cross sections the resistance and rotation capacity due to local buckling is supposed to be determined.

Table 3 Classification on the bases of c/t- and d/t-ratios of cross section parts subjected to compression

Cross section	Class	Pure compression	Pure bending
	1	$c/t \leq 33\ \varepsilon$	$c/t \leq 72\ \varepsilon$
	2	$c/t \leq 38\ \varepsilon$	$c/t \leq 83\ \varepsilon$
	3	$c/t \leq 42\ \varepsilon$	$c/t \leq 124\ \varepsilon$
	1	$d/t \leq 50\ \varepsilon^2$	
	2	$d/t \leq 70\ \varepsilon^2$	
	3	$d/t \leq 90\ \varepsilon^2$	

$\varepsilon = \sqrt{235/f_y}$, f_y in N/mm²						
	f_y	235	275	355	420	460
	ε	1.00	0.92	0.81	0.75	0.71
	ε^2	1.00	0.85	0.66	0.56	0.51

Cross sections which do not comply to the conditions of the classes 1, 2 or 3 are classified as **class 4**.

The tables of the sections 14 to 16 include details on the **classification using the steel grade S 355.** The first digit describes the classification for pure compression, the second for pure bending.

3 Calculation methods/Determination of internal forces

Internal forces can be determined using an elastic or a plastic structural analysis. A plastic analysis can only be performed, if the structure provides sufficient rotation capacity at the locations where plastic hinges occur. For the structural analysis the design values of the loading have to be taken into consideration, which means that partial safety factors γ_F and combination factors ψ have to be regarded for the actions. As a result the design values of the internal forces N_{Ed}, V_{Ed} und M_{Ed}.

4 Resistance of cross sections

		Class:
Tension:	$\frac{N_{Ed}}{N_{pl}/\gamma_{M0}} \leq 1.0$	all
Compression:	$\frac{N_{Ed}}{N_{pl}/\gamma_{M0}} \leq 1.0$	1, 2 or 3
	$\frac{N_{Ed}}{A_{eff} \cdot f_y/\gamma_{M0}} \leq 1.0$	4
Bending moment:	$\frac{M_{Ed}}{M_{pl}/\gamma_{M0}} \leq 1.0$	1 or 2
	$\frac{M_{Ed}}{W_{el} \cdot f_y/\gamma_{M0}} \leq 1.0$	3
Shear:	$\frac{V_{Ed}}{V_{pl}/\gamma_{M0}} \leq 1.0$	no shear buckling!

Partial safety factors:
According to DIN EN 1993-1-1 $\gamma_{M0} = \gamma_{M1} = 1.00$ is recommended. The definition will be stated in the national annex, which is not yet available.

N_{pl}, V_{pl} and M_{pl} for f_y = 35.5 kN/cm²:
see tables in sections 14 to 16. For a different yield strength the values can be converted using the ratio of the strengths.

Bending moment and shear force:

The influence of the shear force on the bending moment resistance has to be taken into consideration if the shear force V_{Ed} exceeds $0.5 \cdot V_{pl}/\gamma_{M0}$. In that case a reduced yield strength has to be regarded for the parts of the cross section subjected to shear:

$$\text{red } f_y = (1 - \rho) \cdot f_y \text{ where } \rho = \left(\frac{2 \cdot V_{Ed}}{V_{pl}/\gamma_{M0}} - 1 \right)^2$$

Bending moment and axial force:

For classes 1 and 2 cross sections the following criterion should be satisfied:
$M_{Ed} \leq M_{N,Rd}$
where $M_{N,Rd}$ is the design plastic moment resistance reduced by the axial force N_{Ed}.
For **rectangular hollow sections** the following approximation may be used:

$$M_{N,Rd} = \frac{M_{pl}}{\gamma_{M0}} \cdot \frac{1-n}{1-0.5 \cdot a_w} \text{ where: } M_{N,Rd} \leq \frac{M_{pl}}{\gamma_{M0}}$$

$$\text{where: } n = \frac{N_{Ed}}{N_{pl}/\gamma_{M0}}$$

$$a_w = 1 - \frac{2bt}{A} \text{ but } a_w \leq 0.5$$

For circular hollow cross sections EC 3 does not provide any specifications. Analogously the following condition is obtained according to Kindmann/Frickel „Elastische und plastische Querschnittstragfähigkeit“ (Ernst & Sohn publishing, Berlin):

$$\frac{N_{Ed}}{N_{pl}/\gamma_{M0}} + \frac{2}{\pi} \cdot \text{arc sin} \left(\frac{M_{Ed}}{M_{pl}/\gamma_{M0}} \right) \leq 1.0$$

5 Buckling resistance of members

Buckling resistance of members in compression

Uniform members with class 1, 2 and 3 sections shall be verified against buckling as follows:

$$\frac{N_{Ed}}{\chi \cdot N_{pl}/\gamma_{M1}} \leq 1.0$$

$$\chi = \frac{1}{\Phi + \sqrt{\Phi^2 - \bar{\lambda}^2}} \quad \text{aber } \chi \leq 1.0$$

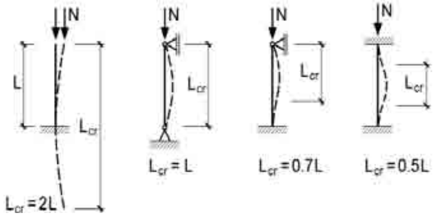
$$\Phi = 0.5 \cdot \left[1 + \alpha \cdot (\bar{\lambda} - 0.2) + \bar{\lambda}^2\right]$$

$$\bar{\lambda} = \sqrt{\frac{N_{pl}}{N_{cr}}} = \frac{L_{cr}}{i \cdot \pi} \cdot \sqrt{\frac{f_y}{E}} \; ; \; N_{cr} = \frac{\pi^2 EI}{L_{cr}^2}$$

$\alpha = 0.21$ for buckling curve a (S 235 to S 420)

$\alpha = 0.13$ for buckling curve a_0 (S 460)

L_{cr}: buckling length



$\bar{\lambda}$	χ for curve a	χ for curve a_0
0.20	1.000	1.000
0.25	0.989	0.993
0.30	0.977	0.986
0.35	0.966	0.978
0.40	0.953	0.970
0.45	0.939	0.961
0.50	0.924	0.951
0.55	0.908	0.940
0.60	0.890	0.928
0.65	0.870	0.913
0.70	0.848	0.896
0.75	0.823	0.876
0.80	0.796	0.853
0.85	0.766	0.827
0.90	0.734	0.796
0.95	0.700	0.762
1.00	0.666	0.725
1.05	0.631	0.687
1.10	0.596	0.648
1.15	0.562	0.610
1.20	0.530	0.573
1.25	0.499	0.538
1.30	0.470	0.505

$\bar{\lambda}$	χ for curve a	χ for curve a_0
1.35	0.443	0.475
1.40	0.418	0.446
1.45	0.394	0.420
1.50	0.372	0.395
1.55	0.352	0.373
1.60	0.333	0.352
1.65	0.316	0.333
1.70	0.299	0.315
1.75	0.284	0.299
1.80	0.270	0.283
1.85	0.257	0.269
1.90	0.245	0.256
1.95	0.234	0.244
2.00	0.223	0.232
2.10	0.204	0.212
2.20	0.187	0.194
2.30	0.172	0.178
2.40	0.159	0.164
2.50	0.147	0.151
2.60	0.136	0.140
2.80	0.118	0.122
2.90	0.111	0.114
3.00	0.104	0.106

Buckling resistance of members in bending

Procedure for the verification of sufficient carrying capacity:
- Application of equivalent geometric imperfections
- Determination of internal bending moments using a second order theory analysis taking the equivalent geometric imperfections into account (approximations see below)
- Verification of sufficient cross section carrying capacity according to section 4 for "bending and axial force"

Equivalent geometric imperfections:

a) Initial sway imperfections

$\phi = 1/200 \cdot \alpha_h \cdot \alpha_m$

Reduction factor for height h [m] applicable to columns:

$$\alpha_h = \frac{2}{\sqrt{h}} \text{ but } \frac{2}{3} \leq \alpha_h \leq 1.0$$

Reduction factor for the number of columns in a row:

$$\alpha_m = \sqrt{0.5 \cdot \left(1 + \frac{1}{m}\right)}$$

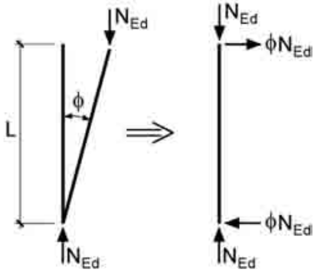
m is the number of columns in a row including only those columns which carry a vertical load N_{Ed} not less than 50% of the average value of the column in the vertical plane considered.

b) Initial bow imperfections

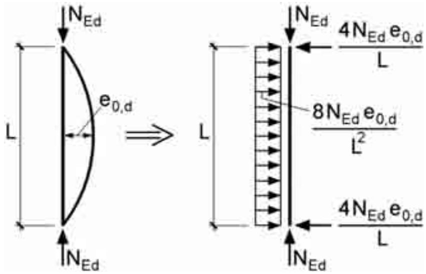
According to DIN EN 1993-1-1 the initial bow imperfections are recommended as stated in the following table. The definition will be stated in the national annex, which is not available yet.

Buckling curve	$e_{0,d}$ / L Elastic analysis	Plastic analysis
a_0	1/350	1/300
a	1/300	1/250

Equivalent loading



Equivalent loading



Approximations for the bending moment according to second order theory:

For the approximation the first order theory bending moment is multiplied by an enlargement factor α:

$M^{II} \cong \alpha \cdot M^{I}$

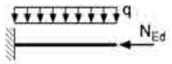
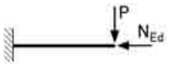
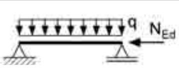
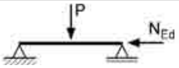
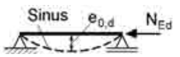
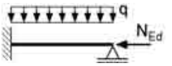
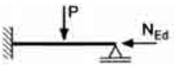
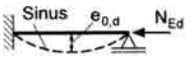
$$\alpha = \frac{1 + \delta \cdot N_{Ed}/N_{cr,d}}{1 - N_{Ed}/N_{cr,d}}$$

$N_{cr,d} = N_{cr}/\gamma_{M1}$

Condition: $\alpha \leq 3$

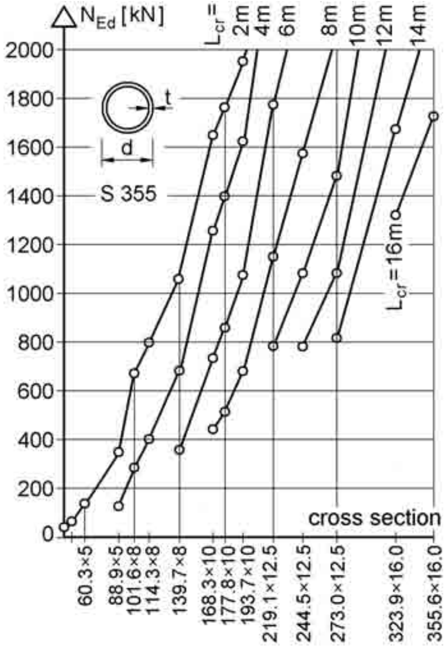
L = beam length

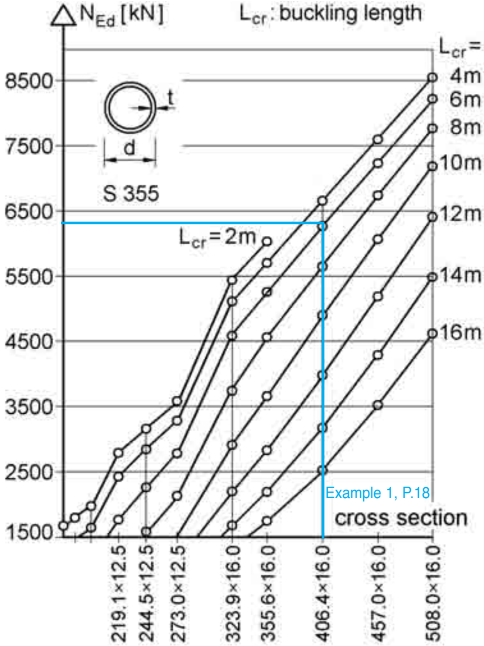
Bending moment according to first order theory and correction factors δ for selected cases

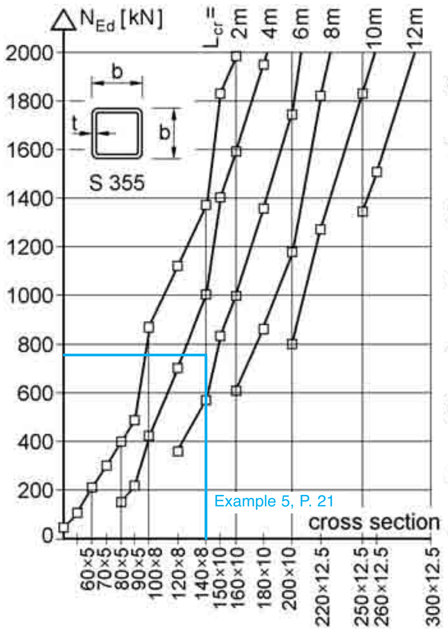
 Hog. moment: $M^I = -q \cdot L^2/2$, $\delta = -0.40$	 Hog. moment: $M^I = P \cdot L$, $\delta = -0.18$	 Hog. moment: $M^I = -N_{Ed} \cdot \phi \cdot L$, $\delta = -0.18$
 Sag. moment: $M^I = q \cdot L^2/8$, $\delta = +0.03$	 Sag. moment: $M^I = P \cdot L/4$, $\delta = -0.18$	 Sag. moment: $M^I = N_{Ed} \cdot e_{0,d}$, $\delta = 0$
 Hog. moment: $M^I = -q \cdot L^2/8$, $\delta = -0.37$; Sag. moment at: 5/8 · L: $M^I = 9\,q\,L^2/128$, $\delta = +0.10$	 Hog. moment: $M^I = -3\,PL/16$, $\delta = -0.27$; Sag. moment: $M^I = 5\,PL/32$, $\delta = -0.30$	 Hog. moment: $M^I \cong -N_{Ed} \cdot e_{0,d}$, $\delta = -0.33$; Sag. moment at: 5/8 · L: $M^I \cong 0.6\,N_{Ed} \cdot e_{0,d}$, $\delta = +0.07$

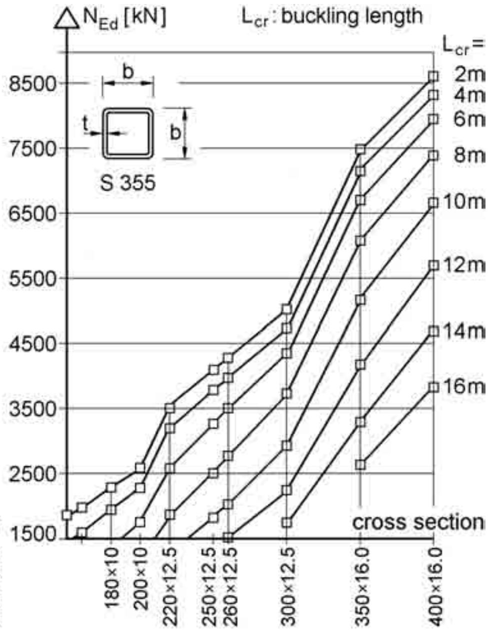
Online verification against buckling at www.vmtubes.com (STACOM)

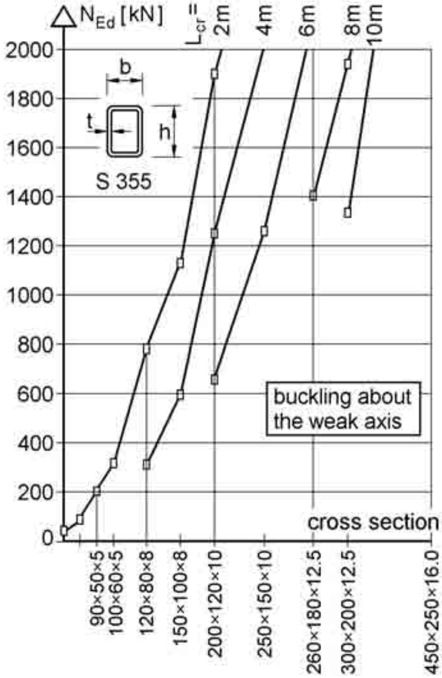
6 Design-support for members in compression

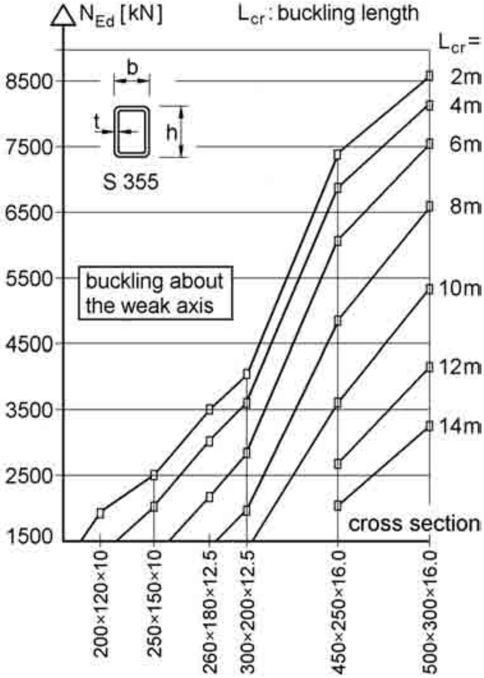








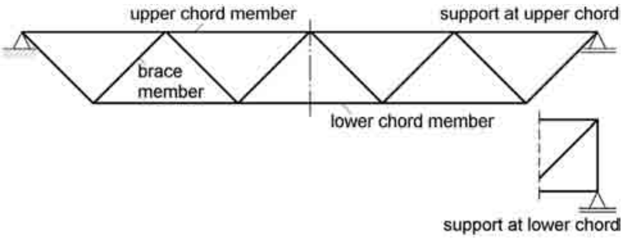




7 Lattice girders

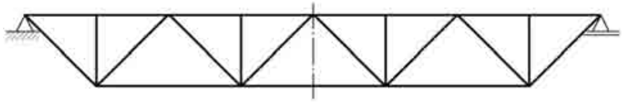
Lattice structures are often designed as single span girders with parallel chords, as for example roof girders of long span constructions. Established structures in practice are:

- Warren truss



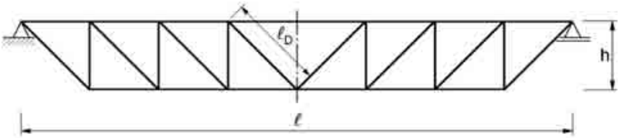
- small amount of work due few joints
- long diagonals in compression
- few points of load application at the upper chord

- Warren truss with vertical posts



- many points of load application at the upper chord
- many joints
- extensive joints at lower chord and large amount of work

- Pratt truss



- short diagonals in compression
- many points of load application at upper chord
- many joints and therefore large amount of work

Compared to plate girders lattice girders with parallel chords using hollow members provide economic advantages for span lengths greater than about 20 m. The split-up of the internal bending moment into tension and compression forces leads to light roof constructions saving material. Additionally hollow profiles provide an ideal cross section shape for centrical compression loading.

Support for the construction:

- Lattice girders with parallel chords usually have heights from 1/10 to 1/20 of the system lengths. As a guide value for pre-design a girder height of 1/15 of the span length is appropriate.

- The angles between the chords and the brace members should be in-between 45° and 60°. In any case an angle **greater than 30°** has to be chosen.

- Joints of lattice structures should be designed in a way that the centrelines of the members intersect in a single point. In the case they show eccentricities chapter 5.1.5 of DIN EN 1993-1-8:2005 has to be regarded (see section 8).

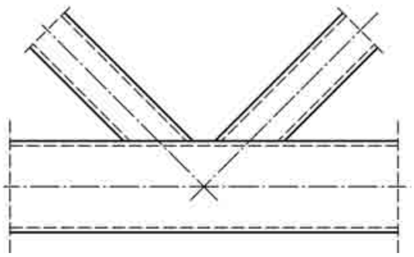
- Loadings, as for instance from purlins, should be introduced at the joints of the structure.

- Moments at the joints, caused by the actual rotational stiffness of the connections, may be neglected in the design of the members and joints, provided that the range of validity for the joints are observed and the ratio of the system length to the heights of the members is not less than 6.

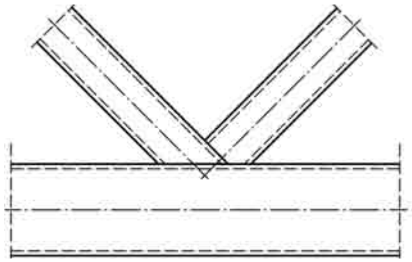
The cross section carrying capacity has to be verified for each member and for those in compression the **stability** as well. For connections the **design joint resistance** according to DIN EN 1993-1-8:2005 has to be verified.

8 Joints of lattice girders

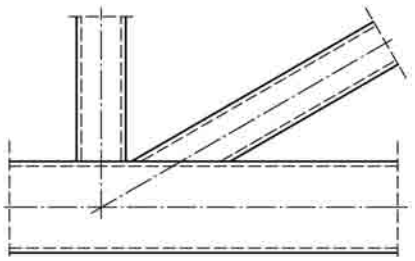
Each member of a lattice structure is usually loaded by axial forces for which they have to be designed. At joints, several members come together and the directions of force-actions have to be redistributed in order to fulfil the equilibrium. Joints are highly stressed details of the structure for which the design joint resistance has to be determined and verified. Usually hollow profiles are welded at the connections; welds have to be verified separately however. The ends of brace members may not be flattened or pressed together. The following types of joints are often used:



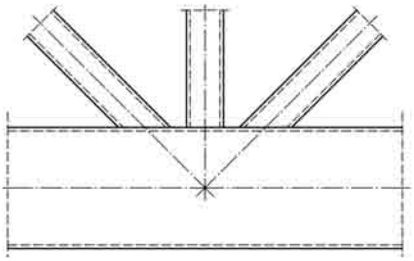
K gap joint



K overlap joint



K joint with vertical post (N joint)



KT joint

The following supports for design may be applied for mainly stationary loading. Moments resulting from eccentricities of the centrelines have to be regarded in the design of tension chord members and brace members as well as the design of the connections if the following limits are not fulfilled:

CHS: $-0.55 \cdot d_0 \le e \le 0.25 \cdot d_0$ resp. RHS/SHS: $-0.55 \cdot h_0 \le e \le 0.25 \cdot h_0$

In the design of compression chord members eccentricities usually have to be taken into account, even if they are within the limits specified above. According to DIN EN 1993-1-8 a **partial safety factor** of $\boldsymbol{\gamma_{M5} = 1.00}$ is recommended for the design of the joints. The definition will be stated in the national annex, which is not available yet.

Definition and Notation

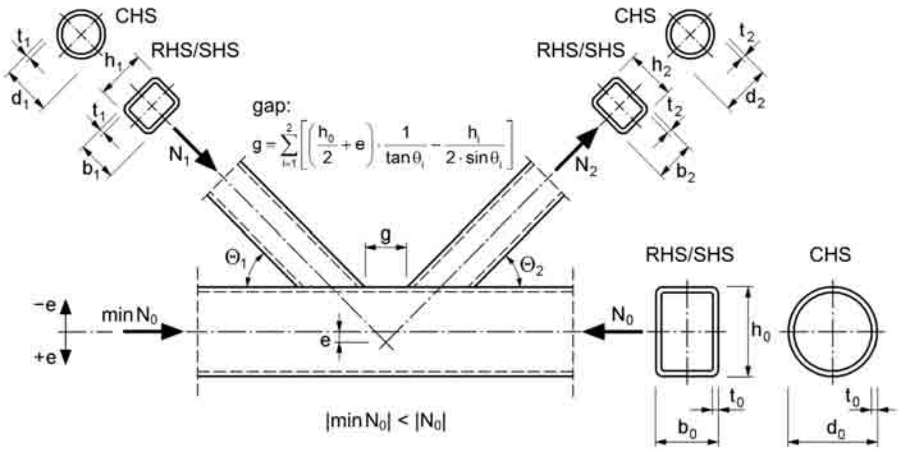


Table 4 Range of validity for K and N gap joints according to DIN EN 1993-1-8:2005

Rectangular MSH sections (RHS):

1. $b_i/b_0 \ge \text{Max}\begin{pmatrix}0.35\\ 0.1 + 0.01 \cdot b_0/t_0\end{pmatrix}$
2. $b_i/t_i \le 35$ und $h_i/t_i \le 35$
3. $b_0/t_0 \le 35$ und $h_0/t_0 \le 35$
4. $0.5 \le h_0/b_0 \le 2.0$
5. $0.5 \le h_i/b_i \le 2.0$
6. $g \ge \text{Max}\begin{pmatrix}0.5 \cdot b_0 \cdot (1-(h_1 + b_1 + h_2 + b_2)/(4 \cdot b_0))\\ t_i + t_2\end{pmatrix}$
7. If $g \ge 1.5 \cdot b_0 \cdot \left(1 - \frac{(h_1 + b_1 + h_2 + b_2)}{4 \cdot b_0}\right)$ the joint has to

be treated as two separate Y and T joints

8. Class 2 sections in terms of pure bending at least (see section 2)
9. $\Theta_i \ge 30°$

Circular MSH sections (CHS):

1. $0.2 \le d_i/d_0 \le 1.0$
2. $10 \le d_0/t_0 \le 50$
3. $10 \le d_i/t_i \le 50$
4. $\Theta_i \ge 30°$
5. Class 2 sections in terms of pure bending at least (see section 2)
6. $g \ge t_1+t_2$

Square MSH sections (SHS):

Points 1-9 see RHS

10. $15 \le b_0/t_0 \le 35$
11. $0.6 \le \frac{b_1 + b_2}{2 \cdot b_1} \le 1.3$

Table 5 Range of validity for K and N overlap joints according to DIN EN 1993-1-8:2005

Rectangular and square MSH sections (RHP/QHP):

1. $b_i/b_0 \ge 0.25$
2. Chord: $0.5 \le h_0/b_0 \le 2.0$ and class 2 section in terms of pure bending at least
3. Braces (in compression): class 1 sections (pure bending)
4. Braces (in tension): $b_i/t_i \le 35$ and $h_i/t_i \le 35$
5. $25\% \le \lambda_{0V} \le 100\%$ and $b_i/b_j \ge 0.75$
6. $\Theta_i \ge 30°$

Circular MSH sections (CHS):

Points 1-5 see table 4

6. $\lambda_{0V} \ge 25\%$

9 Design-support for K gap joints with square MSH-chords (SHS)

Preconditions:

– Joint has to be within the range of validity given in table 4!

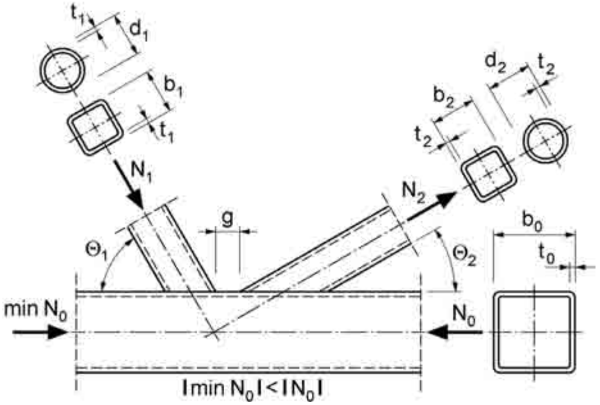
– Same yield strength fy for all members

Design resistance of the joint

$$N_{1,Rd} = \frac{n_{Rd} \cdot k_n \cdot N_{pl,0}}{\sin \theta_1 \cdot \gamma_{M5}}$$

$$N_{2,Rd} = N_{1,Rd} \cdot \frac{\sin \theta_1}{\sin \theta_2}$$

n_{Rd} see diagram below



Note:

For circular braces the design resistances $N_{i,Rd}$ have to be multiplied by the factor $\pi/4$. For that case $b_i = d_i$ is valid.

k_n is obtained

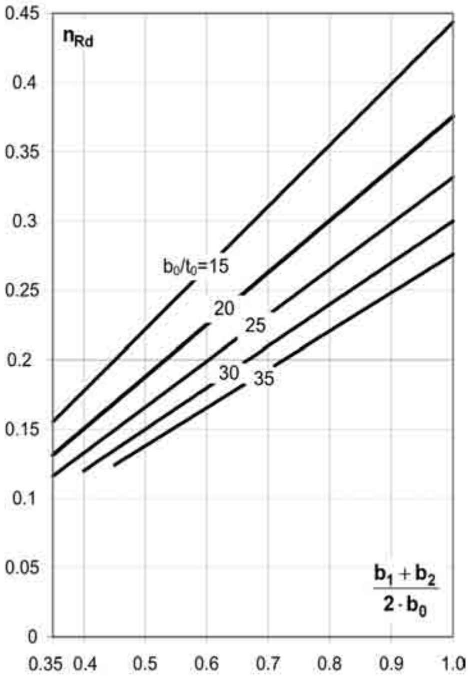
for compression chords by:

$$k_n = 1.3 - 0.4 \cdot \frac{|N_{o,d}| \cdot \gamma_{M5}}{N_{pl,0}} \cdot \frac{2 \cdot b_0}{b_1 + b_2} \leq 1.0$$

for tension chords by: $k_n = 1.0$

sin Θ is given by:

θ	sin θ
30°	0.50
40°	0.64
45°	0.707
50°	0.77
60°	0.87



Example:

- Chord member SHS 150x150x6.3 mm (tension)
- Brace members SHS 80x80x5 mm
- Gradient of the brace members 45° (e = 0 cm)

Check of the validity given in table 4:

1. $b_i/b_0 = 8/15 = 0.533 \geq 0.35$

2. $b_i/t_i = h_i/t_i = 80/5 = 16 \leq 35$

6. $g = 15 - \frac{8}{\sin 45°} = 3.7\ \text{cm} \geq \text{Max}\begin{pmatrix} 7.5 \cdot \left(1 - \frac{8}{15}\right) = 3.5\ \text{cm} \\ 1.0\ \text{cm} \end{pmatrix}$

7. $g = 15 - \frac{8}{\sin 45°} = 3.7\ \text{cm} \leq 1.5 \cdot 15 \cdot (1 - 8/15) = 10.5\ \text{cm}$

8. Members are at least class 2 sections

9. $\Theta_1 = \Theta_2 = 45° \geq 30°$

10. $15 \leq b_0/t_0 = 150/6.3 = 23.8 \leq 35$

11. $0.6 \leq \frac{b_1 + b_2}{2 \cdot b_1} = \frac{8 + 8}{2 \cdot 8} = 1.0 \leq 1.3$

Determination of the design resistance:

With $\frac{b_1}{b_0} = \frac{8}{15} = 0.533$ and $\frac{b_0}{t_0} = \frac{15}{0.63} = 23.8$: $n_{Rd} \approx 0.18$

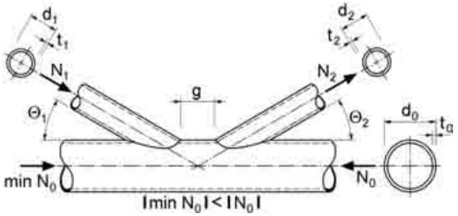
The limit brace force for a tension chord is:

$$N_{1,Rd} = \frac{0.18 \cdot 1.0 \cdot 1270}{0.707 \cdot 1.0} = \underline{323.3\ \text{kN}}$$

10 Design-support for K joints with circular MSH sections (CHS)

Preconditions:
– Joint has to be within the range of validity given in tables 4 and 5!
– Same yield strength f_y for all members
Conditions for design:

$$N_{1,Rd}\ \mathrm{Min}\begin{cases}\dfrac{n_{Rd}\cdot k_p\cdot N_{pl,0}}{\sin\theta_i\cdot\gamma_{M5}}\\[2ex]\dfrac{d_i\cdot k_{\Theta i}\cdot N_{pl,0}}{(d_0-t_0)\cdot\gamma_{M5}}\end{cases}\geq N_{i,d}\qquad \text{where } i=\begin{matrix}1-\text{Comp.}\\2-\text{Tension}\end{matrix}$$



n_{Rd} see diagram below
(Interim values may be interpolated)
Notes: g<0: overlap joint (table 5)
g>0: gap joint (table 4)

k_p is obtained

for compression chords by:

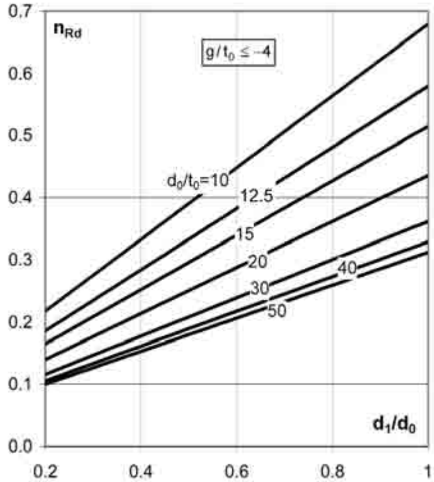
$$k_p = 1-0.3\cdot\frac{|\mathrm{min}N_{o,d}|\cdot\gamma_{M5}}{N_{pl,0}}\left(1+\frac{|\mathrm{min}N_{o,d}|\cdot\gamma_{M5}}{N_{pl,0}}\right)\leq 1.0$$

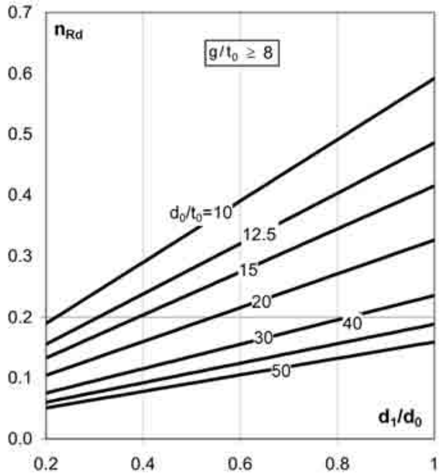
for tension chords by: $k_p = 1.0$

$k_{\Theta i}$ is obtained by:

$$k_{\Theta i}=\frac{1+\sin\Theta_i}{\sqrt{12}\cdot\sin^2\Theta_i}$$

Θ_i	$k_{\Theta i}$
35°	1.38
40°	1.15
45°	0.99
50°	0.87
60°	0.72





Example:
- Chord member: 101.6 x 6.3 mm (tension)
- Brace members: 60.3 x 5mm
- Gradient of the brace members: 45° (e = 0 cm)

Check of validity given in table 4:
1. $0.2 \leq d_i/d_0 = 60.3/101.6 = 0.594 \leq 1.0$
2. $10 \leq d_0/t_0 = 101.6/6.3 = 16.1 \leq 50$
3. $10 \leq d_i/t_i = 60.3/5 = 12.1 \leq 50$
4. $\Theta_1 = \Theta_2 = 45° \geq 30°$
5. Members are at least class 2 sections

6. $g = 10.16-\dfrac{6.03}{\sin 45°} = 1.6\text{ cm} \geq t_1+t_2 = 1.0\text{ cm}$

Determination of the design resistance:

with $\dfrac{d_1}{d_0}=0.594$, $\dfrac{d_0}{t_0}=16.1$ and $\dfrac{g}{t_0}=2.54$ and by interpolation:

$n_{Rd}\approx 0.32\ (g/t_0\leq -4)$, $n_{Rd}\approx 0.26\ (g/t_0\geq 8)$
$n_{Rd}\approx 0.26+(0.32-0.26)\cdot(8-2.54)/(4+8) = 0.287$
The limit brace force for a tension chord is:

$$N_{Rd}=\mathrm{Min}\begin{cases}\dfrac{0.287\cdot 669.6}{0.707\cdot 1.0}=272\\[2ex]\dfrac{6.03\cdot 0.99\cdot 669.6}{(10.16-0.63)\cdot 1.0}=419.4\end{cases}=\underline{\underline{272\text{ kN}}}$$

11 Design-support for K gap joints with rectangular MSH-chords (RHS)

Preconditions:
- Joint has to be within the range of validity given in table 4!
- Brace members are equal profiles SHS/CHS
- Same yield strength f_y for all members
- The compression force in the chord shall satisfy: $\frac{|N_{o,d}|}{N_{pl,0}} \cdot \gamma_{M5} \leq 0.5$

  (For small b_i/b_0-ratios and small compression forces or tension forces in the chord the exact verification according to Eurocode can lead to favourable results)

Note:
For circular braces the design resistances $N_{i,Rd}$ have to be multiplied by the factor $\pi/4$. For that case $b_i = d_i$ is valid.

Conditions for design:

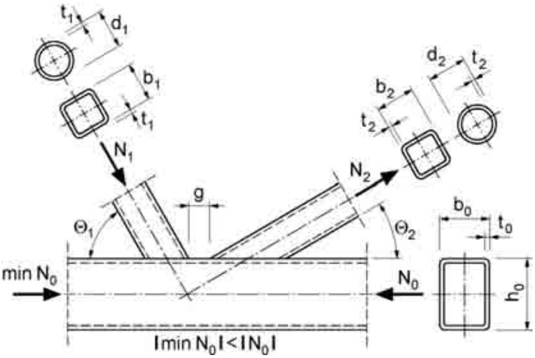
1. Condition (Verification of the chord force)

$$V_{Ed} = \frac{N_{1,d} \cdot \sin \Theta_1}{V_{pl,0}} \cdot \gamma_{M5}$$

$$k_\alpha = 0.2 \frac{h_0}{b_0} + 0.35$$

$$n_{0,Rd} = 1 - \left(1 - \sqrt{1 - v_{Ed}^2}\right) \cdot k_\alpha$$

$$\mathbf{N_{0,Rd}} = \frac{\mathbf{n_{0,Rd} \cdot N_{pl,0}}}{\gamma_{M5}} > \mathbf{N_{0,d}}$$

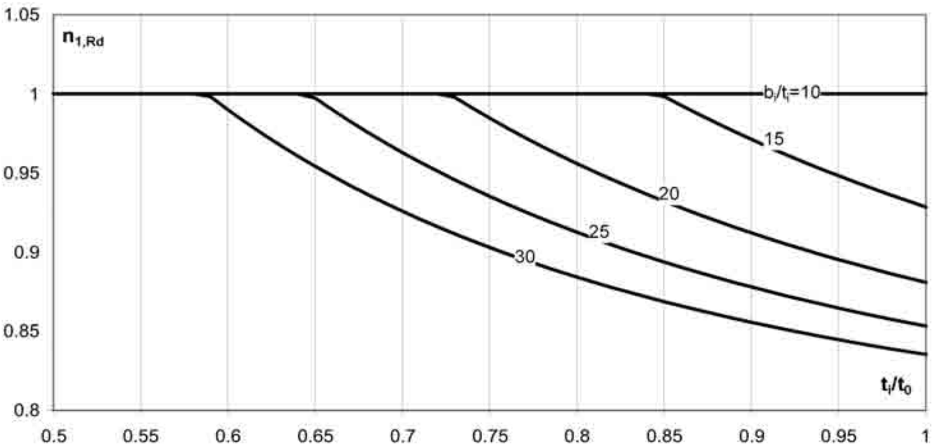


2. Condition (Verification of the brace force)

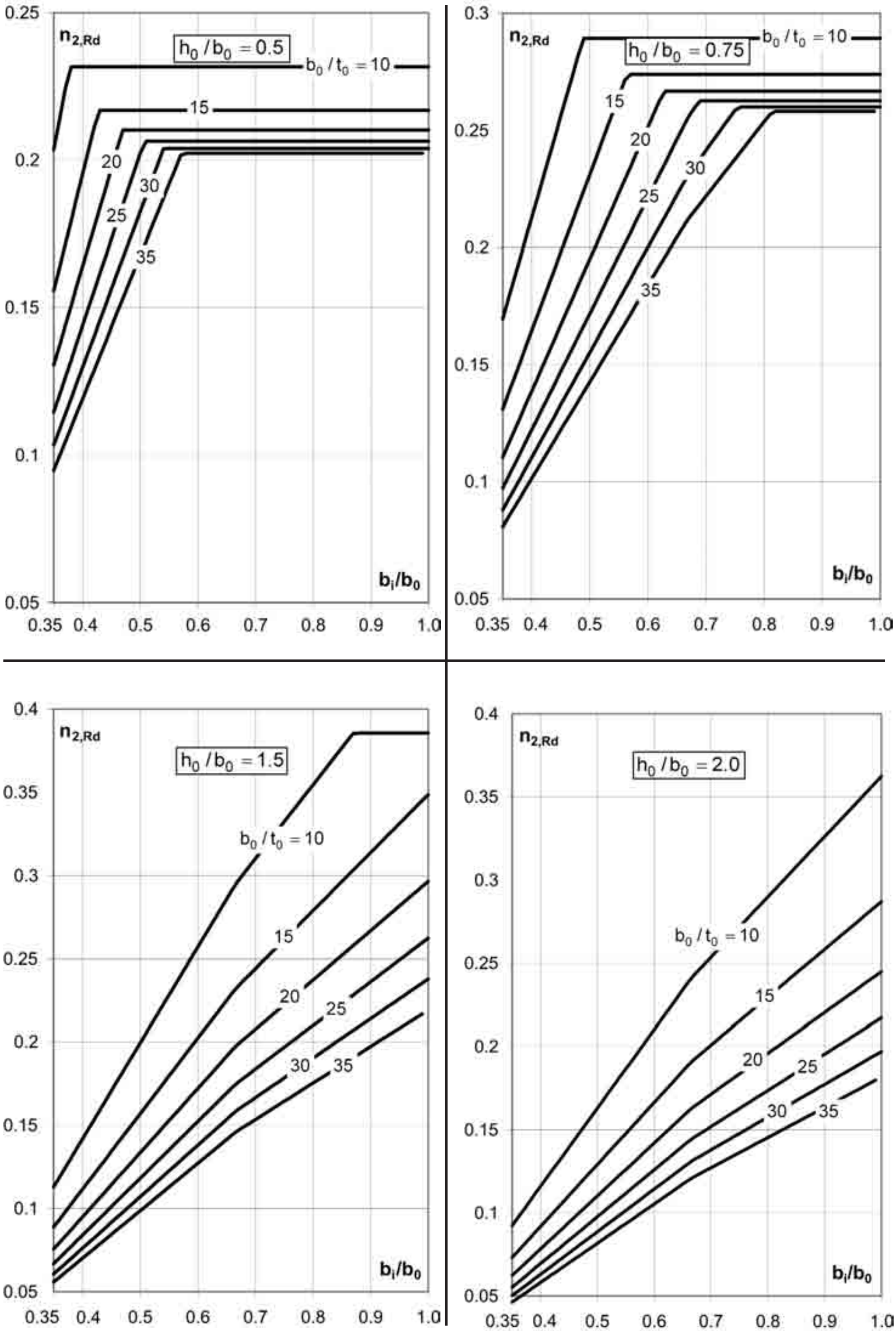
$$\mathbf{N_{i,Rd}} = \text{Min} \left\{ \begin{array}{c} \frac{\mathbf{n_{1,Rd} \cdot N_{pl,i}}}{\gamma_{M5}} \\ \frac{\mathbf{n_{2,Rd} \cdot N_{pl,0}}}{\sin \Theta_i \cdot \gamma_{M5}} \end{array} \right\} > \mathbf{N_{i,d}}$$

$n_{1,Rd}$ and $n_{2,Rd}$ see diagrams below

Diagram for $n_{1,Rd}$:



Diagrams for $n_{2,Rd}$:



12 Design-support for K overlap joints with square MSH-chords (SHS)

Preconditions:

- Joint has to be within the range of validity given in table 5!
- Brace members are equal profiles SHS/CHS
- Same yield strength f_y for all members

Note:

For circular braces the design resistancese $N_{i,Rd}$ have to be multiplied by the factor $\pi/4$. For that case $b_i = d_i$ is valid.

Design resistance of the joint:

$$N_{1,Rd} = \frac{n_{Rd} \cdot N_{pl,1}}{\gamma_{M5}}$$

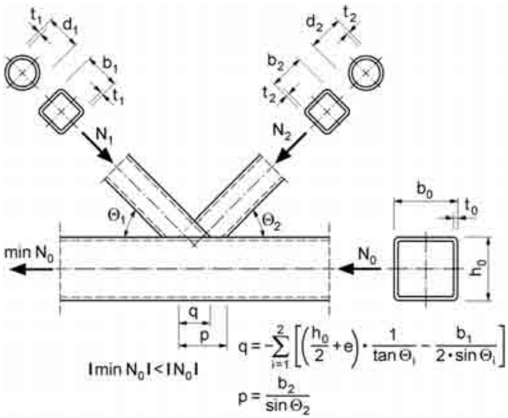
The overlapping brace member 2 does not have to be verified.

Determination n_{Rd} taking into account:
$\lambda_{0V} = q/p \cdot 100\% \geq 25\%$ (see table 5)

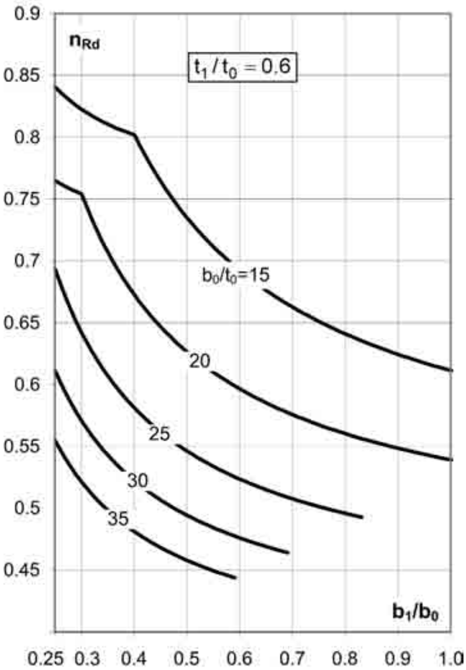
With the overlap ratio λ_{0V} the following cases can be distinguished:

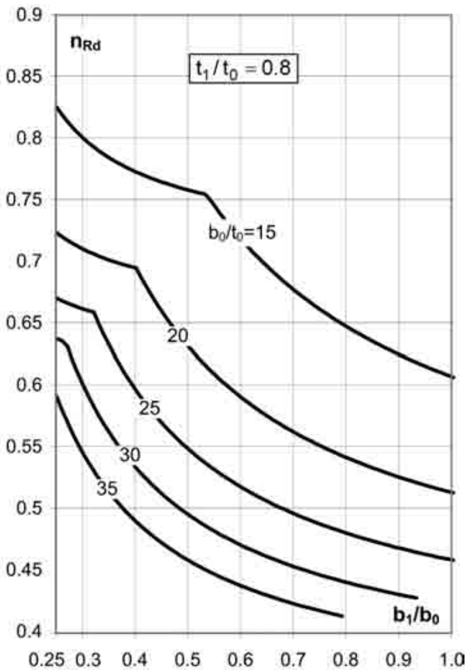
- Case 1: $\lambda_{0V} = 25\%$
- Case 2: $25\% < \lambda_{0V} < 50\%$

  linear interpolation of n_{Rd} using case 1 and case 3
- Case 3: $50\% \leq \lambda_{0V} < 80\%$
- Case 4: $80\% \leq \lambda_{0V} \leq 100\%$

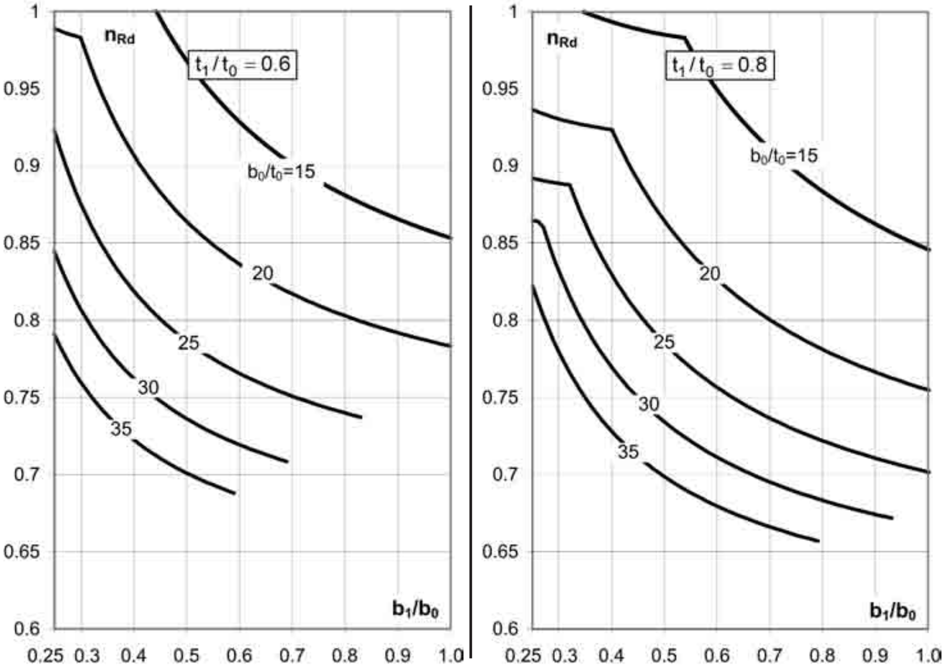


Diagrams for n_{Rd} in case 1 ($\lambda_{0V} = 25\%$):

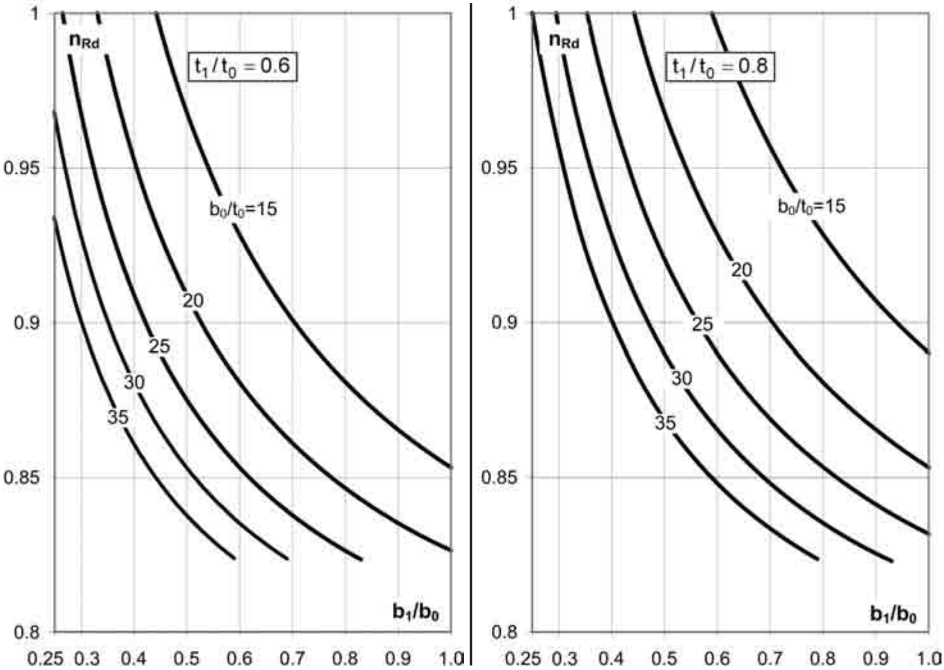




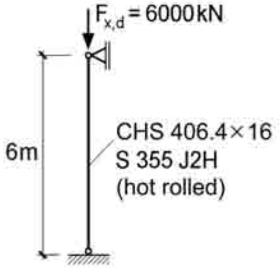
Diagrams for n_{Rd} in case 3 ($50\% < \lambda_{0V} < 80\%$):



Diagrams for n_{Rd} in case 4 ($80\% \leq \lambda_{0V} \leq 100\%$):



Example 1: Column with hinged supports (L = 6 m):



By considering $L_{cr} = L = 6$ m the following can directly be taken from the design-support of section 6: CHS 406.4 x 16 ⇨ $N_{Ed} \approx 6250$ kN > 6000 kN

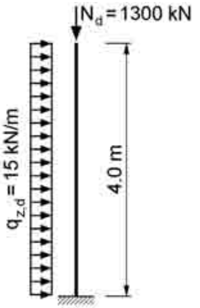
In comparison to that the verification against buckling according to sect. 5 is carried out: I = 37449 cm^4, N_{pl} = 6966 kN (see section 14), buckling length: L_{cr} = 600 cm (see section 5)

$$N_{cr} = \frac{\pi^2 EI}{L_{cr}^2} = \frac{\pi^2\, 21000 \cdot 37449}{600^2} = 21560 \text{ kN}; \quad \bar{\lambda} = \sqrt{\frac{N_{pl}}{N_{cr}}} = \sqrt{\frac{6966}{21560}} = 0.57$$

⇨ $\chi \approx 0.9$ (buckling curve a, see section 5)

Verification against buckling: $$\frac{N_{Ed}}{\chi \cdot N_{pl}/\gamma_{M1}} = \frac{6000}{0.9 \cdot 6966/1.0} = 0.96 < 1.0$$

Example 2: Column with fixed support (L = 4 m) and lateral loading:



SHS 250×250×10
S 355 J2H (hot rolled)

The column shown in the figure has to be verified for stability. Due to the lateral loading the verification will be achieved by a **second order theory** analysis (I_y = 9055 cm^4).
The buckling length of the column is $L_{cr} = 2L = 8$ m.

$$N_{cr} = \frac{\pi^2 EI}{L_{cr}^2 \cdot \gamma_{M1}} = \frac{\pi^2\, 21000 \cdot 9055}{800^2 \cdot 1.0} = 2932.4 \text{ kN}$$

The bending moment at support due to the uniformly distributed load is (see sect. 5):

$$M_q^I = -15 \cdot \frac{4^2}{2} = -120 \text{ kNm}$$

With $\delta = -0.40$ from the table of section 5 the enlargement factor α is determined as follows:

$$\alpha = \frac{1+\delta \cdot N_{Ed}/N_{cr.d}}{1-N_{Ed}/N_{cr,d}} = \frac{1-0.4 \cdot 1300/2932.4}{1-1300/2932.4} = 1.48 \leq 3.0$$

The **second order theory** moment is gained with the multiplication of the moment at support by the enlargement factor α (see section 5).

$$M_q^{II} = M_q^I \cdot \alpha = (-120) \cdot 1.48 = -177.6 \text{ kNm}$$

The initial sway imperfection is regarded with $\phi = \frac{1}{200}$ (for the application of equiv. geo. imperfections see section 5)

$$H_0 = \phi \cdot N_{ED} = \frac{1300}{200} = 6.5 \text{ kN}; \qquad M_\phi^I = -H_0 \cdot 1 = -6.5 \cdot 4 = -26 \text{ kNm}$$

With $\delta = -0{,}18$ (see section 5):

$$\alpha = \frac{1-0.18 \cdot 1300/2932.4}{1-1300/2932.4} = 1.65 \leq 3.0; \qquad M_\phi^{II} = (-26) \cdot 1.65 = -42.9 \text{ kNm}$$

The internal forces according to the second order theory analysis may only be superposed, if the axial compression force of the loading conditions is identical (limited superposition). In this example the axial compression force is regarded with N_d = 1300 kN in combination with the uniformly distributed load q_d as well as the sway imperfection ϕ.

$$M_{Ed}^{II} = M_q^{II} + M_\phi^{II} = -177.6 - 42.9 = -220.5 \text{ kNm}$$

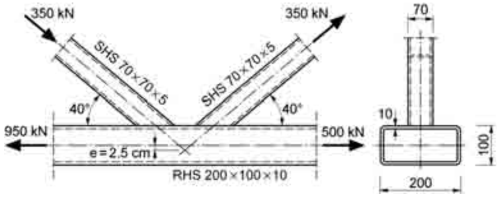
The **bending moment resistance** is determined according to section 4 with regard of the axial compression force (since V/V_{pl} is smaller than 0.5, a reduction of the yield strength is not necessary):

$$n = \frac{N_{Ed}}{N_{pl}/\gamma_{M0}} = \frac{1300}{3370/1.0} = 0.386; \qquad a_w = 1 - \frac{2 \cdot b \cdot t}{A} = 1 - \frac{2 \cdot 25 \cdot 1.0}{94.93} = 0.473$$

$$M_{N,Rd} = \frac{M_{pl}}{\gamma_{M0}} \cdot \frac{1-n}{1-0.5 \cdot a_w} = \frac{302}{1.0} \cdot \frac{1-0{,}386}{1-0.5 \cdot 0.473} = 242.9 \text{ kNm} \geq M_{Ed}^{II} = 220.5 \text{ kNm}$$ **Condition satisfied!**

Example 3: K gap joint with RHS-chord and SHS-brace members

Check of validity: (see section 8)



1. $b_i/b_0 = \frac{7}{20} = 0.35 \geq \text{Max} \begin{cases} 0.35 \Leftarrow \text{decisive} \\ 0.1 + 0.01 \cdot \frac{20}{1} = 0.3 \end{cases}$

2. $b_i/t_i = h_i/t_i = 7/0.5 = 14 \leq 35$
3. $b_0/t_0 = 20/1 = 20 \leq 35$
   und $h_0/t_0 = 10/1 = 10 \leq 35$
4. $0.5 \leq h_0/b_0 = 10/20 = 0.5 \leq 2.0$
5. $0.5 \leq h_i/b_i = 7/7 = 1 \leq 2.0$

6. $g = \frac{10 + 2 \cdot 2.5}{\tan 40°} - \frac{7}{\sin 40°} = 6.99 \text{ cm} \geq \text{Max} \begin{cases} 0.5 \cdot 20 \cdot \left(1 - \frac{2 \cdot 7 + 2 \cdot 7}{4 \cdot 20}\right) = 6.5 \text{ cm} \Leftarrow \text{decisive} \\ 0.5 + 0.5 = 1.0 \text{ cm} \end{cases}$

7. $g = 6.99 \text{ cm} \leq 1.5 \cdot 20 \cdot \left(1 - \frac{2 \cdot 7 + 2 \cdot 7}{4 \cdot 20}\right) = 19.5 \text{ cm}$

8. Members are at least class 2 sections
9. $\Theta_1 = \Theta_2 = 40° \geq 30°$

Check of eccentricities:

$$-0.55 \leq \frac{e}{h_0} = \frac{2.5}{10} = 0.25 \leq 0.25$$

Condition satisfied, which means, that the moments resulting from eccentricities may be neglected in the design of the connection. The tension chord does not have to be verified for the moments of eccentricities as well.

Determination of the design resistance:

1. Condition (Verification of the chord force)
Determination of the plastic shear resistance according to DIN EN 1993-1-1:2005:

$$V_{pl,0,d} = \frac{A \cdot h_0}{b_0 + h_0} \cdot \frac{f_{y,d}}{\sqrt{3}} = \frac{54.93 \cdot 10}{10 + 20} \cdot \frac{35.5}{1.0 \cdot \sqrt{3}} = 375.3 \text{ kN}$$

With $v_{ed} = \frac{350 \cdot \sin 40°}{375.3} = 0.599$, $k_\alpha = 0.2 \cdot \frac{10}{20} + 0.35 = 0.45$ and $n_{0,Rd} = 1 - \left(1 - \sqrt{1 - 0.599^2}\right) \cdot 0.45 = 0.910$

$N_{0,Rd}$ can be determined according to section 11 as follows:

$N_{0,Rd} = 0.910 \cdot \frac{1950}{1.0} = 1774.5 \text{ kN} \geq N_{0,d} = 950 \text{ kN}$ **Condition satisfied!**

2. Condition (Verification of the brace force)

The following ratios are necessary for the use of the diagrams:

$\frac{t_i}{t_0} = \frac{5}{10} = 0.5$; $\frac{b_i}{b_0} = \frac{7}{20} = 0.35$; $\frac{b_0}{t_0} = \frac{20}{1} = 20$; $\frac{h_0}{b_0} = \frac{10}{20} = 0.5$; $\frac{b_i}{t_i} = \frac{7}{0.5} = 14$

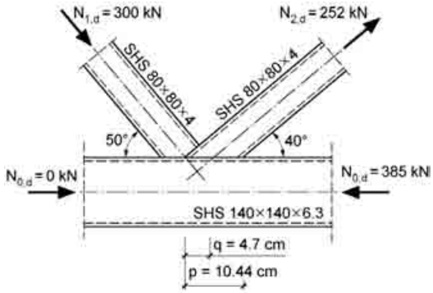
With the diagrams $n_{1,Rd} \approx 1{,}0$ and for $n_{2,Rd} \approx 0.135$ is provided. The maximum brace force can be determined as follows:

$$N_{i,Rd} = \begin{cases} \frac{1.0 \cdot 452}{1{,}0} = 452.0 \text{ kN} \\ \frac{0.135 \cdot 1950}{\sin 40° \cdot 1.0} = 409.5 \text{ kN} \Leftarrow \text{decisive} \end{cases}$$

$N_{i,Rd} = 409.5 \text{ kN} \geq N_{i,d} = 350 \text{ kN}$ **Condition satisfied!**

Example 4: K overlap joint with SHS

Check of validity: (see table 5)



1. $\frac{b_1}{b_0} = \frac{b_2}{b_0} = \frac{8}{14} = 0.57 \geq 0.25$

2. $\frac{h_0}{b_0} = 1.0$ and class 1 cross section

3. and 4. $\frac{b_i}{t_i} = \frac{h_i}{t_i} = 20 \leq 35$ and class 1 cross section

5. $\lambda_{0V} = \frac{4.7 \text{ x } 100}{10.44} = 45\%$ and $\begin{cases} \geq 25\ \% \\ \leq 100\ \% \end{cases}$ and $\frac{b_i}{b_j} = 1 \geq 0.75$

6. $\Theta_i > 30$

Determination of the design resistance:
For $\lambda_{0V} = 0.45$ case 2 is decisive. n_{Rd} has to be interpolated using the cases 1 and 3. With the ratios

$\frac{t_i}{t_0} = \frac{4}{6.3} = 0.63 \approx 0.6$, $\frac{b_1}{b_0} = \frac{80}{140} = 0.57$ and $\frac{b_0}{t_0} = \frac{140}{6.3} = 22.2$ the diagrams provide:

$n_{Rd,25} \approx 0.56$ $n_{Rd,50} \approx 0.81$

Interpolation:

$$n_{Rd} = 0.56 + (0.81 - 0.56) \cdot \frac{(45 - 25)}{25} = 0.76$$

$$N_{1,Rd} = 0.76 \cdot \frac{425.6}{1.0} = 323 \text{ kN}$$

Verification of the design joint resistance:

$$\frac{N_{1,Ed}}{N_{1,Rd}} = \frac{300}{323} = 0.93$$

Check of eccentricities:
Using the eccentricity e the ratio e/h_0 can be determined (see section 8):

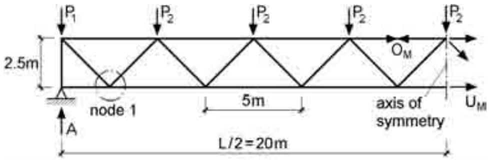
$e = -3.68$ cm

$$-0.55 \leq \frac{e}{h_0} = \frac{-3.68}{14} = -0.26 \leq 0.25$$

Condition satisfied, which means, that the moments resulting from eccentricities may be neglected in the design of the connection. For the design of the compression chord the eccentricities have to be regarded.

Example 5: Lattice girder L = 40 m

Rectangular hollow sections made of S 355 J2H (hot rolled). The example deals with a roof girder designed as a warren truss. The single span girder is loaded by the self-weight, snow and suction forces due to wind. The loads are combined according to DIN EN 1990:2002. Afterwards the verifications against buckling and for the joint resistances are carried out.



Loading table:

Load case	Dead load G	Snow S	Wind (suction) Ws
P1	9.85 kN	7.8 kN	–6.9 kN
P2	19.7 kN	15.6 kN	–13.8 kN

(The dead load includes the self-weight of the girder.)

Decisive load combinations according to DIN EN 1990:2002:

LCC 1: 1.35 * G + 1.5 * S

LCC 2: 0.9 * G + 1.5 * Ws

Internal forces	LCC 1:	LCC 2:
Load at each node:	$P_{1,d} = 1.35 \cdot 19.7 + 1.5 \cdot 15.6 = 50$ kN	$P_{1,d} = -3$ kN
	$P_{2,d} = P_{1,d}/2 = 25$ kN	$P_{2,d} = -1.5$ kN
Bearing reaction:	$A_d = 3.5 \cdot 50 + 25 = 200$ kN	$A_d = -3.5 \cdot 3 - 1.5 = -12$ kN
max. force in upper chord:	$O_M = \frac{-(200-25) \cdot 17.5 + 50 \cdot (12.5 + 7.5 + 2.5)}{2.5} = \underline{\underline{-775 \text{ kN}}}$	$O_M = 46.5$ kN
max. force in lower chord:	$U_M = 775 + 50/2 = \underline{\underline{800 \text{ kN}}}$	$U_M = \underline{\underline{-48 \text{ kN}}}$
max. force in braces:	$D_1 = \pm (200 - 25) \cdot \sqrt{2} = \underline{\underline{\pm 247.5 \text{ kN}}}$	$D_1 = \pm 14.9$ kN

Buckling of the upper chord member (SHS 140 x 8):

The nodes of the upper chords are fixed laterally.
Buckling length for hollow section chord members according to Annex BB.1.3 of DIN EN 1993-1-1: $L_{cr} = 0.9 \cdot 500 = 450$ cm. Using the design-support of section 6 the required cross section can be chosen. With. $N_{Ed} = -775$ kN and $L_{cr} = 4.5$ m follows a hollow profile 140 x 140 x 8: $I = 1195\ cm^4$, $N_{pl} = 1475$ kN (see section 15).

$$N_{cr} = \frac{\pi^2 EI}{L_{cr}^2} = \frac{\pi^2 21000 \cdot 1195}{450^2} = 1223 \text{ kN}; \ \bar{\lambda} = \sqrt{\frac{N_{pl}}{N_{cr}}} = \sqrt{\frac{1475}{1223}} = 1.1 \Rightarrow \chi \approx 0.596 \text{ (buckling curve a, see sect. 5)}$$

Verification against buckling for O_M: $\frac{N_{Ed}}{\chi \cdot N_{pl}/\gamma_{M1}} = \frac{775}{0.596 \cdot 1475/1.0} = \underline{\underline{0.9 < 1.0}}$

Buckling of the lower chord member (SHS 140 x 6.3) :

Perpendicular to the girder-plane the lower chord is fixed at the bearings and in mid-span by structural elements.
Buckling length for hollow section chord members according to Annex BB.1.3 of DIN EN 1993-1-1: $L_{cr} = 0.9 \cdot 2000 = 1800$ cm

$$N_{cr} = \frac{\pi^2 EI}{L_{cr}^2} = \frac{\pi^2 21000 \cdot 983{,}9}{1800^2} = 62.9 \text{ kN}; \ \bar{\lambda} = \sqrt{\frac{N_{pl}}{N_{cr}}} = \sqrt{\frac{1181}{62.9}} = 4.33 \Rightarrow \chi \approx 0.051 \text{ (buckling curve a, see sect. 5)}$$

Verification against buckling for U_M: $\frac{N_{Ed}}{\chi \cdot N_{pl}/\gamma_{M1}} = \frac{46.5}{0.051 \cdot 1181/1.0} = \underline{\underline{0.77 < 1.0}}$

Buckling of the brace members (SHS 80 x 5):

The brace members are welded continuously to the chord members.
Since $b_i = 0.8$ cm $< 0.6 \cdot b_0 = 0.6 \cdot 14 = 8.4$ cm and the connection to the chords is presumed as continuously welded the buckling length for the brace members according to Annex BB.1.3 of DIN EN 1993-1-1 is:

$$L_{cr} = 0.75 \cdot 250 \cdot \sqrt{2} = 265 \text{ cm}$$

This length is valid for in-plane as well as out-of-plane buckling of the brace members.

$$N_{cr} = \frac{\pi^2 EI}{L_{cr}^2} = \frac{\pi^2 21000 \cdot 136.6}{265^2} = 403 \text{ kN}; \ \bar{\lambda} = \sqrt{\frac{N_{pl}}{N_{cr}}} = \sqrt{\frac{523}{403}} = 1.14 \Rightarrow \chi \approx 0.562 \text{ (buckling curve a, see sect. 5)}$$

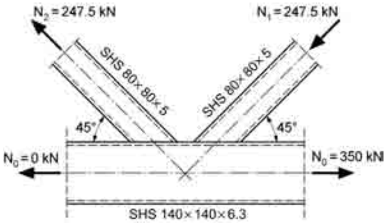
Verification against buckling for D_1: $\frac{N_{Ed}}{\chi \cdot N_{pl}/\gamma_{M1}} = \frac{247.5}{0.562 \cdot 523/1.0} = \underline{\underline{0.84 < 1.0}}$

Design joint resistance of node 1:

1. $b_i/b_0 = 8/14 = 0.57 \geq 0.35$
2. $b_i/t_i = h_i/t_i = 8/0.5 = 16 \leq 35$
3. and 10. $15 \leq b_0/t_0 = 14/0.63 = 22.2 \leq 35$
4. and 5. $h_i/b_i = 1$ (QHP)

6. and 7. $g = 3.1$ cm $\begin{cases} \geq 0.5 \cdot 14 \cdot \left(1 - \frac{8}{14}\right) = 3.0 \text{ cm} \\ \leq 1.5 \cdot 14 \cdot \left(1 - \frac{8}{14}\right) = 9.0 \text{ cm} \end{cases}$ where e = 2 mm

(The eccentricity is within the range according to section 8)
8. Members are at least class 2 sections
9. $\Theta_1 = \Theta_2 = 45° \geq 30°$
11. $0.6 \leq \frac{b_1 + b_2}{2 \cdot b_1} = \frac{8 + 8}{2 \cdot 8} = 1 \leq 1.3$



Determination of $N_{i,Rd}$:
With $k_n = 1.0$ (tension chord) and $\frac{b_1 + b_2}{2 \cdot b_0} = 0.57$ the diagram in section 9 provides:

$n_{Rd} \approx 0.20$ $\quad N_{i,RD} = \frac{0.20 \cdot 1181}{0.707 \cdot 1.0} = 334$ kN

Verification of the design joint resistance: $\frac{N_{i,d}}{N_{i,Rd}} = \frac{247.5}{334} = \underline{\underline{0.74 < 1.0}}$

14 Circular MSH sections according DIN EN 10210

Dimensions d mm	t mm	A cm²	G kg/m	U m²/m	Bending and Torsion $I = I_T/2$ cm⁴	W_{el} cm³	i cm	max S cm³	$f_y = 35.5$ kN/cm² N_{pl} kN	V_{pl} kN	M_{pl} kNm	Class S 355
42.4	3.2	3.941	3.094	0.133	7.620	3.594	1.391	2.464	139.9	51.42	1.750	1
	4	4.825	3.788	0.133	8.991	4.241	1.365	2.960	171.3	62.96	2.101	1
	5	5.875	4.612	0.133	10.46	4.932	1.334	3.518	208.6	76.65	2.498	1
	6.3	7.145	5.609	0.133	11.99	5.657	1.296	4.147	253.6	93.23	2.944	1
48.3	3.2	4.534	3.559	0.152	11.59	4.797	1.599	3.260	161.0	59.16	2.315	1
	4	5.567	4.370	0.152	13.77	5.701	1.573	3.936	197.6	72.64	2.794	1
	5	6.802	5.339	0.152	16.15	6.689	1.541	4.708	241.5	88.75	3.343	1
	6.3	8.313	6.525	0.152	18.74	7.761	1.502	5.598	295.1	108.5	3.975	1
60.3	4	7.075	5.554	0.189	28.17	9.344	1.996	6.350	251.2	92.31	4.509	1
	5	8.687	6.819	0.189	33.48	11.10	1.963	7.666	308.4	113.3	5.443	1
	6.3	10.69	8.390	0.189	39.49	13.10	1.922	9.227	379.4	139.5	6.551	1
	8	13.14	10.32	0.189	45.99	15.25	1.871	11.03	466.6	171.5	7.829	1
88.9	5	13.18	10.35	0.279	116.4	26.18	2.972	17.62	467.9	172.0	12.51	1
	6.3	16.35	12.83	0.279	140.2	31.55	2.929	21.53	580.4	213.3	15.29	1
	8	20.33	15.96	0.279	168.0	37.79	2.874	26.26	721.8	265.3	18.65	1
	10	24.79	19.46	0.279	196.0	44.09	2.812	31.29	879.9	323.4	22.22	1
	12.5	30.00	23.55	0.279	224.8	50.57	2.737	36.81	1 065	391.5	26.13	1
101.6	5	15.17	11.91	0.319	177.5	34.93	3.420	23.35	538.7	198.0	16.58	1
	6.3	18.86	14.81	0.319	215.1	42.34	3.377	28.65	669.6	246.1	20.34	1
	8	23.52	18.47	0.319	259.5	51.08	3.321	35.13	835.1	306.9	24.94	1
	10	28.78	22.59	0.319	305.4	60.12	3.258	42.12	1 022	375.5	29.90	1
	12.5	34.99	27.47	0.319	354.1	69.70	3.181	49.94	1 242	456.5	35.46	1
114.3	5	17.17	13.48	0.359	256.9	44.96	3.868	29.89	609.5	224.0	21.22	1
	6.3	21.38	16.78	0.359	312.7	54.72	3.825	36.78	758.8	278.9	26.12	1
	8	26.72	20.97	0.359	379.5	66.40	3.769	45.28	948.4	348.6	32.15	1
	10	32.77	25.72	0.359	449.7	78.68	3.704	54.56	1 163	427.5	38.74	1
	12.5	39.98	31.38	0.359	525.7	91.98	3.626	65.10	1 419	521.6	46.22	1
	16	49.41	38.79	0.359	612.6	107.2	3.521	77.99	1 754	644.7	55.37	1
139.7	5	21.16	16.61	0.439	480.5	68.80	4.766	45.38	751.1	276.1	32.22	1
	6.3	26.40	20.73	0.439	588.6	84.27	4.722	56.10	937.3	344.5	39.83	1
	8	33.10	25.98	0.439	720.3	103.1	4.665	69.46	1 175	431.9	49.32	1
	10	40.75	31.99	0.439	861.9	123.4	4.599	84.28	1 446	531.7	59.84	1
	12.5	49.95	39.21	0.439	1 020	146.0	4.519	101.4	1 773	651.8	72.03	1
	16	62.18	48.81	0.439	1 209	173.1	4.410	123.1	2 207	811.3	87.40	1
168.3	8	40.29	31.63	0.529	1 297	154.2	5.675	102.9	1 430	525.7	73.04	1
	10	49.73	39.04	0.529	1 564	185.9	5.608	125.5	1 765	648.9	89.08	1
	12.5	61.18	48.03	0.529	1 868	222.0	5.526	152.0	2 172	798.3	107.9	1
	16	76.55	60.10	0.529	2 244	266.7	5.414	186.2	2 718	998.9	132.2	1
	20	93.18	73.15	0.529	2 608	309.9	5.291	221.3	3 308	1 216	157.1	1
177.8	8	42.68	33.50	0.559	1 541	173.4	6.010	115.4	1 515	556.8	81.94	1
	10	52.72	41.38	0.559	1 862	209.4	5.943	141.0	1 871	687.8	100.1	1
	12.5	64.91	50.96	0.559	2 230	250.8	5.861	171.1	2 304	847.0	121.5	1
	16	81.33	63.84	0.559	2 687	302.3	5.748	210.1	2 887	1 061	149.2	1
	20	99.15	77.83	0.559	3 136	352.7	5.624	250.3	3 520	1 294	177.7	1
193.7	8	46.67	36.64	0.609	2 016	208.1	6.572	138.0	1 657	609.0	98.00	1
	10	57.71	45.30	0.609	2 442	252.1	6.504	168.9	2 049	753.0	119.9	1
	12.5	71.16	55.86	0.609	2 934	303.0	6.422	205.5	2 526	928.5	145.9	1
	16	89.32	70.12	0.609	3 554	367.0	6.308	253.3	3 171	1 165	179.8	1
	20	109.1	85.67	0.609	4 171	430.6	6.182	303.1	3 874	1 424	215.2	1
	25	132.5	104.0	0.609	4 817	497.4	6.030	358.4	4 704	1 729	254.4	1
	30	154.3	121.1	0.609	5 342	551.5	5.884	406.5	5 477	2 013	288.6	1

For further available dimensions see MSH technical information 1

Dimensions d mm	t mm	A cm^2	G kg/m	U m^2/m	Bending and Torsion $I = I_T/2$ cm^4	W_{el} cm^3	i cm	max S cm^3	$f_y = 35.5$ kN/cm^2 N_{pl} kN	V_{pl} kN	M_{pl} kNm	Class S 355
219.1	10	65.69	51.57	0.688	3 598	328.5	7.401	218.8	2 332	857.1	155.3	1
	12.5	81.13	63.69	0.688	4 345	396.6	7.318	267.1	2 880	1 059	189.6	1
	16	102.1	80.14	0.688	5 297	483.5	7.203	330.7	3 624	1 332	234.8	1
	20	125.1	98.20	0.688	6 261	571.5	7.075	397.7	4 441	1 632	282.4	1
	25	152.4	119.7	0.688	7 298	666.2	6.919	473.5	5 412	1 989	336.2	1
	30	178.2	139.9	0.688	8 167	745.5	6.769	540.9	6 327	2 325	384.0	1
244.5	8	59.44	46.66	0.768	4 160	340.3	8.366	223.8	2 110	775.6	158.9	1
	10	73.67	57.83	0.768	5 073	415.0	8.298	275.1	2 615	961.3	195.3	1
	12.5	91.11	71.52	0.768	6 147	502.9	8.214	336.7	3 234	1 189	239.1	1
	16	114.9	90.16	0.768	7 533	616.2	8.098	418.4	4 077	1 499	297.1	1
	20	141.1	110.7	0.768	8 957	732.7	7.969	505.3	5 008	1 841	358.8	1
	25	172.4	135.3	0.768	10 517	860.3	7.811	604.9	6 120	2 249	429.4	1
	30	202.2	158.7	0.768	11 854	969.7	7.658	694.7	7 177	2 638	493.2	1
273	10	82.62	64.86	0.858	7 154	524.1	9.305	346.0	2 933	1 078	245.7	1
	12.5	102.3	80.30	0.858	8 697	637.2	9.221	424.5	3 632	1 335	301.4	1
	16	129.2	101.4	0.858	10 707	784.4	9.104	529.1	4 586	1 686	375.6	1
	20	159.0	124.8	0.858	12 798	937.6	8.973	641.4	5 643	2 074	455.4	1
	25	194.8	152.9	0.858	15 127	1 108	8.813	771.4	6 915	2 541	547.7	1
	30	229.0	179.8	0.858	17 162	1 257	8.657	890.2	8 130	2 988	632.1	1
	36	268.0	210.4	0.858	19 254	1 411	8.475	1 019	9 515	3 497	723.4	1
	40	292.8	229.8	0.858	20 455	1 499	8.358	1 096	10 394	3 820	778.5	1
323.9	8	79.39	62.32	1.018	9 910	611.9	11.17	399.3	2 818	1 036	283.5	2
	10	98.61	77.41	1.018	12 158	750.7	11.10	492.8	3 501	1 287	349.9	1
	12.5	122.3	95.99	1.018	14 847	916.7	11.02	606.4	4 341	1 596	430.5	1
	16	154.8	121.5	1.018	18 390	1 136	10.90	759.1	5 494	2 019	539.0	1
	20	190.9	149.9	1.018	22 139	1 367	10.77	924.9	6 779	2 491	656.7	1
	25	234.8	184.3	1.018	26 400	1 630	10.60	1 119	8 334	3 063	794.8	1
	30	277.0	217.4	1.018	30 219	1 866	10.44	1 300	9 833	3 614	923.1	1
	36	325.6	255.6	1.018	34 263	2 116	10.26	1 500	11 559	4 249	1 065	1
	40	356.8	280.1	1.018	36 657	2 263	10.14	1 623	12 665	4 655	1 152	1
355.6	10	108.6	85.23	1.117	16 223	912.5	12.22	597.4	3 854	1 417	424.1	2
	12.5	134.7	105.8	1.117	19 852	1 117	12.14	736.1	4 783	1 758	522.6	1
	16	170.7	134.0	1.117	24 663	1 387	12.02	923.3	6 060	2 227	655.5	1
	20	210.9	165.5	1.117	29 792	1 676	11.89	1 128	7 486	2 751	800.6	1
	25	259.7	203.8	1.117	35 677	2 007	11.72	1 369	9 218	3 388	971.9	1
	30	306.9	240.9	1.117	41 011	2 307	11.56	1 595	10 894	4 004	1 132	1
	36	361.5	283.7	1.117	46 737	2 629	11.37	1 846	12 832	4 716	1 311	1
	40	396.6	311.3	1.117	50 171	2 822	11.25	2 003	14 079	5 175	1 422	1
406.4	10	124.5	97.76	1.277	24 476	1 205	14.02	785.8	4 421	1 625	557.9	2
	12.5	154.7	121.4	1.277	30 031	1 478	13.93	970.1	5 491	2 018	688.7	1
	16	196.2	154.0	1.277	37 449	1 843	13.81	1 220	6 966	2 561	866.2	1
	20	242.8	190.6	1.277	45 432	2 236	13.68	1 494	8 619	3 168	1 061	1
	25	299.6	235.1	1.277	54 702	2 692	13.51	1 821	10 634	3 909	1 293	1
	30	354.7	278.5	1.277	63 224	3 111	13.35	2 130	12 594	4 629	1 512	1
	36	418.9	328.8	1.277	72 520	3 569	13.16	2 477	14 871	5 466	1 759	1
	40	460.4	361.4	1.277	78 186	3 848	13.03	2 696	16 345	6 008	1 914	1
457	10	140.4	110.2	1.436	35 091	1 536	15.81	999.2	4 985	1 832	709.4	2
	12.5	174.6	137.0	1.436	43 145	1 888	15.72	1 235	6 197	2 278	877.0	2
	16	221.7	174.0	1.436	53 959	2 361	15.60	1 557	7 869	2 892	1 105	1
	20	274.6	215.5	1.436	65 681	2 874	15.47	1 911	9 747	3 583	1 357	1
508	10	156.5	122.8	1.596	48 520	1 910	17.61	1 240	5 554	2 041	880.5	3
	12.5	194.6	152.7	1.596	59 755	2 353	17.52	1 535	6 908	2 539	1 090	2
	16	247.3	194.1	1.596	74 909	2 949	17.40	1 937	8 779	3 227	1 375	1
	20	306.6	240.7	1.596	91 428	3 600	17.27	2 383	10 885	4 001	1 692	1

For further available dimensions see MSH technical information 1

15 Square MSH sections according DIN EN 10210

Dimensions b x b mm	t mm	A cm^2	G kg/m	U m^2/m	Bending $I_y = I_z$ cm^4	W_{el} cm^3	$i_y = i_z$ cm	I_T cm^4	f_y = 35.5 kN/cm^2 N_{pl} kN	V_{pl} kN	M_{pl} kNm	Class S 355
40 x 40	**4.0**	**5.588**	4.387	0.1497	**11.83**	5.915	1.45	19.48	198.4	57.27	2.641	1
	5.0	**6.732**	5.284	0.1471	**13.37**	6.684	1.41	22.50	239.0	68.99	3.075	1
	6.3	**8.067**	6.332	0.1438	**14.68**	7.339	1.35	25.36	286.4	82.67	3.516	1
50 x 50	**4.0**	**7.188**	5.643	0.1897	**24.97**	9.990	1.86	40.39	255.2	73.67	4.357	1
	5.0	**8.732**	6.854	0.1871	**28.88**	11.55	1.82	47.56	310.0	89.48	5.158	1
	6.3	**10.59**	8.310	0.1838	**32.76**	13.10	1.76	55.19	375.8	108.5	6.037	1
60 x 60	**4.0**	**8.788**	6.899	0.2297	**45.39**	15.13	2.27	72.51	312.0	90.06	6.499	1
	5.0	**10.73**	8.424	0.2271	**53.26**	17.75	2.23	86.40	381.0	110.0	7.773	1
	6.3	**13.11**	10.29	0.2238	**61.65**	20.55	2.17	102.0	465.3	134.3	9.229	1
	8.0	**15.95**	12.52	0.2194	**69.73**	23.24	2.09	118.2	566.3	163.5	10.81	1
70 x 70	**4.0**	**10.39**	8.155	0.2697	**74.69**	21.34	2.68	118.2	368.8	106.5	9.067	1
	5.0	**12.73**	9.994	0.2671	**88.50**	25.29	2.64	142.0	452.0	130.5	10.92	1
	6.3	**15.63**	12.27	0.2638	**103.8**	29.67	2.58	169.5	554.7	160.1	13.09	1
	8.0	**19.15**	15.04	0.2594	**119.8**	34.22	2.50	199.7	679.9	196.3	15.54	1
80 x 80	**4.0**	**11.99**	9.411	0.3097	**114.5**	28.61	3.09	180.0	425.6	122.9	12.06	1
	5.0	**14.73**	11.56	0.3071	**136.6**	34.15	3.05	217.4	523.0	151.0	14.60	1
	6.3	**18.15**	14.25	0.3038	**161.9**	40.47	2.99	261.5	644.2	186.0	17.63	1
	8.0	**22.35**	17.55	0.2994	**189.3**	47.32	2.91	311.7	793.5	229.1	21.13	1
	10.0	**26.93**	21.14	0.2942	**213.9**	53.47	2.82	360.0	955.9	275.9	24.60	1
90 x 90	**5.0**	**16.73**	13.13	0.3471	**199.6**	44.35	3.45	315.5	594.0	171.5	18.81	1
	6.3	**20.67**	16.22	0.3438	**238.3**	52.95	3.40	381.8	733.7	211.8	22.83	1
	8.0	**25.55**	20.06	0.3394	**281.5**	62.55	3.32	459.0	907.1	261.9	27.56	1
	10.0	**30.93**	24.28	0.3342	**322.3**	71.61	3.23	536.0	1 098	316.9	32.40	1
100 x 100	**5.0**	**18.73**	14.70	0.3871	**279.4**	55.89	3.86	439.4	665.0	192.0	23.56	1
	6.3	**23.19**	18.20	0.3838	**335.6**	67.11	3.80	534.2	823.1	237.6	28.71	1
	8.0	**28.75**	22.57	0.3794	**399.6**	79.92	3.73	646.2	1 021	294.7	34.86	1
	10.0	**34.93**	27.42	0.3742	**462.1**	92.42	3.64	761.0	1 240	357.9	41.26	1
	12.5	**42.07**	33.03	0.3678	**522.2**	104.4	3.52	879.0	1 494	431.2	48.05	1
120 x 120	**5.0**	**22.73**	17.84	0.4671	**497.7**	82.95	4.68	776.5	807.0	233.0	34.64	1
	6.3	**28.23**	22.16	0.4638	**602.9**	100.5	4.62	950.2	1 002	289.3	42.47	1
	8.0	**35.15**	27.60	0.4594	**726.3**	121.1	4.55	1 160	1 248	360.2	51.99	1
	10.0	**42.93**	33.70	0.4542	**852.1**	142.0	4.46	1 382	1 524	439.9	62.18	1
	12.5	**52.07**	40.88	0.4478	**981.8**	163.6	4.34	1 623	1 849	533.6	73.42	1
140 x 140	**6.3**	**33.27**	26.11	0.5438	**983.9**	140.6	5.44	1 540	1 181	340.9	58.92	1
	8.0	**41.55**	32.62	0.5394	**1 195**	170.7	5.36	1 892	1 475	425.8	72.54	1
	10.0	**50.93**	39.98	0.5342	**1 416**	202.3	5.27	2 272	1 808	521.9	87.36	1
	12.5	**62.07**	48.73	0.5278	**1 653**	236.1	5.16	2 696	2 204	636.1	104.1	1
	16.0	**76.61**	60.14	0.5188	**1 916**	273.7	5.00	3 196	2 720	785.1	124.3	1
	20.0	**91.71**	71.99	0.5085	**2 128**	304.0	4.82	3 634	3 256	939.8	143.0	1
150 x 150	**6.3**	**35.79**	28.09	0.5838	**1 223**	163.1	5.85	1 909	1 270	366.7	68.15	1
	8.0	**44.75**	35.13	0.5794	**1 491**	198.7	5.77	2 351	1 589	458.6	84.09	1
	10.0	**54.93**	43.12	0.5742	**1 773**	236.4	5.68	2 832	1 950	562.9	101.5	1
	12.5	**67.07**	52.65	0.5678	**2 080**	277.4	5.57	3 375	2 381	687.4	121.4	1
	16.0	**83.01**	65.17	0.5588	**2 430**	324.0	5.41	4 026	2 947	850.7	145.8	1
	17.5	**89.46**	70.23	0.5549	**2 553**	340.4	5.34	4 267	3 176	916.8	155.0	1
	20.0	**99.71**	78.27	0.5485	**2 724**	363.2	5.23	4 617	3 540	1021	168.8	1
160 x 160	**6.3**	**38.31**	30.07	0.6238	**1 499**	187.4	6.26	2 333	1 360	392.6	78.05	1
	8.0	**47.95**	37.64	0.6194	**1 831**	228.9	6.18	2 880	1 702	491.4	96.49	1
	10.0	**58.93**	46.26	0.6142	**2 186**	273.2	6.09	3 478	2 092	603.9	116.8	1

For further available dimensions see MSH technical information 1

Dimensions b x b mm	t mm	A cm^2	G kg/m	U m^2/m	Bending $I_y = I_z$ cm^4	W_{el} cm^3	$i_y = i_z$ cm	I_T cm^4	f_y = 35.5 kN/cm^2 N_{pl} kN	V_{pl} kN	M_{pl} kNm	Class S 355
160 x 160	**12.5**	**72.07**	56.58	0.6078	**2 576**	322.0	5.98	4 158	2 559	738.6	140.1	1
	16.0	**89.41**	70.19	0.5988	**3 028**	378.5	5.82	4 988	3 174	916.3	169.0	1
	17.5	**96.46**	75.72	0.5949	**3 191**	398.9	5.75	5 299	3 424	988.6	180.1	1
	20.0	**107.7**	84.55	0.5885	**3 422**	427.8	5.64	5 760	3 824	1 104	196.8	1
180 x 180	**6.3**	**43.35**	34.03	0.7038	**2 168**	240.9	7.07	3 361	1 539	444.2	99.87	1
	8.0	**54.35**	42.67	0.6994	**2 661**	295.6	7.00	4 162	1 930	557.0	123.9	1
	10.0	**66.93**	52.54	0.6942	**3 193**	354.8	6.91	5 048	2 376	685.9	150.5	1
	12.5	**82.07**	64.43	0.6878	**3 790**	421.1	6.80	6 070	2 914	841.1	181.5	1
	16.0	**102.2**	80.24	0.6788	**4 504**	500.4	6.64	7 343	3 629	1 047	220.5	1
	17.5	**110.5**	86.71	0.6749	**4 768**	529.8	6.57	7 833	3 921	1 132	235.8	1
	20.0	**123.7**	97.11	0.6685	**5 156**	572.9	6.46	8 576	4 392	1 268	259.2	1
200 x 200	**6.3**	**48.39**	37.98	0.7838	**3 011**	301.1	7.89	4 653	1 718	495.9	124.4	2
	8.0	**60.75**	47.69	0.7794	**3 709**	370.9	7.81	5 778	2 157	622.6	154.6	1
	10.0	**74.93**	58.82	0.7742	**4 471**	447.1	7.72	7 031	2 660	767.8	188.5	1
	12.5	**92.07**	72.28	0.7678	**5 336**	533.6	7.61	8 491	3 269	943.6	228.1	1
	16.0	**115.0**	90.29	0.7588	**6 394**	639.4	7.46	10 340	4 083	1 179	278.8	1
	17.5	**124.5**	97.70	0.7549	**6 794**	679.4	7.39	11 063	4 418	1 276	298.9	1
	20.0	**139.7**	109.7	0.7485	**7 393**	739.3	7.27	12 177	4 960	1 432	330.1	1
220 x 220	**6.3**	**53.43**	41.94	0.8638	**4 049**	368.1	8.71	6240	1 897	547.5	151.5	3
	8.0	**67.15**	52.7	0.8594	**5 002**	454.7	8.63	7 765	2 384	688.2	188.8	1
	10.0	**82.93**	65.10	0.8542	**6 050**	550.0	8.54	9 473	2 944	849.8	230.7	1
	12.5	**102.1**	80.13	0.8478	**7 254**	659.5	8.43	11 481	3 624	1 046	280.1	1
	16.0	**127.8**	100.3	0.8388	**8 749**	795.3	8.27	14 054	4 537	1 310	344.0	1
	17.5	**138.5**	108.7	0.8349	**9 324**	847.6	8.21	15 072	4 915	1 419	369.5	1
	20.0	**155.7**	122.2	0.8285	**10 198**	927.0	8.09	16 658	5 528	1 596	409.5	1
250 x 250	**8.0**	**76.75**	60.25	0.9794	**7 455**	596.4	9.86	11 525	2 725	786.6	246.5	2
	10.0	**94.93**	74.52	0.9742	**9 055**	724.4	9.77	14 106	3 370	972.8	302.0	1
	12.5	**117.1**	91.90	0.9678	**10 915**	873.2	9.66	17 164	4 156	1 200	368.1	1
	16.0	**147.0**	115.4	0.9588	**13 267**	1 061	9.50	21 138	5 219	1 507	454.5	1
	17.5	**159.5**	125.2	0.9549	**14 187**	1 135	9.43	22 732	5 661	1 634	489.3	1
	20.0	**179.7**	141.1	0.9485	**15 609**	1 249	9.32	25 244	6 380	1 842	544.6	1
260 x 260	**8.0**	**79.95**	62.76	1.019	**8 423**	647.9	10.3	13 006	2 838	819.4	267.4	2
	10.0	**98.93**	77.66	1.014	**10 242**	787.9	10.2	15 932	3 512	1 014	327.9	1
	12.5	**122.1**	95.83	1.008	**12 365**	951.1	10.1	19 409	4 334	1 251	400.1	1
	16.0	**153.4**	120.4	0.9988	**15 061**	1 159	9.91	23 942	5 446	1 572	494.7	1
	17.5	**166.5**	130.7	0.9949	**16 121**	1 240	9.84	25 766	5 909	1 706	533.0	1
	20.0	**187.7**	147.4	0.9885	**17 766**	1 367	9.73	28 650	6 664	1 924	594.0	1
300 x 300	**8.0**	**92.75**	72.81	1.179	**13 128**	875.2	11.9	20 194	3 293	950.5	359.6	1
	10.0	**114.9**	90.22	1.174	**16 026**	1 068	11.8	24 807	4 080	1 178	442.2	1
	12.5	**142.1**	111.5	1.168	**19 442**	1 296	11.7	30 333	5 044	1 456	541.3	1
	16.0	**179.0**	140.5	1.159	**23 850**	1 590	11.5	37 622	6 355	1 835	672.7	1
	17.5	**194.5**	152.7	1.155	**25 608**	1 707	11.5	40 587	6 903	1 993	726.4	1
	20.0	**219.7**	172.5	1.148	**28 371**	1 891	11.4	45 318	7 800	2 252	812.4	1
350 x 350	**10.0**	**134.9**	105.9	1.374	**25 884**	1 479	13.9	39 886	4 790	1383	608.9	3
	12.5	**167.1**	131.2	1.368	**31 541**	1 802	13.7	48 934	5 931	1 712	747.8	1
	16.0	**211.0**	165.7	1.359	**38 942**	2 225	13.6	60 990	7 491	2 162	933.5	1
400 x 400	**10.0**	**154.9**	121.6	1.574	**39 128**	1 956	15.9	60 092	5 500	1 588	802.3	4
	12.5	**192.1**	150.8	1.568	**47 839**	2 392	15.8	73 906	6 819	1 968	987.6	2
	16.0	**243.0**	190.8	1.559	**59 344**	2 967	15.6	92 442	8 627	2 490	1.237	1
	20.0	**299.7**	235.3	1.548	**71 535**	3 577	15.4	112 489	10 640	491.4	1.508	1

For further available dimensions see MSH technical information 1

16 Rectangular MSH sections according DIN EN 10210

Dimensions		A	G	Bending strong and weak axis						I_T	f_y = 35.5 kN/cm²			Class
h x b	t			I_y	$W_{el.y}$	i_y	I_z	$W_{el.z}$	i_z		N_{pl}	$M_{pl.y}$	$M_{pl.z}$	
mm	mm	cm²	kg/m	cm⁴	cm³	cm	cm⁴	cm³	cm	cm⁴	kN	kNm	kNm	S 355
50 x 30	**4.0**	**5.588**	4.387	**16.49**	6.596	1.72	**7.084**	4.722	1.13	16.59	198.4	3.051	2.089	1-1
	5.0	**6.732**	5.284	**18.71**	7.486	1.67	**7.888**	5.258	1.08	18.97	239.0	3.560	2.413	1-1
60 x 40	**4.0**	**7.188**	5.643	**32.83**	10.94	2.14	**17.03**	8.517	1.54	36.66	255.2	4.909	3.663	1-1
	5.0	**8.732**	6.854	**38.09**	12.70	2.09	**19.53**	9.767	1.50	42.98	310.0	5.820	4.318	1-1
80 x 40	**4.0**	**8.788**	6.899	**68.20**	17.05	2.79	**22.24**	11.12	1.59	55.19	312.0	7.744	4.686	1-1
	5.0	**10.73**	8.424	**80.28**	20.07	2.74	**25.70**	12.85	1.55	65.05	381.0	9.275	5.560	1-1
	6.3	**13.11**	10.29	**93.28**	23.32	2.67	**29.16**	14.58	1.49	75.63	465.3	11.03	6.531	1-1
90 x 50	**4.0**	**10.39**	8.155	**107.1**	23.80	3.21	**41.95**	16.78	2.01	97.52	368.8	10.60	6.970	1-1
	5.0	**12.73**	9.994	**127.3**	28.28	3.16	**49.21**	19.69	1.97	116.4	452.0	12.78	8.353	1-1
	6.3	**15.63**	12.27	**149.9**	33.30	3.10	**56.99**	22.80	1.91	137.7	554.7	15.34	9.947	1-1
	8.0	**19.15**	15.04	**173.6**	38.57	3.01	**64.58**	25.83	1.84	160.3	679.9	18.25	11.69	1-1
100 x 50	**4.0**	**11.19**	8.783	**139.6**	27.92	3.53	**46.19**	18.48	2.03	112.8	397.2	12.51	7.623	1-1
	5.0	**13.73**	10.78	**166.5**	33.30	3.48	**54.30**	21.72	1.99	134.7	487.5	15.13	9.152	1-1
	6.3	**16.89**	13.26	**197.1**	39.42	3.42	**63.05**	25.22	1.93	159.7	599.5	18.23	10.92	1-1
	8.0	**20.75**	16.29	**229.9**	45.98	3.33	**71.72**	28.69	1.86	186.4	736.7	21.79	12.89	1-1
100 x 60	**4.0**	**11.99**	9.411	**158.0**	31.61	3.63	**70.52**	23.51	2.43	155.9	425.6	13.87	9.680	1-1
	5.0	**14.73**	11.56	**189.1**	37.82	3.58	**83.59**	27.86	2.38	187.5	523.0	16.81	11.68	1-1
	6.3	**18.15**	14.25	**224.8**	44.96	3.52	**98.15**	32.72	2.33	224.4	644.2	20.32	14.03	1-1
	8.0	**22.35**	17.55	**263.8**	52.77	3.44	**113.3**	37.78	2.25	265.4	793.5	24.40	16.71	1-1
120 x 60	**4.0**	**13.59**	10.67	**248.7**	41.46	4.28	**83.09**	27.70	2.47	200.7	482.4	18.41	11.27	1-1
	5.0	**16.73**	13.13	**299.2**	49.87	4.23	**98.76**	32.92	2.43	241.8	594.0	22.40	13.63	1-1
	6.3	**20.67**	16.22	**358.3**	59.71	4.16	**116.4**	38.80	2.37	290.0	733.7	27.21	16.44	1-1
	8.0	**25.55**	20.06	**424.7**	70.79	4.08	**135.1**	45.05	2.30	344.3	907.1	32.91	19.67	1-1
	10.0	**30.93**	24.28	**488.1**	81.36	3.97	**151.5**	50.51	2.21	395.7	1 098	38.75	22.85	1-1
120 x 80	**5.0**	**18.73**	14.70	**365.4**	60.90	4.42	**192.9**	48.24	3.21	401.3	665.0	26.48	19.92	1-1
	6.3	**23.19**	18.20	**439.8**	73.30	4.36	**230.5**	57.62	3.15	486.6	823.1	32.30	24.22	1-1
	8.0	**28.75**	22.57	**525.3**	87.54	4.27	**272.6**	68.14	3.08	586.6	1 021	39.27	29.31	1-1
	10.0	**34.93**	27.42	**609.5**	101.6	4.18	**312.6**	78.14	2.99	687.6	1 240	46.56	34.54	1-1
140 x 80	**5.0**	**20.73**	16.27	**534.0**	76.28	5.08	**221.1**	55.28	3.27	499.4	736.0	33.48	22.59	1-1
	6.3	**25.71**	20.18	**645.8**	92.26	5.01	**264.8**	66.20	3.21	606.5	912.6	40.98	27.52	1-1
	8.0	**31.95**	25.08	**776.3**	110.9	4.93	**314.2**	78.55	3.14	732.9	1 134	50.04	33.40	1-1
	10.0	**38.93**	30.56	**908.1**	129.7	4.83	**361.9**	90.47	3.05	862.1	1 382	59.67	39.51	1-1
150 x 100	**5.0**	**23.73**	18.63	**738.7**	98.50	5.58	**392.3**	78.47	4.07	806.7	842.5	42.40	31.99	1-1
	6.3	**29.49**	23.15	**897.9**	119.7	5.52	**474.1**	94.81	4.01	986.5	1 047	52.08	39.18	1-1
	8.0	**36.75**	28.85	**1 087**	144.9	5.44	**569.3**	113.9	3.94	1 203	1 305	63.92	47.92	1-1
	10.0	**44.93**	35.27	**1 282**	171.0	5.34	**665.4**	133.1	3.85	1 432	1 595	76.70	57.24	1-1
	12.5	**54.57**	42.84	**1 488**	198.4	5.22	**763.1**	152.6	3.74	1 679	1 937	90.94	67.47	1-1
160 x 80	**5.0**	**22.73**	17.84	**744.0**	93.00	5.72	**249.3**	62.32	3.31	600.0	807.0	41.20	25.25	2-1
	6.3	**28.23**	22.16	**903.2**	112.9	5.66	**299.1**	74.78	3.26	729.6	1 002	50.55	30.81	1-1
	8.0	**35.15**	27.60	**1 091**	136.4	5.57	**355.8**	88.96	3.18	883.1	1 248	61.96	37.48	1-1
	10.0	**42.93**	33.70	**1 284**	160.6	5.47	**411.2**	102.8	3.10	1 041	1 524	74.20	44.48	1-1
	12.5	**52.07**	40.88	**1 485**	185.7	5.34	**464.7**	116.2	2.99	1 204	1 849	87.76	51.98	1-1
180 x 100	**5.0**	**26.73**	20.98	**1 153**	128.1	6.57	**460.1**	92.02	4.15	1 042	949.0	55.84	37.05	3-1
	6.3	**33.27**	26.11	**1 407**	156.4	6.50	**557.2**	111.4	4.09	1 277	1 181	68.79	45.47	1-1
	8.0	**41.55**	32.62	**1 713**	190.4	6.42	**671.1**	134.2	4.02	1 560	1 475	84.77	55.76	1-1
	10.0	**50.93**	39.98	**2 036**	226.2	6.32	**787.4**	157.5	3.93	1 862	1 808	102.2	66.82	1-1
	12.5	**62.07**	48.73	**2 385**	265.0	6.20	**907.6**	181.5	3.82	2 191	2 204	122.0	79.12	1-1
	16.0	**76.61**	60.14	**2 777**	308.6	6.02	**1 033**	206.6	3.67	2 564	2 720	146.0	93.55	1-1
200 x 100	**6.3**	**35.79**	28.09	**1 829**	182.9	7.15	**612.5**	122.5	4.14	1 475	1 270	81.04	49.66	2-1
	8.0	**44.75**	35.13	**2 234**	223.4	7.06	**739.0**	147.8	4.06	1 804	1 589	100.1	60.98	1-1
	10.0	**54.93**	43.12	**2 664**	266.4	6.96	**868.8**	173.8	3.98	2 156	1 950	121.0	73.21	1-1
	12.5	**67.07**	52.65	**3 136**	313.6	6.84	**1 004**	200.8	3.87	2 541	2 381	144.9	86.88	1-1
	16.0	**83.01**	65.17	**3 678**	367.8	6.66	**1 147**	229.5	3.72	2 982	2 947	174.3	103.1	1-1

For further available dimensions see MSH technical information 1

Dimensions h x b mm	t mm	A cm^2	G kg/m	I_y cm^4	$W_{el.y}$ cm^3	i_y cm	I_z cm^4	$W_{el.z}$ cm^3	i_z cm	I_T cm^4	N_{pl} kN	$M_{pl.y}$ kNm	$M_{pl.z}$ kNm	Class S 355
				Bending strong and weak axis							$f_y = 35.5$ kN/cm^2			
200 x 100	17.5	89.46	70.23	3 870	387.0	6.58	1 194	238.8	3.65	3 137	3 176	185.5	109.1	1-1
	20.0	99.71	78.27	4 140	414.0	6.44	1 254	250.8	3.55	3 350	3 540	202.3	117.6	1-1
200 x 120	6.3	38.31	30.07	2 065	206.5	7.34	929.0	154.8	4.92	2 028	1 360	89.71	62.81	2-1
	8.0	47.95	37.64	2 529	252.9	7.26	1 128	188.1	4.85	2 495	1 702	111.0	77.44	1-1
	10.0	58.93	46.26	3 026	302.6	7.17	1 337	222.9	4.76	3 001	2 092	134.5	93.42	1-1
	12.5	72.07	56.58	3 576	357.6	7.04	1 562	260.4	4.66	3 569	2 559	161.6	111.6	1-1
	16.0	89.41	70.19	4 221	422.1	6.87	1 813	302.2	4.50	4 247	3 174	195.2	133.7	1-1
	17.5	96.46	75.72	4 455	445.5	6.80	1 900	316.7	4.44	4 496	3 424	208.2	142.0	1-1
	20.0	107.7	84.55	4 791	479.1	6.67	2 019	336.5	4.33	4 856	3 824	227.9	154.4	1-1
220 x 120	6.3	40.83	32.05	2 610	237.3	8.00	1 010	168.4	4.98	2 315	1 449	103.8	67.90	3-1
	8.0	51.15	40.16	3 203	291.2	7.91	1 229	204.8	4.90	2 850	1 816	128.6	83.80	1-1
	10.0	62.93	49.40	3 844	349.4	7.82	1 459	243.1	4.81	3 431	2 234	156.1	101.2	1-1
	12.5	77.07	60.50	4 560	414.5	7.69	1 707	284.5	4.71	4 087	2 736	188.0	121.1	1-1
	16.0	95.81	75.21	5 413	492.1	7.52	1 988	331.3	4.55	4 873	3 401	228.1	145.5	1-1
	20.0	115.7	90.83	6 185	562.3	7.31	2 222	370.3	4.38	5 589	4 108	267.5	168.6	1-1
250 x 150	6.3	48.39	37.98	4 143	331.4	9.25	1 874	249.9	6.22	4 054	1 718	142.9	100.3	4-1
	8.0	60.75	47.69	5 111	408.9	9.17	2 298	306.4	6.15	5 021	2 157	177.7	124.4	2-1
	10.0	74.93	58.82	6 174	493.9	9.08	2 755	367.3	6.06	6 090	2 660	216.8	151.2	1-1
	12.5	92.07	72.28	7 387	590.9	8.96	3 265	435.4	5.96	7 326	3 269	262.7	182.5	1-1
	16.0	115.0	90.29	8 879	710.4	8.79	3 873	516.4	5.80	8 868	4 083	321.6	221.9	1-1
	17.5	124.5	97.70	9 448	755.9	8.71	4 098	546.4	5.74	9 463	4 418	344.9	237.4	1-1
	20.0	139.7	109.7	10 306	824.5	8.59	4 427	590.3	5.63	10 368	4 960	381.3	261.1	1-1
260 x 140	6.3	48.39	37.98	4 355	335.0	9.49	1 660	237.2	5.86	3 803	1 718	145.9	94.80	4-1
	8.0	60.75	47.69	5 373	413.3	9.40	2 032	290.3	5.78	4 704	2 157	181.5	117.5	2-1
	10.0	74.93	58.82	6 490	499.3	9.31	2 432	347.4	5.70	5 698	2 660	221.4	142.7	1-1
	12.5	92.07	72.28	7 767	597.4	9.18	2 876	410.9	5.59	6 841	3 269	268.3	172.0	1-1
	16.0	115.0	90.29	9 337	718.3	9.01	3 400	485.8	5.44	8 257	4 083	328.4	208.8	1-1
	17.5	124.5	97.70	9 936	764.3	8.93	3 592	513.2	5.37	8 800	4 418	352.2	223.2	1-1
	20.0	139.7	109.7	10 838	833.7	8.81	3 872	553.1	5.26	9 619	4 960	389.4	245.2	1-1
260 x 180	6.3	53.43	41.94	5 166	397.4	9.83	2 929	325.4	7.40	5 810	1 897	168.6	130.9	4-1
	8.0	67.15	52.72	6 390	491.5	9.75	3 608	400.9	7.33	7 221	2 384	210.1	162.9	2-1
	10.0	82.93	65.10	7 741	595.5	9.66	4 351	483.4	7.24	8 798	2 944	256.9	198.8	1-1
	12.5	102.1	80.13	9 299	715.3	9.54	5 196	577.3	7.13	10 643	3 624	312.2	240.9	1-1
	16.0	127.8	100.3	11 245	865.0	9.38	6 231	692.3	6.98	12 993	4 537	383.8	295.0	1-1
	17.5	138.5	108.7	11 998	922.9	9.31	6 624	736.0	6.92	13 918	4 915	412.5	316.5	1-1
	20.0	155.7	122.2	13 147	1 011	9.19	7 215	801.6	6.81	15 351	5 528	457.6	350.1	1-1
300 x 200	8.0	76.75	60.25	9 717	647.8	11.3	5 184	518.4	8.22	10 562	2 725	276.7	209.1	3-1
	10.0	94.93	74.52	11 819	788.0	11.2	6 278	627.8	8.13	12 908	3 370	339.2	255.9	1-1
	12.5	117.1	91.90	14 273	951.5	11.0	7 537	753.7	8.02	15 677	4 156	413.7	311.3	1-1
	16.0	147.0	115.4	17 390	1 159	10.9	9 109	910.9	7.87	19 252	5 219	511.4	383.4	1-1
	17.5	159.5	125.2	18 616	1 241	10.8	9 717	971.7	7.81	20 677	5 661	550.9	412.3	1-1
	20.0	179.7	141.1	20 518	1 368	10.7	10 647	1 065	7.70	22 912	6 380	613.6	457.9	1-1
400 x 200	8.0	92.75	72.81	19 562	978.1	14.5	6 660	666.0	8.47	15 735	3 293	427.1	263.7	4-1
	10.0	114.9	90.22	23 914	1 196	14.4	8 084	808.4	8.39	19 259	4 080	525.4	323.4	4-1
	12.5	142.1	111.5	29 063	1 453	14.3	9 738	973.8	8.28	23 438	5 044	643.7	394.5	2-1
	16.0	179.0	140.5	35 738	1 787	14.1	11 824	1 182	8.13	28 871	6 355	800.7	487.9	1-1
450 x 250	10.0	134.9	105.9	36 895	1 640	16.5	14 819	1 185	10.5	33 284	4 790	710.0	472.4	4-1
	12.5	167.1	131.2	45 026	2 001	16.4	17 973	1 438	10.4	40 719	5 931	872.4	578.9	3-1
	16.0	211.0	165.6	55 705	2 476	16.2	22 041	1 763	10.2	50 545	7 491	1 090	720.3	1-1
500 x 300	10.0	154.9	121.6	53 762	2 150	18.6	24 439	1 629	12.6	52 450	5 500	921.1	648.1	4-1
	12.5	192.1	150.8	65 813	2 633	18.5	29 780	1 985	12.5	64 389	6 819	1 134	796.5	4-1
	16.0	243.0	190.8	81 783	3 271	18.3	36 768	2 451	12.3	80 329	8 627	1 422	995.3	2-1
	20.0	299.7	235.3	98 777	3 951	18.2	44 078	2 939	12.1	97 447	10 640	1 734	1 210	1-1

For further available dimensions see MSH technical information 1

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