Calculation dimensions for drive by parallel or diagonal square head ISO 5211

The advantage of this connection is easy assembly and disassembly. The disadvantage is the low manufacturing precision and consequent consequences for limited speeds and small torques.
For a simplified calculation, it is assumed that the joint is without will, and that the torque causes the contact stress to be half of each function area of the square head. It is possible to assume a triangular distribution of this stress.
Load distribution will differ from the assumption due to production inaccuracy due to looseness or prestressing of joints and shaft deformations by from torsion torque. These deviations can include in the calculation a coefficient max. stress $S_s = 1{,}3 - 2$ the lower value of which applies to short joints $l \leq s$ and for high accuracy of manufacturing.

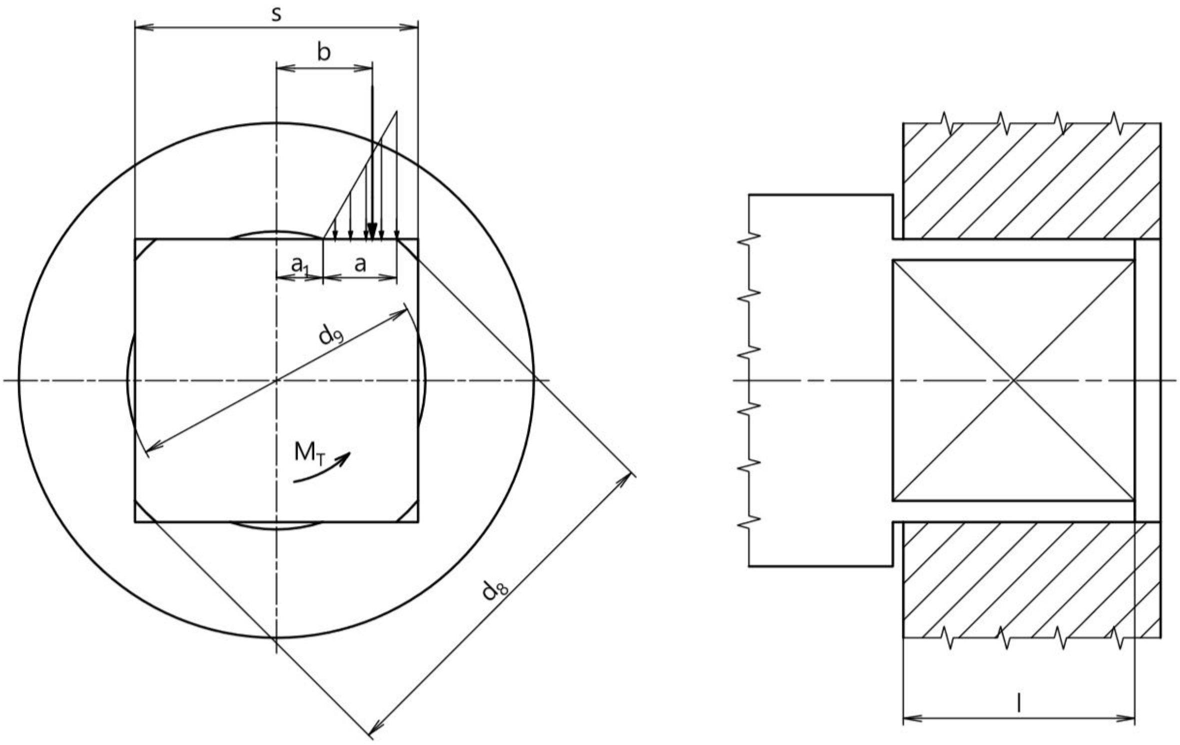

fig. 1 The square head joint

Torsion stress:

$$\tau = \frac{0{,}601 M_T}{(0{,}5s)^3} \leq \tau_{all}$$

τ	torsion stress	[MPa]
M_T	torque	[Nm]
s	width square head	[mm]
τ_{all}	Allowable torsion stress	[MPa]

Allowable torsion stress:

$$\tau_{all} = \frac{0{,}4R_{p0,2T}}{S_F} * C_c$$

τ_{all}	Allowable torsion stress	[MPa]
$R_{p0,2T}$	the minimum yield strength or 0,2% proof strength at calculation temperature	[MPa]
S_F	safety factor	[]
C_c	coefficient of use of joints according to load	[]

Coefficient of use of joints according to load:

load	[]
Unidirectional load, non-impact load	0,8
Unidirectional load, with a small impact load	0,7
Unidirectional load, with a big impact load	0,6
Alternating load, with a small impact load	0,45
Alternating load, with a big impact load	0,25

Bearing stress:

$$p = \frac{M_T * s_s}{2a * l * b} \leq \sigma_{all}$$

p	bearing stress	[MPa]
M_T	torque	[Nm]
s_s	coefficient of maximum stress increase	[]
a	length square head load	[mm]
l	length square head in the hub	[mm]
b	distance of the resultant of the pressure	[mm]

Distance of the resultant of the pressure:

$$b = a_1 + \frac{2}{3}a$$

b	distance of the resultant of the pressure	[mm]
a_1	length square head without load	[mm]
a	length square head load	[mm]

Length square head without load:

$$a_1 = \frac{d_9}{2}\sin\left(\cos^{-1}\frac{s}{d_9}\right)$$

a_1	length square head without load	[mm]
d_9	free diameter	[mm]
s	width square head	[mm]

Length square head with load:

$$a = \frac{d_8}{2}\sin\left(\cos^{-1}\frac{s}{d_8}\right) - a_1$$

a	length square head with load	[mm]
d_8	diameter square head	[mm]
s	width square head	[mm]
a_1	length square head without load	[mm]

Allowable bearing stress:

$$\sigma_{all} = \frac{0{,}9R_{p0,2T}}{S_F} * C_c$$

σ_{all}	allowable bearing stress	[MPa]
$R_{p0,2T}$	the minimum yield strength or 0,2% proof strength at calculation temperature	[MPa]
S_F	safety factor	[]
C_c	coefficient of use of joints according to load	[]

Example:

We have to determine the safety factor for the bearing stress of the hub. Dimensions will be from the standard EN ISO 5211 flange type F25. The hub material will be GGG70.
M_T=8000Nm, $R_{p0,2T}$=380MPa, s_s=1,5, s=55mm, l=52mm, d_8=72,2mm, d_9=57,9mm.

Length square head without load:

$$a_1 = \frac{d_9}{2}\sin\left(\cos^{-1}\frac{s}{d_9}\right) = \frac{57{,}9}{2}\sin\left(\cos^{-1}\frac{55}{57{,}9}\right) = 9{,}05mm$$

Length square head load:

$$a = \frac{d_8}{2}\sin\left(\cos^{-1}\frac{s}{d_8}\right) - a_1 = \frac{72{,}2}{2}\sin\left(\cos^{-1}\frac{55}{72{,}2}\right) - 9{,}05 = 14{,}34\,mm$$

Distance of the resultant of the pressure:

$$b = a_1 + \frac{2}{3}a = 9{,}05 + \frac{2}{3}14{,}34 = 18{,}61mm$$

Bearing stress:

$$p = \frac{M_T * s_s}{2a * l * b} = \frac{8000000 * 1{,}5}{2 * 14{,}34 * 52 * 18{,}61} = 432{,}4MPa$$

Safety factor under bearing stress:

$$S_F = \frac{0{,}9R_{p0,2T}}{p} * C_c = \frac{0{,}9 * 380}{432{,}4} * 0{,}8 = 0{,}63 \rightarrow does\ not\ suit$$

Value safety factor for the bearing stress is lower than 1. The square head does not meet any safety of the connection.

Literature:

AISC: Specification for structural steel buildings: Allowable Stress design and plastic design 1989
František Boháček: Části a mechanismy strojů I. 1984.
Joseph E. Shigley, Charles R. Mischke, Richard G. Budynas: Konstruování strojních součástí 2010.