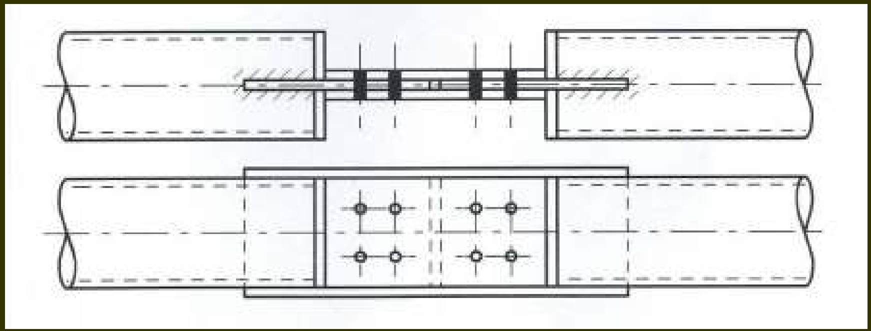
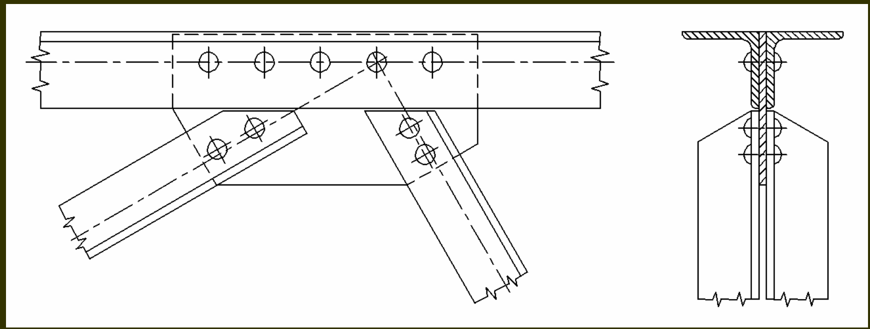
Steel Structures

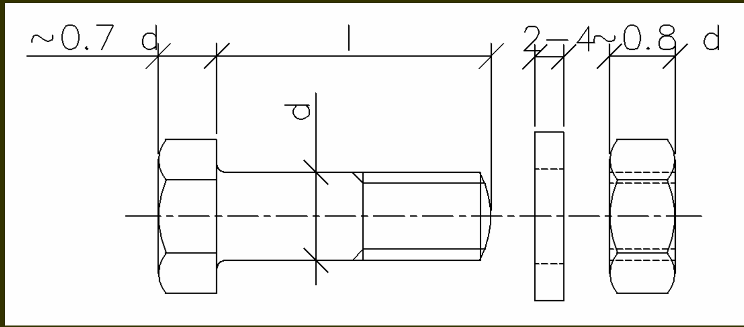
Bolts

The bolts and rivets





The bolt



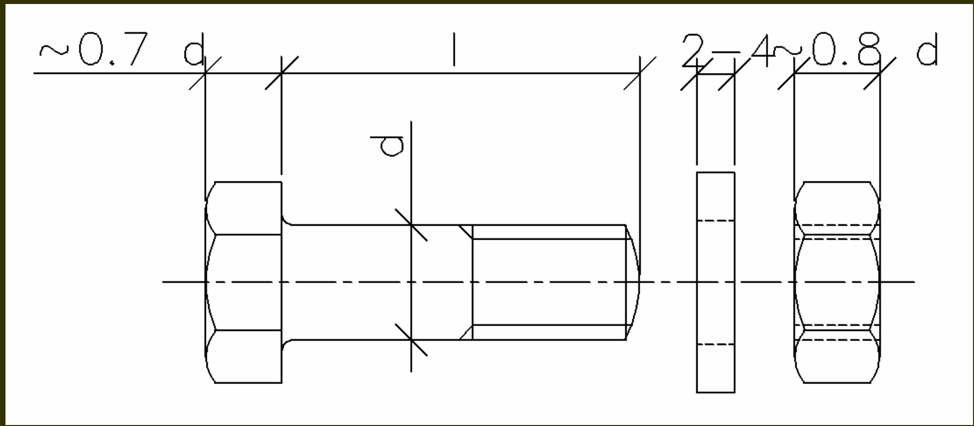
The most common bolts					
	diameter d - [mm]	diameter of hole d_0 - [mm]	area A - [mm^2]	area for tension A_s - [mm^2]	diameter of punching d_m - [mm]
M12	12	13	113	84.3	20.5
M14	14	15	154	115	23.7
M16	16	18	201	157	24.6
M18	18	20	254	192	29.1
M20	20	22	314	245	32.4
M22	22	24	380	303	34.5
M24	24	26	452	353	38.8
M27	27	30	573	459	44.2
M30	30	33	707	561	49.6

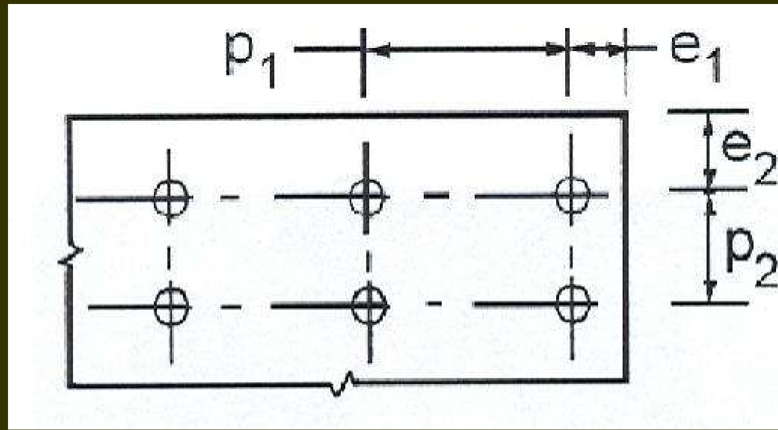
Bolt connection categories

- A class: perpendicular load => shear stress and bearing
- B-C class: perpendicular load => friction
- D class: parallel load => no pretension
- E class: parallel load => with pretension
- AD class: parallel and perpendicular load together without pretension
- CE class: parallel and perpendicular load together with pretension

Strength data of bolts		
	f_{yb} [N/mm^2]	f_{ub} [N/mm^2]
4.6	240	400
5.6	300	500
6.8	480	600
(8.8)	640	800
(10.9)	900	1000

Design rules





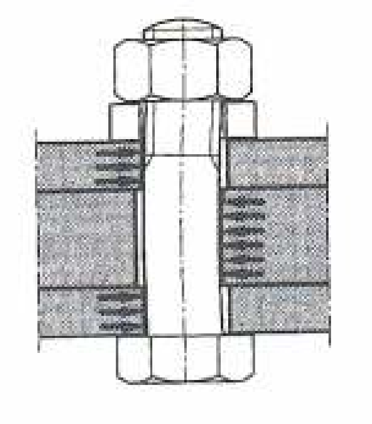
side "1" -parallel to the force
side "2" -perpendicular to the force

distance	minimum distance	Suggested values for high bearing resistance ($t_{min} \leq 0.185d$)	maximum distance		
			corrosive influence	non corrosive influence	stainless steel
e1	$1.2d_0$	$3.0d_0$	40mm+4t	-	8t or 125mm
e2		$1.5d_0$			
p1	$2.2d_0$	$3.75d_0$	14t or 200mm	14t or 200mm	14t or 175mm
p2	$2.4d_0$	$3.0d_0$			

"Perpendicular to the bolt resistance"

t -the thickness of the plate

n -the number of the sheared surface



$$F_{v,Ed} \leq F_{v,Rd} = n \frac{0,6 f_{ub} A}{\gamma_{M2}}$$ -shear resistance

$$F_{v,Ed} \leq F_{b,Rd} = k_1 \frac{\alpha_b f_u d\, t}{\gamma_{M2}}$$ -bearing resistance

$$k_1 = 2,8 \frac{e_2}{d_0} - 1,7$$ for edge bolt

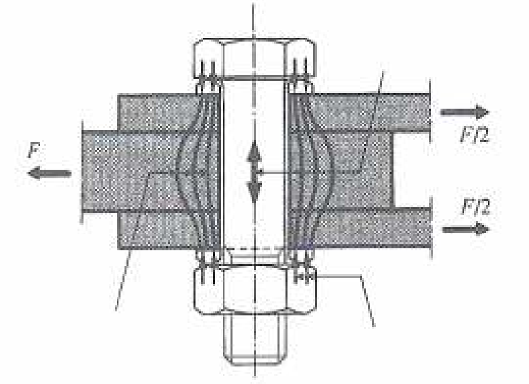
$$k_1 = 1,4 \frac{p_2}{d_0} - 1,7$$ for inner bolt, but $k_1 \leq 2,5$

$$\alpha_b = \frac{e_1}{3 d_0}$$ for end bolt

$$\alpha_b = \frac{p_1}{3 d_0} - \frac{1}{4}$$ for inner bolt, but $\alpha_b \leq 1$

$$F_{v,Ed} \leq F_{s,Rd} = \frac{n\, \mu}{\gamma_{M3}} F_{p,C}$$ -slip resistance

$$F_{p,C} = 0,7 f_{ub} A_s$$ -preload force



"Parallel with the bolt resistance"

$$F_{t,Ed} \leq F_{t,Rd} = \frac{0{,}9\, f_{ub}\, A_s}{\gamma_{M2}}$$

-tension resistance

$$F_{t,Ed} \leq B_{p,Rd} = \frac{0{,}6 \pi\, d_m\, t_p\, f_u}{\gamma_{M2}}$$

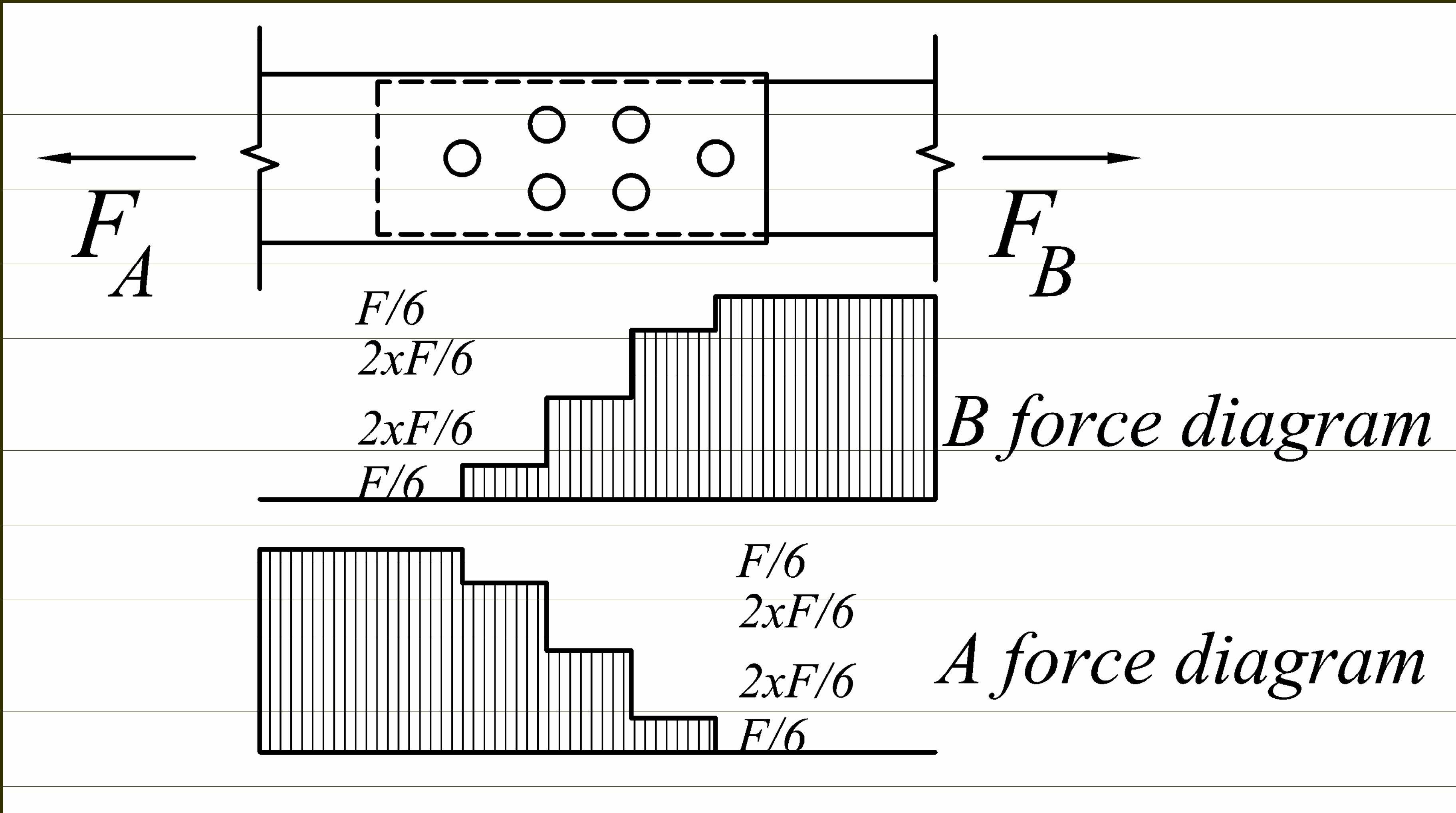
-punching resistance

$$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1{,}4\, F_{t,Rd}} \leq 1{,}0$$

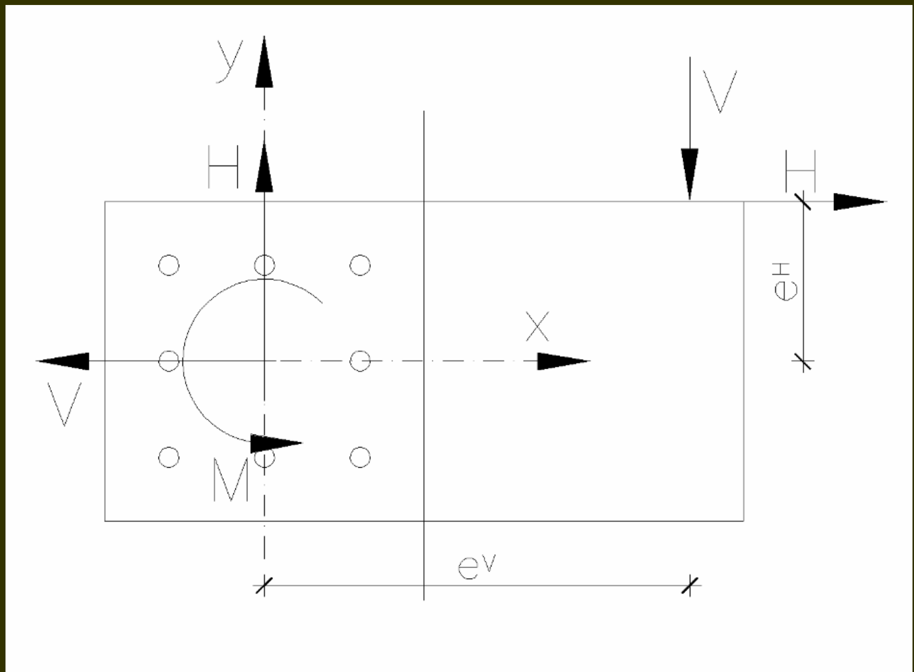
-combined shear and tension resistance

$$F_{v,Ed} \leq = F_{s,Rd} = \frac{n\, \mu}{\gamma_{M3}} \left(F_{p,C} - 0{,}8\, F_{t,Ed} \right)$$

Force distribution for bolts with no moment



Force distribution for bolts with moment



$$M = H * e^H + V * e^V$$

$$\sum r^2 = \sum x^2 + y^2$$

$$F_x = \frac{M}{\sum r^2} * y + \frac{H}{n}$$

$$F_y = \frac{M}{\sum r^2} * x + \frac{V}{n}$$

$$F = \sqrt{F_x^2 + F_y^2}$$