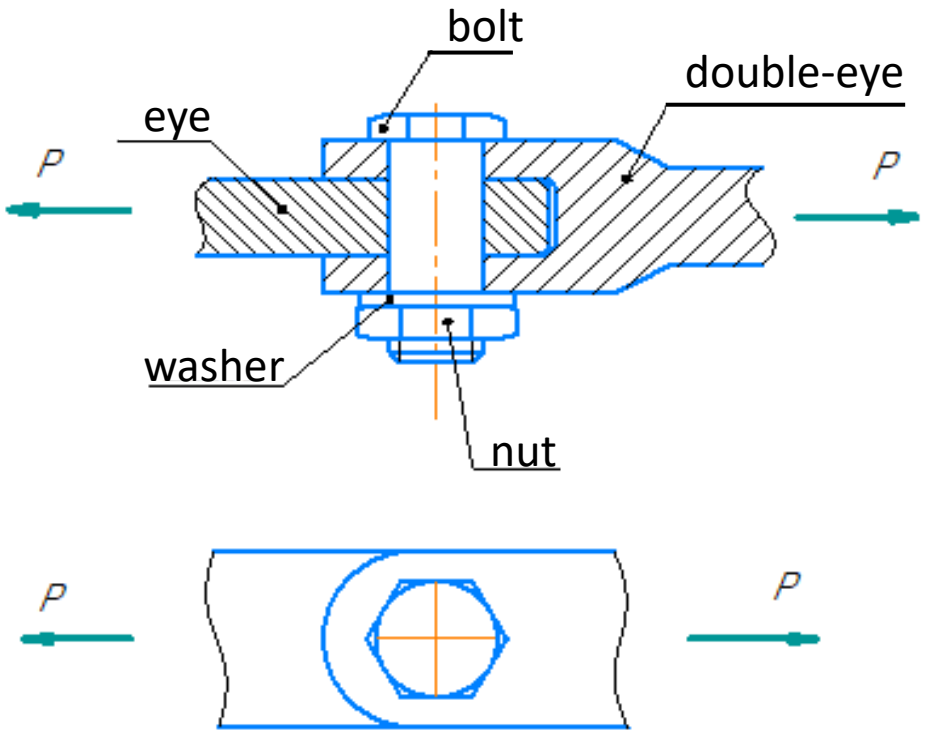
Parts and assemblies engineering

Lab-3

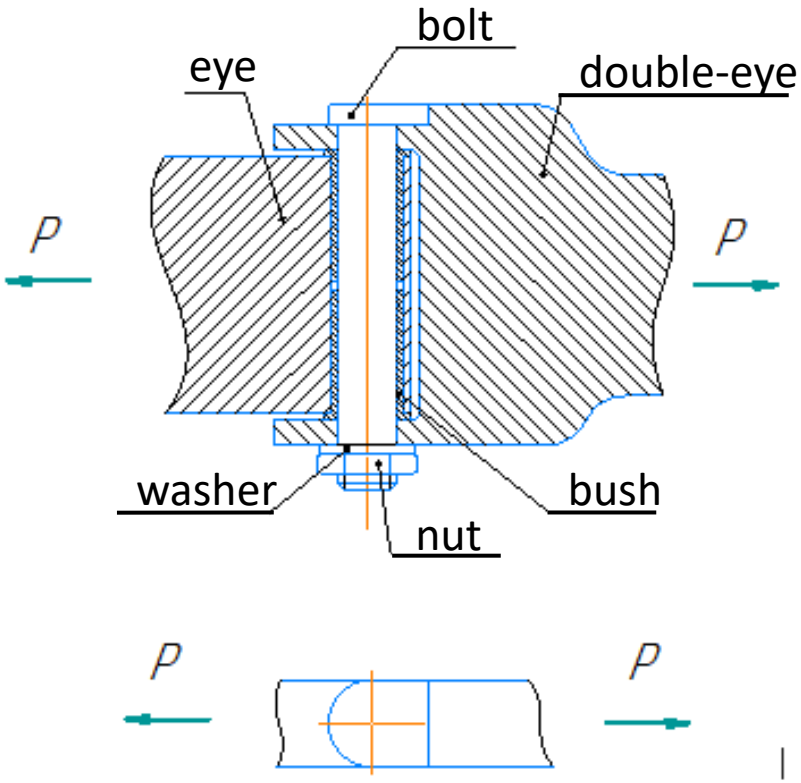
Denis Dukhnovskiy and Olga Rod

The task

Design the hinge-bolt connection for two variants:



Fixed joint



Sliding joint/
Small-sliding joints

Task guide

Table – Variants of Task

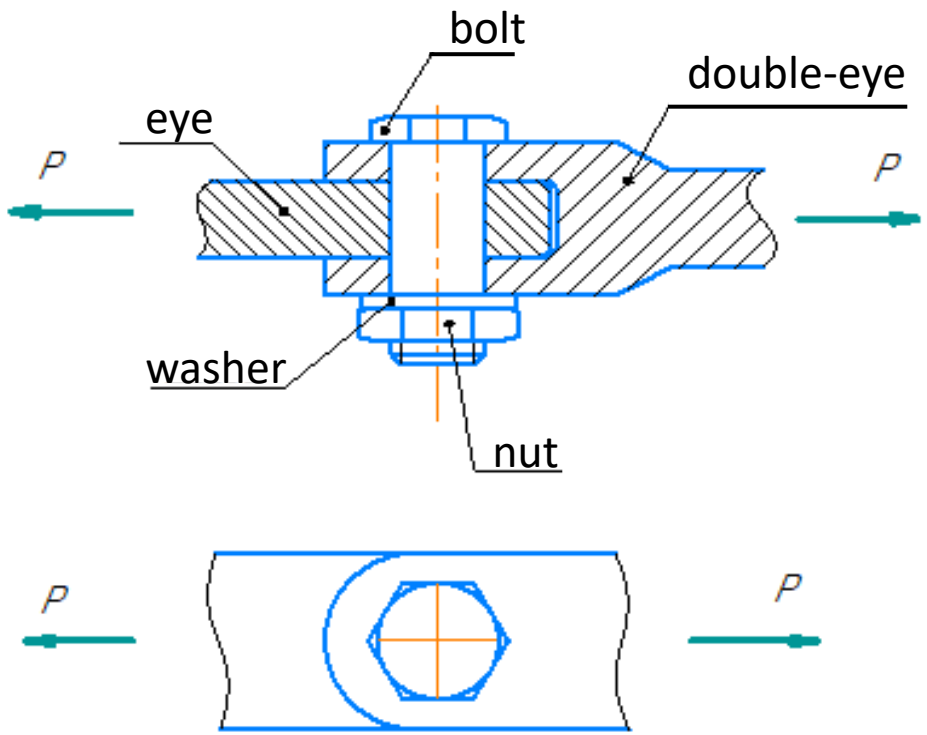
	Fixed joint				Sliding joint/Small-sliding joints			
Variants	1	2	3	4	1	2	3	4
P, [N]	160000	185000	175000	155000	145000	150000	165000	170000

Task guide

Table 1 – Material Properties

Materials	Ultimate tensile strength σ_{ult}, [MPa]	Proof strength σ_{02}, [MPa]	Shear strength* τ_{ult}, τ_{02} (% of tensile strength)	Modulus of elasticity E, [Gpa]	Shear modulus G, [Gpa]	Density, ρ, [g/cm^3]
30ХГСА	1100	850	63	210	78	7,85
ОТ4	700	600	50	110	80	4,5
ВТ20	1000	910	50	110	44	4,5
ВНС-2	1250	1100	60	190	76	7,8

Fixed joint



Task guide

1. Choose the materials of eye, double eye, bolt complex (bolt, nut, washer) from Table 1.

2. There are two options for determining the bolt diameter according to the strength criteria for the cut:

2.1 From shear stress

2.2 From max cutting load of bolt

Task guide

2.1 From shear stress:

$$\tau_{cut} = \frac{P_{cut}}{A_{cut}}$$

Double cutting
(P divided by 2)

$$P_{cut} = \frac{P}{2}$$

$$A_{cut} = \frac{\pi d^2}{4}$$

$$\tau_{cut} = \frac{2 \cdot P}{\pi \cdot d^2}$$

Determine the diameter of bolt:

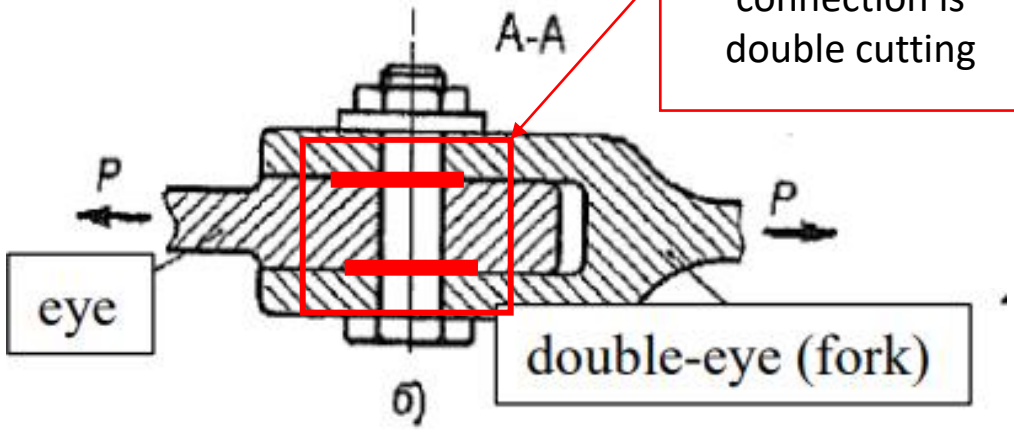
$$\tau_{cut} \geq \tau_{ult}$$

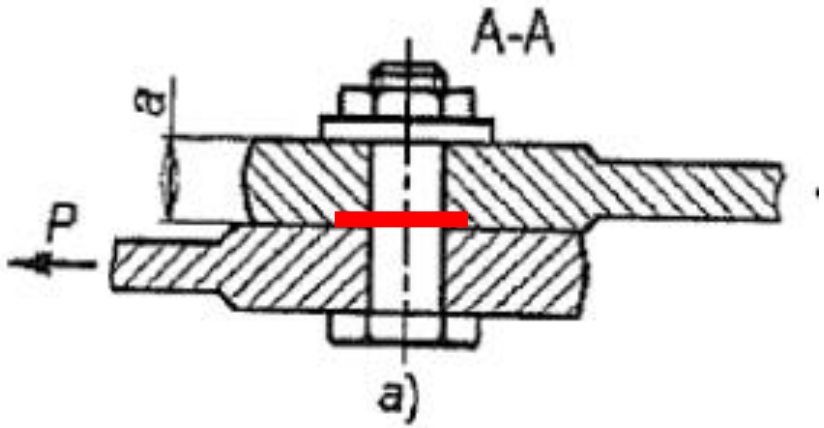
Strength criteria for shear stress

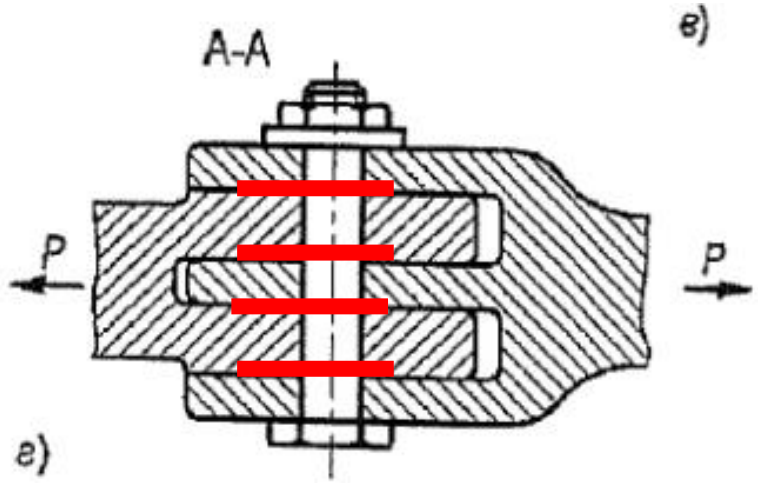
$$d_{bolt} \geq \sqrt{\frac{2 \cdot P}{\pi \cdot \tau_{ult}}}$$

Task guide

For this case eye-double eye the connection is double cutting







Task guide

Recalculate the current shear stress:

$$\tau_{cut} = \frac{2 \cdot P}{\pi \cdot d^2}$$

Calculate the coefficient of shear stress safety η :

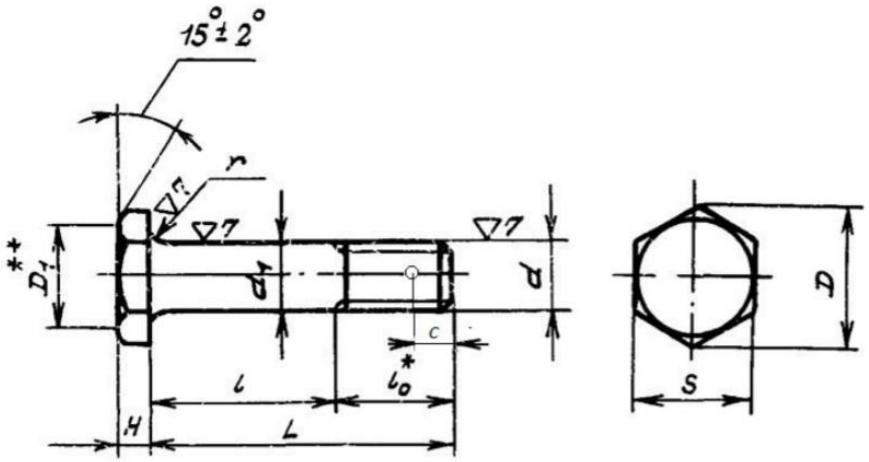
$$\eta = \frac{\tau_{ult}}{\tau_{cut}}, \quad \textit{ideally} \quad \eta = [1\ldots1.5]$$

Task guide

2.2 From max cutting force of bolt:

Double cutting
(P divided by 2)

$$P_{\text{cut}} \leq [P_{cut}], \qquad P_{cut} = \frac{P}{2}$$



where:

P_{cut} - is current force of bolt

$[P_{cut}]$ max cutting force is determine from table in OCT 1 31100-80.

! Value of $[P_{cut}]$ must be larger then P_{cut} !

Task guide

The max load of cutting bolt in depending of diameter and material of bolt

Номинальный диаметр гладкой части стержня болта, мм	Марка материала							
	30ХГСА	16ХСН, 40ХН2МА		30ХГСН2А	14Х17Н2		07Х16Н6	
	Температура, °С							
	25	100 – 300	400	25	25	400	25	400
	Расчетная разрушающая нагрузка на срез, Н (кгс)							
4	8340 (850)	7950 (810)	–	–	6370(650)	4800(490)	–	–
5	13400 (1370)	13400 (1370)	–	–	10000(1020)	7450(760)	13330(1360)	12160(1240)
6	19300 (1970)	19300 (1970)	16500 (1680)	28000 (2850)	14410(1470)	10780(1100)	19310(1970)	17550(1790)
7	26400 (2690)	26400 (2690)	22400 (2280)	–	19700(2010)	14700(1500)	26270(2680)	23820(2430)
8	34300 (3500)	34300 (3500)	29200 (2980)	49700 (5070)	25680(2620)	19310(1970)	34410(3510)	31180(3180)
9	43700 (4450)	43700 (4450)	37100 (3780)	–	32650(3330)	24410(2490)	43530(4440)	39510(4030)
10	53900 (5490)	53900 (5490)	45600 (4650)	77500 (7900)	40290(4110)	30200(3080)	53820(5490)	48820(4980)
12	77500 (7900)	77500 (7900)	–	111800 (11400)	–	–	–	–
14	105000 (10700)	105000 (10700)	–	152100 (15500)	–	–	–	–
15	120700 (12300)	120700 (12300)	–	–	–	–	–	–
16	137300 (14000)	137300 (14000)	–	198200 (20200)	–	–	–	–
17	155000 (15800)	155000 (15800)	–	–	–	–	–	–
18	174600 (17800)	174600 (17800)	–	251100 (25600)	–	–	–	–
20	214800 (21900)	214800 (21900)	–	311000 (31700)	–	–	–	–
22	260000 (26500)	260000 (26500)	–	375700 (38300)	–	–	–	–
24	310000 (31600)	310000 (31600)	–	447300 (45600)	–	–	–	–

Task guide

From the ОСТ 1 31100-80 determent the main parameters of bolt:

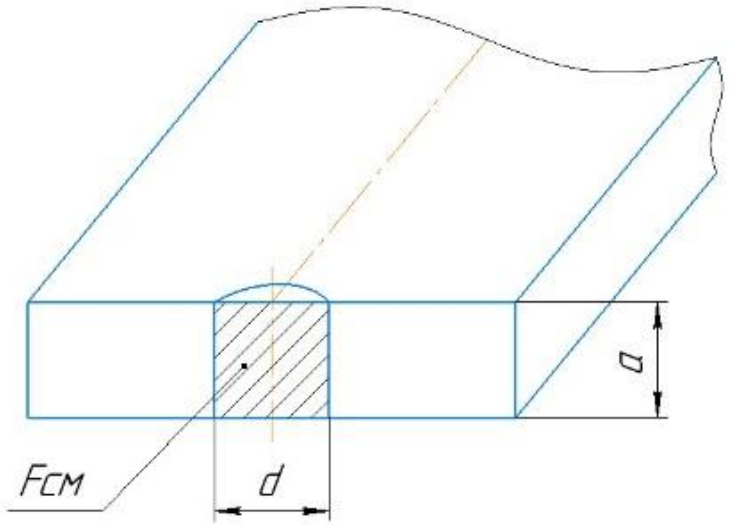
Calculate the coefficient of cutting force safety η :

$$\eta = \frac{[P_{cut}]}{P_{cut}}, \quad ideally \quad \eta = [1...1.5]$$

Task guide

3.1 Calculate the current crumpling stress of eye:

$$\sigma_{\mathrm{crump}} = \frac{P_{crump}}{d \cdot a};$$



For eye: $P_{crump} = P$

For double eye: $P_{crump} = \frac{P}{2}$

Task guide

3.2 For fixed joint K=1:

$$[\sigma_{crump}] = K \cdot \sigma_{ult};$$

$$\sigma_{\mathrm{crump}} = \frac{P_{crump}}{d \cdot a};$$

From strength criteria

$$\sigma_{crump} \leq [\sigma_{crump}]$$

$$a = \frac{P_{\mathrm{crump}}}{d \cdot \sigma_{\mathrm{ult}}};$$

Calculate the thickness for eye AND double eye!!!!

3.3 Recalculate the current crumpling stress of eye and double eye σ_{crump} and calculate the stress safety factor:

$$\eta = \frac{[\sigma_{crump}]}{\sigma_{crump}},\ \textit{ideally} \quad \eta = [1\ldots1.5]$$

Task guide

4. Determine the length of bolt:

$$L = a_{eye} + 2 \cdot a_{double-eye} + \delta_{washer} + \delta_{nut}$$

Determine the value of thickness of washer and nut from OCT 1 33048-80.

Task guide

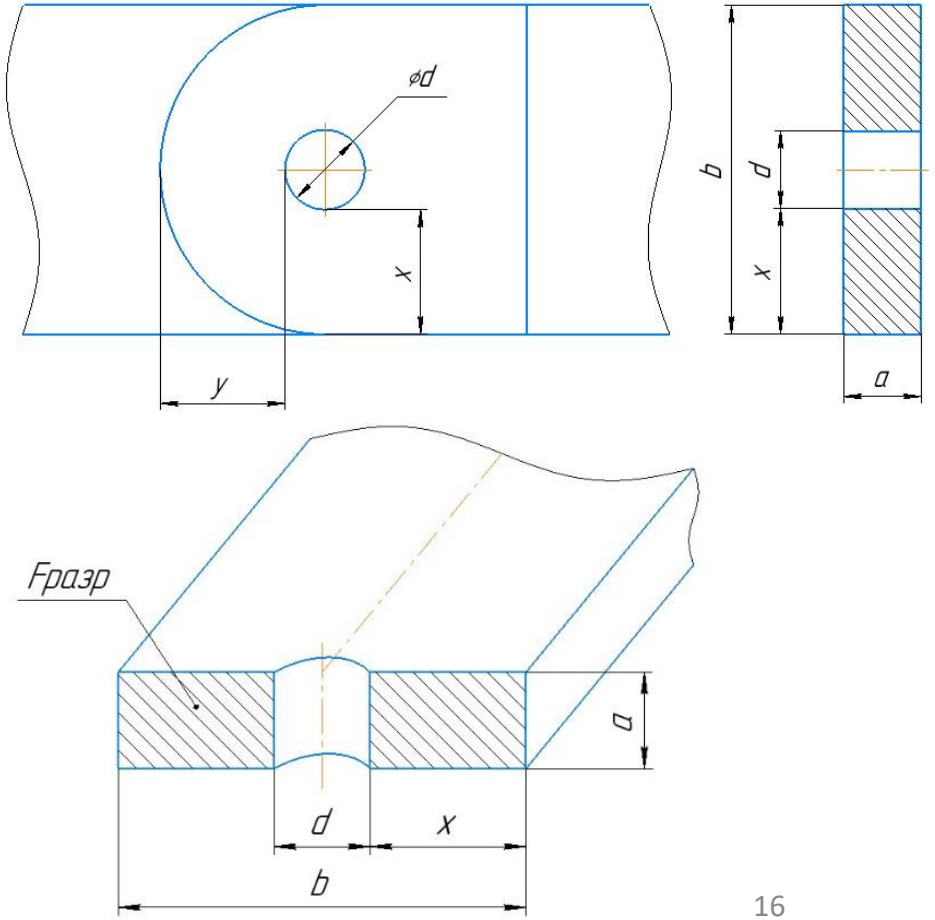
5.Check the strength design of eye and double eye on break load

5.1 Calculate the break load for eye and double-eye:

$$\sigma_{\text{break}} = \frac{P_{\text{break}}}{A_{\text{break}}}$$

For eye: $P_{break} = P$

For double eye: $P_{break} = \frac{P}{2}$



$$A_{\text{break}} = (b - a) \cdot a = 2 \cdot a \cdot x$$

$$\sigma_{\text{break}} = \frac{P_{\text{break}}}{A_{\text{break}}} = \frac{P_{\text{break}}}{(b - d) \cdot a} = \frac{P_{\text{break}}}{2 \cdot a \cdot x}$$

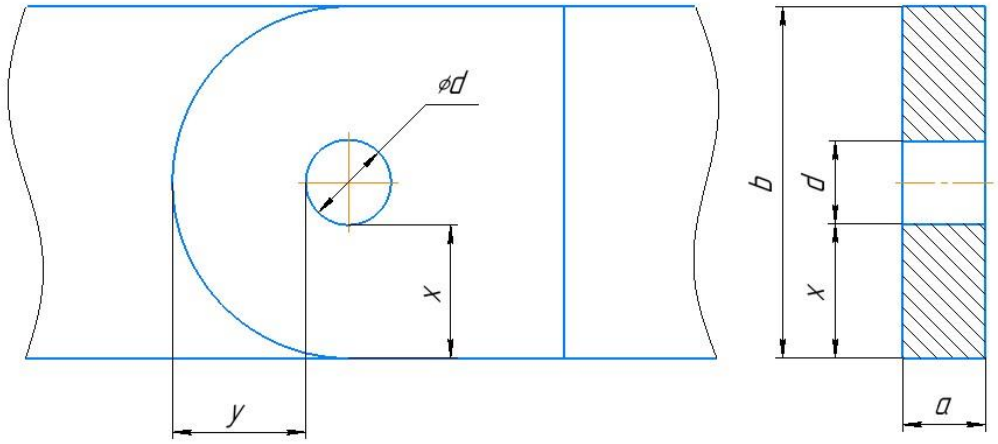
Task guide

5.2 Calculate the K breaking coefficient for eye and double-eye:

$$\sigma_{\text{break}} \leq [\sigma_{break}]$$

$$[\sigma_{\text{break}}] = K_{break} \cdot \sigma_{ult};$$

$$K_{break} = 0{,}565 + 0{,}48 \cdot \frac{y}{x} - 0{,}1 \cdot \frac{b}{a}$$



For fixed joint $\frac{y}{x}$ =1,4 and $\frac{b}{a}$ = 2

$K_{break} \approx 1$, so

$[\sigma_{break}] = \sigma_{\text{B}}$

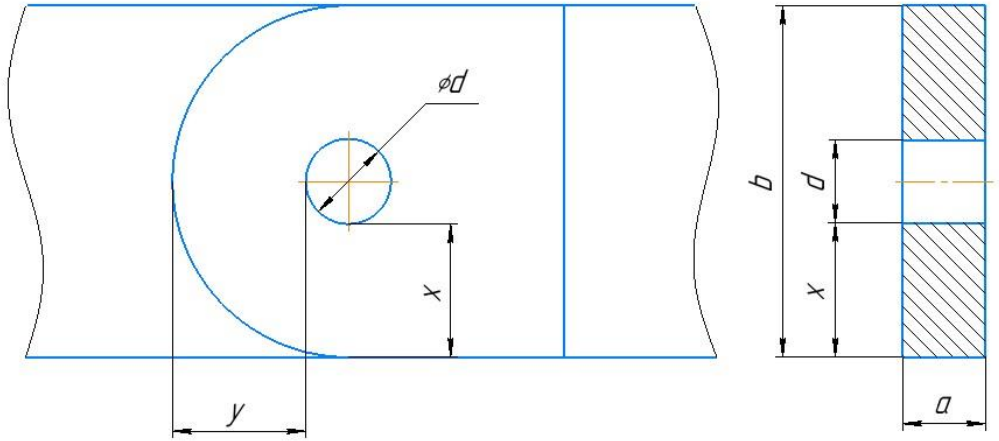
Task guide

5.3 Calculate the geometric parameters of eye and double-eye:

$K_{\text{break}} \approx 1$, so

$[\sigma_{break}] = \sigma_{\text{B}}$

$$x = \frac{P_{\text{break}}}{2 \cdot a \cdot \sigma_{\text{ult}}}$$



$$\frac{y}{x} = 1{,}4 \quad and \quad b = 2 \cdot x + d$$

5.4 Recalculate the σ_{break} and determine the stress safety factor for eye and double-eye:

$$\eta = \frac{[\sigma_{\text{break}}]}{\sigma_{\text{break}}}, \qquad \textit{ideally} \quad \eta = [1\ldots1.5]$$

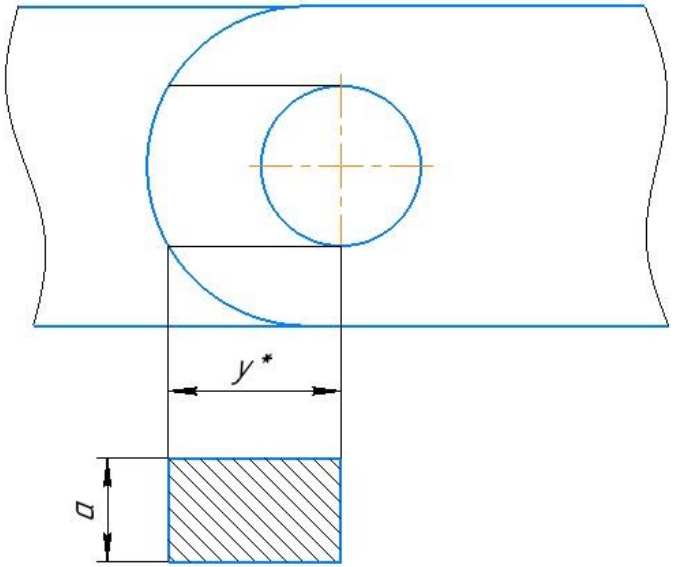
Task guide

6. Check the strength design of eye and double eye on cutting:

$$\tau_{\text{cut}} = \frac{P_{\text{cut}}}{F_{cut}} = \frac{P_{\text{cp}}}{2 \cdot a \cdot y^*}$$

For eye: $P_{cut} = P$

For double eye: $P_{cut} = \frac{P}{2}$

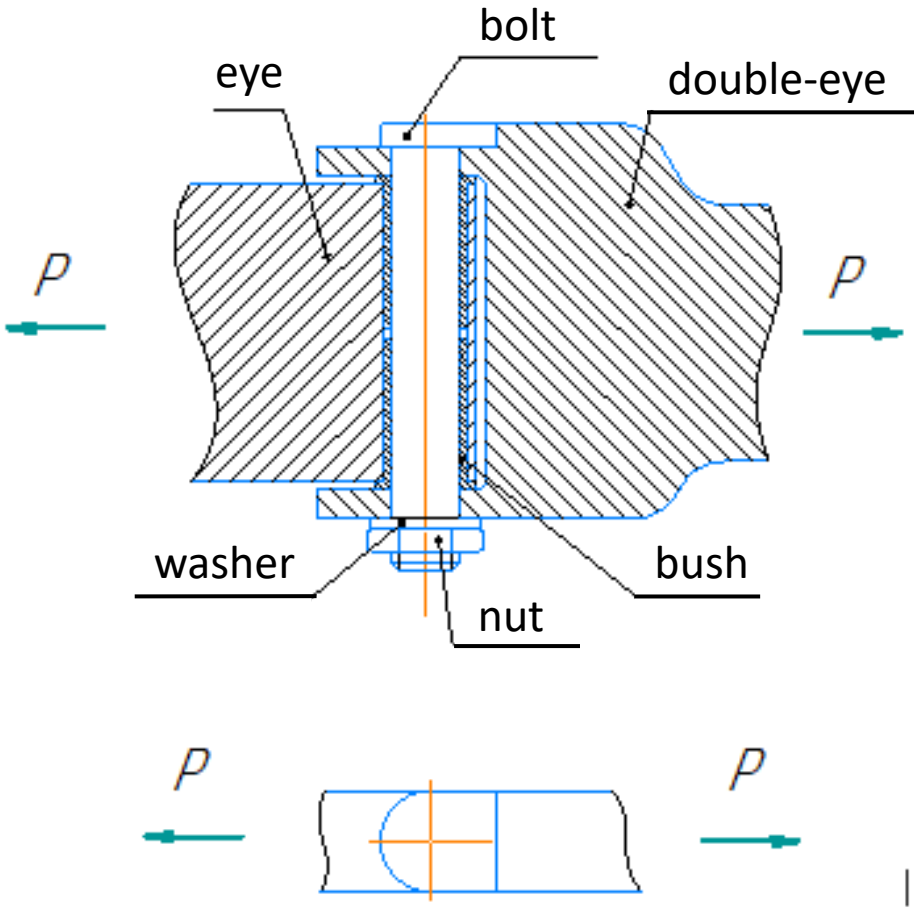


y^* - determine from draw

6.1 Recalculate the shear cut stress τ_{cut} for eye and double eye and calculate the stress safety factor:

$$\eta = \frac{[\tau_{\text{cut}}]}{\tau_{\text{cut}}}, \qquad \textit{ideally} \quad \eta = [1\ldots1.5] \qquad \text{Where } [\tau_{\text{cut}}] = \tau_{ult}$$

Sliding joint/Small-sliding joints



Task guide

1. For this case, step of “determine bolt diameter” the same that describe on slide 7.

2*. After obtain the bolt diameter, determine the thickness of eye and double eye with two options:

2.1 Crumpling along the inner diameter d of the bush;

2.2 Crumpling along the outer diameter D of the bush;

* - additional task

Task guide

Calculate all steps described on last slides

Calculate the geometric parameters of eye and double-eye:

$$K_{break} = 0{,}565 + 0{,}48 \cdot \frac{y}{x} - 0{,}1 \cdot \frac{b}{d}$$

For sliding joint: $\frac{y}{x} = 1,\ \frac{b}{d} = 2.$

And recalculate remaining steps.

Task guide

- Create a report of the laboratory work
- Make assemblies drawings
- Build a table with the main structures parameters.

Task guide

Link for section data, variants and PPT