Parts and assemblies engineering

Lab-2

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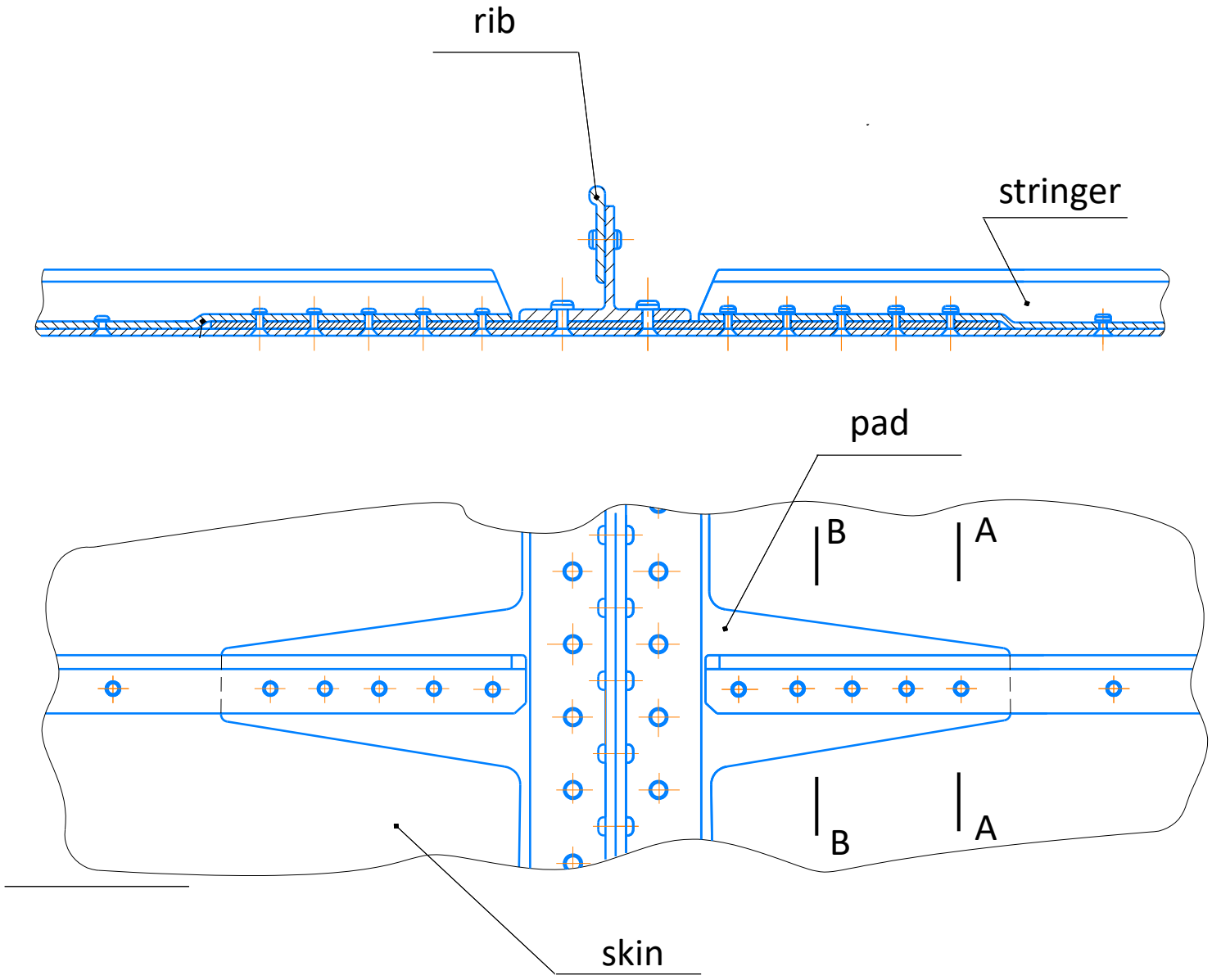
The task

Design the overlap joint (rivet) between two stringers and the rib

The goals of task:

- Determine the number of rivets
- Calculate the diameter of rivet
- And determine the overlap joint position between two stringers and rib with pad
- Determine the thickness and dimensions of pad



Task guide

1. Choose the task variant and obtain maximum tensile load for stringer:

$$P_{\max\_str} = A_{str} \cdot \sigma_{B\_str} \text{ or } P_{\max\_str} = P \cdot 1.3$$

Type of stringer	Dimensions, $[mm]$				Cross-section area, $[mm^2]$
710012	H	B	S=S1	a	65
	20	15	1.5	2	

	Variants			
Variants	1	2	3	4
Type of stringers	710010	710003	710020	710012
P, N	13500	10000	190000	24000

2. Choose the materials of stringers, pad and skin

Task guide

Table – Variants of Task

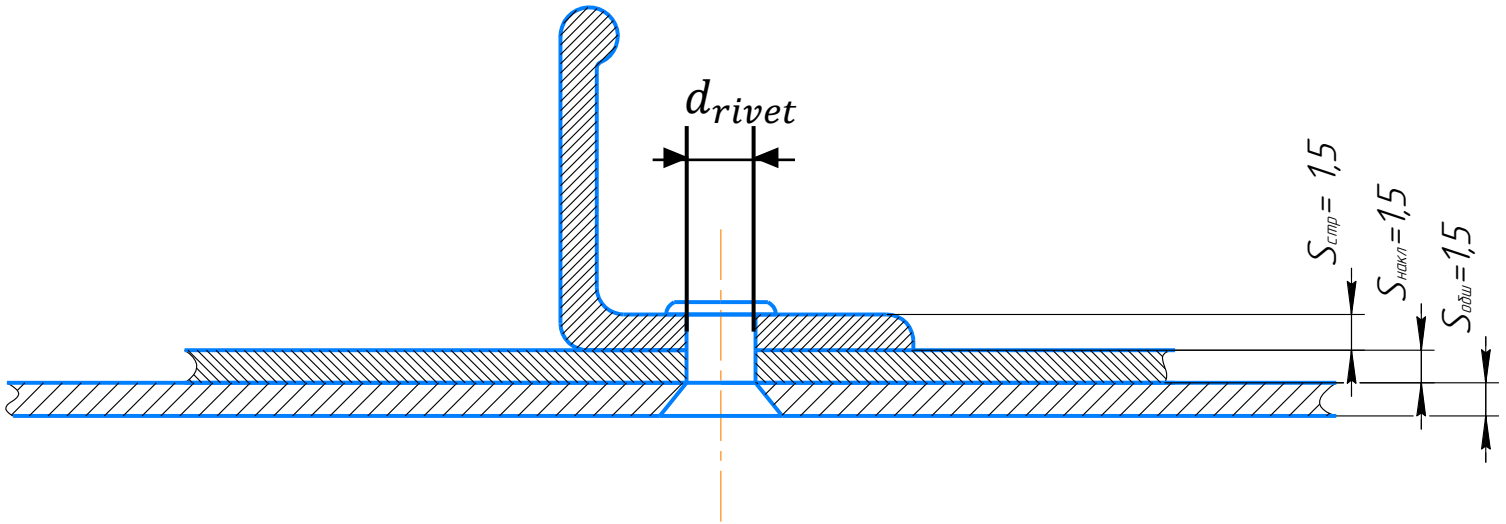
	Variants						
Variants	1	2	3	4	5	6	7
Type of stringers	710010	710003	710020	710012	420069	420075	710017
P, N	13500	10000	19000	24000	27000	38000	23000

Task guide

3. Preliminary diameter of rivet calculate by equation:

$$d_{\text{rivet}} = 2\sqrt{t_{total}}, \quad \text{where} \quad t_{total} = t_{str} + t_{skin} + t_{pad}$$

t_{str}= S or S1 - thickness of stringer, t_{skin} - thickness of skin, t_{pad} - thickness of pad



For preliminary calculation thickness of skin and pad equal 1.5 mm

Task guide

4. Checking of tensile stress:

$$\sigma \leq [\sigma], \textit{ where } \sigma = \frac{P_{\max\_str}}{A_{str} - d_{\text{rivet}} \cdot t_{str}}$$

The value of $[\sigma]$ is equal to $[\sigma] = 0.8 \cdot \sigma_{B,srt}$;

5. Calculate the coefficient of safety η :

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

Task guide

6. After assuming the material and diameter of the rivet we can calculate the requirable number of rivets :

$$n_{rivet} = \frac{P_{\max\_str}}{P_{rivet}};$$

where P_{rivet} - determine the cutting force of rivet with GOST 134104-80 data and the maximum number of rivets in a row along stringers axis a 5…6;

For different diameter of rivet find the minimum cutting force for rivet from the table (in the next slide)

Task guide

Cutting force of rivet P_{rivet}, kN (1000*N)

Name of material

Diameter of rivet d, mm

The cutting force P_{rivet}, [kN] for rivet with d=4 mm using 12X18H9T material

Минимальные разрушающие нагрузки на одинарный срез, $\frac{кН}{кгс}$

Марка материала	Диаметр заклепки d, мм													
	2		2,6		3		3,5		4		5		6	
	2,0	2,1	2,6	2,7	3,0	3,1	3,5	3,6	4,0	4,1	5,0	5,1	6,0	6,15
10	1,05 / 106,8	1,15 / 117,7	1,77 / 180,4	1,91 / 194,6	2,35 / 240,2	2,51 / 256,5	3,16 / 322,8	3,39 / 345,9	4,18 / 427,0	4,40 / 448,7	6,54 / 667,2	6,80 / 694,2	9,42 / 960,8	9,89 / 1009,5
20Г2	—	—	—	—	—	—	4,65 / 474,7	4,98 / 508,7	6,15 / 628,0	6,47 / 659,8	9,62 / 981,2	10,00 / 1020,9	13,85 / 1413,0	14,55 / 1484,6
12Х18Н9Т	1,35 / 138,2	1,49 / 152,3	2,29 / 233,5	2,47 / 251,8	3,05 / 310,9	3,25 / 331,9	4,09 / 417,7	4,39 / 447,6	5,42 / 552,6	5,69 / 580,6	8,46 / 863,5	8,80 / 898,4	12,18 / 1243,4	12,80 / 1306,4
ХН78Т	—	—	—	—	3,12 / 317,9	3,33 / 339,5	4,19 / 427,2	4,49 / 457,8	5,54 / 565,2	5,82 / 593,8	8,65 / 883,1	9,00 / 918,8	—	—
ХН60ВТ	—	—	—	—	3,46 / 353,2	3,70 / 377,2	4,65 / 474,7	4,98 / 508,7	6,15 / 628,0	6,47 / 659,8	9,62 / 981,2	10,00 / 1020,9	—	—
В65	—	—	1,30 / 132,7	1,40 / 143,1	1,73 / 176,6	1,85 / 188,6	2,33 / 237,4	2,49 / 254,4	3,08 / 314,0	3,23 / 329,9	4,81 / 490,6	5,00 / 510,4	6,92 / 706,5	7,27 / 742,5
АМг5П	0,50 / 50,2	0,54 / 55,4	0,83 / 84,9	0,90 / 91,6	1,11 / 113,0	1,19 / 120,7	1,49 / 151,9	1,60 / 162,8	1,97 / 201,0	2,07 / 211,1	3,08 / 314,0	3,20 / 326,7	4,43 / 452,2	4,66 / 475,0
Д18	0,60 / 59,7	0,64 / 65,8	0,99 / 100,8	1,06 / 108,7	1,32 / 134,2	1,40 / 143,3	1,77 / 180,4	1,89 / 193,3	2,34 / 238,6	2,46 / 250,7	3,65 / 372,9	3,80 / 387,9	5,26 / 536,9	5,53 / 564,1
Д19П	—	—	1,46 / 148,6	1,57 / 160,2	1,94 / 197,8	2,07 / 211,2	2,60 / 265,8	2,79 / 284,9	3,45 / 351,7	3,62 / 369,5	5,38 / 549,5	5,60 / 571,7	7,75 / 791,3	8,15 / 831,3
ВТ16	—	—	2,86 / 291,9	3,08 / 314,8	3,81 / 388,6	4,07 / 414,9	5,18 / 522,2	5,48 / 559,6	6,77 / 690,8	7,11 / 725,8	10,58 / 1079,4	11,00 / 1123,0	15,23 / 1554,3	16,00 / 1633,0

ОСТ 1 34104-80 с.8

Task guide

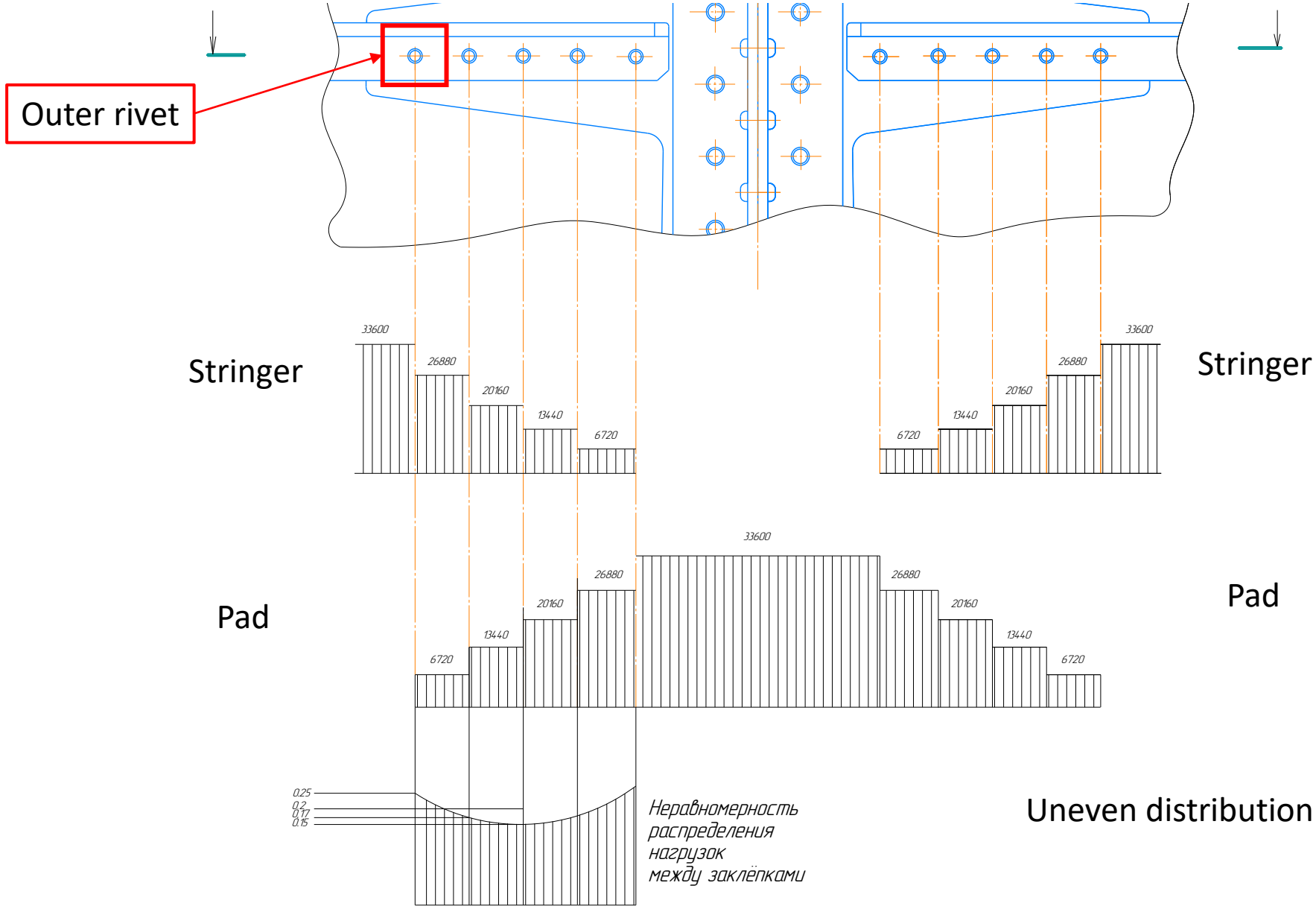
7. Check for crumbling of stringer under rivet:

$$\sigma_{crumbling} = \frac{P_{rivet}}{d_{\text{rivet}} \cdot t_{str}} \leq 1.3 \ldots 1.5 \cdot \sigma_{B,str};$$

8. And calculate the coefficient of safety η :

$$\eta = \frac{[\sigma]}{\sigma_{crumbling}}, \textit{ ideally } \eta = [1.2 \ldots 1.6], [\sigma] = 1.3 \cdot \sigma_{B,srt};$$

Task guide



Uneven distribution of force from all rivets

Task guide

7. Check the coefficient of safety η for unevenly distributed force.

How we can see from last slide, the outer rivet has a maximum value from distributed force, so:

$$P_{rivet,outer} = 0.25 \cdot P_{\max\_str}$$

8. And calculate the coefficient of safety η :

$$\eta = \frac{P_{rivet}}{P_{rivet,outer}}, \textit{ ideally } \eta = [1.2 \ldots 1.6]$$

Task guide

9. Checking the edge distance m for cutting failure:

$$2 \cdot d_{\text{rivet}} \leq m \leq 2 \cdot d_{\text{rivet}} + 2;$$

10. Calculate the actual shear stresses from cutting force:

$$\tau_{act} = \frac{P_{\max\_riv}}{2 \cdot m \cdot t_{str}} < \tau_B;$$

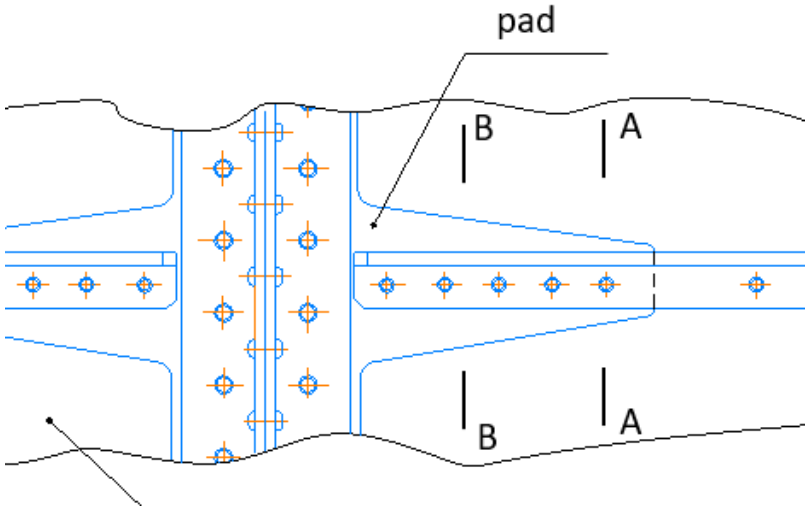
Where $\tau_B = (0.6 \ldots 065) \cdot \sigma_{B,str};$

Task guide

11. Analysis of pad:

Check the crumbling in A-A section, assuming the thickness and material of the pad:

$$\sigma_{crumbling,pad} = \frac{P_{\max\_riv}}{d_{\text{rivet}} \cdot t_{str}} \leq [\sigma]_{crumbling} = 1.3 \ldots 1.5\sigma_{B,pad};$$



One should use $\sigma_{B,riv}$ if $[\sigma]_{B,riv} \leq [\sigma]_{B,pad}$ in the upper expression;

Task guide

12. Tension failure in A-A and B-B sections:

Calculating the stress:

$$\sigma_{A-A} = \frac{P_{\text{str}}}{A_{pad}}$$

$$\sigma_{A-A} = \frac{P_{\text{str}}}{t_{\text{pad}} \cdot (b_{min} - n_{rivet\ A-A} \cdot d_{\text{rivet}})} \leq [\sigma]_{bear} = 1.3 \ldots 1.5 \cdot \sigma_{B,pad};$$

where: k≈1,15…1,2 stress concentration factor

Task guide

The minimum width $b_{\min}$ of the pad in a section is obtained due to tension in section:

$$b_{\min\,A-A} = \frac{k \cdot P_{\max\_riv}}{t_{\text{pad}} \cdot \sigma_{B\_pad}} + n_{rivet\,A-A} \cdot d_{\text{rivet}}$$

$$where \quad n_{rivet\,A-A} = 1$$

$n_{rivet\,A-A}$ -number of rivets in the section A-A (equal to 1)

$\sigma_{B,pad}$ -strength of material of the pad

Task guide

14. Calculate the length of the rivet:
For rivet joint the skin and stringers:

$$t_{stringer\_skin} = t_{str} + t_{skin}$$

Check the length with GOST 1 10642-72

For rivet joint the skin, stringers and pad:

$$t_{total} = t_{str} + t_{skin} + t_{pad}$$

Check the length with GOST 1 10642-72

15. Sketch the joint and prepare the report of lab

Task guide

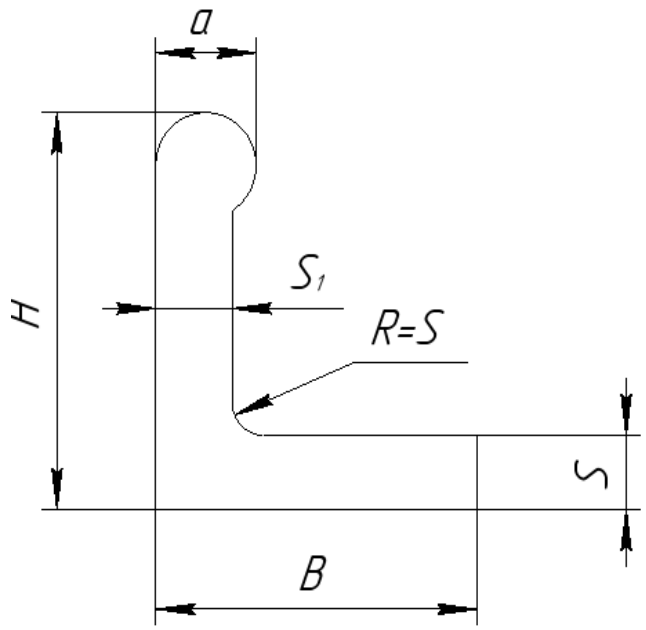


Table – Variants-1

Type	Dimensions, $[mm]$				Cross-section area, $[mm^2]$
710010	H	B	S=S1	a	37
	20	13	1.0	3	

Task guide

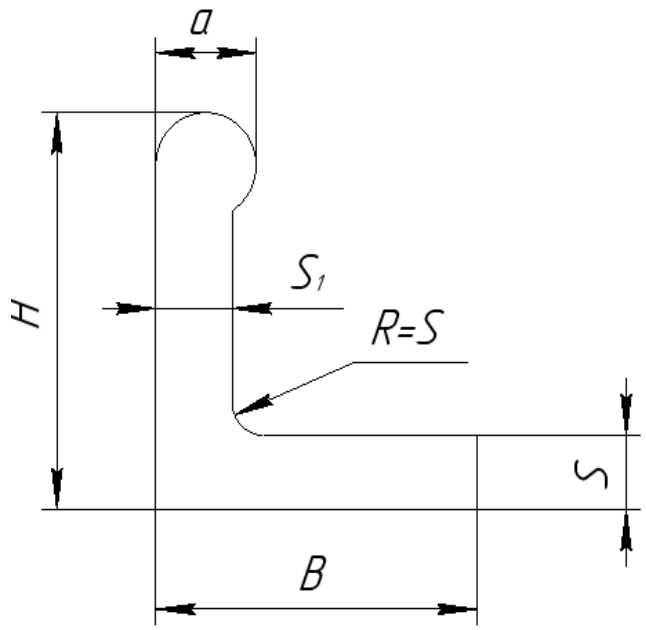


Table – Variants-2

Type	Dimensions, $[mm]$				Cross-section area, $[mm^2]$
710003	H	B	S=S1	a	37
	15	18	1.0	3	

Task guide

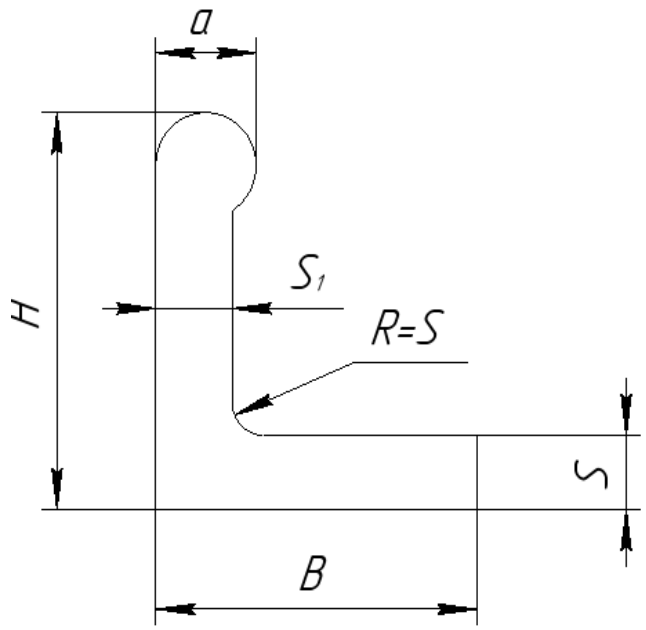


Table – Variants-3

Type	Dimensions, $[mm]$				Cross-section area, $[mm^2]$
710020	H	B	S=S1	a	52
	23	13	1.5	4	

Task guide

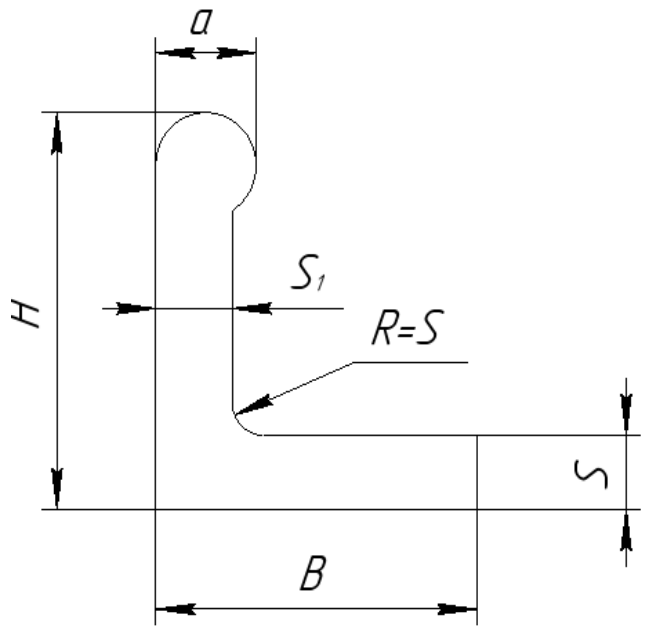


Table – Variants-4

Type	Dimensions, $[mm]$				Cross-section area, $[mm^2]$
710012	H	B	S=S1	a	65
	20	15	1.5	2	

Task guide

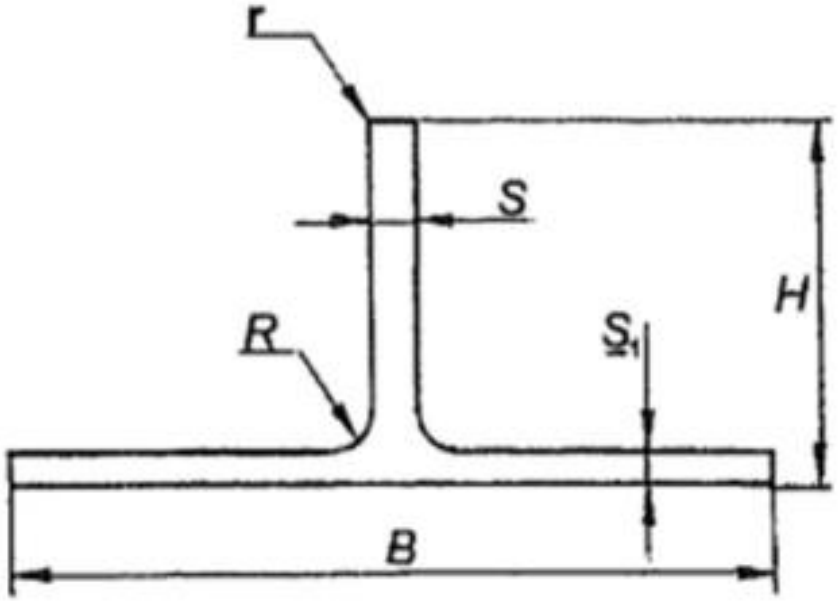


Table – Variants-5

Type	Dimensions, $[mm]$					Cross-section area, $[mm^2]$
420069	H	B	S	S1	R	82
	20	30	1.5	2.0	2.0	

Task guide

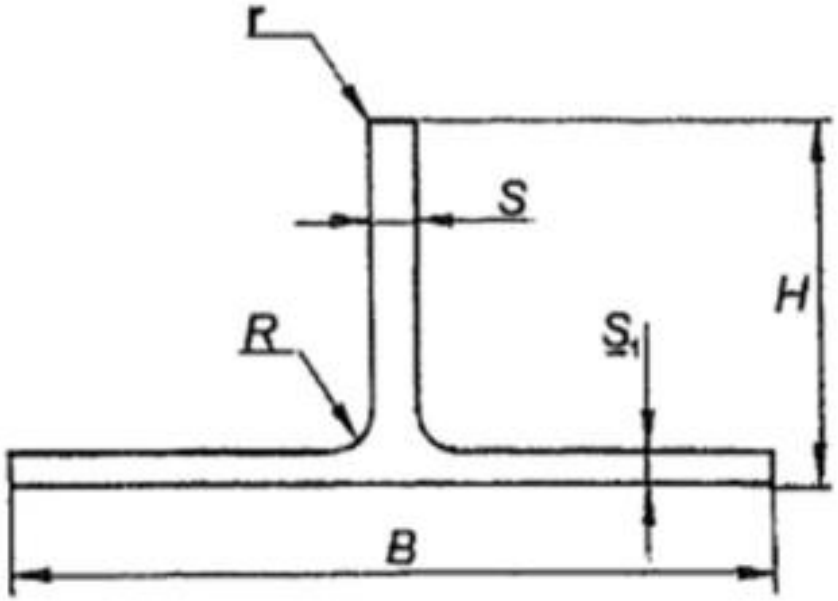


Table – Variants-6

Type	Dimensions, $[mm]$					Cross-section area, $[mm^2]$
420075	H	B	S	S1	R	105
	20	38	2.0	1.5	2.0	

Task guide

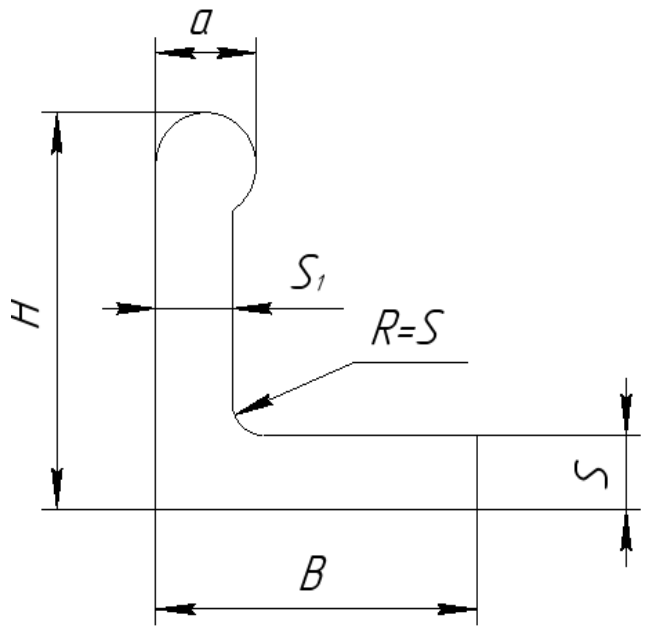


Table – Variants-7

Type	Dimensions, $[mm]$				Cross-section area, $[mm^2]$
710017	H	B	S=S1	a	98
	20	20	1.5	3.5	

Task guide

Table – Material Properties

Material	Ultimate tensile strength σ_B, MPa	Proof strength σ_{02}, MPa	Shear strength* τ_B, 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
Д16Т	450	300	50	72	28	2,8
ВТ20	1000	910	50	110	44	4,5

* - ultimate shear strength and proof strength are approximated by taking the denoted percentage of tensile ultimate and proof strength respectively

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Task guide

Link for section data, variants and PPT