Lecture 3
THE METHOD OF CALCULATION THE BAR ON STRENGTH

Assos. Prof. A. Kutsenko

Plan of lecture

- **1.** Draw the diagram of normal forces for a bar
- 2. Drawing the diagrams of central forces and normal tensions for a squared beam
- 3. The selection of the cross-section of bar from the condition of strength

Draw the diagram of normal forces for a bar

Let us calculate the normal forces for a given bar (Fig. 1):

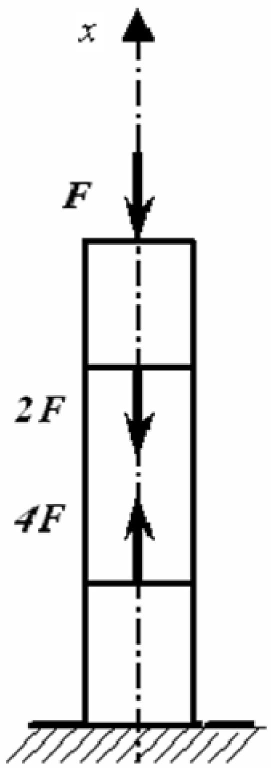


Fig. 1

I portion

$$N_1 = -F$$

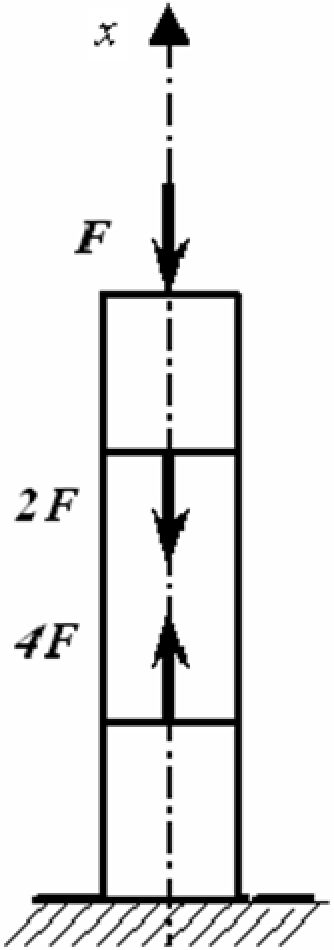
II portion

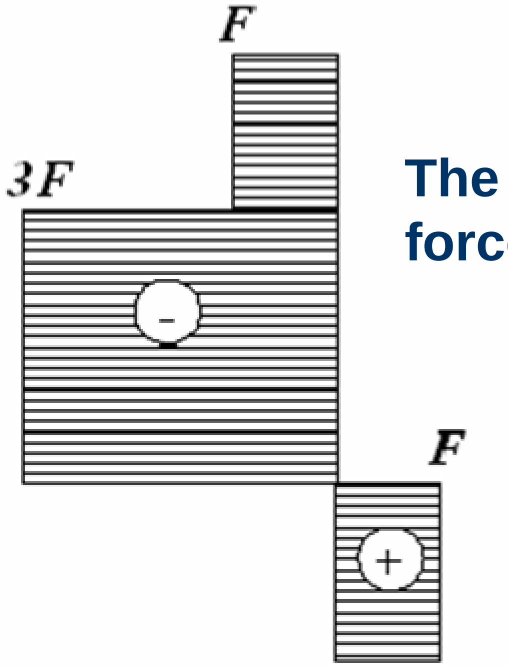
$$N_2 = -F - 2F = -3F$$

III portion

$$N_3 = -F - 2F + 4F = F$$

Draw the diagram of normal forces for a bar





The diagram of normal force N

Drawing the diagrams of central forces and normal tensions for a squared beam

$F_1 = 30$ **kN** $F_2 = 38$ **kN** $F_3 = 42$ **kN** $A_1 = 1{,}9$ cm^2

$A_2 = 3{,}1$ cm^2

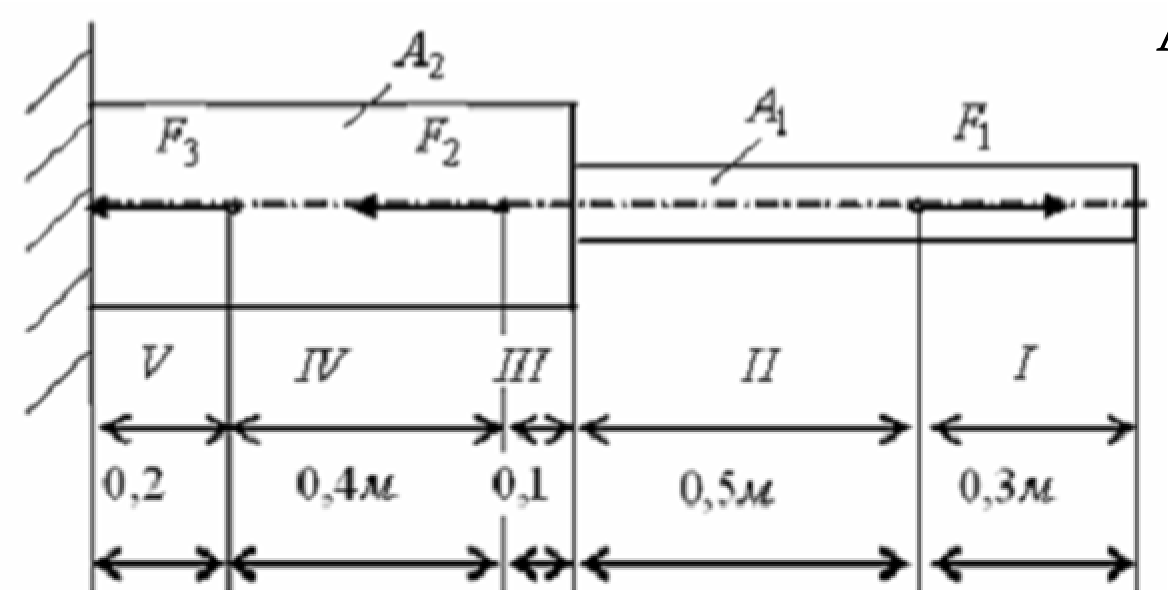


Fig. 2

Drawing the diagrams of central forces and normal tensions for a squared beam

Determine the value of central force on the areas of the squared beam:

$N_I = 0$ $\quad N_{II} = F_1 = 30$ **kN**

$N_{III} = F_1 = 30$ **kN**

$N_{IV} = F_1 - F_2 = -8$ **kN**

$N_V = F_1 - F_2 - F_3 = -50$ **kN**

Drawing the diagrams of central forces and normal tensions for a squared beam

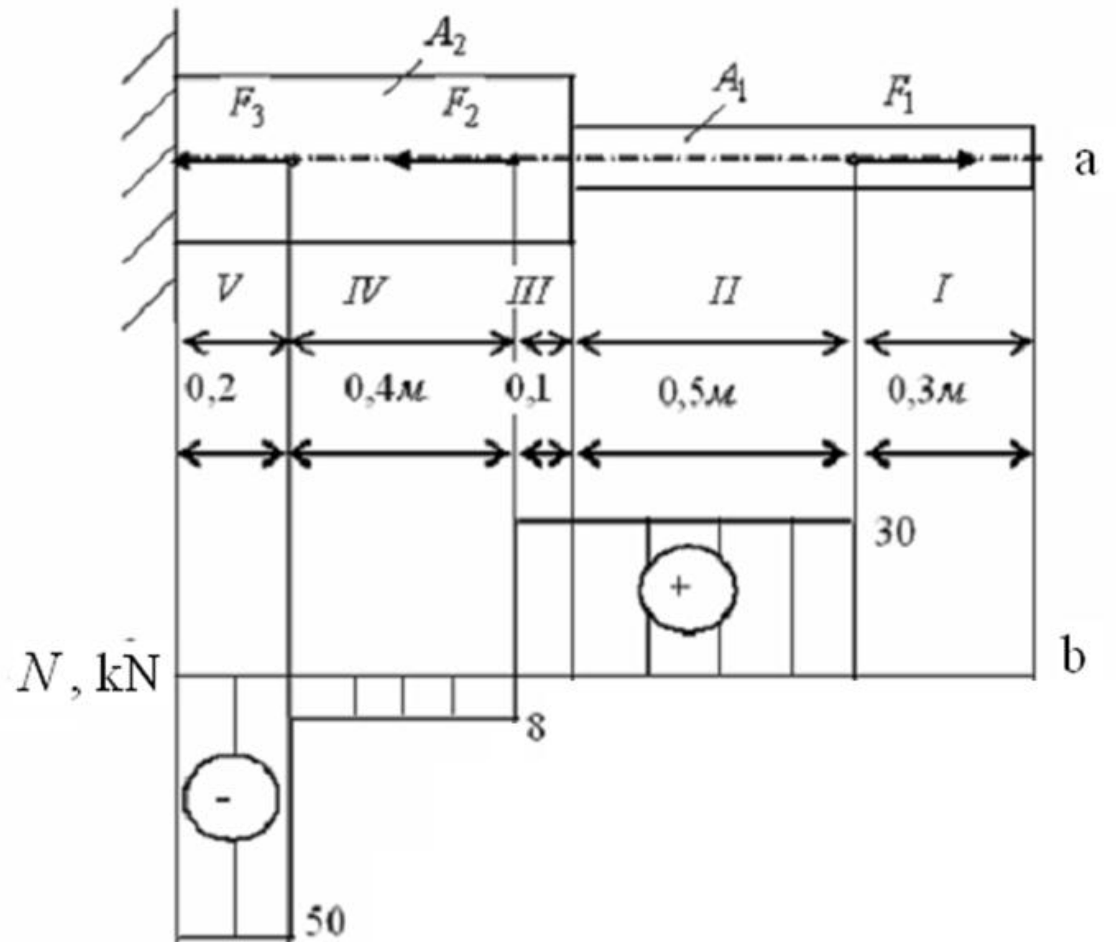


Diagram of normal force N

Drawing the diagrams of central forces and normal tensions for a squared beam

Calculate the value of normal tensions:

$$\sigma_I = \frac{N_I}{A_1} = 0$$

$$\sigma_{II} = \frac{N_{II}}{A_1} = \frac{30 \cdot 10^3}{1{,}9 \cdot 10^2} = 158 \text{ MPa}$$

$$\sigma_{III} = \frac{N_{III}}{A_2} = \frac{30 \cdot 10^3}{3{,}1 \cdot 10^2} = 96{,}8 \text{ MPa}$$

$$\sigma_{IV} = \frac{N_{IV}}{A_2} = -\frac{8 \cdot 10^3}{3{,}1 \cdot 10^2} = -25{,}8 \text{ MPa}$$

$$\sigma_V = \frac{N_V}{A_2} = -\frac{50 \cdot 10^3}{3{,}1 \cdot 10^2} = -163 \text{ MPa}$$

Drawing the diagrams of central forces and normal tensions for a squared beam

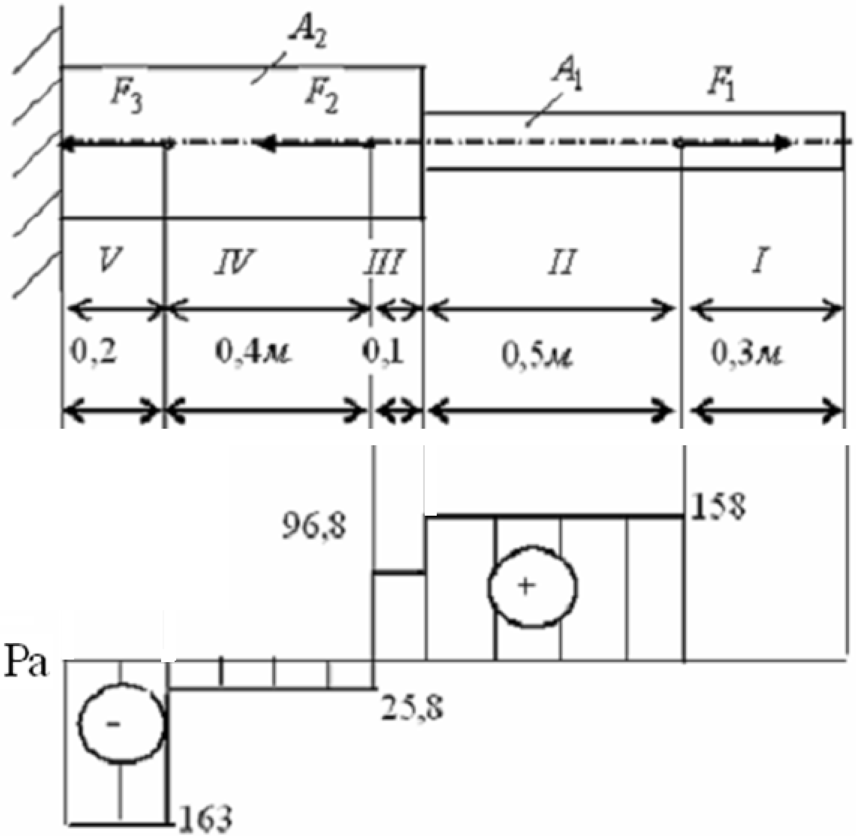


Diagram of normal stresses σ

Selection of the cross section of the bar from the condition of strength

$F = 170$ **kN** $[\sigma] = 140$ **MPa**

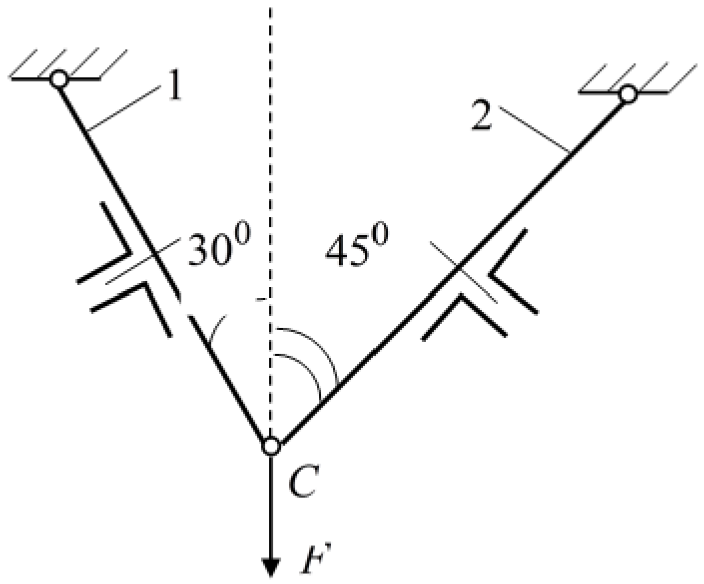


Fig. 3

Problem consists in:

1. to define the area of cross – section, which consists of two L-bars with unequal legs;

2. to calculate the percent of overload of the most loaded bar

Selection of the cross section of the bar from the condition of strength

$$F = 170$$ **kN** $$[\sigma] = 140$$ **MPa**

To find the forces N1 and N2 from static equation:

$$\sum F_{xi} = 0 \qquad -N_1 \cdot \sin 30^0 + N_2 \cdot \sin 45^0 = 0$$

$$\sum F_{yi} = 0 \qquad N_1 \cdot \cos 30^0 + N_2 \cdot \cos 45^0 - F = 0$$

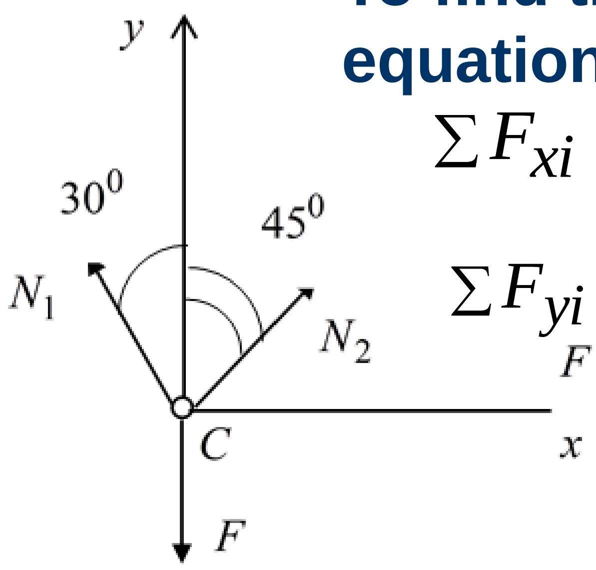


Fig. 4

Finally we get that:

$$N_2 = \frac{F}{1{,}41 \cos 30^0 + \cos 45^0} = 88{,}3$$ **kN**

$$N_1 = 1{,}41 N_2 = 1{,}41 \cdot 88{,}3 = 124$$ **kN**

Selection of the cross section of the bar from the condition of strength

Determine the desired area of cross – section for a given bar**:**

$$N_{max} = N_1 = 124{,}5 \text{ kN}$$

$$A_1 = \frac{N_1}{[\sigma]} = \frac{124{,}5 \cdot 10^3}{140} = 889 \text{ mm}^2$$

Finally we get that: $\frac{A_1}{2} = \frac{8{,}89}{2} = 4{,}445$ cm^2

Choose a profile № 6,3 (63 x 63 x 4), by an area

$$[A] = 4{,}96 \text{ cm}^2$$

Selection of the cross section of the bar from the condition of strength

Thus, the desired area of cross-section of bars will be equal**:**

$$2[A] = 2 \cdot 4{,}96 = 9{,}92 \text{ cm}^2$$

Then maximum tension in the cross-section of bar will be equal**:**

$$\sigma = \frac{N_1}{2[A]} = \frac{124{,}5 \cdot 10^3}{2 \cdot 4{,}96 \cdot 10^2} = 125{,}5 \ \textbf{MPa}$$

Check to durability of the most loaded bar:

$$\frac{[\sigma] - \sigma}{[\sigma]} \cdot 100\% = \frac{140 - 125{,}5}{140} 100\% = 10{,}3\%$$