Lecture 3
THE METHOD OF CALCULATION THE BAR ON STRENGTH

Plan

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

3.1. **Draw the diagram of normal forces N for a bar**.

Let us draw the diagram of normal forces N for a bar (Fig. 3.1, a).

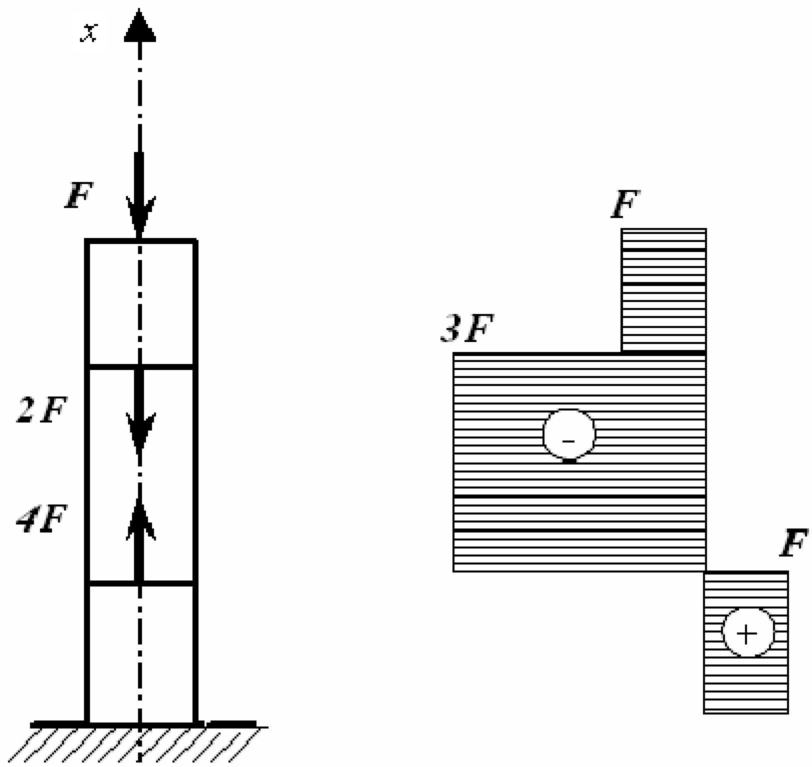

Fig. 3.1

Bar is divided by three areas. The limits of areas are sections where external forces are added. Let us determine the value of normal force on separate areas and draw the diagram as shown in Fig. 3.1, b:

I portion.

$$N_1 = -F.$$

II portion.

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

III portion.

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

On beginning

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

For this squared beam (Fig. 3.2) to draw the diagrams of central forces and normal tensions, if: $F_1 = 30$ kN, $F_2 = 38$ kN, $F_3 = 42$ kN, $A_1 = 1{,}9$ cm^2, $A_2 = 3{,}1$ cm$^{1.}$

1. Areas are indicated, as shown on Fig. 3.2, a.
2. Determine the value of central force N on the areas of the squared beam :

$$N_I = 0, \qquad N_{II} = F_1 = 30 \text{ kN}, \qquad N_{III} = F_1 = 30 \text{ kN},$$

$$N_{III} = F_1 = 30 \text{ kN}, \qquad N_{IV} = F_1 - F_2 = -8 \text{ kN},$$

$$N_V = F_1 - F_2 - F_3 = -50 \text{ kN}.$$

Let us draw the diagram of central forces (Fig. 3.2, b).

3. Calculate the value of normal tensions:

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

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

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

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

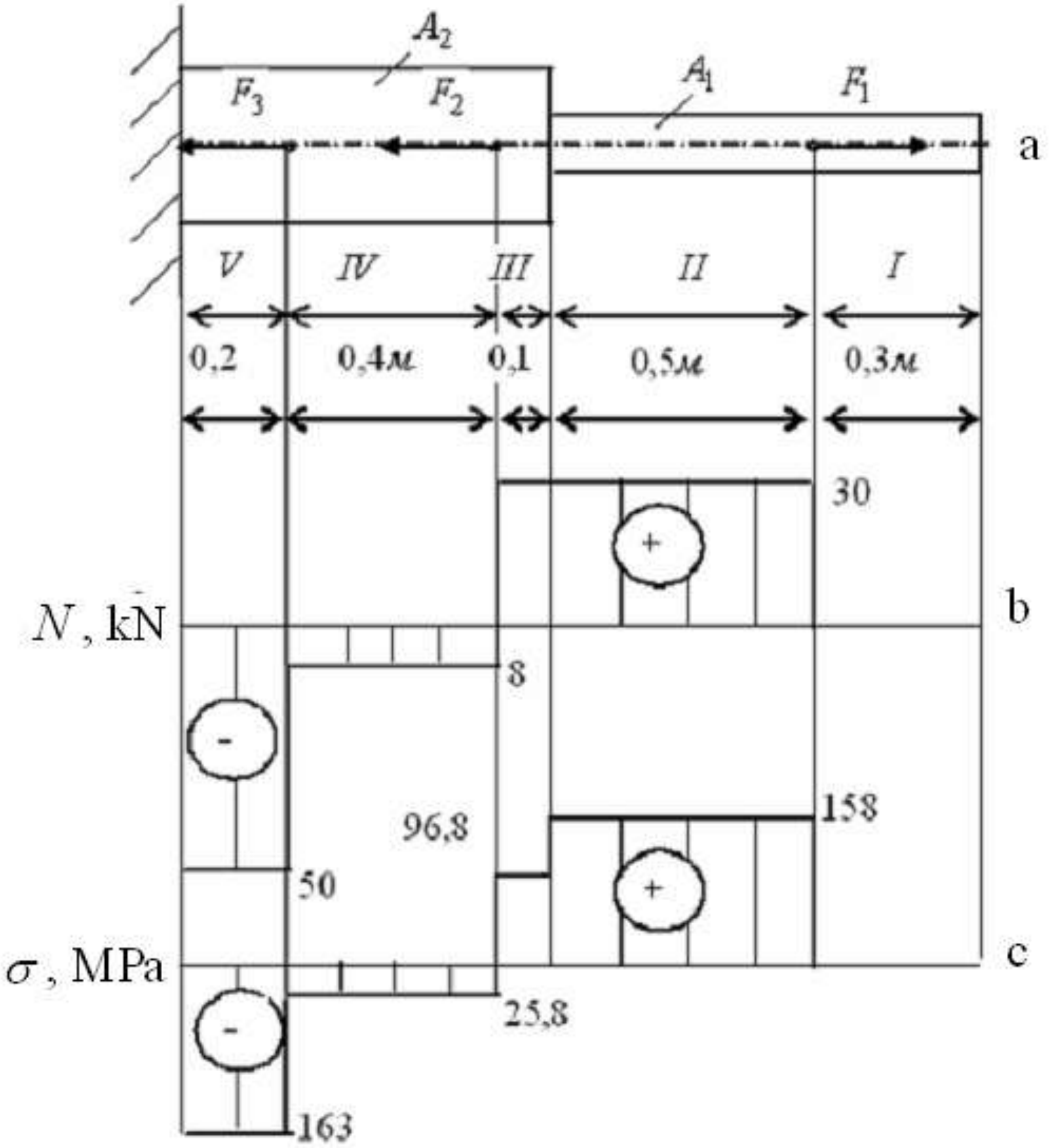

Fig. 3.2

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

Let us draw the diagram of normal tensions (Fig. 3.2, c).

On beginning

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

For this system of two bars of identical transversal sections (Fig. 3.3, a), loaded by force $F = 170$ kN to define:

1) necessary area of transversal sections, that consists of two L-bars with unequal legs, and to pick up the corresponding profile of L - bar;

2) the percent of overload of the most loaded bar for the accepted standard sizes of cut, taking into account, that $[\sigma] = 140$ MPa.

1. In this case the system of converge forces is applied on the hinge of C, as it is shown in Fig. 1.43, b. Using equation of equilibrium find forces N_1 and N_2 of corresponding bars 1 and 2:

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

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

Than:

$$N_1 = N_2 \frac{\sin 45^0}{\sin 30^0} = N_2 \frac{0{,}707}{0{,}5} = 1{,}41 N_2. \qquad (*)$$

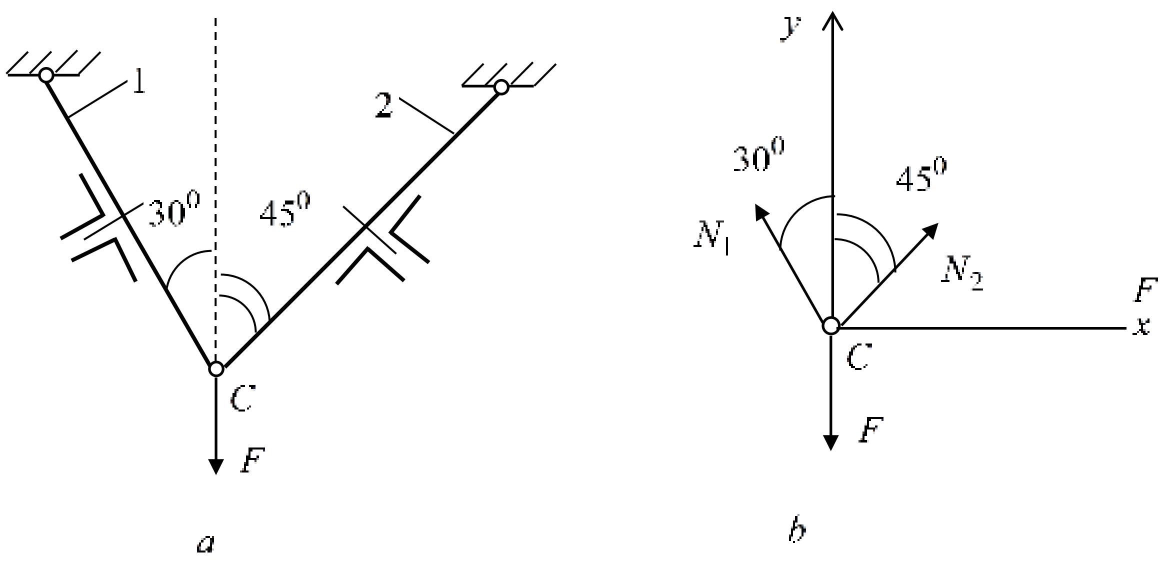

Fig. 3.3

Substituting the value of force N_1 in the second equation of equilibrium, get:

$$1{,}42N_2 \cdot \cos 30^0 + N_2 \cdot \cos 45^0 - F = 0,$$

or

$$N_2 = \frac{F}{1{,}41\cos 30^0 + \cos 45^0} = \frac{170}{1{,}41 \cdot 0{,}866 + 0{,}707} = 88{,}3 \text{ kN.}$$

Than:

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

2. Determine the desired area of transversal section for the most loaded bar:

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

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

Area of L- bar pick up by value $\frac{A_1}{2} = \frac{8{,}89}{2} = 4{,}445$ cm^2. Using data of reference book, choose a profile № 6,3 (63 x 63 x 4), by an area $[A] = 4{,}96$ cm^2. Thus, the desired area of transversal section of bars will be equal:

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

Then tension in the transversal section of the most loaded bar will be equal:

$$\sigma = \frac{N_1}{2[A]} = \frac{124{,}5 \cdot 10^3}{2 \cdot 4{,}96 \cdot 10^2} = 125{,}5 \text{ N/mm}^2 = 125{,}5 \text{ MPa.}$$

Check to durability of the most loaded bar:

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

Thus, underloading is 10,3 %.

On beginning