Lecture 25
COMBINED BENDING AND TENSION OR COMPRESSION

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Plan of lection

- 1. Classification of combined stresses
- 2. Combined bend and tension or compression
- 3. Example of beam calculation on bend and tension

Classification of combined stresses

A combined stresses is called such a stress state of building that can be replaced by a combination of the simplest kinds of deformations

In engineering calculations, combined stresses may be classified into the following four main types:

- **combined bending and tension or compression**;
- **a complex bending**;
- **the off-centre acting of force of tension or compression**;
- **combined bending and torsion**

Combined bend and tension or compression

The case of stresses state, when in an arbitrary cross-section internal force factors are given to the normal force and to one or two bending moments are in the perpendicular planes

Combined bend and tension or compression

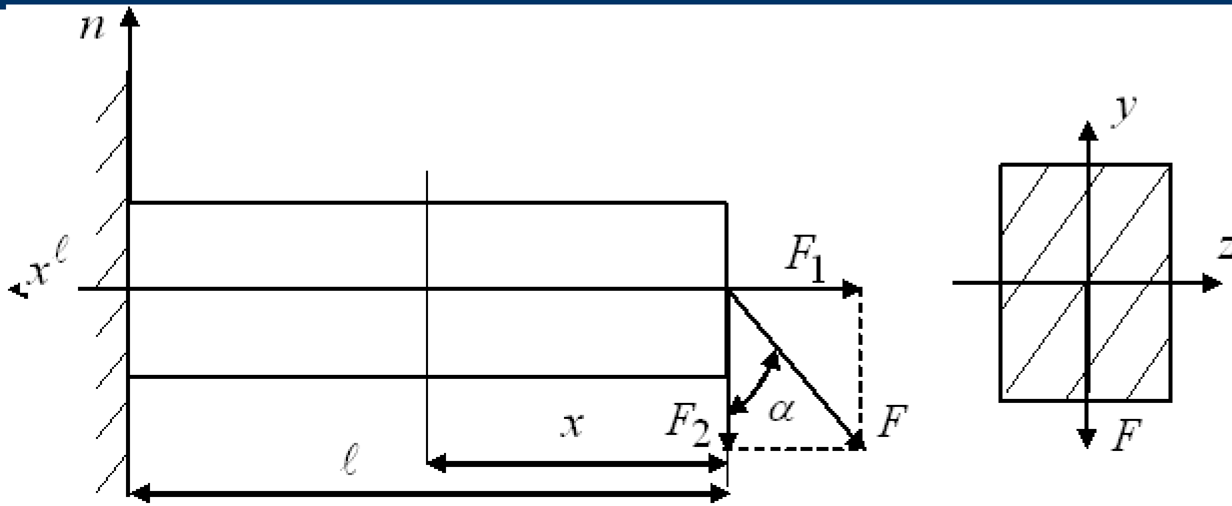


Fig. 1

Consider the problem of determining the normal stresses in arbitrary cross-section of a straight beam of big stiffness (Fig. 1), when we have direct transverse bending by force F_2 and simultaneously tension by force F_1.

Combined bend and tension or compression

Since the beam has a constant cross-sectional shape, the value of normal stresses in arbitrary cross-section is determined by the formula:

$$\sigma_N = \frac{N}{A} \qquad (1)$$

The stresses by bending moment which are caused by force are determined by the formula:

$$\sigma_y = \frac{M_x \cdot y}{I_z} \qquad (2)$$

Combined bend and tension or compression

Then the magnitude of total stresses, due to the principle of the independence acting of forces, at an arbitrary point of the cross-section of the beam, will determine from:

$$\sigma = \sigma_N + \sigma_y = \frac{N}{A} + \frac{M_x \cdot y}{I_z} \qquad (3)$$

Combined bend and tension or compression

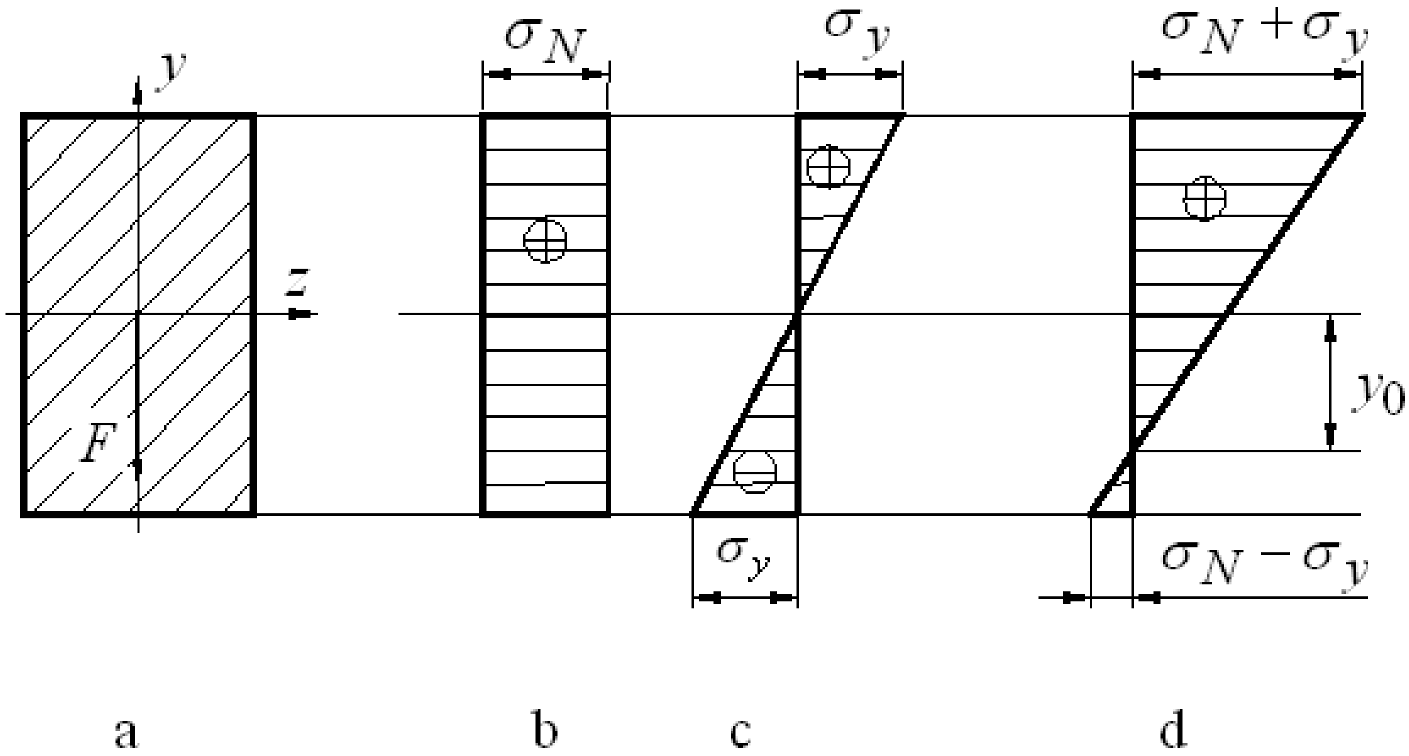


Fig. 2

Combined bend and tension or compression

Let us define a new position of the neutral axis of the cross section relative to the centroid of the section:

$$\frac{N}{A} + \frac{M_x \cdot y}{I_z} = 0$$

where

$$y_0 = -\frac{N}{A} \cdot \frac{I_z}{M_x} \qquad \textbf{(4)}$$

Combined bend and tension or compression

The strength condition of the beam, which is based on the magnitude of normal stresses in the dangerous cross-section, in the place of fixing, and will take the form:

$$\sigma_{\max} = \pm \frac{N}{A} \pm \frac{M_x}{W_z} \le [\sigma] \qquad \textbf{(5)}$$

Example

Let q=10 kN/m; M=20 kNm; α=60

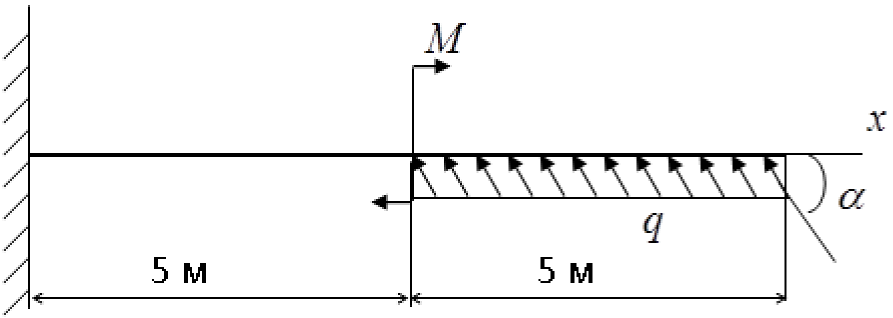


Fig. 3

Calculate the double T-beam cross-section of the beam

Example

The diagram of normal force for given beam

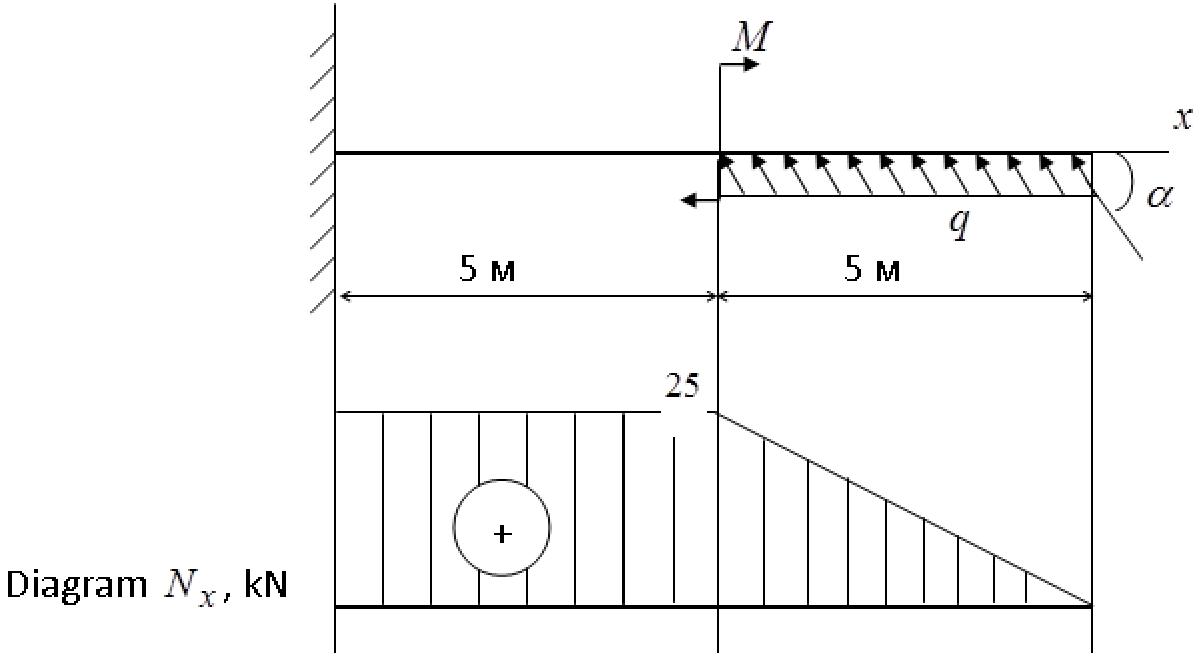
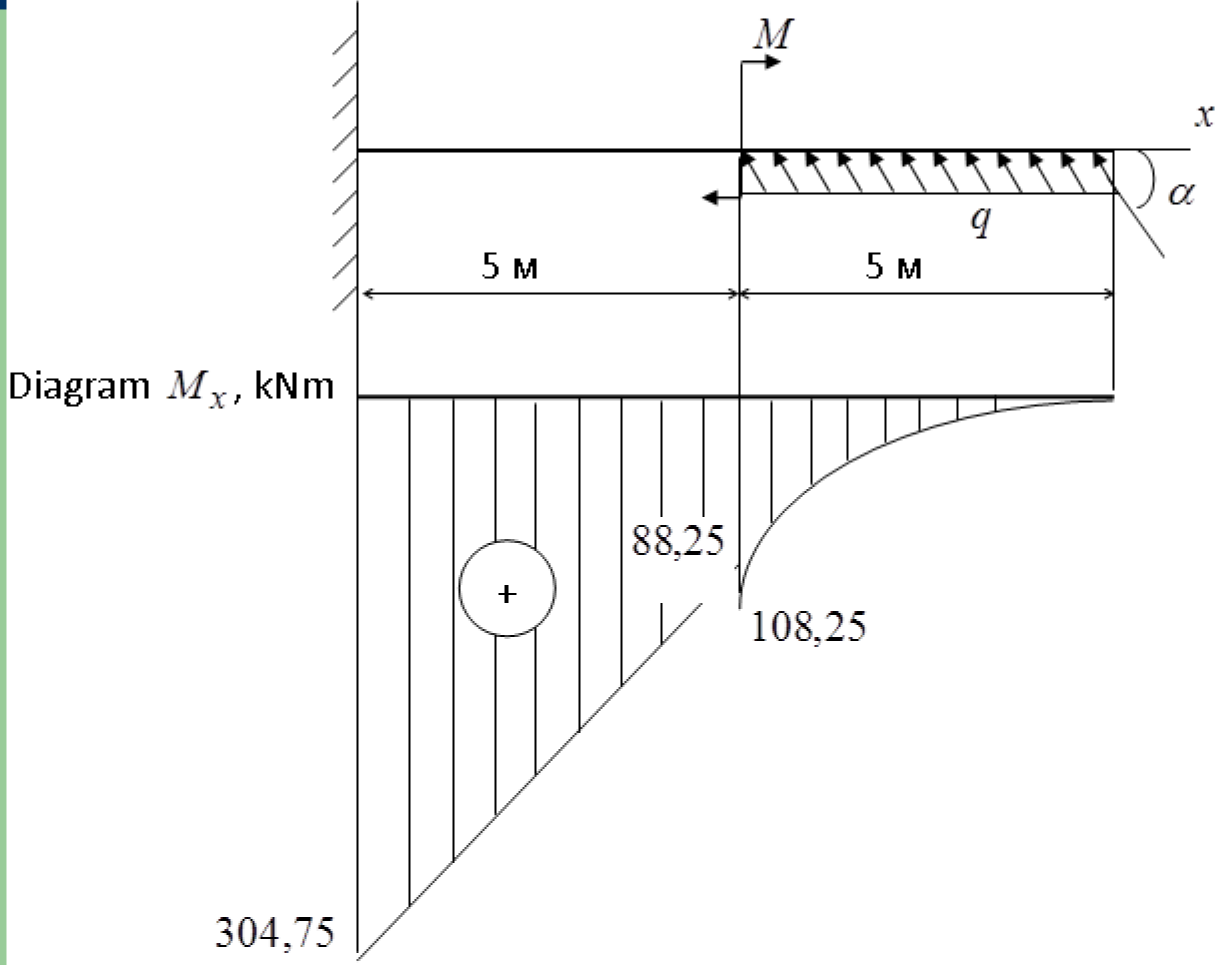


Fig. 4

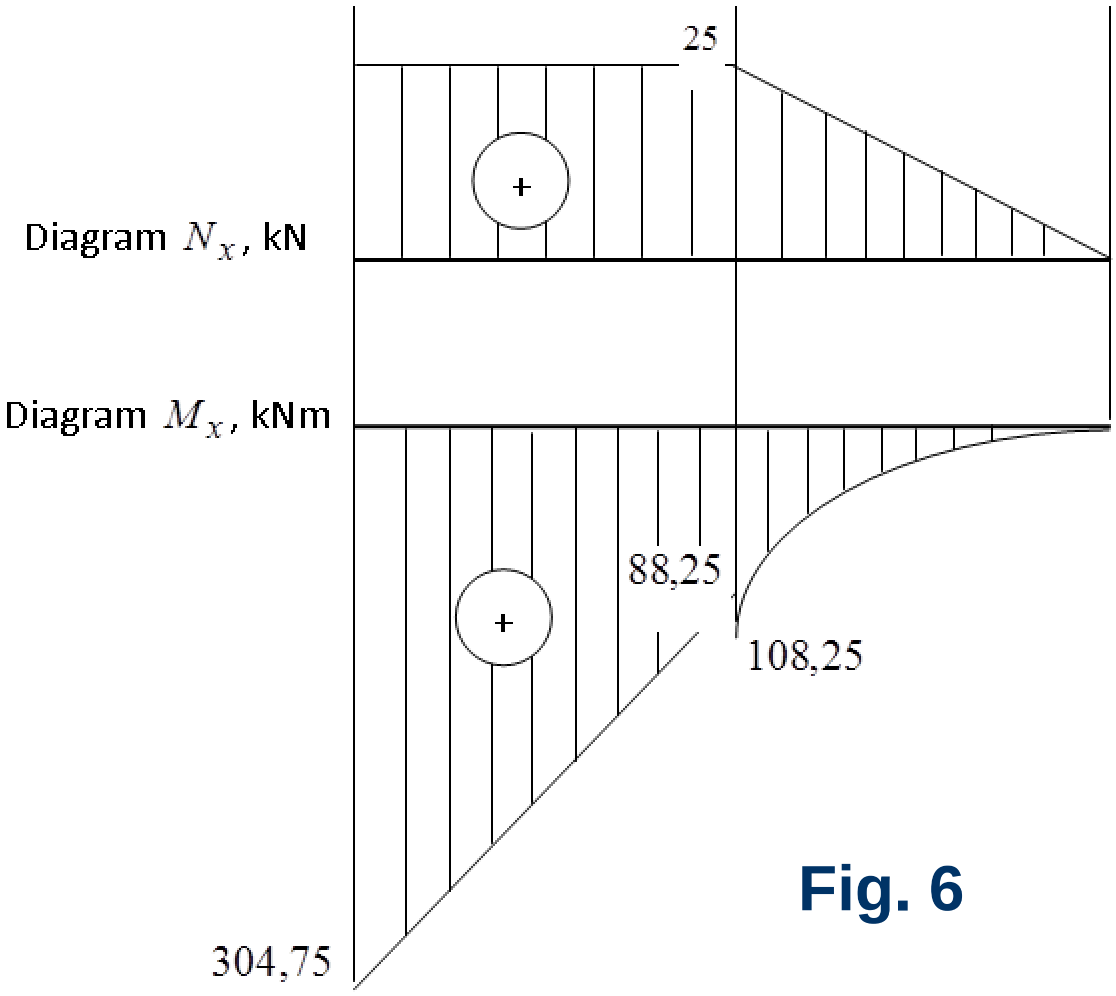
Example



The diagram bending moment for given beam

Fig. 5

Example



$$M_{max} = 304{,}75$$

kNm

$$N = 25$$ **kN**

Fig. 6

Example

The the condition of strength is:

$$\sigma_{\max} = \frac{304{,}75 \cdot 10^{-3}}{W_z} + \frac{25 \cdot 10^{-3}}{A} \leq 160 \text{ MPa}$$

Let us calculate dimensions of the cross-section from the bending:

$$W_z \geq \frac{304{,}75 \cdot 10^{-3}}{160} = 1905 \cdot 10^{-6} \text{ m}^3$$

Example

From the table sorts of steel we choose double T-beam № 55. For it we have:

$W_z = 2035$ sm^3 $A = 118$ sm^2

Checking on the strength of the beam by the formula :

$$\sigma_{max} = \frac{304{,}75 \cdot 10^3}{1905 \cdot 10^{-6}} + \frac{25 \cdot 10^3}{118 \cdot 10^{-4}} = (149{,}8 + 2{,}1) \cdot 10^6 = 151{,}9 \text{ MPa}$$

Example

The beam is not loaded with:

$$\frac{160-151{,}9}{160}100\% = 5{,}1\%$$