CHECKING THE BEAMS FOR STRENGTH IN LONGITUDINAL BENDING BY PLOTTING THE GEOMETRIC SIZE OF THE CROSS SECTION

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Annotation: the article gave rise to the equation of choice of its cross-section by constructing an epuyur for a geometric dimension with the selection of a plot in which the maximum full voltage of the cross-section of the balka working on the bend is formed. These issues are known to have previously been identified by constructing cutting force and bending moment epures.
Keywords: Shear force, bending moment, diagrams, tangential stresses, normal stresses, geometric dimensions, equations.

The testing of beams for bending strength has been extensively studied in the discipline of strength of materials. The solution of the problem is based on the construction of diagrams of shear force Q and bending moment M. A diagram built taking into account the dimensions of the cross section of the beam using these methods can simplify the problem for some time. When finding this equation, the methods of mathematics and strength of materials were used. It is known that the test for the strength of various materials during bending of beams is carried out using the formula for rectangular cross sections [1], [2],:

$$\sigma = \frac{M}{W} \le [\sigma] \quad (a) \qquad\qquad \tau = \frac{Q \cdot S}{b \cdot J} \le [\tau] \quad (b) \qquad (1)$$

where M is the bending moment, W is the moment of resistance, Q is the shear force, S_x is the static moment of the allocated cross-sectional area, b is the width of the rectangle, J is the moment of inertia of the cross-sectional area.

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Figure 1 shows stress graphs constructed according to equations (1). The maximum value of the tangential stress reaches the line of the neutral axis, and the maximum values of the normal stress at the end of the cross section [3], [4].

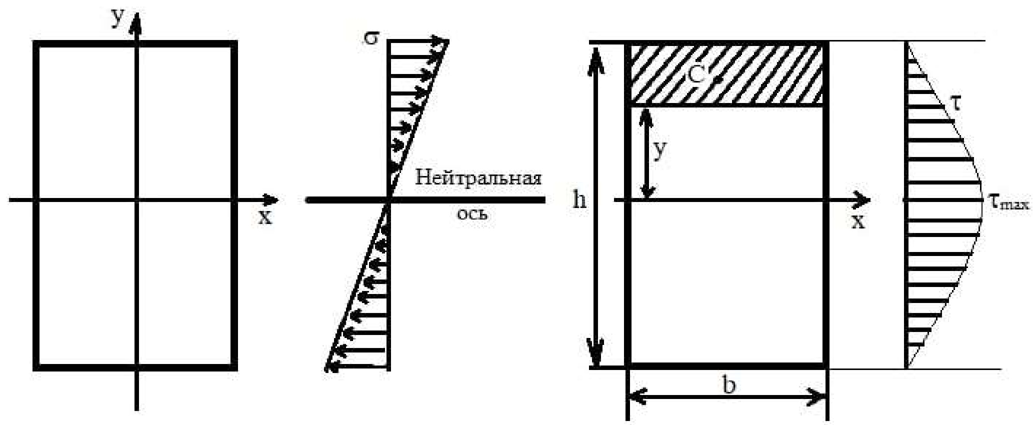

Fig.1

As is known, the maximum value of the cross-sectional tension is between the neutral and extreme points, since tangential and normal stresses are applied at these points simultaneously. Based on these considerations, we rewrite equation (1) as follows, taking into account the allowable stress and geometric dimensions:

$$\sigma = \frac{M_{\max.}}{J_x} \cdot y \le [\sigma] \quad (a) \qquad \tau = \frac{Q_{\max.} \cdot \frac{b}{2} \cdot (\frac{b^2}{4} - y^2)}{b \cdot J_x} \le [\tau] \quad (b) \tag{2}$$

or by transforming the equation,

$$p = \sqrt{\left(\frac{M}{J_x} \cdot y\right)^2 + \left(\frac{Q}{2 \cdot J_x} \cdot \left(\frac{b^2}{4} - y^2\right)\right)^2} \tag{3}$$

To determine the maximum value of the total voltage p, we take the values M=1 and Q=1 i.e. equal to one, while taking into account that the moment of inertia are equal,

$$J_x = \frac{b \cdot h^3}{12} \quad (a) \qquad b = \frac{h}{k} \quad (b) \tag{4}$$

If k=1 then the section of a rectangular quadrilateral turns into a square.
Transforming equation (3), taking into account expressions (4), we get

$$p = \sqrt{\frac{36 \cdot k^2}{h^8} \cdot y^4 + \frac{144 \cdot k^2}{h^8} \cdot y^2 - \frac{18}{h^6} \cdot y^2 + \frac{9}{4 \cdot h^8 \cdot k^2}} \tag{5}$$

If we accept that, $h = 1$, then its value means relative to h

$$p = \sqrt{36 \cdot k^2 \cdot y^4 + (144 \cdot k^2 - 18) \cdot y^2 + \frac{9}{4 \cdot k^2}} \tag{6}$$

noting,

$$A = 36 \cdot k^2 \cdot \qquad B = 144 \cdot k^2 - 18 \qquad C = \frac{9}{4 \cdot k^2} \tag{7}$$

$$p = \sqrt{A \cdot y^4 + B \cdot y^2 + C} \tag{8}$$

As a result, we get:

$$\dot{P} = \frac{4 \cdot A \cdot y^3 + 2 \cdot B \cdot y + C}{2\sqrt{A \cdot y^4 + B \cdot y^2 + C}} = 0 \tag{9}$$

Solving equations (9) we find the extreme points of the function, we construct its graph. And we find that, for $y=y_0$, $p=p_{max}$.

Then equations (2) take the following form:

$$\sigma = \frac{M_{\max.}}{J_x} \cdot y_0 \le [\sigma] \quad (a) \qquad \tau = \frac{Q_{\max.} \cdot (\frac{b^2}{4} - y_0)}{2 \cdot J_x} \le [\tau] \quad (b) \tag{10}$$

$$\text{где} \qquad J_x = \frac{b \cdot h^3}{12} \quad (a) \qquad k = \frac{h}{b} \quad (b) \tag{11}$$

Taking into account (11), we write equations (10) as follows,

$$h^4 = \frac{12 \cdot k \cdot M \cdot y_0}{[\sigma]} \quad (a) \qquad h^4 - \frac{3 \cdot Q}{2 \cdot [\tau] \cdot k} \cdot h^2 + \frac{6 \cdot k \cdot Q \cdot y_0{}^2}{[\tau]} = 0 \quad (b) \tag{12}$$

From equation (12 b) we find h, for this we accept the following notation:

$$A = 1 \qquad h^4 = E^2 \qquad B = -\frac{3 \cdot Q}{2 \cdot [\tau] \cdot k} \qquad C = \frac{6 \cdot k \cdot Q \cdot y_0{}^2}{[\tau]} \tag{13}$$

then we get the equation: $E^2 + B \cdot E + C = 0$

$$\text{then,} \quad E = \frac{-B \pm \sqrt{B^2 - 4 \cdot A \cdot C}}{2} = \frac{\frac{3 \cdot Q}{2 \cdot [\tau] \cdot k} \pm \sqrt{\frac{9 \cdot Q^2}{4 \cdot [\tau]^2 \cdot k^2} - \frac{24 \cdot k \cdot Q \cdot y_1{}^2}{[\tau]}}}{2} \tag{14}$$

Knowing that $h = \sqrt{E}$ we get the following expression

$$h = \sqrt{\frac{\frac{3 \cdot Q}{2 \cdot [\tau] \cdot k} \pm \sqrt{\frac{9 \cdot Q^2}{4 \cdot [\tau]^2 \cdot k^2} - \frac{24 \cdot k \cdot Q \cdot y_1{}^2}{[\tau]}}}{2}} \tag{15}$$

Multiplying the equations (12 a) and (15) the right and left parts, respectively, we have the following equations:

$$h = \sqrt[5]{\left(\sqrt{\frac{\frac{3 \cdot Q}{2 \cdot [\tau] \cdot k} \pm \sqrt{\frac{9 \cdot Q^2}{4 \cdot [\tau]^2 \cdot k^2} - \frac{24 \cdot k \cdot Q \cdot y_1^2}{[\tau]}}}{2}} \right) \cdot \frac{12 \cdot k \cdot M \cdot y_1}{[\sigma]}} \tag{16}$$

Equation (16) is a solution to a problem in which you can find the size of the cross section of a rectangular quadrilateral or square, while it takes into account the most stressed y_0 ordinate from the neutral axis of the cross section using the auxiliary equation (9). M and Q, since they are a function of the *Ox* axis, will give us their directly proportional value of *h* where it has the most maximum value. This shows that we do not need to choose the value of external forces, (16) the equation itself chooses which coordinate *Ox* corresponds to the maximum value of *h*.

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