AJEMA GLOBAL RESEARCH NETWORK

AMERICAN Journal of Engineering, Mechanics and Architecture
Volume 2, Issue 3, 2024 ISSN (E): 2993-2637

Calculation of Rod Bolt Strength

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Abstract: In this article, it is assumed that under the action of an external force, various stresses arise in the bolt joint rod. For example, when only a tensile force is applied to the bolt rod, the bolt is strongly tensioned, and when no external force is applied to the bolt rod, the bolt is stretched, when a tensile force is applied to the bolt rod from the outside, when the force in the bolted joint is directed perpendicular to the axis, when the acting force creates a bending moment on the bolt shaft, and the stresses were determined when calculating the bolt end connections.

Keywords: bolt, rod, hook, thread, yoke, external thread, thread, equivalent, metric thread, hermetic.

Introduction: Under the influence of an external force, various stresses arise in the rod of a bolted connection.

In this case, the magnitude of stresses in the stern depends on the direction of external forces and is determined as follows;

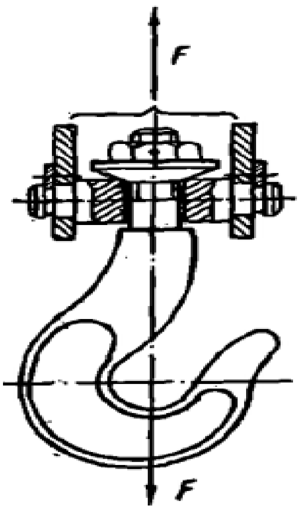

Figure 1

a) Let only a tensile force act on the bolt shaft. To do this, we can take as an example a hook that is not too tight and not stressed (Fig.1).

Under the influence of an external force, various stresses arise in the bolted connection rod, the magnitude of which depends on the direction of the external forces and is determined as follows;

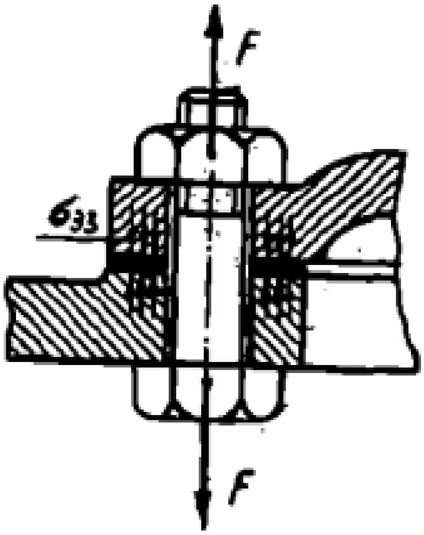

Figure 2

Its threaded part is checked for elongation under the action of an external force R along the d-diameter:

b) The bolt is tightened tightly, and no external force acts on the rod (Fig.2).

$$б = \frac{P}{\pi d_1^2/4} \leq [б] \qquad\qquad d_1 = \sqrt{\frac{4P}{\pi[б]}}$$

This includes the bolts used to slide and secure the closed transmission cover. As a result of tightening, tensile and torsional stresses arise in the bolt shaft, while the stresses created by the external tensile force

$$\mathrm{b} = \frac{4P}{\pi d^2}$$

The torsional tension created by the torque in the rod thread is:

$$\tau = \frac{T_p}{w} = \frac{0{,}5Pd_2\mathrm{tg}(\varphi + \mathrm{p}^I)}{0{,}2d_l^3}$$

Total (equivalent) voltage in the stern

$$б_{экв} = \sqrt{б^2 + 3\,\tau^{\,2}} = б\sqrt{1 + 3(\frac{\tau}{б})^2}$$

here, $$\frac{\tau}{б} = \frac{0{,}5Pd_2\mathrm{tg}(\varphi + \mathrm{p}^I)\pi d_1^2}{(\pi d_l^3/16)4P}$$

For metric threads with relatively large pitches: $d_2 \approx 1.1d_{\tau^3}$ $\beta = 2^\circ 30^I$, $\mathrm{p}^I = 9^\circ 45^I$

provided that $\frac{\tau}{б} \approx 0{,}5$. In that d_2, φ, p' for accepted values $б_{экв} \approx 1{,}3б$

Therefore, the value of the total force R acting on the bolt shaft when tensile and torsional forces are applied is recommended to be taken as indicated above, where the tension value is determined as follows:

$$б_{экв} \approx 1{,}3б = \frac{5.2P}{\pi d_1^2} \leq [б]$$

Design diameter of threaded bolt $d_1 \geq \sqrt{5.2P_Y}$ мм. (6).

Here, [б] = $б_{oқ}$/ [S] — permissible tensile stress for a bolt. $б_{oқ}$— yield strength of the bolt material; [S] is the safety factor, its value is taken according to depending on the nature of the load, diameter and material of the bolt.

The bolt is pulled out, and a tensile force is applied to the bolt shaft from the outside. Examples of this are bearing units in a closed gear, lids of sealed containers under pressure (Fig.3). Air or liquid does not come out of the connection groove when the bolt is pulled out by force Pc, but due to the external force P_1, the bolt rod is stretched by the amount Δl_b.

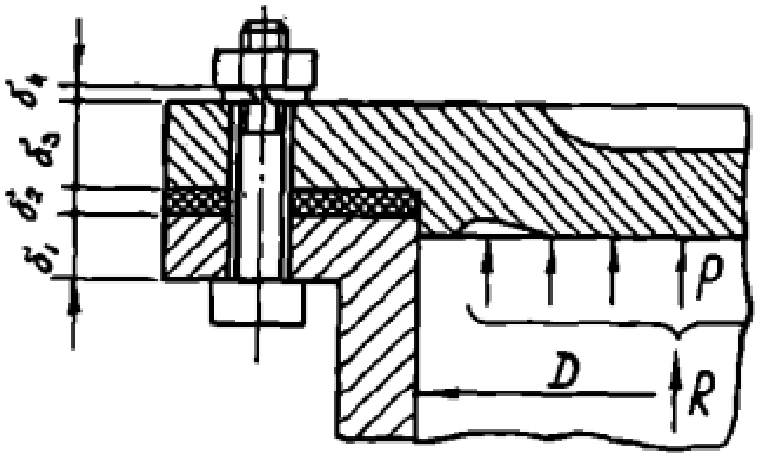

Figure 3

When calculating the strength of a bolt in connections, torque is taken into account, as a result the bolt must be pulled with the following force.

In this case, the connection parts are compressed, i.e. $\Delta l_b = \Delta l_g$. (1— Figure).

The result is the total value of the forces acting on cj. $P_{\Sigma} = P + P_1$ (13) will

The elongation and compression of the connection parts is influenced by the external force P_1, at which P_1 power to the rod, bolt, the rest (1 - power connection details $(1 - P_1)$ influences. In this case, the total force acting on the shutter rod

$$P_{ум} = P + P_1 \text{ will}$$

The diameter of the bolt can be determined using formula (1.6), the value of the safety factor is selected according to table 1.2.

d) In a bolted connection, the force is directed perpendicular to the axis. In this case, the bolt can be installed in two different ways.

1) There is a gap between the bolt and the part, and the external force is balanced by friction between the parts (Fig. 4). The magnitude of the force acting on the bolt

$$P = \frac{kP_1}{f\,i\,z}$$

here: P_1 - external force: f - coefficient of friction between parts: k= 1.4...2 - coefficient of caution: i - number of sections: z - number of bolts.

A threaded bolt acts in tension and torsion, resulting in a calculation strength values P_x=1/3P will be. The diameter of the bolt is determined by formula (1.6). Figure 4

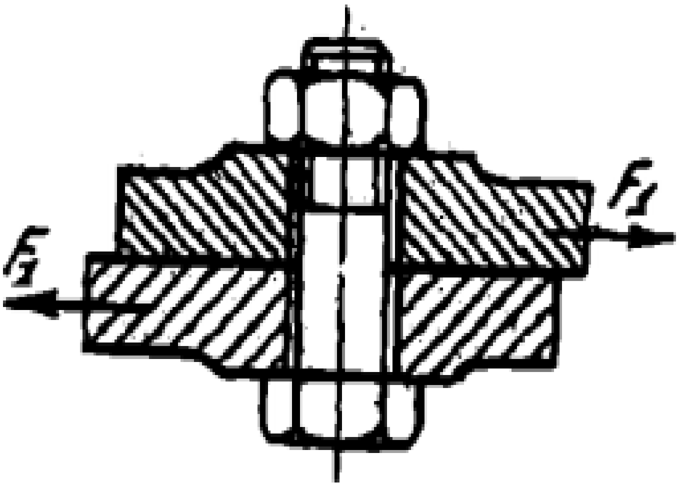

Figure 4

2) There is no gap between the bolt and the part (Fig. 4). The shank of such bolts is tested for shear stress, and its diameter is determined as follows;

$$d = \sqrt{\frac{4P}{\pi iz[\tau_{\text{кес}}]}}$$

e). The acting force creates a bending moment in the rod member. When the surface of the part connecting to the surface of the nut is uneven (Fig. 1.4) or when using bolts made in the form of hooks with a head not specified in the standard, in addition to the tensile force, a bending moment is created. in its stem. Therefore, when calculating such bolts, in addition to the tensile force, it is necessary to pay attention to the bending moment. Tensile stress:

$$б = \frac{P}{(\pi d_k/4)}$$

4) Stress created by bending moment: $\sigma_{\text{эг}} = \frac{P_x}{(0{,}1/d_1^2)}$ If $x = d_1$ If $\sigma_{\text{эг}=}P/(0{,}1/d_1^2$

2) when the value of the angle a is small, the value of the stress in the bend is determined as follows, taking into account the additional deformation caused by this bending:

$$\sigma_{\text{эг}} = \frac{M}{W_{\text{эг}}} \approx \text{E}d\alpha/2I_б$$

Here, : M=EI/p, $\rho = \frac{I_б}{\alpha}$; $W_{\text{эг}} = \frac{I}{d/2}$

The smallest value of these determined stresses is taken as the design bending stress. The general conditions for bolt strength are as follows:

$б = б_1 + б_{\text{эг}} \leq [б]$ (8)

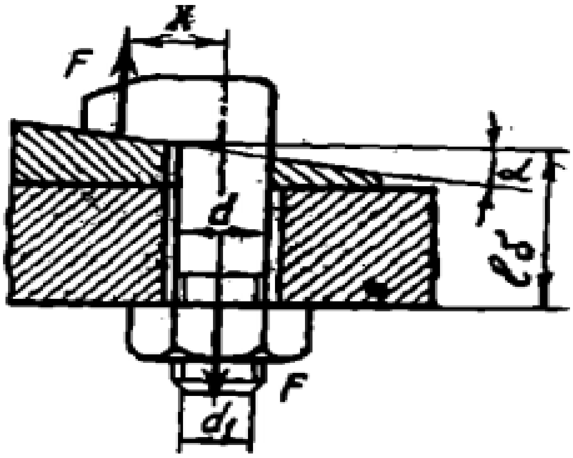

Figure 5

Calculations show that the ratio of these stresses $\frac{б_{эг}}{б_1} \approx 7.5$ equals Therefore, the bending stress sharply reduces the strength of the bolt shank. Therefore, in such conditions it is better to use as few bolts as possible.

Calculation of end connection bolts. Clamping connections are designed for fastening parts to shafts, axles, cylindrical columns and are formed by tightening the bolts themselves (Fig.6).

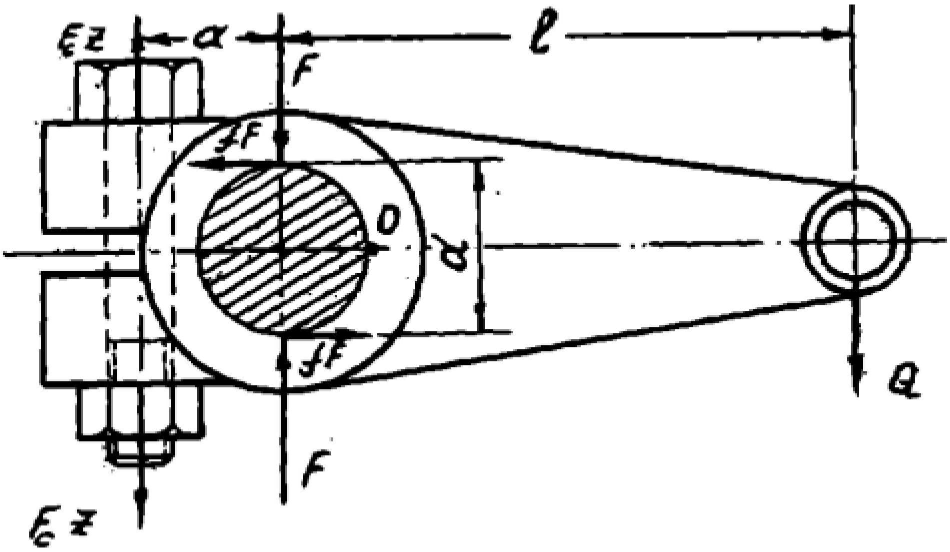

Figure 6

At one end of the lever prepared for this purpose there is a hole for the installation of a shaft, its diameter is easily adjusted to the shaft by a slot for the purpose, and by tightening the bolts it is compressed, and it is firmly fixed to the shaft. In this case, the moment of friction force arising between the surface of the hole and the surface of the shaft from the lever must be equal to or greater than the moment of external force (20% more), that is:

$$f F d = 1{,}2 Q I$$

As a result, the force generated on the surface of the terminal with the shaft:

$$F = 1{,}2 Q 1 / f d *$$

where: f – friction coefficient; d – shaft diameter, – 1 – lever arm. If we assume that the lever with the terminal pin is fixed in a hinged position at point 0, then the condition for maintaining the equilibrium position of the terminal connection will be as follows, i.e. the sum of the moments about point O is obtained:

$$P_C z\left(\alpha + \frac{d}{2}\right) - P\frac{d}{2} = 0 \text{ **}$$

From here the value of the force P_C required to pull the bolt is determined:

$$P_C = \frac{Pd}{(2\alpha + d)z}$$

will be equal to Considering formulas :

$$P_C Z = P$$

Using formulas the amount of force required to tighten the bolt is determined as follows:

$$P_C = 1.2\, QI/fdz \qquad (9)$$

Conclusion: Thus, to calculate the bolts of terminal connections, the force P_C required to tighten the bolts is determined. Then their strength is calculated using the method given in b), i.e.

$$\sigma_{экв} = \frac{1.3P}{\frac{\pi d_k^2}{4}} \leq [\sigma] \qquad (10)$$

The main advantage of clamp connections is that the lever can be positioned at any angle, creating a keyless connection, and is relatively easy to assemble and repair. The disadvantage is that these connections are unreliable (especially under the influence of variable forces).

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