METHOD OF ASSESSMENT RELIABILITY OF THE BOLTED CONNECTION

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***Abstract**: The bolted connection are deactivated mainly due to crushing and shearing stresses. Request bolt bending can neglect because of elements of the assembly clearences are generally very small. This paper presents a design variant of this type of assembly, ultimately determining the reliability of the assembly function.*

***Keywords**: bolted connection, crushing stresses, shearing stresses, statistical parameters, percentage reliability,Laplace function.*

1. DETERMINATION THE STATISTICAL PARAMETERS OF SHEARING STRESS

The shearing stress of the bolted connection is described by relation [1]:

$$\tau_s = \frac{F}{n \cdot A_1} \tag{1}$$

where: τ_s - tension shear bolt material; F - force applying assembly; A_1 - section shear bolt; n - number of sections of shear (generally n = 2).

Considering that the bolt have the nominal diameter d, a_s higher deviation and lower deviation a_i, field size tolerance is considered:

$$T_d = a_s - a_i \tag{2}$$

Considering that the size distribution is where most likely a Normal partition law, then 99.72% of values fall in the variable d:

$$\Delta = 6\sigma_d = (m_d - 3 \cdot \sigma_d; \quad m_d + 3 \cdot \sigma_d) \tag{3}$$

where: m_d - mean random variable d; σ_d - standard deviation of the random variable d.

Mean cross-sectional bolt has the expression:

$$m_{A_1} = \frac{\pi \cdot m_d^2}{4} \tag{4}$$

where: m_d - mean value of the bolt diameter, approaching the average nominal value;

Equation (4) shows that random variable A_1 - cross section bolt, is a function of random variable d - diameter bolt. As a result, cross-sectional standard deviation value is determined by the relation:

$$\sigma_A = \sqrt{\left(\frac{\partial A_1}{\partial d}\right)^2 \cdot \sigma_d^2} = \frac{\pi}{4} \cdot 2 \cdot m_d \cdot \sigma_d \tag{5}$$

Given the relation (1), the average shear bolt stress is:

$$m_{\tau_s} = \frac{m_F}{2 \cdot m_{A_1}} \tag{6}$$

Standard deviation of the shear bolt stress is calculated with relation:

$$\sigma_{\tau_s} = \sqrt{\left(\frac{\partial \tau_s}{\partial F}\right)^2 \cdot \sigma_F^2 + \left(\frac{\partial \tau_s}{\partial A_1}\right)^2 \cdot \sigma_{A_1}^2} \tag{7}$$

or:

$$\sigma_{\tau_s} = \frac{1}{2}\sqrt{\frac{m_F^2 \cdot \sigma_{A_1}^2 + m_{A_1}^2 \cdot \sigma_F^2}{m_{A_1}^2}} \tag{7'}$$

$$\sigma_{\tau_s} = \frac{1}{2m_{A_1}}\sqrt{\sigma_F^2 + \left(\frac{m_F}{m_{A_1}} \cdot \sigma_{A_1}\right)^2} \tag{7''}$$

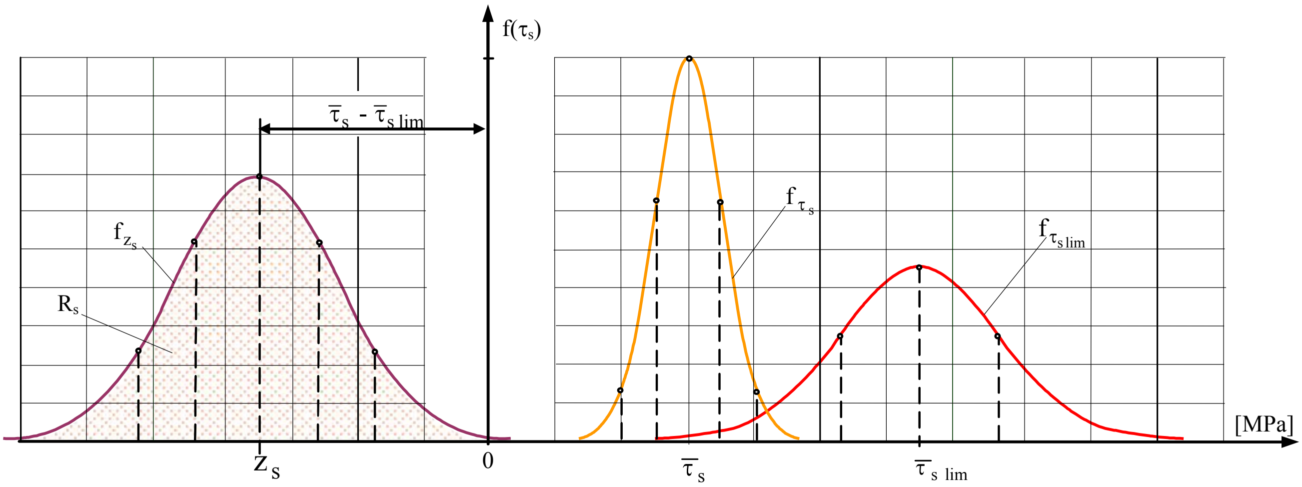

Fig.1 Graphical representation of admissible and effective stress distributions for the application of shear and reliability function for this application

Because the terms of (6) and (7") values are known, the bolt shear stresses can be defined as a random variable, namely: $(m_{\tau_s}, \sigma_{\tau_s})$.

Shear stress allowable bolt material is also considered a random variable $(m_{\tau_{sa}}, \sigma_{\tau_{sa}})$, its can determine the statistical parameter of safety at the request of shear bolt, a_{b_s} (Tudor, 1988:138):

$$a_{b_s} = (m_{\tau_{sa}} - m_{\tau_s}) \Big/ \sqrt{D_{\tau_{sa}} + D_{\tau_s}} \qquad (8)$$

where: $m_{\tau_{sa}}, m_{\tau_s}$ - means of the shear stress admissible and effective; $D_{\tau_{sa}}, D_{\tau_s}$ - dispersions of the shear stress admissible and effective;

Reliability function of the assembly of the bolt resistance provided at the request of shear is determined by the relation:

$$R_{b_s} = \Phi\left(a_{b_s}\right) = \frac{\gamma_{b_s}}{100} \qquad (9)$$

where: $\Phi\left(a_{b_s}\right)$ - Laplace function argument a_{b_s}; γ_{b_s} - reliability percentage for application of shear;

In fig. 1 were represented in the same coordinates system of probability density distributions for the shear stress admissible and effective, the shaded area representing the bolt assembly reliability.

Similarly proceed to determine the reliability and assembly with bolts for requests for crushing material between bolt and hook (if clambolt assembly).

2. DETERMINATION THE STATISTICAL PARAMETERS OF CRUSHING STRESS

The crushing stress of the bolted connection is described by relation (Chișiu, 1981:142):

$$\sigma_c = \frac{F}{n \cdot A_2} = \frac{F}{n \cdot l_1 \cdot d} \qquad (10)$$

where: σ_c - the tension of the bolt crushing material; F - force applying assembly; A_2 - crushing section of the bolt; n - number of sections of crushing (generally n = 2).

Mean crushing section is expressed as:

$$m_{A_2} = m_{l_1} \cdot m_d \qquad (11)$$

From equation (11) that the random variable A_2 - crushing section, is a function of random variables l_1 and d. In this case, the standard deviation of the crushing section is determined by the relation:

$$\sigma_{A_2} = \sqrt{m_{l_1}^2 \cdot \sigma_d^2 + m_d^2 \cdot \sigma_{l_1}^2} \qquad (12)$$

Given the relation (10), the mean crushing stress is expressed as:

$$m_{\sigma_c} = \frac{m_F}{2 \cdot m_{A_2}} \qquad (13)$$

Standard deviation of the crushing stress relationship is determined by (Martinescu, Popescu, 1995:87):

$$\sigma_{\sigma_c} = \sqrt{\left(\frac{\partial \sigma_c}{\partial F}\right)^2 \cdot \sigma_F^2 + \left(\frac{\partial \sigma_c}{\partial A_2}\right)^2 \cdot \sigma_{A_2}^2} \qquad (14)$$

$$\sigma_{\sigma_c} = \sqrt{\frac{m_F^2 \cdot \sigma_{A_2}^2 + m_{A_2}^2 \cdot \sigma_F^2}{m_{A_2}^2}} \qquad (14')$$

$$\sigma_{\sigma_c} = \frac{1}{m_{A_2}} \sqrt{\sigma_F^2 + \left(\frac{m_F}{m_{A_2}} \cdot \sigma_{A_2}\right)^2} \qquad (14'')$$

Since the terms of relations (13) and (14”) are known values, crushing stress can be defined as a random variable, namely: $(m_{\sigma_c}, \sigma_{\sigma_c})$.

Crushing admissible stress bolt material is also considered a random variable $(m_{\sigma_{ca}}, \sigma_{\sigma_{ca}})$, we can calculate the statistical parameter of safety at the request of crush a_{b_c} [4]:

$$a_{b_c} = (m_{\sigma_{ca}} - m_{\sigma_c}) \Big/ \sqrt{D_{\sigma_{ca}} + D_{\sigma_c}} \qquad (15)$$

where: $m_{\sigma_{ca}}, m_{\sigma_c}$ - means crushing stress admissible and effective; $D_{\sigma_{ca}}$, D_{σ_c} - dispersions admissible crushing stress and effective;

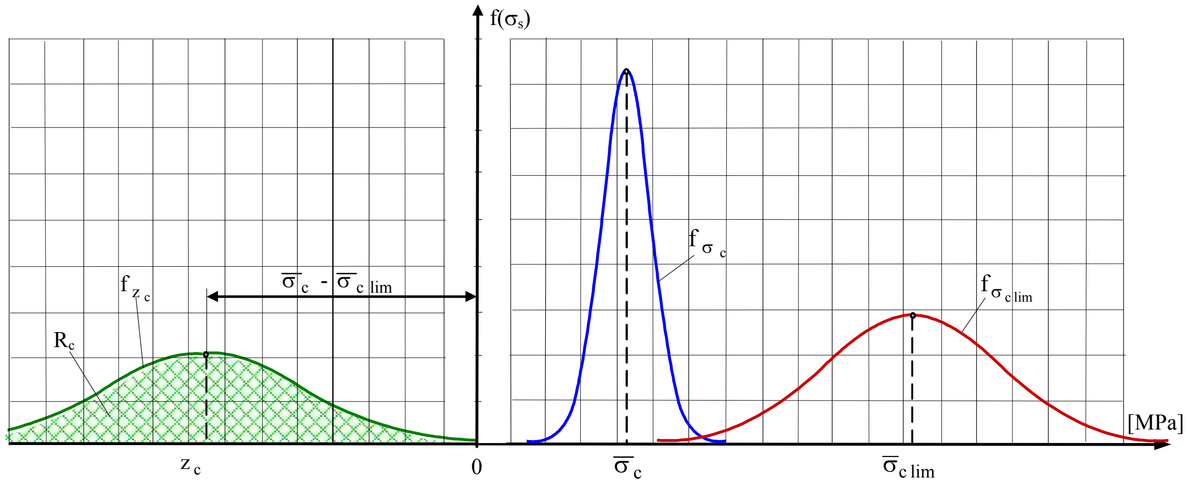

Fig.2 Graphical representation of admissible and effective stress distributions for the application of crush and reliability function for this application

In figure nr. 2 is represented in the same coordinates system of probability density distributions for effective crushing stress and admissible, the shaded area bounded by the graph of the function and reliability being abscises axis assembly with bolts.

Reliability function of the assembly of resistance provided at the request of crushing bolt is determined by the relation:

$$R_{b_c} = \Phi\left(a_{b_c}\right) = \frac{\gamma_{b_c}}{100} \qquad (16)$$

where:

$\Phi\left(a_{b_c}\right)$- Laplace function argument a_{b_c}; γ_{b_c} - Reliability percentage at the request of crushing;

Taking into account the principle that resistance of materials used in theory, the "overlapping effects" case analyzed in this article, the bolt assembly during operation, appear simultaneously both shear stress and the crushing stress.

In this case the overall reliability function of the bolt assembly is expressed as:

$$R_b = R_{b_s} \cdot R_{b_c} \qquad (17)$$

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