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ANALYSIS OF INFLUENCE OF VALUES INITIAL AXIAL FORCES IN THE BOLTS OF STIRRUPS ON VALUE OF A YIELD IN THE FRICTIONAL JOINT

On the operational parameters of frictional joints being applied in the yielding support of dog headings a very significant influence have the initial values of axial forces in the bolts of stirrups, since they decide on load capacity and yield capacity. Value of displacement of a section sliding down (value of the yield in the joint) is a measure of the yield capacity of the frictional joint. In the paper results of stand tests are presented. They were carried out in order to determine the influence of initial values of axial forces in the bolts of stirrups on the value of the yield in the frictional joint. The tests were performed for the straight frictional joints loaded with an impact of freely falling mass. Obtained results should be used practically, at the selection of yielding support for dog headings threatened by dynamic loadings.

Keywords: yielding mining support, stirrups, frictional joint

1. Introduction

The basic parameters of an operation of yielding support applied in dog headings are its load capacity and yield capacity.

Very significant influence on the values of these parameters have a value of force, with which the sections cooperating in the frictional joint are pressed against. Cause value of this force decides on the value of friction force between the cooperating sections, which in turn influences on the resistances to motion in the frictional joint. Value of these resistances, in a form of friction force between the contacting sections, influences on the value of force, which joint transmits, and on the value of displacement of section sliding down (value of a yield).

In a Figure 1 there is presented a simplified scheme of the frictional joint with denoted axial forces (Q) in the bolts of stirrups and the friction force (T) between the cooperating sections. The joint is loaded with an external force $P(t)$, and its pressure on the base is denoted by $R(t)$. If the value of external force $P(t)$ exceeds the maximum value of static friction force ($T_{st\ max}$), displacement $y(t)$ of upper section (A) will occur. Value of this displacement defines the value of a yield, and it is a measure of the yield capacity of the frictional joint.

Maximum value of static friction force ($T_{st\ max}$) between the cooperating sections is dependent on the total value of axial forces (N) in bolts of stirrups, and on the static friction coefficient (μ_{st}) between the contacting surfaces of sections:

$$T_{st\,max} = N \cdot \mu_{st} \tag{1}$$

Value of force, with which the sections cooperating in the frictional joint are pressed against, we determine from the relationship:

$$N = \sum_{i=1}^{n} Q_i$$

where: n – number of bolts in a joint.

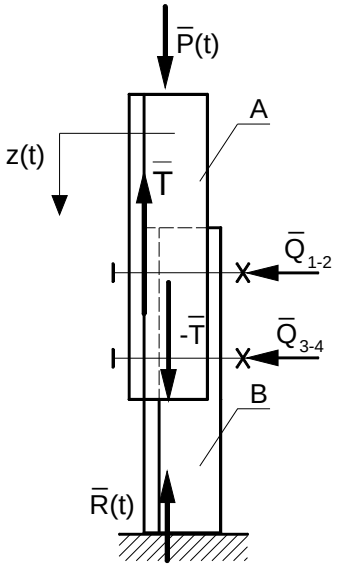

Fig. 1. Scheme of the frictional joint

Analyzing presented scheme one can state, that values of axial forces in the bolts of stirrups have very significant influence on the operational parameters of frictional joint, and subsequently a whole yielding support.

Particular importance for the operation of the frictional joint have the initial values of these forces obtained during the assembly of the yielding support. Values of these forces are dependent on the value of a torque, with which the nuts of bolts are tighten up, and on the friction coefficients in the thread and between the resistance s?-faces of the nuts of bolts and flanges of stirrups [3].

During the operation of yielding support, in a case of occurrence of yields in the frictional joints, a considerable decrease of values of axial forces in the bolts of stirrups takes place [1, 4]. Due to that, after the occurrence of yields a tightening of nuts of bolts in stirrups is recommended, in order to maintain a proper value of axial forces in the bolts [2].

In a case of more frequently occurring dynamic loadings of yielding support, process of tightening the nuts of bolts in stirrups is not always possible. Therefore, values of initial axial forces in the bolts of stirrups have very significant influence on the proper operation of support.

In order to determine the influence of values of axial forces in the bolts of stirrups on the value of yield in the frictional joint (value of relative displacement of cooperating sections), stand tests of frictional joints loaded with an impact of freely falling mass were carried out.

These tests were performed for the frictional joints of different values of initial axial forces in the bolts of stirrups. Value of loading force *P(t)* was a result of drop of impact mass amounting to 4000 kg on a traverse of mass 1600 kg. During the tests a height, from which the impact mass was falling, underwent a change. Product of this height, and value of impact mass, and the gravitational acceleration defines the impact energy.

2. Measurement of value of axial force in the bolt of stirrup

To measure a value of axial forces in the bolts of stirrups of the frictional joint, a sleeve strain gauges were used, whose method of assembly is presented in a Figure 2.

In order to provide the uniform axial loading of these strain gauges, two-sided spherical washers were applied.

Fig. 2. Method of assembly of sleeve strain gauges for the measurement of values of axial forces in the bolts of stirrups

Applied sensors enabled a measurement of initial values of axial forces in the b?-ts of stirrups and determination of temporal courses of their change during the test.

In a Figure 3 there is presented temporal course of change in values of axial forces in bolts of stirrups of frictional joint, loaded with an impact mass falling from the height of 0.5 m (impact energy in that case amounts to 19.62 kJ). In this example initial values of these forces amounted to 80 kN in each bolt.

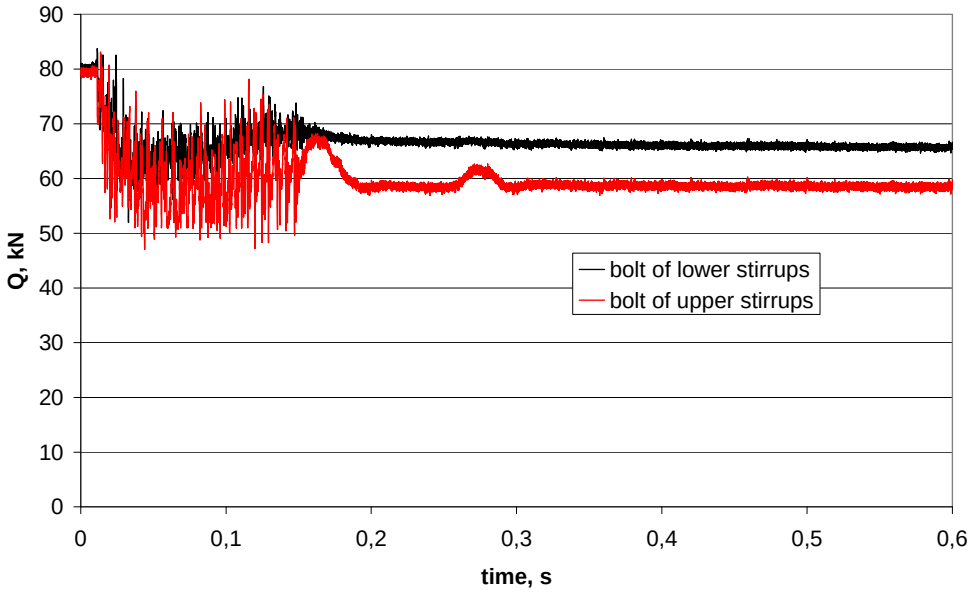

Fig. 3. Change in values of axial forces in the bolts of stirrups of the frictional joint loaded with an impact mass falling from the height of 0.5 m

Analyzing obtained courses one can state, that with an occurrence of a yield in the frictional joint, a significant decrease of values of axial forces in bolts of stirrups takes place. It causes a decrease of values of pressing force of cooperating sections, a decrease of resistances to motion in the joint, and in consequence a deterioration of o?-rational parameters of the joint, and subsequently in the whole yielding support.

Due to that, very significant meaning have the values of initial axial forces in the bolts of stirrups, because in practice they decide on the value of loading, which is t?-nsmitted through the support, and on the value of a yield.

3. Measurement of value of a yield in the frictional joint

To determine the value of a yield in the frictional joint loaded dynamically with an impact of freely falling mass, a high-speed camera was used.

Application of the camera enabled an observation of a state of the frictional joint during the yield and registration of values of a displacement of selected points of the joint. In a result of performed tests, a displacement characteristics of the points located on the sliding down section and additionally on the yokes of stirrups, were determined.

In a Figure 4 there are presented temporal courses of change in value of d?-placement in the vertical axis of three points located at the upper section and on the stirrups of the frictional joint.

In the presented joint point 1 was placed in the upper section displacing during the yield, which was connected through the drivers with the lower stirrup, on whose lower yoke was placed point 3. During the yield, the displacement characteristics in the vertical axis of these points are practically identical. A slightly greater displacement of point 1 results from the bending of the lower stirrup, causing that displacement of its lower yoke is slightly lower, than that of the upper yoke. Total value of the yield of displacing upper section in this joint amounted to 0.155 m.

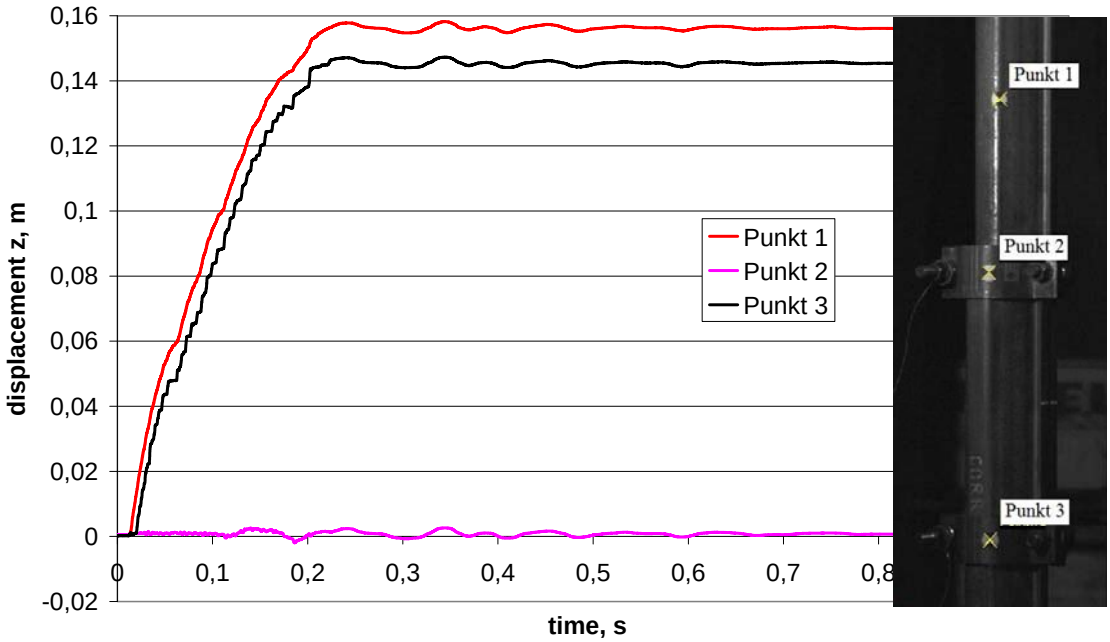

Fig. 4. Designation of the points and their displacements during the test of frictional joint

Point 2 was located at the lower yoke of the upper stirrup connected through the drivers with the lower section, which during the yield should not displace. However a?-ually due to the vibrations of the whole frictional joint and strain of the upper stirrup, displacements of this point occurred, what is visible in a Figure 4. Total value of this displacement was small and did not exceed 0.01 m.

Performed tests enabled to determine the dependence between the total value of initial axial forces in the bolts of stirrups and the total value of displacement of section sliding down (Fig. 5). Presented dependences were determined for three different values of impact energy (E) of freely falling mass.

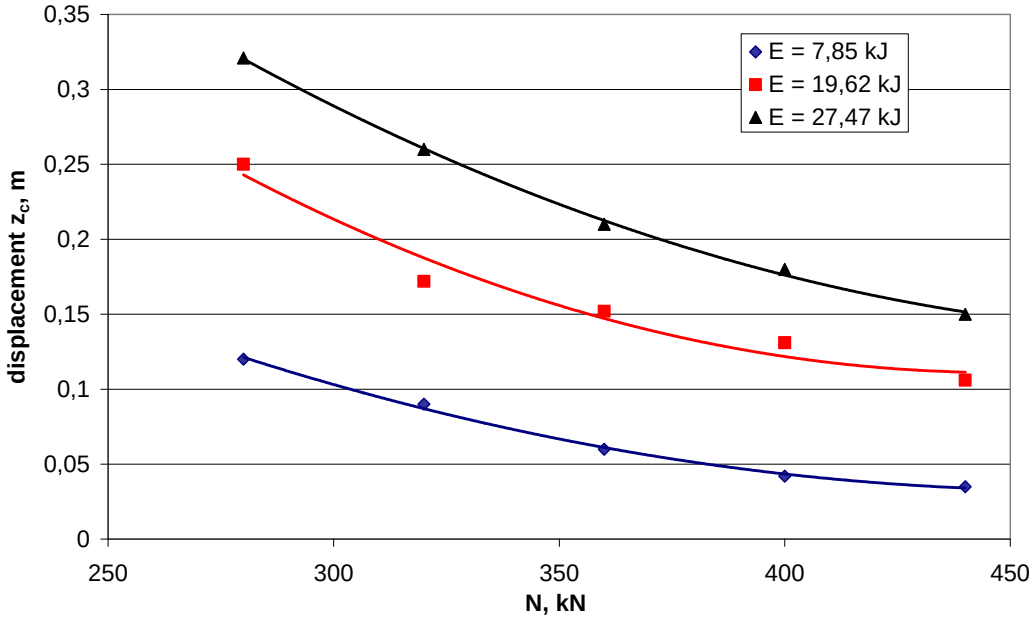

Fig. 5. Dependences between total value of displacement (z_c) of section sliding down, and the total value of initial axial forces (N) in the bolts of stirrups for different values of impact energy (E)

Results of statistical analysis of determined dependences are listed in Table 1.

Table 1 – Results of statistical analysis of dependences between the total value of displacement of section sliding down and the total value of initial axial forces in the bolts of stirrups for different values of impact energy

Second degree polynomial model: $y = a \cdot x^2 + b \cdot x + c$								
E, kJ	Equation of the regression curie	r	Evaluation of the estimator			Standard error of the estimator		
			a	b	c	a	b	c
7,85	$z_c = 0{,}0001N^2 - 0{,}002N + 0{,}593$	0,9971	0,0001	-0,002	0,593	1e-5	0,0003	0,057
19,62	$z_c = 0{,}0001N^2 - 0{,}004N + 1{,}051$	0,9644	0,0001	-0,004	1,051	1e-5	0,0011	0,310
27,47	$z_c = 0{,}0001N^2 - 0{,}003N + 1{,}067$	0,9987	0,0001	-0,003	1,067	1e-5	0,0004	0,074

Obtained results unequivocally indicate, that with an increase of the total value of initial axial forces in the bolts of stirrups, total value of a yield in the frictional joint decreases. Whereas this value obviously rises with an increase of the impact energy of falling mass.

3. Summary and Conclusions

Analysis of operation of the yielding support of dog headings loaded dynamically unequivocally indicates that very significant influence on its operational parameters have the values of initial axial forces in the bolts of stirrups of frictional joints applied in this support.

On the basis of obtained results one can state, that the increase of values of initial axial forces in the bolts of stirrups of frictional joints results in the decrease of the total value of a yield in the frictional joint. It causes that the joint transmits higher values of forces, but simultaneously becomes less yielding.

In a case of dynamic loading of the support, limitation of the bearing-sliding capacity of the frictional joints, at increase of their loading capacity should be evaluated positively.

Measurement of values of axial forces in the bolts of stirrups confirmed the results of previous observations, that together with a yield, the very significant decrease of values of these forces takes place. In a case of dynamic loading of the support it is very negative phenomenon. It causes a very large decrease of loading capacity of the joint, what in consequence leads to very large yields, and threatens damage of the support.

Presented results of the tests unequivocally indicate, that current constructional solutions of the frictional joints applied in the yielding support of dog headings, cause that this support is weakly resistance to action of dynamic loadings.

In this context a search of new solutions of the frictional joints, which will influence on the improvement of operational parameters of the joint and the whole support becomes necessary. These solutions especially should cause an increase of resistance to motion in the joint during a yield.

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