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WORK ANALYSIS OF FRICTIONAL JOINT WITH THE RESISTANCE WEDGE

Frictional joint constitutes a constructional connection and have decisive influence on the basic operational parameters of the steel frames and props, i.e. their loading capacity and yielding capacity. Currently applied constructions of frictional joints characterize with low loading capacity and unstable operation. In order to improve their operational parameters a new constructional solution of frictional joint, consisting on the application of resistance wedge assembled between the cooperating sections, was developed. In the paper results of stand tests of frictional joints with the resistance wedge, subjected to the static axial compression, were presented. In order to determine the influence of the resistance wedge on the operational parameters of the frictional joint, obtained results were compared with the results of studies of the frictional joints without the resistance wedge. On the basis of conducted tests and analysis one can state, that application of the resistance wedge influences on the enhancement of loading capacity, improves the state of loading the bolts in stirrups, and creates possibility of regulation of operational characteristics of the frictional joints.

Keywords: friction joint ,yielding support, resistance wedge

Introduction

The basic part of the steel frames and props are frictional joints, providing the constructional connection of particular elements of steel frames and friction props, and deciding about their basic parameters, which are load capacity and yielding capacity.

Current applied constructional solutions of the frictional joints are the source of unstable operation of yielding steel frames and friction props loaded statically and dynamically. Yields occur at relatively low loadings and loading potential of sections, of which steel frames and friction props are made, is insufficiently used [2, 3, 5].

Series of studies was carried out up to now, in order to enhance the load capacity and improvement of operational characteristics of the frictional joints [1, 4]. In majority of presented works to achieve this goal, there are proposed an increase of value of torque moment with which the nuts of bolts in stirrups are tighten up, an increase of number of stirrups in the frictional joint or application of more and more heavier sections of which the friction props and steel frames are made. Due to complicated constructions and consequential high costs connected with the manufacture and implementation, these solutions did not find practical use.

In order to improve their operational parameters a new constructional solution of frictional joint, consisting on the application of resistance wedge assembled between the cooperating sections, was developed.

The main aim of application of the resistance wedge is an increase of value of forces transmitted through the frictional joint (increase of the load capacity of the frictional joint) through the rise of resistances to motion during a yield. It was assumed that in consequence of displacement of sliding down section in the frictional joint, there will occur a deformation of the resistance wedge and the cooperating sections. It will cause an increase of resistances to motion during a yield, what will influence on the rise of load capacity of the joint.

Application of the resistance wedge should also limit sudden and often of great value uncontrolled yields in the joint, and influence on the increase of value of axial forces in the bolts of stirrups, what additionally will improve a load capacity of the frictional joint.

In the paper construction and principle of operation of the frictional joint with the resistance wedge are discussed, and results of stand tests of frictional joints with the resistance wedge loaded statically and dynamically are presented.

Principle work of the frictional joint with the resistance wedge

The principle of operation of the frictional joint with the wedge is that the upper section displacing during the yield, is pressed to the lower section, due to the action of stirrups, during the beginning of contact with the resistance wedge increases the resistances to motion. Further yield in the joint can occur due to the increase of an external force, acting on the upper section. A result of this is the increase of value of force transmitted through the frictional joint (an increase of load capacity of frictional joint).

In Figure 1 there is presented simplified scheme of frictional joint with the resistance wedge. In this joint the wedge is assembled between cooperating sections so as to fill the free space between the bottoms of sections.

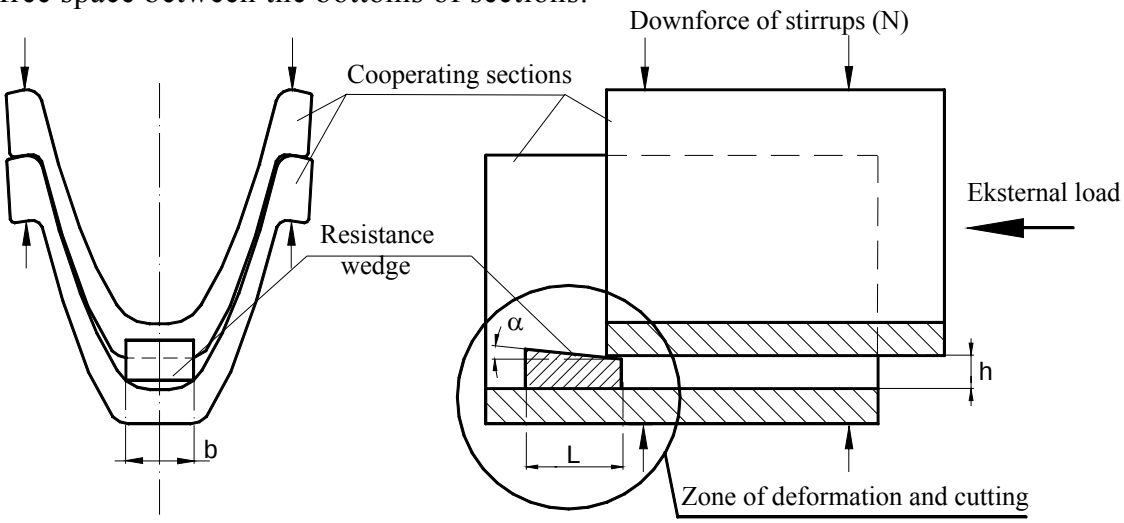

Fig. 1. Scheme of frictional joint with the resistance wedge

Geometrical parameters describing shape of the wedge and having significant influence on the operational characteristics of frictional joint with the wedge are: angle inclination of wedge's generatrix α, height of the wedge in its initial part h and length L. It was assumed that the width of the resistance wedge will be equal to the width of internal section's bottom.

Principle of operation of the frictional joint with the resistance wedge depends on the increase of the resistances to motion of upper section displacing during the yield, which is pressed against to the lower section in a result of stirrups' action (Fig. 1). Beginning of the increase of these resistances occurs at the moment of beginning of contact of upper section with the resistance wedge. In this case, to yield could occur, an increase of value of external force acting on the upper section is necessary. It results in an increase of the value of force transmitted through the frictional joint, i.e. load capacity of the frictional joint.

Therefore application of the resistance wedge in the frictional joint causes that the resistances in the joint at which the yield can occur and resistances during the yield increase.

In a Figure 2 there are presented distributions of forces in the frictional joint, in which the resistance wedge is so assembled, that in the initial stage the joint operates as without the wedge. After given time, when the yields of assumed value can occur (depending on the distance from the assembled resistance wedge to the edge of upper section) the joint begins to operate as with the resistance wedge.

According to description in Figure 2, at the moment of wedge's action depending on its geometrical parameters and material, of which was made, one can get different change characteristics of value of force transmitted through the joint.

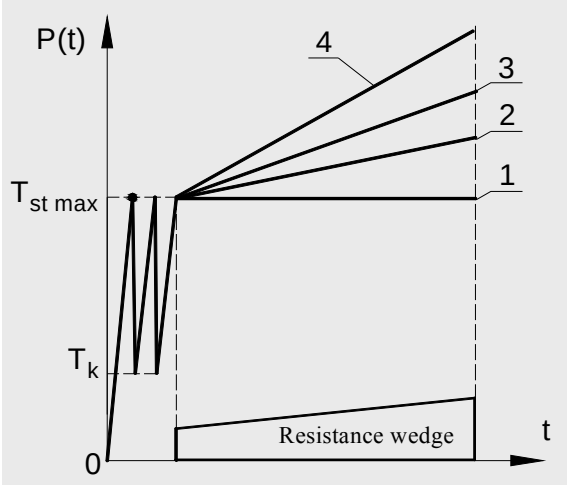

Fig. 2. Change of value of forces in the frictional joint with the resistance wedge

Presented characteristics designated from 1 to 4 are the simplified image of increasing resistances in the frictional joint, whose consequence is greater value of force transmitted through the frictional joint.

In presented case application of resistance wedge causes an increase of load capacity of the frictional joint with the increase of yield's magnitude. Simultaneously the drop of this load capacity does not occur during the yield, what is a large problem during the operation of yielding support with the classical frictional joints.

On this basis one can state, that application of resistance wedge should significantly improve the operational characteristics of the frictional joint.

Analysis of operation of the frictional joint with the resistance wedge subjected to the static compression

Fig. 3. Method of assembly the frictional joint with the resistance wedge at the static compression

Tests of frictional joint with the resistance wedge were performed on the testing machine equipped in the control system which enables continuous regulation of piston's displacement speed or the speed of increment of loading in the unit of time.

For the necessity of the studies a measuring system was developed, which enables the continuous registration of values of force transmitted through the joint with the resistance wedge, values of axial forces in the bolts of stirrups, and displacements, accelerations of sliding down section.

The method of assembly the frictional joint made of V29 section with two stirrups of SDO29 type with the resistance wedge on the testing stand was presented in Figure 3.

To determine the effect of resistance wedge on the performance characteristics of frictional joint, performance characteristics of frictional joint with and without the resistance wedge are presented in a Figure 4. Both joints were made of the same V29 sections with two stirrups of SDO29 type. In both cases there were the same values of initial axial forces in the bolts of stirrups.

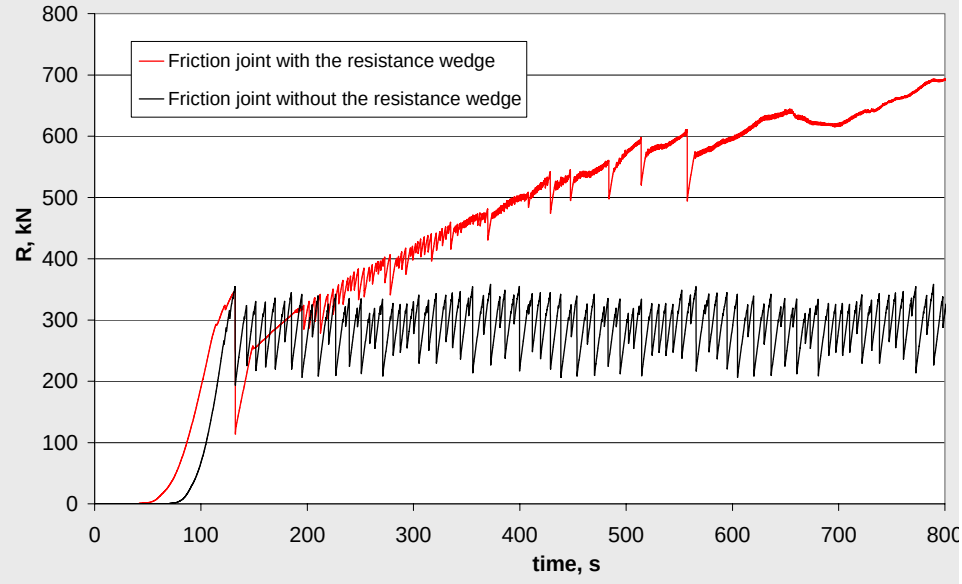

Fig. 4. Performance characteristics of the frictional joint with and without the resistance wedge

Based on the obtained characteristics one can state, that for the frictional joint with the resistance wedge, the loading transmitted by it increases with the displacement of the section sliding down. The result of this displacement is an increase of the resistances to motion resulting from the action of the resistance wedge, what causes an increase of the value of force transmitted through the frictional joint.

The presence of the resistance wedge causes that the sudden yields in the frictional joint are not observed. The process of a displacement of sliding down section proceeds more smoothly than in a case of a joint without the resistance wedge. Also the magnitude of the yield is smaller than for a joint without the resistance wedge. Thus the yield capacity of a joint decreases and it becomes more rigid.

State of the resistance wedge and the displacing section after the test is presented in a Figure 5. There is clearly visible the deformation state of the resistance wedge together with its fragments, which underwent the cutting, and the deformation state of external section.

Fig. 5. Deformation state of the resistance wedge and the external section

Analyzing the determined performance characteristics of frictional joints with and without the resistance wedge and analyzing the deformation of elements of the frictional joint and the resistance wedge, one can state that selecting the proper geometrical dimension of the wedge it is possible to regulate the distribution of resistances to motion in the joint during the yield. It gives possibility to influence directly on the performance characteristics of the frictional joints.

Influence of resistance wedge on the values of axial forces in the bolts of stirrups of frictional joint

During the tests of frictional joints with the resistance wedge loaded statically with an axial force there were registered also the changes of values of axial forces in the bolts of stirrups.

It has to be emphasized that in practice, the axial forces in the bolts have very significant impact on the performance characteristics of the frictional joint. They decide on the value of friction force between the cooperating sections, what influences directly on the yield capacity of the frictional joint and its load capacity [1].

For registration of values of axial forces in the bolts of stirrups during the test of frictional joints there were used specialized sleeve sensors, and in order to provide their uniform axial loading there were used spherical washers.

Frictional joint with assembled sensors for measurement of axial forces in the bolts of stirrups is presented in Figure 6.

Fig. 6. View of frictional joint with assembled sleeve sensors on the bolts of stirrups

As a result of the studies carried out the changes of values of axial forces in the bolts of stirrups of frictional joint with the resistance wedge during their static axial compression were determined.

Changes of values of these forces for the joint, whose initial values varied in a range between 125 and 133 kN are presented in a Figure 7. External bolts denoted on the chart, were placed further, and internal bolts were placed nearer the resistance wedge.

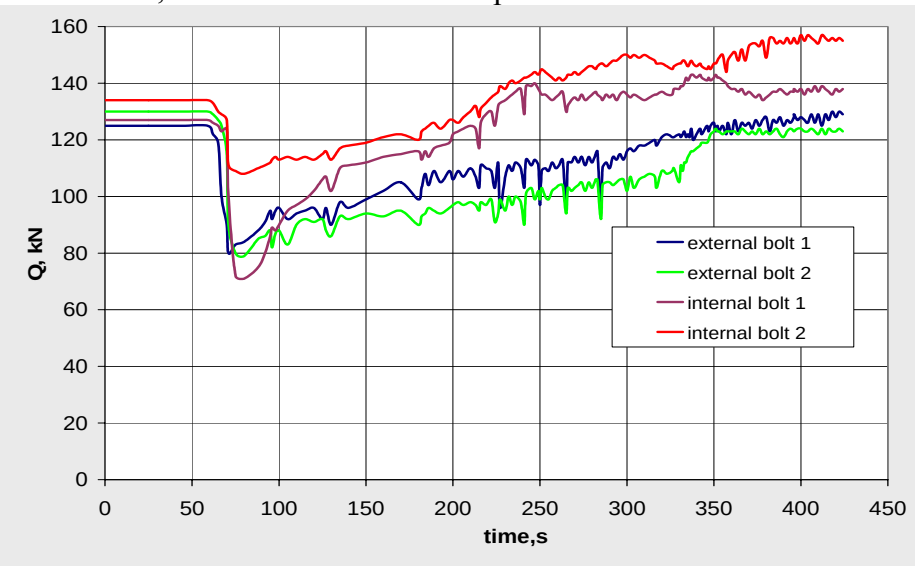

Fig. 7. Changes of values of axial forces in the bolts of stirrups during the test of frictional join with the resistance wedge

Analyzing obtained charts one can state, that at the first yield the considerable drop of value of axial forces in the bolts occurred, what is normal phenomenon occurring in frictional joints.

Further displacement of sliding down section causes increase of value of these forces. It is a result of operation of resistance wedge, thanks to which a transverse force begins to act on the cooperating sections, causing their increased pressure on the stirrups, which is transmitted to the bolts, causing an increase of their axial forces (values of forces stretching the bolts increase).

Summary and Conclusions

Presented in this elaboration a constructional solution, consisting of application in the frictional joint the new element in form of resistance wedge, should eliminate many problems connected with the operation of yielding support and improve its performance characteristics.

Results obtained on the basis of tests carried out unequivocally indicate, that application of resistance wedge in the frictional joint influences in the significant way on its operation, causing an increase of resistances to motion in the joint during the yield. It causes an increase of value of force transmitted through the frictional joint, that is its load capacity, what is a positive effect of application of the resistance wedge.

Thus, an increase of the resistances to motion during the yield of the joint, enables a fuller utilization of load capacity of construction of support and sections, at the simultaneous maintenance of yield capacity of the joint.

Very significant meaning for the operation of the frictional joint with the resistance wedge, has a maintenance the proper yield capacity by this system.

This causes that the frictional joint with the resistance wedge during the yield in continuous way transmits an external loading. Sudden unpredictable large yields undergo the limitation. During these yields, often occurring in the joints without the resistance wedge, the joint practically do not transmit any loading.

Application of the resistance wedge in the frictional joint causes also an increase of values of axial forces in the bolts of stirrups. It has very significant meaning for the correct operation of the frictional joint. Application of the wedge causes, that the forces in the bolts increase without the necessity of their additional tightening up, what in a case of the joints without the wedge, is necessary for providing the proper pressing forces of cooperating sections.

Developed construction should influence on the more effective use of the strength parameters of the yielding supports' construction, stabilize their operation, and improve the assembly. All this influences on the improvement of the occupational safety in the mining industry, and on the improvement of economical parameters.

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