Experimentální Analýza Napětí 2009
Experimental Stress Analysis

MUTUAL COMPARISON OF EXPERIMENTAL TESTS OF TENSION CLAMPS

Jozef Melcer[1]

Abstract: In the Slovak Republic the tension clamps PANDROL, EWEM, SKL1, SKL12, SKL14 are most frequently used in rail constructions. Due to reality that tension clamps have considerable working imperfections and also dispersion of their mechanical properties is wide it is necessary to test their mechanical properties by experimental way. The submitted paper is dedicated to mutual comparison of mechanical properties three types of tension clamps PANDROL, EWEM, SKL experimentally tested in the laboratory of the Department of Structural Mechanics Faculty of Civil Engineering University of Zilina. It describes the methodology of experimental test and it evaluates individual tension clamps also from the point of practical service aspects.

1. Introduction

The rail construction must be correctly dimensioned and tuned with respect to mechanical properties of moving vehicles and its parameters must be maintained in the strictly determined boundaries. The important role in the behaviour of such structure represents the points of connection of rails with cross sleepers or with slab supports. These points of connexion it is possible to regard as so call tuning joints, because of through mechanical properties of their elements we can influence the behaviour of the whole system (the mutual interaction of rail vehicles with railway track and in the final phase the straining of the structure and the riding comfort of passengers). This paper is dedicated to the static analysis of tension clamps PANDROL, EWEM, SKL currently used as a part of elastic fastening the rails on the high-speed railway lines [1], [2].

2. Description of the tested tension clams

The experimentally tested tension clamps PANDROL, EWEM and SKL12 are shown on the *Figure 1*. Sixteen clamps of every type were subjected to the static analysis. Before analysis the clams were marked and their working imperfections were detected. The pairs of clamps of approximately equal proportions were formed on the basis of this detection.

Figure 1: *The experimentally tested* ***t****ension clamps PANDROL, EWEM and SKL*

[1] Prof. Ing. Jozef Melcer, DrSc.; University of Zilina; Univerzitná 8215/1, 010 26 Zilina, Slovak Republic, jozef.melcer@fstav.uniza.sk

The tension clamps PANDROL were marked as *A, B, C, D, E, F, G, H, I, J, K, L M, N, O, P*. The distance of 2 contact points of pressing arm from the bottom of sole plate were measured, see *Figure 2*. The results of measurements are put into *Table 1*. In the next the pairs *A-B, I-D, E-O, M-P, G-L, K-H, C-F, J-N* were formed. The average value of distances were 8,78 mm and its standard deviation was 1,2367 mm.

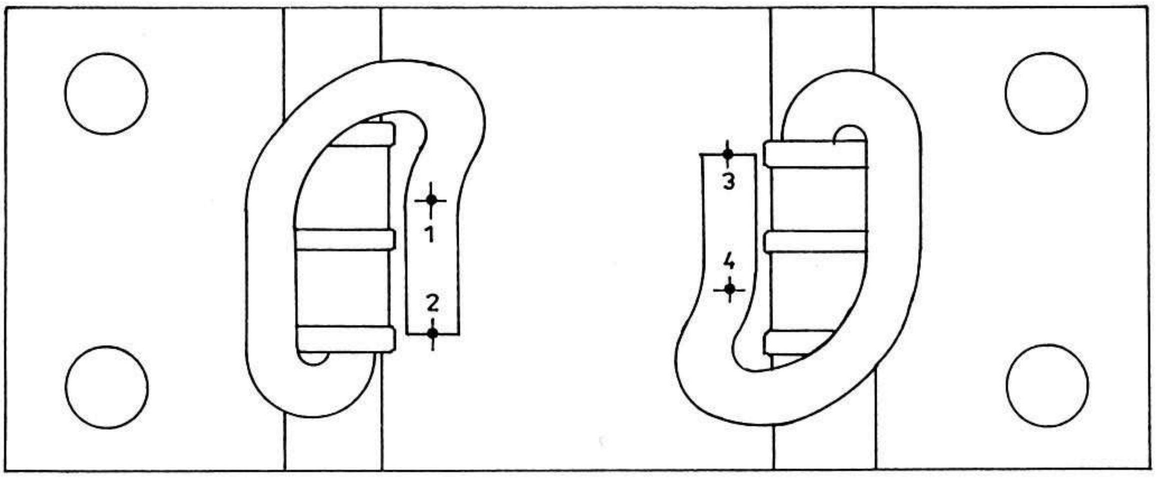

Figure 2: *Numbering of contact points - PANDROL*

Table 1: *Tension clamps PANDROL, distances of contact points from the bottom of sole plate*

Clamp	Dist. in 1 [mm]	Dist. in 2 [mm]	Diff. |1-2| [mm]	Clamp	Dist. in 3 [mm]	Dist. in 4 [mm]	Diff. |3-4| [mm]
A	10,9	9,8	1,1	*B*	11,2	11,2	0,0
C	9,6	7,3	2,3	*D*	8,4	8,9	0,5
E	7,6	7,4	0,2	*F*	7,3	8,5	1,2
G	8,3	9,9	1,6	*H*	8,5	9,0	0,5
I	8,6	8,9	0,3	*J*	8,9	6,9	2,0
K	8,4	9,6	1,2	*L*	7,2	10,0	2,8
M	8,3	10,3	2,0	*N*	7,1	8,2	1,1
O	7,4	7,8	0,4	*P*	9,0	10,5	1,5

The tension clamps EWEM were marked as *a, b, c, d, e, f, g, h, i, j, k, l m, n, o, p*. The distance of contact point on the left and right pressing arms from the bottom of sole plate were measured, see *Figure 3*. The results of measurements are put into *Table 2*. In the next the pairs *o-p, e-k, j-d, l-f, b-h, m-n, g-i, a-c* were formed. The average value of distances were 8,59 mm and its standard deviation was 0,7987 mm.

The tension clamps SKL12 were marked as *1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16*. The pairs *1-2, 3-4, 5-6, 7-8, 9-10, 11-12, 13-14, 15-16* were formed. All the clamps were installed into the sole plate with the rail S49 and rubber pad. Pad nuts were tightened by tightening moment in the value of 180 N.m. In this state the spaces between top edge of sole plate rib and down edge of clamp were measured, see *Figure 4*. The results of measurements are put into *Table 3*. The average value of distances was 5,82 mm and its standard deviation was 0,7985 mm.

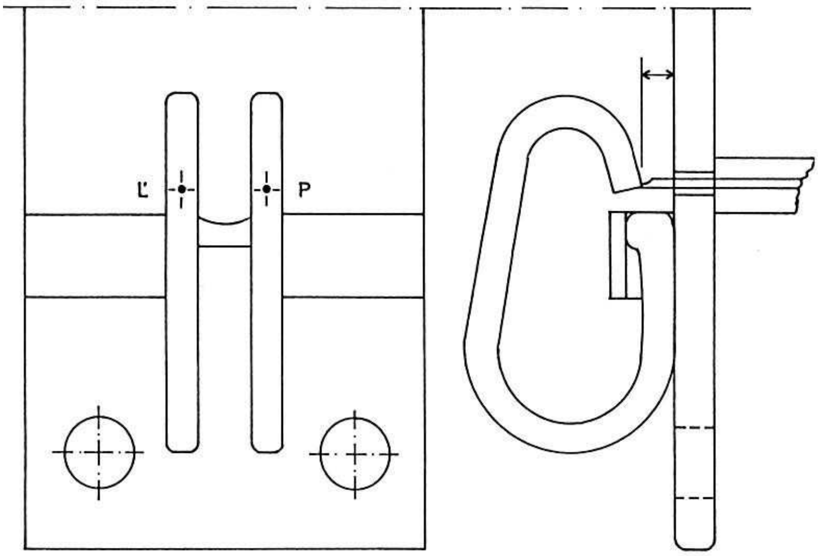

Figure 3: *Designation of contact points - EWEM*

Table 2: *Tension clamps EWEM, distances of contact points from the bottom of sole plate*

Clamp	Dist in L [mm]	Dist in P [mm]	Diff. |L-P| [mm]	Clamp	Dist in L [mm]	Dist in P [mm]	Diff. |L-P| [mm]
a	8,7	9,2	0,5	*i*	8,3	9,0	0,7
b	8,2	7,7	0,5	*j*	8,7	8,6	0,1
c	8,7	9,0	0,3	*k*	8,2	8,2	0,0
d	8,6	8,2	0,4	*l*	7,1	8,3	1,2
e	8,2	8,2	0,0	*m*	10,4	10,5	0,1
f	8,6	7,8	0,8	*n*	9,7	10,1	0,4
g	7,8	7,7	0,1	*o*	8,6	8,6	0,0
h	7,7	7,7	0,0	*p*	9,3	9,2	0,1

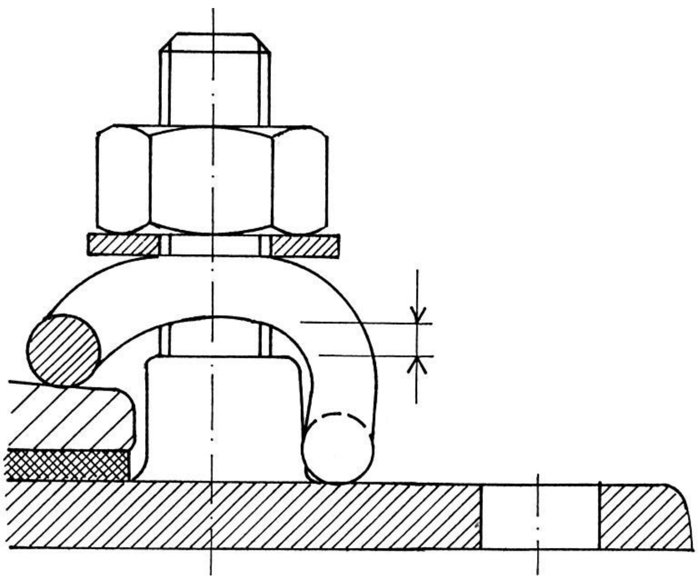

Figure 4: *Designation of contact points - EWEM*

Table 3: *Tension clamps SKL12, distances between sole plate rib and clamp pressing arm*

Zvierka	Medz. v Ľ [mm]	Medz. v P [mm]	Zvierka	Medz. v Ľ [mm]	Medz. v P [mm]
1	7,3	7,3	9	5,2	5,2
2	7,4	7,4	10	5,3	5,3
3	5,5	5,5	11	5,5	5,5
4	4,5	4,5	12	6,0	6,0
5	6,1	6,1	13	6,8	6,8
6	6,0	6,0	14	5,8	5,8
7	5,5	5,5	15	5,1	5,1
8	6,0	6,0	16	5,1	5,1

3. Static test of tension clamps

The goal of static test was to obtain stiffness characteristics of the clamp pairs. The stiffness characteristics of the clamp pairs were determined by the following way. The steel beam with adapted sole plate was situated on the support from the steel profile I_{500}. The adaptation of sole plate was realized by the following way. The central part of sole plate between the ribs was cut out to originate adequate space for plugging the rail without pressing the tension clamps, Fig. 3. The set of tested tension clamps and short rail were installed into sole plate, Fig. 4. The rib sole plate and the rail of the type S49 were used within the tests. The press force was initialized by the hydraulic cylinder TOS CHZM 25-15-2. The pressure in the cylinder was regulated by the mechanical pump TOS CHZM 100-15. The force magnitude was indicated by the dynamometer of German production KMB M 10187 with the working scale to 100 kN. The equipment was braced towards the frame of pulsating device. The deformations of clamps were measured by the indicating gauge SONET with the accuracy of 0,01 mm. Four symmetrically situated indicating gauges were applied. The average values were used for the graphic presentation of the results. The indicating gauge Frich was used as a control gauge. The view on arrangement of all equipments is in the *Figure 5*.

Recapitulation of static tests of tension clamps PANDROL is on the *Figure 6*. Stiffness characteristics of all tested clamp pairs are situated in the interval bounded by stiffness characteristics of pairs *A-B* and *C-F*. Stiffness characteristic of the pair *M-P* can be considered as “*average value*“ of 8 tested pairs. If the value of pressing force corresponding to the pair *M-P* at picking up of the pressing arm 10,0 mm is considered as 100 % than the pressing force for the pair *A-B* at the same picking up is about 16,8 % higher and for the pair *C-F* about 16,0 % lower. The plastic deformations of tension clamps start to occur at the value of picking up of the pressing arm in the interval 11,7 – 12,5 mm. So there is a certain possibility of overloading the clamps within transport and within manipulation with track panels. The stiffness characteristics are nonlinear with mellowing characteristic but it is not material nonlinearity.

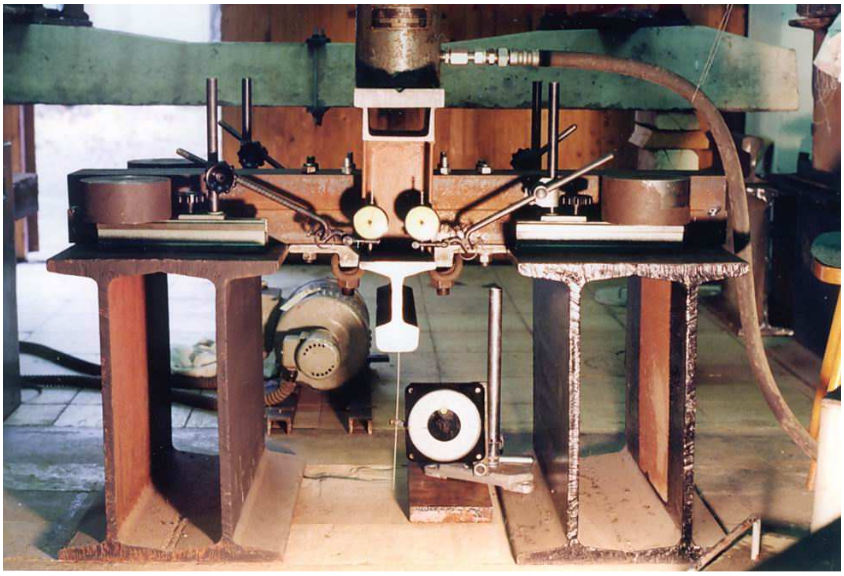

Figure 5: *Arrangement of all equipments during static test of tension clamps*

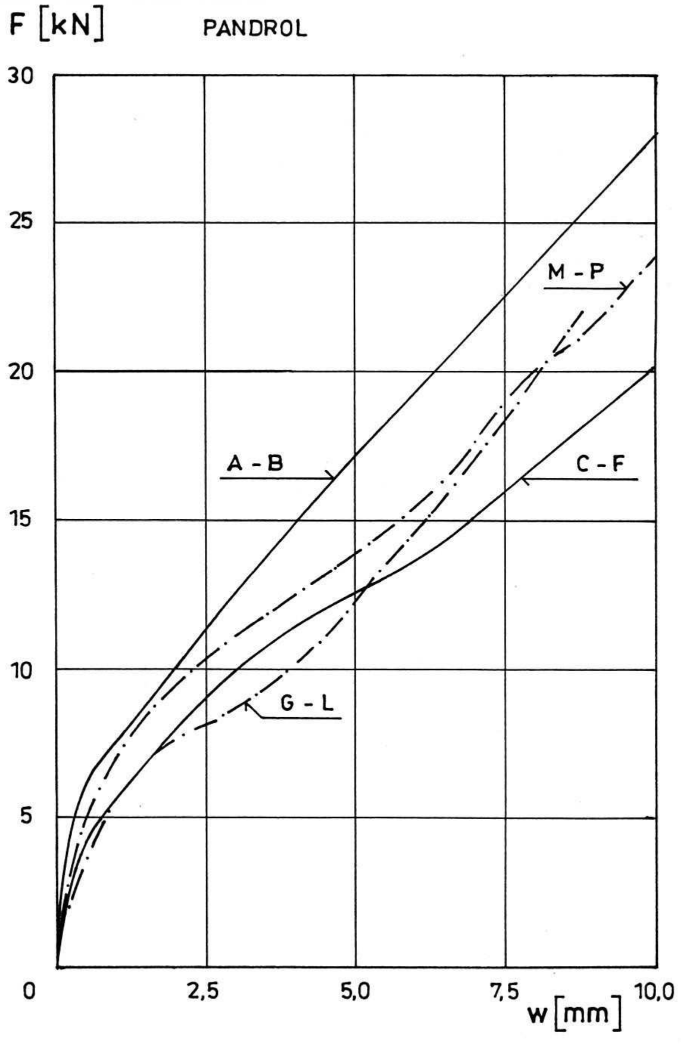

Figure 6: *Stiffness characteristics of tension clamps PANDROL – recapitulation*

Recapitulation of static tests of tension claps EWEM is on the *Figure 7*. Stiffness characteristics of all tested clamp pairs are situated in the interval bounded by stiffness characteristics of pairs *j-d* and *o-p*. Stiffness characteristic of the pair *m-n* can be considered as "*average value*" of 8 tested pairs. If the value of pressing force corresponding to the pair *m-n* at picking up of the pressing arm 10,0 mm is considered as 100 % than the pressing force for the pair *j-d* at the same picking up is about 10,2 % higher and for the pair *o-p* about 12,4 % lower. The plastic deformations of tension clamps start to occur at the value of picking up of the pressing arm about 13 mm. There is also the possibility of overloading the clamps within transport and within manipulation with track panels. The stiffness characteristics are linear to the value of picking up of the pressing arm 13,0 mm. At the picking up of the pressing arm higher than 13,0 mm the stiffness characteristics are nonlinear with mellowing characteristic.

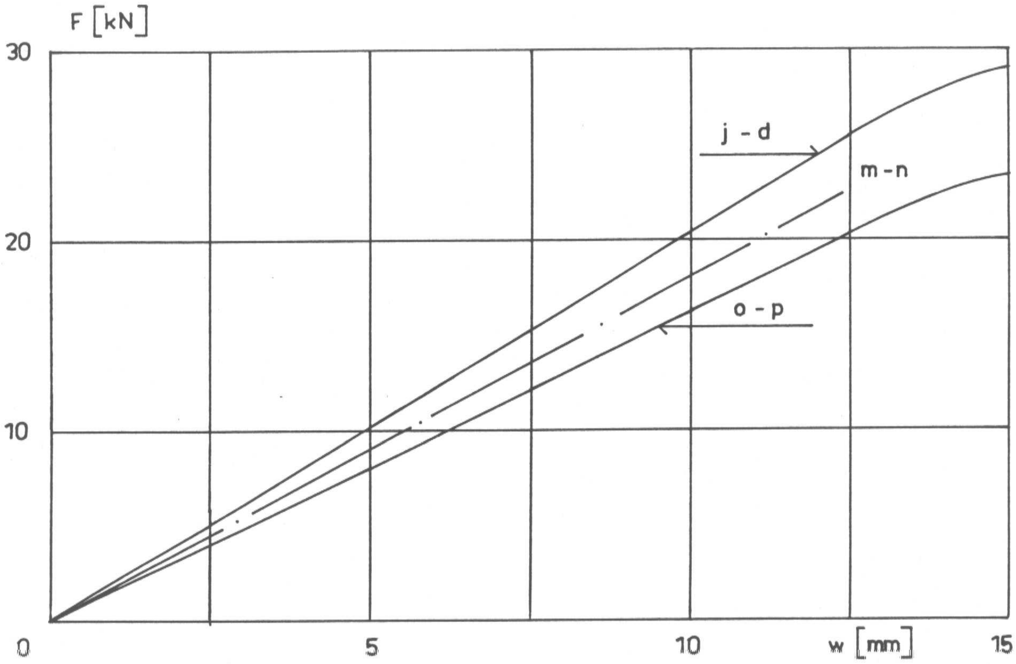

Figure 7: *Stiffness characteristics of tension clamps EWEM – recapitulation*

Recapitulation of static tests of tension claps SKL12 is on the *Figure 8*. Stiffness characteristics of all tested clamp pairs are situated in the interval bounded by stiffness characteristics of pairs *13-14* and *1-2*. Stiffness characteristic of the pair *15-16* can be considered as "*average value*" of 8 tested pairs. If the value of pressing force corresponding to the pair *15-16* at picking up of the pressing arm 10,0 mm is considered as 100 % than the pressing force for the pair *13-14* at the same picking up is about 4,2 % higher and for the pair *1-2* about 4,8 % lower. It was not achieved such stage during the test to come to the occurrence of permanent irreversible deformations because of by the picking up of pressing arm of tension clamp circa 15,0 mm the rail forces down the pressing arms of the clamp to the level of that part of clamp which encircle the clamp bolt. From this moment not only the pressing arms of the clamp but also the part of clamp encircling the clamp bolt resist against the rail shifting. This encircling part of the clamp is considerably stiffer than pressing arms of the clamp. This fact is registered as expressive dislocation in the running of stiffness characteristics and by essentially steeper course of the graph, *Figure 9*. Probability of occurrence of permanent irreversible deformations of the clamp is minimal. It is not practically realized in rail construction. Repeated tests (No.2) showed that the clamp works after such loading as well as before loading (No.1). The risk of clamp defect within rail installation and within manipulation with track panels is eliminated.

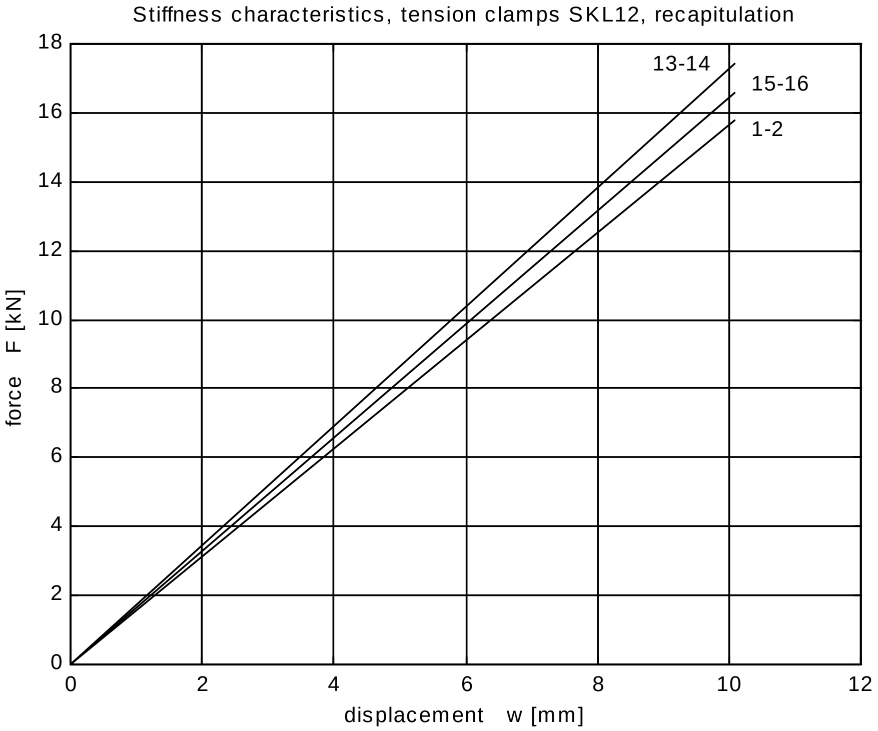

Figure 8: *Stiffness characteristics of tension clamps EWEM – recapitulation*

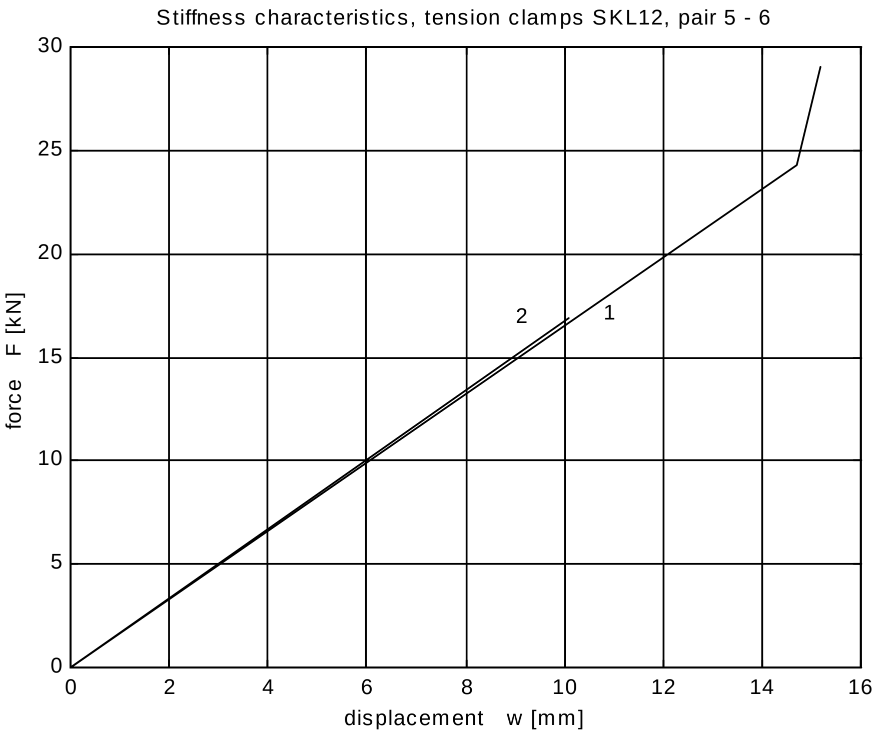

Figure 9: *Stiffness characteristics of tension clamps EWEM – pair 5-6*

4. Conclusions

The places of connection of rails on cross sleepers or slab supports in which the elastic fastening the rails is realised represent so-called tuning joints, because through mechanical properties of their elements we can influence the mutual interaction of rail vehicles with railway track and in the final phase to influence the straining of the structure and the riding comfort of passengers. The tension clamps PANDROL, EWEM or SKL are currently used as a part of elastic fastening the rails in the construction of high-speed railway lines. All types of the clamps show considerable working imperfections. It is the reason to test the clamps experimentally.

The clamps PANDROL have nonlinear mellowing stiffness characteristics but it is not material nonlinearity. The boundary of critical picking up of the pressing arm is in the interval 11,7 – 12,5 mm. Overloading of this interval leads to the occurring of permanent irreversible deformations. The value of picking up of the pressing arm 13,0 mm is the critical value which can be still accepted without more severe effect to generate the pressing force in the needed value. So there is a certain possibility of overloading the clamps within transport and within manipulation with track panels.

The stiffness characteristics of the clamps EWEM are linear to the value of picking up of the pressing arm in the interval 11,5 - 13,5 mm. Overloading of this interval leads to the occurring of permanent irreversible deformations. The value of picking up of the pressing arm 15,0 mm is the critical value which can be still accepted without more severe effect to generate the pressing force in the needed value. So there is also the possibility of overloading the clamps within transport and within manipulation with track panels. So the manipulation with track panels should be very friendly.

The clamps SKL12 have linear stiffness characteristics and the risk of the clamp defect within rail installation and within manipulation with track panels is practically eliminated. From the certain moment not only the pressing arms of the clamp but also the part of clamp encircling the clamp bolt resist against the rail shifting. This encircling part of the clamp is considerably stiffer than pressing arms of the clamp. This fact is registered as expressive dislocation in the running of stiffness characteristics and by essentially steeper course of the graph. The tension clamps SKL12 showed the smallest dispersion of mechanical properties. The high stability of mechanical properties guarantees the right function of clamp in rail construction all along the time of its operation.

References

[1] Melcer, J. et al.: *Experimental study of components for elastic fastening the rails – final report 36/SvF/99*, Faculty of Civil Engineering, University of Zilina, (2000)

[2] Melcer, J.: Tuning joints of slender transport structures, *Building Research Journal*, **Vol.** (52) No. 2, pp. 81-88, ISSN 1335-8863