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ANALYSIS OF THE RESULTS OF THE STRENGTH TESTS OF FINGER SPLICES

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Abstract: The paper analyses the results of the strength tests of finger splices of conveyor belts carried out at the Belt Transport Laboratory (LTT). The article presents a statistical analysis of data and assessment the reasons of the reduced strength of finger splices. The results of these tests are a valuable source material, which should be used in further works.

Keywords: conveyor belt, finger splice, tensile strength of conveyor belt joints

1. INTRODUCTION

Monoply conveyor belts are produced in sections of varying length, which should be connected with each other to form a belt loop. The belt splicing place is the weakest element (Hardygóra et al., 2012). The strength of the splice depends on its type, technology and its quality. The belt splices should be tested for their strength and quality of manufacture. The Belt Transport Technology has been testing for many years the monoply and multiply belts, belts with steel ropes and the splices of the belts, and verifies them through strength tests (the only ones in Poland) of full length belt splices. The construction of monoply belts prevents the application of the joint method as is the case of multiply belts.

The finger splice presented on Fig. 1 is a proven and most often used joint.

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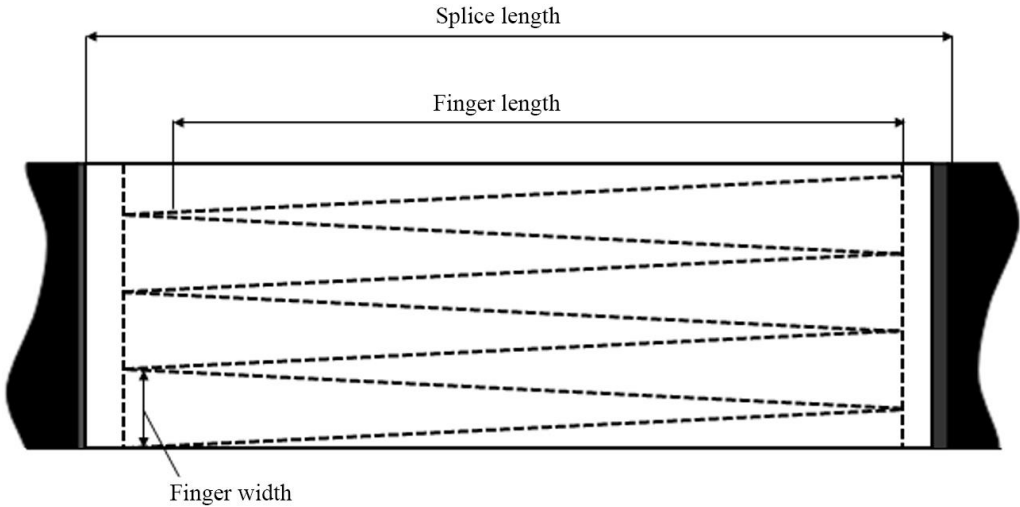


Fig. 1. Finger splice scheme monopoly belt

Finger splice consists of mutually overlapping belt strips in a V shape, cut out at both ends of the jointed belt (Hardygóra et al., 1999). A strengthening polyamide fabric is placed between the bottom cover raceway side of the belt and the spliced fingers. Subsequently the aforementioned splices are covered with a vulcanization mixture. The length and width of the fingers depends on the strength properties of the belt. The joint method of monopoly belt is presented in the textile belt splice manual. Table 1 presents the recommended geometry of splices according to standard DIN 22102.

Table 1. Minimum step and splice lengths for conveyor belts with one ply link (DIN 22102)

Belt type	Finger length l_{fin}	Finger width w	Length of covering fabric l_{fab}	No. of steps l_s
630/1	800	60	1100	1300
800/1	1000		1300	1500
1000/1	1200		1500	1700
1250/1	1500		1800	2000
1600/1	2000	70	2300	2500
2000/1	2400		2700	2900
2500/1	3000		3300	3500
3150/1	3800		4100	4300
4000/1	4200		4500	4700

The strength of splices of a monoply belt is not defined in the standard, however, the practice shows that these splices have very high strength parameters. Thus it is adopted that the correctly executed finger splice should achieve tensile strength at the level of 80% of the rated strength of the belt. Finger splices are difficult to make because they require a high degree of precision in the course of preparation of the belt for joint. Incorrect cut-out of the fingers, grinding of the ply, lack of axiality of the fingers are the main reasons of reduced strength in addition to:

- adhesion properties of adhesive materials,
- strength properties of the ply, friction rubber and vulcanization materials,
- splice technology,
- failure to vulcanize the sides of splice,
- quality of execution of the splice.

2. TESTING THE SPLICES OF CONVEYOR BELTS ON A HORIZONTAL TENSILE STRENGTH TESTER

Tensile strength tests of finger splices of conveyor belts are conducted using the samples collected from the entire length of the splice. The samples should be cut out maintaining the full width of several fingers (e.g. three). The measurements are taken at ZP-40 type tensile strength tester (Fig. 2). It allows to determine the tensile strength of splices of textile belts and the belts with steel ropes of full length and to test the impact of material and geometrical parameters of spliced elements on strength of the joints. The tester is a horizontal frame structure. It is powered by two hydraulic cylinders. The forces stretching the tested sample of the conveyor belt are transferred through the structure of the tester (unloaded foundations). The ends of the tested samples are fixed in self-clamping grips supported by cramps. One grip has a screw-regulated protrusion and the second grip is attached to the sliding beam with two hydraulic cylinders (Błażej, 2001).

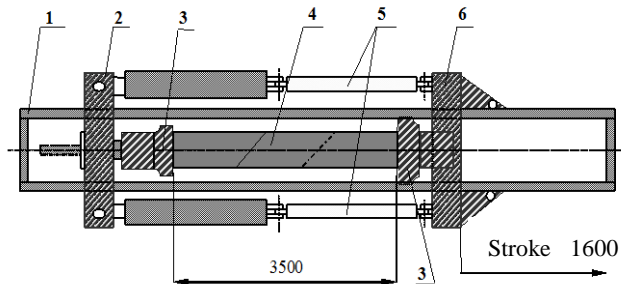


Fig. 2. ZP-40 tensile strength tester for testing of the belts and their splices (Błażej, 2001); 1 – frame; 2 – fixed beam; 3 – belt grips; 4 – belt sample; 5 – hydraulic cylinders; 6 – sliding beam

The software of the tester allows to write information originating from the tensometric head to the disc in a text file (ASCII). The maximum time of writing to computer memory depends on the frequency of sampling (from 5 Hz to 100 Hz). The additional attachment with the force indicator allows its direct monitoring during the test (Błażej, 2001).

3. ANALYSIS OF THE REASONS OF THE REDUCED STRENGTH OF FINGER SPLICES

The paper analyses 21 finger splices tested at the Belt Transport Laboratory during period between 2012 and 2014 and contains an analysis of the reasons of their reduced strength. Table 2 presents a summary of the results of average strength of splices for belts with four different rated strengths.

The width of tested samples ranged from 120 mm to 210 mm.

Table 2. Summary of the results of tested finger splices

Belt strength kN/m	Number of splices	Average strength of splice %
1250	6	65.5
1600	3	69.8
2500	5	51.6
2650	7	65.5

Tests were conducted on samples prepared and delivered by clients. Minimum three samples were tested for each splice type. The arithmetic mean of the test results was adopted as the strength of the splice. It was noted that the results of the tests conducted on the samples cut from a single splice show high differentiation, which is expressed by very high value of standard deviation. Figure 3 presents the minimum and maximum values and their differences for the tested splices.

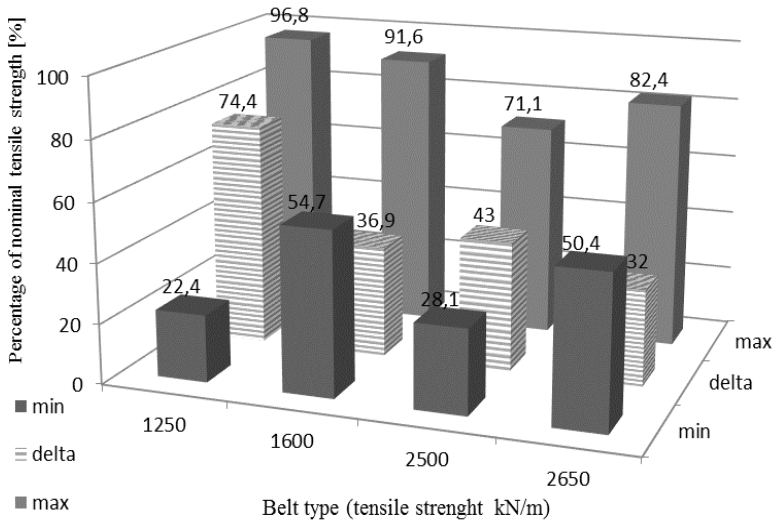


Fig. 3. Summary of differences between the minimum and maximum value for the splices of four belt types

The graph demonstrates that the differences between the minimum and maximum value range from 32 to 74.4% of the nominal tensile strength. The fluctuation indicator, i.e. the dispersion of the results in relation to the value of the average strength from the test was determined to compare the results of the tests of belt splices of varying tensile strength. Figure 4 presents the values of the fluctuation indicator for all tested splices.

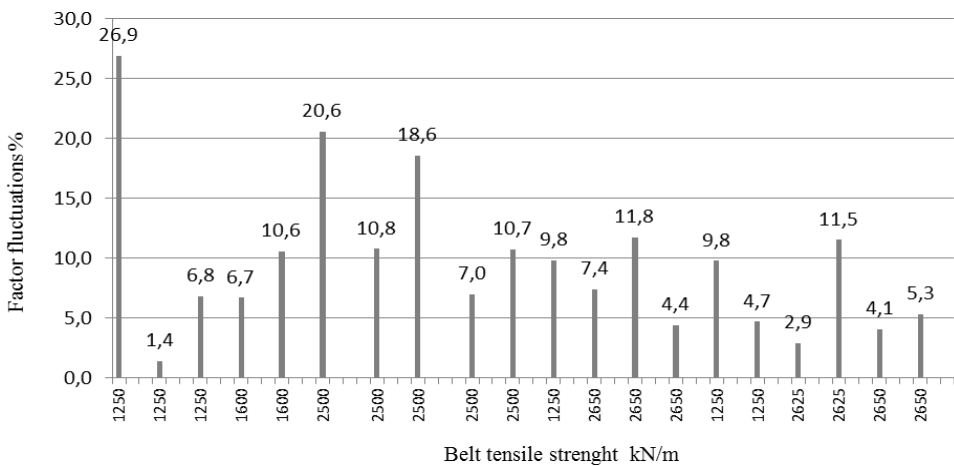


Fig. 4. Fluctuation indicator for all tested samples

8 out of 21 tested splices exceeded the value of 10%, meaning that the results of the tensile strength tests are significantly different in statistical terms. This indicator is more than twice the value of the average for three tested splices, which is presented on Fig. 5.

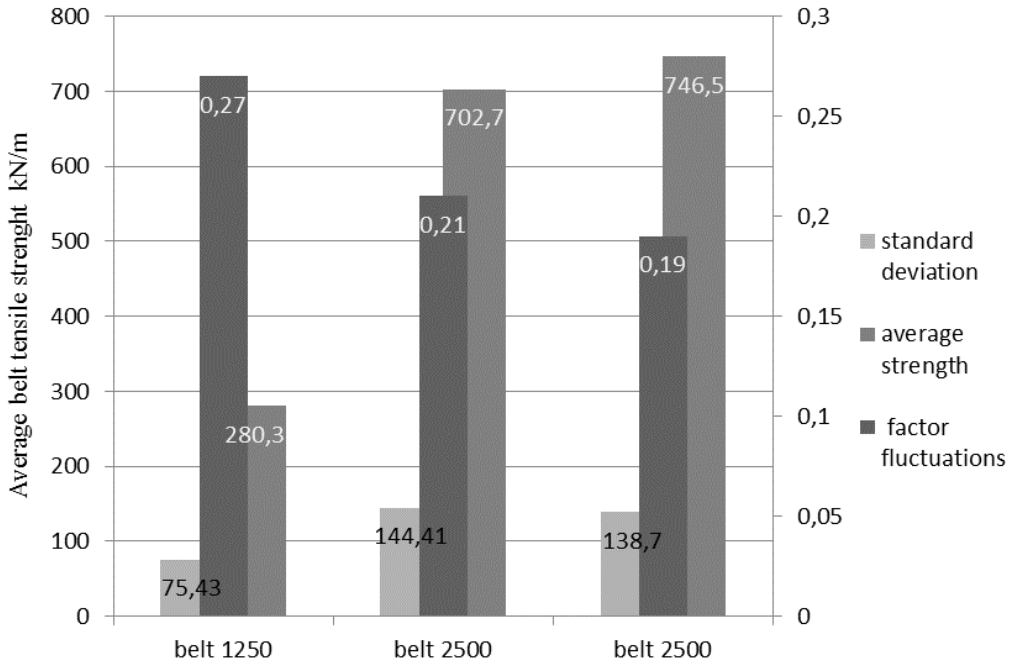


Fig. 5. Value of the fluctuation indicator for three selected connections

Such spread of the results does not allow to determine the actual strength of the splice, which could be reduced by:

- asymmetrical cut-out of the samples in relation to the axes of the fingers,
- grinding of the core surface.

4. SUMMARY

Insufficient data does not allow to conduct extensive statistical analysis, however, the available results point at the issue concerning the actual strength of finger splices. The tensile strength tests are conducted on the samples 120 to 210 mm wide. The increase of the width of tested samples should be considered. However, this causes the increase of the maximum force breaking the splice and as a result might involve the need to make structural changes to the testing station.

Summarising the results of the tests for the samples, which showed the high fluctuation indicator, it cannot be unequivocally resolved that the tensile strength of the splices determined at the laboratory reflects the actual tensile strength of the splice of the full width of the belts.

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