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Monitoring creep and stress relaxation in splices on multiply textile rubber conveyor belts

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Introduction- Belt Conveying Laboratory

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Field of interest

The Belt Conveying Laboratory has over 20 years of experience in the laboratory research related to conveyors, conveyor links, rubber, fabrics, caoutchouc mixes and plastics. The laboratory tests physical-mechanical properties of products and checks if they are compliant with the national, European and international standards.

The laboratory conducts works related to the improvement of the methods of making the joints of conveyor belt segments and is the only entity in Poland which verifies the full length of conveyor joints strength.

Thanks to its equipment as well qualified and experienced staff the laboratory does a lot of scientific-research work related to the improvement and optimisation of conveyor belt construction and belt joints, it also designs new technologies of making conveyor belt joints.

The laboratory supports the research and development work of conveyor manufacturers when their solutions are innovative, ecological and energy saving.

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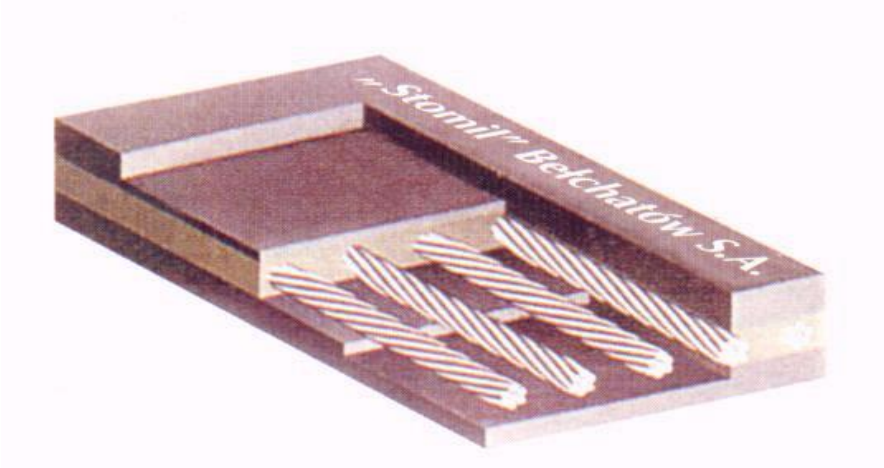
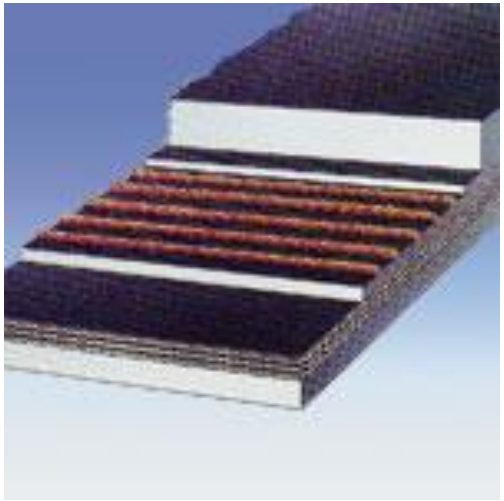
The prime tasks of the conveyor belt

•The conveyor belt is used to maintain yield moving it along the conveyor.

• The task is to move the conveyor belt longitudinal forces necessary to overcome resistance to motion, if the conveyor does not have a separate tendon propellant.





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Conveyor belt requirements

- Conveyor belt must be durable
- Conveyor belt must be resistant to punctures, mechanical damage and abrasion, insensitive to weather conditions, etc.
- Belt surface should have the smallest possible adhesion to the output, but also the highest coefficient of friction against the drum drive.

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The importance of the conveyor belt

- The most expensive element of the belt conveyor
- The lowest life element

Conveyor belts installed in the National mining

- Coal - 2400 km
- Lignite - 500 km
- Copper ore - 250 km

Belt durability depends on the level of damage. Increasing the durability of belt reduces the transport costs.

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Conveyor belt joints

• **Splices are the weakest elements of a belt loop**. In practise a large number of splices are prematurely destroyed durning belt loop operation. The designe of new construction of splices is the aim of the project which is currently carried out at the Wroclaw University of Science and Technology. Stresses in the adhesive bond in splices, their strength and fatigue life have been determined based on orginally developed research method. The obtained results will be the basis to define the new requirements regarding belt and joining materials properties.

• About 50% of joints are vulcanized or glued connections of textile-rubber belts, mechanical and finger joints while the rest are belt joints with steel cords.

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Method of evaluating the tensile strength of joints

ZP-40 tensile testing machine for belt's joints

The extension strength of joints was determined using the samples which were 200 mm wide while their length was equal to the total length of the joint plus the handle parts according to the PN-C-94147:1997 standard requirements [2]. Tests were carried out on joints ripper specially designed for such tests (Fig 1). Tested joints were of different structure what is schematically showed on figure 2.

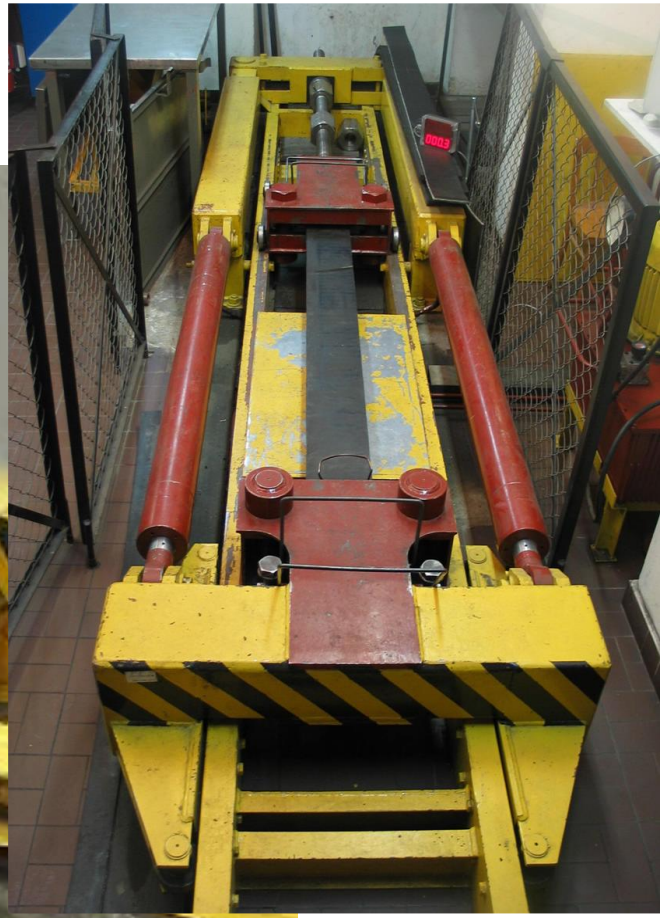

Fig. 1

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Method of evaluating the tensile strength of joints Schematic layout of joints

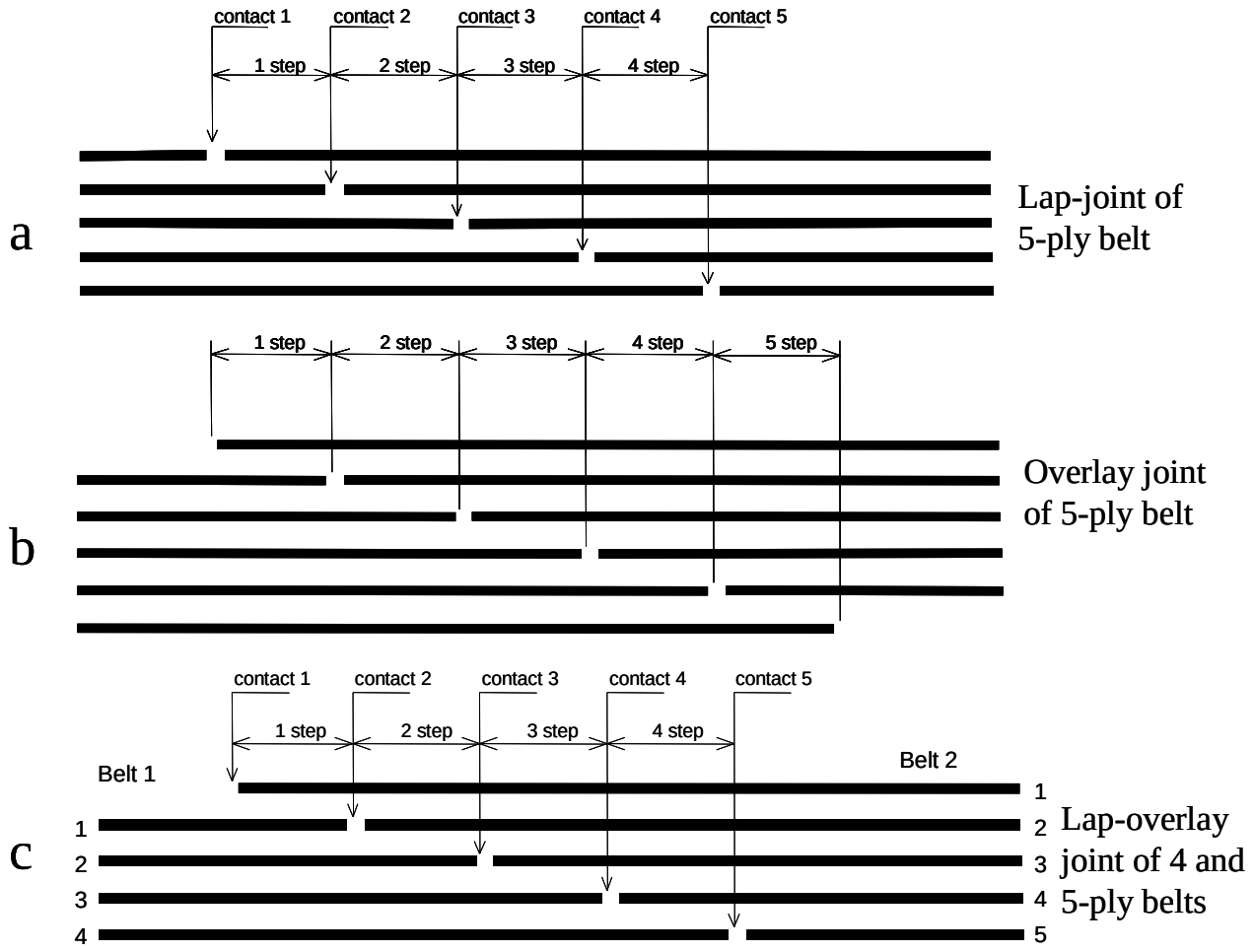

Fig. 2

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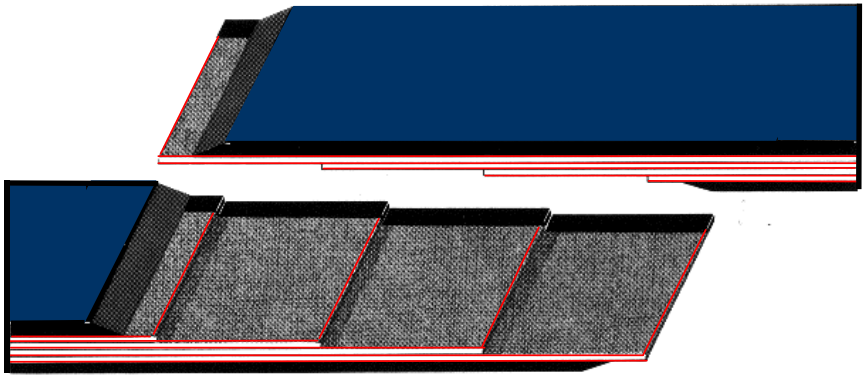
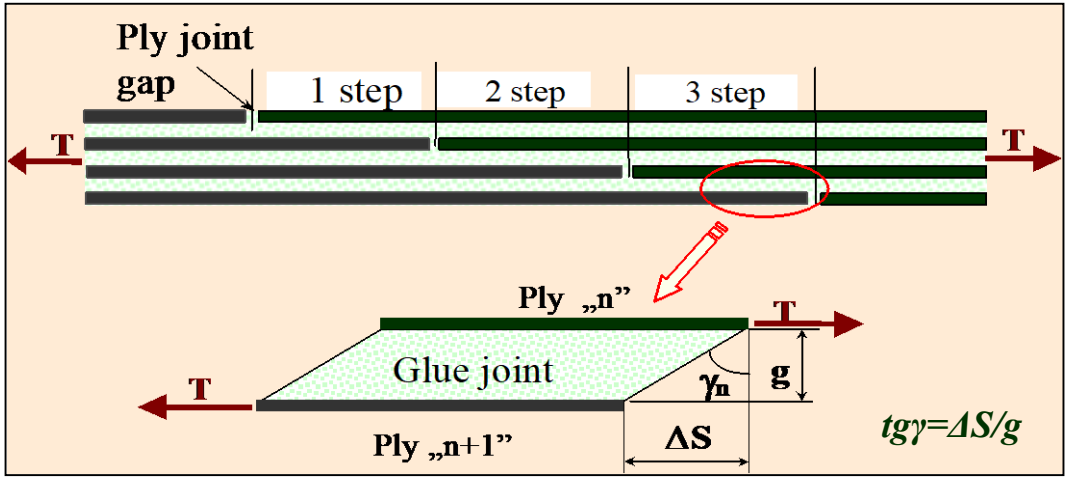
Model of interply rubber loaded with force T



Conveyor belt splices typically have multiple steps and the stresses that occur in individual plies on the first belt are transferred to plies on the second belt via an adhesive joint layer. Figure shows an exemplary 4-ply splice.



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The main aim of the studies was to compare the obtained stress distributions

The following were determined in the tests:

- the conveyor belt's tensile characteristic,
- the adhesive-bonded joint's tensile characteristic,
- the belt conveyor's creep characteristic,
- the belt splice's creep characteristic.

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Conveyor belt creep tests were performed on EP1000/4 belt, using a test stand shown in Figure

A 2000 mm long measurement basis was marked on the samples. Sample dimensions were as follows: length – 3000 mm, width – 200 mm.

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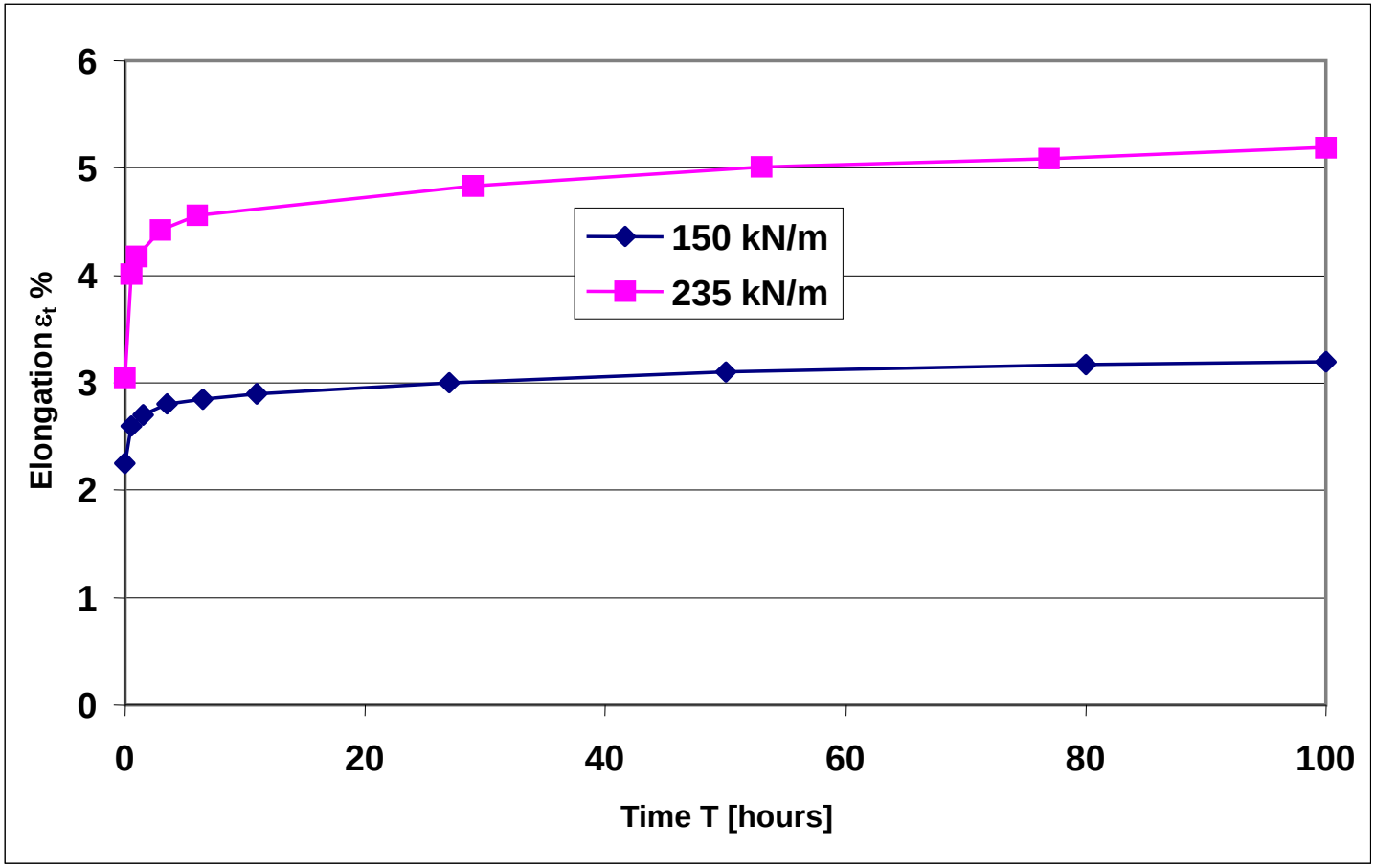
Results of creep of belt EP1000/4



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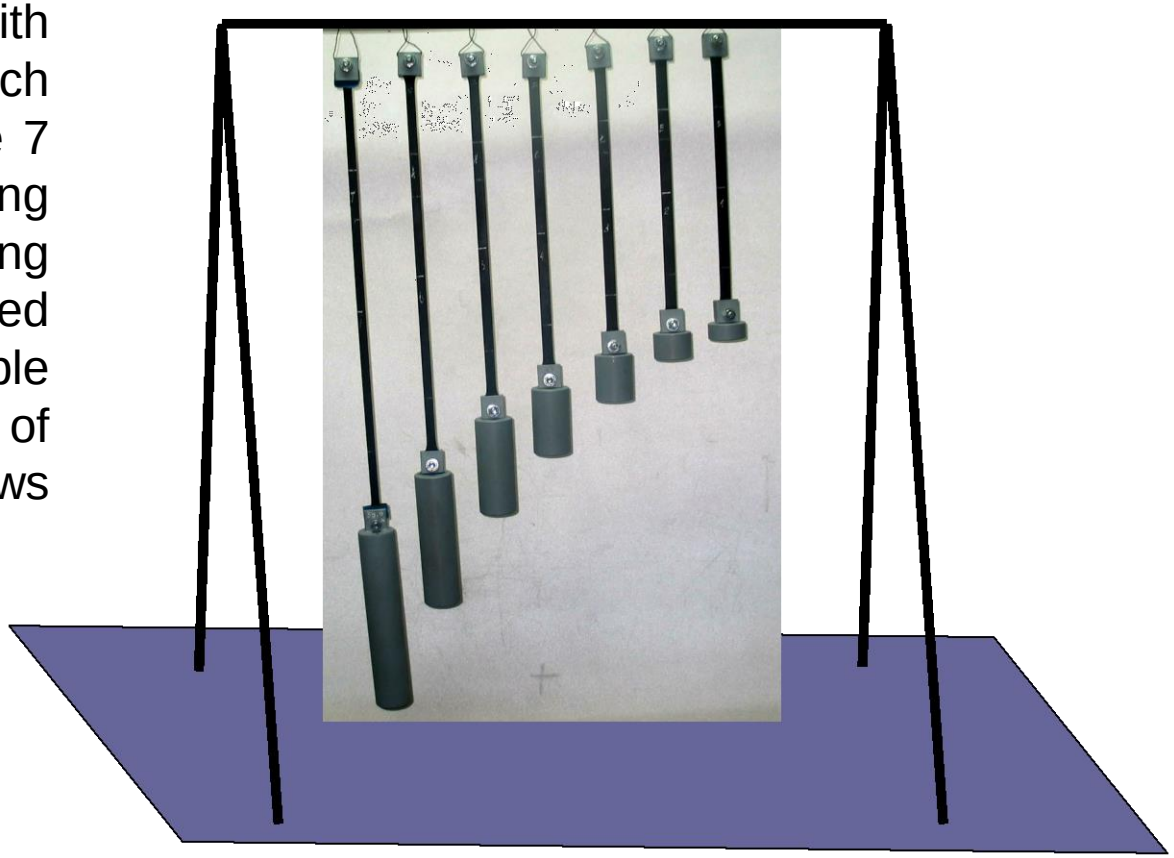
The stand for creep testing

Rubber creep tests were performed on two types of concoctions marked with symbols ANX and FPN. Each rubber type served to prepare 7 samples measuring 2x15x330 mm. A 200 mm long measurement basis was marked on the samples. Each sample was loaded with weights of increasing mass. Figure shows the test stand.



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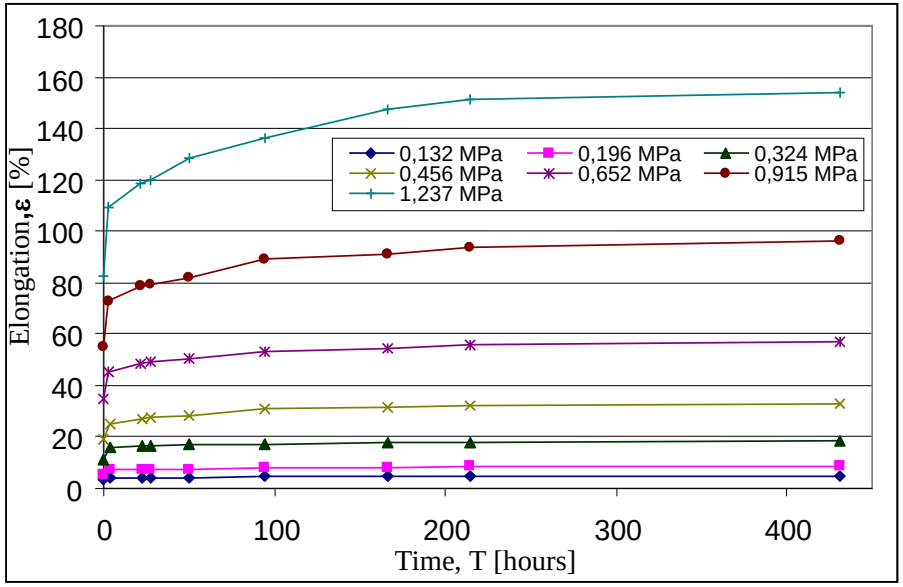
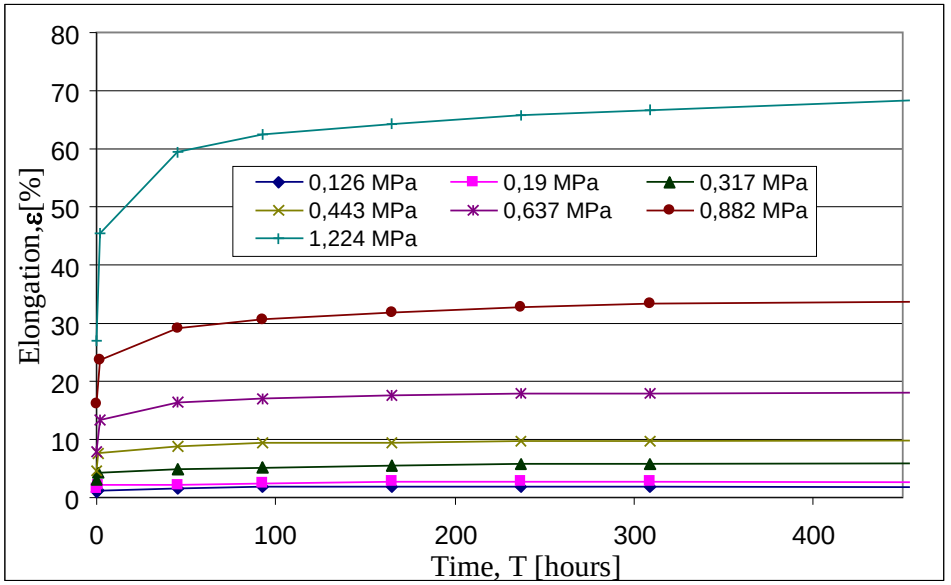
Results of creep of rubber



Creep test results for FPN rubber



Creep test results for ANX rubber

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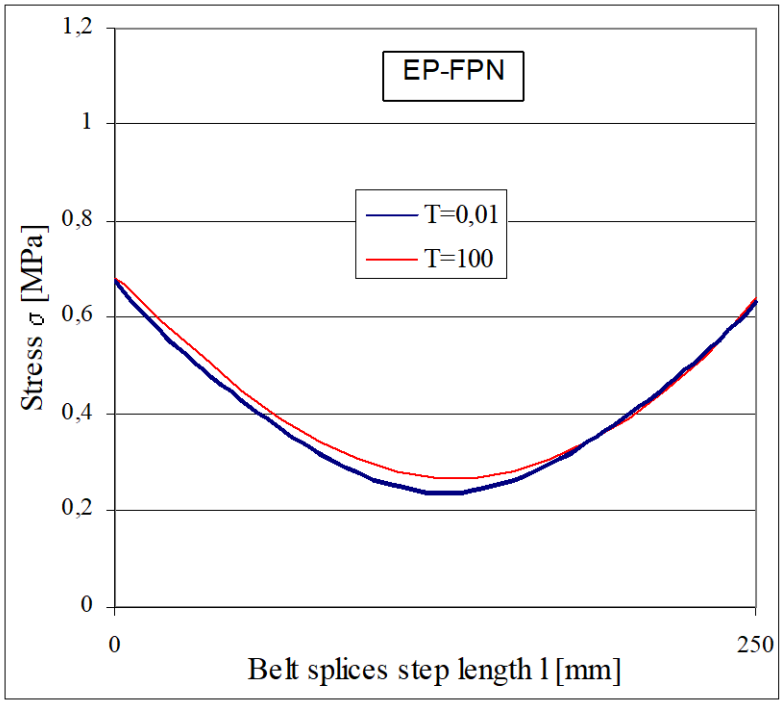
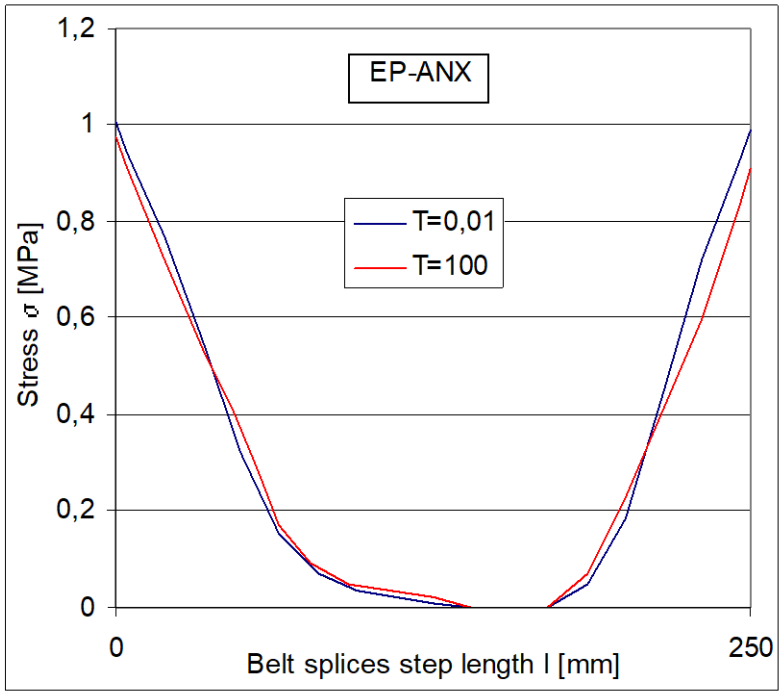
Distribution of stress σ along the splice step length





The results of adequate calculations are shown in two Figures (figure shows the joint tensile stress σ distribution along the outermost splice step *(served to immediately after F force which corresponds to 15% of the belt's nominal strength was reached, after time T=0.01 hr and T=100 hrs)*.

The EP-FPN splice is characterized by a more advantageous, more uniform stress distribution along the joint, as compared to the EP-ANX splice. Stress values in the contact areas of the first splice are also about 30% smaller than in the second splice.

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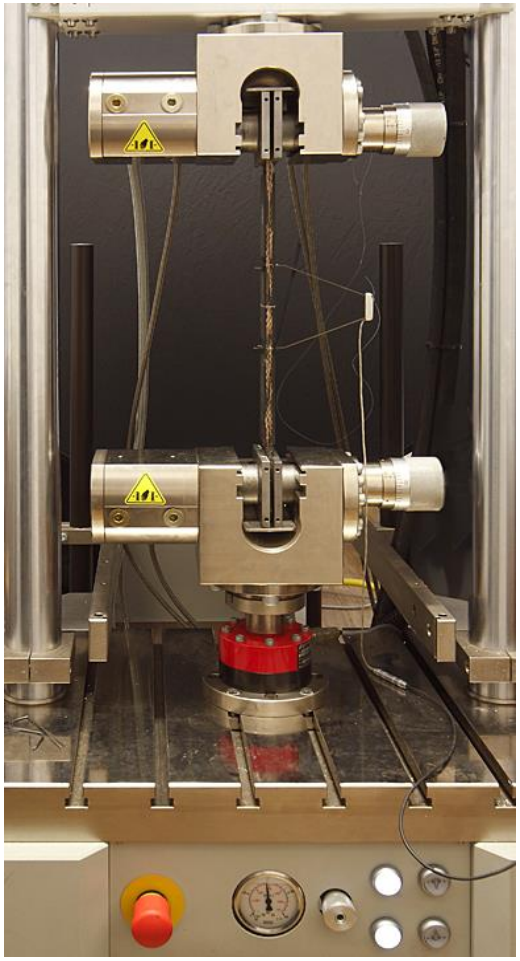
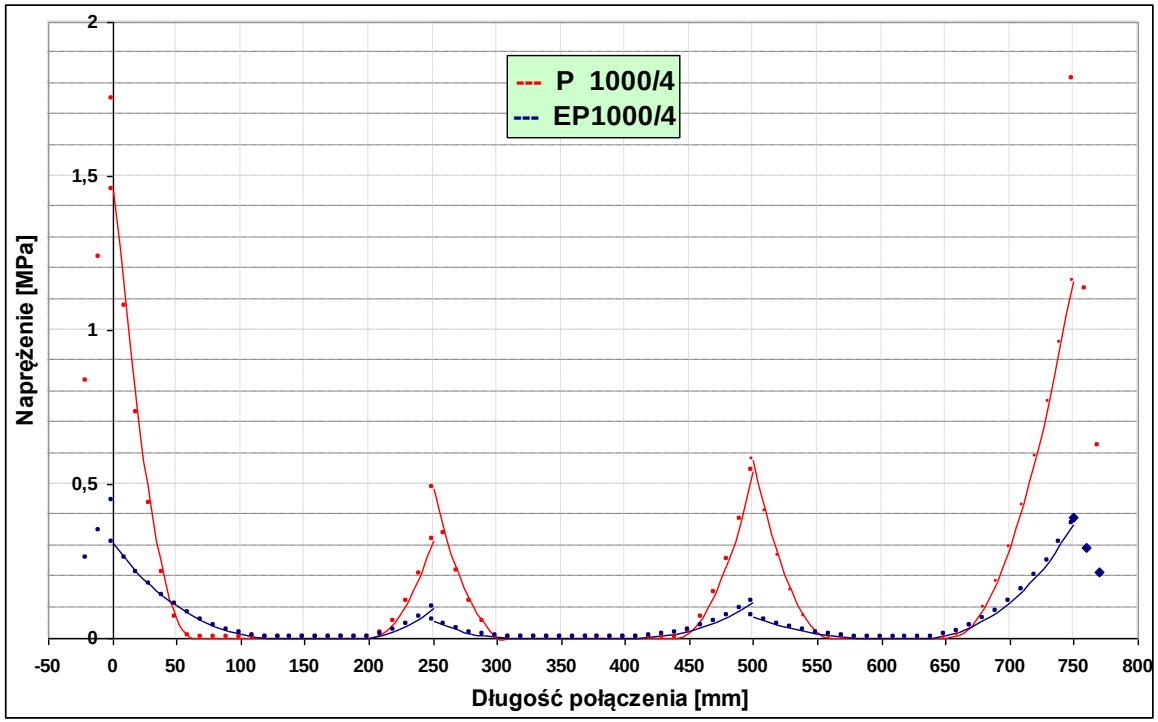
Stresses distribution in belt joint

Dynamic tests of conveyor belt connections

Distribution of shear stresses in adhesive-bonded joint



Dynamic machine ZD-25 Zwick/Roell



Distribution of shear stresses in adhesive-bonded joint of belt EP 1000/4 and P 1000/4 connection loaded by the force equal 15% of belt strength

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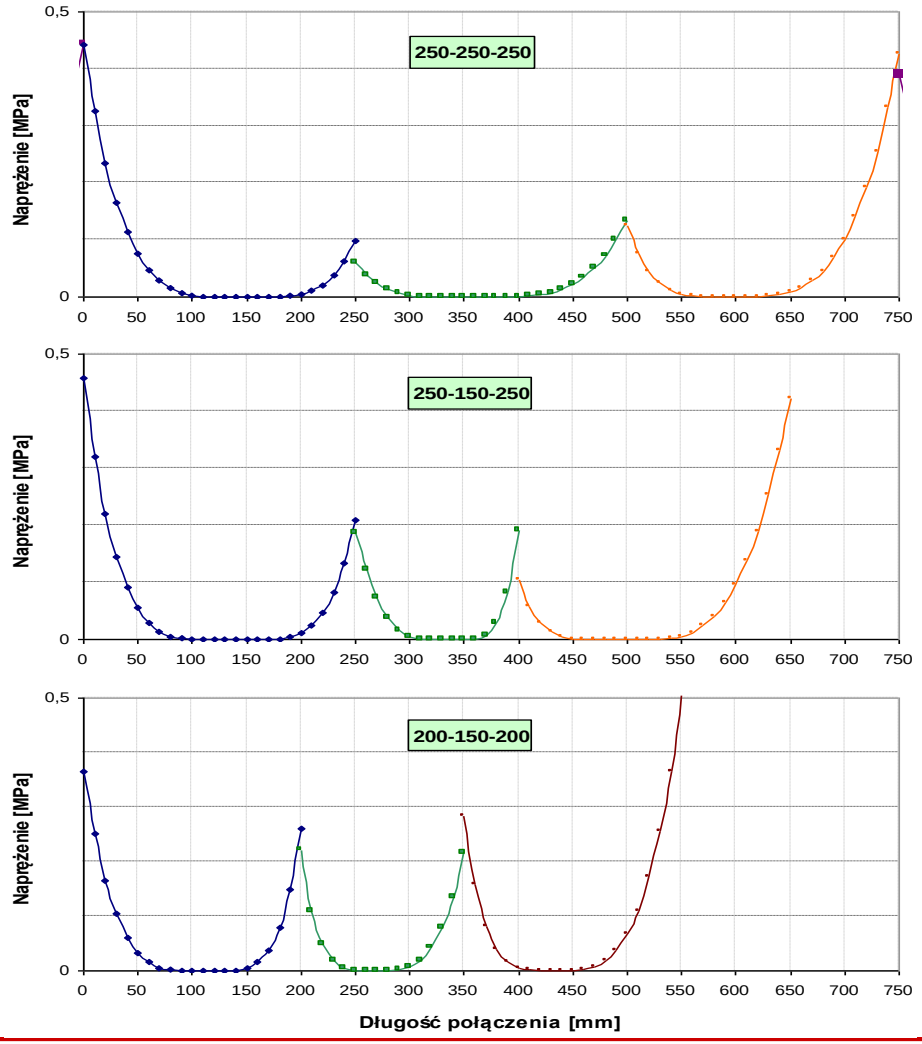
Stresses distribution in belt joint

NILOS POLSKA

Distribution of shear stresses in adhesive-bonded joint of tape EP 1000/4 connection depending on the length of connections



- The first graph is showing stresses in the standard joint 750 mm long. One can see the very uneven distribution of stresses - high stresses on outside joints and small on internal. Simultaneously large areas which don't participate in the transfer of stresses are appearing.

- The shortened joints for 200 mm in arrangement 200 +150 +200 is more beneficial schedule of stresses. Stresses on outside joints didn't grow, and areas not moving forces decreased.

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Conclusions

1. It has been found that despite the considerable strains, the stresses in the joint change minimally owing to stress relaxation.

2. From the test results one can conclude that it is not necessary to determine the stress in the splice joint after sustained loading. However, to avoid large measuring errors measurements should not be performed immediately after loading the splice because of the high rate of elongation increment in the initial period of tensioning. Practically, measurements should be performed a few hours after loading.

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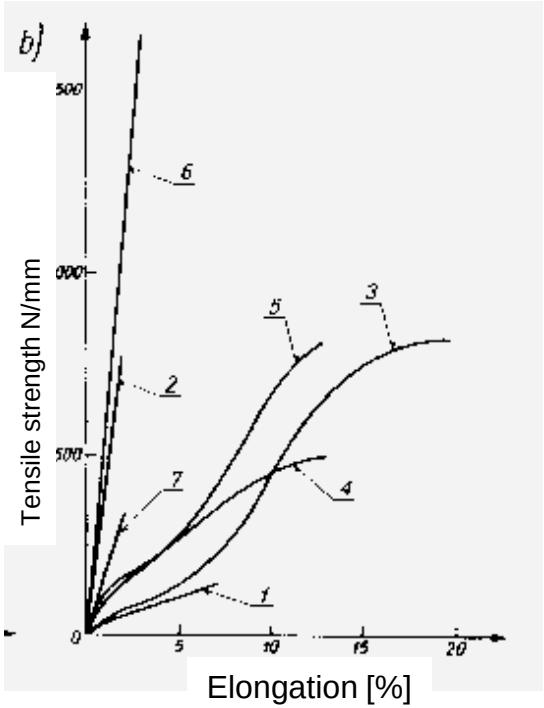
Construction of a conveyor belt

- Core, whose task is to transfer the load,
- Covers, borders, plies, whose task is protect the core

Textile cord

1 – cotton
2 – glass fibers
3 – poliamid
4 – viscose fibers
5 – poliester
6 – aramid
7 – steel cable



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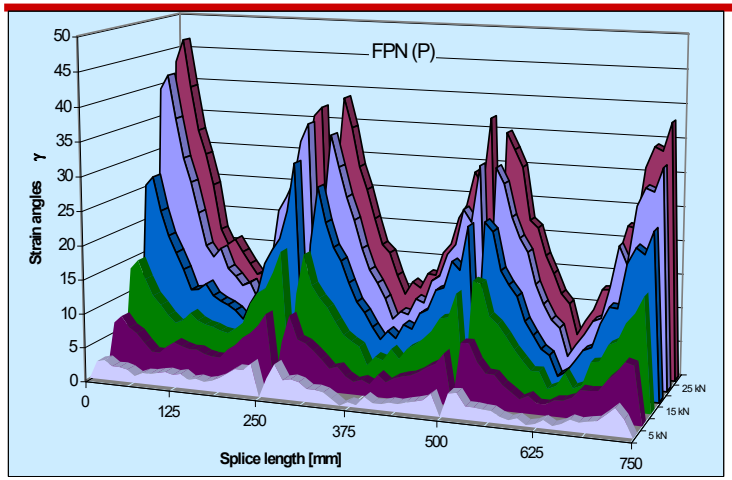
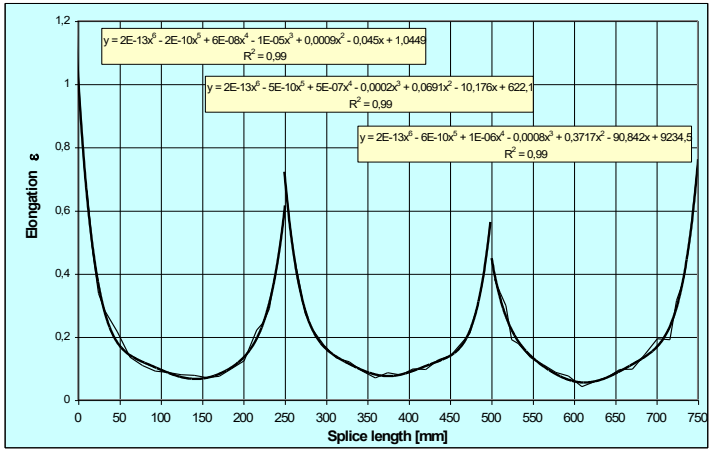
Measuring and calculating results

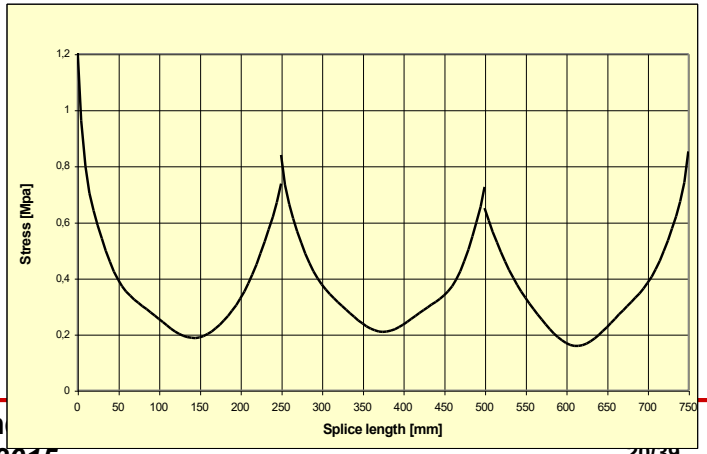


Distribution of strain angles in a joint belt splice



Strain distribution in a joint belt splice

Stress distribution in a joint belt splice



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