WMESS 2017
World Multidisciplinary Earth Sciences Symposium
11-15 September, 2017 - Prague (Czech Republic)

# Accelerated comparative fatigue strength testing of belt adhesive joints

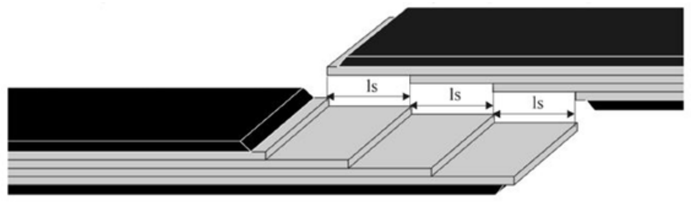
Mirosław BAJDA, Ryszard BŁAŻEJ, Leszek JURDZIAK
Faculty of Geoengineering, Mining and Geology, Wroclaw University of Technology, ul. Na Grobli 15, 50-421 Wrocław, Poland

## Introduction

Belt joints are the weakest link in the serial structure that creates an endless loop of spliced belt segments. This affects not only the lower strength of adhesive joints of textile belts in comparison to vulcanized splices, but also the replacement of traditional glues to more ecological but with different strength parameters. This is reflected in the lowered durability of adhesive joints, which in underground coal mines is nearly twice shorter then the operating time of belts. Vulcanized splices require high precision in performance, they need long time to achieve cross-linking of the friction mixture and, above all, they require specialized equipment (vulcanization press) which is not readily available and often takes much time to be delivered down, which means reduced mining output or even downtime. All this reduces the reliability and durability of adhesive joints. In addition, due to the consolidation on the Polish coal market, mines are joined into large economic units serviced by a smaller number of processing plants. The consequence is to extend the transport routes downstream and increase reliability requirements. The greater number of conveyors in the chain reduces reliability of supply and increases production losses. With high fixed costs of underground mines, the reduction in mining output is reflected in the increase in unit costs, and this at low coal prices on the market can mean substantial losses for mines. The paper describes the comparative study of fatigue strength of shortened samples of adhesive joints conducted to compare many different variants of joints (various adhesives and materials). Shortened samples were exposed to accelerated fatigue in the usually long-lasting dynamic studies, allowing more variants to be tested at the same time. High correlation between the results obtained for shortened (100 mm) and traditional full-length (3x250 mm) samples renders accelerated tests possible.

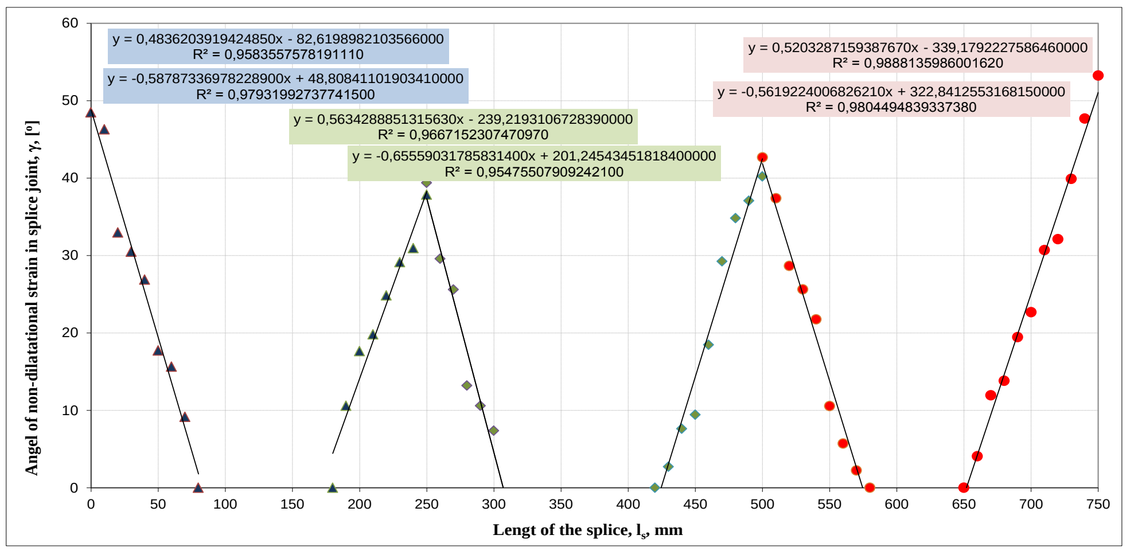
## Splicing methods and the role of adhesive joints

Textile rubber belts are cold spliced using two-component glue. With time, molecules in such glue undergo cross linking. This process is equivalent to vulcanization and hence it is frequently referred to as cold vulcanization. Adhesive joints are used in all types of textile belts, irrespective of their width. Prior to splicing, belt ends need some adequate preparation. The rubber cover and the individual plies are torn along the length of each step. The rubber layer between the plies is roughed delicately so that the ply fabric is not damaged – for instance using a wire brush. In the next step, after an adequate quantity of adhesive and curing agent has been prepared, splice surface is glued. This action is usually repeated twice or three times (at adequate time intervals). The upper and the bottom half of the splice are carefully assembled and then roller finished. This last step is necessary in order to press out gas pockets, which occur in the adhesive joint. It also ensures better adhesion between the spliced belts.



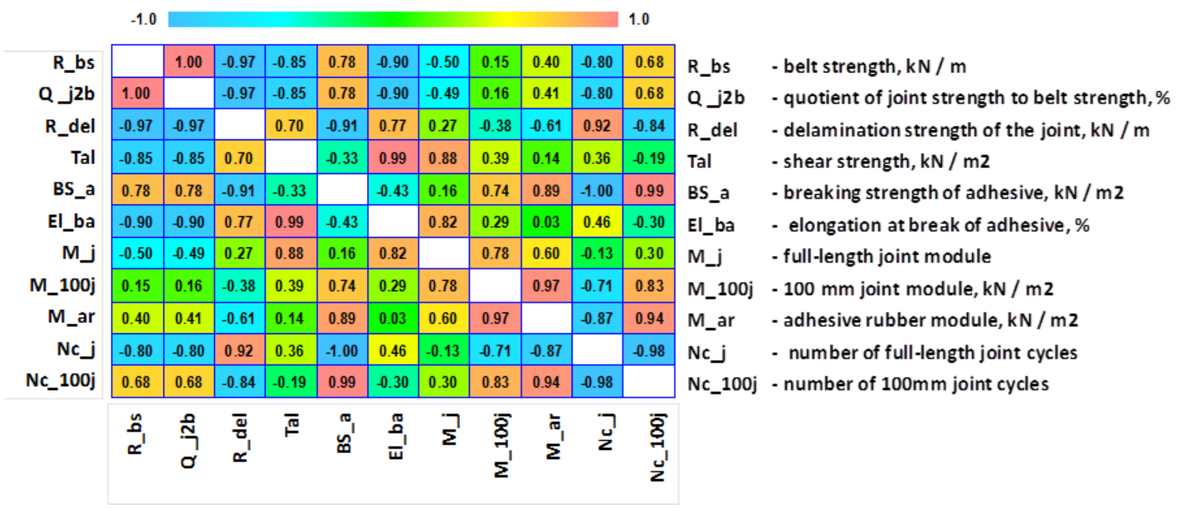

## Investigations of the splices fatigue strength carried out at the LTT laboratory

The fatigue life of splices was tested using four-ply samples of a 750 mm long splice (3 steps, each of 250 mm in length). Cyclic loading had the frequency of 0.3 Hz and the following sinusoidal pattern: for minimum load B = ¾· $R_r$ ·b ·0.05 N, for maximum load B = ¾· $R_r$ ·b ·0.02 N, where: $R_r$ – actual belt tensile strength, in N/mm; b – the width of the measurement part of the sample, in mm.
The tests performed as part of the tasks listed in the project's schedule covered stress in the adhesive material of the splice and the fatigue of sample splices. The tests of strain in the adhesive joints were performed on four-ply belts having nominal strengths of 800, 1000, 1400 and 1600 kN/m. The test were performed according to the following procedure: the sample of a joint made with chemically hardening glues was properly prepared and placed in the jaws of the testing machine; in the next step, it was loaded with a force which caused the stress in the belt to exceed the belt's actual strength by 20%; the final step consisted in measuring the non-dilatational strain in the adhesive joint.




## Accelerated tests of splice fatigue strength

The methodology for accelerated splice strength tests uses static and dynamic loads and requires easily available equipment and small sized samples. Shear stress in the layer between the plies is considered to be a reliable measure. Therefore, fatigue strength is described as the number of loading cycles which the sample is subjected to before it is damaged. The dimensions of the tested samples are: sample width is 30 mm, its total length – 500 mm, while the length of the section subjected to shearing is 100 mm. These are optimal dimensions selected on the basis of pilot tests..
The sample was subjected to cyclical loading and unloading with 0.3 Hz frequency and within the range of forces which correspond to 3,5% and 35% of the belt's actual strength. The splices were prepared so as to investigate the stress in the adhesive joint and also to observe stress in the friction rubber layer above and below the adhesive joint. This provides means to verify the results of tests performed on full-length splices (3x250 mm).
The initial results from the tests were subjected to statistical multivariable analysis. The Pearson Product Moment Correlation between the investigated parameters was graphically represented in figure (right). Its analysis revealed many interesting relationships of varying strength, which enable the construction of predictive models based on the parameters of the belt, the rubber and the glue. The correlation of the number of fatigue cycles for samples cut from full-size splices and from shortened splices with multiple parameters allows a more extensive analysis, since not only the test time shortens (fatigue occurs at a smaller number of cycles) but also the same amount of material can provide more samples.




## Conclusions and recommendations

Research into such relationships is ongoing and will be continued. A plan exists to select multivariable regression models which will allow the prediction of the practical properties of a splice, based on strength parameters of the belt, the friction rubber and glues, so as to find optimal parameters for splices and splicing materials.
This paper describes the research methodology for fatigue strength tests of conveyor belts, developed and used in the LTT laboratory at Wrocław University of Science and Technology to investigate full length splices on textile belts. Since such tests are expensive and long, this paper also offers accelerated tests for splices shortened to 100 mm, performed by applying cyclical dynamic load exceeding the stress which occurs in the belt when normally operated. The paper also presents the results of preliminary research. These results are insufficient to build models, but they point to strong correlations between the investigated parameters, which may be used to build such models in the future.

## Acknowledgements

*The publication was financed from the funds of a project realized under the Applied Research Programme in path A, titled* ***"Joints of multi-ply conveyor belts with increased functional durability"*** *No. PBS3/A2/17/2015.*