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LABORATORY TESTING OF ASPHALT BELTS RHEOLOGICAL PROPERTIES EXPOSED TO SHEAR LOADS

LABORATORNÍ MĚŘENÍ REOLOGICKÝCH VLASTNOSTÍ ASFALTOVÝCH PÁSŮ PŘI SMYKOVÉM ZATÍŽENÍ

Abstract

At faculty of civil engineering research is underway which appears with application sliding joints into foundation structures for several years. These sliding joints are applied in order reduce friction from deformation horizontal load effect (effect of undermining or shrinkage and concrete creep and also in prestressed foundation structures in order to allow introduction of prestressing) and they are usually formed from asphalt belts. To better describe the behavior of asphalt belts in sliding joint, it is necessary to know their behavior under the action shear loads over time. For this purpose many laboratory tests are long conducted both for different load conditions (size of the horizontal and vertical loads, the influence of environmental temperature) and different kinds of materials. This paper presents the current knowledge on the basis of measurements carried out so far.

Keywords

Sliding joint, asphalt belt, horizontal load of foundation, laboratory testing.

Abstrakt

Na stavební fakultě již několik let probíhá výzkum, který se zabývá aplikací kluzných spár do základových konstrukcí. Tyto kluzné spáry se do základové spáry aplikují z důvodu snížení tření od deformačních horizontálních účinků zatížení (účinky poddolování, účinky smršťování a dotvarování betonu a také u předpjatých základových konstrukcí z důvodu umožnění vnesení předpětí) a jsou obvykle tvořeny asfaltovými pásy. Abychom mohli lépe popsat chování asfaltových pásů v takto vytvořené kluzné spáře, je třeba znát jejich chování za působení smykového zatížení v průběhu času. K tomuto účelu je dlouhodobě prováděna řada laboratorních zkoušek jak pro různé zatěžovací podmínky (velikost horizontálního a vertikálního zatížení, vliv teploty prostředí) tak pro různé druhy materiálů. V tomto příspěvku jsou prezentovány aktuální poznatky na základě doposud provedených měření.

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Klíčová slova

Kluzné spáry, asfaltový pás, horizontální zatížení základu, laboratorní zkoušky.

1 INTRODUCTION

This paper deals with laboratory testing of different types of asphalt belts with the influence of ambient temperature. The aim of these tests is to simulate the behavior of asphalt belts which form sliding joint in foundation structure. Vertical load is introduced on the test sample in the first step of the test which represented load of foundation from top construction and after 24 hours the middle block of the test sample is loaded with horizontal force which causes its displacement. It is this displacement which is in the tests monitored and automatically recorded by electronic sensors. The test is completed after six days from the time of introduction of the horizontal load when a constant speed is also achieved typically.

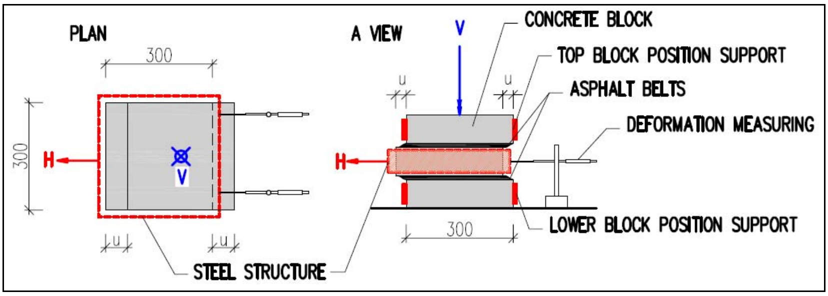

Fig. 1: Basic principle of the test of asphalt belts

The test sample consists from three concrete blocks 300x300x100mm and two sliding joints are between these (Figure 1). These sliding joints are filled with test material (always one loosely placed asphalt belts; but it is planned measurement where more asphalt belts will be or the asphalt belts will be molten or glued in the future). The steel structure was used for introducing vertical and horizontal load which is is showed in Figure 2. The vertical load is carried out using hydraulic press through steel load distribution plate and horizontal load is carried out using basket with weight, which is attached to a middle concrete block. Top and lower block are firmly fixed.

Fig. 2: Steel test equipment

The air-condition room was constructed due to the impact the influence of ambient temperature and the steel test equipment was placed into this room (Figure 3). More information on the test can be found in [1] and [2].

Fig. 3: Steel test equipment placed in air-condition

Concrete values of introduced loads are derived from real stress and displacement speed, which can rise in foundation joint. Vertical load (which can usually rise in foundation joint) are considered in the range of 100 to 500kPa and the limits 100 and 500kPa are tested given the time-consuming of measurement (one measurement last 7 days). Horizontal loads are considered so that displacement speed measured of the middle concrete block match the displacement speed of the real construction. Concrete horizontal loads values 0,95kN and 2,0kN was chosen which in the test sample concludes constant shear stress of asphalt belts 5,28kPa and 11,1kPa. Individual load combinations are showed in the table 1, each set of measurement is carried out at least for two temperatures (usually 10°C and 20°C), total at least 8 measurement for each type of asphalt belt.

Tab. 1: Individual load combinations

Combination	Vertical load [kPa]	Horizontal load [kN]
1	500	0,95
2	500	2,00
3	100	0,95
4	100	2,00

Other quantities and dependencies are derived from the test results for example real displacement speed, shear modul of elasticity, etc. The test results can be used for numerical modeling using FEM [3-12].

As it was quoted in [1] and [2] the ambient temperature is significant input factor for resulting deformations and it is advanced to include it into tests. The influence of temperature will be introduced in following paragraphs of the concrete results.

2 TESTING MATERIALS

The type of asphalt and its behavior is influenced by the way of its production. The resulting products can be fragile, flexible as rubber or their properties can be between these extremes. There are appeared oxidized belts and modified belts as using APP polymers (plastic type of modification) as using SBS elastomers (elastic type of modification) in our market.

Types of materials used for laboratory tests are based on material base which is available on our today market. As oxidized asphalt belts as modified asphalt belts are tested assuming that modified belts are preferable for create sliding joint and that not only with regard to measured deformations but mainly with regard to durability and stability of properties of modified asphalt belts.

2.1 Oxidized asphalt belts

Low ductility of lower temperatures is the general lack of belts from oxidized asphalt. It leads to cracking the cover asphalt layer, to penetration moisture to insert and to degradation acceleration of belt by deploy belts at low outdoor temperature. The belts become fragile, inflexible and break down due to the time or lower temperatures.

Currently oxidized asphalt belt of thickness 3,5mm, the weight of 4,9kg/m^2 and with fine-grained strewn trade name IPA S35 V60 is the main representative of this group tested in our laboratory. Figure 4 shows total deformations in the dependence of temperature for the selected load combination.

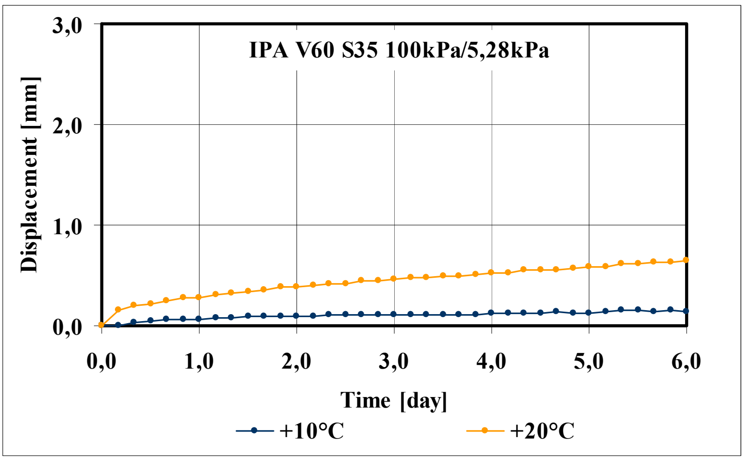

Fig. 4: Horizontal deformation on the test sample during the measurement for oxidized belt (shear stress 5,28kPa, vertical stress 100kPa)

2.2 Modified asphalt belts

The asphalts which are modified using addition polymer belong to new kinds of quality asphalt products. The primary asphalt with addition suitable of elastomers (caoutchoucs) or plastomers (termoplastics) is the raw material for production f modified asphalts.

Styrene-butadiene-styrene (SBS) is the most used elastomer today which is named termoplastic caoutchouc too. Atactic (amorphous) polypropylene (APP) is almost exclusively used plastomer. The thermoviscosit and viscoelastic properties of original asphalts are changed by adding different quantities of these substances substantially and there are obtained materials with substantially better user properties. The asphalts modified using elastomers show more or less elastic behavior, during loading they are deformed but after unloading they come back to original place or form in contrast to oxidized asphalts which show only plastic behavior.

Therefore it is necessary to divide the range of modified asphalt belts also for purpose of laboratory test into two groups depending on their modification. A range of tests was carried out in common laboratory temperature which is presented in [2]. The tests are carried out in air condition room newly currently. With regard to time-consuming two sets of measuring was carried out of the asphalt belts modified with SBS but it will be executed other sets of measurement for modified belts as with SBS as with APP.

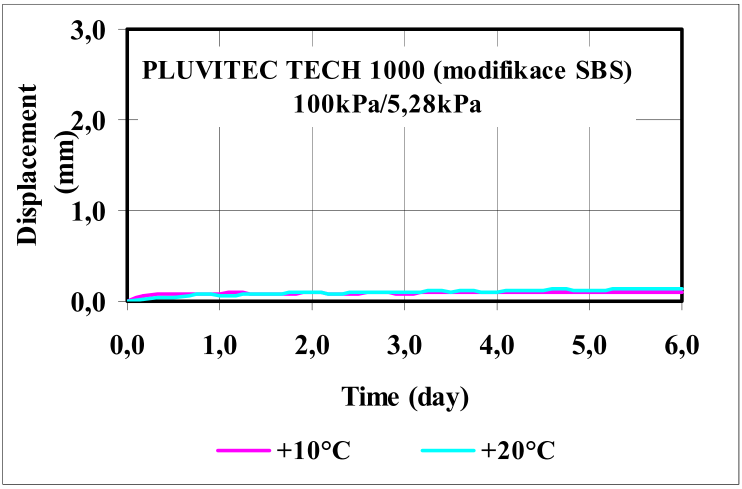

Fig. 5: Horizontal deformation on the test sample during the measurement for modified belt (shear stress 5,28kPa, vertical stress 100kPa)

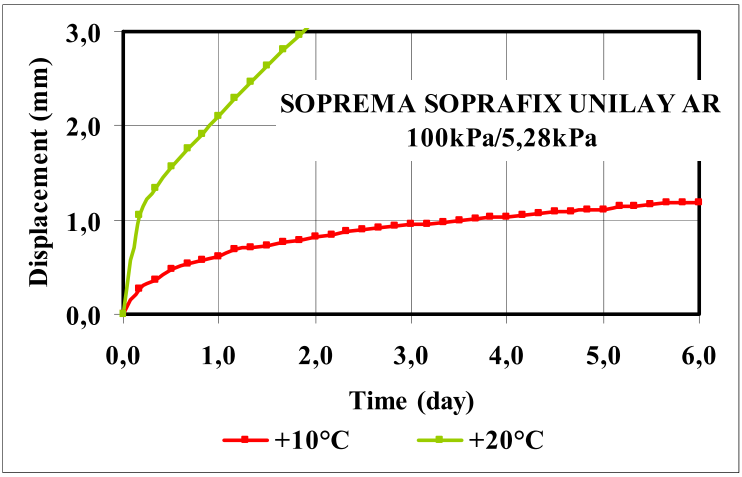

Fig. 6: Horizontal deformation on the test sample during the measurement for modified asphalt belt with slate strewing (shear stress 5,28kPa, vertical stress 100kPa)

The Figure 3 and 4 shown total deformation in dependence of temperature for SBS modified asphalt belts with the trade name PLUVITEC TECH 1000 (thickness of 3,4mm, weight of 4,0 kg/m^2) and SOPREMA SOPRAFIX UNILAY AR (thickness of 4,7mm, weight of 5,7 kg/m^2).

3 DISCUSSION OF RESULTS

It is clear from the shown graphs (Figure 4 to 6) that the change of temperature of 10°C results to twice increase total deformation in the majority of tests. It confirms our presumption that the temperature has a significant influence [1].

The Figure 7 shows graph which compares deformation of asphalt belts according to type of used asphalt (modified/oxidized). This graph shows that the difference is variable between total deformation for oxidized asphalt belts and for modified asphalt belts. Modified asphalt belt can result much larger deformation than oxidized belts at the same load condition (SOPREMA SOPRAFIX) but also can have very similar values (PLUVITEC TECH 1000). Also thickness of asphalt belt is important and their finish adjustment too. It is impossible to determine with certain a general difference between rheological properties in the relation to application of sliding joint with regard to a small quantity of test samples represented individual groups of asphalt belts.

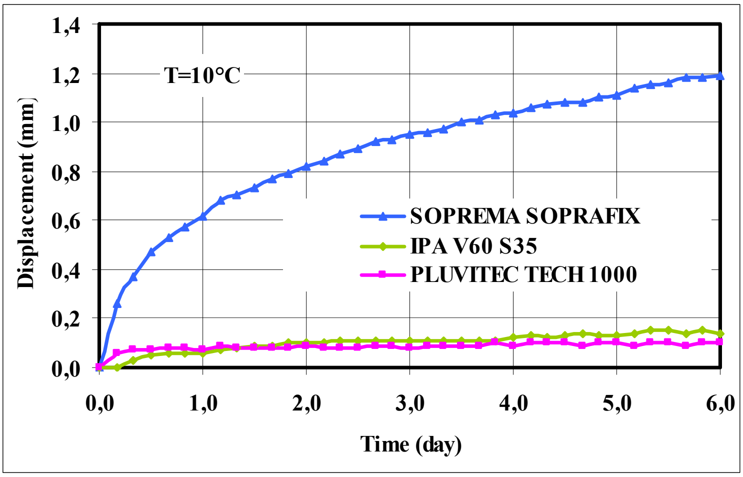

Fig. 7: Comparison of horizontal deformation on the test sample during the measurement for oxidized and SBS modified asphalt belts (10°C)

The choice between oxidized and modified belt is not the only decision factor when choosing the type of asphalt belt to create a sliding joint. Important in the choice of the asphalt belt is compared both stress-strain state of concrete structures with specific properties of the asphalt belt, not least the durability and time stability properties of asphalt belts. When measured in the laboratory, for example, was the finding that the age of a test sample of belts from oxidized asphalt affects the resulting deformation to a large extent. For clarity the graph on the Figure 8 shows deformation during the age of the sample for oxidized asphalt belt IPA. This comparison, however, is not final and the dependence of rheological properties on the age of the sample will continue to be monitored. Based on general knowledge of the behavior of oxidized and modified asphalts, however, implies a greater dependence on the age of the sample results for oxidized belts than modified, which corresponds with previous results.

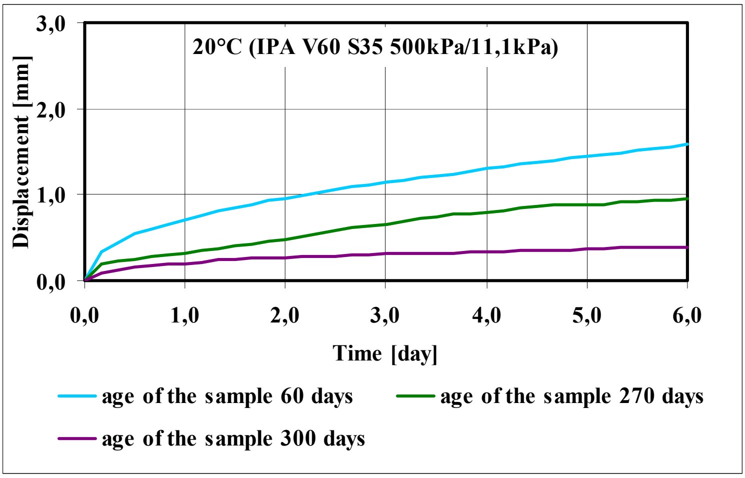

Fig. 8: Comparison of horizontal deformation on the test sample from oxidized asphalt belts with regard to age of the sample

4 CONCLUSION

There was carried out several sets of measurement of rheological response of asphalt belts and it was verified influence of the ambient temperature on total deformations. There was also monitored influence of asphalt modification of asphalt belt behavior. It is impossible to determine with certain a general difference between modified and oxidized asphalt belts with regard to a big quantity of existing materials. On the base of original tests by common laboratory temperature and on the base general knowledge about modification of asphalt belts, particular described in previous chapters, it can be assumed that modified asphalt belt will have better properties than oxidized asphalt belts. Another question is also a difference between behaviors of asphalt belts with regard to type of modification. It is necessary to test both types of asphalt belts to verify assumes which are based on general knowledge and especially it is necessary to extend the range of modified asphalt belts.

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LITERATURE

[1] ČAJKA, R., JANULÍKOVÁ, M., MATEČKOVÁ, P. and M. STARÁ, Laboratory Testing of Asphalt Belts with the Influence of Temperature: paper #4. *Transactions of the VŠB - Technical University of Ostrava*: *Construction Series* [online]. Warsaw, Poland: Versita, 2011, Volume 11, Issue 2, p. 1-6 (6 pages). ISSN 1804-4824 (Online); ISSN 1213-1962 (Print). DOI: 10.2478/v10160-011-0020-0.

[2] MAŇÁSEK, P.: *Základové konstrukce s kluznou spárou*. Doctoral thesis at the Faculty of Civil Engineering, VŠB-TU, Ostrava, 2008. (in Czech)

[3] ČAJKA, R., JANULÍKOVÁ, M., MATEČKOVÁ, P. and M. STARÁ, Modeling of Foundation Structures with Sliding Joint Using Results of Asphalt Belts Laboratory Tests: paper #2. *Transactions of the VŠB - Technical University of Ostrava*: *Construction Series* [online]. Warsaw, Poland: Versita, 2012, Volume 12, Issue 1, p. 1-7 (7 pages). ISSN 1804-4824 (Online); ISSN 1213-1962 (Print). DOI: 10.2478/v10160-012-0002-x.

[4] ČAJKA, R. & MAŇÁSEK, P. Finite Element Analysis of a structure with a sliding joint affected by deformation loading. In *The eleventh International Conference on Civil, Structural*

and Environmental Engineering Computing. 18-21.9. 2007, St. Julians, Malta, ISBN 978-1-905088-17-1

[5] ČAJKA, R. Contact subsoil shear FEM element. In *SEMC 2007 The third International Conference on Structural Engineering, Mechanics and Computation*, 10.-12. September, Cape Town, South Africa, ISBN 9789059660540.

[6] ČAJKA, R. and L. MYNARZOVÁ, Využití numerického modelování při analýze zděné konstrukce na poddolovaném území. In *Sborník vědeckých prací Vysoké školy báňské – Technické univerzity Ostrava*, rok 2009, ročník IX, č. 1, řada stavební, s. 1-6, ISSN 1213-1962

[7] ČAJKA, R. Semispace FEM element and soil - structure interaction. In *The Third International fib Congress and Exhibition & PCI Annual Convention and Bridge Conference*, May 29 - June 2, Washington, D.C. 2010, USA

[8] ČAJKA, R. & MAŇÁSEK, P. Numerical analysis of the foundation structures with sliding joint. In *Eleventh East Asia-Pacific Conference on Structural Engineering & Construction - Building a Sustainable Environment*, Taipei, Taiwan, 19. - 21.11. 2008. S. 716-717. Sborník příspěvků X. konference a CD, ISBN 978-986-80222-4-9

[9] JANULÍKOVÁ, M. & MATEČKOVÁ, P. & STARÁ, M. Numerical modeling of foundation structures with sliding joints. In *The 9th fib International PhD Symposium in Civil Engineering*. Karlsruhe, Germany: Karlsruhe Institute of Technology (KIT), 2012

[10] SUCHARDA, O. and J. BROŽOVSKÝ, Effect of Selected Parameters of Non-Linear Analysis of Concrete Structures: paper #9. *Transactions of the VŠB - Technical University of Ostrava*: *Construction Series* [online]. Warsaw, Poland: Versita, 2012, Volume 12, Issue 1, p. 1-9 (9 pages). ISSN 1804-4824 (Online); ISSN 1213-1962 (Print). DOI: 10.2478/v10160-012-0009-3.

[11] SUCHARDA, O. and J. BROŽOVSKÝ, Elastic-Plastic Modelling of Reinforced Concrete Beam: Implementation and Comparison with the Experiment: paper #14. *Transactions of the VŠB - Technical University of Ostrava*: *Construction Series* [online]. Warsaw, Poland: Versita, 2011, Volume 11, Issue 1, p. 1-7 (7 pages). ISSN 1804-4824 (Online); ISSN 1213-1962 (Print). DOI: 10.2478/v10160-011-0014-y.

[12] SUCHARDA, O. and J. BROŽOVSKÝ, Models for Reinforcement in Final Finite Element Analysis of Structures: paper #9. *Transactions of the VŠB - Technical University of Ostrava*: *Construction Series* [online]. Warsaw, Poland: Versita, 2011, Volume 11, Issue 2, p. 1-11 (11 pages). ISSN 1804-4824 (Online); ISSN 1213-1962 (Print). DOI: 10.2478/v10160-011-0032-9.

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