Utilization of Temperature Dependency of Asphalt Belts to Reduce Shear Stress into Foundation Structures

Martina Janulikova

Abstract—Asphalt belts are commonly used to the hydro insulation of flat roofs and to the hydro insulation of foundations. These belts are also used to auxiliary function as part of roof layer or as under layer in many construction. But asphalt belts can be also used to reduce shear stress into foundation structures. The basic principle of this reduction is in application asphalt belts between foundation and concrete base layer. This creates a sliding layer which eliminates friction forces in foundation bottom. This paper explains reasons for using of sliding joint in to foundation structures and its basic function in the building. The experimental tests of modern sliding joint and their results are presented too. At the long term tests it was verified that the ambient temperature has a heavy effect of asphalt belt behavior. For this reason the new laboratory tests deal with electronic temperature control directly in the sliding joint. Such sliding joint can be also very helpful for all types of foundation which are loaded with horizontal deformations (undermining, pre-stressing, creep and shrinkage etc.).

Keywords—temperature dependency, sliding joint, undermining, asphalt belt, shear stress, electronic heating, viscoelasticity.

I. Introduction

SLIDING joint and its using in civil engineering were in Czech Republic at first solved in 80th. In this period its positive effect were monitored and tested. Then was sliding joint at first used also in real structure. It was proved that sliding joint into foundation structure helps to solve problems associated with horizontal deformation of subsoil or into foundation. Viscoelastic behavior of asphalt contributes to this positive effect. Rheology of asphalt materials is very often researched problem [1, 2, 3]. But asphalt belts have quite different properties as asphalt mixtures. Problems with effect of undermined areas and need to know behavior of today used materials are main reason to testing sliding joint in our region. But sliding joint can be advantageously used also to reduce unpleasant effect of shrinkage and creep in concrete. Last but not last these can be used during pre-stressing of concrete foundation or concrete industrial floors [4]. Sliding joint enables to pre-stressed structure deformation and then right insert of pre-stressing.

The most used material to create sliding joint is an asphalt belt. It is known that the temperature influences properties of asphalt product and due to this fact the laboratory test were performed. At first modern asphalt belt was tested at the common laboratory temperature [5]. In the second step modern materials at the controlled ambient temperature were tested [6, 7, 8, 9, 10, 11]. In the third step are conducted experimental tests with sliding joint which is directly heated using electronic heating. This paper offers an innovative approach to creating a sliding joint. Innovation is in the fact that the function of the sliding joint may be controlled using of increased temperature.

II. The Basic Principle of Sliding Joint

Shear stress on the surface between foundation and soil on undermined areas can be very danger because it can create great tensile forces in foundation structure. These forces can be reduced using sliding joint. It is usually applied as layer of suitable material between foundation structure and concrete base layer. The basic principle of sliding joint function in foundation on undermined areas is explained on the course of shear stress along the foundation on the Figure 1. Analogical it acts in structures where horizontal deformation arises directly into structure (not into subsoil).

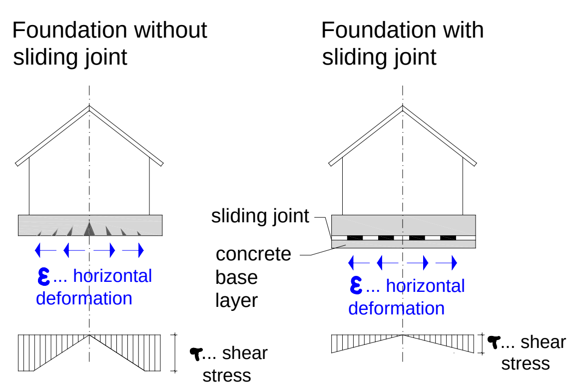

Fig. 1 The course of shear stress along foundation without and with sliding joint

The works were supported from sources for conceptual development of research, development and innovations for 2015 at the VŠB-Technical University of Ostrava which were granted by the Ministry of Education, Youths and Sports of the Czech Republic.

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Typical example is pre-stressed foundation belt. Specific loss of pre-stress caused by friction between foundation and subsoil arises in these structures. This loss of pre-stress has to be included into calculation. If sliding joint is used these losses could be eliminate strongly. Above described is shown on the Figure 2.

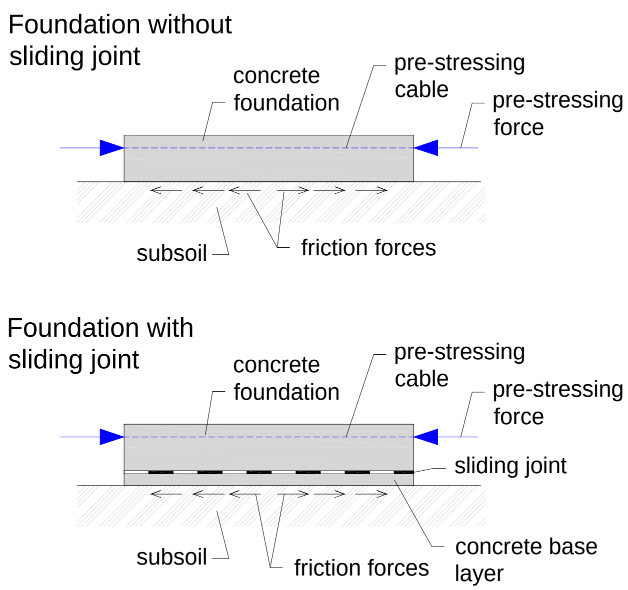

Fig. 2 The scheme of pre-stressed foundation with and without sliding joint

III. THE BASIC PRINCIPLE OF THE TESTS

The aim of all test sets is to simulate behavior of concrete structure with sliding joint which is loaded with shear stress.

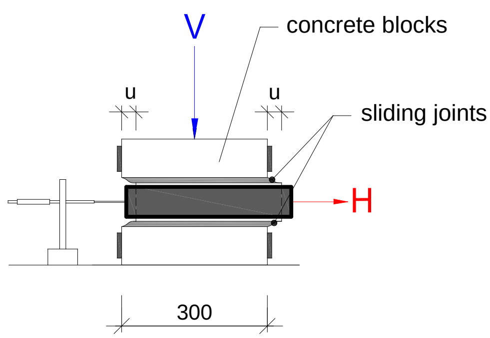

Fig. 3 The test sample

The test sample which consists from three concrete blocks 300x300x100mm with two sliding joints is shown on the Figure 3. Both sliding joints are filled with test material. A steel structure is used for introducing vertical and horizontal load which is shown on the Figures 4 and 5. The test has two parts. In the first part the test sample is loaded with vertical load (V) and after one day (24 hours) it is introduced horizontal load (H) on the middle concrete block.

The entire test takes one week. During whole test it is monitored horizontal deformation of the middle concrete block.

The vertical load is introduced using a hydraulic press and the horizontal load is carried out using a basket with weights, which is attached to the middle concrete block. The top and lower blocks are fixed.

Fig.4 The steel test equipment

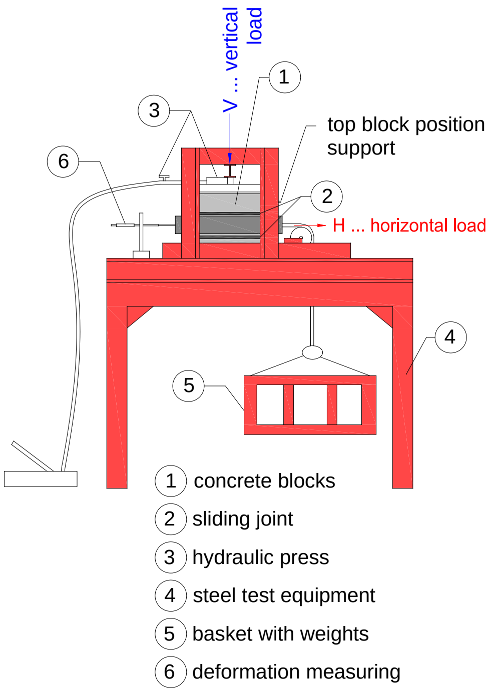

Fig. 5 The scheme of steel test equipment

A great attention is also focused on thermal sensitivity of majority of used materials. An air conditioned room (Figure 6) was constructed due to the impact of the influence of ambient temperature and tests were carried out in this room. More information on these tests can be found in [6, 7, 8, 9, 10, 11]. Partial result from the test show graphs on the Figure 7. Modified asphalt belt (thickness 4,2mm, weight 4,93kg/m2) was chosen to comparison with new test. Curves in this graph represent total horizontal deformation on the middle concrete block during the test for different load combination - at the contact stress 500kPa, shear stress 5,28kPa and different temperatures. It is necessary to remark that higher deformation means that the material is more pliant and a smaller shear resistance arises in the sliding joint. Then smaller deformation means higher shear resistance. It was also confirmed that a temperature plays a significant role and at the higher temperatures arise higher deformation and that means also smaller shear resistance.

This research relates to interaction between foundation and

Fig. 6 The air conditioned room

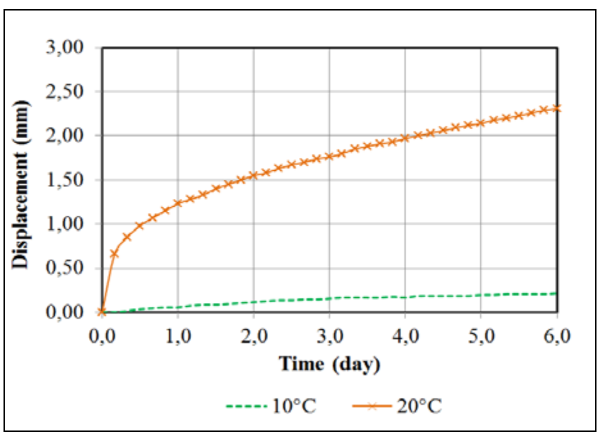

Fig. 7 Result deformation for shear stress 5,28kPa, vertical stress 500kPa and different temperatures

subsoil. Because of strong influence of contact stress, contact stress in the foundation bottom with or without sliding joint is measured at VŠB Technical University of Ostrava too [12, 13, 14, 15, 16]. More information about other solutions of problems with horizontal deformation can be found in [17, 18, 19, 20]. Results from tests are used to determine friction parameters for stress calculating of foundation structures [21, 22].

IV. THE BASIC PRINCIPLE OF ELECTRONIC HEATING OF SLIDING JOINT

Because of confirmation positive effect of higher temperature the heating grid was constructed to regulate temperature directly into sliding joint.

Newly it is sliding joint heated using electronic heating system to the desired temperature. Heating grid for

Fig. 8 Heating grid

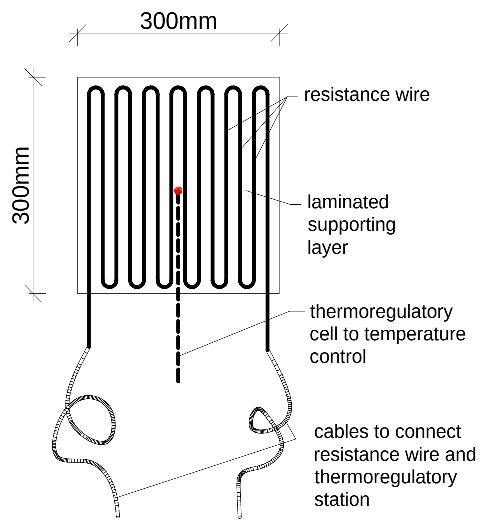

Fig. 9 Scheme of heating grid

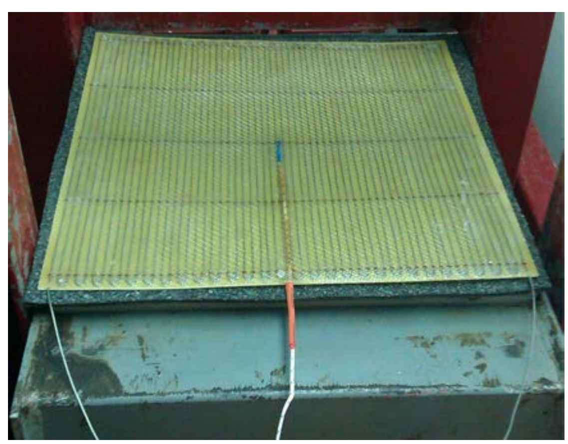

Fig. 10 Heating grid into sliding

temperature regulation is shown on the Figures 8, 9 and 10.
The basis part of this grid is the resistance wire which is connected with thermoregulatory station. Thermoregulatory

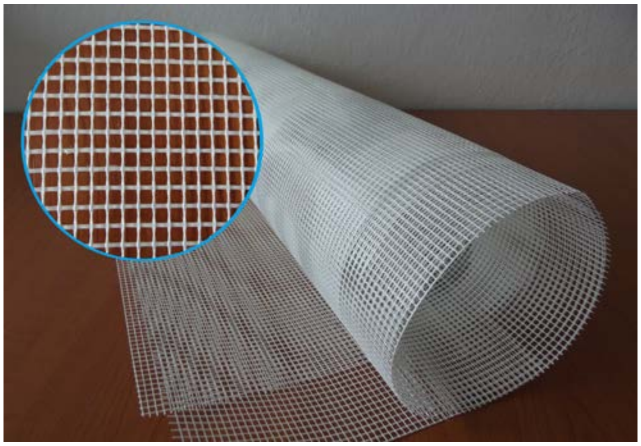

Fig. 11 Planed materials to supporting grid

station serves to set and control of temperature in sliding joint as required. Laminated supporting layer was chosen for the first test. Different materials to create supporting layer will be tested to find best materials in the next research. Supporting material has to be light, strong, durable and first of all cheap.

If electronic heating would be more expensive than increasing amount of reinforcement, it will not make sense. The next plan is to use glass fiber fabric (Figure 11) which is cheap and strong.

Heat of hydration can be used to heating of sliding joint too [23].

V. RESULTS FROM THE NEW TEST

The modified asphalt belt with thickness 4,2mm and weight 4,93kg/m2 was chosen for the first experimental test with heating grid. Every sliding joint was consisting of two these belts and one heating grid between belts. The original results for this belt without heating into sliding joint and for one asphalt belt in sliding joint are presented above (Figure 7). The test equipment with tested sample was placed into air conditioned room where were maintained the temperature 4°C. It is average temperature in the foundation bottom during whole year.

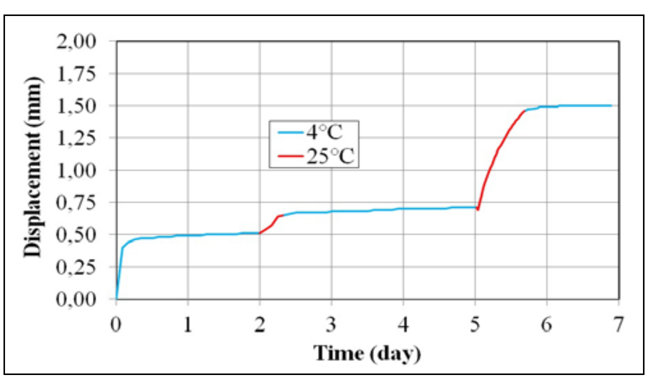

Fig. 12 Result deformation for modified asphalt belt with variable temperature during test

Graphs on the Figure 12 and 13 show first results from the sliding joint heating. It is clear from graphs that the asphalt

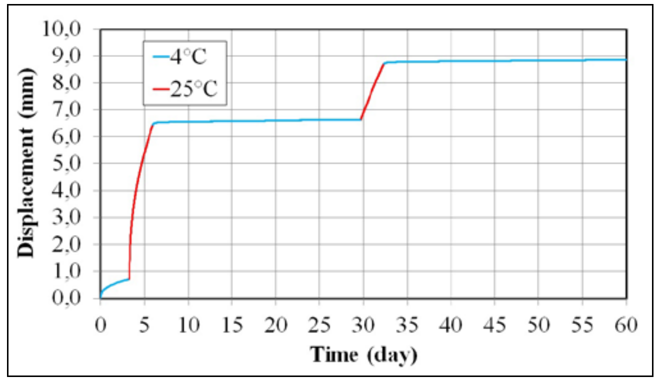

Fig. 13 Result deformation for modified asphalt belt with variable temperature during long-term test

belt reacts to temperature change according to assumptions which were achieved in the test into air conditioned room. At the higher temperature (25°C) higher velocity of deformation was reached and vice versa. It is also clear from the graph that the velocity of deformation returns to original velocity at the temperature 4°C after cooling to original temperature. The graph on the Figure 13 shows that the heating fulfills the function after a month into sliding joint too.

VI. PRACTICALY USING OF OBTAINED KNOWLEDGE

Heating is suitable for more effective using of sliding joint. In the graph on the Figure 14 is shown how can be shear stress reduced for temperatures 10°C and temperature 20°C.
There are linear dependencies between shear stress and velocity of deformation. These dependencies are derived from test results. From the graph it is clear that the resulting stress is strongly dependent on the temperature and it can be very different. For example resulting shear stress are derived for temperature 10°C and 20°C for the velocity of deformation vu = 5 ·10-9 m/s which is value known from behaviour of

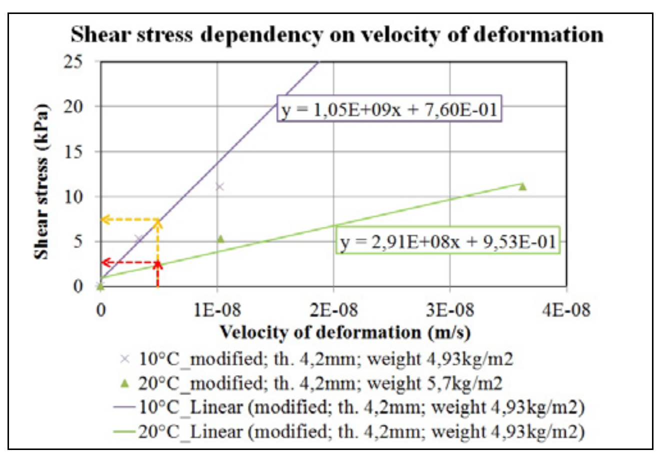

Fig. 14 Shear stress into foundation structure

settlement trough (it can be calculated from the values from the mining office). If the difference between temperatures will be larger, the difference between stress will be larger too.

VII. Conclusion

It was described the basic function of sliding joint and the advantages of its using. There introduced behavior of asphalt belt at the different temperature. Tests also show that the total deformations and also analogical shear response are dependent on temperature. These findings are very important for foundation structures because sliding joint can be used to reduce shear stress under structure. The first results from new tests with electronic heating show that heating of sliding joint can have very positive effect of sliding joint function. Long-term effect of this fact was also verified.

In this field will be carried out sets of measurement and evaluation off economic aspects of heating will carried out based on results of new tests. In further research suitable heating grid to using in real structure will be developed.

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