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Chapter 33

Protection of Buildings at Areas Affected by Mining Activities

Pavlina Mateckova, Martina Janulikova and David Litvan

Additional information is available at the end of the chapter

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Abstract

Building structures in areas affected by underground mining demand specific treatment due to expected terrain deformation. In this chapter, expected horizontal terrain deformation and its effect especially on foundations structure is analyzed. Through the friction between subsoil and foundations, the foundation structure must resist significant normal forces. The idea of sliding joints between subsoil and foundation structure, which eliminates the friction in footing bottom, comes from the 1970s. The bitumen asphalt belt given rheological properties has been proven as an effective material for sliding joints. In the chapter, there are test results of shear resistance of currently used asphalt belts and example of sliding joint application in real structure.

Keywords: underground mining, protection of structures, sliding joint, asphalt belt

1. Introduction

Building structures in areas affected by underground mining demand specific treatment due to expected terrain deformation, special requirements mentioned also in CSN 730039 (2015). Terrain deformation comprises subsidence, declination, curvature, and horizontal deformation (**Figure 1**). The most demanding, and also most expensive, are requirements for terrain horizontal deformation. One of the reasons is that, through the friction between subsoil and foundations, the foundation structure must resist significant normal forces. The idea of sliding joints between subsoil and foundation structure, which eliminates the friction in footing bottom, comes from the 1970s (Balcarek and Bradac, 1982). In the beginning there were several materials considered (e.g., use of cardboard with ash, isinglass, graphite). Finally, the bitumen asphalt belt given its rheological properties has been proven as an effective material for sliding joints. When the terrain deformation velocity is low the shear resistance of bitumen asphalt belt is also low.

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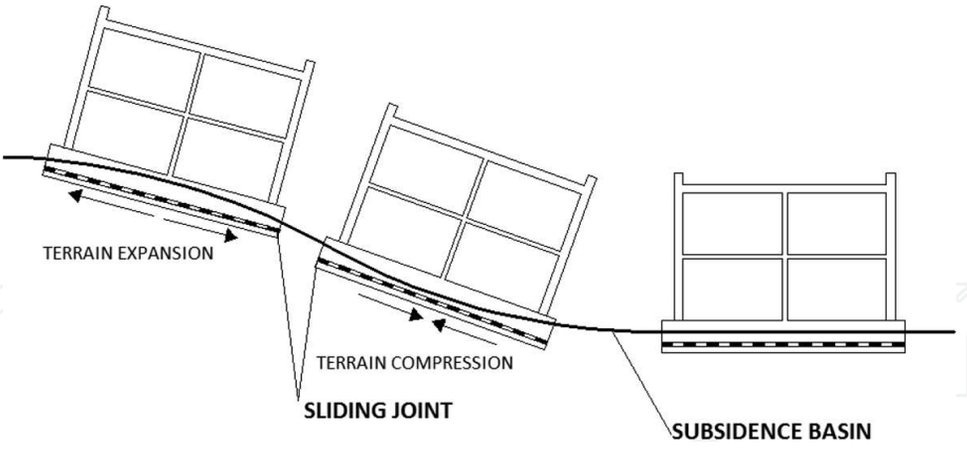


Figure 1. Horizontal terrain deformation on the margin of subsidence basin.

2. Sliding joint testing

2.1. Testing principle

When using asphalt belt as a sliding joint, the shear resistance is the main material characteristic. It was found out that the shear resistance of slide joints is primarily dependent on the deformation velocity. When the deformation velocity is slow the shear resistance of the bitumen sliding joint is low. The terrain deformation velocity could be estimated on the basis of exploitation plan.

However, testing of the shear resistance for particular deformation velocity is problematic. It was decided to appoint experimentally the deformation velocity for different shear stresses. Using linear regression, it is possible to appoint the shear resistance of a slide joint as a function of deformation rate.

Results of asphalt belt testing can be used also for parametrical subsoil model. On the basis of test results it is possible to appoint horizontal resistance with parameters C_{1x}, C_{1y}, analogically to vertical resistance C_{1z} defined in Winkler one parametrical model (Cajka[a,b], 2013).

2.2. Testing equipment

At VSB–Technical University of Ostrava unique equipment was designed for shear resistance testing (**Figure 2**). Experiments on testing equipment started in 2008 and have been in process continuously.

Asphalt belt specimens are placed in between concrete blocks with a dimension of 300 × 300 × 100 mm. Specimens are exposed to a vertical load. A horizontal load is applied after a one-day delay. Displacement of the middle concrete block is measured for 6 days, and sometimes also for more days.

The specimens were exposed to vertical load of 100 and 500 kPa, values that correspond with the expected stress in the footing bottom. The horizontal load is between 1.0 and 2.0 kN, such that the deformation velocity corresponds with expected terrain deformation velocity.

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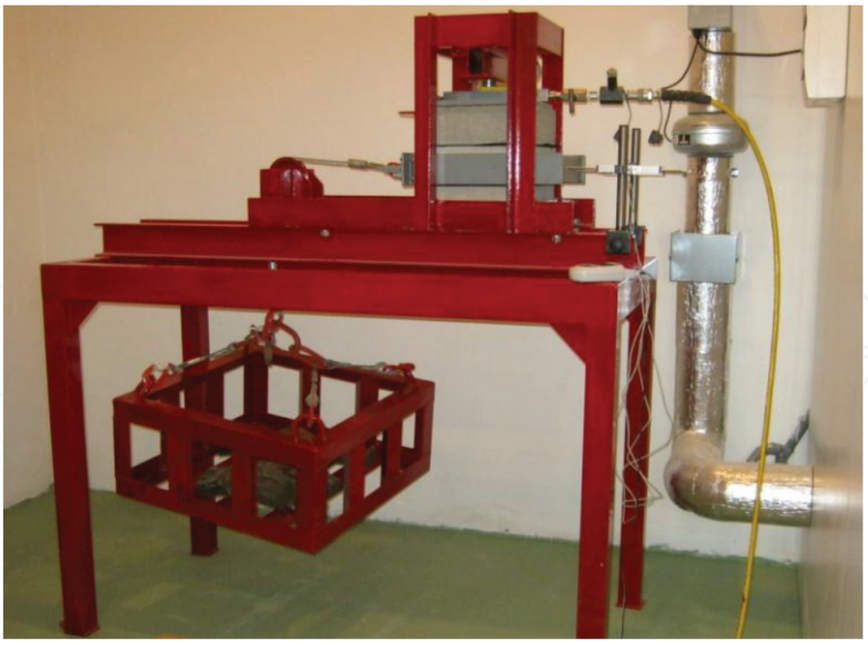


Figure 2. Testing equipment.

2.3. Testing the temperature dependence

One of the important factors that affect the rheological shear resistance of a sliding joint is temperature. For that reason, selected materials have been tested by dependence on temperature. The testing equipment was placed in a temperature-controlled room with limit from −20 to +40°C (**Figure 3**). The aim is to determine the slide joint shear resistance for temperatures expected in a footing bottom, more detailed description is presented in the paper of Cajka and Mateckova (2011).



Figure 3. Testing equipment in temperature controlled room.

3. Selected test results

3.1. Different types of asphalt belt

Primitive asphalt is refined with oxidization or modified with an admixture of polymers. Depending on the type of admixture polymer there are asphalt belts modified with rubber, usually styrene-butadiene-styrene (SBS asphalt) and thermoplastics, mostly amorphous polypropylene (APP asphalt). Oxidized and modified asphalts possess different temperature sensitivity, elasticity, and plasticity or adhesiveness also in correlation with the amount of admixture. Consequently, the asphalt belts show different rheological shear characteristics for the group of oxidized bitumen asphalt belts, SBS asphalt belts, and APP asphalt belts.

3.2. Oxidized and modified asphalt belt

Until now 14 types of different trademark bitumen asphalt belts have been tested within new testing since the year 2008. The thickness of asphalt belts is between 3 and 5 mm, and they are predominantly covered with mineral gritting. Four types were oxidized, nine types were SBS modified, and one type was APP modified. Specimens of APP modified asphalt belt were not available. Six types of asphalt belt were tested with dependence on temperature. Particular experiment results were published in few papers, such as Cajka et al. (2012), Cajka et al. (2011), Cajka and Manasek (2007), and Janulikova and Stara (2013).

Generally, tested SBS asphalt belts show higher deformation than oxidized asphalt belts. This finding is demonstrated in **Figure 4**, with two asphalt belts: an oxidized asphalt belt with a thickness of 3.5 mm with fine-grained mineral gritting, and a modified SBS asphalt belt with a thickness of 4.7 mm with a slate gritting. Nearly the same shape of chart is for the relative displacement in relation with the specimen thickness.

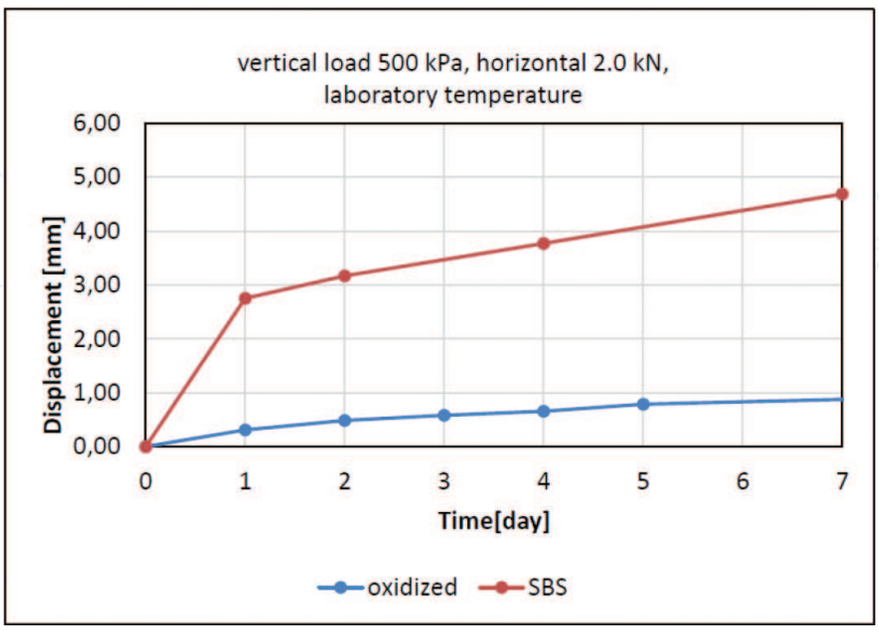


Figure 4. Experiment results, different types of asphalt belt.

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3.3. Temperature dependence

In **Figure 5**, test results of specimens made of oxidized asphalt belt exposed to various temperatures are presented. Higher temperature leads to higher deformation, both for the group of oxidized and SBS modified asphalt belts.

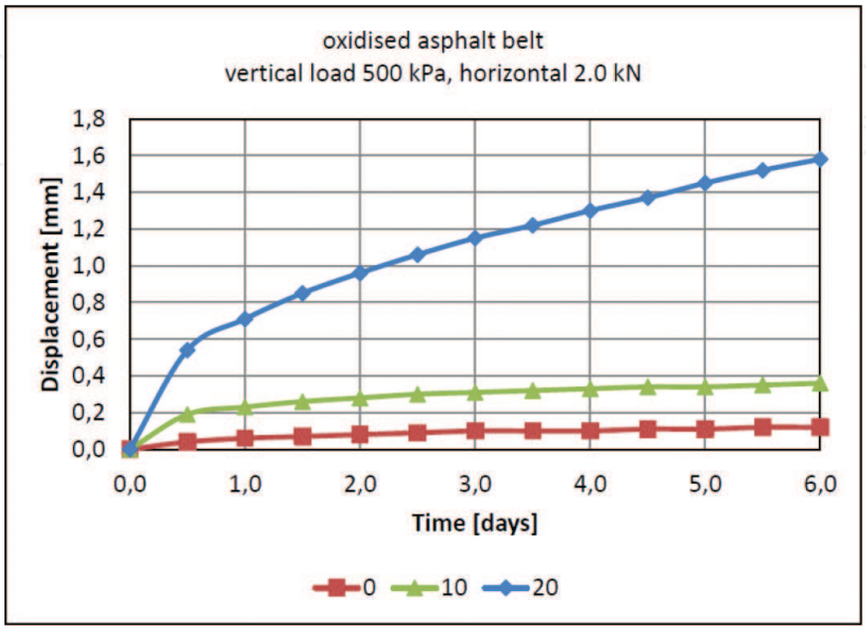


Figure 5. Experiment results, temperature dependence.

4. Sliding joint application

4.1. Complex of buildings: University of Ostrava

The new buildings of the Faculty of Science, University of Ostrava (**Figure 6**) are situated in an area with extremely unstable subsoil. The area is intersected with a tectonic fault activated by underground mining activity. Though the effects of undermining on the surface are gradually subsiding, in combination with tectonic fault and quicks and it could lead to significant subsoil deformation.

The entire design concept is adapted to extreme foundation conditions. The substructure is rigid slab-wall structure realized on a sliding joint made of SBS modified asphalt belt with a thickness 3.5 mm, reinforced with composite polyester fleece, without surface coating. Asphalt belt used at this building foundation was tested at VSB–Technical University of Ostrava.

4.2. Golf club building

A natural golf course was created in Czech Republic in the Moravian-Silesian Region (**Figure 7**). The territory is a protected coal deposit territory where mining is still in process and related phenomena occur actively on the surface. A load bearing structure is made of steel

and masonry. The entire design concept is adapted to undermining effects, e.g., building is divided into deformation units and rectification is possible. The structure is realized on a sliding joint consisting of two layers of SBS modified asphalt belt. More details are in the study of Cajka et al. (2014).



Figure 6. University of Ostrava Building, application of sliding joint.



Figure 7. Golf club building at undermined territory.

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5. Conclusion

The aim of the authors was to present possible protection of buildings affected with underground mining. Friction in footing bottom and consequent internal forces in foundation structure resulting from horizontal terrain deformation is possible to reduce with sliding joint made of asphalt belt.

Testing of asphalt belt sliding joint is presented in this chapter. Shear resistance test results for different types of asphalt belts are listed, and dependence on temperature is mentioned. Testing of sliding joints at Faculty of Civil Engineering, VSB–Technical University of Ostrava indicates better shear characteristics of SBS modified asphalt belts then oxidized asphalt belts.

Though the bitumen sliding joint was successfully applied in few buildings, sliding joints have not been widely used yet. Experiments should contribute to a wider utilization of bitumen sliding joint and thus enable design of more durable and sustainable building structures.

Acknowledgments

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