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Tensile Stress and Crack Elimination in Concrete Floors and Foundations

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ABSTRACT

Using the rheological sliding joint is effective method to decrease the friction between structure and subsoil. Convenient material for sliding joint is bitumen asphalt belt, given its rheological properties. Sliding joints were applied successfully on a few buildings in Czech Republic at the undermined area but the utilization is much wider, e.g. pre-stressed foundations, elimination of creep and shrinkage and thermal strain and others. At VSB ï TU Ostrava unique equipment was designed for sliding joint shear resistance testing. Experiments for different types of asphalt belts passed in 2008. One of the important factor which affect the shear resistance is the temperature and that is way the experiments continues with measuring the shear resistance of slide joint as a function of temperature in temperature controlled room. In the paper particular experiment results of temperature dependant shear resistance are presented and their utilization in soil-structure interaction analysis in concrete floor.

Keywords. Soil-structure interaction, concrete floor, creep, shrinkage, crack

INTRODUCTION

The idea of sliding joint comes from the area affected with underground mining, where terrain deformations are expected. Terrain deformation comprises subsidence, declination, curvature and also relative horizontal stretch and compression. In case of horizontal terrain deformation structure has to bear significant normal forces generated through friction between the foundation structure and the subsoil. The idea of sliding joint comes from the seventies of the last century and in the beginning several materials were considered. Finally bitumen asphalt belt, widely available and reasonably priced material, given its rheological properties has been proven as an effective material for sliding joints. When the deformation rate is slow the shear resistance is small.

Similarly it is possible to apply the sliding joint in concrete floors and pre-stressed foundations where horizontal deformations are expected due to pre-stressing, creep and shrinkage, Fig. 1. Though the bitumen sliding joint was successfully applied in a few buildings, sliding joints have not been widely used yet and ongoing experiments should contribute to a wider utilization of sliding joint.

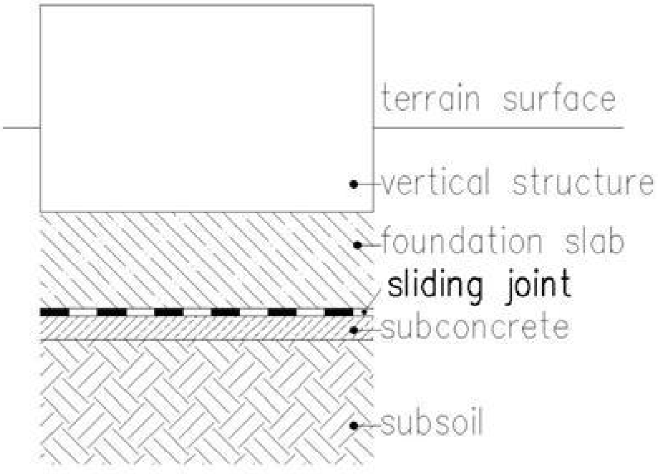

Figure 1. Schematic drawing of sliding joint

TESTING EQUIPMENT

The shear resistance of bitumen asphalt belt is primarily dependent on deformation rate. As the measurement of shear resistance for particular deformation rate is problematic, it was decided to appoint experimentally the deformation rate 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. One of the other significant factors which affect the slide joint shear resistance are the vertical load and the temperature.

At VSB ï Technical University of Ostrava unique equipment was designed for shear resistance testing, Fig. 2. Two asphalt specimens in between 3 concrete blocks are exposed to arbitrary vertical and horizontal forces. The deformation - displacement of middle concrete block is measured and deformation rate is derived.

Figure 2. Testing equipment and temperature controlled room

Experiments for different types of bitumen belts passed in 2008. Experiments were carried out only at laboratory temperature and the results could be found e.g. in (Cajka, 2007). This year the experiments continues with measuring the shear resistance of slide joint as a function of temperature in temperature controlled room, Fig.2 (Cajka et al, 2011).

The asphalt belts show different rheological shear characteristics for the group of oxidized bitumen asphalt belts, e.g. traditional asphalt belt modified with polymers, sample No.1, mentioned in this paper and asphalt belt modified with rubber, sample No.2. The shear resistance of asphalt belts modified with polymers is higher than that of traditional oxidised asphalt belt. The shear resistance of asphalt belts modified with rubber is lower than that of oxidised asphalt belt (Cajka et al, 2007, 2012).

PARTICULAR TEST RESULTS

In this paper particular results of asphalt belt modified with polymers (sample 1) are presented. This asphalt belt is modified with polymers and was chosen for testing because it was used as sliding joint in building of University of Ostrava at undermined area (Mateckova et al, 2012).

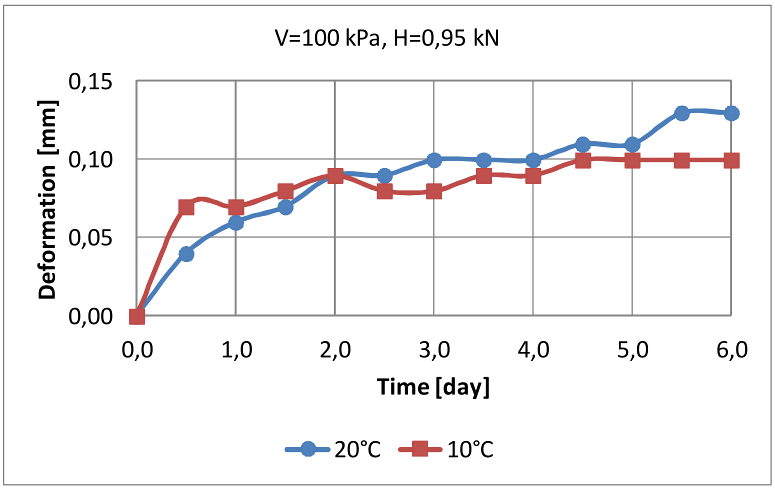

Figure 3. Sample No. 1, influence of temperature, vertical load 100 kPa, horizontal force 0.95 kN

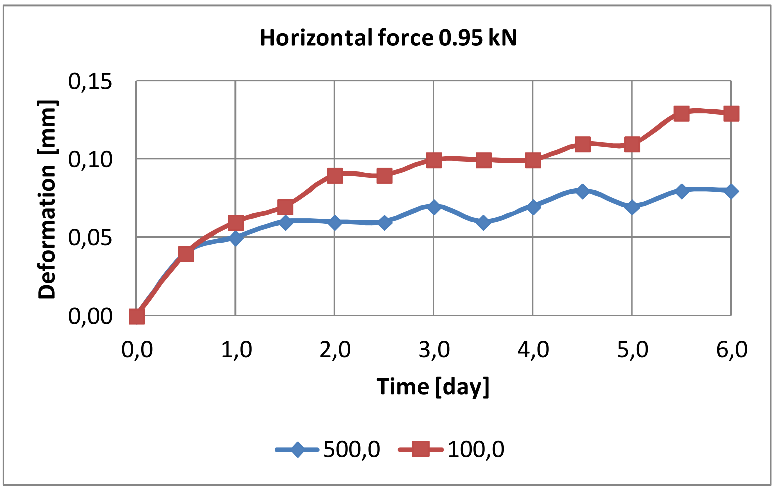

Figure 4. Sample No. 1, influence of vertical load, temperature 20°C

Influence of temperature. Test results affirmed influence of temperature to specimen displacement and consequently shear resistance. Temperature controlled room enable measurement in the range from -20°C to +40°C, however displacements measured for temperatures 0°C and -10°C are on the border of potentiometers accuracy. In this paper the test results for temperature 10°C and 20°C are presented which represent the laboratory temperature and the temperature expected in footing bottom. In the Fig. 3 there are test results for specimens exposed to vertical load 100 kPa and horizontal force 0.95 kN, more in (Cajka et al, 2011).

Influence of vertical load. In the Fig. 4 there is chart with test results, where the influence of vertical load is illustrated. Displacements are presented for specimens exposed to vertical load 100 kPa and 500 kPa, horizontal load is 0.95 kN, temperature 20°C.

APPLICATION

Sliding joint shear resistance. In the charts, Fig. 3 and Fig. 4 it is possible to mention that after one day the deformation increment became nearly steady. This fact was also proven with a few experiments which lasted 13 days. Steady deformation rate for horizontal force 0.95 kN (shear stress 5.28 kPa) and horizontal force 2.0 kN (shear stress 11.11 kPa), for the temperature 10°C, which represents the temperature in footing bottom and vertical load 100 kPa is in the Fig. 5. Analogously it is possible to derive other functions and charts.

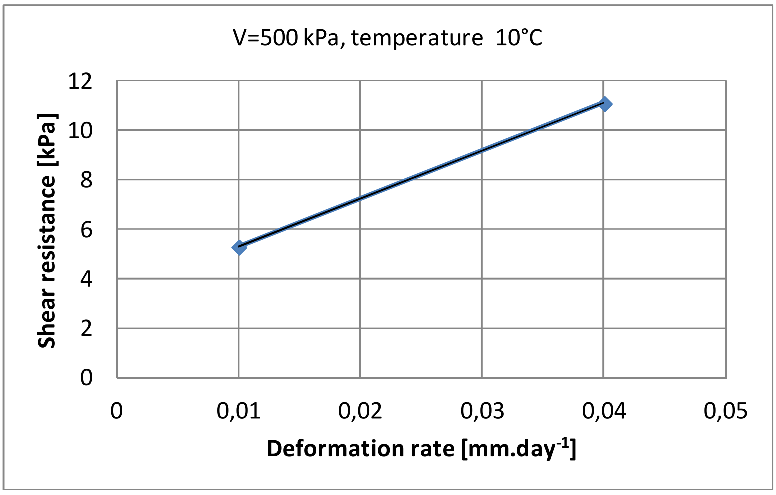

Figure 5. Shear stress as a function of deformation rate for the temperature 10°C and vertical load 100 kPa

Expected deformation rate. Total shrinkage in first 28 days for relative humidity 80% according to Eurocode is approximately ε_{cs} = 400.10^{-6}. Displacement of concrete floor or foundation depends on size of dilatation units or alternatively on the distance between cut shrinkage joints in concrete floors. Displacement and consequently displacement rate is determined for particular coordinate of dilatation unit. In the chart, Fig. 5 it is possible to appoint the slide joint shear resistance for the particular deformation rate. In the Table 1 there are shear stresses in sliding joint appointed for different displacement rate. On the basis of calculated normal forces it is possible to modify size of dilatation unit or distance between shrinkage joints in concrete floors.

Table 1. Shear stresses in sliding joint for different dilatation units

Size of dilatation unite Distance between shrinkage joints	L	Displacement on the edge of foundation	u	Displacement rate on the edge of foundation	v_1	v_2	Shear stress in sliding joint	τ_{SJ}
	m		m		mm.day^{-1}	m.s^{-1}		kPa
	5.00		0.001		0.036	4.13E-10		10.28
	10.00		0.002		0.071	8.27E-10		17.22
	15.00		0.003		0.107	1.24E-09		24.16
	20.00		0.004		0.143	1.65E-09		31.10
	25.00		0.005		0.179	2.07E-09		38.04
	30.00		0.006		0.214	2.48E-09		44.98

Soil-structure interaction. Authors have been interested in soil-structure interaction analysis in areas with the danger of floods where the terrain deformations are expected, (Cajka et al, 2005), (Cajka, 2005). On the basis of test results it is possible to derive the shear parameters C_x (C_y) analogically to parameter C_z for one parametrical nonlinear Winkler subsoil model, Fig. 6. In simplified analysis the shear parameter could be stated as constant, for detailed analysis it is necessary to appoint the parameter C_x (C_y) as a function of coordinate of the foundation structure. Shear parameters could be used in commercial FEM software, more details in (Cajka et al., 2011), (Cajka, 2012).

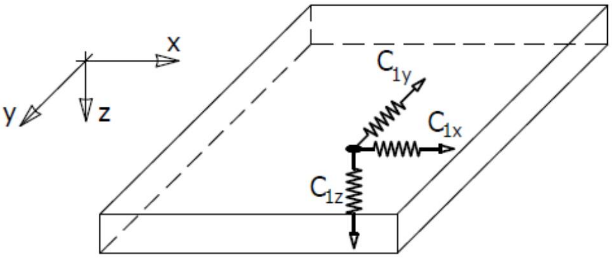

Figure 6. Scheme of parameters C_z, C_x, C_y

CONCLUSION

In the paper experimental testing of shear resistance of bitumen asphalt belt modified with polymers, sample No.1, is presented. Bitumen asphalt belt is used as sliding joint when the horizontal deformation of subsoil or foundation structure is expected. The shear resistance depends on the deformation rate, temperature and vertical load. In the paper simple example of shear resistance calculation is presented for different dilatation units or distances between cut shrinkage joints. With more measured data the stochastic analysis of failure is possible (Sejnoha et al., 2007) or vibrations of structures decrease (Kalab et al., 2012).

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