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Road and Rail Infrastructure V

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TESTING OF BITUMINOUS PAVEMENT LAYERS REINFORCED WITH FIBERGLASS GRIDS

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Abstract

The usage of fiberglass grids in asphalt layers helps to restrain the crack propagation and thus can significantly improve pavement life time. The grids can be used in both new road constructions with decreased asphalt layer thickness and in road rehabilitations, respectively. Further, it can be used to decrease the road failure caused by settling of pavement construction in outer vehicle path of strengthened and widened old secondary road, which is a frequent type of pavement failure in the Czech Republic. However, the testing methods for evaluating grid effect and its bond condition to the surrounding asphalt layers differ. This paper presents the specimen preparation, specimen quality test and results of the four-point bending creep test performed on reinforced asphalt beams. The results are then compared with specimens without a fiberglass grid. The possible modes of failure are described and discussed. The test arrangement and loading procedure was adopted from the American standard ASTM D7460, where the specimens are loaded by a constant force and mildly oscillated. However, the four-point bending test cannot properly describe the real behaviour of fiberglass grid and asphalt in real road construction. The paper therefore mentions also an alternative test arrangement for better modelling and understanding of the grid contribution to the pavement.

Keywords: asphalt, bending test, glass grid, reinforcement, pavement

1 Introduction

The usage of reinforcing materials in asphalt layers began in the ‘60s when the first tests were carried out in the United States. Back then, it was common to use reinforcing grids made of steel. Despite the initial problems, practical tests were during the ‘70s and ‘80s also carried out in the Netherlands. The most important aspect was to define the installation process in terms of reliability and accuracy and to ensure an adequate bond of the grid and the base layer. As the technology progressed, different materials were put to use, among them propylene, polyester and fiberglass. Eventually, it turned out that using reinforcing geosynthetic materials is particularly beneficial for reconstructing existing asphalt pavements as it can notably reduce reflective cracking. The use of geosynthetics also significantly reduces costs of large-scale repair projects of asphalt surfaces. Currently, investors and road network administrators in the Netherlands and Germany derive benefit from such approach, [1].
To make proper use of these geosynthetic elements, one needs to not only have considerable knowledge and understanding of the basic principles of their performance within the road structure, but also needs to comply with the specific rules of the so-called “proper technology implementation”. On that account, several professional associations supporting the industry were founded, among them “The Industrial Fabrics Association” [2] and more detail-focused

"The Geosynthetic Materials Association" [3], providing engineering, trade, educational and expert support for those working with geosynthetic materials. After all, accurate installation at the actual construction site is crucial for obtaining satisfactory results. Unfortunately, investors often regard geosynthetics as an unnecessary expense with no substantial benefit.
Nowadays, there is a number of industrially manufactured products ready to be incorporated into the road structure. Their common characteristics can be generally described as follows: "Those are the products being used in road construction so as to improve the properties of any unbound base course, asphalt base course or asphalt wearing course by functionally reinforcing it, by dissipating or potentially loosening the stress caused by the traffic load, or by creating a separation layer" [4].
This paper deals with the use of fiberglass grids in between the asphalt layers and evaluates its effect on the reinforcing of the asphalt layer. As a part of the research project TH01011292 [5] of the Technology Agency of the Czech Republic, a reinforced complex of layers was tested in the laboratory. It comprised of two asphalt layers and one interlayer made of varied fiberglass grids. The testing was done by means of the four-point bending creep test.

2 The influence of fiberglass on the propagation of reflective cracking

The main function of reinforcing materials is to dissipate the stress imposed on a road due to traffic load, but also to prevent the occurrence of critical deformations and failures. Reflective cracks originate in the construction layers under the asphalt layer towards which they propagate in time.
According to [6], the cracks propagate approximately 2 – 3 centimeters per year, depending on the traffic load and weather conditions. It can thus be concluded that should the cracks be covered by a 5-centimeter thick layer of regular asphalt, they would appear on the surface as early as in approximately two years. Nonetheless, if there is a reinforcing grid used as an interlayer, the process can be significantly delayed. Figure 1 shows how the crack propagation differs with and without the reinforcing grid.

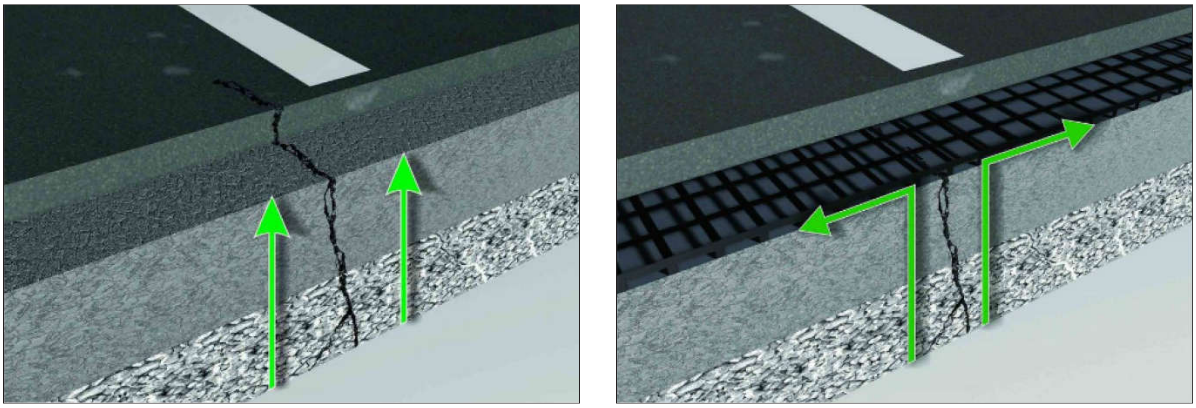

Figure 1 The influence of reinforcing grid on reduction of crack propagation [7]

3 Test specimens

The specimens took shape of asphalt slabs and were made of an asphalt mixture of the commonly used type, asphalt concrete for asphalt wearing course (ACO 11).
Further, a fiberglass reinforcement grid was used. Grid with opening size of 25 mm x 25 mm, 115 ± 15 kN tensile strength per m of grids in both direction. Glass fibres of the grid are coated by a thick film of pressure sensitive polymer, that prevents glass fibre damage during trafficking and asphalt layers compaction. The coating ensures better adhesion of the reinforcing element and the asphalt layers and thus increases the compatibility of the two materials.

An optimal positioning of the reinforcing element in the road structure is important for increasing the resistance to fatigue. In terms of fatigue cracking, the optimal position is in the bottom part of the asphalt layers.
The test slabs were made using segment compactor in accordance with EN 12967-33 [8]. The slabs consist of two layers of asphalt concrete used for wearing course. The layers were compacted to the required compaction ratio of 100 ± 1 %. At first the bottom layer was made of dimensions 500 x 300 x 50 mm. The grid was installed on the slab surface and pressure sensitive adhesive backing of the grid helps correct instalation. Subsequently, the cationic emulsion was applied on top of layer. The second asphalt layer was placed and compacted. The thickness of the second layer was 40 mm. Three (65 mm wide) or two (125 mm wide) testing beams were cut from each slab. The length of the beams was 381 mm. The thickness of the beam was 50.8 mm, thickness of the upper layer 30.4 mm and the thickness of the bottom layer 20.4 mm. The fiberglass grid is placed in between the layers symmetrically to the longitudinal axis of the beam.

4 Methods

4.1 Four-point bending creep test

To assess fatigue-related properties of an asphalt mixture, the cyclic four-point creep bending test is commonly used. The loading procedure was set in accordance to the American standard ASTM 7460 [9]. This enables a comparison of the results to the results obtained by other laboratories. The testing beams were loaded by 350 N, which oscillate with amplitude 40 N for 65 mm wide beam and loading by 700 N with amplitude 80 N for 125 mm vide beam. The test was terminated when the deflection (measured in loading points) reached 30 mm or when the beam was broken. The temperature of the test was 18 ± 0.5 °C. The beams had been tempered to the required temperature for at least 4 hours. Figure 2 (on the left) shows the above-mentioned test.

4.2 Bond condition test

The Leutner shear test, performed in accordance with the ČSN 73 6160 [10], was used to assess the bond condition between the layers. The test is performed on a core sample by applying shear force at the interface between two layers while sheared at a controlled rate (Figure 2, on the right). The maximum shear load at the interface is used to assess the quality of the layer bonding. ČSN 73 6121 [11] demands minimum power 15 kN in case of core in diameter 150 mm.

Figure 2 Four-point bending test arrangement (on the left) and Bond condition test (on the right)

5 Results and discussion

5.1 Four-point bending creep test

Figure 3 shows the specimen after the test. Various failure modes of the specimen occurred even in one test series as can be seen in Figure 3. The typical one is a formation of a bending cracks which propagates upwards (to the grid). The grid then prevents the crack propagation (Figure 4, upper specimen) or the crack slowly propagates through the grid upwards, but the specimen resists the load (Figure 4, middle specimen). Other failure mode is a longitudinal slip caused by insufficient strength of the bond between layers. If the grid stays fixed to the upper layer, the specimen withstands the load (Figure 4, lower specimen). If the grid stays fixed to the lower layer, the specimen breaks. Figure 5 shows the unreinforced specimen after test.

Figure 3 Example of the reinforced specimen after the test

Figure 4 Examples of failure modes of the reinforced specimens

Figure 5 Example of the unreinforced specimen after the test

The main parameter to compare the results is the time when the stiffness of the specimen changes and the grid is supposed to be more activated. This point is determined as the mid-point between two tangents from the chart in log scale [12]. However, the result variance is relatively high (22003 ± 9602 cycles), as can be seen in Figure 6. Several series of test specimens without fiberglass grids were also performed, and the results are shown in the last column of this chart.

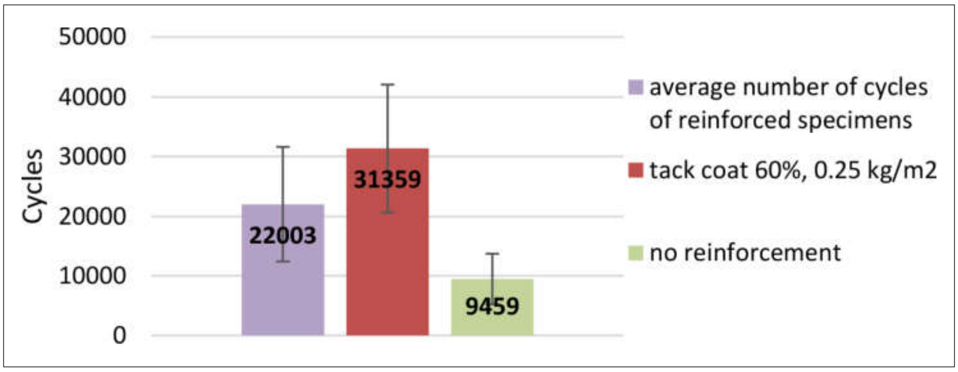

Figure 6 Comparison of test results obtained by tangent method for various tack coats

5.2 Layer bond

The testing of the layer bond was performed on 2 asphalt slabs – with and without the reinforcing grid. In both cases, the bond was ensured with cationic bitumen emulsion with 60 % of bitumen tack coat. Each series comprised of three testing specimens (core samples). The following Table 1 shows the average results of the testing. Figure 7 shows the distressed specimen after the testing was performed.

Table 1 Bond condition test results

Type of reinforcement	The amount of tack coat [kg/m²]	Deformation [mm]	Measured shear load [kN]	Minimum required shear load [kN] by [11]
No grid included	0,25	1,1	26,9	15
Reinforcing grid included	0,25	0,86	21,6	

Figure 7 Test specimen reinforced by fiberglass grid after the bond condition test

Table 1 shows that using the reinforcing fiberglass grid caused only a slight decrease in shear load describing the bond condition of the layers. The measured shear load on the reinforced specimens, however, remains above the required minimum as per [11]. It can be thus deduced that the asphalt slab reinforced by the fiberglass grid fully meets the requirements set for the layer bond.

6 Conclusions

The testing of asphalt beams by means of the four-point bending creep test enables the comparison of results with various type of fibreglass grids and represents a method to evaluate the contribution of the fiberglass grid to the mechanical load bearing capacity of the structure. An accurate fiberglass geogrids installation is crucial for achieving the good results in the pavement. The variation of the tack coat is the subject of further research.

The specimens tested in the four-point bending creep test showed various failure modes, which is usually caused by bending, longitudinal shear or by a combination of those.

The fatigue cracking in the reinforced specimens occurred in the bottom layer, where the tensile stress reaches its maximum. The crack propagation into the upper layer occurred very rarely. By contrast, the specimens that were not reinforced showed a singular failure where crack propagated through whole height of the specimen. Such situation reflects the benefit of the reinforcement in the asphalt layers on the final structure life time.

The tests showed that the reinforcement layers resisted to the maximum measured deflection of the beam up to 30 mm, while the beam without fiberglass grid was broken at one third of this value. The beam deflection under loading increased more slowly as the fiberglass grid was activated. The loading time to breakdown or to the total deflection of test beam up to 30 mm was several times longer than loading time of the beams without reinforcement.

The disadvantage of the four-point bending creep test in this arrangement is the high variance of results and the fact that it does not fully represent the real situations in the road structure. On that account, different types of test are under development, being a combination of bending and shear loading tests created to simulate the real situation in the case of strengthening and widening of narrow pavement structure and strengthening of pavement with wide transverse cracks.

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