Lifetime extension of reconstructed asphalt pavements by using geosynthetic interlayers: effectiveness of an innovative combined system

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ABSTRACT:
The reconstruction of cracked paved roads is a challenge for all who have to service such roads. For several years there is another option to reconstruct cracked paved roads by using asphalt interlayer instead of a complete new buildup. Asphalt interlayers are available in three different types: asphalt grids, nonwovens and combinations of grid a nonwoven. All three share the same goal: to prevent or reduce reflective cracking in paved roads. To investigate the performance of miscellaneous asphalt interlayer a comprehensive research program with eleven different asphalt interlayers (grid, nonwoven, combined) was carried out. The investigation included the influence of asphalt interlayer onto the bonding through large scale shear tests and the ability to reduce reflective cracking in cyclic bending tests.

1 INTRODUCTION

The available asphalt reinforcements can be divided into three categories. There are nonwovens, grids and combined products where a nonwoven of different grammage is applied to a grid. Nonwovens are mostly used as sealing and stress absorbing interlayer (SAMI) while asphalt grids are used to absorb tensile stresses. For combined products it is assumed that they will combine the mode of action of grids and nonwovens.

From long term in-situ experiences it is known that asphalt interlayer are able to extend the lifetime of reconstructed asphalt roads, if the right type of asphalt interlayer is chosen for the conditions the specific road is subjected to. Also the installation must be done in the correct way.

In the following a comprehensive research program is described which goal it was to determine the effectiveness of eleven different asphalt interlayer under cyclic bending.

2 TEST SAMPLES

The necessary test samples for the research program (interlayer 1 to 8 and the unreinforced references) are taken from an especially build test road (35 m long and 2.5 m wide). The buildup of the road is analog to the BK III RStO 2004 (german standard for road construction). In difference to BK III the base course for the samples is only 6 cm instead of 14 cm. Because the base course is nearly cut through for the bending tests, the thickness of the base course has no major influence onto the results of the tests. The interlayers were installed between the base course and the binder course which leads to a covering of 8 cm. The minimum coverage of the installed interlayer varies between 2 cm and 6 cm. The installation was done by hand according to the instructions provided by the manufacturer for each interlayer. The used bitumen emulsion was a polymer modified U60k Pmb, the amount of bitumen emulsion corresponded to the particular installation instructions.

After the test road was completely cooled down, the road was cut into pieces of 90 cm x 30 cm edge length. Afterwards the pieces were shipped to Institute of geotechnical engineering and mine surveying, Clausthal Technical University where the samples were trimmed to the final dimensions of 30 cm x 30 cm edge length.

This kind of sample preparation allows getting a large number of samples in an economic way, further more the samples were treated like installed on a construction site. (Meyer, Nernheim, Tazl (2007))

Later on three more asphalt interlayers (interlayer 9 to 11) were included in the research program. For these three types of interlayer, the test samples were built in laboratory. The laboratory built samples have been built up in a mould by compacting every layer to 100% Marshall Density. In difference to the construction site, the layers in laboratory has been build up “hot in hot”, the interlayer hasn’t been treated by a paver and the amount of bitumen emulsion has been applied very exactly. Because of the mentioned differences a comparison of laboratory-build and construction-site-build samples are not fully comparable. For this reason in the following the two sample types have to be observed separately.

Table 1. Used identifiers for bonding and bending test samples

	Identifiers for bonding tests: E.X (e.g. E.4)	Identifiers for bending tests: Interlayer X (e.g.: Interlayer 4)
Asphalt grids	1, 2, 3, 9, 10	1, 2, 3, 9, 10
Nonwovens	4, 8	4, 8
Combined Products	5, 6, 7, 11	5, 6, 7, 11

3 BONDING

The bonding between the different asphalt layers is very important for the lifetime behavior and the maximum bearing capacity of asphalt roads. Bonding here means the shear resistance in the interface area between two layers of asphalt, e.g. between base course and binder course, under horizontal loading. The bonding depends on surface finish, the adhesion between the layers and the axial stress in the shearing area.

The using of asphalt interlayers may affect the bonding between two layers of asphalt. By using a nonwoven for a SAMI, reducing the bonding is part of the mode of action. The reduced bonding e.g. is useful in case of temperature induced horizontal stresses (e.g. asphalt layer over concrete slabs). (De Bondt, A. H.; Scarpas, A (1996); De Visscher, J. et al. (2003))

3.1 *Test procedure*

To determine the influence of every of the eleven interlayer onto the shear resistance/bonding large scale shear tests were carried out. The sample dimensions were 30 cm x 30 cm. Leutner shear tests (fast shear test on drill cores, diameter 15 cm) were not carried out, because a shear load in the interface area during drilling cannot be eliminated. Further more local imperfections and positions of grid nods are less carrying authority. The tests were carried out at a constant temperature of 20 °C and a shear rate of 2 mm/Min. The shear plane is arranged that it is congruent to the interlayer plane. For the unreinforced samples, the shear plane is arranged in the interface plane of the base and binder course.

3.2 *Influence of incorrect amount of bitumen emulsion*

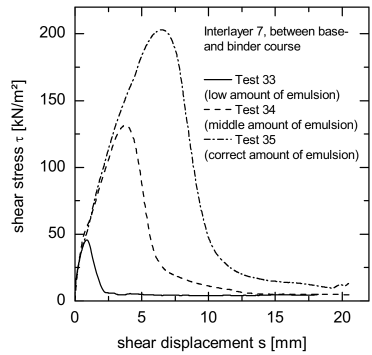

Figure 1 Influence of three different emulsion amounts onto the maximum shear resistance

As known from many cases of damage when asphalt interlayers were used, the correct amount of bitumen emulsion is very important for the success of asphalt interlayers. An incorrect amount of bitumen emulsion will affect the bonding. For this reason tests with a varied amount of bitumen emulsion for the same interlayer were carried out. Figure 1 shows, that between the lowest and the correct amount of bitumen emulsion the maximum shear resistance varies by nearly 400%. On the other hand, too much bitumen emulsion may lead to bleeding and reduces the maximum shear resistance. This is especially important for asphalt grids, which need a good bonding to the asphalt to be able to absorb the tensile stresses.

3.3 *Results of the bonding tests*

The main intention for carrying out so much bonding tests was to quantify how much the different asphalt interlayer will influence the boding. Therefore a so called ***efficiency*** is defined as the ratio between the shear resistance of unreinforced and a reinforced sample.

$$Efficiency = \frac{\tau_{\text{max, interlayer}}}{\tau_{\text{max, reference}}}$$

Figure 2 shows that the efficiency of the investigated asphalt interlayer varies for different shear displacements from 40% to 200%. The variation of the results for the same interlayer in different tests is caused by the inhomogeneity of the asphalt and the slightly varying amount of bitumen emulsion for different samples.

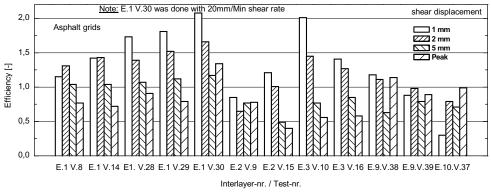

Figure 2 Efficiency of different grids compared to unreinforced samples

Apparently the open structure of asphalt grids allows a good interlocking of the asphalt layers through the asphalt grid. Furthermore it is noticeable that for smaller shear displacements there is higher shear resistance compared to unreinforced samples at the same shear displacement.

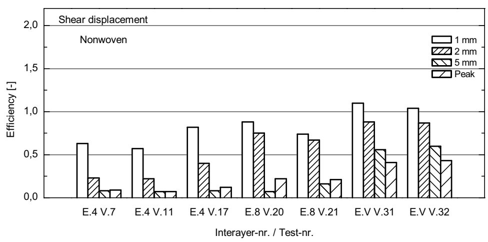

Figure 3 Efficiency of different nonwovens compared to unreinforced samples

Compared to asphalt grids, nonwovens show for all shear displacements a lower shear resistance. For small displacements the may reach an efficiency of 100%. For nonwovens the reduced shear resistance is part of their mode of action (cf. SAMI).

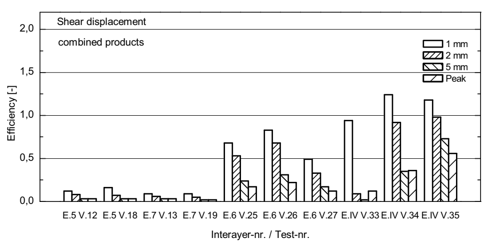

Figure 4 Efficiency of different combined products compared to unreinforced samples

The efficiencies found for combined products are highly varying. Probably V12, V13, V18 and V19 didn't get enough bitumen emulsion, so the bonding is substandard because test V33 to V35 (same interlayer as V12 and V18) do show a significantly better efficiency. This shows again how important the correct amount auf bitumen emulsion is for an appropriate bonding.

3.4 *Bonding test conclusion*

The results of the bonding tests are showing typical efficiencies for the three types of asphalt interlayer. Asphalt grids, while installed correctly and for small displacements (max 3 mm), have no negative influence on the bonding. For larger displacements there is a reduced efficiency. Nonwovens and combined products on the other hand are showing, as expected, a reduced efficiency. Only for very small displacements of circa 1 mm efficiencies from 70% to 100% can be seen. The conducted bonding tests are showing how sensible bonding is to the correct amount of bitumen emulsion for the installed interlayer.

4 CYCLIC BENDING TESTS

To investigate influence of different kinds of asphalt interlayer on reflection cracking, subsequent to the bonding tests, cyclic bending tests were carried out. The samples for the cyclic bending tests had the dimensions 30 x 30 x 14 cm.

4.1 *Test procedure*

To simulate a reflection cracking the base course of the samples got a 5 mm wide gap. In the vertical there is appr. 5 – 10 mm base course left. The gap is simulating the cracked base course which is reconstructed with asphalt interlayer.

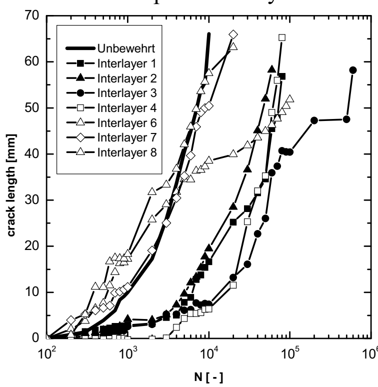

Figure 5 Comparison of crack lengths under 8 kN cyclic load (construction site samples)

For all tests the temperature was 20 °C, the cyclic load of 8 kN was applied by a frequency of 1 Hz. For technical reasons a minimum load of 1 kN was necessary, so the resulting load amplitude is 7 kN. The used elastic foundation guarantees a vertical deformation of 1 mm under maximum load. The crack development was observed by measuring the crack mouth opening (CMOD) (continuously) and crack length (optical, post processing).

For all interlayer a satisfying repeatability was found, so. that the following graphs only show the averages of multiple tests (same interlayer.

As can be seen in Figure 5, a distinct reduction of reflective cracking can be observed for asphalt grid interlayers (Interlayer 1 to 3). Nonwovens and combined products don’t show a significant reduction of the reflective cracking in the conducted bending tests.

4.2 *Results of cyclic bending tests*

Figure 6 shows the results for the laboratory built samples. Compared to the construction site samples, the laboratory ones are showing a once more better reduction of reflective cracking by the asphalt grids. Also the combined product “Interlayer 11” shows a performance comparable to the asphalt grids. Interlayer 11 has, in contrast to the other combined products, a distinct 3D structure what maybe allows some kind of interlocking to one of the asphalt layers. The reason for the all over better performance of laboratory built samples is most likely the way of production.

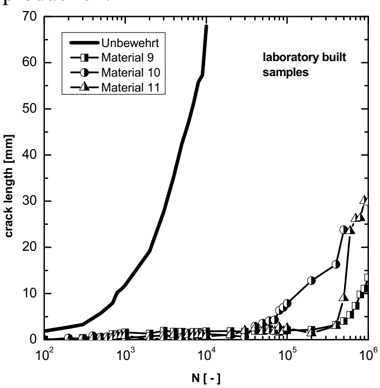

Figure 6 Comparison of crack lengths under 8 kN cyclic load (laboratory samples)

A comparison of the cyclic bending test results and the observed bonding efficiencies shows that with increasing bonding efficiency the ability of crack reduction is also increasing. (Figure 7)

5 CONCLUSION

A large number of tests with 11 different interlayers were carried out to determine the influence on bonding and reduction of reflective cracking. The results show the sensibility to the correct amount of bitumen emulsion while installation. Furthermore it can be seen that large displacements also reduces the bonding. In addition the comparison of the cyclic bending test and bonding test results reveal a close dependency between bonding and reduction of reflective cracking. Zielinski (2008) also found that dependency in his researches.

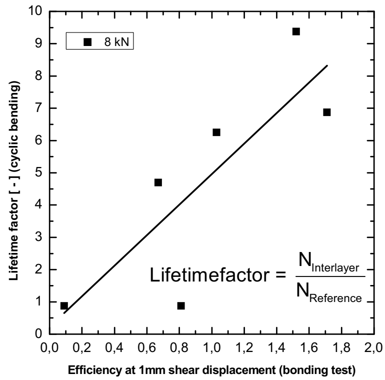

Figure 7 Influence of the bonding onto the reduction of reflective cracking

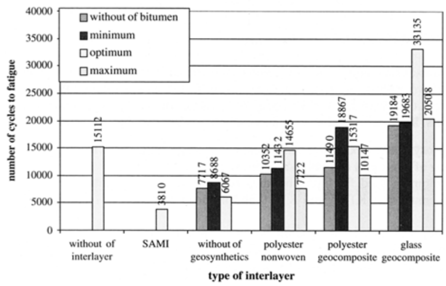

Figure 8 Influence of the bitumen amount onto the lifetime. (T=10 °C, asphalt concrete 0/12.8 mm (Zielinski, P.; 2008))

Finally it can be concluded that asphalt interlayer are able to reduce reflective cracking in paved roads. It also can be found that for using asphalt interlayers a particular accuracy while installing is necessary (FGSV 2006). The asphalt interlayer should be chosen according to the mechanism of damage.

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