Influence of installation damage on the tensile strength of asphalt reinforcement products

Influence de l'endommagement de mise en place sur la traction des produits de renforcement en asphalte

Sakou Touole L., Thesseling B.
Huesker Synthetic GmbH, Gescher, Germany

ABSTRACT: One of the major problems associated with the use of asphaltic pavements is reflective cracking. This phenomenon is commonly defined as the propagation of cracks from an existing pavement or base course into and through a new asphalt overlay, resulting from load- and/or temperature-induced stresses. One of the proven techniques to reduce/delay reflective cracking is the use of asphalt reinforcement. The properties of asphalt reinforcement (e.g. tensile strength, tensile strain) are influenced during the paving and compaction procedures of the asphalt. The loss of tensile strength during those procedures is known as installation damage. The degree of installation damage largely depends on the raw material used, the number of passes of trucks and compactors. There is currently a lack of experience and knowledge concerning the real residual properties (what could be termed "effective tensile strength") of asphalt reinforcement products after the paving and compaction procedures. This paper describes a test procedure developed at the University of Aachen. The research illustrates a considerable difference in loss of tensile strength, due to the effects of installation damage.

RÉSUMÉ : Un des problèmes majeurs liés à l'utilisation d'asphalte pour les chaussées est la fissuration réflective. Ce phénomène est défini comme la propagation des fissures à partir de la couche d´usure ou de base existante à travers la nouvelle couche d´usure d'asphalte, résultant des contraintes induites par le trafic et/ou la température. Une des techniques prouvées pour réduire/retarder la fissuration réflective est l'utilisation d'armature d'asphalte. Les propriétés de l´armature d'asphalte (notamment résistance à la traction, allongement à la rupture) sont influencées durant la pose et le compactage de l'asphalte. La perte de résistance à la traction lors de ces procédures, connue sous le terme «Endommagement mécanique», dépend en grande partie de la matière première utilisée, du nombre de passage de camions et compacteurs. Il existe actuellement un manque d'expérience et de connaissances concernant les propriétés réelles résiduelles «résistance à la traction efficace» des produits d´armature d'asphalte après la pose et le compactage de l´asphalte. Le présent article décrit la méthode d'essai développée à l'Université de Aachen. La recherche révèle une différence notable de perte de résistance à la traction, en raison des effets des endommagements mécaniques.

KEYWORD: installation damage, asphalt reinforcement, effective tensile strength

MOTS-CLÉS : Endommagement mécanique, Armature d´asphalte, résistance à la traction efficace

1 INTRODUCTION

It is well known that cracks appear due to external forces, such as traffic loads and temperature variations. The temperature influence leads to the binder content in the asphalt becoming brittle; cracking starts at the top of a pavement and propagates down (top-down cracking). On the other hand, high stresses at the bottom of a pavement, from external dynamic loads, such as traffic, lead to cracks that propagate from the bottom to the top of a pavement (bottom-up cracking).

A conventional rehabilitation of a cracked pavement involves milling off the existing top layer and installing a new asphalt course, but cracks are still present in the existing (old) asphalt layers. As a result of stress concentrations at the crack tips caused by external forces from traffic and natural temperature variations, the cracks will propagate rapidly to the top of the rehabilitated pavement.

Deteriorated concrete pavements are typically rehabilitated by installing new asphalt layers over the old concrete slabs. Temperature variations lead to a rapid crack propagation especially at the expansion joints to the top of the new asphalt overlay.

Asphalt reinforcement has been used worldwide for many years to delay or even prevent the development of those reflective cracks in asphalt layers. Currently there are a number of different asphalt reinforcement and systems made of different raw materials (e.g. polyester, fiberglass, carbon fiber, polypropylene...) available in the market. It is not disputed that each of these systems has a positive effect in the battle against reflective cracking; however there are differences concerning the real residual properties "effective tensile strength" of each asphalt reinforcement after the paving installation procedure.

The properties of asphalt reinforcement (e.g. tensile strength, tensile strain) are influenced during their installation, the paving procedure (paver and truck passes) and the compaction of the asphalt (Figure 1). The result, specifically the loss of tensile strength of the asphalt reinforcement grid during the paving procedure, is known as installation damage.

After an asphalt reinforcement product is placed, many asphalt delivery trucks have to pass over the grid. Additionally there is the compaction of the hot mix asphalt, during which the individual filaments or strands of the asphalt reinforcement are largely influenced by the movement of aggregates, in particular of coarse and sharp-edged aggregates. Next to the reinforcement characteristics (flexible or brittle raw materials), the degree of installation damage by roller compaction not only depends on the number of passes and the type of compaction (e.g. rubber tired, static, dynamic), but the weight of the compactor and the condition of the base layer (e.g. smooth, rough/milled) as well.

To successfully counteract reflective cracking, installed reinforcement products must resist the installation influences without damage and without significant loss of strength.
There is currently a lack of experience and knowledge concerning the real residual properties "effective tensile strength" of asphalt reinforcement products following their installation and the subsequent paving installation procedure.

In the context of a diploma thesis at the RWTH Aachen University, a test procedure to describe installation damage was developed. One of the aims was to analyze and quantify the "effective tensile strength" for two different asphalt reinforcement products with different raw materials (polyester and fiberglass) after the influence of installation damage.

Figure 1: Influences on asphalt reinforcement products during the asphalt installation

2 INVESTIGATION AT THE RWTH AACHEN UNIVERSITY

As part of the work to assess the resistance of asphalt reinforcement products to installation influences, site-appropriate tests were performed at the institute's installation test track. As one goal, comparable tensile strengths of the tested products after the following influences were intended to be achieved:

- Only the influence of asphalt truck passes
- Only the influence of asphalt compaction passes
- Combination: The influence of asphalt truck and compaction passes.

2.1. Test procedure

To determine the impact of truck traffic only, undamaged specimens of the reinforcement products were placed on a clean and even road and loaded by a truck. The applied load was carried out by 35 passes with a speed of 20 ± 5 km/h without any steering movements or braking activity (Figure 2). Considering a truck with 5 axles who drives backwards to the paver and forward again this corresponds to 3.5 delivery trucks driving over the grid.

Figure 2: Influences due to truck traffic only

In preparation for the tests, an asphalt binder course (AC 16 B S) was installed on the base of the test track first. Onto the binder course, each reinforcement grid has been placed according to the manufacturer´s installation guidelines. Some of the pre-damaged specimen (truck passes) have also been used in the test-track for further exposure to simulate the double load-effect, truck passes and compaction. To differ between undamaged, pre-damaged and the different loading types, the specimen had been placed into separate sections. Subsequent to the installation of the reinforcement specimen a 50mm asphalt wearing course was installed (Figure 3) and compacted with 6 roller passes (Figure 4).

Figure 3: Wearing course installation

Figure 4: Wearing course compaction

To test their tensile strength after the asphalt installation and compaction, some of the specimen had to be removed after the installation of the wearing course. For this reason these specimen have been wrapped into an aluminium foil and coated with a separating agent to create a very bad interlayer bond. To investigate the different influences the test track was divided into different sections:

A - An undamaged fiberglass reinforcement was installed, followed by the installation and compaction of an asphalt wearing course. (→ Load influence: Compaction only)

B - An undamaged Polyester reinforcement was installed, followed by the installation and compaction of an asphalt wearing course. (→ Like „A", load influence: Compaction only)

C - A pre-damaged fiberglass reinforcement was installed. Subsequently the asphalt wearing course was installed and compacted. (→Load influence: Truck passes and compaction)

D - A pre-damaged Polyester reinforcement was placed. Subsequently the asphalt wearing course was installed and compacted. (→ Like „C", load influence: Truck passes and compaction)

2.2. Results

In the context of the research the final material characteristics (e.g. tensile strength) have been tested with the wide width tensile test according to EN ISO 10319. To compare the separate types of tests (variants) the property "residual strength" was chosen. The residual strength is defined as the maximum tensile strength after the installation damage tests, expressed as a percentage of the maximum tensile strength of the undamaged reference material. The detailed result can be found in chart 1.

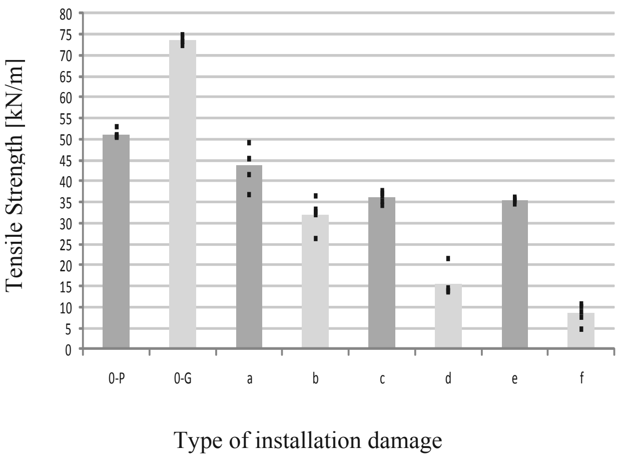
After the load influence "truck passes" only, the polyester grid showed a residual strength of 85%, while the fiberglass grid had only 44% residual strength. After the load influence "compaction" only, the polyester grid showed a residual strength of 71%, while the fiberglass grid had only 21%.

The polyester grid specimens which were subjected to both loading influences - asphalt compaction and truck passes still had a residual strength of 70% while the fiberglass grid subjected to both loading influences revealed further damage with a residual strength of only 11%.
The results revealed the considerable difference between the influence from truck traffic and asphalt compaction on the tensile strength of the specimens.

2.3. Summary

After a series of testing, it can be safely concluded that installation damage plays an important role on the "effective tensile strength" of asphalt reinforcement products. It was found that the polyester grid lost max. 30% of its tensile strength after loading from truck passes and asphalt compaction. In contrast to the performance of the polyester grid, the fiberglass grid showed a loss of strength up to approximately 90%. The fiberglass grid was damaged significantly more than the polyester grid reinforcement (Figure 5).

Chart 1: Results of the wide width tensile test before and after installation damage tests



O-P: Polyester grid - undamaged reference
O-G: Glass-fibre grid - undamaged reference
a: Polyester grid - Only truck passes
b: Glass-fiber grid- Only truck passes
c: Polyester grid - Only compaction
d: Glass-fibre grid- Only compaction
e: Polyester grid- Combination (truck passes and compaction)
f: Glass-fibre grid- Combination (truck passes and compaction)

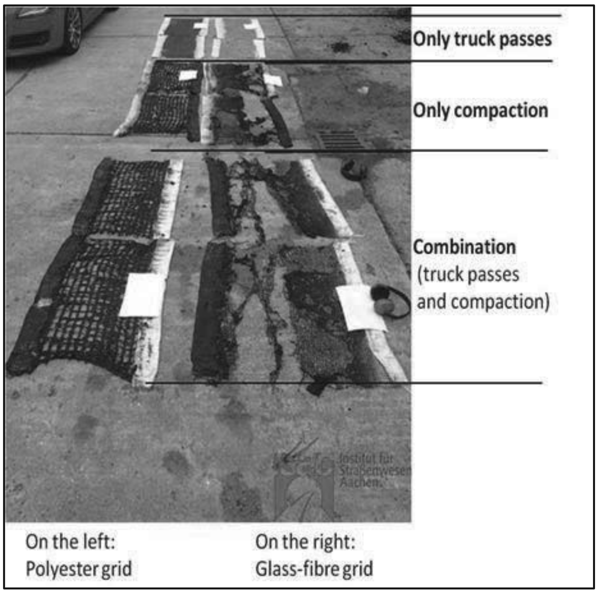


Figure 5: Results of installation damage test

3 CONCLUSIONS

As previously mentioned, asphalt reinforcement products must resist as much damage as possible from the stresses and strains applied during installation and compaction of the asphalt. Very high forces can also be applied to the individual strands of the reinforcement by aggregate movement within the hot asphalt during compaction.

In the research at the RWTH Aachen University, it was shown, that products with a brittle raw material (like fiberglass) can lose a significant part of their tensile strength when loaded by asphalt delivery trucks and after the asphalt compaction (Figure 5). The results of the research are validated by results of tests performed according to EN ISO 10722-1 "Geosynthetics: Procedure for simulating damage during installation" (tBU 2003). Furthermore, it is expected that for fiberglass grids the results would be worse on a milled surface.

The tests reveal that polyester grids exhibit a very good resistance to installation damage compared to other products made with more brittle raw materials.

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