

EXPERIENCE FROM MORE THAN 30 YEARS OF ASPHALT REINFORCEMENT WITH POLYESTER GRIDS

A. Elsing

HUESKER Synthetic GmbH, Gescher, Germany

ABSTRACT: Reflective cracking is a well documented and known phenomenon. Without any treatment cracks and/or joints in existing cracked pavement structures will propagate nearly vertical through a new asphalt overlay, creating a reflective pattern similar to the one existing before. The prevention of reflective cracking in pavements has always been an area of concern when designing for asphalt concrete overlays. A very effective system for the delay or even complete arrest of reflective cracking has proven to be Asphalt Reinforcing Geogrids made out of Polyester fibres, which have successfully been used for about 35 years now.

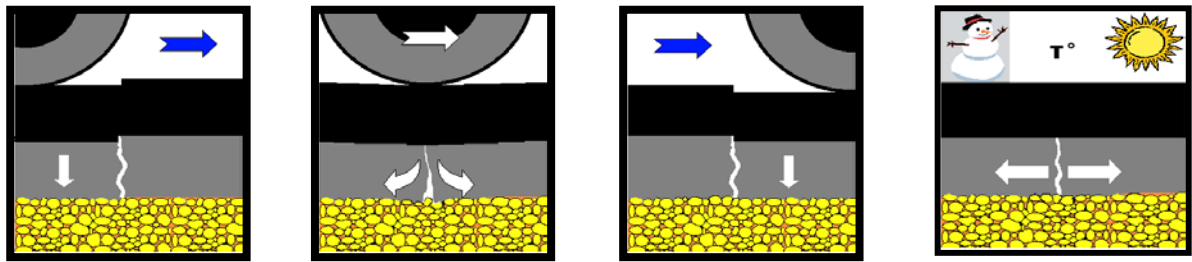
Reinforcements have been successfully used in different applications as roads, highways and airports in nearly all climatic conditions. Examples of evaluations in various countries and conditions are given. Also a number of laboratory studies have been performed on reinforced asphalt systems. The goal of most studies was to simulate the actual load condition of a cracked pavement. When a wheel passes a crack the system is stressed dynamically in different modes (bending and shearing) depending on the wheel position. Additionally horizontal movements may occur due to temperature variations. The results of the studies will be summarised. Special attention is also given on the performance on site, such as the installation process, milling of reinforced asphalt and the reuse of recycled reinforced asphalt.

KEY WORDS: Reflective cracking, asphalt reinforcement, polyester, grid, bituminous grid

1 REFLECTIVE CRACKING

Reflective cracking is a major interest for road engineers facing the problem of road maintenance and rehabilitation.

Reflective cracking can be caused by traffic, temperature variations and/or uneven movements (vertical and horizontal). The literature distinguishes traffic and thermally induced reflective cracking, thereby referring to the different modes of crack propagation (figure 1). The function of an asphalt reinforcement is to increase the resistance of the overlay to high tensile stresses and to distribute the horizontal interface shear stresses over a larger area, thereby reducing the peak shear stresses at the edges of the cracks in the existing old pavement. The reinforcement provides a normal load to the crack surfaces, thereby increasing the aggregate interlock (shear resistance) between both crack surfaces and thus increasing the resistance to reflective cracking. To make the benefits of the asphalt reinforcement clearer all possible load situations and failure modes should be investigated.



Shear mode

Bending mode

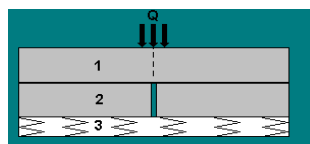
Shear mode

Thermal

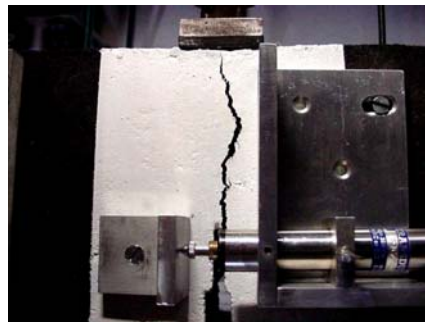
Figure 1: Reflective cracking failure modes

2 DYNAMIC FATIGUE TESTS (Bending and Shearing)

A full description and the results of a testing program performed at the Aeronautics Technological Institute in Sao Paulo, Brazil, were published (Montestruque, Rodrigues, Nods, Elsing, 2004). In this research program which started in 1999 (and is still continuing) an asphalt wearing course was applied over an existing crack in a detailed series of tests. Both the bending mode and the shear mode were investigated under dynamic fatigue loading conditions. The results confirmed that a HaTelit[®] C (asphalt reinforcing grid composed of high tenacity polyester) – reinforced construction considerably delayed the full penetration of cracks. Compared to the unreinforced samples, the HaTelit[®] C- reinforced asphalt layers was subjected to up to 6.1 times the number of dynamic load cycles before a crack reached the surface. The crack pattern clearly shows that the reinforcement takes up and distributes the tensile forces.



- 1 non-cracked asphalt
- 2 cracked asphalt
- 3 elastic base (rubber)



Unreinforced sample
after 80.000 cycles



HaTelit[®] C- reinforced sample
after 490.000 cycles

Figure 2: Dynamic
fatigue testing at ATI
(Brazil)

In a later stage of this research program, the most effective interlayer system should be found. Therefore various asphalt reinforcing products made of different raw materials had been tested under the same conditions. It turned out that the shear mode is the most critical in respect to the lifetime of the system, which means the improvement factors are lower than for the bending mode. Table 1 shows a comparison of the results from the shear mode tests.

Table 1: Results of the dynamic fatigue tests (shear mode) on different asphalt reinforcements

type of reinforcement	number of cyclic loadings until a crack reaches the surface	multiplier (improvement factor)
unreinforced reference sample	145715	1
uncoated glass fibre reinforcement 1	396119	2,7
on a thick PP-nonwoven 2	393582	2,7
coated glass grid	421429	2,9
HaTelit C 40/17	584375	4
HaTelit XP 50	748572	5,1

3 THERMAL CRACKING TESTS

The Belgium Road Research Centre (OCW), has developed a test device to assess the effectiveness of anticracking interlayers, more particularly when used on concrete slabs subject to thermal expansion and shrinkage (Vanelstraete and Francken, 1996).

In the thermal cracking test, schematically represented in fig. 3, specimens comprising a cracked concrete base, an interface system and a bituminous overlay are subjected to opening and closing cycles until the crack in the base becomes apparent at the surface of the overlay.

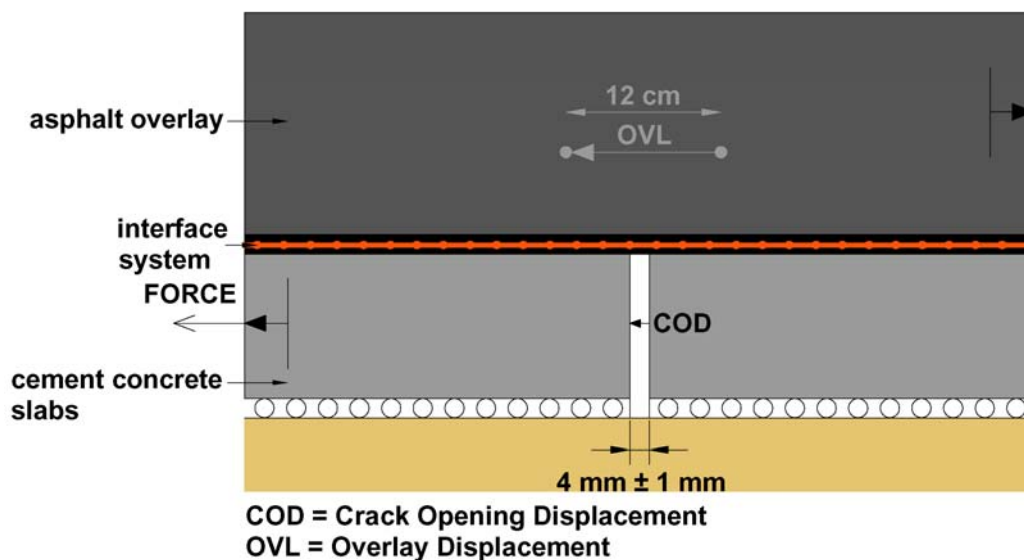


Figure 3: Schematic view of the thermal cracking test

The test sample is placed in an environmental chamber on a bed of steel balls to permit free horizontal movement. The right side of the cement concrete base is fixed and a cyclic force is applied to the left side. The force is driven by the width of the discontinuity: in one cycle the

discontinuity in the cement concrete base is increased by 1 mm and decreased to its initial width. The rate of displacement is very slow, typically a few tenth of a millimeter per hour. This simulates the effect of subsequent shrinkage and expansion of the cement concrete slabs as a result of thermal variations. Figure 4 represents the development of crack length observed in a bituminous overlay during tests performed with various interface systems.

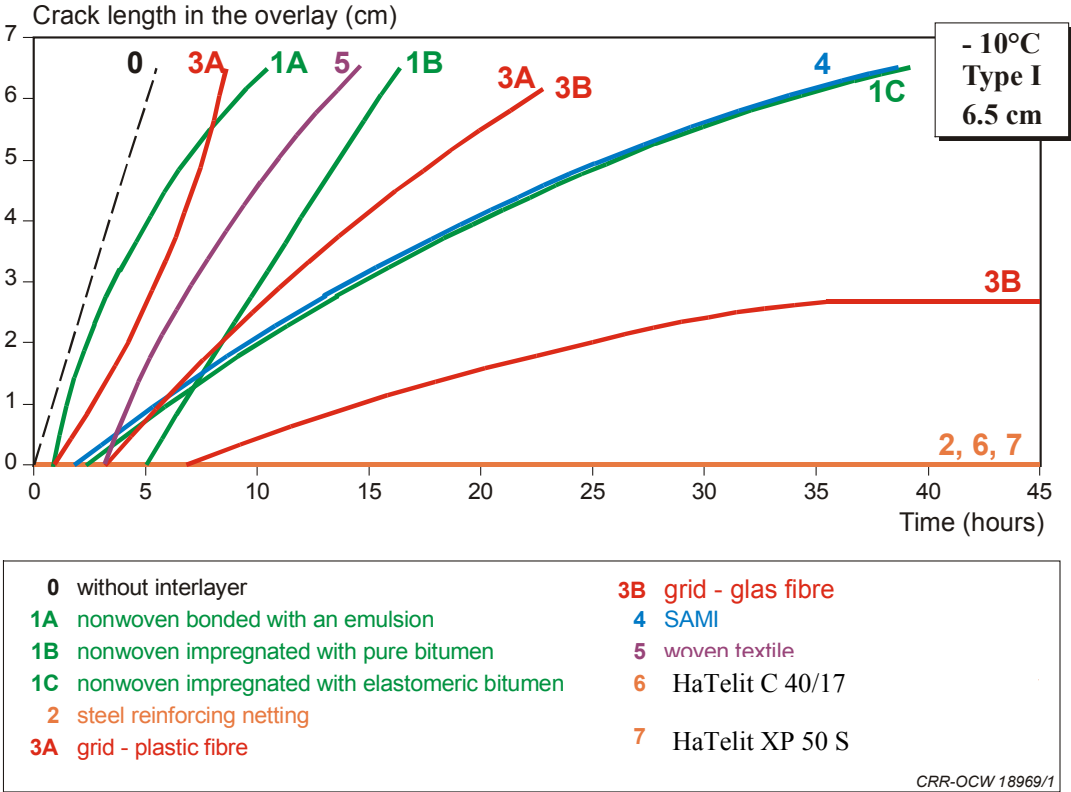


Figure 4: Vertical crack growth in the overlay for different types of interface systems

4 SHEAR TESTS

The long-term interaction of the reinforcement with the asphalt layers is crucial to the proper function of the asphalt reinforcement. Without bonding tensile forces in the reinforcement cannot be mobilized. Bitumen coated grids out of polyester fibers show an excellent and durable!! bonding behaviour. The choice of polyester for reinforcement grids is based on its mechanical properties, which are well compatible with the elasticity and stress-strain behaviour of asphalt.

Since 1994 asphalt bore cores (diameter 150 mm), from various international projects with and without reinforcing grids had been investigated in interface shear tests as developed by Leutner (DIN 1996 T7). The results of cores with HaTelit® as compared to cores without reinforcement confirmed that HaTelit® does not reduce the bond strength between old asphalt and new overlay. Table 1 shows the test results on cores from the re-surfacing at an airport in Germany (Airport Jagel). The milled surface was coated with 0.5 kg/m² bitumen emulsion U 70 K and overlaid with HaTelit® C 40/17 and finally covered with 4.0 – 6.0 cm wearing course. This rehabilitation work had been carried out 1998 and the surface today is still satisfactory in every respect. The first four cores were taken four weeks after construction. One of the cores was an unreinforced reference sample.

Table 2 Leutner shear test results of asphalt cores (diameter 15 cm)

Core No.	Description	Shear force kN
1	HaTelit [®] C 40/17	36.42
2	Unreinforced reference sample	30.17
3	HaTelit [®] C 40/17	37.48
4	HaTelit [®] C 40/17	36.72

The shear strength measured in the tests was very high on all the cores and in this instance even higher in the reinforced samples than in the unreinforced. However, it cannot be deduced from this that HaTelit[®] C 40/17 improves the bond, but it is clear that the bond is not reduced.

Reinforced samples without a bitumen coating and composite products (reinforcement with a non-impregnated nonwoven) all showed a considerable reduction in bond strength between the layers. In many instances these samples separated during coring. Similar results showing the reductions in the bond between layers for various reinforcement types are described in (De Bondt, 1999).

In such composite products the nonwoven has to be saturated during installation, in order to have a SAMI (stress absorbing membrane interlayer) effect. At the same time the grid should provide a reinforcing function. If, however, the nonwoven reduces the bond between layers, the reinforcement cannot mobilise the tensile force. A reinforcing effect can only occur if there is sufficient bond between the layers to transfer the forces. The two effects cannot simply be added together.

Using a thick nonwoven the required amount of bitumen to saturate the nonwoven must be known exactly and applied correctly because of the danger of bleeding, resulting from too much spray being applied, or the danger of a poor bond resulting from too little spray being applied.

5 PROJECT EXAMPLE UNDER SEVERE CIRCUMSTANCES

The project reference to be presented herein shall give an example of successful use of asphalt reinforcement. The project is located in the Northwest German town of Rosendahl. The road is a highly trafficked road. The majority of vehicles are trucks, because the road is the main connection to the nearby border to the Netherlands. The observation revealed severe alligator cracking and longitudinal as well as cross cracking in large scale. The original concept (and budget) called for milling the surface (approx. 5 cm) and installation of a new wearing course of 5cm. The expected lifetime of the new surface was just 2 years.

The more durable (but very expensive) solution was to take up the cracked binder and base course. The alternative, as durable solution to that included a layer of HaTelit[®] over the cracked binder. The thickness of the new wearing course remained 5 cm. Hence, the economical advantage had to be proven by a longer lifetime. This should be the main goal in most of the applications. The layers shall have the standard thickness, the economical advantage then results from the longer life time of the surface over the old cracked area.

After the milling process the finding was a very thin layer of bituminous bound gravel. (Fotograph 1). In local sports the bonding was almost not present, but still the result was very satisfactory.



Fotograph 1: Surface after milling



Fotograph 2: Difficult spots during installation

On top of this layer HaTelit[®] was installed. Under such circumstances a very controlled and carefully organised installation is important.

The project was finished in summer 1996. Regular inspections, with a last one taking place late in 2004 showed, that the road is still in perfect condition, and that HaTelit has proven its life increasing function very well. Important to note is, that the two years estimated time have been increased up today to eight years. Taking into account not only the construction costs, but also the costs of traffic jams due to a road under construction, the environmental effects due to the increased quantities of bitumen used, HaTelit has proven its advantages.

6 DEMANDS OF ASPHALT REINFORCEMENT

The interaction of the bonding between layers and the axial stiffness of the reinforcement are particularly important. To ensure this occurs in the long-term, the reinforcement has to be able to resist the demands made upon it during installation, trafficking with asphalt lorries and finishers, the overlaying and compaction of the asphalt and also it must have a dynamic load bearing capacity.

Even during installation the reinforcement may be subjected to high loading, when trafficked by tracked pavers or 'blacktop' lorries. Very high forces can also be applied to the individual strands of the reinforcement by aggregate movement in the hot blacktop during compaction.



Fotograph 3: HaTelit[®] C 40/17 trafficked by a tracked paver



Fotograph 4: HaTelit[®] C 40/17 trafficked by a 'blacktop' lorry

The very high resistance to mechanical damage also allows HaTelit® C 40/17 to be placed directly onto milled surfaces. Manufacturers of grids made of very high modulus brittle materials like glass fibres point out that, because of its fragility and brittleness, i.e. the low shear strength of glass fibre and the resulting high risk of damage, glass fibre should not to be placed directly onto milled surfaces. How glass fibre reinforcements behave when placed directly over the sharp edges of cracks, especially during compaction, has not been clarified up to now and requires further investigation.

7 MILLING OF REINFORCED ASPHALT

At the end of the pavements life a polyester grid can easily be milled together with the asphalt pavement (Schniering, Thureau, 1992). Large powerful milling machines will reach about 90 % of their usual milling speed of unreinforced asphalt. In 2004 a HaTelit C 40/17 reinforced section has been milled off for investigation purpose (Fotograph 5). A section of 60 m length and 4.0 m width has been milled with a small milling machine Wirtgen W 500 (Fotograph 6). The width of the milling roller is 50 cm. Even with this milling machine, which does not have a very powerful engine, continued milling of the reinforced section was possible, at a reduced but acceptable speed.



Fotograph 5: Milling of reinforced asphalt



Fotograph 6: Milling machine

It can be concluded that the better the bond between the asphalt layers with the interlaying reinforcement, the easier is the milling process. If the bonding is significantly reduced milling problems can occur.

Milling of asphalt with interlaying nonwovens or composite products showed the problems that due to the high elongation of the nonwovens the fibres are not being cut-up during the milling process, but were found around the milling cutter.

8 RECYCLING

The reinforced milled material can be reused in the mixture for asphalt base courses with a percentage of 30 % of milled polyester grid reinforced asphalt without any decrease in quality. The mixtures examined fulfil the requirements of the German guidelines for bituminous base course material not only with regard to composition but also with regard to mix material characteristics (Damisch and Kirschner, 1994).

9 CONCLUSIONS

Numerous laboratory investigations and, above all, over 35 years experience in practice have shown that asphalt reinforcement out of polyester fibres is often a cost-saving and economically viable alternative to conventional construction solutions.

REFERENCES

- Damisch A., Kirschner R., *Recycling of Grid Reinforced Asphalt Pavements*, Proceedings of the Fifth International Conference on Geotextiles, Geomembranes and Related Products, Singapore, 1994
- De Bondt, A.H., *Anti-Reflective Cracking Design of (Reinforced) Asphaltic Overlays*, Ph.D.-thesis, Delft, Netherlands, 1999
- Elsing A., Sobolewski J., *Asphalt-Layer polymer Reinforcement: Long-Term Experience, New Design Method, Recent Developments*, Proceedings of the Fifth International Conference on the Bearing Capacity of Roads and Airfields BCRA'98, Trondheim, Norway, 1998.
- Kunst P.A.J.C., Kirschner R., *Investigations on the effectiveness of synthetic asphalt reinforcements*, Proceedings of the Second International RILEM Conference, Liege, Belgium, 1993.
- Molenaar A.A.A., Nods M., *Design method for plain and geogrid reinforced overlays on cracked pavements*, Proceedings of the Third International RILEM Conference, Maastricht, Netherlands, 1996.
- Montestruque G.E., Rodrigues R.M., Montez F.T., Elsing A., *Experimental Evaluation of a Geogrid as an Anti-Reflective Cracking Interlayer on Overlays*, Proceedings of the Second European Geosynthetics Conference EuroGeo 2000, Bologna, Italy, 2000.
- Montestruque G.E., Rodrigues R.M., Nods M., Elsing A., *Stop of reflective crack propagation with the use of PET geogrid as asphalt overlay reinforcement*, Proceedings of the Fifth International RILEM Conference, Limoges, France, 2004
- Schniering, A., Thurau, W., (in German) *Untersuchungen an einer armierten Asphaltbefestigung hinsichtlich der Ausbaumöglichkeiten durch Fräsen sowie der Wiederverwendbarkeit des Fräsgutes*, 1992
- Vanelstraete A., Francken L., *Laboratory testing and numerical modelling of overlay systems on cement concrete slabs*, Proceedings of the Third International RILEM Conference, Maastricht, Netherlands, 1996.