Asphalt Interlayer Systems – Their Application and their Specification

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ABSTRACT: Pavement rehabilitation with asphalt interlayer systems has become worldwide practice. According to EN 15381 a geosynthetic is able to fulfil one or more of the following functions: stress-relief, barrier and reinforcement. Based upon this European framework standard a number of different national guidelines has been established. Some of them have been remaining in the status of a draft for a longer period. An overview over a number of these papers is given. The guidelines/drafts are compared and analysed. A comparison of existing requirements in different countries is presented.

Furthermore, a number of successful applications of non-woven products used in surface treatments as well as of multi-functional products used in pavement repair are described in the paper. These typical cases are compared and relevant parameters for a correct product selection are identified.

A very simple and easy to use system approach for correct product selection is presented.

Keywords: Asphalt Interlayers, Paving Applications, Asphalt reinforcement, Specification, Guidelines

1 GENERAL

The conservation and maintenance of the considerable value represented by the road network is a challenge for our modern societies. Developing efficient construction methods able to guarantee long life structures without spoiling natural resources and destroying the environment is a major requirement.

Cracking of road pavements can be considered is one of the main causes of road deterioration - the amount of money spent year by year on repairing and maintaining cracked pavements is astronomical. There is no doubt that such arguments justify any effort that is put on promoting research and development in the field of pavement cracking.

Pavement rehabilitation with asphalt interlayer systems (AIS) has become worldwide practice. In Europe many millions of m^2 are installed every year. The main goal of asphalt interlayer systems is to prevent or retard the occurrence of cracks in new asphalt overlays.

2 FUNCTIONS AND PRODUCTS IN USE

2.1 *Functions of Asphalt Interlayer Systems*

It is commonly accepted that geosynthetic interlayer systems in pavements work in one or more of the 3 main functions:

Stress Relief (STR)
Barrier (B)
Reinforcement (R)

Among many other documents, probably the most important one defining this functional systematic is EN 15381.

2.1.1 *Stress Relief Function*

One possibility to prevent or retard cracks is to accommodate, move with and absorb stresses in a flexible mass. This is the way how a bitumen-saturated non-woven, but also how SAMI-systems, are intended to work. This specific function is called stress-relief. If a stress-absorbing layer is installed, limited movements are allowed, stresses will be dissipated, but cracks will not propagate into the newly installed wearing course.

In the usual range of temperatures bitumen shows visco-elastic behaviour. When asphalt is loaded, three different strain responses may occur:

- Elastic Deformation: linear relation between load and deformation. After removal of the load immediate and complete reset (reversible).
- Delayed-elastic Deformation: This kind of deformation will occur with a certain time lag and then approaches a limit which is dependent on load size. The deformation is completely stopped after the removal of the load after a certain time (reversible).
- Viscous Deformation is performed with a constant speed as long as the load is applied (flow or creep); the deformation will remain after the removal of stress (irreversible – plastic deformation). The delayed reaction on stressing the bitumen is mainly responsible for the stress-relaxation or stress- relief effect.

Loading of the asphalt layer systems may be caused by traffic loads, deformations of the subbase or subgrade, by deflections and/or temperature-induced strains.

Tensile tensions due to differential shear deformations between the layers will be largely eliminated within the asphalt interlayer by effects of viscous flow. In case that the crack edge movement will not or only partially propagate, the tensions in the overlying asphalt layer will not exceed the breaking strength of the asphalt. T

Bitumen has to be applied in the correct quantity and quality. The adhesion of the bitumen ensures that the binder layer has a good bond with the base and the overlying asphalt layer. Because of the good connection and viscous deformation ability this system is called a "flexible composite”.

Non-woven fabrics with adequate bitumen storage capacity for the bitumen allow not only for a sufficient amount (“blotter”-effect) but also a uniform distribution of bitumen. Adequate storage capacity for the barrier function can be deducted from Fig2. Additionally, the filament-structure will increase the viscosity of the bitumen layer, in a way to avoid a "swimming" of the overlying layer, while it still enables a reduction in tension in the bitumen layer.

Stress relief can also be defined as a function provided by a bitumen-saturated paving fabric (non-woven or purpose-built composite) which – when properly installed between a road surface and a new asphalt overlay – allows for slight differential movements between the two layers and thus provides stress relief, which delays or stops crack propagation in the asphalt overlay (EN 15381).

2.1.2 Barrier (B)

Both liquids and gases might penetrate into the asphalt layer structure through pores, micro cracks and cracks, causing deterioration of the layers. An efficient and cost effective method of preventing these media from penetrating the surface is to install an impermeable barrier layer. In asphalt road construction, nonwoven fabrics in conjunction with bitumen are used to create a sealing layer. This layer with a binding agent acts as a seal of the base course and prevents the ingress of water and oxygen. Thus, the aging process of the binder due to oxidation and the formation of brittle cracks in the existing asphalt pavement are retarded.

Fig. 1 Bitumen retention test

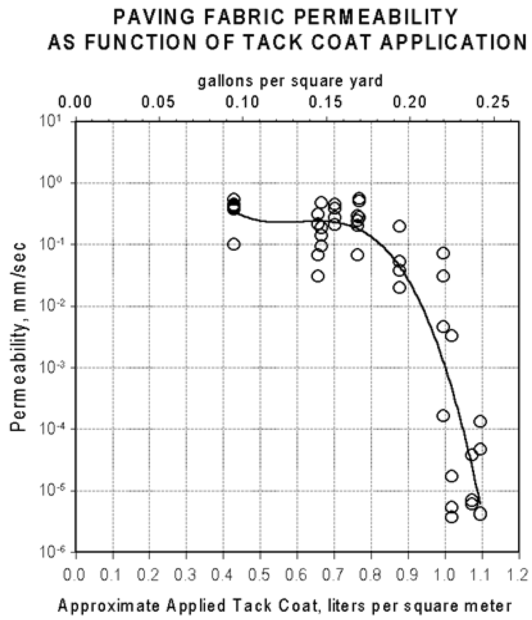

Fig 2 Barrier-function of tack coat (Suits et al. 1999)

This sealing effect reduces the ingress of surface water, which will provide better frost resistance of the underlying layers. Additional damage due to water freezing in the layers (bursting effect, ice lens formation, drenching during defrosting period) is retarded or completely prevented.

The sealing or barrier function may also be defined as follows: to prevent liquids or gases from penetration into lower layers and to avoid associated problems due to freeze/thaw effects and the need for lower drainage to remove subsurface water; potential reduction of oxidation of lower bitumen layers.

To achieve this effect a certain amount of bitumen is necessary. A reasonable basis to define this quantity can be found by Suits, Marienfeld and Baker (1999).

2.1.3 Reinforcement (R)

Another way to avoid cracks is to take up stress by stiff components. The degree of success is mainly determined by proper bonding and sufficient strength/stiffness. This function is called reinforcement. A multi-layered asphalt system can be reinforced by adequate interlayers if it succeeds in transferring the required forces from the asphaltic matrix to the interlayer and vice-versa.

To achieve an effective take-up of tensile forces by the asphalt interlayer, following requirements must be met:

- The interlayer must be located in the tensile zone of the layer system.
- The stresses must be transferred by friction from one structural material to the other.

The transmission of forces from the asphalt to the reinforcement may be secured through mainly two different mechanisms:

- Adhesion is achieved by the surface structure of the interlayer and the application of special tack-coats or coatings (e.g. bitumen coatings).
- Anchoring is achieved through friction.

Due to the relatively long strands and high stiffness of the asphalt interlayers, mechanisms of node-stiffness are of minor importance. Further effects of anchorage arise from the gauge length, which is the length of reinforcement outside region where the loads are applied. Many studies have shown that the fatigue resistance of a reinforced layer of asphalt is higher than that of an unreinforced. This has been shown e.g. by Vismara et.al. (2012).

2.2 Products in use

Asphalt Interlayer Systems are available in many different forms and are manufactured from different raw materials (glass, polymers, carbon and steel). Following types of product are commonly used:

- Needle-punched non-woven fabrics, usually continuous filament polypropylene, sometimes polyester and glass fibre materials can also be found. These products are used to fulfil the functions of stress-relief (STR) and barrier (B). A key- property of these products is an adequate bitumen storage capacity.

- Composites, typically a combination of polymer or glass grids and non-woven textiles combined by lamination or stitching. Composite materials are designed to fullfill mutliple functions. If adequately designed these can be all 3 functions STR, B and B in one product.

Fig. 3 Nonwoven

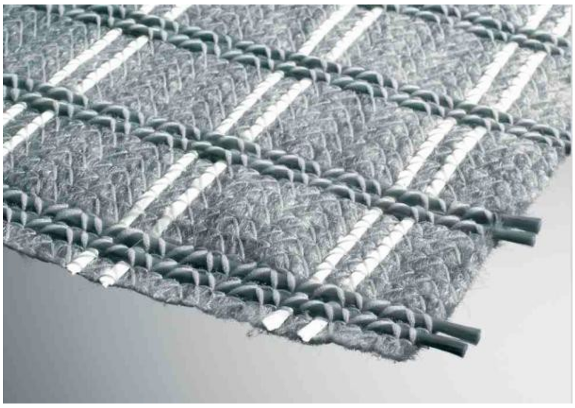

Fig 4 Composite

- Grid structures, made from polymeric materials and/or glass and steel meshes. For steel typically galvanized steel wire is used. All of these products are intended to fulfil the function of reinforcement (R) exclusively. Some of these grid-products have a very thin, lightweight non-woven integrated to ease installation and to allow a better fixation in the tack-coat. However, these structures will show only little storage capacity for bitumen, therefor they are not regarded as barriers or stress-relieving layers.

3 EUROPEAN GUIDELINES AND DRAFT GUIDELINES

3.1 General

A number of different national guidelines has been established or have been remaining in the status of a draft for a longer period based upon it. A list of these papers about which the author of this paper has information, is given in table 1.

3.2 EN 15381 2008; Geotextiles and geotextile-related products- Characteristics required for use in pavements and asphalt overlays.

EN 15381 can be considered as the European framework standard. On its basis some CEN member organisations or related organisations have edited national standards. This standard allows manufacturers to describe geotextiles and geotextile-related products on the basis of declared values for characteristics relevant to the intended use and if tested to the specified method. It also includes procedures for evaluation of conformity and factory production control. This standard may also be used by designers, end-users and other interested parties and enables them to define which functions and conditions of use are relevant. de

3.3 ISO initiative in asphalt reinforcement (ISO TC 221 WG 6)

Within ISO Technical Committee TC 221 a working group is dealing with the design of geosynthetic interlayers. The group has started to work in 2016.

3.4 CFG France

Draft recommendations “Recommandations à l’usage des maitres d’œuvre pour l’emploi des geosynthétiques utilisés dans les dispositifs retardant la remontée de fissures”, unofficial working document.

3.5 FGSV Germany, Arbeitsgruppe Asphaltbauweisen / Arbeitskreis 7.3.8 Asphalteinlagen

Arbeitspapier 69 “Verwendung von Vliesstoffen, Gittern und Verbundstoffen im Asphaltstraßenbau“ Edition 2006, Version 1013. This document is in the status of a “working paper”. It summarizes the state of knowledge in Germany and can be a basis for specification.

3.6 RSTA United Kingdom, Code of practice for geosynthetics and steel meshes

This Code of Practice has been produced by the Road Surface Treatments Association (RSTA) Geosynthetics & Steel Meshes Committee to provide highway authorities, designers and principal contractors a thorough understanding of Geosynthetics and Steel Meshes, their use, laying techniques and applications.

3.7 Slovakian Ministry of transports public works and regional development

Technical conditions for the use of geosynthetics and related products in asphalt layers for roads. 2012,

3.8 Romania

Romanian Norm regarding the use of geosynthetics to reinforce road structures with asphalt layers Reference No: AND 592-2013

3.9 Bulgaria

National Annex to BDS EN 15381; issued in 2015.

3.10 The Netherlands CROW document asfaltwapening (draft 2016)

The paper is in a draft stage. It seems a focus is made on design and technical background.

3.11 Austria RVS

RVS 08.16.02 “Anwendung von Asphaltvlies – Application of Non-woven in Asphalt construction”; This document takes into account nonwovens used for stress-relief and Barrier function. A complete specification is given, not only for non-wovens but also for bitumen emulsions to be used.

Table 1 Standards and Guidelines for Geosynthetics in Paving

Country (Region)	Title	Organisation	Date	Status	Target of the paper	Remarks
AT	Anwendung von Asphaltvlies	FSV	2015	valid	Technical contract conditions	Nonwovens used for B and STR
BUL	National Annex to BDS EN 15381	Bulgarski Institut sa Standardisa-tia	2015	valid	Required technical values	Required technical values for B STR and R
DE	Use of Non-woven Fabrics, Grids and Composites in Asphalt Road Construction	FGSV	Edited 2006/ Version 2013	Working paper	Summarize State of the knowledge in Germany	Numbers are given for 3 typical product types (NW, grid and compo-site)
FR	Recommandations à l'usage des maitres d'œuvre pour l'emploi des geosynthétiques utilises dans les dispositifs retardant la remontée de fissures	CFG	2015	Draft Under revision	Recommendations for selection, installation and control of geosyn-thetics	Some numbers are given for 3 typical product types (NW, grid and composite)
NL	CROW document asfaltwapening	CROW	2016	Draft	State of the art over-view	
SK	Technical Specifications; Use of GSY and related materials in as-phalt roadway layers	Ministry of Transport	2012	valid	Technical Specifica-tions	Part A. general info and technology Part B; Giving required properties
RO	Romanian Norm regarding the use of geosynthetics to reinforce road structures with asphalt layers	CNADNR	2014	valid	Requirements, guide-lines for the use	Classification acc. to road type.
UK	Code of practice for geosynthetics and steel meshes	RSTA		Valid		
ISO members		ISO		Work started	Design	
Europe	Geotextiles and geotextile-related products — Characteristics re-quired for use in pavements and asphalt overlays	CEN	2008	Under review	Application Standard (Framework standard)	Basis for CE Marking Basis for evaluation of conformity

4 EXAMPLES OF APPLICATION

4.1 New surface on old concrete road in Weins-Persenbeug, Austria

During peak hours, sections of the so-called Danube federal road B3 are some of the busiest roads in Austria. The existing road pavement was several decades old and had undergone local repair on numerous occasions. In some areas, the condition of the road surface was in such a critical state that traffic safety could no longer be guaranteed. The surface of the B3 between Weins and Persenbeug was built as a concrete pavement with bituminous expansion joints. Due to inadequate bedding and increasing traffic loads, cracking had developed after many years of trafficking, especially at the joints of the large-sized panels. In order to avoid frost damage that would occur during the cold season, it was decided to rehabilitate the pavement using a multi-functional asphalt interlayer system.

Fig 5 Spraying of tack coat

Fig 6 Installation of first sheet

The existing concrete pavement was stress-relieved and an 8 cm-thick profiling layer placed. Rehabilitation was carried out by placing an asphalt layer and incorporating a multi-functional asphalt interlayer system. A geocomposite combines the functions of stress relief, waterproofing (barrier) and reinforcement in accordance with EN 15381:

Table 2 Specification of the installed product

Tensile strength (MD/CMD)	EN ISO 10319	100/100 kN/m
Elongation at max. load	EN ISO 10319	3/3 %
Dynamic perforation	EN ISO 13433	30
Static puncture strength	EN ISO 12236	1300
Durability	EN 14030	pH > 9
Resistance to weathering	EN 12224	passed
Bitumen Retention	EN 15381 / Annex C	1,1
Melting point	EN ISO 3146	400° C (glass)
Nonwoven component	-	Continuous filament PP nonwoven

Milling operations and possibly required preparation of the subgrade for a new base and wearing course layer could be dispensed with entirely. Thus cost for removal and disposal were eliminated. This allowed a quicker and more economical management of the remediation project. Additionally, the total closure of the road, was not necessary.

4.2 Rehabilitation of Runway at Prague Airport, Czech Republic

Prague Airport is the most important international airport in the Czech Republic and the biggest airport among the new EU member states. It has received the Eagle Award for 2011 awarded by the Association of IATA for being the best developing airport. This international “air-hub” handles about 11 to 12 million passengers annually. They can choose from about 50 regular airlines connecting Prague directly to about 130 destinations around the world.

Pavements in airports generally are subject to high stresses, but also to specifically high requirements concerning quality and safety. At Prague airport after many years of use, the existing old asphalt surface of the runway had reached the end of its lifetime. Due to continuously increasing loading and more and more severe climatic conditions the asphalt of the runways had started to show cracks, natural bitumen aging (oxidation) had occurred. Prague airport therefore had decided to launch a rehabilitation program with a reliable and technically sound method – the use of a geocomposite asphalt interlayer as described in table 2.

Fig 7 Installation of surface course

Fig 8 compaction of surface course

This product consists of a PP continuous filament non-woven which is combined with high tensile glass fibre yarns. When used as asphalt interlayer system it may cause slightly higher investment cost, but provides a long lasting improved surface.

Quality and technical requirements were designed according to Czech standard ČSN 736121 describing construction and requirements of asphalt layers in roads and airports. For the new surface of the runway asphalt concrete ACO 16 S PMB 45/80-60 was specified and installed in 2 layers with a thickness of 6 cm each.

4.3 Surface treatment in Siegerswoude, Netherlands

Surface dressing is a well-known technique for restoring texture depth and sealing the road surface to inhibit the ingress of water. Bituminous overlays consisting of chip sealing and continuous filament nonwoven geotextiles are a cost effective proven approach for extending the life of pavements. When placed in bituminous bound layers these products are able to retard the initiation and propagation of reflective cracking which would lead to premature pavement failure.

Together with the installer ESHA Infra Solutions TenCate Geosynthetics supplied the perfect solution for the needs of the community of Dongeradeel (NL).

The existing road consisted of 80 mm cracked asphalt on a foundation consisting of rough gravel (crushed stone). The profile of the road was good with minimal rutting. Aged bitumen often is the reason for a cracked surface so that water can penetrate into the road construction.

Fig 9 Laying of the non-woven

Fig 10 final surface installed

The ideal situation for the application of a continuous filament fabric combined with polymer modified bitumen. The installation of several thousand m^2 was easily done within a few hours, so that the whole job, including double surface-treatment, was arranged within 1 day.

5 FAILURE MODES IN ASPHALT SURFACES

5.1 *Reasons of Failure of Asphalt Surface course*

Pavements may crack due to following reasons and effects:

- Asphalt (Bitumen) Aging
- Traffic counts and loading
- Environmental conditions
- Original design and quality of materials and installation
- Level of maintenance
- Existing Pavement distresses

5.2 *Types of failure and mechanical background*

5.2.1 *General*

In principle 3 main types of cracks may be distinguished: Tschegg et.al. (2011)

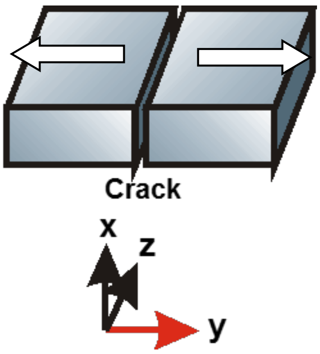

Fig 11 tensile stress

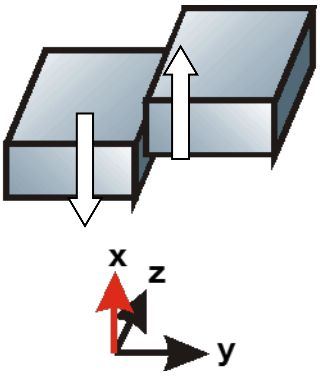

Fig 12 vertical shear stress

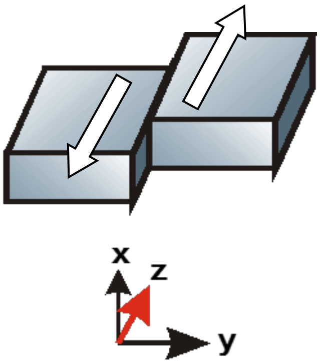

Fig 13 In-plane shear

5.2.2 Cracks caused by horizontal tensile stress

Cracks caused primarily by horizontal movements due to temperature changes can appear in the following forms:
a) Cracks in longitudinal and transversal direction in asphalt surfaces with insufficient binder content, with too hard or aged binder
b) Propagating cracks:
- over cracked cement stabilized base courses or improved subgrades with too high stiffness
- over cracked brittle asphalt binder or base courses
- over joints or seams in asphalt binder or base courses
- over ditches, dug up and refilled etc.
- over joints in overlaid concrete surfaces
c) Opening of longitudinal and transversal joints and seams
In the case of cracks caused by horizontal movement, a limited horizontal movement of the overlay will be allowed due to the installation of a bituminous impregnated nonwoven; The geosynthetic may act as a stress absorbing membrane interlayer (SAMI) or as a reinforcement.

5.2.3 Cracks caused by vertical movement

Cracks caused primarily by vertical movements can appear in the following forms:
a) Propagation of joints and cracks in concrete surfaces and in cement stabilized base courses.
b) Single cracks and alligator cracks in wearing courses over asphalt layers with reduced bearing capacity (e.g. caused by ageing of the binder, loss of binder etc.)
The use of geosynthetic interlayers in the case of vertical movements will provide a limited benefit, as the vertical stresses cannot be taken up by the interlayer. This is the reason why concrete slabs usually need to be de-stressed and/or a levelling layer will be installed.

5.2.4 Cracks caused by shear stress

Cracks caused by movements due to excess shear stress can appear in the following forms:
a) Alligator cracks in a thin asphalt overlay over a structure with insufficient frost resistance. In this case a bitumen impregnated interlayer can reduce the penetration of surface water and therefore improve the frost resistance of the structure indirectly.
b) Cracks in the wheel track caused by insufficient bearing capacity of the base course and/or subgrade, or caused by excessive traffic stress.
c) Crack due to horizontal traffic forces

The use of geosynthetic interlayers is recommended, as the multiaxial structure of reinforcing interlayers will reduce movements by taking up tensile forces.

6 PRODUCT SELECTION MATRIX - CONCLUSIONS

For a correct specification of asphalt interlayer systems, the functional approach is of crucial importance. Therefore, a pre-selection of the right product can be given in table 3.

For barrier and stress relief functions tensile strength of 7 – 9 kN/m is required in many specifications. At the same time a minimum elongation of 50% and a bitumen retention capacity of 1,0 kg/m^2 is required.

Table 3 Product selection matrix

Required Function	Product Type		
	Grid	Non-woven Fabric	Composite
Barrier		X	X
Stress relief		X	X
Reinforcement	X		X

For reinforcement function, in the absence of detailed calculation models of design strength, it can be observed that often an ultimate strength of 100 kN/m is used as a design requirement. In many cases this is combined with a maximum elongation of 3%. In this context it is important to mention that multi-functional composite product will need these properties in combination with the parameters mentioned before.

REFERENCES

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