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Design using geosynthetics —

Part 10:
Asphalt pavements

Conception utilisant des géosynthétiques —

Partie 10: Chaussées bitumineuses

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Contents

Page

Foreword

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This document was prepared by Technical Committee ISO/TC 221, *Geosynthetics*.

A list of all parts in the ISO/TR 18228 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The ISO/TR 18228 series provides guidance for designs using geosynthetics for soils and below ground structures in contact with natural soils, fills and asphalt. The series contains parts which cover designs using geosynthetics, including guidance for characterization of the materials to be used and other factors affecting the design and performance of the systems which are particular to each part, with ISO/TR 18228-1 providing general guidance relevant to the subsequent parts of the series.

The series is generally written in a limit state format and guidelines are provided in terms of partial material factors and load factors for various applications and design lives, where appropriate.

This document includes information relating to the asphalt pavements. Details of design methodology adopted in a number of regions are provided.

For more than 30 years roads have been built, maintained and operated using different types of geosynthetics used as asphalt interlayers incorporated within asphalt pavements. Amongst other benefits, these products are successful in mitigating reflective cracking in pavements, improving pavement performance, extending pavement service life, resulting in a reduced total cost of ownership and a reduced carbon footprint.

Many of these products are related to geosynthetics used in geotechnical engineering and these products have been adapted and adjusted for use as asphalt interlayers. A geosynthetic used as an asphalt interlayer is special in the sense that it is used mostly between an existing pavement and a new asphalt layer. The method of function of these products cannot be directly compared to, for example, concrete reinforcement nor to soil stabilization mechanics. Moreover, geosynthetics used as asphalt interlayers are one part of a system together with the tack or bond coat bonded in between two courses.

Design using geosynthetics —

Part 10:
Asphalt pavements

1 Scope

This document provides general considerations to support the design guidance to geotechnical and civil engineers involved in the design of structures in which a geotextile is used to fulfil the function of an asphalt interlayer. The key potential failure mechanisms and design aspects to be considered are described, and guidance is proposed to select engineering properties.

The state of the art is however limited and does not commend any particular design method. This document can be used as a basis for further research on, for example, system selection, design, performance testing, creation of local guidelines.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
bond coat
tack coat
bituminous binder used to promote the adhesion between layers in the construction and maintenance of roads and paved areas

Note 1 to entry: In some countries a bond coat refers to a polymer modified bitumen while a tack coat refers to a regular bitumen. In this document bond coat is used synonymously also for tack coat.

3.2
flexible pavement
layers of asphalt or bituminous concrete layers overlying a base of granular material on a prepared subgrade

3.3
installation aid
product attached to a paving grid in order to support the installation process in different ways without providing any additional function (B, STR and R)

Note 1 to entry: An installation aid could consist of a light non-woven fabric, additional fibres in the apertures of the grid or a thin synthetic foil. An installation aid can improve contact of the product to the base thus achieving better adhesion during the paving process. A thin synthetic foil attached to a grid is sometimes used to decrease adhesion experienced during unrolling.

3.4
interlayer barrier
B
function provided by paving geotextiles saturated by bitumen, which act, in conjunction with a bitumen layer, as a barrier to the ingress of water and gasses, and thus prevent or delay the deterioration of the pavement

3.5
interlayer system
geosynthetic products bonded in between two pavement layers for asphalt pavement application

Note 1 to entry: These can be paving geotextile, paving grid or paving geocomposite.

3.6
paving geocomposite
product that combines a paving geotextile and a paving grid

3.7
paving geotextile
geotextile fabric adequately saturated with bitumen providing a stress relief function (STR) and acting as an interlayer barrier (B)

3.8
paving grid
product that has tensile elements which provides a reinforcement function (R) only

3.9
reflective cracking
vertical cracking through a pavement structure caused by stresses generated in the pavement foundations resulting from movements that propagate upwards or downwards through the pavement structure

3.10
reinforcement
R
function which is provided by tensile elements of a geosynthetic used as an asphalt interlayer to delay or prevent reflective cracking by the absorption of tensile forces

Note 1 to entry: Use of the stress-strain behaviour of a paving grid can improve the long-term mechanical properties of asphalt.

3.11
rigid pavement
hydraulically bound pavement on a granular subbase

3.12
semi-rigid pavement
intermediate state between flexible and rigid pavements

Note 1 to entry: Lean cement concrete, roller compacted concrete, soil cement and lime-pozzolanic concrete construction are examples of semi-rigid pavements.

3.13
stress relief
STR
function provided by an adequately bitumen-saturated interlayer (e.g. paving geotextile or paving geocomposite) which allows for slight differential movements between the two layers and thus provides stress relief to delay or prevent reflective cracking

4 Design considerations

4.1 General

This clause provides an overview of the different types of geosynthetics used as asphalt interlayers, their functions, and their relation to the pavement design. These are crucial for differentiation of the products and their functions in the system, particularly for specification purposes. The corresponding system functions, related to each product type, are also described.

NOTE These functions do not occur in practice in their pure form and often overlap.

4.2 General design considerations

When working with a geosynthetic used as an asphalt interlayer system, the selection of the system components is crucial for a successful project outcome. Detailed information about the trafficked area is required and the expected performance of the chosen interlayer is usually clearly identified. For an economic comparison it is often reasonable to estimate the expected performance of a system with and without an interlayer. A comparison is normally be carried out over a period of time that demonstrates the efficiency of the interlayer.

A geosynthetic used as an asphalt interlayer can have very different characteristics depending on the method of manufacturing and the type(s) of raw material(s) used. Therefore, asphalt interlayers are not simply interchangeable.

The objectives of using a geosynthetic as an asphalt interlayer include:

— extension of maintenance and rehabilitation intervals;

— extension of service life; and

— reduction of whole-of-life costs.

A geosynthetic used as an asphalt interlayer in a system can provide the following positive effects by their different functions, or as a secondary effect of the function.

— Mitigation of reflective cracking through a reinforcing function and/or a stress relief function.

— Mitigation of water and gas ingress into the bound and unbound layers through their interlayer barrier function.

— Enhanced uniform layer adhesion.

— Optimizing the performance of bound layers above and below the interlayer through their functions.

— Structural improvement through the reinforcement and/or stress relief function.

Increased stiffness, structural improvement and mitigation of water ingress can improve the fatigue behaviour of the bound layers above the asphalt interlayer which again leads to the mitigation of reflective cracking (including top down cracking).

In an interlayer system, it is essential that the properties of each element be adapted to the specific objective of the measure to achieve the expected performance. Due to the temperature dependent visco-elastic properties of the asphalt and further elements of the system, the properties of the entire system alter with changes in temperature and loading. Therefore, any characteristics used in design normally take these variations into account.

4.3 Geosynthetics used as an asphalt interlayer: product types and system functions

4.3.1 General

Geosynthetics used as asphalt interlayers are one part of a system which are combined to provide positive outcomes. These systems usually consist of:

— the bound layer (flexible, rigid or semi-rigid) with an adequately prepared surface (milled or not-milled);

— a bituminous adhesive layer (type, quality and quantity according to each specific product);

— the geosynthetic used as an asphalt interlayer; and

— one or more layers of asphalt, a slurry seal overlaid with asphalt layers or a chip-seal (used, for example, when using a paving geotextile under a surface dressing).

In combination with the system, each product provides different valuable functions to the construction.

4.3.2 Asphalt interlayer functions

4.3.2.1 Reinforcing function (R)

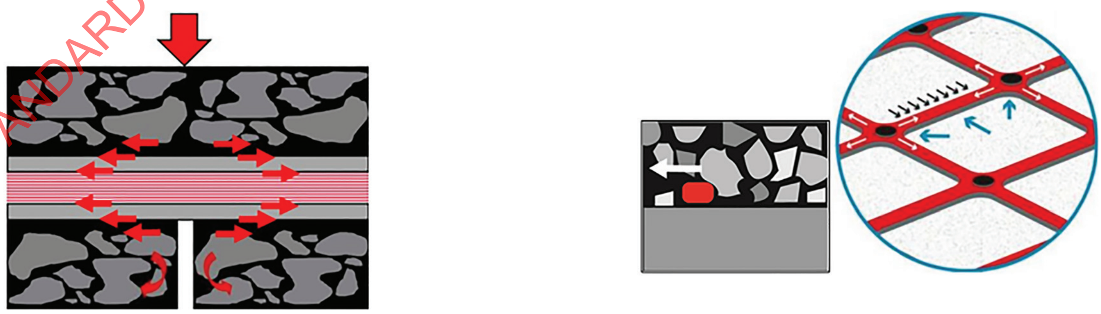
A new asphalt layer can be reinforced to mitigate the effects of reflective cracking using a paving grid or paving geocomposite. Therefore, the product is normally anchored in the system in such a way that it is able to absorb tensile forces. By absorbing tensile forces, the reinforcement can mitigate reflective cracking. Further, if applied in the tension zone of the bound structure, it can increase the stiffness and strength of the structure and lead to structural improvement of the asphalt layers. Both effects result in an improved fatigue resistance in comparison to an unreinforced structure with the same thickness.

In general, there are two different mechanisms of load transfer from the asphalt to the grid which provide reinforcement through (see Figure 1):

a) Adhesive shear bonding: The load transfer from the asphalt into the paving grid is achieved by the adhesion and friction between the asphalt and the surface of the grid.

b) Integral ribs and load transferring junctions by structural horizontal interlock: The load transfer from the asphalt into the paving grid is achieved by the anchorage of the paving grid in the asphalt matrix. This type of load transfer occurs in combination with adhesive shear bonding.

Both mechanisms of load transfer result in a strengthening or stiffening of the asphalt layers. To dissipate the forces, the interlayer normally has a certain anchorage length outside the tension zone. A minimum length of 0,5 m to each side of a crack is usually sufficient, though this does ultimately depend on the specific system and product.



a) Schematic illustration of load transfer "asphalt – grid" through adhesion **b) Schematic illustration of load transfer "asphalt – grid" through horizontal interlock**

Figure 1 — Illustration of load transfer through adhesion and interlock

4.3.2.2 Interlayer barrier functions (B)

In asphalt road construction, an interlayer barrier is a layer which prevents the ingress of liquids (e.g. water) and gases (e.g. oxygen) into the bound and unbound layers of the structure below the barrier. This can be provided by a paving geotextile in conjunction with bitumen. When a paving geotextile is used, it is important to have a certain bitumen retention capacity. Furthermore, an adequate quantity of bitumen is needed to create a barrier with a sufficiently low permeability to mitigate aging and cracking of the surrounding pavement. Refer to Table 4 for suggested quantities to provide interlayer barrier function (see Figure 2).

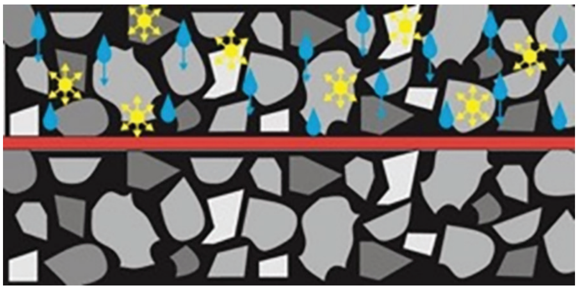


Figure 2 — Schematic representation of interlayer barrier function

The interlayer barrier can provide the following benefits:

— maintaining the structural stiffness and the bearing capacity of bound and unbound layers over a longer period of time;

— improvement of frost resistance and reduction of frost damage caused by freezing water in the structure, bound and unbound layers (e.g. bursting effect, formation of ice lenses, drenching during defrosting period);

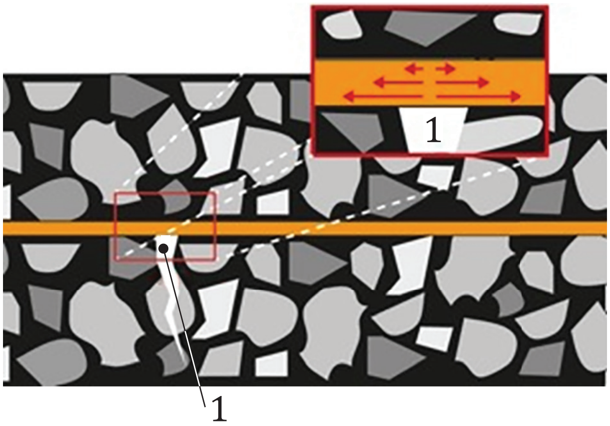
— reduction in aging of the bitumen in asphalt layers surrounding the interlayer barrier caused by oxidation;

— slowdown of formation of embrittlement cracks below the interlayer barrier caused by oxidation.

4.3.2.3 Stress relief function (STR)

In asphalt road construction, stress relief function (see Figure 3) dissipates tensile strain, typically provided by the visco-elastic characteristics of bitumen. Bitumen exhibits a visco-elastic behaviour in the service temperature range, which means that when a load is applied to a bitumen film, there are three different deformation reactions: elastic deformation (reversible), delayed elastic deformation (reversible), and viscous deformation (irreversible). For a visco-elastic material it is typical that temperature and loading speed determine the elastic or viscous behaviour.

A paving geotextile will store and hold the applied bitumen in place over the long-term. Moreover, the paving geotextile assures a consistent and even layer thickness.



Key
1 crack

Figure 3 — Schematic representation of stress relief function of an interlayer

Stress in the bitumen layer can be caused by, for example, traffic loading and deformation of the base course. These stresses can result in flow due to the visco-elastic properties of the bitumen used.

Tensile strain from movements of the underlying structure are absorbed to a large extent within the bitumen layer by viscous flow reaction. Movements of the underlying structure are not propagated to the new overlying layers of asphalt. Strain in the asphalt is reduced in order to avoid the local overstressing of the asphalt. At the same time, the adhesion of the bitumen ensures that the bitumen layer has a good bond to the underlying structure and the overlying layer of asphalt.

4.3.3 Geosynthetics used as an asphalt interlayer: product categories

4.3.3.1 Paving geotextile

A paving geotextile (see Figure 4) can be used in an asphalt pavement construction to provide, in conjunction with an adequate quantity of bitumen, an interlayer barrier (B) and stress relief (STR) function. It can be used as a single element or as part of a paving geocomposite. In order to provide an adequate level of performance and lifetime in accordance with its functions, a typical nominal fabric weight is ≥130 g/m^2 (according to ISO 9864) with a bitumen retention of ≥ 0,9 kg/m^2 (e.g. according ASTM D6140 or EN 15381, Annex C). The paving geotextile in conjunction with the bitumen additionally provides a uniform layer thickness and an enhanced uniform layer bonding.

Paving geotextiles do not increase the load-bearing capacity of the existing road structures but can maintain the existing load-bearing performance by their ability to limit water penetration and frost damage due to the barrier function. A paving geotextile alone does not provide a reinforcing function.

Figure 4 — An example of a paving geotextile

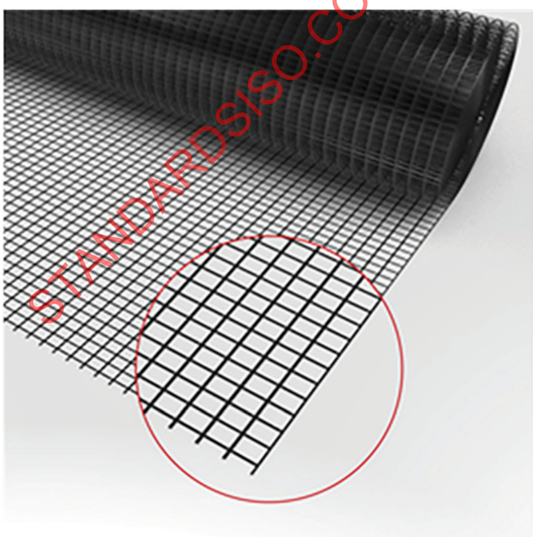
4.3.3.2 Paving grids

A paving grid (see Figure 5) is used in an asphalt pavement construction to provide a reinforcing function (R). It can be used as single grid element or combined with an installation aid. The load transfer from the asphalt into the paving grid is achieved by the anchorage of the paving grid in the asphalt matrix (see 4.3.2.1).

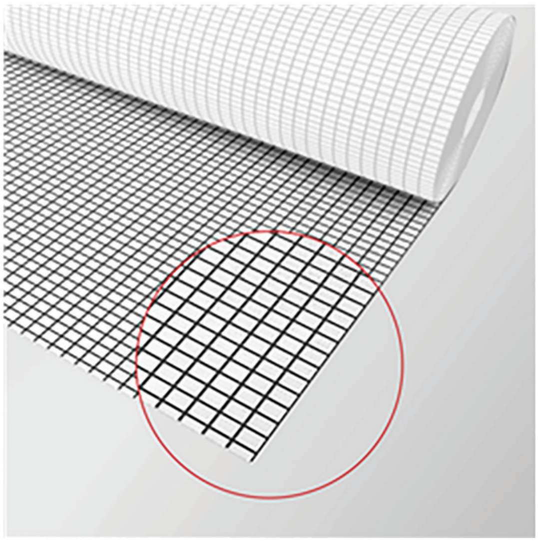
Paving grids provide a reinforcing function (4.3.2.1) by the absorption of tensile stress. The reinforcing effect of the grids depends on the mechanical properties of the product, the position of the product in the entire road pavement and its anchorage length.

Paving grids in asphalt systems can preserve the effective thickness of the asphalt by mitigating reflective cracking from the underlying layer into the newly paved asphalt layers. Further, if applied in the tension zone of the bound layers, they can, when loaded e.g. during trafficking, increase the stiffness and lead to structural improvement of the bound layers above the interlayer.

A paving grid alone does not provide a stress relief (STR) or interlayer barrier (B) function.



a) A paving grid only consisting of reinforcement elements



b) A paving grid consisting of a reinforcement grid and a low weight geotextile acting as installation aid

Figure 5 — Examples of paving grids

4.3.3.3 Paving geocomposite

A paving geocomposite (see Figure 6) is used in asphalt pavement construction to provide, together with an adequate quantity of bitumen, an interlayer barrier (B), stress relief (STR) and reinforcing (R) function. It is composed of a paving grid attached to a paving geotextile.

A good bond between the bound layers is required in order to get a proper mobilization of the tensile forces in the reinforcement.

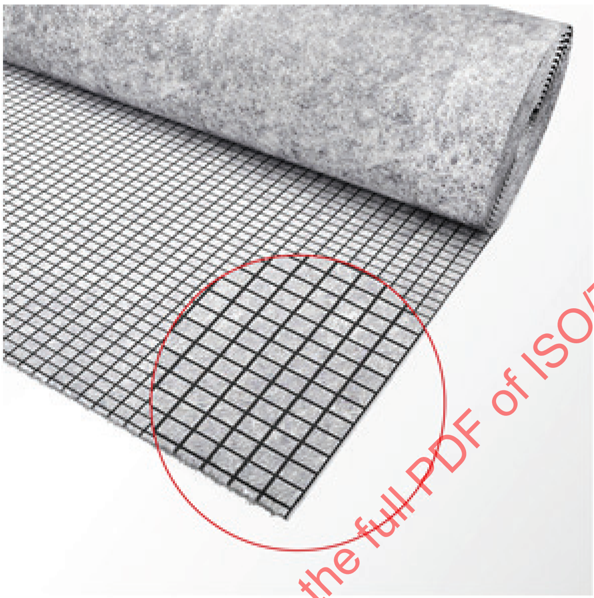


Figure 6 — An example of a paving geocomposite

4.4 Crack categories

4.4.1 General

The following subclauses detail examples of crack origins and damages often seen through visual assessment. These examples are not exhaustive. Cracks are mainly caused by different loads applied on the road construction by:

— traffic: this can be because of vertical loads due to the axle loads, and/or tangential loads due to speeding/ braking or steering;

— temperature changes: contraction/expansion of materials due to temperature changes, and/or expansion by freezing of water; and/or

— displacements in foundation and/or underground: this can be due to a variety of reasons, e.g. due to contraction of bound material; settlements; post compaction; shear; contraction or expansion due to a change in moisture content. These displacements can occur as rapid permanent deflection or as a result of longer term repeated cyclic movement.

4.4.2 Cracks with horizontal movements

Cracks that are mainly caused by horizontal stresses or shear caused by temperature changes (seasonal as well as daily; see Figure 7) occur in the following forms:

— cracks in longitudinal and lateral directions in asphalt paving with insufficient binder content, a too hard binder, an aged binder on a load-bearing and deformation-resistant underlayer;

— cracks in longitudinal and lateral directions in cracked hydraulically bound and unbound subgrades, subbases and concrete layers; and

— opening of longitudinal and traverse joints and of working seams.

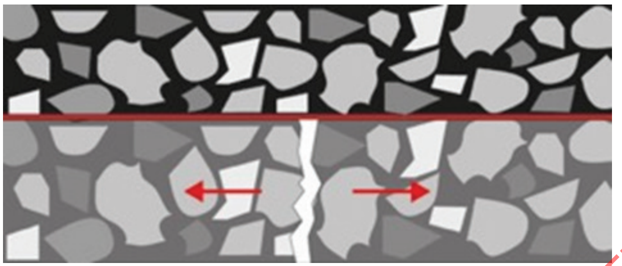


Figure 7 — Temperature induced horizontal movement

4.4.3 Cracks with vertical movements

Cracks resulting from limited vertical bending or shear are often caused by traffic (see Figure 8) in the following way:

— reflection of joints and cracks in underlying concrete layers and subbases with hydraulic binders into the overlaying asphalt (can include limited bending of slabs); and

— reflection of single cracks and net-like cracks in surface layers of asphalt pavements, whose carrying capacity is significantly reduced (e.g. by embrittlement of the binder or substantial traffic-based deflections due to low load-bearing capacity of the subsoil).

Maximum vertical bending is achieved when the axle is immediately above the joint/crack while maximum shear is achieved when the wheel is adjacent to the joint/crack.

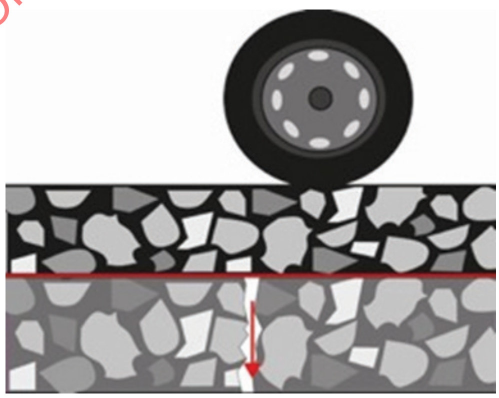


Figure 8 — Traffic-induced vertical movement

4.4.4 Cracks from horizontal and vertical movement

Cracks from the combined effect of horizontal and vertical movements occur in the following forms.

— Net-like cracks in a thin asphalt paving.

NOTE Possible causes include insufficiently frost-proofed overall structure (alligator cracks), damaging water penetration and self-cementing road bases.

— Crack accumulation in the wheel path of the asphalt pavement due to insufficient load-bearing capacity of the layers underneath such as binder-poor bound layers or due to a too thin bound pavement for the level of traffic loading.

— Cracks caused by temperature changes in rigid pavements.

4.4.5 Structure-related cracks

Structure-related cracks that are mainly caused by horizontal movements – as well as by vertical movements at the same time – occur in the following forms.

— Longitudinal cracks due to road widening. The cracks are caused by changes of structural construction (e.g. outer edge of old rough-stone pitching), changes in the thickness of the frost-proof paving, and/or changes in the stiffness/load-bearing capacity between the old consolidated pavement construction and the widened section or adding of another lane of differing material such as adjacent rigid and flexible construction.

— Longitudinal cracks that occur when paving over concrete edging strips, tram rails and excavation of all types.

4.5 Site investigation

The existing site conditions that are usually considered when using a geosynthetic as an asphalt interlayer include:

— climate;

— type of the road (category, speed regime, number of lanes);

— current and expected traffic loads;

— type and condition of the existing unbound layers;

— type and condition of the bound flexible, rigid or semi-rigid layers;

— load bearing capacity of the traffic area;

— conditions lateral of the road (drainage, trees, etc.); and

— type and composition of the proposed new overlay.

Identifying the source of damage in the existing pavement structure is crucial for planning a successful asphalt interlayer solution. There are different approaches to identifying and recording damage such as visual inspection, destructive testing and non-destructive testing.

With a visual inspection the general condition of a pavement, the location and crack type as categorized in 4.4, and deformations (e.g. rutting) can be identified. A visual inspection can only provide limited data on the underlying layers. In addition to this, destructive testing is essential (e.g. core drilling) for getting more information about the pavement structure (e.g. complete pavement thickness, pavement composition, condition of the asphalt layers/concrete layer/cement stabilization, etc.), degree of layer bonding and crack direction (top-down/bottom-up). Complementary additional non-destructive testing might be carried out with, for example, ground penetrating radar (GPR). Falling weight deflectometer (FWD) is normally used where differential vertical movement at a crack/joint is suspected.

4.6 Examples of system selection

Interlayer systems can be selected based on the mode of failure of the existing pavement and taking into account the three functions (B, R, STR) of the solutions to be considered. In many cases there are a number of reasons for cracking, so that one system is not be able to address all types of failures.

Tables 1 to 3 can help to select a suitable system depending on different requirements. In every case, it is crucial that a system selection for the individual project is carried out carefully. The table shows which properties are important for the specific case; a 0 means neutral while the number of + shows the effectiveness of this function against the specific failure type.

Once the required function or functions for each area to be treated has been selected and a suitable interlayer system found, a check is to be carried out to confirm that the chosen product is suitable for the individual project conditions. The following conditions can limit the application of individual product types.

— Installation on a milled underlying layer: check if the geosynthetic used as an asphalt interlayer can be installed on the milled surface and check the acceptable surface roughness.

— Installation in an environment with high pH-value (e.g. installation directly on concrete slabs or cement-bound layers): check if the geosynthetic used as an asphalt interlayer is durable under these conditions.

— Minimum required asphalt thickness in the first layer above the interlayer: check minimum required asphalt thickness for individual product.

Table 1 — Horizontal movements

	Shrinkage through hardening / ageing (in asphalt)		**Thermal expansions and contraction**		**Moisture induced swelling (and shrinkage) of underlying layers**	
Example of possible origin	Bitumen embrittled due to oxidation through surrounding conditions (e.g. ingress of water and oxygen, UV, etc.)		Different behaviour of materials, e.g. asphalt on concrete slabs or “new” asphalt on aged and hardened asphalt layer(s)		Cohesive underlying layer swelling (and shrinking) from change of water content due to changing weather conditions and/or vegetation	
Crack width	≤ 6 mm	> 6 mm	≤ 6 mm	> 6 mm	≤ 6 mm	> 6 mm
R	+++	++	+++	++	+++[a]	++[a]
STR/B	++	+	++	+	+++[a]	+++[a]
R/STR/B	+++	++	+++	++	+++[a]	+++[a]

Key

\+ improves performance

++ better performance

+++ best performance

[a] In case failure is caused by water ingress or a changing water content, an intact drainage system is a significant factor for the success of the rehabilitation.

Table 2 — Vertical movements

	Shrinkage through hardening / ageing (in asphalt)		Moisture induced swelling (and shrinkage) of underlying layers	
Example of possible origin	Rocking concrete slabs paved with asphalt due to eroded foundation through ingress of water and/or insufficient preparation of the unbound foundation		"Hard" change of bearing capacity in underlying construction, e.g. caused by use of different construction materials in joint region and/or material migration due to ingress of water	
Settlement	≤ 0,1 mm	> 0,1 mm	≤ 0,1 mm	> 0,1 mm
R	++[a]	+[a,b]	++[a]	+[a,b]
STR/B	+[a]	0	+[a]	0
R/STR/B	++[a]	+[a,b]	++[a]	+[a,b]

Key

+ improves performance

++ better performance

0 no improvement

[a] In case failure is caused by water ingress or a changing water content, an intact drainage system is a significant factor for the success of the rehabilitation.

[b] Limited range of products due to different raw materials (check with the manufacturer).

Table 3 — Combined horizontal and vertical movements

	Traffic induced bending	Settlement	Edge settlement	Frost heave; Swelling of unbound layer through ingress of water	Thermal expansion
Example of possible origin	Traffic; high axel loads	Change of bearing capacity in underlying construction, e.g. caused by different soil conditions or ingress of water	Sliding of the structure, induced by traffic loads at the edge	Frost bursting or expansion of ice lenses or expansive soils through ingress of water	Expansion of underlying concrete slabs with insufficient expansion joints
Crack width	≤ 6 mm	> 6 mm	[c]	[c]	[c]
Settlement	[c]	[c]	[c]	[c]	[c]
R	++	+	++[a,b]	++[b]	0
STR/B	+	0	++[a,b]	+[b]	0
R/STR/B	++	+	+++[a,b]	++[b]	0

Key

+ improves performance

++ better performance

+++ best performance

0 no improvement

[a] In case failure is caused by water ingress or a changing water content, an intact drainage system is a significant factor for the success of the rehabilitation.

[b] Limited range of products due to different raw materials (check with the manufacturer).

[c] Individual project related engineering judgement necessary (check with the manufacturer).

4.7 Design models

The goal of designers is to be able to incorporate analysis of the crack driving mechanisms presenting themselves by simulating their progression through the overlay. As there is no single calculation method for the design of roads accepted by all agencies or all countries, there are also no single design methods for pavements incorporating anti-cracking interlayers. The design approach cannot be generalized and is usually associated with the particular interlayer product being proposed. There are, however, several specific calculation methods with all their advantages and disadvantages.[4] The disadvantage of these calculation methods is that they are limited to the use of a certain product or to a certain failure mode. Recent studies deal with modelling the behaviour of a geosynthetic used as an asphalt interlayer in asphalt layers. Current ME, 2D and 3D Finite Element design models (FEM) show good correlation with results of laboratory tests and the results gained from use in on-site practice. However, because of the complex interrelation and the many influencing factors, it is crucial that the design models are confirmed through long term, real life performance measurements before they can be considered reliable. Therefore, the design of asphalt interlayers still relies strongly on practical experience.

Some existing design methods are presented in Table A.1. Some of them are proprietary to some specific product(s). Design methods often use reference designs based on laboratory and in-situ verification of final performance.

5 Installations

5.1 General

Asphalt road paving with a geosynthetic used as an asphalt interlayer requires particular care and experience. It is essential that specific project conditions are reviewed with a technical representative of the interlayer manufacturer, who can provide expert assistance during installation. The system components of the old roadway (including site conditions like dewatering and drainage, presence of existing cracks, method of milling, etc.), the geosynthetic used as an asphalt interlayer, and the paving of any surface layers is normally considered and coordinated. Therefore, it is crucial that the installation be carried out only by qualified companies (see Annex C) or under the supervision of the manufacturer/supplier of the asphalt interlayer. It is essential that the installation guidelines of the manufacturer are always considered and, if necessary, adapted to the specific site conditions as the guidelines cannot cover all potential scenarios. A non-conforming installation of a geosynthetic used as an asphalt interlayer can lead to premature failure of the pavement. Annex B provides a checklist that can be used for quality control purposes and documentation of the site condition. During installation, it is essential that health and safety instructions are considered.

5.2 Site preparation

The receiving surface has to be clean, dust-free, dry and free of loose particles. All potholes are to be filled with bituminous material. It is crucial that cracks are treated according to the local guidelines. It is good practice to treat cracks with a width of 3 mm to 20 mm, with an appropriate flexible sealant. Any unevenness and/or vertical movements in the pavement structure are to be eliminated (e.g. by stabilizing concrete slabs, relaxing unstable concrete slabs/levelling course). Depending on the product of the chosen solution, the installation of the geosynthetic is to be carried out on a fine milled surface, of up to 10 mm peak to trough regularity.

5.3 Bond coat application

A geosynthetic used as an asphalt interlayer is requiring a bond coat for installation. It is vital to understand its importance as follows.

a) A bond coat is required to achieve a proper bonding between the asphalt layers – independent of using an asphalt interlayer or not.

b) When using a geosynthetic used as an asphalt interlayer, the bond coat holds the asphalt interlayer in position (i.e. no wrinkling or creasing) during the asphalt paving process.

c) If a certain quantity of bond coat is sprayed, it forms a seal/barrier between the underlying surface and the overlaying asphalt (see 4.3.3.1).

The quantity and type of bond coat can change because of the type of geosynthetic used as an asphalt interlayer and the conditions on site, including weather. Bond coats can be emulsions or hot bitumen, polymer modified or unmodified. An immediate fixing, such as obtained with a hot bitumen, reduces the possibilities of correcting measures if the asphalt-interlayer is not laid exactly in the right place.

It is essential that bitumen emulsion is cured (fully broken) before asphalt is overlaid on the interlayer.

The rate of spread of the bond coat can be varied to accommodate different types of interlayer product, surface conditions, and weather. The bitumen emulsion example in the following table is based on a residual bitumen content of 70 %. If the bitumen content changes (e.g. to 60 %), the spray rates change accordingly. The spray rates provided are typical values and are to be checked for each project before being applied.

Table 4 — Some suggestions on spray rate of bond coat when using geotextile products as asphalt interlayer

Product type	Bitumen emulsion spray rate (based on 70 % residual binder content) kg/m^2	Straight run bitumen and polymer-modified bitumen kg/m^2
Paving geotextile	1,6 to 2,3	1,1 to 2,5
Paving grid	0,3 to 1,2	0,3 to 0,9
Paving geocomposite	1,6 to 2,3	1,1 to 2,5

5.4 Installation of a geosynthetic used as an asphalt interlayer

The following suggestions for the installation of asphalt interlayers are of a general and typical nature. Considering that installation is a key requisite for the long-term performance of asphalt-interlayers, it is usual to follow the installation guidelines of the supplier and to adapt them, if necessary, to the specific site conditions.

The geosynthetic used as an asphalt interlayer needs to be applied by a purpose-made applicator capable of laying the geosynthetic product under tension, without wrinkles or creases, and brushing it firmly into the fresh or partially cured bond coat. Rolling out the geotextile by hand is to be avoided except at very small projects or areas inaccessible for the applicator, or when using products specially made for manual installation (e.g. patch products). It is essential that considerable care is exercised to avoid wrinkles and creases in the installed geosynthetic used as an asphalt interlayer, but in the event of a wrinkle or crease occurring it needs to be repaired in accordance with the manufacturer's installation guidelines. For geosynthetics used as an asphalt interlayers which show a memory-effect during installation, proper fixing of the full surface is ensured by additional means in compliance with product manufacturer installation instructions (e.g. nailing, slurrying, etc.).

Depending on the type of geosynthetic used as an asphalt interlayer and project conditions, overlapping in longitudinal and/or cross-direction is required to ensure continuous coverage without gaps and avoid issues that can occur from reduced overlay thickness. Overlaps, having more than two overlying asphalt interlayers are to be avoided to ensure that enough asphalt thickness above the interlayer is achieved.

NOTE Additional bond coats could also be required at overlaps.

When paving on a geosynthetics used as asphalt interlayers, there is a risk of installation damage. The level of damage will vary according to, among other factors, the interlayer product type, the structure of the underlying layer, the quantity and type of bond coat, the asphalt mix type, its overlay thickness and the type of installation equipment (interlayer and paving procedure). The damage caused during the installation of the interlayer product will vary according to its mode of action, raw material, product structure and the method of manufacturing.

5.5 Overlay application

Asphalt is laid over the geosynthetic used as an asphalt interlayer following national and local guidelines and is subject to the points referred to above. If the geosynthetic used as an asphalt interlayer is fixed with a bituminous emulsion, it is necessary that the emulsion is completely cured before overlaying. The time this takes is strongly connected to the weather conditions (e.g. temperature, humidity). It is important that the correct minimum thickness of the first overlay (overlay immediately above the geosynthetic used as an asphalt-interlayer) is achieved, as insufficient thickness is a principle cause of post-installation issues and premature cracking. Each geosynthetic used as an asphalt interlayer material will have a required minimum compacted thickness of overlay; it is important that manufacturers' best practices and/or guidelines are followed and strictly adhered to in this respect.

6 Performance of interlayer systems

6.1 General

The interlayer is normally evaluated as an installed system together with type of bond coat, method of installation, etc. Moreover, the existing road and its condition, as well as the properties of the applied overlay, plays a dominant role in the performance of the final interlayer system. Care is usually taken with the interpretation of performance data whether they were collected through field testing or testing in lab conditions.

This clause focuses on good practice and important aspects of both field assessment and lab testing of interlayer systems. Since there is currently no standardized performance test, this document does not present a single test but gives an overview of different existing tests and the important site conditions which need to be taken into consideration when testing is being proposed and carried out.

6.2 Field assessment

Evaluation of performance in the field is a complex process as every site has its own unique conditions which can have an influence on the interlayer and hence pavement performance. In order to understand and evaluate performance of the interlayer system, proper preparation and an agreed method for long-term follow-up is needed. Long-term follow-up will, over time, build knowledge of the particular system, in conjunction with the asphalt overlay information, to provide confidence to specifiers. The following points are important to consider:

a) Detailed inspection of the existing situation (before rehabilitation). Following the visual inspection, a map detailing the location and number of cracks needs to be recorded for future reference. This includes a visual and structural inspection of the road surface detailing the location, length, width, potential for movement (e.g. patches or slab movement) and number of different cracks and any other surface damage being important to record. Locations susceptible to increased cracking (due to, for example, heavier traffic, a sewage system under the surface, higher temperature differences, etc.) also need to be recorded. Core drilling, radar, falling weight deflectometer or geophysical surveys can contribute to information towards this investigation.

b) Based on the site conditions, (different) solution(s) could be proposed for evaluation. Where practical, it is good practice to include a test section without any interlayer as this is the best method by which to assess the lifetime increase brought by the interlayer system in use. For the selection of the reference section, it is usual to select a section that is representative of the entire road, having similar build-up/history and similar future conditions of use (i.e. traffic, environment).

c) Application of the interlayer needs to be done according to the producers'/installers' guidelines. It is also important to monitor and archive as much as possible the conditions such as surface cleanliness, type and quantity of bond coat applied, air temperature, etc. It is also important to note any difficulties, issues and problems encountered during the project. This monitoring is required throughout the project, including during the preparation of the jobsite, application of the interlayer system, and the asphalting process.

d) Short-term performance of the interlayer systems.

   Typically, after the first year following the application, quality checks are usually done. Layer adhesion can be tested in accordance with local and national guidelines, but it is essential that care is taken to ensure damage is not caused to the interface during coring; that test conditions are suitable; and with any interpretation of the results (e.g. Leutner shear testing).

Initial inspection of the surface can also be useful to identify defects from construction which are not related to reflective cracking.

e) Long-term performance of interlayer systems.

Crack growth is the dominant failure mechanism which is intended to be mitigated by interlayer systems. The easiest way to evaluate the performance of interlayer systems is to monitor the crack growth in the road over time.

Knowing the number of original joints/cracks, the percentage of (equivalent) cracks reflected can be calculated.

It is essential that cracks are evaluated in a consistent way over time in order to make legitimate conclusions of performance. The inspector, the season (due to the self-healing properties of asphalt concrete), and conditions of the weather on the inspection day can influence the number of cracks detectable to the eye. An ideal period for visual inspection is in spring time when the road is drying as this makes cracks more visible.

6.3 Laboratory tests

The performance of interlayers are normally considered in the pavement as a whole. Although there are currently no standardized tests for this, there are a broad variety of tests available to assess the performance of these systems, all of which simulate specific failure mechanisms. There are limitations on simulating the performance of geosynthetic interlayers in asphalt within laboratory and in-situ testing, particularly when simulating pavement ageing on-site. At best, laboratory tests can offer relative comparisons between different materials, but only within the context of the test itself.

Below is an example overview of laboratory tests.

— Static 3-point or 4-point bending test – monotone bending of the base layer.

— Cyclic 3-point or 4point bending test – fatigue under traffic.

— Cyclic horizontal movement testing – thermal movement of the underlying structure (temperature variation: day/night and/or seasonal variation).

— Cyclic vertical shear testing – shear due to slab rocking.

These tests can only be interpreted for the specific investigated failure mechanism and cannot be generalized. For these tests, samples can either be prepared in a laboratory or taken from a working site. As reflective cracking can be related to fatigue, it is important to focus on cyclic tests generating fatigue. In any case, for all tests there are some specific points of attention that need to be considered, listed below.

— The entire pavement construction, including the interlayer system, is important to the final performance.

— Testing temperature, loading amplitude and frequency are determining parameters in the test. Different parameters can under- or over-estimate differences between systems.

— Sample size and type is important, depending on the size and type of the anti-reflective cracking interlayer. For example, some grids have an aperture size of 12 mm while others have a size of 300 mm. For a larger grid, a larger sample is required to be representative.

In addition, the width, length and thickness of the tested specimen are important, and a slight difference in thickness of the sample might impact conclusions made on the fatigue lifetime drastically.

There are a wide variety of special simulators which can be used to investigate accelerated ageing in pavements (Accelerated Pavement Test, or APT). Examples of these devices include the Mobile Load Simulator (MMLS3) and a full-scale traffic load simulator (Mobile Load Simulator MLS10).

7 End-of-life and recycling

7.1 General

When the service life of an interlayer pavement structure expires, the layers, including the interlayer, can often need to be milled and recycled. This clause provides an overview of points to be considered before and during these procedures.

Geosynthetics used as asphalt Interlayers are composed of different raw materials which consequently lead to different behaviours when milling and recycling. While some steel reinforcements need to be removed and recycled separately, polymer and mineral fibre products can usually be milled and recycled together with the asphalt granulate.

The design specification needs to outline the type and location of the interlayers in the construction process. This can vary along the same stretch or different sections of a pavement and is often not recorded, or the records are found to be inadequate for the purposes of locating the reinforcement prior to commencing the milling process. In these cases, cores can be taken or non-destructive testing (such as georadar) can be useful in locating the reinforcement.

7.2 Milling

If the project circumstances allow, the asphalt needs to be milled down to just above the asphalt interlayer followed by paving with the new asphalt. It is important to consider this option to maintain the benefits of the interlayer. In these cases, it is necessary to ensure an adequate distance between the interlayer and the cutting tool of the milling machine to avoid any damage to the interlayer. The layer bonding at the level of the interlayer needs to be adequate to allow milling without debonding the upper remaining asphalt from the interlayer. Due to the common use of an increased quantity of bitumen for the installation of most geosynthetics used as an asphalt interlayers – and therefore increased adhesion between the asphalt layers – the risk of debonding is relatively low.

When milling a geosynthetic used as an asphalt interlayer, the composition of the interlayer has less impact on the milling procedure and later reuse than the milling procedure itself and the handling of the asphalt granulate which are decisive for both milling and recycling. The following aspects mainly influence the results and can be considered to optimise a proper milling process and the particle size of the interlayer in the recycled asphalt.

— Milling depth:

  When milling includes the complete removal of the interlayer, it is good practice to mill at a minimum depth of 15 mm below the interlayer, so that the angle of the milling tool is steep and cuts the interlayer into small pieces. Milling at the level of the interlayer generally results in cutting out larger strands and/or pieces of the interlayer. If these materials hinder conveyance through the milling machine the milling process can be delayed. Remaining parts of the product on the underlying layer need to be avoided and removed before paving.

— Driving speed:

  The driving speed of the milling machine has an influence on the particle size left in the asphalt granulate. The slower the milling machine drives, the smaller the strands and/or pieces of the interlayer become.

— Milling drum speed:

  The speed of the milling drum has an influence on the particle size left in the asphalt granulate. The faster the milling drum rotates, the smaller the strands and/or pieces of the interlayer become.

— Distance of cutting tools:

  The distance between the cutting tools around the milling drum have an influence on the particle size left in the asphalt granular. The less distance between them, the smaller the strands and/or pieces of the interlayer become.

— Layer bonding:

The better the adhesion of the layers below and above the interlayer, the smaller the strands and/or pieces of the interlayer become.

Often, the asphalt granulate is transported from the milling machine to a truck via a conveyor belt. In these cases, it is essential that remaining loose parts of the interlayer on the road are disposed of separately and not added to the granulate on the truck. This usually happens within the regular procedure for the road surface preparation for later paving.

7.3 Recycling

Research and testing have shown that asphalt granulate including polymer or mineral based fibre products can usually be recycled and used in new asphalt mixes.

In order to fulfil individual or national restrictions on maximum allowable foreign object content and maximum allowable particle size for asphalt granulate, it is common practice to sieve the material before reuse. Depending on the milling procedure some materials can be separated better than others which will remain in the recycled asphalt.

The manufacturer of the product needs to provide sufficient information based on experience to allow the user to ensure a proper reuse in line with the individual product requirements.